River Protection Project System Plan

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Office of River Protection

P.O. Box 450
Richland, Washington 99352

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River Protection Project
System Plan

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

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

Washington River Protection Solutions, LLC

L.M. Bergmann, R.O. Lokken, A.N. Praga, S.N. Tilanus, M.N. Wells
AEM Consulting, LLC

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FOREWORD

The U.S. Department of Energy (DOE) is submitting to the Washington State Department of Ecology, Revision 8 of the River Protection Project (RPP) System Plan (System Plan 8), in accordance with Tri-Party Agreement Milestone M-062-40. System Plan 8 is a computer modeling exercise, which evaluates a set of 11 technical scenarios and provides rough cost and schedule estimates for completing the RPP mission at the Hanford Site.

The scenarios analyzed in System Plan 8, and their underlying assumptions and conditions, were collaboratively developed by DOE and Washington State Department of Ecology. While the baseline case reflects a theoretically achievable technical approach for completing the RPP mission based on conditions, constraints, assumptions, and direction existing at the time the System Plan 8 modeling effort began in early 2016, it does not account for delays associated with addressing tank vapors-related issues and makes other technical assumptions that have not been proven to be implementable. The baseline case identifies estimated tank waste retrieval and treatment completion dates that incorporate the revised milestones contained in the 2016 Amended Consent Decree. The baseline case also reflects an approach that does not factor in anticipated federal budgetary constraints.

System Plan 8 is not intended as a decision document or budget document, and DOE believes further analysis is needed to fully understand how the System Plan 8 assumptions and conditions interact with one another to impact the costs and the hypothetical completion dates. DOE does anticipate, however, that the information included in System Plan 8 will aid discussions with regulators and other stakeholders near Hanford regarding improved approaches for conducting the RPP mission.

As noted above, DOE will seek an improved understanding of the underlying drivers in the modeling approach to analyze the various scenarios included in System Plan 8. DOE intends to convene an expert team to examine the models, assumptions, algorithms, work sequencing, and parametric cost analyses used to prepare System Plan 8 to pinpoint specific cost drivers.

Under the baseline technical approach and selected scenarios, System Plan 8 forecasts a significant increase in lifecycle cost and schedule for completing the RPP mission. The lifecycle cost estimates reflected for the baseline case and each alternative scenario in System Plan 8 were developed solely for comparison purposes and were not intended to serve as a complete analysis. They do reflect substantial increases in annual costs.

As part of DOE’s continuous effort to identify new and more efficient ways to perform cleanup, initial brainstorming sessions were recently held utilizing a multi-disciplinary team from DOE offices and contractors to identify near-term potential opportunities to attempt to drive down the cost and schedule of the RPP mission. These initial near-term opportunities include:

- Transitioning the direct-feed low-activity waste initiative to the use of a nonelutable resin to capture and retain cesium rather than return the cesium to the tank waste system. This nonelutable resin would be stored similar to the cesium and strontium capsules at the Hanford Site.
• Removing and preparing waste, determined not to be high-level waste, contained within specific tanks as contact-handled transuranic waste for disposal.

• Closing Waste Management Area C.

These near-term initiatives, followed by the use of a risk-informed decision-making framework to identify potential disposition pathways, could have a significant positive impact on the efficient disposition of tank waste at Hanford.

DOE is committed to working with its regulators and other stakeholders to continue to identify and implement ways to perform the RPP mission at Hanford in a safe and efficient manner while serving as a good steward of taxpayer resources.
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 only, not for decisional purposes, which will be conducted following the National Environmental Policy Act process.

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OFFICE OF RIVER PROTECTION
RIVER PROTECTION PROJECT SYSTEM PLAN

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T.W. Crawford  
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C.T. Whiteley
<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Reason for Revision</th>
<th>Revised By</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>August 2002</td>
<td>Initial issuance.</td>
<td>K.R. Wells</td>
</tr>
<tr>
<td>1</td>
<td>April 2003</td>
<td>Reflect proposed changes and additions to the waste treatment processes and facilities to accelerate mission completion.</td>
<td>K.R. Wells</td>
</tr>
<tr>
<td>2</td>
<td>September 2003</td>
<td>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.</td>
<td>P.J. Certa</td>
</tr>
<tr>
<td>3</td>
<td>May 2008</td>
<td>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.</td>
<td>P.J. Certa</td>
</tr>
<tr>
<td>3A</td>
<td>July 2008</td>
<td>Incorporate comments from the Office of Management and Budget.</td>
<td>P.J. Certa</td>
</tr>
<tr>
<td>4</td>
<td>September 2009</td>
<td>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.”</td>
<td>M.N. Wells</td>
</tr>
<tr>
<td>5</td>
<td>November 2010</td>
<td>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.</td>
<td>M.N. Wells</td>
</tr>
<tr>
<td>6</td>
<td>October 2011</td>
<td>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.</td>
<td>M.N. Wells</td>
</tr>
<tr>
<td>7</td>
<td>October 2014</td>
<td>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.</td>
<td>M.N. Wells</td>
</tr>
<tr>
<td>8</td>
<td>October 2017</td>
<td>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.</td>
<td>S.D. Reaksecker, S.N. Tilanus</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), Office of River Protection, manages the River Protection Project at the Hanford Site. The mission of the River Protection Project is to safeguard the nuclear waste stored in 177 underground tanks and to manage the waste safely and responsibly until it can be treated in the Waste Treatment and Immobilization Plant (WTP) prior to final disposition. The Office of River Protection is responsible for the storage, retrieval, \textsuperscript{1} treatment, and disposal \textsuperscript{2} of approximately 56 million gallons of radioactive waste contained in the Hanford Site waste tanks and closure of all the tanks and associated equipment.

BACKGROUND

The current Office of River Protection strategy\textsuperscript{3} for completing the River Protection Project mission involves a number of interrelated activities and facilities. The Office of River Protection’s objective is to reduce risk to the environment posed by tank wastes by:

- Retrieving the waste from single-shell tanks (SST) to double-shell tanks (DST) and delivering the waste to the WTP.
- Constructing and operating the WTP, which includes the Pretreatment Facility, Low-Activity Waste Vitrification Facility, High-Level Waste Vitrification Facility, Analytical Laboratory, and the Balance of Facilities.
- Direct-feeding low-activity waste to the Low-Activity Waste Vitrification Facility as part of a phased startup.
- Developing and deploying supplemental treatment capability to safely treat the remainder of the low-activity waste not immobilized by the Low-Activity Waste Vitrification Facility. Grout volume and quantity of vitrification containers are provided to indicate scale of supplemental treatment capacity in this System Plan.
- Developing and deploying supplemental capability for separating solids and soluble cesium as needed.
- Developing and deploying treatment and packaging capability for potential transuranic tank waste, followed by interim storage at the Central Waste Complex pending determination of the final disposal pathway.

\textsuperscript{1} Selected terms are hyperlinked to definitions provided in the list of terms.

\textsuperscript{2} HNF-EP-0182, 2017, Waste Tank Summary Report for Month Ending May 31, 2017, Rev. 353, Washington River Protection Solutions LLC, Richland, Washington. The total volume of tank waste fluctuates over time because water and chemicals may be added to tanks to facilitate waste retrieval processes; water is also removed by evaporation.

\textsuperscript{3} DISCLAIMER: Some of the activities described herein may be subject to and/or undergoing analysis required by the \textit{National Environmental Policy Act of 1969} (42 USC 4321, et seq.). These activities are included for planning purposes only, not for decisional purposes. Decisional planning is conducted in accordance with the \textit{National Environmental Policy Act of 1969} process.
- Deploying interim storage capacity for the immobilized high-level waste pending determination of the final disposal pathway.
- Disposing of packaged immobilized low-activity waste onsite at the Integrated Disposal Facility.4
- Closing the SST and DST farms, ancillary facilities, and associated waste management and treatment facilities.
- Sequencing the River Protection Project mission around resolution of technical and programmatic uncertainties.
- Upgrading the tank farms to provide a steady, well-balanced feed to the WTP.
- Investigating trade-offs of the required amount and type of supplemental treatment and pretreatment and the amount of immobilized high-level waste and immobilized low-activity waste.

The Hanford Federal Facility Agreement and Consent Order (HFFACO),5 also known as the Tri-Party Agreement, became effective when it was signed by DOE, Washington State Department of Ecology, and U.S. Environmental Protection Agency in 1989. This comprehensive agreement includes legally enforceable milestones for regulatory compliance and environmental remediation. Between 2007 and 2009, as a result of a lawsuit filed by the state of Washington, DOE and Washington State Department of Ecology negotiated new and revised HFFACO milestones, along with new milestones in a Consent Decree6 filed in federal district court. Both the Consent Decree and HFFACO changes became effective on October 25, 2010, the date the Consent Decree was entered into federal court. One of the HFFACO milestones, M-062-40, requires the Office of River Protection to prepare a System Plan every 3 years with its own specific set of requirements. Because various technical issues, funding constraints, sequestration, labor shortages, and equipment failures occurred after the Consent Decree became effective, DOE provided the required notification that a serious risk had arisen that DOE may be unable to meet several WTP and SST retrieval milestones; this ultimately resulted in informal and formal negotiations along with contested litigation and an Amended Consent Decree issued by the Court on March 11, 2016, as well as a jointly agreed-to Second Amended Consent Decree on April 12, 2016. The Amended Consent Decree7 generally continued the existing milestones from the 2010 Consent Decree but extended the milestone dates. One new milestone of note is B-3, which requires DOE retrieve at least five of the Consent Decree SSTs by December 31, 2020; if DOE cannot accomplish this milestone, the Amended Consent Decree gives the state the right to petition the Court to immediately order DOE to begin construction of new DSTs. The

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4 Office of River Protection planning pertaining to the final disposal of immobilized high-level waste is subject to the recognition of uncertainties associated with an assumed, planned national offsite geologic repository.


Amended Consent Decree schedule and milestones are incorporated into this revision of the System Plan.

**PURPOSE**

This revision of the River Protection Project System Plan (Rev. 8) is a major update to the previous revision and is intended to satisfy the requirements of HFFACO Milestone M-062-40D. This revision includes a new baseline case, along with the following 10 alternative scenarios jointly selected by the DOE, the Office of River Protection, and the Washington State Department of Ecology:

- Scenario 1 – Baseline Case
- Scenario 2 – Early Direct-Feed High-Level Waste
- Scenario 3 – Early Direct-Feed High-Level Waste with No WTP Pretreatment Facility
- Scenario 4 – Risk-Informed Single-Shell Tank Retrievals
- Scenario 5 – Accelerated Retrieval Completion
- Scenario 6 – Tri-Party-Agreement Compliant
- Scenario 7 – Reduced Throughput
- Scenario 8 – Early 241-U Tank Farm Retrievals
- Scenario 9 – Offsite Effluent Treatment
- Scenario 10 – Retrieval Contingency
- Scenario 11 – Direct-Feed High-Level Waste with Liquids-Only WTP Pretreatment Facility.

A hierarchy of assumptions underpins the scope of each case. The key assumptions for the Baseline Case are provided in Appendix A. The key assumptions for each alternative scenario are described in terms of the changes from the Baseline Case. Washington River Protection Solutions LLC, modeled the cases using the TOPSim model and prepared this System Plan on behalf of the Office of River Protection.

The Baseline Case flowsheet and modeling approach has changed substantially from previous system plans. Table ES-1 summarizes the key changes from previous system plans and their relative impact on the modeling results. The modeling tools and methodology used to define the

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

9 “Early” refers to an earlier startup of high-level waste treatment compared to the Baseline Case.

10 “Early” refers to an earlier start of 241-U Tank Farm single-shell tank retrievals compared to the Baseline Case.
scenarios are discussed in Section 2.0. Descriptions of the systems are provided in Section 3.0, and the state of the systems used in the current flowsheet is discussed in Section 4.0.

The key assumptions for each alternative scenario are documented in RPP-RPT-59581, Selected Scenarios for the River Protection Project System Plan, Revision 8, and each scenario is described in Section 5.0. Section 6.0 compares key results across all scenarios, which are also summarized below. A discussion of key risks associated with the Baseline Case, along with contingency planning for the six risks identified in HFFACO Milestone M-062-40, is provided in Section 7.0.

RESULTS

In the course of modeling and analysis, many of the largest contributors to changes in mission duration (and thus lifecycle cost) were identified as programmatic inputs or assumptions, rather than flowsheet changes. Table ES-2 summarizes the key programmatic inputs and assumptions for each scenario.

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## Table ES-1. Comparison of Key Changes from Previous System Plan Baselines.

<table>
<thead>
<tr>
<th>Item</th>
<th>System Plan (Rev. 6) – Baseline</th>
<th>System Plan (Rev. 7) – Baseline</th>
<th>System Plan (Rev. 8) – Baseline</th>
<th>Impact to System Plan (Rev. 8) Relative to System Plan (Rev. 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeling tool</td>
<td>HTWOS</td>
<td>HTWOS</td>
<td>TOP5sim</td>
<td>No change to the RPP mission duration.</td>
</tr>
<tr>
<td>Solubility predictions</td>
<td>Wash factors in tank farms and first order aluminum, phosphate, and oxalate solubility coupled with leach factors for WTP</td>
<td>Integrated Solubility Model (ISM)</td>
<td>ISM</td>
<td>ISM increases the predicted amount of solids in the DSTs over wash factors, which further constrains available DST space. These additional solids require water additions to mobilize and transfer. The ISM also increases the amount of sodium added in PT for leaching, adding additional ILAW containers. These factors together result in an increase to the RPP mission length.</td>
</tr>
<tr>
<td>SST retrieval assumptions</td>
<td>SVF-1647, Rev. 3D* (Retrieval factor = 2)</td>
<td>SVF-1647, Rev. 3D* (Retrieval factor = 2)</td>
<td>SS-1647, Rev. 0* (Retrieval factor = 1)</td>
<td>An increase in SST durations and volumes extends the completion date for all SST retrievals and requires more 242-A Evaporator campaigns.</td>
</tr>
<tr>
<td>WTP operation (excluding DFLAW)</td>
<td>2018</td>
<td>2018</td>
<td>2033</td>
<td>Later WTP startup increases the RPP mission length. The increase is approximately year-for-year with the startup delay.</td>
</tr>
<tr>
<td>PT efficiency included in the WTP integrated facility availability</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Efficiencies in the integrated facilities have been aligned to a WTP availability of 72%, which increases mission length by approximately 4 years.</td>
</tr>
<tr>
<td>Glass formulation model</td>
<td>2009 HLW/2004 LAW</td>
<td>2009 HLW/2004 LAW</td>
<td>2013 LAW and HLW</td>
<td>Less ILAW and IHLW is identified in the 2013 glass formulation models due to higher waste loading (the same amount of waste is treated, but less glass is produced).</td>
</tr>
<tr>
<td>DFLAW operation</td>
<td>No DFLAW</td>
<td>No DFLAW</td>
<td>DFLAW partially offsets the need for LAW supplemental treatment and supports a phased WTP startup.</td>
<td></td>
</tr>
<tr>
<td>Variable melter rate</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>The achieved glass production rate is reduced when waste feed is sufficiently dilute. This reduction mainly occurs during DFLAW and can reduce the melter production rate by 15 to 20% from the assumed rate.</td>
</tr>
<tr>
<td>Tank AY-102</td>
<td>Active for length of mission</td>
<td>Removed from service in 2016</td>
<td>Removed from service in 2017</td>
<td>Reduction in DST space impacts near-term space management.</td>
</tr>
<tr>
<td>TWCS capability</td>
<td>No TWCS</td>
<td>No TWCS</td>
<td>Six 500-kgal TWCS tanks</td>
<td>Allows for more consistent HLW feed through improved mixing and staging capabilities. Increases HLW feed storage space.</td>
</tr>
<tr>
<td>LAW supplemental treatment facility startup</td>
<td>Starts 2022, then ramped to full production 2025</td>
<td>Starts 2022, then ramped to full production 2025</td>
<td>Starts 2034 (no ramp)</td>
<td>Start date was shifted to align with a later WTP startup. This maintains the LAW treatment capacity required to ensure that the mission duration is driven by HLW treatment. An earlier start date of supplemental treatment relative to the HLW treatment start date also improves the first few years of HLW treatment production.</td>
</tr>
<tr>
<td>LAW supplemental treatment facility sizing</td>
<td>63 MTG/day</td>
<td>63 MTG/day</td>
<td>42 MTG/day</td>
<td>No impact to mission length, as LAW supplemental treatment facility is sized to not impact the RPP mission duration relative to the scenario.</td>
</tr>
</tbody>
</table>

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* Due to a procedural change, after SVF-1647 (Rev. 6), the SST retrieval assumptions spreadsheet was renamed SS-1647, “Single-Shell Tank Retrieval Assumptions for Mission Modeling,” Rev. 0, and is included as an attachment to RPP-PLAN–40145, 2016, Single-Shell Tank Waste Retrieval Plan, Rev. 6, Washington River Protection Solutions, LLC, Richland, Washington.

**Abbreviations:**
- DFLAW = direct-feed low-activity waste
- ISM = immobilized solubility model
- ISM = integrated solubility model
- LAW = low-activity waste
- MTG = metric ton of glass
- ORP = oxygen reduction potential
- PT = pretreatment
- RPP = River Protection Project
- SST = single-shell tank
- SVF = supplemental treatment facility
- TWCS = tank waste characterization and staging
- WTP = Waste Treatment and Immobilization Plant
- Yd = yard

**Notes:**
- 1 MTG = 5,000 lb
- 1 Yd³ = 35.3147 ft³
- 1 year = 365 days

**Important:**
- These factors together result in an increase to the RPP mission length.
Table ES-2. Comparison of Key Programmatic Inputs/Assumptions.

<table>
<thead>
<tr>
<th>Programmatic Input</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
<th>Scenario 5</th>
<th>Scenario 6</th>
<th>Scenario 7</th>
<th>Scenario 8</th>
<th>Scenario 9</th>
<th>Scenario 10</th>
<th>Scenario 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT Facility startup</td>
<td>12/2033</td>
<td>12/2033</td>
<td>N/A</td>
<td>12/2033</td>
<td>12/2033</td>
<td>12/2033</td>
<td>12/2033</td>
<td>12/2033</td>
<td>12/2033</td>
<td>12/2038</td>
<td>12/2033</td>
</tr>
<tr>
<td>LAW supplemental treatment startup</td>
<td>12/2034</td>
<td>12/2033</td>
<td>N/A</td>
<td>12/2034</td>
<td>12/2034</td>
<td>12/2034</td>
<td>12/2034</td>
<td>12/2034</td>
<td>12/2034</td>
<td>12/2038</td>
<td>12/2034</td>
</tr>
<tr>
<td>Supplemental CH-TRU waste processing</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DFHLW</td>
<td>No</td>
<td>2024–2033</td>
<td>Full mission</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Full mission</td>
<td></td>
</tr>
<tr>
<td>New DSTs</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Other</td>
<td></td>
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<tr>
<td>CH-TRU = contact-handled transuranic.</td>
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<tr>
<td>DFHLW = direct-feed high-level waste.</td>
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<tr>
<td>DFLAW = direct-feed low-activity waste.</td>
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<tr>
<td>DST = double-shell tank.</td>
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<tr>
<td>LAW = low-activity waste.</td>
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<td>HLW = high-level waste.</td>
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<tr>
<td>PT = pretreatment.</td>
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<tr>
<td>SST = single-shell tank.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>TWCS = tank waste characterization and staging.</td>
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<tr>
<td>WTP = Waste Treatment and Immobilization Plant.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

49 SSTs not retrieved

Offsite effluent treatment/disposal

Supplemental treatment at half capacity, no LAWPS after DFLAW

WTP at 50% TOE, 2.5x SST retrieval durations

CH-TRU = contact-handled transuranic.

DFHLW = direct-feed high-level waste.

DFLAW = direct-feed low-activity waste.

DST = double-shell tank.

LAW = low-activity waste.

HLW = high-level waste.

PT = pretreatment.

SST = single-shell tank.

TOE = total operating efficiency.

DST = double-shell tank.

DFLAW = direct-feed low-activity waste.

TWCS = tank waste characterization and staging.

WTP = Waste Treatment and Immobilization Plant.
Escalated and unescalated lifecycle cost profiles were created for all scenarios except Scenario 6. Figure ES-1 provides a comparison of the unescalated lifecycle costs for each scenario. Although the operating costs for WTP are included, the capital costs associated with WTP construction are not. Individual lifecycle cost profiles for each scenario are provided in their respective analysis discussions in Section 5.0. The lifecycle cost comparison shows that total lifecycle costs are closely correlated with total mission durations due to operating costs and escalation in the later years of the mission. Scenario 3 had the longest mission duration and thus the highest escalated lifecycle cost. Scenarios 2 and 4 had the shortest mission durations and thus the lowest lifecycle costs. The lifecycle cost for Scenario 4 was approximately $1 billion less than Scenario 2, despite a slightly longer mission duration because of reduced expenditures relating to SST retrievals.

The planned start dates for the WTP waste processing facilities are pivotal to long-term costs and schedules. Not only do the costs directly associated with the plant facilities increase when start dates are delayed (caused by escalation), the costs associated with supporting facilities also increase for the same reason because construction and operation schedules are tied to the dates the WTP facilities are needed.

In addition to lifecycle cost, scenario performance against HFFACO and Consent Decree milestones was assessed. Resultant quantities of immobilized waste products and associated waste loading were calculated, which helped predict when storage, shipping, and disposal facilities were needed. The model results also forecasted when key activities could occur, such as the mitigation of special DST wastes (e.g., buoyant displacement gas release event, saltcake, complexed concentrate waste), and when other supporting facilities will be needed (e.g., the waste receiving facilities). Table ES-3 summarizes these findings for each scenario.
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Table ES-3. Comparison of Key Scenario Results.

<table>
<thead>
<tr>
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<th>Scenario 9 – Offsite Effluent</th>
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<th>Scenario 11 – DFHLLW with Lidded-Only WTP PT Facility</th>
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</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Unescalated Lifecycle Cost, FY 2017 to End of Mission</td>
<td>$111B</td>
<td>$104B</td>
<td>$151B</td>
<td>$103B</td>
<td>$117B</td>
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<td>$148B</td>
<td>$112B</td>
<td>$110B</td>
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<td>Projected 200 East Area WRF Required Date</td>
<td>1/2035</td>
<td>1/2034</td>
<td>9/2036</td>
<td>1/2035</td>
<td>1/2033</td>
<td>N/A</td>
<td>1/2035</td>
<td>1/2035</td>
<td>1/2035</td>
<td>6/2033</td>
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<tr>
<td></td>
<td>Projected 200 West Area WRF Required Date</td>
<td>4/2040</td>
<td>6/2036</td>
<td>2/2036</td>
<td>11/2038</td>
<td>7/2038</td>
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<td>4/2038</td>
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<tr>
<td></td>
<td>Complete Potential TRU Waste Packaging</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1/2036</td>
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<td>1/2036</td>
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<tr>
<td></td>
<td>HLW Glass Canisters</td>
<td>7.800</td>
<td>11.400</td>
<td>63.600</td>
<td>7.200</td>
<td>8.000</td>
<td>7.800</td>
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<td>7.800</td>
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<tr>
<td></td>
<td>HLW Glass Waste Oxide Loading</td>
<td>44%</td>
<td>46%</td>
<td>22%</td>
<td>43%</td>
<td>44%</td>
<td>44%</td>
<td>45%</td>
<td>44%</td>
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<td>44%</td>
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<tr>
<td></td>
<td>Total LAW Glass Containers</td>
<td>94.000</td>
<td>92.600</td>
<td>58.700</td>
<td>85.500</td>
<td>94.000</td>
<td>94.000</td>
<td>94.000</td>
<td>95.400</td>
<td>94.800</td>
<td>95.700</td>
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<tr>
<td></td>
<td>ILAW Sodium Oxide Loading</td>
<td>22%</td>
<td>21%</td>
<td>19%</td>
<td>22%</td>
<td>22%</td>
<td>22%</td>
<td>22%</td>
<td>22%</td>
<td>23%</td>
<td>22%</td>
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<tr>
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<td>Total LAW Glass Containers from LAW Supplemental Treatment</td>
<td>42.300</td>
<td>47.200</td>
<td>N/A</td>
<td>37.100</td>
<td>42.300</td>
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<td>45.800</td>
<td>42.700</td>
<td>34.300</td>
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<td>Sodium to LAW Treatment (MT)</td>
<td>84.100</td>
<td>79.100</td>
<td>46.400</td>
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<td></td>
<td>Potential TRU Waste Drum</td>
<td>8.400</td>
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<td>N/A</td>
<td>8.400</td>
<td>8.400</td>
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<tr>
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<td>LAW Supplemental Treatment Projected Grout Volume (yd³)</td>
<td>419,200</td>
<td>469,500</td>
<td>N/A</td>
<td>389,400</td>
<td>412,600</td>
<td>N/A</td>
<td>416,500</td>
<td>419,500</td>
<td>395,000</td>
<td>430,500</td>
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</tbody>
</table>

* In contrast to Scenario 2, the lack of pretreatment capability in Scenario 3 results in feeding many solids to the HLW Vitification Facility in the latter part of the mission that would otherwise be treated as LAW. This causes poor waste loading in the HLW and a large increase to the total HLW quantity and HLW treatment duration.

DFHLLW = direct-feed high-level waste.
DFST = double-shell tank.
ILAW = immobilized low-activity waste.
ILAW = single-shell tank.
LAW = low-activity waste.
MT = metric ton.
N/A = not applicable.
PT = pretreatment.
SST = Tri-Party Agreement.
TRU = transuranic.
WMA = waste management area.
WRF = waste receiving facility.
WTP = Waste Treatment and Immobilization Plant.
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Appendix B Lifecycle Cost Model Scenario Results Summaries
# TERMS

## Acronyms

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<th>Description</th>
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<tr>
<td>Ba</td>
<td>barium</td>
</tr>
<tr>
<td>BBI</td>
<td>best-basis inventory</td>
</tr>
<tr>
<td>BDGRE</td>
<td>buoyant displacement gas release event</td>
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<tr>
<td>BNI</td>
<td>Bechtel National, Inc.</td>
</tr>
<tr>
<td>BOF</td>
<td>balance of facilities</td>
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<tr>
<td>CD</td>
<td>critical decision</td>
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<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act</td>
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<tr>
<td>CFF</td>
<td>cross-flow filter</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<td>CH-TRU</td>
<td>contact-handled transuranic</td>
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<td>CHPRC</td>
<td>CH2M HILL Plateau Remediation Company</td>
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<td>Cs</td>
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<td>CSL</td>
<td>criticality safety limit</td>
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<td>CWC</td>
<td>Central Waste Complex</td>
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<td>D&amp;D</td>
<td>decontamination and decommissioning</td>
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<td>DFHLW</td>
<td>direct-feed high-level waste</td>
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<td>DFLAW</td>
<td>direct-feed low-activity waste</td>
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<td>DOE</td>
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<td>DST</td>
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<td>DSTIP</td>
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<td>HLW</td>
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<tr>
<td>HPH</td>
<td>high-level waste canister pour handling (system)</td>
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HVAC  heating, ventilation, and air conditioning
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
IQRPE  Independent Qualified Registered Professional Engineer
ISM  integrated solubility model
IX  ion exchange
LAW  low-activity waste
LAWPS  Low-Activity Waste Pretreatment System
LCM  Lifecycle Cost Model
LDR  land disposal restrictions
LERF  Liquid Effluent Retention Facility
LLW  low-level waste
M  Manual
MARS  mobile arm retrieval system
MLLW  mixed low-level waste
MUST  miscellaneous underground storage tank
Na  sodium
NEPA  National Environmental Policy Act
NLD  nonradioactive liquid waste disposal
NRC  U.S. Nuclear Regulatory Commission
NWPA  Nuclear Waste Policy Act
O  order
OR  operations research
ORP  U.S. Department of Energy, Office of River Protection
PA  performance assessment
PCB  polychlorinated biphenyl
PCT  product consistency test
PMB  performance measurement baseline
PNNL  Pacific Northwest National Laboratory
PT  pretreatment
Pu  plutonium
RAMI  reliability/availability/maintainability/inspectability
RCRA  Resource Conservation and Recovery Act
RCW  Revised Code of Washington
RH-TRU  remote-handled transuranic
RL  U.S. Department of Energy, Richland Operations Office
ROD  record of decision
RPP  River Protection Project
SALDS  State-Approved Land Disposal Site
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<td>specific gravity</td>
</tr>
<tr>
<td>Sr</td>
<td>strontium</td>
</tr>
<tr>
<td>sRF</td>
<td>spherical resorcinol-formaldehyde</td>
</tr>
<tr>
<td>SRNL</td>
<td>Savannah River National Laboratory</td>
</tr>
<tr>
<td>SST</td>
<td>single-shell tank</td>
</tr>
<tr>
<td>SSTIP</td>
<td>single-shell tank integrity program</td>
</tr>
<tr>
<td>TC &amp; WM</td>
<td>tank closure and waste management</td>
</tr>
<tr>
<td>TEDF</td>
<td>Treated Effluent Disposal Facility</td>
</tr>
<tr>
<td>TOC</td>
<td>Tank Operations Contractor</td>
</tr>
<tr>
<td>TOE</td>
<td>total operating efficiency</td>
</tr>
<tr>
<td>TPA</td>
<td>Tri-Party Agreement</td>
</tr>
<tr>
<td>TRU</td>
<td>transuranic</td>
</tr>
<tr>
<td>TRUM</td>
<td>transuranic mixed</td>
</tr>
<tr>
<td>TWCS</td>
<td>tank waste characterization and staging</td>
</tr>
<tr>
<td>TWRWP</td>
<td>tank waste retrieval work plan</td>
</tr>
<tr>
<td>U</td>
<td>uranium</td>
</tr>
<tr>
<td>VSL</td>
<td>Vitreous State Laboratory of the Catholic University of America</td>
</tr>
<tr>
<td>WAC</td>
<td>Washington Administrative Code</td>
</tr>
<tr>
<td>WESP</td>
<td>wet electrostatic precipitator</td>
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<tr>
<td>WIPP</td>
<td>Waste Isolation Pilot Plant</td>
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<tr>
<td>WIR</td>
<td>waste incidental to reprocessing</td>
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<td>WMA</td>
<td>waste management area</td>
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<td>WOL</td>
<td>waste oxide loading</td>
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<tr>
<td>WRF</td>
<td>Waste Receiving Facility</td>
</tr>
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<td>WRPS</td>
<td>Washington River Protection Solutions LLC</td>
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<td>Waste Treatment and Immobilization Plant</td>
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<tr>
<td>WVR</td>
<td>waste volume reduction</td>
</tr>
<tr>
<td>Y</td>
<td>yttrium</td>
</tr>
</tbody>
</table>
Units

°C  degrees Celsius
°F  degrees Fahrenheit
ηCi  nanocurie
Ci  curie
ft  feet
ft²  square feet
g  gram
gal  gallon
kg  kilograms
kgal  thousand gallons
L  liter
lb  pound
m³  cubic meter
M  molar
MCi  megacurie
Mgal  million gallons
MT  metric ton
MTG  metric tons of glass
Sv  sievert
yd³  cubic yard
vol%  volume percent
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.

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.

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 (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 Washington Administrative Code (WAC) 173-303-610, “Closure and Post-Closure.”

Cross-site transfer. The Hanford waste tanks are located in two physically separated areas, 200 East Area and 200 West Area, which are about seven miles apart. The cross-site transfer system comprises the transfer pipelines and ancillary equipment used to transfer supernate 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 (per DOE M 435.1-1).

Early. As used in this System Plan, an activity or start date that occurs earlier than that modeled in the Baseline Case.

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.

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 (RAMI) failures applied, divided by the total time to treat all tank wastes, with all RAMI failures applied (DE-AC27-01RV14136, Design
Gas release event. Flammable gases, primarily hydrogen, are generated by tank waste. Hydrogen is generated via hydrolysis of water and organics, thermolytic decomposition of organic compounds, and corrosion of the tank’s steel walls. 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) (RPP-13033, Tank Farms Documented Safety Analysis, Rev. 7B, Section 3.3.2.4.1.)

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 were released into the tank headspace, the concentration of the flammable gas 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). 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.

Hot commissioning. The phase in which a facility does production runs using actual tank waste.

Intentional blending. Any blending that is specifically orchestrated and, therefore, requires additional effort. Examples of intentional blending include pairwise blending (blending two tanks at a time), metered blending (where small amounts of a problematic waste are blended into a number of successive feed batches), and the blending of different wastes first segregated according to limiting constituents.

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 Waste Treatment and Immobilization Plant (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 liquid. If the tank was jet pumped to achieve interim stabilization, the jet pump flow or saltwell screen inflow must also have been at or below 0.05 gal/minute before interim stabilization criteria are met (Consent Decree 2000 [CT-99-5076-EFS]).

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.
**LAW supplemental treatment.** Proposed supplemental treatment process(es) that will complement the LAW Vitrification Facility treatment capacity. The treatment technology is yet to be determined.

**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, with the consideration of practicability, including risk reduction, facilitating tank closures, costs, potential for exacerbating leaks, worker safety, and impact on the tank waste retrieval and treatment mission (Consent Decree [2010], 08-5058-FVS, Appendix C, p 37, lines 16-22).

**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 LLW in a near-surface facility.

**Low-activity waste (LAW) feed.** The liquid waste stream (supernate plus a small amount of entrained solids), after removal of key radionuclides, that is intended to be delivered to the LAW Vitrification Facility or LAW supplemental treatment facility.

**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 that is designed to access all areas of a tank (unless obstructed by an airlift circulator). (Additional details are provided in RPP-PLAN-40145, Single-Shell Tank Waste Retrieval Plan.)

**Modified sluicing.** Modified sluicing refers to the addition of water or supernate to a tank for the purposes of dissolving and retrieving salt or retrieving sludge. (Additional details are provided in RPP-PLAN-40145.)

- Modified sluicing for sludge removal with supernate consists of directing a stream of supernate from one tank onto the sludge of another tank to mobilize the slurry and push the slurry to the inlet of a pump. The pump transfers the slurry to a DST, where the sludge settles out and the liquid is returned to the tank for reuse.
- Modified sluicing for sludge removal with water is similar to using supernate, except that a DST pump, shielded transfer lines to the SST, and shielded sluicing equipment are not required. Liquid added to the DST system will require evaporation following retrieval.
- Modified sluicing for saltcake dissolution is similar to sluicing with water, except the solution may reside in the tank longer to promote effective saltcake dissolution.
**Programming techniques.** Programming techniques involve minor manipulations of the detailed elements of the model software necessary to ensure that the model is able to meet the key and detailed modeling assumptions defined for each scenario.

**Retrieval.** The process of removing, to the maximum extent practical, all the waste from a given underground storage tank. The retrieval process is selected specific to each tank and accounts for the waste type stored and the access and support systems available. In accordance with OSD-T-151-00031, *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.”

**Retrieval factor.** A factor used to scale the assumed SST retrieval durations. The assumed SST retrieval durations are divided by the retrieval factor, such that a factor >1 decreases the SST retrieval durations, while a factor <1 increases the duration.

**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 off of a primary scenario/case) in which limited model parameter(s) or sequence of events are altered to identify the impact 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 supernate 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 evaporating supernate originally removed from tanks containing saltcake so that aluminum salts begin to precipitate in addition to the sodium salts. This material, called “double-shell slurry” or “double-shell slurry feed,” is present in the DSTs (specifically Tanks AN-103, AN-104, AN-105, and AW-101). For simplicity, this System Plan will use the term “settled salts” or “saltcake” instead of slurry in this context.

Special DST wastes. Special DST wastes are wastes that require mitigation before the waste can be fed to the WTP, including Group A, high-fissile uranium blending in Tank AN-101 originating from SST C-104, blending of high-zirconium waste stored in certain tanks in the AW Tank Farm, and strontium/TRU precipitation in Tanks AN-102 and AN-107.

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

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. 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 WRF, located near the SSTs, will accumulate and condition retrieved waste before transfer to a DST. (Note that the WRF was once referred to as a waste retrieval facility.)
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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Hanford Site (see Figure 1-1) in southeast Washington State has 56 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 two parallel efforts, both aimed at reducing the threat posed to the Columbia River by the Hanford hazardous, radioactive tank waste:

- Retrieve waste from 149 single-shell tanks (SST) to 27 double-shell tanks (DST) where it can be safely stored awaiting treatment; and
- Treat the tank waste, producing a stable waste form that can be permanently disposed.

These efforts must be performed in parallel because the DST system does not have the capacity to hold all of the waste currently in the SSTs at one time. Because several complex technical issues arose during design and construction activities that adversely impacted DOE’s ability to meet negotiated milestones in the 2010 Consent Decree, these milestone dates were extended by U.S. District Court Judge Peterson in an Amended Consent Decree issued March 11, 2016, after lengthy litigation between the parties. As a result of that litigation, the Court extended the start of initial operations milestone date for the Waste Treatment and Immobilization Plant (WTP) to December 31, 2036, thus necessitating changes to the Tri-Party Agreement (TPA) end dates for completing all remaining SST retrievals and completing all tank waste treatment commitments; these milestone dates were predicated on the WTP start of initial operations by December 31, 2022, as negotiated in the 2010 Consent Decree. Changes in mission strategies to treat waste as soon as 2022 such as directly feeding low-activity waste (LAW) to the LAW Vitrification Facility (i.e., direct-feed LAW [DFLAW]), including advancements in technologies and glass formulation models, are examples of the efforts being engaged by ORP to mitigate the RPP mission challenges.
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 impacts of various scenario-specific planning assumptions on the RPP mission. DFLAW, 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 December 2033, at which time the Pretreatment (PT) Facility and High-Level Waste (HLW) Facility are anticipated to be ready for operation. 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 predominant priority and principle applies to all RPP work activities. With safety integrated throughout, and in order to achieve the milestones established by the Court in the March 11, 2016, Amended Consent Decree, the ORP has set the following five operational priorities (in no particular order):

- Complete construction and startup of the LAW Vitrification Facility, balance of facilities (BOF), and Analytical Laboratory
- Complete Low-Activity Waste Pretreatment System (LAWPS) and tank farms upgrades to initiate DFLAW operations
- Complete the infrastructure required to support DFLAW operations
- Continue tank waste retrievals
Complete the HLW and PT facilities.

1.1 BACKGROUND

The RPP is comprised of a fully integrated system of waste storage, treatment, and disposal facilities that is in varying stages of design, construction, operation, or future planning at the Hanford Site. These facilities are needed to complete the DOE RPP mission to safely manage, treat, and dispose of the nuclear waste stored in 177 underground tanks at Hanford. 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 DOE 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:

- 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-05085-RMP (March 11, 2016) and the Second Amended Consent Decree (April 12, 2016).
- Resource Conservation and Recovery Act of 1976 (RCRA)
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
- National Environmental Policy Act of 1969 (NEPA)
- Washington State Environmental Policy Act
- Nuclear Waste Policy Act of 1982 (NWPA)
- Code of Federal Regulations (CFR)
- Washington Administrative Code (WAC)
- Clean Water Act of 1972
- Safe Drinking Water Act of 1974
- Atomic Energy Act of 1954

12 Selected terms are hyperlinked to definitions provided in the list of terms.
Prior System Plan documents discuss these regulatory drivers, most recently in Section 2.0 of ORP-11242 (Rev. 7). Changes or updates that have occurred since System Plan (Rev. 7) regarding this information are addressed in Section 4.0 of this document.

1.1.1 Understanding Hanford 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 Nuclear Waste Policy Act of 1992:

(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.

DOE implements this definition by way of DOE O 435.1 and the associated DOE M 435.1-1, which establishes DOE’s definition of HLW as well as the process by which DOE will classify and manage radioactive waste.

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 waste incidental to reprocessing (WIR) process is defined in DOE M 435.1-1. Three criteria that the waste streams must meet include:

1. Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical
3. 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 Chapter IV of this Manual, 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 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 low-level waste (LLW) or LAW at Hanford. Once LAW has been immobilized and meets the land disposal restriction (LDR) criteria for solid wastes, the waste can be disposed of in a near-surface LLW repository. The radionuclides that are removed are planned to be combined with the remaining HLW and vitrified.

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” (Papierllo 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 waste determination by DOE, in consultation with the NRC, will be required prior to beginning processing of immobilized LAW (ILAW).

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 contained in or disposed of in long-term storage. In accordance with the HFFACO, 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 DOE/EIS-0391, Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (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”).

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

HFFACO Appendix I explains the procedure for the “Single-Shell Tank System Waste Retrieval and Closure Process,” and requires that each of the seven waste management areas (WMA)\(^{13}\) undergo a thorough Performance Assessment (PA). 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.

\(^{13}\) The seven waste management areas include C, A/AX, B/BX/BY, S/SX, T, TX/TY, and U.
Appendix I, Section 2.5, of the HFFACO requires the development of a PA for the SST system and the development of a PA for each WMA. The PAs will address the post-closure, long-term risk to human health and the environment presented by residual waste (containing both radionuclides and hazardous chemicals), equipment, and contaminated soil. Performance requirements are provided by the Revised Code of Washington (RCW) 70.105, “Hazardous Waste Management;” RCRA; Safe Drinking Water Act of 1974; 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. 8) is defined by the HFFACO (Ecology et al. 1989) and aligns with the Consent Decree. As noted in Milestone M-062-40, the System Plan is to “[describe] the disposition of all tank waste managed by the Office of River Protection, including the retrieval of all tanks not addressed by the Consent Decree 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. ORP defined the modeling starting assumptions (provided in Appendix A) from which the Baseline Case was developed for System Plan (Rev. 8) modeling on January 17, 2017 (16-WSC-0068, “Contract No. DE-AC27-08RV14800 – Approval of System Plan, Rev. 8, Model Starting Assumptions”). However, in addition to the Baseline Case, “DOE and Ecology each having the right to select a minimum of three scenarios each” can conduct what if options to assess the impacts of various scenario-specific planning assumptions on the RPP mission. Sections 1.3 and 1.3.1 discuss these scenarios in more detail.

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

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 Consent Decree [2010]) and completion of the treatment mission. Although included in the provided lifecycle cost analyses, facility decontamination and decommissioning (D&D) is outside the scope of the System Plan.

One year prior to issuing the System Plan, DOE and Ecology select scenarios to be analyzed. This was accomplished and presented as a joint package (RPP-RPT-59581, Selected Scenarios for the River Protection Project System Plan, Revision 8) agreed to by 16-NWP-172, “Department of Ecology Concurrence on Selected Scenarios for the River Protection Project System Plan”, Revision 8.
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.
- Impacts on closure activities for each scenario.

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 in Table 1-2 (page 1-13) including how they are addressed by this document.

### 1.3.1 Scenarios

All of the scenarios listed in Table 1-1, and several additional sensitivity cases, were jointly defined by DOE and Ecology. Although in prior System Plans, these scenarios were identified typically by the party who proposed each individual scenario (and as joint when proposed by both), the parties have agreed to consider all of the 11 scenarios as jointly proposed. Key assumptions for Scenario 1 (Baseline Case) were established by ORP, however, they were reviewed jointly and adjustments made accordingly so that this case could be altered for the additional scenarios. That is the Baseline Case assumptions served as the foundation from which each additional scenario was developed. The process, illustrated in Figure 1-2, is described further in Section 2.0, and the detailed assumptions for the Baseline Case are listed in Appendix A. 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 (not sensitivity cases), with the exception of Scenario 6, as this scenario was not modeled using the simulation modeling tools described in Section 2.2.

Table 1-2 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 1-1. System Plan, Revision 8, Scenarios with Objectives. (2 pages)

<table>
<thead>
<tr>
<th>Scenario #</th>
<th>Scenario Name</th>
<th>Scenario Objective</th>
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<tbody>
<tr>
<td>Scenario 1</td>
<td>Baseline Case</td>
<td>Reflect the best estimate of how the mission is thought to proceed given current conditions, constraints, and assumptions. The Baseline Case seeks to assess DOE’s ability to meet Amended Consent Decree and TPA milestones, excluding the two dates the case seeks to define (retrieval and treatment completion dates using input dates from the Amended Consent Decree)</td>
</tr>
<tr>
<td>Scenario 1A</td>
<td>Baseline Case Early DFLAW Sensitivity</td>
<td>Scenario 1A evaluates the effects of starting DFLAW processing on December 1, 2021.</td>
</tr>
<tr>
<td>Scenario 1B</td>
<td>Baseline Case 2016 Glass Formulation Model Sensitivity</td>
<td>Scenario 1B evaluates the impact of using the 2016 GFMs on the RPP mission.</td>
</tr>
<tr>
<td>Scenario 1C</td>
<td>Baseline Case No Supplemental LAWPS to LAW supplemental treatment</td>
<td>Scenario 1C evaluates the impact of not continuing to use the LAWPS to supplement the LAW supplemental treatment facility after DFLAW operations complete.</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>Early Direct-Feed High-Level Waste</td>
<td>Scenario 2 evaluates an alternative mission strategy that involves completing the HLW Vitrification Facility hot commissioning/hot start and achieving WTP initial plant operations 9 years earlier than required by the Amended Consent Decree (hot commissioning/hot start complete by 12/31/2024, initial plant operations achieved by 12/31/2027). The HLW Vitrification Facility is directly fed from the TWCS capability prior to completing the PT Facility hot commissioning/hot start by the date required by the Amended Consent Decree (12/31/2033). Supplemental CH-TRU waste treatment is not included in the Scenario 2 flowsheet.</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>Early Direct-Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment Facility</td>
<td>Scenario 3 evaluates an alternative mission strategy that involves completing the HLW Vitrification Facility hot commissioning/hot start and achieving WTP initial plant operations 9 years earlier than required by the Amended Consent Decree (hot commissioning/hot start complete by 12/31/2024, initial plant operations achieved by 12/31/2027). The HLW Vitrification Facility is directly fed from the TWCS capability and the LAW Vitrification Facility is directly fed from the LAWPS for the duration of the mission. The PT Facility, LAW supplemental treatment, and supplemental CH-TRU waste treatment are not included in the Scenario 3 flowsheet.</td>
</tr>
<tr>
<td>Scenario 3A</td>
<td>Early DFHLW with No PT 2016 GFM Sensitivity</td>
<td>Scenario 3A assesses the same configuration as Scenario 3 but uses the 2016 GFMs instead of 2013 GFMs.</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>Risk-Informed Single-Shell Tank Retrievals</td>
<td>Scenario 4 evaluates the cost and mission completion benefits of retrieving 98% of the remaining Hanford SST waste radioactivity (Ci) without retrieving all of the SSTs.</td>
</tr>
</tbody>
</table>

14 The Scenario numbers (shown as blue underline in Table 1-1) are hyperlinked to their respective sections in this document for aid in digital navigation. Additional hyperlinks and cross-references are provided whenever possible to aid in the digital navigation of the document using the same convention.
Introduction

**Table 1-1. System Plan, Revision 8, Scenarios with Objectives.** (2 pages)

<table>
<thead>
<tr>
<th>Scenario #</th>
<th>Scenario Name</th>
<th>Scenario Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 5</strong></td>
<td>Accelerated Retrieval Completion</td>
<td>Scenario 5 determines the number and timing of new DSTs that would have to be constructed in order to complete all remaining SST retrievals by June 2047.</td>
</tr>
<tr>
<td><strong>Scenario 6</strong></td>
<td>Tri-Party Agreement Compliant</td>
<td>Scenario 6 calculates the required retrieval/treatment capacities that are needed to meet the TPA milestones for retrieving all SST waste (12/31/2040) and treating all tank waste (12/31/2047). Note: The SST retrieval calculation and tank waste treatment calculation are evaluated separately.</td>
</tr>
<tr>
<td><strong>Scenario 7</strong></td>
<td>Reduced Throughput</td>
<td>Scenario 7 evaluates the impacts of lower-than-anticipated waste retrieval and treatment rates on the RPP mission and identifies potential contingencies.</td>
</tr>
<tr>
<td><strong>Scenario 7A</strong></td>
<td>Reduced Throughput – Reduced Retrieval Rates Only Sensitivity</td>
<td>Scenario 7A evaluates the impacts of lower-than-anticipated waste retrieval rates on the mission separately from reduced treatment rates and maintains treatment rates equivalent to the Baseline Case.</td>
</tr>
<tr>
<td><strong>Scenario 7B</strong></td>
<td>Reduced Throughput – Reduced Treatment Rates Only Sensitivity</td>
<td>Scenario 7B evaluates the impacts of lower-than-anticipated treatment rates on the mission separately from reduced waste retrieval rates and maintains retrieval rates equivalent to the Baseline Case.</td>
</tr>
<tr>
<td><strong>Scenario 8</strong></td>
<td>Early 241-U Farm Retrievals</td>
<td>Scenario 8 determines the impacts to SST retrieval completion metrics, DST space availability, glass loading, and associated treatment completion metrics when U Tank Farm is retrieved as the next SSTs after the retrievals of A/AX Tank Farms complete.</td>
</tr>
<tr>
<td><strong>Scenario 9</strong></td>
<td>Offsite Effluent Treatment</td>
<td>Scenario 9 evaluates the opportunity for treating vitrification facility effluents offsite and disposing of the effluent at the IDF, or other disposal site, to quantify the benefits to glass loading, DST space, and waste treatment throughput over the duration of the mission.</td>
</tr>
<tr>
<td><strong>Scenario 10</strong></td>
<td>Retrieval Contingency</td>
<td>Scenario 10 determines the number and timing of new DSTs that would have to be constructed to maintain the Baseline Case retrieval completion date, assuming a 5-year delay to the start of DFLAW operations and the WTP.</td>
</tr>
<tr>
<td><strong>Scenario 11</strong></td>
<td>Direct-Feed High-Level Waste with Liquids-Only Waste Treatment and Immobilization Plant Pretreatment Facility</td>
<td>Scenario 11 evaluates an alternative mission strategy of reducing the schedule risk associated with the PT Facility startup by simplifying the PT Facility flowsheet by removing the solids washing and leaching capability and batching HLW feed from the TWCS capability to the back end of the PT Facility.</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.
DFHLW = direct-feed high-level waste.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
GFM = glass formulation model.
HLW = high-level waste.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
LAWPS = Low-Activity Waste Pretreatment System.
PT = pretreatment.
RPP = River Protection Project.
SST = single-shell tank.
TPA = Tri-Party Agreement.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.
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Figure 1-2. Relationships of the System Plan (Revision 8) Scenarios.

**Acronyms**
- DFHLW: direct-feed high-level waste
- DFLAW: direct-feed low-activity waste
- GFM: glass formulation model
- LAWPS: Low-Activity Waste Pretreatment System
- PT: Pretreatment Facility
- SST: single-shell tank
- TPA: Tri-Party Agreement
- WTP: Hanford Waste Treatment and Immobilization Plant
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### Table 1-2. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (5 pages)

<table>
<thead>
<tr>
<th>Item</th>
<th>HFFACO Milestone M-062-00 Requirement</th>
<th>Implementation in System Plan (Rev. 8)</th>
<th>Cross-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Submit a System Plan to Ecology describing the disposition and treatment of all tank waste managed by ORP.</td>
<td>All scenarios treat and/or disposition all waste managed by ORP and are described in detail in this System Plan.</td>
<td>4.0, State of the System 5.0, Scenarios</td>
</tr>
<tr>
<td>2a</td>
<td>Update every 3 years to document optimizations in retrievals and treatment.</td>
<td>This revision of the System Plan was submitted to Ecology by October 31, 2017. The previous revision was submitted by October 31, 2014. The System Plan discusses the most up-to-date optimizations and studies of retrieval sequencing and retrieval and treatment technologies.</td>
<td>2017 System Plan submittal letter(^a) 2014 System Plan submittal letter(^b) 4.0, State of the System 5.0, Scenarios</td>
</tr>
<tr>
<td>2b</td>
<td>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]).</td>
<td>The TPA Compliant Case, Scenario 6, describes how these dates could be achieved.</td>
<td>5.6, Scenario 6 – Tri-Party Agreement Compliant</td>
</tr>
<tr>
<td>3</td>
<td>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.</td>
<td>This information is provided for each scenario in Section 5.0.</td>
<td>3.0, System Descriptions 4.0, State of the System 5.0, Scenarios</td>
</tr>
</tbody>
</table>
| 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. | 4.0, State of the System 5.0, Scenarios |
| 4a   | Describe how the tank waste treatment mission can pretreat 100% of the retrievable tank waste. | All scenarios, with the exception of Scenario 4, describe how 100% of the waste can be pretreated in various forms. Forms of pretreatment, including the PT Facility, are described in the system descriptions (Section 3.3). | 3.3, Treatment 5.1, Scenario 1 – Baseline Case 5.2, Scenario 2 – Early Direct-Feed High-Level Waste 5.3, Scenario 3 – Early Direct-Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment 5.5, Scenario 5 – Accelerated Retrieval Completion 5.6, Scenario 6 – Tri-Party Agreement Compliant 5.7, Scenario 7 – Reduced Throughput 5.8, Scenario 8 – Early U Tank Farm Retrievals 5.9, Scenario 9 – Offsite Effluent Treatment 5.10, Scenario 10 – Retrieval Contingency 5.11, Scenario 11 – Direct-Feed High-Level Waste with Liquids-Only Waste Treatment and Immobilization Plant Pretreatment Facility |
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§ 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.  

### Table 1-2. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (5 pages)

<table>
<thead>
<tr>
<th>Item</th>
<th>HFFACO Milestone M-062-40 Requirement</th>
<th>Implementation in System Plan (Rev. 8)</th>
<th>Cross-Reference</th>
</tr>
</thead>
</table>
| 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, with the exception of Scenario 4, describe how the tank waste treatment mission can vitrify 100% of the separated high-level waste stream. | 5.1, Scenario 1 – Baseline Case  
5.2, Scenario 2 – Early Direct-Feed High-Level Waste  
5.3, Scenario 3 – Early Direct-Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment  
5.4, Scenario 4 – Risk-Informed Single-Shell Tank Retrievals  
5.5, Scenario 5 – Accelerated Retrieval Completion  
5.6, Scenario 6 – Tri-Party Agreement Compliant  
5.7, Scenario 7 – Reduced Throughput  
5.8, Scenario 8 – Early U Tank Farm Retrievals  
5.9, Scenario 9 – Offsite Effluent Treatment  
5.10, Scenario 10 – Retrieval Contingency  
5.11, Scenario 11 – Direct-Feed High-Level Waste with Liquids-Only Waste Treatment and Immobilization Plant Pretreatment Facility |
| 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, with the exception of Scenario 4, 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 secondary waste management are described in the system descriptions (Section 3.0). | 5.0, Scenarios  
3.4.1, Central Waste Complex  
3.4.2, State-Approved Liquid Disposal Site  
3.4.3, Integrated Disposal Facility  
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. 7), and the updates provided in Section 4.0. | 4.0, State of the System |
| 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. | 5.0, Scenarios  
Table 6-1. Comparison of Key Scenario Results. |
| 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]) if 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. | Scenario 6 provides the supplemental treatment capacity that would be required to treat all tank waste by 12/31/2047. | 5.6, Scenario 6 – Tri-Party Agreement Compliant |
| 6c   | The System Plan will outline specific options to treat all the LAW. | Representatives from DOE and Ecology decided jointly that bulk vitrification did not need to be evaluated as part of this revision of the System Plan. However, grout treatment is considered in this revision. All scenarios except Scenario 3 outline options to treat all LAW using either vitrification or grout technologies for supplemental treatment. | 5.1, Scenario 1 – Baseline Case  
5.2, Scenario 2 – Early Direct-Feed High-Level Waste  
5.4, Scenario 4 – Risk-Informed Single-Shell Tank Retrievals  
5.5, Scenario 5 – Accelerated Retrieval Completion  
5.6, Scenario 6 – Tri-Party Agreement Compliant  
5.7, Scenario 7 – Reduced Throughput  
5.8, Scenario 8 – Early U Tank Farm Retrievals  
5.9, Scenario 9 – Offsite Effluent Treatment  
5.10, Scenario 10 – Retrieval Contingency  
5.11, Scenario 11 – Direct-Feed High-Level Waste with Liquids-Only Waste Treatment and Immobilization Plant Pretreatment Facility |
| 7    | Tank Waste Retrieval | | |
| 7a   | The Plan will evaluate scenarios and identify potential near- and long-term actions to optimize tank waste retrieval. | | 5.0, Scenarios |
The Plan will consider SST integrity information, including the SST integrity assurance review provided under Milestone M-045-91 and any further integrity assessments.

All scenarios except Scenario 7 demonstrated that current estimated retrieval rates were sufficient to maintain feed to the waste treatment facilities. Scenario 7 increased the assumed SST retrieval durations to 2.5 times the estimated durations, which showed that the waste treatment facilities could run out of feed if SST retrievals are significantly slower than the current estimates.

The Plan will consider the effect on waste retrieval rates of the waste retrieval technologies selected via the TWRWP process. RPP-PLAN-40145 and RPP-40545 include the retrieval technologies already selected for 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. 8). (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.)

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 Waste Management Area closure considerations. All scenarios incorporate risk and waste treatment feed optimization in the modeled retrieval sequences. Scenario 4 evaluates a specific risk-based approach to retrievals. Scenario 8 examines an option for accelerating a Waste Management Area closure.

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 and RPP-40545 take into account results from previous waste retrievals. Retrieval processes selected for specific tanks are reflected in RPP-PLAN-40145 and RPP-40545, 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 5, 6, and 10 evaluate adding new DSTs to support SST retrievals. Scenarios 2, 4, and 5 evaluate strategies for accelerating the SST retrieval mission.

Scenario 5 demonstrated that current estimated retrieval rates 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. 8). (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.)

The Plan will 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

Details are provided in Section 7.2.

Details are provided in Section 7.2.

Details are provided in Section 7.2.

Details are provided in Section 7.2.

Details are provided in Section 7.2.

Details are provided in Section 7.0.
### Table 1-2. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (5 pages)

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<thead>
<tr>
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<th>Implementation in System Plan (Rev. 8)</th>
<th>Cross-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>8h</td>
<td>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.</td>
<td>Details are provided in Section 7.2.</td>
<td>7.2, Contingency Planning</td>
</tr>
</tbody>
</table>


DOE = U.S. Department of Energy.

HFFACO = Hanford Federal Facility Agreement and Consent Order.

PT = pretreatment.

TWRWP = tank waste retrieval work plan.

DST = double-shell tank.

LAW = low-activity waste.

SST = single-shell tank.

WTP = Waste Treatment and Immobilization Plant.


TPA = Tri-Party Agreement.
1.3.2 Conventions
This section explains the conventions used in this System Plan and considerations in interpreting results.

1.3.2.1 Reference Dates
Several dates are essential to understanding the basis of this System Plan.

- The demarcation between historical and projected activities is March 2016 (MMR-50087, “Multi-Year Operating Plan, Rev. 5”).
- The starting point for cost and schedule estimates and performance measurement baseline (PMB) scope is October 2016.
- The effective date of the Project Lifecycle Schedule is October 2016.
- The description of the RPP tank waste treatment complex status is current as of May 2017.
- The effective date for tank waste inventory in TOPSim is January 2016 (RPP-33715, Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operation Simulator Model – 2016 Update).
- The decay date for reporting radionuclides is January 2008, unless stated otherwise.

1.3.2.2 Baseline
The tank farms project baseline also includes ORP technical support for the Tank Operations Contract and the WTP Contract, WTP ramp-up and operations estimates, and D&D of the WTP, but does not include scope for the design, construction, and startup of WTP. The last approved baseline change proposal on workscope beyond the current Tank Operations Contract was 10 years ago (RPP-06-003, Alignment of TFC Lifecycle Baseline).

Much of the System Plan Baseline Case is consistent with the Hanford Tank Waste Retrieval, Treatment, and Disposition Framework (DOE 2013) and follows the Amended Consent Decree (2016). DOE intends to update the baseline after the negotiations for TPA Milestone M-062-45 are complete and results are understood.

1.3.2.3 Scenario Optimization
Scenario 1 (Baseline Case) is the current plan DOE has to meet the Amended Consent Decree (2016), support near-term operational needs, and reduce RPP technical and programmatic risks and challenges. Refinements reflect the year-to-year evolution of assumptions and status (e.g., progress toward the completion of retrievals in C Tank Farm and the first DST leak and

\[ \text{15 RPP-06-003 provides the project baseline summaries for ORP-0014 and HQ-HLW-0014X.} \]
associated retrieval), and inclusion of directly feeding LAW to vitrification as soon as 2022 (discussed in Sections 3.0 and 3.3.2).

The additional scenarios evaluated in this System Plan were not optimized to the same degree as the Baseline Case. All scenarios evolved from the Baseline Case; therefore, minimal changes were made in each scenario so impacts of the change could be quantified more easily. In past System Plans, many changes may have been made in a scenario, masking one impact by another, only showing the combined impacts. This resulted in fewer scenarios, but were less useful in understanding impacts. This revision attempts to make singular changes to provide more granularity in the results. The technical evaluation of the scenarios provided the opportunity for significant insight into the behavior of the RPP mission through comparison of assumptions, results, and issues for selected mission scenarios.

1.3.2.4 Reporting
In the model starting assumptions in Appendix A, the general convention is to 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 “full” precision, typically to the nearest $100,000 for costs, and to the nearest whole unit for other quantities (metric ton [MT] or metric tons of glass [MTG] for product mass, canisters, containers, or drums for product containers). This approach is used to provide consistency in presentation and to promote traceability between TOPSim and Lifecycle Cost Model (LCM) results, spreadsheets, figures, tables, and text. Calendar events are rounded to the nearest month.

The reported precision does not reflect the underlying accuracy or uncertainties in technical and programmatic assumptions and modeling methodology.
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...
and:
One year prior to the issuance of the System Plan, DOE and Ecology will each select the scenarios (including underlying common and scenario-specific assumptions) that will be analyzed in the System Plan... (Ecology et al. 1989)

2.1 METHODOLOGY

This System Plan 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 their scenarios to the combined working group to discuss and understand at this point, it was determined that who proposed the scenario was irrelevant and that they would be presented as combined ownership. 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. Finally, they were prioritized to ensure the scenarios deemed most important by the working group would be able to be completed over those less significant or more known. Modeling then began according to priority established. DOE is responsible to provide the document and the balance of TPA-required information to Ecology (see Table 1-2).

For System Plan (Rev. 8), Ecology and ORP mutually agreed to the Baseline Case (Scenario 1) and the alternative scenarios. The selected scenarios and the process by which the scenarios were defined were then described in a “Selected Scenarios Document,” which was then approved and forwarded to the EPA 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, 2016. The process and scenarios were briefly described in RPP-RPT-59581, and approval of the scenarios is documented in 16-NWP-172. The selected scenarios are also described in Section 1.3.1. Each scenario is defined by a set of case-specific detailed assumptions, which are converted into modeling requirements. Modeling reveals the impacts of the assumptions for each case on the RPP mission duration, infrastructure needs, and cost, compared to the Baseline Case. Detailed case-specific system descriptions, planning bases, and projected results, including cost and schedule impacts, issues, and vulnerabilities are disclosed in each scenario discussion in Section 5.0.

The approach taken for modeling the System Plan (Rev. 8) 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 can then be used to inform negotiations of the TPA milestones. Note, however, that Scenario 6 provides only information on what would be required to meet the existing TPA milestones for SST retrievals and waste treatment.
TPA milestone M-062-40 directs that the scenarios include a comparison to a baseline (item #3 on Table 1-2). The milestone also includes specific requirements related to tank waste treatment, supplemental treatment, tank waste retrieval, and contingency planning. The alternative scenarios are compared to the Baseline Case are provided in each of their respective sections in Section 5.0. Discussions on tank waste treatment, supplemental treatment, tank waste retrieval, and contingency planning are discussed throughout the entire document, and specifically addressed in Section 3.0.

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 11) was to minimize changes from the Baseline Case. This made each alternative scenario directly comparable to the baseline so that the impact 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

Prior System Plans were developed using the Hanford Tank Waste Operations Simulator (HTWOS) as a modeling tool (ORP-11242, Rev. 6 and Rev. 7). After the release of ORP-11242 (Rev. 7), Washington River Protection Solutions LLC (WRPS) started the transition process from HTWOS to a new simulation tool referred to as TOPSim. TOPSim was created using the same commercial off-the-shelf modeling platform as HTWOS. However, the model implements more efficient simulation algorithms and uses a database for data output, which allows for greater flexibility in data manipulation. The transition was finalized in November 2016. TOPSim has followed the required protocols and procedures for software development and was audited by DOE and reviewed by Ecology prior to being used for simulation runs for System Plan (Rev. 8) (16-QAD-0057, Contract No. DE-AC27-08RV14800 – U.S. Department of Energy, Office of River Protection Transmittal of Surveillance Report S-16-QAD-TANKFARM-003, Review of Washington River Protection Solutions LLC Software Life Cycle Documentation).

A variety of computer software tools were used in the process of modeling and analyzing the System Plan scenarios. The primary tools include:

- **TOPSim** – A software application developed using a Gensym G2\textsuperscript{16} platform that simulates the Hanford tank farms and processing plant operations.
- **Glass formulation models (GFM)** – Modeling tools that are incorporated into TOPSim enabling the model to formulate projected WTP waste glasses over a wide range of compositions and properties.
- **Integrated solubility model (ISM)** – 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.

\textsuperscript{16} Gensym\textsuperscript{®}, G2\textsuperscript{®}, and Gensym G2\textsuperscript{TM} are either trademarks or registered trademarks of Ignite Technologies in the United States and/or other countries.
- **Lifecycle Cost Model (LCM)** – A tool that electronically links the TOPSim output to schedule- and cost-processing software to generate lifecycle 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 (defined in RPP-55533, *TOPSim Software Design Description*) that can be configured to model the physical plant, including tanks, process equipment, and transfer lines. The TOPSim environment also includes chemistry models to support calculations and tracking of chemical components through the 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 database (developed with SQL Server). 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.

The purpose of the Hanford Simulation Model is to provide 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 Hanford Simulation 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, which 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 perturbations 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. Perturbations that occur

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17 SQL Server® is a registered trademark of Microsoft Corporation in the United States and/or other countries.
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, TOPSim Software Design Description
- RPP-RPT-59470, TOPSim V2.1 Model Requirements.

### 2.2.2 Glass Formulation Models

Four GFMs were added to TOPSim for System Plan (Rev. 8), two for HLW glass and two for LAW glass. The new 2013 and 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 GFM for HLW and the 2004 GFM for LAW glass are still available GFMs in TOPSim, although the 2013 GFMs are the default and the 2016 GFMs can also be used on request. The 2013 and 2016 GFMs were developed to be less conservative than the 2004 or 2009 GFMs. Descriptions of the four primary GFMs are provided below.

- The “advanced” 2013 HLW GFM was developed by Pacific Northwest National Laboratory (PNNL) and builds on the 2009 HLW GFM using updated glass-formulation and melter-testing data. The increased range of successful melter test data used to create this model provides for a less conservative approach than previous GFMs. This approach produces higher predicted waste oxide loading (WOL) in the glass, which reduces the total glass produced. The reduction in glass produced leads to a shorter RPP mission duration compared to the 2009 HLW GFM.

- The “advanced” 2013 LAW GFM is independent of the 2004 LAW GFM and is the result of an independent analysis conducted by PNNL using data from other melter tests. The analysis resulted in a set of “loading rules” and property constraints. A set of component concentration limits was also developed, which encompasses the limits of validity for the model. The new set of constraints developed for the 2013 LAW GFM accounts for interactions and effects of many more glass components than the DOE 2004 GFM. The increased specificity of the 2013 GFM, based on a large amount of actual melter test data, enables the model to be less conservative than the DOE 2004 GFM, resulting in higher WOL and less total LAW glass produced.

- The 2016 HLW GFM is a refinement of the “advanced” 2013 HLW GFM that incorporates more test data and makes computational improvements.

- The 2016 LAW GFM is a refinement of the “advanced” 2013 LAW GFM that incorporates more test data and makes computational improvements.

Previous GFMs have been described in earlier versions of the System Plan. The following is a brief description of the evolution of the GFMs.
HLW Glass Formulation Models

- **2009 HLW GFM (PNNL-18501, Glass Property Data and Models for Estimating High-Level Waste Glass Volume)**
  - Updated the previous 1996 GFM by including glass performance and processing data in a database collected from PNNL, West Valley Demonstration Project, Savannah River National Laboratory (SRNL), Vitreous State Laboratory of the Catholic University of America (VSL), and Idaho National Laboratory, among other sources
  - Divided the property-composition models between several key glass properties
  - Approved as the baseline GFM in System Plan (Rev. 5, 2010).
- **2013 HLW GFM (PNNL-22631, Glass Property Models and Constraints for Estimating the Glass to be Produced at Hanford by Implementing Current Advanced Glass Formulation Efforts)**
  - Updated the 2009 HLW GFM to develop a nonconservative set of constraints and properties to increase waste loading
  - Based on glass formulation and melter testing data
  - Adopted as the baseline for System Plan (Rev. 8, 2017).
- **2016 HLW GFM (PNNL-25835, 2016 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)**
  - Builds on the 2013 HLW GFM by incorporating additional test data, expanding validity ranges, and improving computational methods.

LAW Glass Formulation Models

- **2004 DOE LAW GFM (D-03-DESIGN-004, An Assessment of the Factors Affecting the Ability to Increase the Na₂O Loading in the Waste Treatment and Immobilization Plant (WTP) Low-Activity Waste (LAW) Glass)**
  - Simple LAW GFM developed by DOE and WTP Engineering Division to model increased loading from previous models of sodium and sulfur in LAW glass and to provide a basis to select LAW for treatment in the WTP
  - Contained only two constraints: sodium and sulfur weight percent limits in glass
  - Updated the GFM in HTWOS in 2014 to change the interpretation of the sulfur constraint to match that assumed by WTP and DOE
  - Approved as the baseline in System Plan (Rev. 3A, 2008).
- 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements* (Rev. 6, 2011)
- Developed by VSL to meet the WTP statement of work, operational specification (Section C.8, Specification 2.2.2.2), which describes waste loading based on concentration of Na₂O in waste envelopes A, B, and C
- Implemented in HTWOS in 2015 for use in cases where the impact of halides on glass loading was needed.
- 2013 LAW GFM (PNNL-22631)
  - Updated the 2009 HLW model to develop a nonconservative set of constraints and properties that fit the criteria for LAW glass
  - Increased waste loading based on glass-formulation and melter-testing data
  - Adopted as the baseline for System Plan, Rev. 8 (2017).
- 2016 LAW GFM (PNNL-25835)
  - Builds on the 2013 LAW GFM by incorporating additional test data, expanding validity ranges, and improving computational methods.

The models and constraints are only meant to give an indication of rough glass volumes and are not intended to be used in plant operations or waste form qualification activities. A current research program is in place to develop the data, models, and uncertainty descriptions for that purpose (PNNL-22631).

Additional information on the glass formulation models 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*

### 2.2.3 Integrated Solubility Model

The ISM was developed specifically for HTWOS and was later implemented in TOPSim. The ISM is a tool created to use a graded approach to predict the solubility of each waste constituent in HTWOS and its impact to the RPP mission (based on each constituent’s relative solubility using a set of theoretical waste correlations). For example, the constituent’s solubility helps determine the total mass of glass produced and the corresponding mission length. HTWOS relied primarily on simple wash and leach factors applied with a single temperature and waste pH at specific points in the flowsheet, which is not representative of the range of conditions that the
waste will encounter during processing. Wash factors also limited the prediction of phase changes to dissolution reactions only.

The best-basis inventory (BBI) data is used as the TOPSim starting inventory. However, the BBI is neither charge-balanced nor evaluated against the criteria established by the ISM prior to being entered into TOPSim. Therefore, there may be dissolution and/or precipitation of components that occurs the first time ISM is applied to a DST. Examining the effect of this implementation is beyond the scope of this document.

The ISM for HTWOS was initially built by binning chemical components into one of the four categories listed below:

- **Category 1** components are either very soluble and assumed to reside exclusively in the liquid phase, or very insoluble and assumed to reside only in the solid phase. Category 1 components have a low impact on mission metrics such as glass loading. Examples include isotopes of cesium (very soluble) and zirconium (very insoluble).

- **Category 2** components exhibit intermediate solubility and a low impact on mission metrics. The solubility of Category 2 components is best described by the previous wash and leach factors. Examples include bismuth and various isotopes of uranium.

- **Category 3** components have intermediate solubility and a high impact on mission metrics. Phase distribution for these components is determined thermodynamically. Examples include phosphate and sulfate in the liquid phase and gibbsite in the solid phase.

- **Category 4** pertains to kinetic-dependent species and includes only one component – boehmite (AlOOH), which has been shown to be an inert solid under all conditions except during the caustic leaching step of pretreatment. The amount of solid boehmite dissolved during caustic leaching is predicted using a kinetic dissolution equation.

The implementation into TOPSim takes those categories and groups Categories 1 and 2 together. All Category 1 and 2 components, with the exception of strontium (Sr$^{+2}$/Sr-90)/yttrium(Y)-90, are changed to wash and leach factors if wash or leach factors are available. If wash factors are not available, the components are placed in a Category 0, which does not undergo phase changes.

A table of categories and associated components is provided in RPP-RPT-58972, *ISM Simple Solubility Change Evaluation*. Additional information on the implementation of the ISM in TOPSim is also provided in RPP-RPT-58972.

### 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.

Fiscal year (FY) escalation in the LCM was based on the aggregate price and wage forecast information developed by the Tank Operations Contractor (TOC) cost estimating organization. This forecast information provides annual escalation rates through fiscal year FY 2026 from multiple sources, including the employment cost index from the Bureau of Labor Statistics, Material Price Index from Information Handling Services, and other industry sources. The TOC generates escalation rates for labor, materials, and subcontract services. These labor and non-labor escalation rates are averaged to form a composite rate for use in the LCM cost-processing algorithm.

Time-phasing for all work to support tank farms activities was developed using Primavera P6\textsuperscript{18} scheduling software, an industry standard project management tool. A separate P6 schedule is created for each System Plan scenario. The results from each scenario cause the schedule to shorten or lengthen, depending on TOPSim model results. Escalation is then applied to the results of the P6 fiscal year time phasing. The TOC escalation factors are provided through FY 2026. For periods beyond FY 2026, the LCM cost processor multiplies all future fiscal years by the last year where a rate is developed, which is 1.0286 for FY 2026.

All escalation rates are compounded each fiscal year to simulate the changes in price for specific goods and services necessary to support Hanford tank waste processing. Escalation rates through FY 2026 are shown in Table 2-1.

\begin{table}[h!]
\centering
\begin{tabular}{|l|c|c|c|c|c|c|c|c|}
\hline
\hline
\textbf{Escalation factor} & 1.0300 & 1.0298 & 1.0307 & 1.0299 & 1.0299 & 1.0300 & 1.0296 & 1.0290 & 1.0286 \\
\hline
\end{tabular}
\caption{Fiscal Year Escalation Rates Used by the Lifecycle Cost Model Cost Processor.}
\end{table}

The LCM uses the TOC PMB as of October 2016 as the starting point for the current model run. The TOC PMB includes the scope, schedule, and cost for the authorized baseline activities for the Tank Operations Contract period. An out-year planning estimate range schedule is used beyond the TOC period through the end of the RPP mission. Because several activities and strategies involve new facilities or system configurations that require additional workscope, some supplemental cost estimates were added. These estimates, time-phased with a 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.

\begin{footnote}
\textsuperscript{18} Primavera\textsuperscript{®} and P6\textsuperscript{®} are either trademarks or registered trademarks of Oracle and/or its affiliates in the United States and/or other countries.
\end{footnote}
Future workscope estimates (beyond the current WRPS Tank Operations Contract 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 strategy-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 PMB or to deviate from the existing set of estimating assumptions.

Additional information on the cost analysis in System Plan (Rev. 8) is provided in RPP-RPT-60192, *System Plan Rev. 8, Lifecycle Cost Analysis*. The LCM is described in more detail in AEM-WRPS-2012-MDD-003, *Life-Cycle Cost Model (LCM) Design Document*. 
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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 addresses waste retrieval from SSTs, waste transfers into and out of DSTs, miscellaneous underground storage tanks (MUST), inactive miscellaneous underground storage tanks (IMUST), waste transfer systems, various supplemental treatment facilities, and other interfacing facilities.

This section includes brief system descriptions for Scenario 1 (Baseline Case). The additional scenarios describe how their individual flowsheets and systems differ from the Baseline Case. The section is divided into 3.1, Storage/Retrieval, 3.2, Testing, 3.3, Treatment, and 3.4, Disposal, and roughly follows the flow of waste throughout the process.

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, Rev. 353). Note that total waste volumes fluctuate slightly from the addition of water and chemicals during waste retrieval operations, the receipt of laboratory wastes, and operation of the 242-A Evaporator.

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.

In September 2013, as a starting point for discussions on potential modifications to the 2010 Consent Decree made necessary by emergence of technical issues at the WTP, DOE issued a Framework document that involved, among other things, adoption of a DFLAW approach to immobilize waste into a glass form as soon as practicable while working through the WTP technical issues. Although the Framework document was not a proposal, some elements, for example, DFLAW, were later incorporated into formal proposals submitted to the Court during the litigation that followed unsuccessful negotiations. Although Judge Peterson did not expressly adopt DFLAW and subject its design, construction, and operation to milestones because it was beyond the scope of the 2010 Consent Decree, she did advance the milestone date for completion of hot commissioning of the LAW Vitrification Facility in express recognition that DOE was pursuing DFLAW.

The DFLAW flowsheet includes the LAWPS between the tank farms and the LAW Vitrification Facility. The LAWPS includes filtration to remove entrained solids and ion exchange to remove cesium, and is sized to support feeding two LAW melters operating at 30 MTG/day at 70 percent total operating efficiency (TOE). Additional details regarding DFLAW and the assumptions used

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19 Note that in this plan, MUSTs and IMUSTs are collectively referred to as MUSTs (described further in Section 3.1.3).
for the cases analyzed in this System Plan revision are provided in Section 3.3.2, the individual scenario discussions in Section 5.0, and Appendix A.

The Framework also discussed DFHLW, which would route HLW from the tank farms to the HLW Vitrification Facility through a tank waste characterization and staging (TWCS) capability. This capability would provide vessels designed specifically to support waste mixing, blending, resizing, sampling, and filtration of retrieved wastes to provide acceptable feed directly to the HLW Vitrification Facility.

RPP-RPT-59470 provides detailed descriptions of the individual systems and how these systems are modeled in TOPSim.
Figure 3-1. 200 East Area Tank Waste Contents.
Figure 3-2. 200 West Area Tank Waste Contents.
Figure 3-3. Simplified Baseline System Flowsheet.
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3.1 STORAGE/RETRIEVAL

3.1.1 Single-Shell Tanks

Status: Existing (interim stabilized/retrievals in progress)

Current Responsibility: ORP Tank Operations Contract (WRPS)

Discussion: The 149 SSTs on the Hanford Site were constructed between 1943 and 1964. 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 SSTs contain wastes; nearly all of the drainable interstitial liquids have been removed to the criteria required by the SST interim stabilization program.\(^\text{20}\) The SST waste inventories consist primarily of sludges 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 RPP mission is to retrieve waste from SSTs into the DST system, where the waste will be staged for immobilization at the WTP or by another secondary LAW treatment process. Eleven SSTs may be determined to contain potential contact-handled transuranic (CH-TRU) waste (discussed in Section 3.3.1). If the waste is determined to be CH-TRU, ORP intends to retrieve and treat this waste using a separate CH-TRU waste treatment process. The SSTs in the T Complex farms (T, TX, and TY) and B Complex farms (B, BX, and BY) not assumed to contain potential CH-TRU waste will be retrieved into one of two waste receiving facilities (WRF) prior to delivery to the DST system.

In accordance with HFFACO interim Milestone M-045-91, a panel of nationally recognized technical experts was established in 2009 to review SST integrity. The panel developed 38 recommendations in four main areas of interest: confirmation of tank structural integrity, assessment of the likelihood of future tank liner degradation, leak identification and prevention, and mitigation of contaminant migration. The panel identified the “top ten” recommendations that form the foundation of a robust SST Integrity Program (SSTIP). The SSTIP has addressed many of the recommendations, and the results are discussed in RPP-PLAN-60765, Single-Shell

\(^{20}\) The interim stabilization criteria allowed the following amounts to remain in a tank that was then deemed “interim stabilized” if these criteria were met: 50,000 gal of drainable interstitial liquids, 5,000 gal of supernatant; and less than 0.05 gpm if jet pumping was used.
Tank Integrity Program Plan. An Independent Qualified Registered Professional Engineer (IQRPE) review of the SSTs is projected to occur in 2018.

Retrieval of waste from the SSTs requires the addition of retrieval water and dissolution chemicals, as needed. 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-40545, Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning
- RPP-PLAN-40145, Single-Shell Tank Waste Retrieval Plan
- RPP-PLAN-60765, Single-Shell Tank Integrity Program Plan.

3.1.2 Double-Shell Tanks

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

Current Responsibility: ORP Tank Operations Contract (WRPS)

Discussion: The DSTs differ from SSTs primarily by the secondary containment liner (Figure 3-5). There are 28 DSTs on the Hanford Site – three in the 200 West Area and 25 in the 200 East 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:

- Storing tank waste in accordance with RCRA
- 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 (DSTIP) evaluates and maintains the structural integrity of the DSTs and ancillary equipment. The scope of the DSTIP includes:

- DST and 242-A Evaporator integrity inspections (e.g., ultrasonic and video examinations) and documentation of results for use in periodic reinspections
- DST waste chemistry sampling and adjustments for corrosion mitigation to ensure compliance with corrosion control specifications

Figure 3-5. Simplified Depiction of an Underground Double-Shell Tank.
- DST waste chemistry corrosion optimization studies to refine the waste chemistry parameters to minimize DST corrosion
- Development and installation of in-tank corrosion probes for DSTs to evaluate the corrosion potential of stored waste
- DST structural analysis and studies for thermal, operating, and seismic loads
- Periodic testing, evaluation, and certification of the DST ancillary equipment (e.g., valve pits, transfer piping) that supports the operation of the DST system
- Periodic testing and integrity assessment of the 242-A Evaporator Facility.

The DSTIP receives input from a nationally and internationally recognized Tank Integrity Expert Panel and the reviews and recommendations by an IQRPE, in accordance with HFFACO Milestone M-048-14.

In 2012, DST AY-102 was discovered to have a small amount of dry material at two locations in the tank annulus. 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 supernate and sludge in DST AY-102 was then moved to tanks AW-105 and AP-102, respectively, in FY 2016 and 2017, and DST AY-102 was taken out of service. The waste located in DST AY-102 was originally intended to be the hot commissioning feed to the integrated WTP; however, DST AP-102, where the DST AY-102 sludge was retrieved, will now fulfill that purpose. The supernate currently in Tank AP-105 will be moved to Tank AP-107 and will act as the hot commissioning feed for the DFLAW process (see Section 3.3.2).

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 31,176,500 gal. 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 (i.e., 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.

Under current TPA Milestone M-045-00A, DOE is to complete the closure of all DST tank farms on a “to be determined” basis established as 5 years after retrieval under M-062-45 but no later than 9/30/2052. Closure will be conducted in accordance with applicable regulatory requirements. Additional information regarding the DST assumptions used for modeling the cases analyzed in this System Plan is provided in Appendix A.

Detailed information regarding the DSTs and TOC management of the tanks is provided in:

- OSD-T-151-00007, Operating Specifications for the Double-Shell Storage Tanks
- HNF-SD-WM-OCD-015, Tank Farms Waste Transfer Compatibility Program.
Additional resources include:

- RPP-6213, *Hanford Waste Tank Bump Accident and Consequence Analysis*
- RPP-7574, *Double-Shell Tank Integrity Project Plan*
- RPP-7771, *Flammable Gas Safety Issue Resolution*
- RPP-23584, *Safety Evaluation of Waste Gel in the Tank Farms*
- RPP-RPT-24887, *The Long-Term Management of Tank Waste at Hanford*

### 3.1.3 Inactive Miscellaneous Underground Storage Tanks

**Status:** Operational/Inactive

**Current Responsibility:** ORP Tank Operations Contract (WRPS)/RL (CH2M HILL Plateau Remediation Company [CHPRC])

**Discussion:** Additional minor waste sources exist at the Hanford Site in active and inactive miscellaneous underground storage tanks (collectively referred to as IMUSTs). Dozens of IMUSTs 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 HFFACO (Ecology et al. 1989).

The number of IMUSTs under ORP management changes over time as the status of waste sites and operable units is better understood and as agreements between ORP and RL are adjusted. ORP is currently responsible for approximately 60 IMUSTs, including 43 inactive and 17 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 from RPP-33715. 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. Other resources available to understand the IMUSTs and their role in the RPP mission include:

- RPP-RPT-31148, *Composite Liquid Mitigation Report*
- RPP-RPT-42231, *Summary of Twenty-Five Miscellaneous Tanks Associated with the Single-Shell Tank System*

### 3.1.4 Waste Receiving Facilities

**Status:** Proposed

**Current Responsibility:** ORP Tank Operations Contract (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 timely and efficient waste retrievals 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 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. Other SSTs are retrieved directly into the DST system, except for those handled as CH-TRU waste. The waste to be designated as CH-TRU will be retrieved directly to the supplemental CH-TRU waste treatment facility (see Section 3.3.1). Each WRF provides the following:

- Six 150,000-gal waste receipt tanks with pumps, transfer lines to the SSTs, and other ancillary equipment for recycling of supernatant liquid 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 B and T Complexes (one line for each complex.) The retrieval of U Tank Farm will be supported by use of the T Complex transfer line with installation of an additional diversion box.

• Pumping capacity to transfer the retrieved waste slurries at high solids concentrations over a considerable distance to the nearest DST storage tanks, without exceeding the allowable pressure ratings for transfer system components.

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 Tank Operations Contract (WRPS)

Discussion: Over half of the SSTs and three DSTs are located in the 200 West Area. With the exception of potential transuranic (TRU) waste, when retrieved from the 200 West Area, the waste will need to be transferred to the 200 East Area to be concentrated\(^2\) and prepared for processing through DFLAW and/or 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 West, and 200 East Areas
• SY and AN Tank Farms
• Booster pumps, valving, and components at the 6241-A diversion box
• Valving and components at the 6241-V vent station
• Monitoring and control hardware and software
• Instrumentation.

The cross-site transfer systems were designed, fabricated, and installed as part of Projects W-058, W-211, and W-314. The cross-site transfer system consists of two parallel, pipe-in-pipe lines. The supernatant line, WT-SNL-3150, extends from the SY-A valve pit in the 200 West Area to the AN-01A valve pit in the 200 East Area (from where the line can be routed to AN Tank Farm DSTs), then to the AZ valve pit (from where the line can be routed to AY and AZ Tank Farm DSTs), and then finally to the AP valve pit (from where the line can be routed to AP or AW Tank Farm DSTs). The slurry line, WT-SLL-3160, 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. The transfer route passes through a diversion box (6241-A) and a vent station (6241-V) located between the 200 West and 200 East Areas. When placed into service, the slurry line will be monitored by leak detectors on the existing master pump shutdown system. An operations control system located in the control room at the 242 S Evaporator was intended to provide remote monitoring

\(^2\) Concentration is performed for DST space management purposes and is not a prerequisite for treatment.
for the cross-site transfer system. The 242-S Evaporator control room has now been consolidated in 274-AW. 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*. 
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Figure 3-8. Simplified Representation of the Hanford Waste Feed Delivery System.
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3.1.6 242-A Evaporator

**Status:** Operational

**Current Responsibility:** ORP Tank Operations Contract (WRPS)

**Discussion:** The primary mission of the 242-A Evaporator, 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. After the facility upgrades and preventive maintenance activities (discussed in System Plan [Rev. 7]) were completed, normal evaporator campaigns resumed in September 2014.

The 242-A Evaporator began operating in 1977, and since then, the evaporator has removed more than 80 Mgal of water from Hanford waste—maximizing DST space availability. Space within the existing DSTs is limited; therefore, the 242-A Evaporator is critical to meeting TPA milestones and continuing the cleanup mission. By boiling off liquids in the waste feed sent to the evaporator, space is created in the DSTs. This additional space enables SST waste retrievals to continue in the near-term and waste treatment returns from initial plant operations in the future, including direct-feed operations to the WTP vitrification facilities. The 242-A Evaporator is also used to concentrate the waste to meet interface control document (ICD) feed requirements.

The 242-A Evaporator is located in the 200 East Area, south of the A Tank Farm and north of the AW Tank Farm. The 242-A Evaporator employs a conventional forced circulation, vacuum evaporation system. Components of the evaporator system include the reboiler, vapor-liquid separator, recirculation pump and pipe loop, bottoms product pump, condensers, condensate collection vessel, and vessel ventilation system. A forced circulation pump recirculates the evaporator contents and discharges to the evaporator reboiler, which raises the temperature of the liquid. The waste feed enters the recirculation line and is pumped to the reboiler where the waste is heated. Steam condensate from the reboiler and cooling water from the condensers are continually monitored for radiation, pH, and conductivity, and then discharged from the building to the 200 Area Treated Effluent Disposal Facility (TEDF).

The vapor-liquid separator is maintained at a negative gauge pressure by a two-stage steam eductor system and by controlling the in-bleed of air to the suction side of the vacuum eductor. Under this vacuum pressure, a fraction of the water in the heated feed flashes to steam in the separator vessel and is drawn through two wire mesh deentrainer pads into the primary condenser.

As evaporation takes place in the separator vessel, the feed becomes concentrated. When the process solution is concentrated to the specific gravity specified for the campaign, a fraction is withdrawn from the recirculation line, upstream of the feed addition point, and is either gravity
drained or pumped by the bottoms pump to DSTs in either the AP or AW Tank Farm. The offgas leaving the evaporator separator vessel passes through three condensers. The condensate from all three condensers is collected in the condensate collection tank. The process condensate from the collection tank is discharged to the Liquid Effluent Retention Facility (LERF).

Non-condensable vapors from the evaporator are filtered and discharged to the atmosphere via the vessel vent system. This system consists of a de-entrainment pad, prefilter, heater, high-efficiency filter assembly, and vessel vent exhauster. The 242-A Evaporator stack is equipped with sampling, monitoring, and alarms to ensure that the offgas meets environmental and safety requirements.

Each campaign requires staging and sampling of the candidate feed waste to ensure that the material can be processed within the operating limits of the evaporator and transfer system per HNF-SD-WM-OCD-015. The 242-A Evaporator has a final status RCRA Part B permit.

### 3.2 TESTING

#### 3.2.1 222-S Laboratory

**Status:** Operational

**Current Responsibility:** ORP Laboratory Analytical Services and Testing Contract (Wastren Advantage, Inc. for routine testing/analysis); ORP Tank Operations Contract (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) that is capable of handling highly radioactive samples. Organic, inorganic, materials, and radiochemical analyses are performed on samples in a variety of sample 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, Effluent Treatment Facility (ETF) operations, and LERF management. In the future, the 222-S Laboratory may 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 from 1950 to 1951. As the mission warranted, the laboratory, supporting structures, and office space have been progressively enlarged and upgraded, such as modernizing the facility infrastructure, regularly replacing analytical equipment, removing obsolete structures, constructing new or replacement support facilities, and other projects to extend the life of the facility in support of current mission needs (RPP-RPT-40632, 222-S Life Extension Strategic Management Plan).

### 3.3 TREATMENT

At present, the majority of the Hanford tank waste will be immobilized by the WTP (Figure 3-11), which is currently being designed and built by Bechtel National, Inc. (BNI). Tank waste from the tank farms will be pumped to the WTP, separated into HLW and LAW streams, and vitrified. The HLW molten glass will be poured into stainless steel canisters and stored onsite until the canisters can be shipped to an offsite HLW repository. The LAW molten glass will be poured into stainless steel containers and transported to the onsite Integrated Disposal Facility (IDF) for final disposal. There are five major facilities within the WTP project: the PT Facility, HLW Vitrification Facility, LAW Vitrification Facility, dedicated Analytical Laboratory, and Balance of Facilities (BOF).

The WTP will generate secondary solid and liquid waste streams. The secondary solid waste (e.g., spent LAW melters, spent ion-exchange [IX] resin, high-efficiency particulate air [HEPA] filters, carbon adsorbers, silver mordenite columns) is planned to be disposed of in the IDF (see Section 3.4.3). A disposal path for spent HLW melters has not yet been identified. The secondary liquid waste is planned to be treated at the LERF/ETF (see Section 3.3.11). The individual facilities of WTP are described in more detail in the subsections that follow.

Additional waste is assumed to be treated with the supplemental CH-TRU waste packaging facility, a supplemental LAW immobilization facility with a technology yet to be determined, the DFLAW Program, and other possible treatment options under discussion (e.g., direct-feed high-level waste [DFHLW]).
3.3.1 Contact-Handled Transuranic Waste Packaging

**Status:** Early design

**Current Responsibility:** ORP Tank Operations Contract (WRPS)

**Discussion:** Eleven SSTs have been evaluated as containing waste that could potentially be designated as CH-TRU 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 because:

- The sludge in the tanks is not waste from reprocessing spent nuclear fuel and, therefore, is not within the NWPA definition of HLW (see Section 1.1.1)

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 the TC & WM EIS, and further clarified this preference in a *Federal Register*.

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(FR) 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 TRU mixed (TRUM) waste for disposal at the Waste Isolation Pilot Plant (WIPP). Initiating retrieval of tank waste for disposition as TRUM waste will be contingent on DOE obtaining the applicable and necessary permits, ensuring that the WIPP waste acceptance criteria and all other applicable regulatory requirements are met, and making a determination that the waste is properly classified as TRUM waste. DOE did not implement a preferred or any other alternative associated with Hanford TRU waste in the TC & WM EIS ROD.

The System Plan (Rev. 8) model starting assumptions (provided in Section A1.4.2) indicate that 11 SSTs will be handled as containing potential CH-TRU tank waste that would be treated at a supplemental TRU treatment facility (described below), and then stored onsite at the Central Waste Complex (CWC) until final disposition has been determined.23

The SSTs containing potential CH-TRU sludge 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.

The potential CH-TRU tank waste treatment and packaging process, as designed, uses a modular approach. The facility is 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 WIPP waste acceptance criteria. 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 HEPA filters and then discharged to the atmosphere (RPP-21970, CH-TRUM WPU&SE 11-Tank Material Balance).

23 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.
Significant design of the potential TRU tank waste packaging system was completed, and several pieces of long-lead fabrication equipment were procured and fabricated. The project was placed on “standby” by DOE in 2005 to await final approval of the TC & WM EIS. Reactivation of the project will initially involve generation of critical decision 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 existing flowsheet provides a basis for comparison between model results in System Plan (Rev. 8). The timing of the restart of the potential CH-TRU waste project will likely be determined by the availability of capital funds. Waste packaging will start approximately 5 years after project reactivation.

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

- RPP-21970, CH-TRUM WPU&SE 11-Tank Material Balance
- RPP-56063, Transuranic Tank Waste Project Technology Approach Planning
- WIPP Hazardous Waste Permit (WIPP 2016).

### 3.3.2 Direct-Feed Low-Activity Waste Process

There have been significant delays to completion of the WTP Project as originally conceived, due primarily to the emergence of several technical issues involving mainly the PT Facility but also the HLW Vitrification Facility. As a result, DOE has modified the project to include a phased approach starting with direct feed of LAW to the LAW Vitrification Facility from the 200 East Area DST tank farms via the DFLAW process. The DFLAW process generates space in DSTs to support waste feed preparation, SST retrievals, or other emerging issues, while technical issues and risks associated with the PT Facility are being resolved. DFLAW also enables operating experience to be gained in the LAW Vitrification Facility, which could expedite startup of the integrated WTP.

Supernatant liquid is staged and sampled in the DSTs and transferred to the LAWPS via DST AP-107. Various DSTs are used in the DFLAW process for staging, supplying feed, and accepting returns. Once the waste is delivered to the LAWPS, entrained solids and radioactive cesium are removed prior to feeding the waste to the LAW Vitrification Facility. The solids and concentrated cesium eluate from the LAWPS are returned to the tank farms. The LAWPS will be located outside of the WTP in the 200 East Area. The LAWPS has completed conceptual design in support of Critical Decision 1 (CD-1) (RPP-RPT-57120, Low-Activity Waste Pretreatment System (T5L01) Conceptual Design Report), and CD-1 has been approved.

Prior to completion of the integrated WTP, the Effluent Management Facility (EMF) functions are being added to the WTP BOF to manage liquid effluent wastes generated in the LAW.
vitrification offgas system. The WTP EMF will receive secondary liquid waste from the LAW Vitrification Facility and Analytical Laboratory to concentrate the waste before returning it to the LAW melter concentrate receipt vessels. When the WTP EMF is offline for maintenance, this stream can be returned to the tank farms. Sodium nitrite and sodium hydroxide may be added to the portion returned to the tank farms to meet DST corrosion mitigation specifications. The EMF design is complete and construction is in progress.

Additional information on the DFLAW process is provided in the following documents:

- RPP-RPT-59314, *Integrated DFLAW Feed Qualification Program Description*
- RPP-40149-VOL1, *Integrated Waste Feed Delivery Plan, Volume 1 – Process Approach*
- RPP-40149-VOL2, *Integrated Waste Feed Delivery Plan, Volume 2 – Campaign Plan*

### 3.3.3 Low-Activity Waste Pretreatment System

**Status:** Early design

**Current Responsibility:** ORP Tank Operations Contract (WRPS)

**Discussion:** The LAWPS is an underground vault-based system receiving feed directly from Tank AP-107. The LAWPS objective is to remove undissolved solids and radioactive cesium from tank waste prior to feeding the material to the LAW Vitrification Facility. The LAWPS is planned to be located outside of the WTP in the 200 East Area.

Diagrams of the proposed LAWPS are shown in Figure 3-13 and Figure 3-14.
The LAWPS is being built in the 200 East Area near the WTP boundary (see Figure 3-15), and is planned to operate until the PT Facility becomes available. At that point, the LAWPS will be placed in an idle mode and maintained in an operable condition, so that operations can resume if the PT Facility requires an outage. The LAWPS can also be used “on demand” to provide additional LAW pretreatment capacity for feeding the LAW Vitrification Facility (after DFLAW operations) and the supplemental treatment facility in situations where additional capacity is needed. The LAWPS project is currently at CD-1 and development is progressing.
The vault-based system will include the following major components:

- Two cross-flow filters (CFF)
- Two IX columns in a lead-polish configuration using spherical resorcinol-formaldehyde (sRF) cesium IX media
- A cesium product storage and neutralization tank, wherein IX eluate is neutralized prior to sending the solution back to the DSTs
- Above-grade chemical storage for IX media elution, flushing, and conditioning
- Self-engaging dewatering system for disposing of spent IX media
- Three 89,000-gal treated waste lag storage tanks
- Treated waste pump/sample capabilities
- Permanent transfer lines:
  - One from the LAWPS treated-waste lag-storage tanks to the LAW Vitrification Facility
  - One from the LAW Vitrification Facility to the AP Tank Farm for secondary liquid waste returns
The LAWPS CFF system consists of a feed tank and a CFF loop that removes undissolved solids from the feed waste stream in preparation for treatment through the IX system. The filtrate continues on to the IX system, while the filtered solids are returned to the tank farms.

The LAWPS cesium IX system consists of two IX columns operated in series (lead and lag). The columns use elutable sRF resin to remove cesium (Cs-134, Cs-137, and Cs⁺) from the liquid waste feed. When radioactive cesium reaches the maximum setpoint, the resin is eluted, and the eluted cesium product is collected in an ancillary vessel for chemical adjustment prior to being transferred to the tank farms. The resin degrades as loading and elution cycles continue and must be replaced on a periodic basis. Spent resin is packaged in casks for shipment.

The LAWPS lag storage system receives pretreated liquid waste from the IX system. Since the IX resin does not remove barium (Ba)-137m, the daughter product of Cs-137 decay, a treated waste delay tank provides residence time to allow the Ba-137m to decay to stable Ba-137 prior to the waste being staged for delivery to the LAW Vitrification Facility. Waste flows from the treated waste delay tank to three large storage vessels, where the waste is staged for delivery to the LAW Vitrification Facility. These vessels allow for accumulation of pretreated waste to ensure that an adequate supply of feed is available to maintain vitrification facility operations. Sampling is also performed on the waste in these vessels, as needed, to confirm that the waste meets applicable acceptance criteria.

### 3.3.4 Tank Waste Characterization and Staging

Tank waste characterization and staging (TWCS) is a potential new capability in the 200 East Area envisioned to provide better slurry mixing, sampling, and feed staging than would otherwise be possible using DSTs. The TWCS tanks will potentially accept transfers from DSTs, keep waste slurries adequately suspended to allow representative sampling of the waste, make transfers to each other for blending, and transfer batches of feed to the WTP. Additional functions that could be implemented within the TWCS capability include large particle segregation/size reduction and the capability to deliver feed batches directly to the HLW Vitrification Facility. This capability has not been designed and details of the vessel configuration and capabilities are not available.

The potential TWCS capability predecisional concept, as modeled in System Plan (Rev. 8) and shown in Figure 3-16, has six 500-kgal tanks in a vault configuration (RPP-RPT-45955, *East Area Waste Retrieval Facility Location and Tank Configuration Study*), with mixing, transfer, and sampling capabilities.

The TWCS capabilities (yet to be developed) might include:

- Receiving, staging, mixing, and blending tank farms waste
- Sampling and characterizing HLW feed to the WTP
- Feeding HLW to the WTP
- Storing problematic wastes for later pretreatment
- Potentially mitigating problematic wastes prior to WTP feed
- Providing additional RCRA-compliant waste storage capacity
- Providing consistent HLW feed to the WTP
- Potentially segregating and/or reducing particle size to meet the WTP waste acceptance criteria.

Figure 3-16. Potential Tank Waste Characterization and Staging Layout.

Few details are available for this capability, as CD-0 for TWCS was approved in September 2015 (Whitney 2015). Risks associated with TWCS are discussed in Section 7.0.

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.

3.3.5 Waste Treatment and Immobilization Plant Pretreatment Facility

**Status:** Design and construction

**Current Responsibility:** ORP WTP Contract (BNI)

**Discussion:** The PT Facility (Figure 3-17) prepares waste for delivery to the HLW and LAW Vitrification Facilities. Under normal operations (not DFLAW operations), waste is received from the tank farms into the PT Facility waste receipt vessels. The LAW feed is transferred from a designated DST to the WTP as supernatant liquid that may contain a small amount of undissolved solids.

Figure 3-17. Waste Treatment and Immobilization Plant Pretreatment Facility.

About 1 Mgal of LAW feed (excluding flushes) is typically transferred at a time to the four feed-receipt process vessels inside the PT Facility. The HLW is transferred as a slurry (containing both dissolved and undissolved solids) from the TWCS tanks to the HLW feed receipt vessel.
The LAW feed is blended with the HLW feed in the ultrafiltration system. The ratio of LAW to HLW undissolved solids is established to support the LAW and HLW glass production rates. The blended HLW and LAW feed streams are caustic and oxidative leached (as necessary), washed, and filtered to separate the waste into 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 LAW Vitrification Facility.
- **Concentrated HLW solids slurry**, which is blended with Cs-137 from IX before being transferred to the HLW Vitrification Facility.

The PT Facility waste feed evaporators process recycle streams from the PT Facility and 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 PT 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 3.3.11).

The WTP Contract requires the PT Facility to have a LAW treatment²⁴ capacity to process 2,620 MT waste²⁵ sodium/year and a HLW treatment capacity to process 860 MT of as-delivered feed solids per year. These design capacities are not intended to reflect a rate-limiting operating limit for the PT Facility; instead, the specifications enable ORP to evaluate how changes to the WTP design, flowsheet, and operating modes affect the mission and to establish minimum performance requirements so that design margins are not inadvertently lost.

The WTP Contract requirement, from Section C.7 (b.1) of the Statement of Work (DE-AC27-01RV14136, Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant), defines facility availability as follows.

The Contractor is to estimate the integrated facility availability factor from the Operations Research Assessment as defined in Standard 2 (b) (1) Operational Research Assessment. The determination of integrated facility availability for the purpose of WTP facility design compliance shall be based on estimates of the total time to treat all tank wastes, with no reliability/availability/maintainability/inspectability (RAMI) failures applied, divided by the total time to treat all tank wastes, with all RAMI failures applied.

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²⁴ Treatment capacity is determined by multiplying the design capacity by the integrated facility availability. The WTP contract requires an integrated facility availability of 70 percent.

²⁵ 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.
The minimum integrated facility availability and the individual facility availabilities shall be equal to or greater than 70 percent.

The Operations Research (OR) assessment (24590-WTP-RPT-PE-12-002, 2012 WTP Operations Research Assessment) predicted that the integrated WTP facility availability will be approximately 72 percent.

In the TOPSim model, the integrated WTP facilities (PT, HLW Vitrification, and LAW Vitrification) availability was calibrated to an efficiency of 72 percent to match the WTP OR assessment (Assumption A1.3.1.3, and RPP-RPT-58581, Facility Availability Application in the Hanford Tank Waste Operations Simulator [HTWOS] Model).

Additional information on the PT Facility is provided in 24590-WTP-RPT-PT-02-005 (Rev. 8).

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

Status: Design and construction

Current Responsibility: ORP WTP Contract (BNI)

Discussion: When not operating in DFLAW mode (see Section 3.3.2), treated LAW from the PT Facility is transferred to the LAW Vitrification Facility (Figure 3-18) for vitrification. The LAW vitrification process 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 an offgas treatment system. The facility also has a secondary offgas system shared by the two melter systems. The following description applies to each of the two LAW melter systems.
Figure 3-18. Waste Treatment and Immobilization Plant
Low-Activity Waste Vitrification Facility.
Pretreated LAW feeds are received into one of two common LAW concentrate receipt vessels within the LAW Vitrification Facility. Batches of concentrated LAW feed are transferred from these vessels to the melter feed preparation vessels, where glass formers and sucrose are added and blended to form a uniform batch of feed to the LAW melters. The slurry feed is transferred to the melter feed vessels, where the slurry is fed continuously to the LAW melters.

Each LAW melter is designed to operate at a facility design capacity of 15 MTG/day of ILAW. The feed enters the melter from the top and forms a cold cap layer on top of the melt pool. Volatile components in the feed are evaporated or decomposed, then drawn off through the melter offgas system. Nonvolatile components react to form oxides or other compounds dissolved in the glass matrix. Bubblers agitate the mixture to increase the glass production rate. An airlift system pours the glass from the melter into stainless steel containers (Figure 3-19).

After being filled, each ILAW container cools for several days, then a lid is sealed to the top of the container and external contamination is removed. Each ILAW container will hold 5.51 MTG on average. 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 (DOE/EIS-0391).

### 3.3.7 Waste Treatment and Immobilization Plant High-Level Waste Vitrification Facility

**Status:** Design and construction

**Current Responsibility:** ORP WTP Contract (BNI)

**Discussion:** The HLW Vitrification Facility (Figure 3-20) has two joule-heated ceramic-lined melters, each with its own dedicated feed train and offgas system. The two melters share a canister handling system and secondary effluent collection system. Each HLW melter is designed to support a combined design capacity of 6 MTG/day with the original melters and up to 7.5 MTG/day with replacement melters.
The PT Facility transfers pretreated HLW feed to the melter feed preparation vessels, where the waste is blended with glass-forming chemicals before being transferred to the melter feed vessel. The melter feed slurry is introduced at the top of the melter and forms a cold cap on the surface of the melt pool. Water and volatile components evaporate or decompose and are drawn off through the dedicated primary and secondary offgas systems. Nonvolatile components react to form oxides that become part of the molten glass. Figure 3-21 provides an example of HLW melting down with glass former.
A common canister receipt system supplies the canisters to each melter pouring system. An airlift system inside the melter transfers molten HLW glass into stainless steel canisters (Figure 3-19). Each HLW canister will have \( \frac{3}{8} \)-inch thick walls and will hold 3.02 MTG on average. After filling, each canister is inspected, the glass is sampled as necessary, and the canister is sealed. The canisters are decontaminated and transferred to the interim storage area within the HLW Vitrification Facility. From there, the canisters are transported to interim Hanford storage (IHS) (see Section 3.4.5), where the canisters will await transport offsite to a geologic repository for disposal.

### 3.3.8 Waste Treatment and Immobilization Plant Analytical Laboratory

**Status:** Construction substantially complete

**Current Responsibility:** ORP WTP Contract (BNI)

**Discussion:** The WTP Analytical Laboratory, shown in Figure 3-22, will provide operational support to the PT, 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.
3.3.9 Waste Treatment and Immobilization Plant Balance of Facilities

**Status:** Construction substantially complete

**Current Responsibility:** ORP WTP Contract (BNI)

**Discussion:** The WTP includes 20 support facilities, collectively referred to as the BOF, which provide various utilities (e.g., effluent management, chilled water, compressed air, diesel generator, fire suppression) and other functions to support the PT Facility, HLW Vitrification Facility, LAW Vitrification Facility, and Analytical Laboratory.

The WTP EMF, currently being constructed, provides an alternate means of handling LAW vitrification offgas effluent when the PT Facility is not operating. During DFLAW, the WTP EMF key services include:

- Providing a low-point drain for waste transfer line flushing
- Concentrating low-activity radioactive effluents from the LAW offgas treatment system using an evaporator
- Transferring evaporator condensate to the ETF (outside of the WTP project) via underground waste transfer lines
- Recycling evaporator concentrate back into the LAW vitrification process.
- Returning unconcentrated effluent to the tank farms during periods of evaporator downtime.

The WTP EMF receives offgas effluent and secondary liquid waste from the WTP Analytical Laboratory, filters it, performs pH adjustments, concentrates it, and recycles it to the front end of the LAW vitrification system for feeding to the melters. The concentrated effluent can also be staged for return to the tank farms on an as-needed basis. When this occurs, additional chemical adjustments may be performed to comply with the tank farms waste acceptance criteria. Evaporator overheads and other low-inventory effluents (e.g., caustic scrubber effluents) are routed to the LERF/ETF.

The WTP EMF is located next to the WTP Analytical Laboratory. The WTP EMF will receive secondary liquid waste from the LAW offgas scrubber system and concentrate the solution before recycling it to the LAW melter concentrate receipt vessels. When the WTP EMF is offline for maintenance, this stream can be returned to the tank farms. Corrosion inhibiting chemicals are added to the portion returned to the tank farms to meet corrosion mitigation requirements. The current WTP EMF design consists of a filter, evaporator feed vessel, evaporator, low-point...
drain vessel, condenser, concentrate vessels, and process-condensate lag-storage vessels (Figure 3-24).

Additional information on the EMF is provided in 24590-WTP-RPT-PT-02-005 (Rev. 8).

Figure 3-24. Effluent Management Facility Simplified Process Flow.

3.3.10 Supplemental Low-Activity Waste Treatment

Status: Future facility

Current Responsibility: ORP Tank Operations Contract (WRPS)

Discussion: The LAW Vitrification Facility was not intended to treat the entire inventory of Hanford LAW in the same period as the HLW can be treated. Supplemental treatment was always envisioned to treat part of the LAW. Technologies that have been considered as potential supplemental treatment technologies include joule-heated melter vitrification (similar to WTP), grout (cast stone), 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 supplemental LAW treatment method. Advancements in GFM and other technologies are improving and assessments have been performed, or are in process, to determine an adequate path forward (GAO-17-306, Opportunities Exist to Reduce Risks and Costs by Evaluating Different Waste Treatment Approaches at Hanford).

Although the decisions have been deferred, studies have been ongoing to evaluate alternative methods of immobilizing LAW. For example, the TOC technology development program has been testing low-temperature waste form (cast stone) compositions, including evaluating additives meant to improve the retention of technetium and iodine. The waste form performance datasets can provide the technical basis needed to support PAs, DOE O 435.1 requirements, advance the technical maturity of cast stone, and other related activities. Although the Tank
Closure and Waste Management Environmental Impact Statement (TC & WM EIS) evaluated information regarding supplemental treatment technologies, no decision was made in the Record of Decision 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.”

3.3.11 Liquid Effluent Retention Facility/Effluent Treatment Facility

Status: Operational

Current Responsibility: ORP Tank Operations Contract (WRPS)

Discussion: The LERF, shown in Figure 3-25, 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, which 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 and the disposal of treated wastes meeting applicable state and federal permit requirements.

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. When below permit limits, the waste is discharged under a state waste discharge permit and approved delisting petition to the State-Approved Land Disposal Site (SALDS) located in the Hanford 600 Area. The treated effluent is discharged as a non-dangerous, delisted waste. Residue from these treatment processes are concentrated and dried into a powder in a secondary treatment train. (A project upgrade to solidify residues is planned.) The LERF and ETF, both co-located in the 200 East Area, have final status RCRA Part B permits.

In addition to the waste streams already being collected, treated, and disposed at LERF/ETF, liquid effluent secondary wastes generated during waste treatment operations (WTP, LAW supplemental treatment, and supplemental treatment of potential TRU tank waste), will be sent to the ETF for treatment and disposal, 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.
Additional information regarding the LERF and the ETF are provided in T3W08-PCR-001, *Secondary Liquid Waste Treatment Project (T3W08) Project Closeout Report*.

### 3.4 DISPOSAL

#### 3.4.1 Central Waste Complex

**Status:** Operational

**Current Responsibility:** RL Plateau Remediation Contract (CHPRC)

**Discussion:** The CWC, located in the 200 West Area (see Figure 3-26), 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, mixed low-level waste (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 ft² 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 LDR-compliant, and TRU waste, for acceptance, must meet the requirements of HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*.

The TC & WM EIS ROD (78 FR 75913) acknowledged that upgrades are needed to expand the treatment capabilities at the CWC, Waste Receiving and Processing Facility, and T Plant to support ongoing and planned waste management activities for LLW and MLLW generated at Hanford and from other DOE sites. For example, a secondary solid waste handling facility (e.g., the Consolidated Waste Management Facility) could be added to CWC. An evaluation was performed in 2013 and updated in 2015 to determine the size and location of this facility based on the amount and type of waste generated by each source (see Section 3.4.4).
The HNF-EP-0063 requirements allow the CWC to accept TRU and TRUM wastes in 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 the supplemental TRU waste treatment system.

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

3.4.2 State-Approved Liquid Disposal Site

**Status:** Operational

**Current Responsibility:** ORP Tank Operations Contract (WRPS)

**Discussion:** The SALDS, shown in Figure 3-27, is located north of the 200 West 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 ETF and transferred via pipeline to the SALDS in the 600 Area, where the effluent is discharged as non-dangerous, delisted waste, permitted under State Waste Discharge Permit ST 4500 (Ecology 2012; RPP-RPT-56516, *One System River Protection Project Mission Analysis Report*).

Additional information on SALDS is provided in the following documents:

- State Waste Discharge Permit ST 4500 (Ecology 2012)
- DOE/RL-2005-10, *Application for Renewal of State Waste Discharge Permit ST 4500 for the 200 Area Effluent Treatment Facility*
3.4.3 Integrated Disposal Facility

**Status:** Construction complete and in pre-active mode

**Current Responsibility:** RL Plateau Remediation Contract (CHPRC)

**Discussion:** In the TC & WM EIS ROD (78 FR 75913), DOE announced a decision to operate the IDF (Figure 3-28) 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:

- Tank waste treatment operations
- Waste generated from WTP and ETF operations
- 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 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. 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 (Cell 1) 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 from the LAW Vitrification Facility. With a permit modification, Cell 1 will also receive the ETF secondary waste and, as designated by the TC & WM EIS ROD (78 FR 75913), the spent or failed LAW melters. The other cell (Cell 2) is specifically excluded from the dangerous waste permit and will receive only LLW, not

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26 There is currently no final disposal location for the spent and failed HLW melters. The alternatives discussed in the TC & WM EIS assume that these spent HLW melters will be packaged in an overpack and stored at IHS until the melters can be removed for disposition and final disposal. For planning purposes, the final disposition of HLW melters is assumed to be at the IDF to maintain consistency with the current PMB. Plans will be updated, as needed, after a ROD that addresses HLW melter disposal is published. Appendix E of the TC & WM EIS provides additional more information (DOE/EIS-0391).
dangerous and/or hazardous waste. 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. When closure plans are developed, the closure cap design will be finalized. The planned date of the IDF to be operational depends on the schedule for the WTP, which was recently revised by U.S. District Court Judge Peterson in the March 11, 2016 Amended Consent Decree.

3.4.4 Consolidated Waste Management Facility

**Status:** Pending

**Current Responsibility:** ORP Tank Operations Contract (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.

The Consolidated Waste Management Facility will support WTP operations by storing and processing radioactive solid waste created during production of the HLW and LAW glass canisters prior to radioactive solid waste permanent disposal in the IDF, another Hanford facility, or offsite.

Most waste streams generated by the WTP will require treatment (i.e., decontamination, void space filling, and some size reduction) prior to final disposal to meet the waste acceptance criteria of the eventual disposal site. With limited space and onsite capabilities for storage and treatment for waste that will accumulate, a waste management area or areas will be required to provide for the accumulation of waste during normal WTP operations and maintenance outages prior to shipment, treatment, and final disposal.

The 616 Facility handles radioactive and dangerous wastes requiring less than 90-day storage. Space is limited, and when the WTP begins operations, the capacity will be inadequate to accommodate even DFLAW operations. In FY 2013, a One System evaluation was performed that identified the need for a new consolidated facility to manage all Tank Operations Contract and WTP solid wastes (RPP-54688, *Consolidated Waste Management Facility Site Evaluation*). The recommendation was to repurpose the T43/T47 WTP construction buildings.

Following direction from DOE to reconsider the use of the CWC for secondary solid waste storage, One System reevaluated several conditions in FY 2015, including updated information on projected waste streams (RPP-54688). Several items were identified, including the continued need for the T43/T47 buildings for PT Facility and HLW Vitrification Facility construction during DFLAW operations, which BNI has indicated are not available. The CWC will likely be available only for use as a backup facility for temporary waste storage, as the potential CH-TRU waste packaging project is delayed.
The reevaluation enabled One System to develop a path-forward in 2015 based on the updated information. The option selected (contract changes will still need to be made) includes constructing new low-cost 90-day storage pad(s) for the staging of WTP waste and possible Tank Operations Contract wastes, while using the CWC for the small amount of waste that might require staging over 90 days. Since additional/new permitting is not required, this option can be implemented, after TOC and WTP DFLAW contract changes are finalized and after WTP solid waste stream volumes for DFLAW are updated, without affecting the DFLAW critical path activities. Exceptions to the Hanford Site solid waste acceptance criteria can be handled on a case-by-case basis for transferring waste to CWC for longer staging times (15-WSC-0020, “One System Decision Document 0003, Consolidated Solid Waste Management Approach”).

3.4.5 Interim Hanford Storage

Status: Planned future facility

Current Responsibility: ORP Tank Operations Contract (WRPS)

Discussion: The current process flowsheet, depicted in Figure 3-3 (Section 3.0), requires temporary storage of immobilized high-level waste (IHLW) canisters prior to being transferred to the Hanford Shipping Facility (HSF) (see Section 3.4.6) and then on to a final offsite disposal location. Interim IHLW canister storage is necessary for RPP mission success.

The HLW Vitrification Facility Export Cave Room has only 46 storage rack slots – one for canister inspection, 21 for nonconforming canisters, and 24 for interim storage pending certification for shipment to interim onsite storage. Without adequate temporary storage for IHLW canisters, HLW processing could be delayed or shutdown.

The System Plan assumes that the IHS, shown above in Figure 3-30, will provide safe, economic, and environmentally sound receipt, handling, and storage of the first 4,000 IHLW canisters after startup of HLW Vitrification Facility operations. Subsequent IHLW canisters are to be shipped to an offsite geological repository. In the TC & WM EIS ROD issued in December 2013, 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 project incorporates expansion capabilities to accommodate the entire IHLW production and for a future offsite shipping module (RPP-PLAN-48151, Interim Hanford Storage Project Execution Plan).

According to RPP-PLAN-48151, Project T3W14 (IHS), is currently at CD-0, having completed conceptual design in this project definition phase and demonstrating a mission need. The result of this current phase will be CD-1, with an approved alternative selection and cost range for the project. 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 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 IHS is provided in RPP-RPT-52176, Interim Hanford Storage (T3W14) Conceptual Design Report.

### 3.4.6 Hanford Shipping Facility

**Status:** Potential future facility

**Current Responsibility:** ORP Tank Operations Contract (WRPS)

**Discussion:** The current flowsheet identifies the HSF, shown in Figure 3-31, as the means of receiving, packaging, and loading the IHLW canisters from the IHS for transport to an offsite repository. In 2009, the near-term focus for the HSF 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”).

As currently envisioned, the HSF will receive, package, and stage the IHLW canisters from the 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 (OCRWM), the canisters and overpacks will be packaged into casks in accordance with OCRWM 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 (RPP-34544, Cost Benefit Analysis for Immobilized High-Level Waste Storage). The HSF is assumed to be available when needed.

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 (Section 3.0), the current flowsheet routes IHLW canisters from the HLW Vitrification Facility to the IHS for temporary storage until the canisters are shipped from the HSF to an offsite repository. A deep geological repository, illustrated in Figure 3-32, 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 disposal site has been determined, Hanford’s IHLW canisters will be stored at the Hanford IHS.

In 78 FR 75913, DOE indicated that enough IHLW interim storage modules should be constructed to store all IHLW generated by WTP treatment. At this time, the IHS project incorporates expansion capabilities to accommodate the entire IHLW production and a future offsite shipping module (RPP-PLAN-48151).

Additional information is provided in the following:


3.4.8 Waste Isolation Pilot Plant

**Status:** Operational

**Current Responsibility:** Other Contractor

**Discussion:** WIPP is the nation’s only deep geologic repository that provides permanent underground disposal for defense-related CH-TRU and remote-handled (RH)-TRU wastes. The underground repository, illustrated in Figure 3-33, is carved out of a 2,000-ft-thick underground salt bed that formed 250 million years ago.
TRU waste is disposed of 2,150 ft underground in rooms mined from the salt bed. The salt bed is free of fresh flowing water, easily mined, impermeable, and geologically stable. 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.

TRU waste must undergo a certification process at the generator site before the waste can be shipped to WIPP. The certification process ensures that the waste meets the WIPP waste acceptance criteria 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 waste acceptance criteria requires that TRU waste be packaged in a WIPP-compliant form before the waste can be accepted for storage.

Additional information is provided in the following documents:

- WIPP Hazardous Waste Permit (WIPP 2016)
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4.0 STATE OF THE SYSTEM

Many updates to regulatory requirements have occurred and improvements to facilities have been completed since System Plan (Rev. 7) was published in October 2014. An Amended Consent Decree (2016) was issued with modified milestones for performing designated SST retrievals and construction and startup of the WTP. Only one of the ten SSTs in C Farm remains to be retrieved. The waste in leaking DST AY-102 was successfully retrieved to other DSTs, and the tank was removed from service. The 242-A Evaporator was successfully restarted after a 3-year maintenance outage and several evaporation campaigns were completed, creating additional space in the DST system for SST retrievals.

In support of DFLAW implementation, the LAWPS completed 60 percent design; the ETF was upgraded and restarted, and treated several million gallons of effluent from the LERF; and the 222-S Laboratory was upgraded. Resolution of technical issues associated with the PT Facility is expected in 2018, along with completion of construction of the LAW Vitrification Facility. The WTP Analytical Laboratory and BOF are largely complete, with design and construction of the EMF progressing in support of DFLAW.

A Justification of Mission Need for the TWCS capability was approved by DOE Headquarters, which will support delivery of HLW feed to the WTP. Analysis and testing supporting construction of the HLW Vitrification Facility was completed, and several major pieces of equipment were received. The IDF PA is expected to start its review as support to the IDF permit modification in 2017 in support of DFLAW startup. A more in-depth discussion of the state of the system is provided in the following subsections.

4.1 REGULATORY MILESTONES

The River Protection Project is subject to regulatory milestones under the Hanford Federal Facility Agreement and Consent Order (HFFACO, also known as the Tri-Party Agreement or TPA) as well as several federal court-enforceable consent decrees. The TPA was executed in 1989 and contains milestones that address various aspects of the RPP. Under TPA Milestone M-062-45, the parties are required to conduct negotiations on the following matters within 6 months of issuance of System Plan 8:27

1. Target dates and milestones for tank waste retrieval sequencing and retrieval as well as installation of infrastructure to feed tank waste from the DST system to the tank waste treatment system.
2. Potential contingency actions and milestones for new DSTs.
3. One-time supplemental treatment selection

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27 Milestone text has been summarized substantially to save space - see TPA Milestone M-062-45 for the precise language.
4. Milestone M-045-70 date for completion of the tank waste retrievals as expeditiously as possible.
5. Milestone M-062-00 date for completion of tank waste treatment as expeditiously as possible.
6. Milestones for IHLW canister storage capacity.
7. Reevaluation of milestones for secondary waste management facilities.

Other TPA milestones affected by the issuance of the Amended Consent Decree (described below) that need to be addressed by the M-062-45 milestone negotiations include, but are not limited to:28

- M-042-OOA for closure of all Double Shell Tank (DST) Farms.
- M-045-00 for closure of all Single Shell Tank (SST) Farms.
- M-045-70 for completion of waste retrieval from SSTs.
- M-047-00 for work necessary to provide facilities for management of secondary waste from the WTP.
- M-062-00 for pretreatment processing and vitrification of Hanford High Level (HLW) and Low Activity (LAW) Tank Wastes.
- M-090-00 for facilities necessary for storage of Immobilized High Level Wastes (IHLW).

The 2010 Consent Decree resulted from litigation initiated by the State of Washington in 2008 because DOE either had missed or was certain to miss TPA milestones involving single-shell tank retrievals and construction and startup of the WTP. Negotiations occurred between approximately June 2007 to August 2009, culminating in the 2010 Consent Decree29 filed October 25, 2010 and a package of TPA modifications that became effective the same day.30 Because of technical and other issues, DOE provided notifications to the states starting in November 2011 that serious risks had arisen that DOE would be unable to meet most of the remaining Consent Decree milestones. After informal and formal negotiations, the parties were unable to agree on new schedules, filed competing Motions to Amend Consent Decree, and ultimately the Court issued an Amended Consent Decree on March 11, 2016, followed by a Second Amended Consent Decree on April 12, 2016. The schedule in the Amended Consent

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28 Milestone language summarized; please refer to the official milestone for precise language.
29 States of Washington and Oregon v. Dept. of Energy, No. 08-5085-FVS.
30 The TPA package included the following signed change requests: M-36-09-01; M-42-09-01; M-45-09-01; M-47-09-01; M-50-09-01; M-51-09-01; M-61-09-01; M-62-09-01; M-90-09-01; P-09-09-02; and I-09-01. The TPA requirements for completing SST retrievals (December 31, 2040 per Milestone M-045-70) and treatment of all tank wastes (December 31, 2047 per Milestone M-062-00), among others, that were established in the TPA modification package that accompanied the 2010 Consent Decree were predicated on DOE achieving initial WTP plant operations by December 31, 2022.
Decree includes, among others, the following milestones that have a bearing on the milestones to be negotiated under TPA milestone M-062-45 and the TPA milestones noted above:

- **Appendix A: WTP Consent Decree Milestones, Schedule, Assumptions**
  - A-16: PT Facility Hot Commissioning Complete by December 30, 2033.
  - A-17: Hot Start of Waste Treatment Plant by December 31, 2033.

- **Appendix B:**
  - 1. Tank Waste Retrievals
    - B-1: Complete retrieval of tanks C-102, C-105 and C-111 by March 31, 2024.
    - B-2: Complete retrieval of wastes from the specified SSTs in A and AX Tank Farms (except Tank A-103) by March 31, 2024.
    - B-3: Complete retrieval of tank wastes in at least five of the tanks specified in milestones B-1 and B-2 by December 31, 2020.

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31 This date was extended by the Court from the 2010 Consent Decree date of December 31, 2022, predicated on completion of hot commissioning for the PT, LAW, and HLW facilities of December 31, 2019.

32 The HLW, LAW, and PT facilities all have three specific milestones: achieve facility construction substantially complete; start cold commissioning; and complete hot commissioning – all prior to hot start of the WTP (milestone A-17).

33 “Hot Start of the Waste Treatment Plant” is defined in Section IV-A-2 of the 2010 Consent Decree as “the initiation of simultaneous operation of the Pretreatment (PT) Facility, High-level Waste (HLW) Facility and Low-Activity Waste (LAW) Facility (including as needed the operations of the Analytical Laboratory (LAB) and the Balance of Facilities) treating Hanford tank wastes and producing a waste glass product.” In issuing the Amended Consent Decree of March 11, 2016 and the Second Amended Consent Decree of April 12, 2016, United States District Judge Peterson published only those portions of the 2010 decree that were being amended; she did not republish or change its unaffected sections. Consequently, this definition remains in effect.

34 In the 2010 Consent Decree, this milestone included ten C Farm tanks that were to be retrieved by September 30, 2014. All except C-102, C-105, and C-111 were retrieved by that date; C-102 and C-111 have been retrieved, leaving only retrieval of C-105 to complete this milestone.

35 The tanks referred to in this milestone were informally referred to as “the next nine tanks” as addressed by 2010 Consent Decree milestone B-4 and were to be retrieved by September 30, 2022. Tank A-103 is not included within this list and is covered separately by TPA milestone M-045-15, due September 30, 2022.

36 Note that Judge Peterson gave the State of Washington the right to petition the Court for an order requiring immediate construction of one or more DSTs if DOE fails, “for whatever reason” to achieve a Consent Decree tank retrieval milestone.
4.2 WASTE STORAGE

4.2.1 Single-Shell Tanks

Tank C-102 retrieval began in April 2014 using an extended reach sluicing system and high-pressure water. Waste retrieval from the tank was suspended in May 2015, when retrieval was determined to have reached the limits of the two technologies. The Request to Forego a Third Retrieval Technology (RPP-RPT-58676) was submitted to the Washington State Department of Ecology on August 10, 2015, (15-TF-0073), upon determination that a third technology was not practicable. The waste was retrieved to DST AN-101. The final estimated volume of waste remaining in SST C-102 is 2,098 ft$^3$ (15,690 gal) (RPP-RPT-59631, Retrieval Data Report for Single-Shell Tank 241-C-102).

Three technologies have been deployed in three separate phases for tank C-105. Supernate sluicing and high pressure waster were first deployed using the mobile arm retrieval system vacuum (MARS-V) in FY 2013. Chemical dissolution of the remaining waste was initiated in FY 2017, using an extended reach sluicing system. Approximately 2,000 ft$^3$ (15 kgal) of waste remain in Tank C-105. Retrieval operations transferred the waste to the DST AN-106. Completion Tank C-105 retrieval will complete retrievals in C Farm.

Retrieval operations in tank C-111 occurred in September through November 2010 using supernate and high pressure water. Chemical Dissolution (third technology) retrieval operations began in October 2015 and ended in March 2016, in conjunction with sluicing and high-pressure water. A continuous water rinse was performed of the remaining heel. Approximately 654 ft$^3$ (4890 gal) of waste remained in Tank C-111 on completion of the third retrieval technology. Tank C-11 waste was retrieved to DST AN-101 (RPP-RPT-59363, Retrieval Completion Certification Report for 241-C-111).

Temporary, above-grade hose-in-hose transfer lines (HIHTL) are used in the tank farms to support SST retrievals. As individual tank retrievals are completed and the HIHTLs approach a 10-year service life, the transfer lines are removed and disposed at the Environmental Restoration Disposal Facility (ERDF). In FY 2016, 19 HIHTLs were removed from C Tank Farm and prepared for shipment to ERDF.

The next tanks to be retrieved under the Consent Decree will be the four AX Farm SSTs, followed by five tanks in A Farm and one (A-103) under the TPA. Preparations for those retrievals are already underway: activities include pit cleanouts, removal and disposal of defunct equipment, installation of a new tank ventilation system, installation of the extended reach sluicing system equipment, and other necessary infrastructure upgrades.

In addition to the preparations for the next retrievals, work is being conducted throughout the farms in support of the SSTIP (Section 3.1.1), visual examination of SSTs and sidewall coring for structural evaluation. Sidewall coring of SST A-106 was completed in 2014 to determine the potential for concrete degradation. Concrete degradation is linked with elevated temperature, and the high-heat history of Tank A-106 provided a bounding case for evaluation. A series of 1-ft to 5-ft cores were drilled and extracted to a depth of 38 ft from the tank sidewall through the haunch, down the full length of the sidewall, and into, but not through, the wall footing. A
similar effort was completed in 1981 on SST SX-115. Laboratory analysis of the Tank A-106 cores showed no deficiencies with the structural integrity of the tank (RPP-RPT-58254, Concrete Core Testing Report for the Single-Shell Tank 241-A-106 Sidewall Coring Project).

The SSTs are visually examined via remote video equipment for conditions inside the tank on the surface of the steel liners, concrete dome, risers, in-tank equipment, and waste surface. The intent is to identify any areas of concern and estimate the need to reexamine any tanks more frequently. In FY 2015, 11 SSTs were inspected; in FY 2016, 14 SSTs were inspected; and in FY 2017, 12 SSTs are planned to be inspected. In the 200 West Area, SST T-111 was observed to be holding a liquid pool above the solid waste layer. The presence of the liquid is attributed to an intrusion. A portable exhauster was installed and began operating in July 2015. The exhauster evaporated approximately 7 kgal of water from the tank and reduced the surface area of the pool by approximately 67 percent. Operations halted in December 2016.

Additional information on the SSTs is provided in the following documents:

- RPP-PLAN-46847, Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks
- RPP-RPT-58849, Fiscal Year 2015 Visual Inspection Report for Single-Shell Tanks

4.2.2 Double-Shell Tanks

Since the last System Plan there have been two substantial events that have impacted the DST system; AY-102 was found to have an internal leak and the flammable gas issue with deep sludge tanks has been resolved. The balance of the activities relate to verifying tank integrity and routine inspections.

Tank AY-102 (AY-102) is an approximate one million gallon underground double-shell tank (DST) containing mixed radioactive and hazardous waste located in the AY Tank Farm (AY Farm). In August 2012, a leak to the annulus was detected. On March 21, 2014, Ecology issued an Administrative Order against DOE and WRPS alleging violations of the Resource Conservation and Recovery Act (RCRA) and identifying 14 action items that DOE/WRPS must comply with including the pumping of AY-102. On April 18, 2014, DOE and WRPS (Appellants) filed Notices of Appeal and Motions to Stay the Administrative Order with the Washington State Pollution Control Hearings Board (PCHB). In September 2014, ORP and WRPS signed a Settlement Agreement with the State of Washington which set forth a path forward for the removal of the waste in AY-102. The Settlement Agreement requires, among other things, that DOE begin retrieving waste no later than March 4, 2016, and earlier if feasible, and to complete waste retrieval no later than March 4, 2017. Retrieval of the waste in AY-102 consistent with the requirements of Settlement Agreement was completed in February 2017. DOE and WRPS are currently inspecting the tank to determine the cause of the leak. The results of inspection will ultimately aid in a decision to repair or close the tank.

In support of continued SST retrievals, the Deep Sludge Gas Release Tall Column Project, completed in 2014, determined that deep sludge beds in DSTs AN-101 and AN-106 do not pose
a risk for a large spontaneous flammable gas release. This alleviated concerns about flammable gas pockets forming in deep sludge in Tanks AN-101 and AN-106, and helped to optimize use of DST space, especially with regard to SST retrievals (RPP-RPT-26836, Gas Retention and Release from Hanford Sludge Waste).

As part of the DSTIP (Section 3.1.2), the DSTs are visually examined using remote video equipment for conditions inside the primary tank and on the annulus surfaces of the primary tank and the secondary liner. Video inspections are typically scheduled in conjunction with the tank ultrasonic examination inspections, approximately every 5 years. Evaluation factors include cracks in the steel tank, visible rust stains, signs of liquid intrusion into the annulus, pitting along the liquid-air interface, corrosion of access risers, and other indicators of potential integrity issues. In FY 2015, 10 DSTs were inspected; in FY 2016, 12 DSTs were inspected; and in FY 2017, 8 DSTs are planned to be inspected (RPP-PLAN-46847).

In 2016, an IQRPE completed an integrity assessment of the DST system. The assessment concluded that 27 of the DSTs (excluding Tank AY-102), 92 pipelines, and 40 pits are fit for use. There were no adverse findings related to operations or maintenance of the DST system. The IQRPE made 24 recommendations for improvements (RPP-RPT-58441, Double-Shell Tank System Integrity Assessment Report).

In FY 2016, the TOC implemented a new fitness-for-service program intended to determine the remaining useful life of the tank farms waste transfer system. The results of approximately 3,200 ultrasonic test measurements and detailed laboratory forensics of multiple different primary and piping encasement specimens show that there is little to no evidence of corrosion within the waste transfer primary piping and only a minor amount on the encasement lines. In the absence of compelling evidence of erosion or corrosion, a wall loss rate has been estimated to determine the design life of new piping and the remaining useful life of existing piping. Wall thickness in strategic pipelines/jumpers will be opportunistically monitored (RPP-RPT-52791, Tank Farm Transfer System Fitness-for-Service Erosion and Corrosion Basis).

4.3 TANK FARMS INFRASTRUCTURE

The existing tank farms infrastructure requires upgrades to meet the performance, operational, and functional requirements of the DFLAW Program. A DST upgrades project is underway to ensure that all necessary upgrades are completed to execute the DFLAW Program. These upgrades include:

- Installation of new transfer lines from the LAWPS interface to pump pit AP-07D, one for feed and one for returns.
- Installation of new transfer lines from LAWPS and the WTP interface point to carry LAWPS cesium eluate returns and EMF returns, respectively.
- Converting one Tank AP-107 mixer pump into a dedicated DFLAW valve pit, including jumpers, valves, nozzles, leak detection, appropriate controls, and installation of new transfer lines connecting the new DFLAW valve pit to the Tank AP-107 pump pits. This work is scheduled to complete at the beginning of FY 2021.
- Removal of the current slurry distributor in Tank AP-107 and installation of two redundant transfer pumps and a new slurry distributor.

Additional DST pump replacements are planned in support of DFLAW operations, 242-A Evaporator campaigns, SST retrievals, and DST transfer activities. Failed pumps in waste tanks are drained of waste and flushed, removed while being simultaneously encapsulated in heavy-duty foam insulation to minimize contamination, and disposed of in ERDF.

Each tank farm has at least one valve pit through which waste moves during SST retrievals or DST transfers; each DST has a valve box. Valve pit upgrade projects are in progress to remove failed equipment, remove debris, clean pit surfaces, and apply fixative to seal surface contamination in place. The upgrade projects also install new valves, jumpers, or other equipment as needed. In addition, new in-pit heaters are being installed to provide freeze protection for waste transfers during cold weather. The new in-pit heaters provide better protection than the heated tent system previously used, and require fewer personnel to operate.

Wireless communication systems are being designed, fabricated and installed in the DST farms. The automation upgrades are intended to increase efficiency and reduce risks to personnel by reducing the number of tank farms entries. Project scope includes adding safety-significant leak detectors in the annuli spaces, installing safety-significant instruments in each DST ventilation exhaust system, and connecting freeze protection components to the wireless system. Installation of safety-significant leak detection instrumentation has been completed in all of the DSTs, except Tank AY-102. The new instruments will be operable on completion of appropriate documented safety analysis (DSA) amendments and turnover activities, scheduled by the end of FY 2017. Installation of freeze protection has been completed in twelve 200 East valve pits and two encasements in AP Tank Farm. The freeze protection systems will be operable on completion of appropriate DSA amendments and turnover activities, scheduled by the end of FY 2017. Installation of safety-significant instrumentation in the exhaust systems and wireless connections for freeze protection systems is in progress in FY 2017; DSA amendments and turnover activities are planned in FY 2018.

Additional information is provided in RPP-RPT-55977, *Infrastructure Stewardship Plan*.

### 4.4 242-A EVAPORATOR

System Plan (Rev. 7) discussed numerous ongoing facility upgrades and preventative maintenance activities. These improvements were necessary to prepare the evaporator systems to support the increase in SST waste retrievals and DST transfers that will be associated with LAWPS and WTP operations.

An extensive cold run was conducted to prepare for the evaporator’s return to radioactive operations. In February 2014, the cold run established all conditions for full operation, except introducing waste and discharging slurry. This activity enabled validation of the procedures for normal and abnormal operation by actual performance, observation of operations staff during cold run operation, and completion of all testing on modifications in accordance with the approved test plan and test procedure. The TOC readiness assessment was completed in July 2014, the DOE readiness assessment was completed in August 2014, and the authorization
to restart 242-A Evaporator was received in September 2014. Between October 2014 and April 2016, six evaporator campaigns were conducted, and 2.2 Mgal of DST tank space were recovered.

In accordance with WAC 173-303-640, “Tank Systems,” and as part of the DSTIP (Section 3.1.2), a periodic IQRPE review of the 242-A Evaporator equipment integrity is required. The fieldwork for the FY 2017 IQRPE review is complete, and the report is being written. Some follow-up actions, including a fluorescent dye test of the reboiler and a full feed loop check, were conducted to check for leaks prior to resuming the next planned evaporator campaign. Evaporator campaigns EC-06 has just been completed, and EC-07 is expected to be completed before the end of summer 2017.

The DSA was recently updated, which includes a change that made the 242-A Evaporator reboiler safety-significant (HNF-14755, 242-A Evaporator Documented Safety Analysis). The safety function of the E-A-1 reboiler is to provide confinement of waste (i.e., E-A-1 reboiler tube/tube sheet integrity). Providing confinement of waste protects facility workers from a flammable gas accident, direct radiation hazards, and chemical burn hazards (i.e., skin contact with caustic waste) due to waste in the steam condensate system resulting from an E-A-1 reboiler tube/tube sheet leak or failure. The TOC purchased a spare reboiler in November 2016 (Consent Decree Milestone D-16E-01) and is in the process of making the spare reboiler available (Consent Decree Milestone D-16E-02). Recovery from failure of a reboiler will likely take longer than the hypothetical 18-month outage, if a spare is not available. A shorter outage is anticipated if a spare is available. Final design approval is scheduled for August 29, 2017, and acceptance testing is scheduled for January 2018.

Additional facility upgrades are being implemented, including 242-A Evaporator radiation monitor replacement and removal (Project #T1P65); 242-A Evaporator vessel vent stack extension (Project #T1P154); 242-A Evaporator vessel vent ammonia analyzer upgrade, Phase 1 (Project #T1P163); slurry pump PB-2 variable frequency drive replacement; and the E-A-1 reboiler integrity test assembly installation.

4.5 LIQUID EFFLUENT RETENTION FACILITY, EFFLUENT TREATMENT FACILITY, AND TREATED EFFLUENT DISPOSAL FACILITY

WRPS assumed management of ETF and its associated facilities, the LERF and TEDF, in March 2015, after RL transferred the facilities to ORP. At the time of the transfer to WRPS, the LERF/ETF was undergoing an outage. Equipment upgrades undertaken during the outage included removing and replacing a 10,000 lb heat exchanger, and significant modification to the chemical supply for the IX system. In addition, procedures were refined and personnel completed additional training. The outage lasted just over 2 years. Since restart, the ETF has processed 7.5 Mgal of water contaminated with radioactive and hazardous materials.

4.6 222-S LABORATORY

The 222-S Laboratory analysis of various tank waste samples supports safe and efficient storage and management of the tank farms wastes. Analytical test results inform blending plans for
evaporator feed and LAWPS feed, evaporator facility campaign operating parameters, tank corrosion prevention, SST retrievals, DST transfer approvals, and other tank farm activities.

A number of upgrade projects have been completed, and others are ongoing or planned. Upgrades include replacing analytical equipment, improving laboratory infrastructure systems (e.g., heating, ventilation, and air conditioning [HVAC] and electrical), replacing failed waste pumps, and expanding archive sample storage capacity. These projects are needed to support processing of qualification samples for DFLAW and to maintain the laboratory’s long-term viability to support tank farms operations through mission completion.

4.7 PRETREATMENT AND TREATMENT IN TANK FARMS FACILITIES

4.7.1 Low-Activity Waste Pretreatment System

The LAWPS 60 percent design review is complete, and the CD-3A package is scheduled to be submitted in calendar year 2017. Preparation of the CD-2/3 package is scheduled to be submitted in FY 2018. Development of specifications for long-lead procurement items was initiated in May 2015. Design and fabrication of long-lead items was initiated in February 2017.

In parallel with design, permitting activities for the LAWPS are in progress. Drafts of the new RCRA treatment, storage and disposal permit application, toxic air permit, and radioactive air license permit are all scheduled to be submitted to ORP in FY 2017.

In support of design activities, integrated engineering-scale and full-scale IX testing was initiated in November 2015 and is scheduled for completion in FY 2017. The preliminary safety design report was initiated in June 2015 and is scheduled to be submitted to ORP in FY 2017. RPP-RPT-59453, Direct Feed Low Activity Waste Rapid Improvement Event #3: Direct Feed Low Activity Waste Feed Qualification, and RPP-RPT-59494, Integrated DFLAW Feed Qualification Data Quality Objectives, were issued in 2016.

4.7.2 Tank Waste Characterization and Staging Capability

TWCS is a future capability that will enable the TOC to mix, characterize, and stage HLW prior to delivery to the PT Facility. TWCS will provide appropriate physical connectivity between the tank farms and WTP, optimize infrastructure upgrades and space management of the DSTs, and enable WTP to minimize full-scale vessel testing and proceed with completion of the PT Facility and HLW Vitrification Facility. A formal Justification of Mission Need was approved by DOE Headquarters in 2015 (Whitney 2015).

4.8 WASTE TREATMENT AND IMMOBILIZATION PLANT TREATMENT FACILITIES

The WTP comprises several related treatment facilities, including the LAW Vitrification Facility, BOF, and Analytical Laboratory.

4.8.1 Pretreatment Facility

The third and final phase of full-scale testing of control equipment and systems designed to safely mix radioactive waste in vessels at the PT Facility is in progress. This phase of vessel
testing is expected to be completed by the end of FY 2018. Results will be used to inform final design of the PT Facility vessels.

DOE has resolved key technical issues 1-3, identified in 2012 at the WTP project, allowing some design activities to resume at the PT Facility. The three technical issues involved:

1. Potential generation and accumulation of hydrogen in process vessels
2. Potential for nuclear criticality in process vessels
3. Potential for hydrogen accumulation in pipes and non-process vessels.

These three issues represented 80 percent of the risk identified in the full set of technical issues. DOE and BNI are working to resolve the remaining technical issues at the WTP by the end of 2018 (Cange 2017).

4.8.2 High-Level Waste Vitrification Facility

Analysis, testing, and construction of the HLW Vitrification Facility continues to progress. In FY 2015, workers completed 22 concrete placements for walls and floors. In FY 2016, WTP completed the 60 percent design review for the plant cooling water system, which was a major step in demonstrating that the project has procedures in place to support a full engineering, procurement, and construction release. The HLW process hazards analysis was also completed, which is one of the first steps toward getting the revised preliminary DSA to DOE.

Qualification testing for the safety-change HEPA filter was completed in collaboration with Mississippi State University. Tests included studies of the filter performance under combined operating conditions that exceeds what is required for standard nuclear-grade filters. The tests specifically challenged the ability of the filters to withstand accident conditions such as an earthquake or fire.

In FY 2017, the HLW integrated project team received three autosamplers in support of the planned construction civil buildout of the HLW Vitrification Facility. Two of the autosamplers will take samples during the vitrification process, when operational, and use capabilities in the Analytical Laboratory to verify that the correct mixture of waste and glass-forming materials exist. The third autosampler will be used to sample radioactive liquid waste before transferring the waste to the PT Facility.

A 25-ton crane was received and will be installed in the second HLW melter bay, which will be used to help employees move support equipment during installation and maintenance of the 90-ton melter. During operations, the crane will assist with maintenance of equipment in the melter bay.

4.8.3 Low-Activity Waste Vitrification Facility

DOE and BNI finalized contract modifications to implement DFLAW operations. This contract change formalizes the work that began in January 2014 when DOE directed BNI to shift to the sequenced approach that enables LAW tank waste treatment to begin no later than 2019.
The LAW Vitrification Facility melters have been fabricated and final assembly is anticipated in 2017. The major pieces of engineered equipment for the melter offgas treatment system have been installed. The LAW Vitrification Facility is scheduled to complete construction in 2018.

The LAW Vitrification Facility DSA preparation is ongoing and is expected to be approved by DOE in FY 2018. Preparation of the LAW radioactive air operating permit and the LAW Class III operating permit (dangerous waste permit) began in FY 2016 and are expected to be approved by Ecology in FY 2019.

4.8.4 Analytical Laboratory
As of May 2017, construction of the Analytical Laboratory is complete and undergoing startup testing. The preparation of the dangerous waste permit application for the Analytical Laboratory is ongoing. The application will be reviewed by DOE in FY 2017, and then transmitted to Ecology for review. Permit approval is anticipated in FY 2018.

4.8.5 Balance of Facilities
The construction of the BOF is largely complete and is scheduled to be finished in 2018. In FY 2016, WTP safely brought in permanent power to Building 87, the primary electrical switchgear building at the 65-acre WTP construction site. This is a major accomplishment – energizing Building 87 represents the transition from temporary construction-phase utilities to permanent utilities that will operate the WTP. By early 2017, WTP had also delivered permanent power to the BOF switchgear building, the Water Treatment Building, and the non-dangerous, nonradioactive Effluent Facility. The BOF DSA preparation began in FY 2017 and is expected to be approved by DOE in FY 2018.

WTP recently transferred 29,000 gal of water from its Nonradioactive Liquid Waste Disposal (NLD) Facility tank to the TEDF. The team flushed raw Columbia River water through the NLD tank and associated piping to TEDF, which is located in the 200 Area of the Hanford Site. The effort was coordinated with WRPS through the One System program.

The WTP EMF design was initiated in October 13, 2014, and is scheduled for completion on June 30, 2017. EMF construction began in March 2017. A temporary authorization for secondary containment construction was granted on February 21, 2017. Permitting is in progress for the EMF evaporator and vessels for underground radioactive transfer lines. The EMF radioactive air construction permit was issued on January 31, 2017. Placement of the basemats for the EMF utility building and EMF process building is complete.

4.9 ONSITE WASTE DISPOSAL
The ERDF supports Hanford Site cleanup projects by providing a final disposal site for a variety of contaminated solid wastes. This waste includes failed tank farms equipment and expired HIHTLs. Past waste projections predicted that ERDF, as currently designed, would reach maximum capacity in 2017. However, the EPA has approved vertical expansion of ERDF, to provide continuous support for various site cleanup projects, at less cost than it would take to build additional cells. Installation of the vertical expansion is in progress.
Construction of the IDF, which allows for ILAW container disposal, is complete. A PA is being prepared and is scheduled to be issued by the end of FY 2017.

4.10 OFFSITE WASTE DISPOSAL

The WIPP underground nuclear repository reopened on January 4, 2017. WIPP is licensed to receive defense-generated TRU wastes from nuclear weapons research and testing operations. Some Hanford wastes may be sent to WIPP in the future based on characterization of the waste.

Canisters of IHLW to be produced at the HLW Vitrification Facility will be permanently disposed at a future federal repository, at a location yet to be determined.

4.11 PERFORMANCE ASSESSMENT FOR WASTE MANAGEMENT AREA C

The first phase in the development of the WMA C PA began with a scoping process that was sponsored by ORP and Ecology. The scoping process, which was initiated in February 2009 and completed in May 2011, comprises a series of 10 technical working sessions attended by regulators and stakeholders to obtain a common understanding of the WMA C PA effort and to solicit input regarding the scope, methods, and data to be used in the planned PA to support closure of WMA C. The working sessions also involved the EPA, NRC, Oregon Department of Energy, interested tribal nations, other stakeholder groups, and members of the public, including the Hanford Advisory Board. The NRC staff was involved in the working sessions as a technical resource per DOE O 435.1, since the state of Washington is not a participant in Public Law 108-375, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Section 3116.

The numerical modeling phase for the PA was reinitiated in July 2013 after completion of the TC & WM EIS in December 2012. The final WMA C PA will be based on the final decisions on a preferred alternative for landfill closure that are documented in the TC & WM EIS ROD. A draft WMA C PA was developed and submitted to Ecology in the first quarter of FY 2017. Ecology is currently reviewing the draft WMA C PA.
5.0 SCENARIOS

The primary purpose of System Plan (Rev. 8) is to provide a baseline for executing the mission and to explore alternate operating scenarios for the RPP tank waste treatment complex in support of the HFFACO (Ecology et al. 1989). The HFFACO, or TPA, combined with the Consent Decree (2010, 08-5085-FVS) and the Amended Consent Decree (2016, 2:08-CV-5085-RMP) form many of the underlying requirements in the scenarios. The Amended Consent Decree dates were used as input for many of the schedules assessed. Scenario 1 (Baseline Case) used the model starting assumptions included in Appendix A. The purpose of the scenarios is to assess the impacts of various scenario-specific planning assumptions on the RPP mission, and the alternate scenarios may have varied the above requirements to analyze the effects.

The TPA requires the System Plan to present the following minimum information for each scenario evaluated:

- A description of each system used in the planning
- Planning bases for each case
- A description of key issues, assumptions, and vulnerabilities for each scenario evaluated; 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 want to analyze further
- Identification of new equipment, technology, or actions needed for the scenario (e.g., new evaporators or DSTs, new retrieval technologies, or 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 to accelerate tank retrievals and tank waste treatment
- Impacts on closure activities for each scenario.

The following sections include the analyses for the scenarios evaluated, which are summarized in Table 5-1. The items listed above that are required by the TPA are addressed throughout the following sections, as needed. Each of the scenarios and evaluated sensitivities were modeled and the results analyzed. 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 B. Additional data are available in RPP-RPT-60146, TOPSim Model Data Package for the River Protection Project System Plan, Revision 8, Scenarios.
Table 5-1. List of Scenarios for System Plan, Revision 8.

<table>
<thead>
<tr>
<th>Scenario #</th>
<th>Scenario Name</th>
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<tbody>
<tr>
<td>Scenario 1a</td>
<td>Baseline Case</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>Early Direct-Feed High-Level Waste</td>
</tr>
<tr>
<td>Scenario 3a</td>
<td>Early Direct-Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment Facility</td>
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<tr>
<td>Scenario 4</td>
<td>Risk-Informed Single-Shell Tank Retrievals</td>
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<tr>
<td>Scenario 5</td>
<td>Accelerated Retrieval Completion</td>
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<tr>
<td>Scenario 6</td>
<td>Tri-Party Agreement Compliant</td>
</tr>
<tr>
<td>Scenario 7a</td>
<td>Reduced Throughput</td>
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<tr>
<td>Scenario 8</td>
<td>Early U Tank Farm Retrievals</td>
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<tr>
<td>Scenario 9</td>
<td>Offsite Effluent Treatment</td>
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<tr>
<td>Scenario 10</td>
<td>Retrieval Contingency</td>
</tr>
<tr>
<td>Scenario 11</td>
<td>Direct-Feed High-Level Waste with Liquids-Only Waste Treatment and Immobilization Plant Pretreatment Facility</td>
</tr>
</tbody>
</table>

* Additional sensitivity scenarios are addressed in Scenarios 1, 3, and 7.
5.1 SCENARIO 1 – BASELINE CASE

5.1.1 Objective/Planning Bases

The objective of the Baseline Case is to evaluate the RPP mission as currently planned to (1) derive estimated retrieval and treatment completion dates using input dates from the Amended Consent Decree (2016), and (2) assess the ability to comply with the Amended Consent Decree and the TPA. Three related sensitivity scenarios were also completed:

- **Scenario 1A**: Starts DFLAW processing on December 31, 2021.
- **Scenario 1B**: Uses the 2016 GFMs instead of the 2013 GFMs.
- **Scenario 1C**: LAWPS is not restarted after the PT Facility starts and is not used to provide additional feed to the LAW supplemental treatment facility.

The planning bases for Scenario 1 (Baseline Case) are captured in the model starting assumptions in Appendix A.

5.1.2 Flowsheet Description

A simplified flowsheet for the Baseline Case is provided in Figure 5-1 (page 5-5). During DFLAW (Section 3.3.2), supernatant liquid is staged in DSTs and delivered to the LAWPS (Section 3.3.2), where most of the cesium is removed using IX. The LAWPS cesium eluate is returned to the DST system, and the pretreated waste is sent to the LAW Vitrification Facility and immobilized. The submerged bed scrubber (SBS) and wet electrostatic precipitator (WESP) offgas condensate from the LAW Vitrification Facility is sent to the WTP EMF (Section 3.3.7) to be concentrated and recycled to the LAW Vitrification Facility. A small portion of the SBS/WESP offgas condensate is sent to tank farms to account for off-normal conditions.

Potential CH-TRU tank waste from the 200 West and 200 East SSTs is retrieved and treated onsite at a proposed supplemental TRU waste treatment facility (Section 3.3.1) and then transported offsite for disposal. All other waste in the SSTs is retrieved into the DST system, and waste in the 200 West DSTs is transferred to the 200 East DSTs. Waste retrieved from the B and T Complexes are sent to their respective WRFs and then to DSTs.

After 10 years of DFLAW operations, the LAWPS is suspended, the WTP EMF operations are discontinued, and the PT Facility and HLW Vitrification Facility are started. Slurries from the DST system are staged and sampled in the TWCS tanks and then fed to the PT Facility. Supernate is fed from the DSTs to the PT Facility instead of the LAWPS. The waste slurries and supernate are combined, and the solids are then filtered, washed, and leached to reduce the amount of IHLW produced. Permeate is fed through an IX process to remove most of the cesium, and the cesium-depleted LAW is concentrated. The cesium product from the IX process is combined with the treated solids. The pretreated slurry from the PT Facility is sent to the HLW Vitrification Facility, and the pretreated supernate is sent to either the LAW Vitrification Facility or a LAW supplemental treatment facility. The SBS/WESP offgas condensate from the HLW and LAW Vitrification Facilities is recycled to the PT Facility. When the supplemental treatment facility starts operations, the LAWPS is restarted and provides an additional source of feed to the facility.
The LERF receives process condensate and other dilute liquid waste streams from the 242-A Evaporator, PT Facility, LAW Vitrification Facility, and WTP EMF. Dilute waste sent to the LERF is treated by the ETF and then disposed of, either as liquids at the SALDS (Section 3.4.2) or as a solidified waste form at the IDF (Section 3.4.3). Immobilized waste from the LAW Vitrification Facility and LAW supplemental treatment facility is also disposed of at the IDF. Immobilized waste from the HLW Vitrification Facility is transported to the IHS (Section 3.4.5), and then to a permanent offsite disposal facility, when available.

5.1.3 Analysis
This section evaluates the results of the Baseline Case modeling. The schedule, lifecycle costs, and mission flowsheet results are presented in the subsections that follow.

5.1.3.1 Schedule Performance
Figure 5-2 shows the operating schedule for the SST retrievals and treatment systems, followed by Table 5-2, which lists the key mission activity dates for the Baseline Case. The LAW Vitrification Facility operates for 40 years, and the PT Facility and HLW Vitrification Facility operate for 30 years.
Figure 5-1. Baseline Case – Simplified Flowsheet.
Figure 5-2. Baseline Case – Operating Schedule of Major Facilities/Processes.
Table 5-2. Baseline Case – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory</strong></td>
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<tr>
<td>Complete C Tank Farm Retrievals (existing Consent Decree 3/31/2024)</td>
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</tr>
<tr>
<td>Complete Five Additional SST Retrievals (existing Consent Decree 12/31/2020)</td>
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<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
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<tr>
<td>Complete Tank A-103 (existing TPA 9/30/2022)</td>
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<tr>
<td>WMA C Closed (existing TPA 6/30/2019)</td>
<td>6/2028</td>
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<td><strong>Storage/Retrieval</strong></td>
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<td>242-A Evaporator Operations</td>
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<td>200 East Area WRF Operational</td>
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<td>200 West Area WRF Operational</td>
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<tr>
<td>200 East Area SST Retrievals Complete</td>
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<tr>
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<tr>
<td>Cross-Site Transfer Line Activated (slurry)</td>
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<tr>
<td>Start of Four Simultaneous SST Retrievals</td>
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<td>Tank AN-104 Group A Mitigation Complete</td>
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<td>Tank AN-105 Group A Mitigation Complete</td>
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<td>Tank AW-101 Group A Mitigation Complete</td>
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<td>Tank SY-103 Group A Mitigation Complete</td>
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<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
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<td>LAW Supplemental Treatment Facility Operations</td>
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<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
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<td>Treatment Completion</td>
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Table 5-2. Baseline Case – Key Mission Activity Dates. (2 pages)

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<tr>
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<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047 – 12/2065</td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.
CWC = Central Waste Complex.
DFLAW = direct-feed low-activity waste.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHS = interim Hanford storage.
LAW = low-activity waste.
LAWPS = Low-Activity Waste Pretreatment System.
LERF = Liquid Effluent Retention Facility.
PT = pretreatment.
SST = single-shell tank.
TPA = Tri-Party Agreement.
TWCS = tank waste characterization and staging.
WMA = waste management area.
WRF = waste receiving facility.
WTP = Waste Treatment and Immobilization Plant.

5.1.3.2 Cost

Table 5-3 summarizes the projected near-term Baseline Case escalated costs through FY 2025, which total $7,870 million. Figure 5-3 shows the lifecycle cost profile for the Baseline Case. The total unescalated lifecycle cost is $111 billion ($231 billion escalated). The near-term cost increases from FY 2021 to 2025 are mainly from the DFLAW Program, including construction completion and startup of the LAWPS, and operations costs for both the LAWPS and LAW Vitrification Facility beginning in FY 2023. The increased costs seen from FY 2026 to 2030 are due to supplemental treatment costs associated with the design and construction of the TWCS capability, supplemental TRU waste treatment facility, and LAW supplemental treatment facility (costed as a vitrification facility). There is a small dip through FY 2031 and 2032, when the LAW supplemental treatment facility has been built but has not started processing waste; however, when the integrated WTP and LAW supplemental treatment facility start, the annual costs are relatively constant until the end of treatment. Small dips and increases are a result of variations in annual SST retrievals and tank closures. Note that construction and startup costs for the PT Facility and HLW and LAW Vitrification Facilities are not included in the System Plan (Rev. 8) lifecycle cost. Operating costs of the aforementioned facilities are included, however.
Table 5-3. Baseline Case – Near-Term Funding Estimates (Unescalated).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>FY 2018</th>
<th>FY 2019</th>
<th>FY 2020</th>
<th>FY 2021</th>
<th>FY 2022</th>
<th>FY 2023</th>
<th>FY 2024</th>
<th>FY 2025</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Case ($M)</td>
<td>$780</td>
<td>$741</td>
<td>$872</td>
<td>$938</td>
<td>$939</td>
<td>$1,243</td>
<td>$1,433</td>
<td>$7,870</td>
<td></td>
</tr>
</tbody>
</table>

FY = fiscal year.

5.1.3.3 Mission Flowsheet Results

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

5.1.3.3.1 Single-Shell Tank Retrievals

The SSTs are projected to be retrieved by December 2056, with the retrievals of C Tank Farm and A/AX Tank Farms being completed in August 2017 and November 2022, respectively. Figure 5-4 shows the historical and projected SST retrieval progress as measured by the approximate volume of original waste remaining in the SSTs as a function of time. After the A/AX Tank Farms retrievals are completed in 2022, 21 SST retrievals (including those retrieved as potential CH-TRU waste) begin prior to startup of the PT Facility and HLW Vitrification Facility at the end of 2033. These retrievals take advantage of the DST space created during...
DFLAW operations. After DFLAW, when the integrated WTP and LAW supplemental treatment are operating (with continued treatment of supernate and the start of sludge treatment), DST space begins to open up and the rate of retrievals increases.

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

Figure 5-5 shows the number of retrievals that are projected to be completed during each calendar year. After the retrievals of A/AX Tank Farms complete in 2022, there is a lapse of retrieval completions while Tank AN-104 (the cross-site slurry receiver DST) and Tank SY-103 are mitigated, restricting retrieval progress of the S/SX Tank Farms. Mitigation of Tanks AN-104 and SY-103 is not completed sooner due to the limited amount of available DST space. After the retrievals of the A/AX Tank Farms and before the integrated WTP begins operating, there is an average of two SSTs retrieved per year. When the integrated WTP and LAW supplemental treatment facility start operating, the average number of SSTs retrieved increases to four tanks per year (including those retrieved to the supplemental TRU waste treatment process).
Figure 5-5. Baseline Case – Total Single-Shell Tank Retrievals Completed per Calendar Year.

Figure 5-6 shows the sequence and timing of each SST retrieval during the RPP mission. The light-blue 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 availability. The two larger delays of Tanks S-105 and S-109 during 2023–2025 are a result of the time required for the cross-site slurry transfer receiver to become available. The cluster of delays between 2035 and 2040 is a result of retrievals competing for DST space with mitigation of special DST wastes (see Assumptions A1.2.2.8, A1.2.2.9, A1.2.2.10, and A1.2.2.11). As the mission proceeds and mitigation of these special wastes is completed, there are fewer delays to SST retrievals.
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Figure 5-6. Baseline Case – Single-Shell Tank Retrieval Sequence and Timing.
Double-Shell Tank Space Management

Figure 5-7 shows the relative volumes processed through the DSTs over the mission. Initially, there is approximately 56 Mgal of waste in the Hanford DSTs and SSTs (HNF-EP-0182). The undissolved solids that are delivered to the HLW Vitrification Facility account for 5 vol% of the original waste. Over 220 Mgal of water and process chemicals are added to the tank farms to retrieve the SST waste, flush the lines, and stage the waste for treatment.

Figure 5-8 shows the utilization of DST space through the completion of the RPP waste treatment mission. The figure shows the total DST capacity, total volume of waste, and various allocations of headspace for purposes other than waste storage (see Table 5-4). During the DFLAW period (2023–2033), the amount of space created by treatment is typically filled with the incoming waste volume from Group A DST mitigations, along with SST retrievals. During this time, the waste volume averages 90 percent of the DST capacity (3 Mgal available). Once the TWCS capability starts up in 2032, followed by the integrated WTP in late 2033 and the LAW supplemental treatment facility in late 2034, available DST space begins to increase, providing room to:

- Mitigate deep sludge tanks
- 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 Sr/TRU precipitation
- Continue to retrieve SSTs.

The available DST volume reaches a maximum of almost 9 Mgal in 2036. Between 2040 and 2050, the inputs into the DSTs outpace the amount removed by treatment caused by the increase in SST retrieval volume and increased dissolution of precipitated solids (i.e., solids mitigation) additions. The average amount of available DST space is reduced to 10 percent (3 Mgal) between 2045 and 2048. After this peak period in the late 2040s, the available DST space gradually increases as treatment continues and SST retrievals are completed. As the demand for space declines, the DSTs begin a phased closure beginning in 2050 and continuing through 2062.

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 retrieval, evaporator, and feed-staging operations becomes increasingly difficult.

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37 The total DST capacity line reflects operating volume reduction due to solids buildup in the 241-AZ and 241-AW Tank Farms. When solids are dispositioned, the operating volume increases back to the original volume.

38 When the ISM was introduced to the model in System Plan (Rev. 7), excess solids were precipitated in the DSTs from evaporator operations, potentially creating Group A tanks and limiting the use of the DSTs. Solids mitigation involves the dissolution of excess precipitated solids in water to prevent the creation of Group A tanks.
Figure 5-7. Waste Volume History Diagram.

The LAWPs and WTP EMF process liquids that return back to the tank farm.

The original SST and DST waste is over 54 Mgal in volume.

Process Returns (7 Mgal)

Undissolved solids account for only 2% (3 Mgal) overall to WTP of the delivered feed.

Sludge and saltcake dissolve during retrieval and operations, reducing the amount of deliverable solids.

Liquid

Solid (Sludge/Saltcake)

The 342A evaporator processes the liquid waste and sends the evaporated water to LERF for treatment and disposal.
Figure 5-8. Baseline Case – Double-Shell Tank Space Utilization.

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DST emergency space</td>
<td>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 (see Appendix A, Assumption A1.2.2.3).</td>
</tr>
<tr>
<td>Other restricted headspace</td>
<td>Space above waste specifically identified as WTP feed source or in tanks used to deliver feed to the WTP throughout the mission.</td>
</tr>
<tr>
<td>Group A tank headspace</td>
<td>Space associated with Group A tanks that cannot be used because of a safety issue associated with the waste.</td>
</tr>
</tbody>
</table>

DST = double-shell tank.  
WTP = Waste Treatment and Immobilization Plant.

Numerous transfers occur between DSTs to support staging of feed to the LAWPS and WTP, 242-A Evaporator operations, and receipt of retrieved SST waste. There are approximately 2,200 DST transfers\(^3\) predicted to occur over the course of the RPP mission. Figure 5-9 shows the projected DST transfer demand. Between the years of 2025 and 2039, there is an average of 31 transfers per year. Between 2040 and 2057, the demand increases to 83 transfers per year as

\[^3\] Transfers in this discussion include all DST-to-DST, DST-to-WTP, DST-to-TWCS, and WRF-to-DSTs. Non-discrete transfers, such as DST-to-LAWPS and 242-A Evaporator-associated transfers, are not included in these projections and are tabulated with their respective facility.
the number of DST waste transfers increases because of increased transfers from the 200 East and 200 West Area WRFs. In the last few years of the mission, DST activity decreases as SST retrievals are completed and DSTs are closed.

Figure 5-9. Baseline Case – Projected Double-Shell Tank Transfer Demand per Calendar Year.

The transfers into the DST system consist mostly of the retrieved SST waste and a variety of other additions from miscellaneous Hanford facility waste generators, returns during DFLAW operations, water and chemical additions resulting from Group A mitigations, Sr/TRU mitigations, flushes, solids dissolution, dilutions, and the DST closure activities. Figure 5-10 summarizes the nearly 220 Mgal of additions to the DSTs over the mission. The volume of additions to the DSTs peaks between the years of 2040 and 2055 mainly due to the increase in as-retrieved SST waste and water additions for dissolution of precipitated solids (i.e., solids mitigation). Figure 5-10 shows the distribution of these additions.
As shown in Table 5-5, the majority of the DST additions (132 Mgal or 60 percent) are from the SST retrievals (as-retrieved volume). The second biggest contribution to the DST additions is water added to dissolve precipitated solids (37 Mgal). There are 18 Mgal of additions to the DSTs associated with the LAWPS and the EMF, consisting of the following:

- 6 Mgal of cesium eluate returns from LAWPS
- 1 Mgal from EMF returns to the tank farms
- 100 kgal filtered solids and associated liquid return from LAWPS to the tank farms

<table>
<thead>
<tr>
<th>DST Addition Type</th>
<th>Mgal</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-retrieved SST waste</td>
<td>132</td>
<td>60.5%</td>
</tr>
<tr>
<td>Solids mitigation</td>
<td>37</td>
<td>16.9%</td>
</tr>
<tr>
<td>LAWPS/EMF additions and returns</td>
<td>18</td>
<td>8.2%</td>
</tr>
<tr>
<td>Flushes</td>
<td>15</td>
<td>6.8%</td>
</tr>
<tr>
<td>Sludge dilution</td>
<td>11</td>
<td>5.0%</td>
</tr>
<tr>
<td>Special DST waste mitigation</td>
<td>4</td>
<td>1.8%</td>
</tr>
<tr>
<td>Waste generators</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>Cleanout</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>219</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

DST = double-shell tank.
EMF = Effluent Management Facility.
LAWPS = Low-Activity Waste Pretreatment System.
SST = single-shell tank.
10.5 Mgal of dilution water added to prepare feed in the DSTs to the target sodium molarity.

The remaining DST additions consist of water and chemical additions that support a wide variety of DST activities, including:

- Special DST waste mitigations
- Waste from other sources to DSTs (IMUSTs, 222-S Laboratory, deactivation of T Plant)
- Sludge dilution water
- DST cleanout at the end of the mission
- Flushes.

5.1.3.3.3 Waste Receiving Facilities
The B Complex WRF is projected to be used from 2035 to 2057 and the T Complex WRF from 2040 to 2050. The combined tanks in the B Complex WRF average 15 transfers per year and a total of 319 transfers over the 22 years of operation. The combined tanks in the T Complex WRF average 30 transfers per year, with 333 transfers over the 10 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. The T Complex retrievals have little wait time and average within 10 percent of the minimum retrieval durations, indicating that the DST space for the T Complex WRF is typically available. The B Complex retrievals are often restricted by competing 200 East Area DST activities, which results in the B Complex retrievals exceeding the minimum retrieval durations by 115 percent. In addition to the competing 200 East Area DST functions, the cross-site transfers from 200 West to 200 East Area are given priority to continue the progression of 200 West Area retrievals, further impacting 200 East Area retrievals.

5.1.3.3.4 242-A Evaporator

Figure 5-11 shows the projected demand on the 242-A Evaporator through the completion of the waste treatment mission. The 242-A Evaporator is expected to process about 200 Mgal of waste, reducing the stored volume by about 100 Mgal over the mission duration. There is an average of approximately five campaigns per year over the mission. The 242-A Evaporator demand peaks between 2043 and 2055 when the average number of campaigns increases to 10 per year, with a maximum number of 17 campaigns per year.

242-A Evaporator operations are regulated by RCRA and air permits, which limit hot operations to approximately 182 days per year (WA 7890008967, Permit for Dangerous and or Mixed Waste Research, Development, and Demonstration). The maximum number of hot operating days in a single calendar year predicted in the Baseline Case is 152 days, which occurs during the peak year of 2045. Even during the most active processing years, the Baseline Case still has over 200 days per year available for maintenance and downtime activity.

The peak operating window for the 242-A Evaporator mirrors the increase in the DST additions from the SST retrievals and solids mitigation (see Figure 5-10). The 242-A Evaporator is modeled with the assumption that the waste is evaporated to a specific gravity (SpG) endpoint of 1.43. At this concentration of waste, the ISM often predicts that solids will precipitate. These
solids then build up in the evaporator bottoms DST above the 70-inch action level used in modeling, which triggers solids mitigation to enable maximum emptying of the tank without solid plugging.

Figure 5-11. Baseline Case – Projected Operation of the 242-A Evaporator.

5.1.3.3.5 Waste Feed Delivery
Projected LAW feed from the LAWPS to the LAW Vitrification Facility was screened against limits in 24590-WTP-ICD-MG-01-030, Table 5, “Treated LAW Feed Acceptance Criteria.” This comparison, summarized in Table 5-6, shows that all of the feed is projected to be within the ICD-30 limits. The table lists the average and maximum values in the feed.
Table 5-6. Baseline Case – Direct-Feed Low-Activity Waste Feed Compared to the Low-Activity Waste Feed Acceptance Criteria (ICD-30). (2 pages)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Limit</th>
<th>DFLAW feeda</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
<td>Max</td>
<td></td>
</tr>
<tr>
<td><strong>Stream Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed bulk density</td>
<td>kg/L</td>
<td>&lt;1.35</td>
<td>1.26</td>
<td>1.28</td>
<td></td>
</tr>
<tr>
<td>Feed pH</td>
<td>Unitless</td>
<td>&gt;12</td>
<td>14.0</td>
<td>13.82 (min)</td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>wt%</td>
<td>&lt;3.4</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Hydrogen generation rate</td>
<td>gmole H₂/L/hour</td>
<td>&lt;8.5E-07</td>
<td>6.57E-08</td>
<td>1.36E-07</td>
<td></td>
</tr>
<tr>
<td>Liquid feed unit dose</td>
<td>Sv/L at 6 M Na</td>
<td>&lt;1.030</td>
<td>9</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td><strong>Chemical Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (Na) molarity</td>
<td>mole/L</td>
<td>≥5 and ≤8</td>
<td>5.55</td>
<td>5.46 (min) 5.97 (max)</td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mole/mole Na</td>
<td>&lt;3.70E-02</td>
<td>1.35E-02</td>
<td>1.86E-02</td>
<td></td>
</tr>
<tr>
<td>Fluoride (F)</td>
<td>mole/mole Na</td>
<td>&lt;9.10E-02</td>
<td>4.55E-03</td>
<td>9.40E-03</td>
<td></td>
</tr>
<tr>
<td>Sulfate (SO₄)</td>
<td>mole/mole Na</td>
<td>&lt;7.00E-02</td>
<td>8.07E-03</td>
<td>1.48E-02</td>
<td></td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>mole/mole Na</td>
<td>&lt;1.40E-05</td>
<td>7.43E-07</td>
<td>6.05E-06</td>
<td></td>
</tr>
<tr>
<td>Total organic carbon</td>
<td>wt%</td>
<td>&lt;10</td>
<td>0.13</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>NH₃</td>
<td>mole/L</td>
<td>&lt;0.04</td>
<td>5.88E-07</td>
<td>3.88E-06</td>
<td></td>
</tr>
<tr>
<td><strong>Radionuclides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cesium-137</td>
<td>Ci/mole Na</td>
<td>&lt;3.18E-05</td>
<td>2.83E-06</td>
<td>4.89E-06</td>
<td></td>
</tr>
<tr>
<td>Europium-154</td>
<td>Ci/L</td>
<td>&lt;1.80E-05</td>
<td>2.09E-06</td>
<td>9.53E-06</td>
<td></td>
</tr>
<tr>
<td>Cobalt-60</td>
<td>Ci/L</td>
<td>&lt;1.10E-06</td>
<td>1.26E-07</td>
<td>3.30E-07</td>
<td></td>
</tr>
<tr>
<td>Strontium-90</td>
<td>Ci/mole Na</td>
<td>&lt;1.19E-03</td>
<td>1.19E-04</td>
<td>1.97E-04</td>
<td></td>
</tr>
<tr>
<td>Technetium-99</td>
<td>Ci/L</td>
<td>&lt;4.80E-04</td>
<td>9.56E-05</td>
<td>1.41E-04</td>
<td></td>
</tr>
<tr>
<td>Plutonium-239</td>
<td>Ci/L</td>
<td>&lt;3.00E-5</td>
<td>1.23E-06</td>
<td>4.71E-06</td>
<td></td>
</tr>
<tr>
<td>Uranium-233</td>
<td>Ci/L</td>
<td>&lt;1.60E-7</td>
<td>1.16E-08</td>
<td>2.42E-08</td>
<td></td>
</tr>
<tr>
<td>Uranium-235</td>
<td>Ci/L</td>
<td>&lt;1.70E-9</td>
<td>3.28E-10</td>
<td>1.18E-09</td>
<td></td>
</tr>
<tr>
<td>TRU</td>
<td>Ci/mole Na</td>
<td>&lt;1.30E-5</td>
<td>8.48E-07</td>
<td>3.15E-06</td>
<td></td>
</tr>
<tr>
<td>Bulk U fissile to U total</td>
<td>wt%</td>
<td>&lt;0.96</td>
<td>0.73</td>
<td>0.82</td>
<td></td>
</tr>
</tbody>
</table>

a Properties and concentrations of the DFLAW feed batches were tabulated on a monthly basis. DFLAW feed is tabulated from the composition of transfers from LAWPS to the LAW Vitrification Facility.

Note: Limits are from Table 5 of 24590-WTP-ICD-MG-01-030, 2015. ICD 30 – Interface Control Document for Direct LAW Feed, Rev. 0, Bechtel National, Inc., Richland, Washington. Items not modeled and reported are feed receipt temperature, feed viscosity, waste compatibility, separable organics, and PCB concentration.

DFLAW = direct-feed low-activity waste.
LAW = low-activity waste.
LAWPS = Low-Activity Waste Pretreatment System.
Na = sodium.
PCB = polychlorinated biphenyl.
TRU = transuranic.
Projected LAW and HLW feed to the PT Facility feed receipt vessels were screened against 24590-WTP-ICD-MG-01-019, ICD 19 – Interface Control Document for Waste Feed (ICD-19). Table 7. Table 5-7 shows the average and maximum values for the LAW and HLW feeds to the integrated WTP and compares this value to the corresponding ICD-19 limit.

Table 5-7. Baseline Case – Waste Treatment and Immobilization Plant Feed Compared to the Feed Acceptance Criteria (ICD-19).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>kg/L</td>
<td></td>
<td>&lt;1.46</td>
<td>&lt;1.5</td>
<td>1.28</td>
<td>1.42</td>
<td>1.23</td>
<td>1.49</td>
</tr>
<tr>
<td>Slurry pH</td>
<td>Unitless</td>
<td></td>
<td>≥12</td>
<td>≥12</td>
<td>13.7</td>
<td>13.1 (min)</td>
<td>13.4</td>
<td>12.8 (min)</td>
</tr>
<tr>
<td>Solids wt%</td>
<td>wt%</td>
<td></td>
<td>≤3.8</td>
<td>N/A</td>
<td>0.00</td>
<td>0.00</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Solids g/L</td>
<td>g solids/L feed</td>
<td>N/A</td>
<td>&lt;200</td>
<td>N/A</td>
<td>107</td>
<td>186</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid fraction feed unit dose</td>
<td>Sv/L at 10 M Na</td>
<td></td>
<td>&lt;1500</td>
<td>&lt;1500</td>
<td>50</td>
<td>124</td>
<td>58</td>
<td>459</td>
</tr>
<tr>
<td>Solid fraction feed unit dose</td>
<td>Sv/L</td>
<td></td>
<td>&lt;2.9E+5</td>
<td>&lt;2.9E+5</td>
<td>0.00</td>
<td>0.00</td>
<td>12,850</td>
<td>207,852</td>
</tr>
<tr>
<td>Total organic carbon</td>
<td>wt%</td>
<td></td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>0.13</td>
<td>0.75</td>
<td>0.25</td>
<td>0.99</td>
</tr>
<tr>
<td>Pu to metals loading ratio (liquids)</td>
<td>g/kg</td>
<td></td>
<td>&lt;6.2</td>
<td>&lt;6.2</td>
<td>0.32</td>
<td>1.3</td>
<td>0.12</td>
<td>1.9</td>
</tr>
<tr>
<td>Pu to metals loading ratio (solids)</td>
<td>g/kg</td>
<td></td>
<td>&lt;6.2</td>
<td>&lt;6.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.7</td>
<td>2.7</td>
</tr>
<tr>
<td>U fissile to U total (liquid)</td>
<td>g/kg</td>
<td></td>
<td>&lt;8.4</td>
<td>&lt;8.4</td>
<td>6.7</td>
<td>7.7</td>
<td>6.1</td>
<td>8.45</td>
</tr>
<tr>
<td>U fissile to U total (solid)</td>
<td>g/kg</td>
<td></td>
<td>&lt;8.4</td>
<td>&lt;8.4</td>
<td>0.00</td>
<td>0.00</td>
<td>7.15</td>
<td>8.78</td>
</tr>
<tr>
<td>Pu concentration of liquids</td>
<td>g/L</td>
<td></td>
<td>&lt;1.3E-2</td>
<td>&lt;1.3E-2</td>
<td>5.6E-05</td>
<td>1.7E-04</td>
<td>2.2E-05</td>
<td>2.2E-04</td>
</tr>
<tr>
<td>Na molarity</td>
<td>mole/L</td>
<td></td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>5.6</td>
<td>9.1</td>
<td>3.3</td>
<td>9.9</td>
</tr>
<tr>
<td>HGR (LAW)</td>
<td>gmole H₂/L/hour at 120°F</td>
<td>≤3.7E-07</td>
<td>N/A</td>
<td>2.7E-8</td>
<td>1.8E-07</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>HGR (HLW)</td>
<td>gmole H₂/L/hour at 150°F</td>
<td>N/A</td>
<td>≤2.1E-06</td>
<td>N/A</td>
<td>3.4E-08</td>
<td>1.8E-07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total radioactive material</td>
<td>Ci/year</td>
<td></td>
<td>&lt;1.1E+08</td>
<td>&lt;1.1E+08</td>
<td>4.7E+05</td>
<td>1.3E+06</td>
<td>1.8E+05</td>
<td>1.1E+06</td>
</tr>
</tbody>
</table>

Note: Limits are from Table 7 in 24590-WTP-ICD-MG-01-019, 2014, ICD 19 – Interface Control Document for Waste Feed, Rev. 7, Bechtel National, Inc., Richland, Washington. Items not modeled and reported are feed receipt temperature, feed viscosity, slurry rheology, critical velocity, particle size, particle hardness, separable organics, and PCB concentration.

- HGR = hydrogen generation rate.
- HLW = high-level waste.
- LAW = low-activity waste.
- N/A = not available.
- Na = sodium.
- PCB = polychlorinated biphenyl.
- Pu = plutonium.
- TRU = transuranic.
- U = uranium.
- WTP = Waste Treatment and Immobilization Plant.
All of the feed is estimated to be within the ICD-19 limits, with the following two minor exceptions for the HLW feed:

- The maximum fissile uranium to total uranium ratio in the HLW liquid feed exceeds the limit by less than one percent and occurs less than two percent of the time.
- The maximum fissile uranium to total uranium ratio in the HLW solids exceeds the limit by three percent and occurs less than four percent of the time.

Some delivered feed is expected to fall outside of the screening criteria and may require substantial coordination with ORP, BNI, and WRPS to fully define an acceptable set of feed requirements or adjustments. The implication of the out-of-specification batches will continue to be assessed and will provide insight for refining future plans.

### 5.1.3.3.6 Waste Treatment and Immobilization

This section discusses the waste treatment and immobilization results for the Baseline Case. Table 5-8 summarizes the waste treatment facilities completion dates and the amount of immobilized products for the potential CH-TRU waste, WTP ILAW and IHLW, and the LAW supplemental treatment facility, both as a glass product and grouted product. The results of the specific treatments and immobilizations are provided in the following subsections.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Start date</th>
<th>Completion date</th>
<th>Immobilized product quantity</th>
<th>MT of product</th>
<th>Waste loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential TRU waste</td>
<td>January 2031</td>
<td>January 2036</td>
<td>8,400 drums</td>
<td>2,300</td>
<td>80%</td>
</tr>
<tr>
<td>WTP IHLW</td>
<td>December 2033</td>
<td>August 2063</td>
<td>7,800 canisters</td>
<td>23,600</td>
<td>44%</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>December 2023</td>
<td>November 2063</td>
<td>51,600 containers</td>
<td>284,300</td>
<td>23% (Na₂O)</td>
</tr>
<tr>
<td>LAW supplemental treatment</td>
<td>December 2034</td>
<td>November 2063</td>
<td>42,400 containers</td>
<td>233,600</td>
<td>21% (Na₂O)</td>
</tr>
<tr>
<td>(vitrification)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAW supplemental treatment</td>
<td>December 2034</td>
<td>November 2063</td>
<td>419,200 yd³</td>
<td>581,660</td>
<td>8% equivalent Na₂O</td>
</tr>
<tr>
<td>(grout)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IHLW = immobilized high-level waste. MT = metric ton.
ILAW = immobilized low-activity waste. TRU = transuranic.
LAW = low-activity waste. WTP = Waste Treatment and Immobilization Plant.

Figure 5-12 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 the radioactive decay of the starting inventory over time. The relative constant slope until the start of HLW vitrification (in 2034) accounts for approximately 35 percent of the reduction in the tank farms radioactive inventory and is primarily due to the radioactive decay of the inventory, with a small percent resulting from DFLAW operations. Once the HLW Vitrification Facility begins operations, the slope of the line increases significantly, which continues to the end of the mission. Only approximately two percent of the total curie content is associated with LAW and is immobilized as ILAW; the remaining 98 percent of the curies are associated with HLW and are immobilized as IHLW (back decayed).
Figure 5-12. Baseline Case – Tank Farm Radioactive Inventory Over Time

Figure 5-13 (page 5-27) shows the simple sodium balance. There is 84,000 MT of sodium predicted to report to the ILAW, of which 57 percent is from the waste sodium and 43 percent sodium is added throughout the process. The majority of the non-waste sodium is added in the PT Facility for caustic leaching and to keep the aluminum in solution (86 percent of the added sodium).
5.1.3.6.1 *Direct-Feed Waste Treatment*

The DFLAW flowsheet is in effect for 10 years prior to the PT Facility startup. In those 10 years, 21 Mgal of LAW at a target concentration of 5.6 M sodium (Na) is sent to the LAWPS, where the waste is pretreated and sent to the LAW Vitrification Facility. During DFLAW operations, approximately 11,000 containers of ILAW are produced (61,000 MTG), which is approximately 12 percent of the total ILAW estimated for the mission (94,000 total ILAW containers estimated for the mission). Roughly 10,000 MT of the original waste sodium is immobilized during the DFLAW period.

Figure 5-14 (page 5-28) shows a water balance of the DFLAW system for the 10 years of DFLAW operations. The LAW Vitrification Facility sends 42 Mgal of dilute effluent to the WTP EMF, of which 26 Mgal is from the SBS/WESP and 16 Mgal is from the caustic scrubber. The caustic scrubber stream is routed through the WTP EMF to LERF. The SBS/WESP stream is split into two fractions in the WTP EMF: (1) two percent of the dilute WTP EMF stream is chemically adjusted and returned to the tank farms, and (2) the remaining 98 percent is sent through the WTP EMF evaporator, and the concentrate is recycled to the LAW Vitrification Facility concentrate receipt tanks. The two percent returns to the tank farms simulates the amount of SBS/WESP recycle that results due to downtime and maintenance activities in the WTP EMF (see Assumption A1.3.5.3). Of the 26 Mgal of dilute SBS/WESP effluent sent to the EMF, approximately 1 Mgal is returned to the tank farms (consisting of 500 kgal SBS/WESP effluent and 500 kgal corrosion chemical additions). The 2 Mgal of WTP EMF concentrate is sent as recycle back to the LAW Vitrification Facility.

As a result of eluting the LAWPS IX columns during the 10 years of DFLAW operations, 4 Mgal of high cesium eluate returns are neutralized, chemically adjusted for corrosion control, and sent to the tank farms. The dilute returns from LAWPS and EMF to the tank farms total approximately 5 Mgal, which reduce to approximately 500 kgal when evaporated.

The DST space created by DFLAW operations is measured as the difference between the volume of effluents returned to the DSTs and the waste volume treated by DFLAW and removed by the 242-A Evaporator. In the System Plan (Rev. 8) Baseline Case, the net DST space created by DFLAW operations is 12.7 Mgal for the 10-year period.\(^40\)

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\(^40\) This is calculated from 13.2 Mgal of original undiluted waste minus 0.5 gal of post-evaporator returns. Post-evaporated return volume is the 1.1 Mgal EMF tank farms returns, plus 3.7 Mgal LAWPS IX elute returns, which total 4.8 Mgal at an average SpG of 1.04. When reduced to the 242-A Evaporator endpoint of 1.43, the volume is 500 kgal.
Figure 5-13. Baseline Case – Simple Sodium Balance.

Legend

Acronyms
CWC Central Waste Complex
HLW high-level waste
LAW low-activity waste
MT metric ton

TBD to be determined
TRU transuranic
WTP Hanford Tank Waste Treatment and Immobilization Plant

For illustrative purposes only: The mass balance has been simplified omitting some secondary waste, recycle streams, facility residuals, and glass-forming chemicals. Results are rounded.

SP8_31NaBalance_2017-07-19_R1
Figure 5-14. Baseline Case – Direct-Feed Low-Activity Waste Water Balance.

Note: Figure 5-14 is for illustrative purposes only. The balance has been simplified by omitting SST contributions and miscellaneous additions, and results have been rounded.

Legend

Acronyms
- DFLAW: Direct Feed Low-Activity waste
- DT: Double-Tank
- LERF: Liquid Effluent Retention Facility
- Mgal: Million Gallons
- SST: Single-Tank
- TOC: Tank Operations Contractor
- WTP: Waste Treatment and Immobilization Plant
- WESP: Wet Electrostatic Precipitator

Schematic Diagram:
- The water balance has been simplified by omitting SST contributions and miscellaneous additions, and results have been rounded.
5.1.3.3.6.2 Pretreatment Throughput

The WTP Contract requires that the PT Facility have a treatment capacity to process 2,620 MT waste sodium per year and 860 MT of as-delivered feed solids per year. The Baseline Case, as modeled, achieves an average of 2,120 MT waste sodium per year and 1,070 MT as-delivered solids per year.

The purpose of the contractual pretreatment capacity requirements is to enable ORP to (1) evaluate how changes to the WTP design, flowsheet, and operating modes impact the mission, and (2) establish minimum performance requirements so that the design margin is not inadvertently lost. The metrics (MT waste sodium/year and MT feed solids/year) do not adequately characterize the operation of the PT Facility; the requirements do not (nor were they intended to) reflect the underlying rate limiting processes and interactions within the PT Facility. In addition, the WTP contract requirements and treatment capacities do not reflect expected operations. For example, the WTP Contract requires the use of a feed vector from HNF-SD-WM-SP-012, Tank Farm Contractor Operation and Utilization Plan, which is not consistent with the updated glass models used in planning. Implementation of the ISM in TOPSim (see Section 2.2.3) increases the volume of soluble solids delivered to the WTP versus the wash factors used in HNF-SD-WM-SP-012. 24590-WTP-RPT-PE-12-001, 2012 WTP Tank Utilization Assessment, evaluates the expected treatment and design capacities of the PT Facility and suggests that the facility may achieve higher capacities than the contract requirements.

The requirement, from Section C.7 (b.1) of the WTP Contract Statement of Work (DE-AC27-01RV14136), defines facility availability as follows.

The Contractor is to estimate the integrated facility availability factor from the Operations Research Assessment as defined in Standard 2 (b) (1) Operational Research Assessment. The determination of integrated facility availability for the purpose of WTP facility design compliance shall be based on estimates of the total time to treat all tank wastes, with no reliability/availability/maintainability/inspectability (RAMI) failures applied, divided by the total time to treat all tank wastes, with all RAMI failures applied. The minimum integrated facility availability and the individual facility availabilities shall be equal to or greater than 70 percent.

In addition, the OR assessment (24590-WTP-RPT-PE-12-002) predicted that the integrated WTP facility availability will be approximately 72 percent.

In the TOPSim model, the integrated WTP facilities (PT, HLW Vitrification, and LAW Vitrification) availability was calibrated to an efficiency of 72 percent to match the WTP OR assessment (Assumption A1.3.1.3, and RPP-RPT-58581).

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41 Treatment capacity is determined by multiplying the design capacity by the integrated facility availability. The WTP Contract requires an integrated facility availability of 70 percent.

42 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.
5.1.3.3.6.3  Glass Production

Figure 5-15 compares the projected IHLW production against the theoretical capacity assumption. Figure 5-16 does likewise for the projected combined ILAW production from the LAW Vitrification Facility and LAW supplemental treatment facility. Figure 5-17 and Figure 5-18 show the glass production of the individual LAW treatment facilities (LAW Vitrification Facility and the LAW supplemental treatment facility, respectively). The net capacities of the HLW Vitrification Facility, LAW Vitrification Facility, and LAW supplemental treatment facility are each assumed to be 70 percent of the respective design capacities (see Assumptions A1.3.3.2, A1.3.4.5, and A1.4.1.5).

Figure 5-15. Baseline Case – Projected Immobilized High-Level Waste Production.
Figure 5-16. Baseline Case – Projected Combined Immobilized Low-Activity Waste Production.

Figure 5-17. Baseline Case – Projected Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production.
The IHLW production does not make full use of the theoretical capacity of 4.2/5.25 MTG/day (first/second generation melters). The average IHLW production is 2.2 MTG/day over the course of the HLW treatment mission. The production of IHLW is limited by the throughput of the PT Facility. A contributing factor is the reduction in PT Facility throughput to account for facility availability; however, if this factor is removed, the IHLW production average only slightly improves to 2.5 MTG/day. In addition, the PT Facility throughput is also reduced by the assumption that all of the batches are caustic leached and the majority of batches are oxidative leached (Assumptions A1.3.2.6 and A1.3.2.8).

WTP modeling using the 2013 GFM also predicted that the HLW Vitrification Facility would not meet the theoretical curve (24590-WTP-RPT-PE-13-003, 2013 Tank Utilization Assessment (TUA) Part 1: Potential Impact of Advanced Glass Models on the WTP). In this study, BNI modeled several flowsheets with and without leaching and varying sizes of supplemental LAW using the 2013 GFM. For the flowsheet, most similar to the Baseline Case and applying the 70 percent TOE, the HLW averaged 3.0 MTG/day (second generation melter), slightly more than the Baseline Case, which averaged 2.5 MTG/day (second generation melter). The WTP modeling and Baseline Case both predict that HLW production will be approximately 50 percent of the theoretical capacity. The HLW Vitrification Facility does not meet the theoretical capacity because the PT Facility is rate limiting and there are insufficient HLW solids in comparison to the amount of LAW in the system.
During DFLAW operations (2023 to 2033), the feed to the LAW Vitrification Facility melters is more dilute than when fed from the PT Facility (less than 5.6 M Na vs. an average of 7.5 M Na), and the melter does not quite meet the theoretical capacity of 21 MTG/day—averaging 18 MTG/day. This small deviation is due to the predicted rate estimated by the variable melter rate equation that factors in the melter feed composition and power limitations of the melter (Assumptions A1.3.3.9 and A1.3.4.12). If the waste is dilute, more power is required to drive-off the water to the offgas, and the throughput of the melter becomes limited by the supply of electricity.

After DFLAW operations, when the PT Facility feeds the LAW Vitrification Facility, the LAW Vitrification Facility ILAW production meets the theoretical capacity of 21 MTG/day. Excess treated LAW from the PT Facility is sent to the LAW supplemental treatment facility. The LAW Vitrification Facility produced 55 percent of the total ILAW, and 45 percent is produced from the LAW supplemental treatment facility.

Assumption A1.4.1.5 requires that the LAW supplemental treatment capacity “be selected with the goal that the combined LAW vitrification capacity will be large enough as to not drive the mission duration, but no smaller than the LAW Vitrification Facility.” 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 drive the mission duration. The average production rate for LAW supplemental treatment is 22 MTG/day over the course of the ILAW treatment mission. Figure 5-18 shows that the LAW supplemental treatment facility operates near capacity after initial startup (2035 to 2038) and again between 2049 and 2053; however, at other times, the facility is operating significantly below capacity.

5.1.3.3.6.4 Glass Drivers

The 2013 GFM (documented in PNNL-22631) consists of a collection of glass property composition models created with the intent to develop a nonconservative set of constraints and property models that can be used to estimate the amount of glass produced at Hanford.

The glass properties include a product consistency test response, viscosity, electrical conductivity, toxicity characteristic leach procedure response, density, one percent crystal temperature (T1%), and liquidus temperature (TL). The glass property composition models were fit to subsets of the database for several key glass properties and are intended for use in optimizing the glass composition to minimize the waste form volume and associated disposal costs.

The Baseline Case assumed that HLW glass would be formulated using the 2013 HLW GFM (PNNL-22631) per Assumption A1.3.3.6. Figure 5-19 graphically depicts the major HLW glass drivers over the mission. The primary glass drivers are T2%\textsuperscript{43}-spinel (70 percent), liquidus temperature zirconium [Tl-Zr] (14 percent), and nepheline discriminator (8 percent).

\textsuperscript{43} T2% is the temperature at 2 vol% crystal in equilibrium with the melt.
The average WOL is 44 percent, although as shown in Figure 5-19, the WOL varies over time based on the composition of the incoming waste and the constraints that are driving a particular batch.

The Baseline Case assumes that ILAW will be formulated using the 2013 LAW GFM (PNNL-22631) per Assumption A1.3.4.9. Figure 5-20 shows the major LAW glass drivers over the mission, and Figure 5-21 shows the major LAW supplemental treatment LAW glass drivers. Table 5-9 (page 5-36) lists the percentage of glass drivers for the WTP and LAW supplemental treatment ILAW. The loading rules are described in PNNL-22631.

The average annual sodium oxide loading is 23 percent for WTP ILAW and 21 percent for LAW supplemental treatment. The WOL averaged 27 percent for WTP ILAW and 25 percent for LAW supplemental treatment. Figure 5-20 and Figure 5-21 show that the sodium and WOL mirror each other and vary over time based on the composition of the incoming waste and the constraints that are driving a particular batch. The WTP ILAW is primarily driven by the alkali content rule (68 percent of the batches) and the combined alkali and sulfur content rule (25 percent). The LAW supplemental treatment glass is also primarily driven by these two constraints; however, the distribution differs because LAW supplemental treatment has a greater amount of melter offgas recycles from the supplemental offgas and a portion of the WTP offgas. This increase in recycles results in an increase of sulfur-related constraints (sulfur rule and combined alkali plus sulfur rule) and an increase in the halide constrained glass. The average sulfur concentration in the LAW glass is 0.65 wt%, and the sulfur concentration in the LAW
supplemental treatment is higher at 0.93 wt%. The higher sulfur constrained glass results in lower sodium and waste oxide glass loadings.

Figure 5-20. Baseline Case – Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Glass Drivers.
Figure 5-21. Baseline Case – Supplemental Low-Activity Waste Vitrification Glass Drivers.

Table 5-9. Baseline Case – Summary of Combined Immobilized Low-Activity Waste Glass Drivers and Na$_2$O Loading.

<table>
<thead>
<tr>
<th>Glass drivers and waste loadings</th>
<th>LAW Vitrification Facility</th>
<th>LAW supplemental treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass drivers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkali content (Na$_2$O,K$_2$O)</td>
<td>67.9%</td>
<td>40.1%</td>
</tr>
<tr>
<td>Alkali and sulfur content (Na$_2$O,K$_2$O,SO$_3$)</td>
<td>25.3%</td>
<td>44.2%</td>
</tr>
<tr>
<td>Halide conservative rule 1 (Cl$^-$,F$^-$,Cr$_2$O$_3$, K$_2$O,SO$_3$)</td>
<td>6.5%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Sulfur content (SO$_3$)</td>
<td>0.3%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Average loading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Na$_2$O loading</td>
<td>23.1%</td>
<td>21.0%</td>
</tr>
<tr>
<td>Average WOL</td>
<td>27.4%</td>
<td>25.2%</td>
</tr>
</tbody>
</table>

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

5.1.3.3.6.5  Supplemental Immobilization – Grout

The WTP is being constructed to treat all of the waste in the tank farms but will not have sufficient capacity to treat all of the LAW within the anticipated period for completion of the waste treatment mission. The LAW Vitrification Facility will need to be supplemented with a LAW supplemental treatment facility. Alternative forms of immobilization have been considered and are in various stages of development and testing (e.g., cast stone, which is a cementitious...
waste form). DOE continues to further study the potential cost, safety, and environmental performance of supplemental technologies.

In 2013, WRPS conducted screening tests of cast stone 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 simulant concentrations ranged from 5 to 7.8 M Na, and the waste loadings were driven by the free-water-to-dry-mix ratio ranging from 0.4 to 0.6. The study concluded that acceptable cast stone formulations could be produced at all concentrations and mix ratios tested.

Based on those results, the quantity of ILAW (grout) to be produced from feed to the LAW supplemental treatment 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 feed to the LAW supplemental treatment facility is grouted, there will be approximately 419,200 yd$^3$ of grout with an eight percent equivalent Na$_2$O loading. This is compared to the 42,000 LAW glass containers from LAW supplemental treatment, which is equivalent to 118,400 yd$^3$ of glass with 22 percent Na$_2$O loading.

5.1.3.3.6.6 **Liquid Effluent Retention Facility**

Approximately 550 Mgal of radioactive dangerous liquid effluent (secondary waste from the WTP, LAW supplemental treatment facility, 242-A Evaporator, and supplemental TRU waste treatment system) is projected to be treated by the ETF over the duration of the treatment mission. Figure 5-22 shows the distribution of feed sources to LERF over the mission.

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44 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 2.7924 yd$^3$ of ILAW per container.
Condensate from WTP and LAW supplemental treatment evaporators and caustic scrubbers contribute nearly 70 percent of the 550 Mgal. The remaining comes from the 242-A Evaporator condenser (24 percent) and the EMF evaporator (5.5 percent). Less than one percent of the volume is made up of condensate from the supplemental TRU waste treatment process.

5.1.3.3.6.7 **Potential Contact-Handled Transuranic Treatment**

The System Plan (Rev. 8) model starting assumptions for potential CH-TRU waste (see Section A1.4.2 assumptions) indicate that 11 SSTs will be handled as containing potential CH-TRU tank waste. This CH-TRU waste will treated at a supplemental TRU waste treatment facility (described in Section 3.3.1), and then stored onsite at the CWC until final disposition has been determined. The SSTs containing potential CH-TRU sludge 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. The treated potential CH-TRU tank waste could be disposed of at WIPP near Carlsbad, New Mexico. However, if the DOE elects not to treat and dispose of this waste at WIPP, that waste could be blended with other Hanford sludge waste and processed in the WTP as HLW.

Processing the potential TRU tank waste is projected to begin in January 2031 and will treat a maximum of 5,300 gal of slurry per day (average of 3,000 gal of slurry per day) retrieved from the 11 SSTs containing potential CH-TRU tank waste. The 8,400 drums of packaged waste that will be stored at the CWC pending final disposition is predicted from processing the potential CH-TRU waste (see Section 3.4.1). Processing is projected to finish in January 2036. This schedule logic and the associated budget used for the cost analysis are consistent with the TOC PMB.
5.1.3.3.6.8  **Storage and Onsite Shipping**

The IHLW canisters from the HLW Vitrification Facility will be transported to the IHS for temporary storage until the canisters are shipped from the HSF to an offsite repository. The first IHS module is planned for availability on June 2034 when the HLW Vitrification Facility has produced 24 canisters, filling the HLW canister pour handling (HPH) system canister cooling rack. The limited internal storage in the WTP canister export area is assumed to be used during hot commissioning until the IHS becomes operational.

The IHS is assumed to provide interim storage for a minimum of 4,000 IHLW canisters. The IHS 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 second 2,000-canister IHS module is projected to be available in April 2041, which is 1.5 years in advance of the projected need date of October 2042 (Assumption A1.5.3.6). If the HSF is delayed and shipping cannot begin, the IHS will reach its maximum storage capacity of 4,000 canisters in August 2048. In that case, additional modules will be added to meet the storage requirements, as outlined in Assumption A1.5.3. With the projected 7,800 canisters, there are two additional IHS expansion modules required to store all of the canisters temporarily.

5.1.3.3.6.9  **Hanford Shipping Facility**

Pending a determination of the final disposal alternative, the enabling assumption is that in December 2037, a decision will be made to construct the HSF and begin shipping canisters to an offsite final disposal alternative (see Assumption A1.5.4.2). Based on the results, the HSF will begin shipping IHLW canisters to the final disposal alternative in August 2047, 1 year prior to the IHS reaching its target operating capacity (4,000 canisters). The HSF is assumed to operate continually until all of the canisters have been shipped to the final disposal alternative, which is projected to be in December 2065.

5.1.3.3.6.10  **Central Waste Complex**

The CWC is assumed to store the 8,400 packaged potential CH-TRU waste drums, generated between January 2031 and January 2036, until final disposition of the CH-TRU waste has been determined (see Assumption A1.5.2.2).

5.1.3.3.6.11  **Disposal Onsite**

**Integrated Disposal Facility**

The IDF is projected to receive 94,000 packages of ILAW, 40 spent LAW melters (16 from the LAW Vitrification Facility and 24 from the LAW supplemental treatment facility), approximately 12,000 55-gal drums of solidified secondary waste from ETF processing, and other solid waste over the duration of the mission.

The schedule of when existing IDF cells will be filled or new cells will be needed has not been determined.
State-Approved Land Disposal Site
Approximately 543 Mgal of treated effluent from the ETF are projected to be disposed of at the SALDS over the duration of the treatment mission.

5.1.3.3.6.12 Disposal Offsite
Potential Transuranic Tank Waste
About 8,400 drums of packaged potential CH-TRU waste are projected to be stored at the CWC pending the determination of final disposition. If these packages are shipped offsite, the shipments can start no earlier than January 2031 and finish no earlier than January 2036 based on the projected retrieval and packaging schedule for this waste.

Final High-Level Waste Disposal Alternative
Shipment of the projected 7,800 IHLW canisters to a planned, offsite geological repository is discussed in Section 5.1.3.3.6.8 (also see Section 3.4.7).

5.1.3.3.7 Closure
The cost profile estimates the closure dates for the SSTs and DSTs by generating a schedule that reflects the baseline closure strategies and logic, and uses the individual SST retrieval dates and the DST final use dates projected by the TOPSim model. All SSTs are projected to be retrieved by December 2056 and closed by February 2061. After bulk retrieval of the last SST is completed, the critical path includes tank-specific and WMA closure activities. All DSTs are projected to be retrieved by October 2063 and closed by October 2068.

5.1.4 Sensitivity Scenarios
5.1.4.1 Scenario 1A – Baseline Case Sensitivity – Earlier Direct-Feed Low-Activity Waste Start
5.1.4.1.1 Objective/Planning Bases
The objective of Scenario 1A – Baseline Case Sensitivity – Earlier DFLAW Start is to evaluate the impacts to the RPP mission compared to the Baseline Case when DFLAW processing is started on the more aggressive ORP target date.

5.1.4.1.2 Adjusted Parameter(s)
Scenario 1A uses the same assumptions as the Baseline Case, with the following exceptions:

- The LAWPS starts operating on October 1, 2021, instead of October 1, 2023.
- LAW Vitrification Facility operations are shifted 2 years earlier, starting on December 31, 2021, instead of December 31, 2023 (same ramp rates as the Baseline Case).
- Near-term transfers and LAWPS feed preparations consistent with the Multi-Year Operating Plan (Assumption A1.1.1.8) are shifted, as needed, to support earlier startup (WRPS-1603955, “WRPS Multi-Year Operating Plan, Revision 5, FY 2017 – FY 2022”).
• Emergency space does not include space available in the five LAWPS dedicated tanks (AP-103, AP-105, AP-107, AP-108, and AW-106).

5.1.4.1.3 Analysis
The mission metrics for Scenario 1A are compared to the Baseline Case in Table 5-10. The total number of ILAW containers and IHLW canisters are approximately the same for the Baseline Case and Scenario 1A. Since Scenario 1A operates DFLAW an additional 2 years, there is an increase in the number of containers produced by the LAW Vitrification Facility and a corresponding decrease in the number of containers produced by the LAW supplemental treatment facility. In Scenario 1A, 2,200 more containers (4 percent increase) are produced at the LAW Vitrification Facility, compared to the Baseline Case. The IHLW production is nearly identical for Scenario 1A and the Baseline Case. The amount of time required to retrieve all of the SSTs is improved by 1 year in Scenario 1A; however, since the mission is HLW treatment-limited, the RPP mission length is approximately the same.

Starting LAWPS 2 years early has an initial improvement to the SST retrievals during the DFLAW period. Figure 5-23 shows the SST retrieval volume for Scenario 1A versus the Baseline Case. Beginning in 2023 when DFLAW starts, more SST waste is initially retrieved. Through the DFLAW period, 2.5 Mgal more as-retrieved SST waste volume is removed from the SSTs in Scenario 1A versus the Baseline Case. This improvement is a result of being able to mitigate Tanks AN-104 and SY-103 sooner and start the use of the cross-site slurry transfer line 1.5 years earlier. The completion of the SST retrievals is improved by 1 year in Scenario 1A versus the Baseline Case.

Figure 5-24 shows the annual average DST waste volume for Scenario 1A compared to the Baseline Case. Since DFLAW operates an additional 2 years in Scenario 1A, there is approximately 4 Mgal more dilute waste, which is fed directly to the LAW Vitrification Facility before the start of the PT Facility. This creates approximately 3 Mgal of additional DST space, which is used to increase the SST retrievals (as discussed above). During DFLAW and over the mission, there is an average of approximately 10 percent more available DST space for Scenario 1A as a result of earlier DFLAW operations.

To assess the impact of excluding the LAWPS tankage from the emergency space restriction, a separate model run was completed with this as the only change. The impacts of this change were

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Baseline Case</th>
<th>Scenario 1A</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST retrieval complete</td>
<td>12/2056</td>
<td>11/2055</td>
</tr>
<tr>
<td>DST retrieval complete</td>
<td>11/2062</td>
<td>9/2062</td>
</tr>
<tr>
<td>Treatment complete</td>
<td>11/2063</td>
<td>8/2063</td>
</tr>
<tr>
<td>IHLW canisters</td>
<td>7,800</td>
<td>7,800</td>
</tr>
<tr>
<td>ILAW containers</td>
<td>51,600</td>
<td>53,800</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass) containers</td>
<td>42,400</td>
<td>39,900</td>
</tr>
<tr>
<td>Total ILAW containers</td>
<td>94,000</td>
<td>93,700</td>
</tr>
<tr>
<td>CH-TRU waste packages</td>
<td>8,400</td>
<td>8,400</td>
</tr>
<tr>
<td>ETF solids drums</td>
<td>11,990</td>
<td>12,000</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
SST = single-shell tank.
negligible to the overall metrics; during LAWPS operations, there is not a large amount of available headspace as the tanks are heavily used throughout the mission. Although not reflected by the model runs, in reality, excluding the LAWPS dedicated tanks from the emergency space has the potential to artificially over-restrict the DST space and reduce operating flexibility.

Figure 5-23. Scenario 1A Comparison – Earlier Direct-Feed Low-Activity Waste Retrieval Progress.
Figure 5-24. Scenario 1A Comparison – Double-Shell Tank Available Space.
Figure 5-25 shows that although the number of 242-A Evaporator campaigns vary throughout the mission, the trend of evaporator usage for Scenario 1A is similar to the Baseline Case. The amount of feed to the evaporator was reduced by 12 Mgal compared to the Baseline Case (6 percent reduction), which corresponds to 14 fewer campaigns over the mission. The small reduction in feed is from more LAW being removed during the DFLAW period, which, in turn, creates more DST space and reduces the demand on the 242-A Evaporator.

Since the DFLAW operates for 12 years in Scenario 1A versus 10 years in the Baseline Case, more waste is treated during DFLAW operations and there is an increase in the volume of returns to the tank farms from the EMF. There is approximately five percent more waste sodium treated during DFLAW operations in Scenario 1A, compared to the Baseline Case. Figure 5-26 shows the water balance for Scenario 1A, which depicts 25 Mgal of feed that is sent from the DSTs to the LAWPS process (4 Mgal more than the Baseline Case). There are 6 Mgal of dilute returns from the LAWPS and EMF in Scenario 1A compared to 5 Mgal in the Baseline Case. The net DST space gained during DFLAW operations is 16.4 Mgal for Scenario 1A versus 12.7 Mgal for the Baseline Case, a net increase of 3.7 Mgal.
Scenario 1A – Water Balance.

Figure 5-26. Scenario 1A – Water Balance.
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5.1.4.2 Scenario 1B – Baseline Case Sensitivity – 2016 Glass Formulation Model

5.1.4.2.1 Objective/Planning Bases

The objective of Scenario 1B – Baseline Case Sensitivity – 2016 Glass Formulation Model is to evaluate the impacts to the mission using the 2016 GFMs compared to the Baseline Case, which used the 2013 GFMs.

5.1.4.2.2 Adjusted Parameter(s)

Scenario 1B changed the model to use the DOE 2016 LAW and HLW GFMs instead of the 2013 GFMs.

5.1.4.2.3 Background

In 2013, a set of models and constraints based on recent glass formulation and melter-testing data was developed and published (PNNL-22631). Since that report, roughly 200 additional glasses have been tested, and lessons were learned in applying the preliminary set of models and constraints. The 2016 GFMs (PNNL-25835) modified the 2013 GFMs using the additional data and lessons learned. The 2013 and 2016 GFMs were both developed based on:

- Using an optimistic approach to help bound the lower amount of glass
- Basing the estimates on recent successful tests with high waste loading for individual waste compositions
- Using models and simple rules to extend the results to the full range of Hanford tank waste compositions.

The DOE 2016 LAW GRM refinements included:

- Fitting a new LAW product consistency test model to make it easier to apply and more predictive, as the neural network vapor hydration test model was difficult to implement and not sufficiently predictive of new data.
- Fitting a new LAW viscosity model. The LAW viscosity model was not refitted in 2013, although significant new data has become available since 2007.
- Adding new halide/chromium rules to optimize. The halide rules split between a conservative and an optimistic approach added confusion and new data, suggesting the need for a new approach.

The DOE 2016 HLW GFM refinements included:

- Incorporating significant new data developed since late 2012
- Refitting the spinel model to encompass higher spinel fractions

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• Updating the nepheline model, as the previous neural network was difficult to implement and not sufficiently predictive of new data; the different equations are easier to apply and more predictive
• Fitting a separate HLW sulfate solubility model, as the 2013 GFM was found to underpredict the new HLW sulfate solubility data
• Fitting a new HLW product consistency test model, trying new methods of accounting for non-linear effects of Al$_2$O$_3$
• Fitting a new HLW viscosity model based on new data since 2009.

5.1.4.2.4 Analysis
Table 5-11 shows the mission metrics for Scenario 1B versus the Baseline Case. Changing to the DOE 2016 LAW and HLW GFMs has a minimal effect on the RPP mission and total IHLW canisters and ILAW containers. The 2016 GFMs produced less than a one percent variation in the mission results, with only 28 more IHLW canisters and one percent more ILAW containers.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Baseline Case</th>
<th>Scenario 1B 2016 Glass Formulation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST retrieval complete</td>
<td>12/2056</td>
<td>12/2055</td>
</tr>
<tr>
<td>DST retrieval complete</td>
<td>11/2062</td>
<td>1/2063</td>
</tr>
<tr>
<td>Treatment complete</td>
<td>11/2063</td>
<td>12/2063</td>
</tr>
<tr>
<td>IHLW canisters</td>
<td>7,800</td>
<td>7,900</td>
</tr>
<tr>
<td>ILAW containers</td>
<td>51,600</td>
<td>51,600</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass) Containers</td>
<td>42,400</td>
<td>43,000</td>
</tr>
<tr>
<td>Total ILAW containers</td>
<td>94,000</td>
<td>94,600</td>
</tr>
<tr>
<td>CH-TRU waste packages</td>
<td>8,400</td>
<td>8,400</td>
</tr>
<tr>
<td>ETF solids drums</td>
<td>11,990</td>
<td>11,950</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
DST = double-shell tank.  
ETF = Effluent Treatment Facility.  
IHLW = immobilized high-level waste.

The average WOL in the IHLW is 44 percent, which is the same as in the Baseline Case, although comparing Figure 5-27 and Figure 5-19 illustrates that the key constraints are different. In Scenario 1B, the major constraints for the 2016 GFM consist of T2% spinel (75 percent), aluminum oxide (Al$_2$O$_3$, 11 percent), and Tl-Zr (9 percent); compared to the Baseline Case where the key constraints consisted primarily of T2% spinel (70 percent), Tl-Zr (14 percent), and nepheline (8 percent).
Scenario 1 – Baseline Case

Figure 5-27. Scenario 1B – High-Level Waste Glass Drivers.

Figure 5-28 shows the major WTP ILAW drivers over the mission, and Figure 5-29 shows the major LAW supplemental treatment ILAW drivers. The loading rules are described in PNNL-22631. The average annual sodium oxide loading is the same as the Baseline Case at 23 percent for WTP ILAW and 21 percent for LAW supplemental treatment. The WOL is also the same as the Baseline Case, with an average of 27 percent for WTP ILAW and 25 percent for LAW supplemental treatment. The ILAW drivers are nearly the same as the Baseline Case, primarily limited by the alkali limits and the combined alkali and sulfur limits.
Figure 5-28. Scenario 1B – Waste Treatment and Immobilization Plant
Low-Activity Waste Vitrification Glass Drivers.
5.1.4.3 **Scenario 1C – Baseline Case Sensitivity – No Continued Low-Activity Waste Pretreatment System Operation after Direct-Feed Low-Activity Waste**

5.1.4.3.1 **Objective/Planning Bases**
The objective of *Scenario 1C – Baseline Sensitivity Case – No Continued LAWPS Operation after DFLAW* is to evaluate the impacts to the mission of not continuing to operate the LAWPS after PT Facility startup. In this scenario, the LAW supplemental treatment facility is only fed by the PT Facility; while in the Baseline Case, the LAWPS was restarted after startup of the PT Facility and used to augment feed to the LAW supplemental treatment facility.

5.1.4.3.2 **Adjusted Parameter(s)**
The only change to the model for Scenario 1C was to not restart LAWPS operations after DFLAW operations end.

5.1.4.3.3 **Analysis**
Not continuing to use LAWPS to feed the LAW supplemental treatment facility extended the completion of SST retrievals by 3 years and the RPP mission by 2 years. Since LAWPS operations are not extended beyond DFLAW operations in Scenario 1C, all of the LAW must be treated through the PT Facility. This extra volume of LAW that must be processed through the PT Facility results in a reduction in the rate at which waste is removed from the DST system. This leads to less available DST space, which adversely affects retrievals and increases the mission length. Not restarting LAWPS after the DFLAW period forces the mission to become even more treatment limited. The following subsections describe the specific impacts of the
Scenario 1C changes to SST and DST retrievals and closures, and to glass production, compared to the Baseline Case. The mission metrics are summarized in Table 5-12.

Table 5-12. Scenario 1C Comparison – Mission Metrics.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Baseline Case</th>
<th>Scenario 1C No Combined LAWPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST retrieval complete</td>
<td>12/2056</td>
<td>2/2060</td>
</tr>
<tr>
<td>DST retrieval complete</td>
<td>11/2062</td>
<td>1/2065</td>
</tr>
<tr>
<td>Treatment complete</td>
<td>11/2063</td>
<td>10/2065</td>
</tr>
<tr>
<td>IHLW canisters</td>
<td>7,800</td>
<td>7,800</td>
</tr>
<tr>
<td>ILAW containers</td>
<td>51,600</td>
<td>54,200</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass) containers</td>
<td>42,400</td>
<td>41,700</td>
</tr>
<tr>
<td>Total ILAW containers</td>
<td>94,000</td>
<td>95,600</td>
</tr>
<tr>
<td>CH-TRU waste packages</td>
<td>8,400</td>
<td>8,400</td>
</tr>
<tr>
<td>ETF solids drums</td>
<td>11,990</td>
<td>11,960</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  ILAW = immobilized low-activity waste.
DST = double-shell tank.  LAW = low-activity waste.
ETF = Effluent Treatment Facility.  LAWPS = Low-Activity Waste Pretreatment System.
IHLW = immobilized high-level waste.  SST = single-shell tank.

5.1.4.3.3.1  Single-Shell Tank Retrievals – Scenario 1C

Figure 5-30 shows the SST retrieval progress for Scenario 1C compared to the Baseline Case. The SST progress is nearly identical until about 2045, when the reduced available DST space begins to impact retrieval progress. Since the rate that LAW is treated is reduced in this case by not continuing to use the LAWPS beyond DFLAW operations, the DST space availability limits retrievals more than in the Baseline Case.
5.1.4.3.3.2 Double-Shell Tank Usage

Figure 5-31 compares the annual average available space in the DSTs in Scenario 1C to the Baseline Case. The two lines are identical until the startup of the LAW supplemental treatment facility in 2034. Continuing from this point, the available space in Scenario 1C runs less than the Baseline Case until near the end of the mission, when additional evaporator campaigns increase the available DST space. With the LAWPS not operating post-DFLAW operations in Scenario 1C, the rate of LAW leaving the DST system is reduced, which corresponds to a decrease in the amount of DST space compared to the Baseline Case.
Figure 5-31. Scenario 1C Comparison – Available Double-Shell Tank Space.

Figure 5-32 shows the 242-A Evaporator usage for Scenario 1C compared to the Baseline Case. There is approximately 10 Mgal more feed to the evaporator and 11 more campaigns, and the evaporator operates an additional 3 years in Scenario 1C compared to the Baseline Case. The usage is distributed slightly differently; however, the trend is similar, with a peak of 242-A Evaporator campaigns in the 2040s.
Figure 5-32. Scenario 1C Comparison – Annual 242-A Evaporator Usage.
5.1.4.3.3 Waste Treatment and Immobilization Plant Production

Figure 5-33 and Figure 5-34 compare the ILAW production for Scenario 1C and the Baseline Case. The figures show that the ILAW production modeled in Scenario 1C is further from the theoretical curve than the Baseline Case because this scenario is more treatment-limited, as the LAW is restricted by PT Facility throughput and is not augmented by LAWPS after DFLAW operations end. The 8 Mgal less feed is sent to the LAW supplemental treatment receipt tank in Scenario 1C, which results in less containers being produced by the LAW supplemental treatment facility and more containers being produced by the LAW Vitrification Facility.

Figure 5-33. Scenario 1C Comparison – Combined Immobilized Low-Activity Waste Production.

Figure 5-34 shows that ILAW production from the LAW supplemental treatment facility in Scenario 1C is further from the theoretical line because there is less feed to the facility over a greater period of time. For Scenario 1C, two percent more of the total ILAW containers are produced by the LAW Vitrification Facility over the Baseline Case. With less feed to the LAW supplemental treatment melters, the number of LAW supplemental treatment melters could potentially be reduced to three melters instead of four, with little impact to the RPP mission.
Scenario 1C modeling results indicate that eliminating the feed augmentation to the LAW supplemental treatment facility by shutting down the LAWPS after the DFLAW period is not advantageous. This scenario increased the retrieval and mission length, and negatively affected available DST space.
5.2 SCENARIO 2 – EARLY DIRECT-FEED HIGH-LEVEL WASTE

5.2.1 Objective/Planning Bases

Scenario 2 (DFHLW) evaluates the impacts on the RPP mission of including early DFHLW prior to startup of the PT Facility. The HLW Vitrification Facility hot start occurs on December 31, 2024, and WTP initial plant operations are achieved on December 31, 2027, both 9 years earlier than required by the Amended Consent Decree (2016). The basis for this accelerated start date is a reasonable engineering projection of startup of the HLW Vitrification Facility in DFHLW mode in 7 years. This time allows for engineering studies, final design, and construction of a feed receipt vessel (or vessels) near the HLW Vitrification Facility (i.e., the TWCS capability), and completion of facility construction.

Table 5-13 identifies the baseline assumptions from Appendix A that were modified for Scenario 2. Note that the PT Facility hot start occurs on December 31, 2033, consistent with the Baseline Case and as required by the Amended Consent Decree (2016), and that the supplemental TRU waste treatment process for potential CH-TRU tank waste is not included in the flowsheet. An additional modeling analysis, including supplemental TRU waste treatment and all other assumption changes (those supporting early DFHLW), was performed to determine the incremental effect of adding early DFHLW only on the mission.

Table 5-13. Scenario 2 – Assumptions Altered from the Baseline Case. (2 pages)

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 2 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.6.2</td>
<td>To support early DFHLW operation, the TWCS capability will be available to receive HLW feed starting on June 30, 2023.</td>
</tr>
<tr>
<td>A1.3.1.6</td>
<td>DFHLW production of IHLW in the HLW Vitrification Facility will begin on December 31, 2024, after completion of hot commissioning.</td>
</tr>
<tr>
<td>A1.3.3.2</td>
<td>The theoretical maximum HLW Vitrification Facility capacity will be ramped as follows, consistent with the acceleration of the facility start date:</td>
</tr>
<tr>
<td></td>
<td>Starting on Rate (MTG/day)</td>
</tr>
<tr>
<td></td>
<td>12/31/2024 3.0</td>
</tr>
<tr>
<td></td>
<td>12/31/2025 4.0</td>
</tr>
<tr>
<td></td>
<td>9/30/2027 4.2</td>
</tr>
<tr>
<td></td>
<td>12/31/2029 5.25</td>
</tr>
<tr>
<td>A1.2.3.17</td>
<td>To support early DFHLW operation, HLW feed batches will be delivered directly from the TWCS capability to the HLW Vitrification Facility until November 30, 2033 (1 month prior to startup of the PT Facility).</td>
</tr>
<tr>
<td>A1.3.1.8</td>
<td>To support early DFHLW operation, effluent – including HLW offgas (SBS and WESP) condensate, IHLW canister decontamination chemicals, and flush water – is returned from the HLW Vitrification Facility to the TWCS capability, where corrosion control chemicals are added, and transferred to the 200 East Area tank farms as required.</td>
</tr>
<tr>
<td>A1.2.6.1</td>
<td>To support early DFHLW operation, the TWCS capability will have the added functions of concentrating solids by decanting the supernatant liquid to tank farms and diluting solids to a concentration of 20 wt% for transfer to the HLW Vitrification Facility</td>
</tr>
</tbody>
</table>
Table 5-13. Scenario 2 – Assumptions Altered from the Baseline Case. (2 pages)

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 2 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.3.4</td>
<td>To support early DFHLW operation, the sequence of SSTs retrieved from the S/SX Tank Farms will be chosen to maintain a constant feed for DFHLW treatment and for DFLAW treatment.</td>
</tr>
<tr>
<td>A1.4.2</td>
<td>Potential CH-TRU tank waste is retrieved through the WRFs to the DST system and eventually treated in the WTP; the proposed supplemental TRU waste treatment facility is not modeled.</td>
</tr>
</tbody>
</table>

CH-TRU  =  contact-handled transuranic.
DFHLW  =  direct-feed high-level waste.
DFLAW  =  direct-feed low-activity waste.
DST  =  double-shell tank.
HLW  =  high-level waste.
IHLW  =  immobilized high-level waste.
MTG  =  metric ton of glass.
PT  =  pretreatment.
SBS  =  submerged bed scrubber.
SST  =  single-shell tank.
TRU  =  transuranic.
TWCS  =  tank waste characterization and staging.
WESP  =  wet electrostatic precipitator.
WRF  =  waste receiving facility.
WTP  =  Waste Treatment and Immobilization Plant.

5.2.2 Flowsheet Description

The simplified flowsheet for Scenario 2 is provided in Figure 5-35. The flowsheet differs from the Baseline Case in several ways. In support of direct-feed operation of the HLW Vitrification Facility, the functionality of the TWCS capability was changed from the Baseline Case for the DFHLW portion of the mission.

In the Baseline Case, the TWCS capability performs the functions of receiving, staging (including supporting sampling), and delivering slurry from the 200 East Area DSTs to the WTP. However, in this DFHLW flowsheet, the TWCS capability must also support fractionation of the as-received slurry into a (1) solids-heavy fraction, which is fed forward to the HLW Vitrification Facility, and (2) supernatant liquid fraction, which is returned to the 200 East Area DSTs. This feature is modeled as a settle-decant process, although added technology (e.g., filtration) may be desirable or required to support this function. After the fractionation is completed, the solids-heavy fraction is diluted in the TWCS capability to support its transfer to the HLW Vitrification Facility. Because the TWCS capability is much closer to the WTP HLW Vitrification Facility than the 200 East Area DSTs, the water flush following the transfers is substantially smaller; from the TWCS capability, the effluent is batched in much larger volume transfers to the 200 East Area DSTs.

Effluent from the HLW Vitrification Facility is returned to the 200 East Area DSTs via the TWCS capability while the HLW Vitrification Facility is operating in direct-feed mode prior to startup of the PT Facility. The TWCS tanks (beyond those required to support DFHLW feed operations) are used for the immediate receipt and corrosion mitigation of this effluent prior to return to the 200 East Area DSTs. Receiving the effluent in the TWCS tanks prior to returning the effluent to the 200 East Area DSTs has the added benefits of (1) reducing the amount of required flush water associated with these returns, 46 (2) maintaining the dilute DFHLW effluent

46 Because the TWCS capability is much closer to the WTP HLW Vitrification Facility than the 200 East Area DSTs, the water flush following the transfers is substantially smaller; from the TWCS capability, the effluent is batched in much larger volume transfers to the 200 East Area DSTs.
Scenario 2

- Early Direct-Feed High-Level Waste

separate from more concentrated waste (supporting the recycle of DFHLW effluent as diluent for DFHLW feed), and (3) reducing the coupling between DFHLW operation and the 200 East Area DSTs. However, this approach reduces the amount of DFHLW feed that that can be staged simultaneously in the TWCS capability.

Independent of the flowsheet changes made in support of DFHLW, the supplemental TRU waste treatment process for potential CH-TRU tank waste was removed from the flowsheet. The 11 SSTs containing potential CH-TRU waste were instead retrieved through the WRFs to the DSTs and eventually treated in the WTP.
Figure 5-35. Scenario 2 – Simplified Flowsheet.
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5.2.3 Analysis

5.2.3.1 Schedule Performance

The key mission activity dates for Scenario 2, compared with the Baseline Case, are included in Table 5-14. Compared to the Baseline Case and with the exception of facility start dates that were modified as input assumptions (see Section 5.2.1), the resulting differences in the operating schedule for Scenario 2 include:

- The mission end date (treat all tank waste) occurs in August 2058, just over 5 years earlier than in the Baseline Case. Consistent with past modeling, if the supplemental TRU waste treatment process is included in the flowsheet (i.e., if the only change from the Baseline Case flowsheet is the inclusion of early DFHLW), treatment completes in January 2058—approximately 6 years earlier than the Baseline Case.

- The SST retrievals complete in August 2053, over 3 years earlier than in the Baseline Case. If the supplemental TRU waste treatment process is included in the flowsheet (i.e., if the only change from the Baseline Case flowsheet is inclusion of early DFHLW), the SST retrievals complete in July 2050—over 6 years earlier than the Baseline Case.

- Driven by the accelerated SST retrieval schedule, the need date for the 200 West Area WRF is June 2036—approximately 4 years earlier than the Baseline Case.

Table 5-14. Scenario 2 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metrics</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 2 – Early DFHLW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete C Tank Farm Retrievals (existing TPA 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td>Complete Five Additional SST Retrievals (existing Consent Decree 12/31/2020)</td>
<td>4/2019</td>
<td>4/2019</td>
</tr>
<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
<td>5/2022</td>
<td>5/2022</td>
</tr>
<tr>
<td>Complete Tank A-103 Retrieval (existing TPA 9/30/2022)</td>
<td>11/2022</td>
<td>11/2022</td>
</tr>
<tr>
<td>WMA C Closed (existing TPA 6/30/2019)</td>
<td>6/2028</td>
<td>6/2028</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Supernate)</td>
<td>9/2025</td>
<td>10/2026</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Slurry)</td>
<td>7/2025</td>
<td>5/2026</td>
</tr>
<tr>
<td>200 West Area SST Retrievals Complete</td>
<td>4/2055</td>
<td>8/2052</td>
</tr>
<tr>
<td>200 East Area SST Retrievals Complete</td>
<td>12/2056</td>
<td>8/2053</td>
</tr>
<tr>
<td>200 West Area WRF Operational</td>
<td>4/2040</td>
<td>6/2036</td>
</tr>
<tr>
<td>200 East Area WRF Operational</td>
<td>1/2035</td>
<td>1/2034</td>
</tr>
<tr>
<td>Start of Four Simultaneous Retrievals</td>
<td>1/2035</td>
<td>1/2034</td>
</tr>
<tr>
<td>AN-103 Group A Mitigation Complete</td>
<td>9/2032</td>
<td>5/2029</td>
</tr>
<tr>
<td>AN-104 Group A Mitigation Complete</td>
<td>6/2025</td>
<td>5/2026</td>
</tr>
<tr>
<td>Tank AN-105 Group A Mitigation Complete</td>
<td>1/2033</td>
<td>1/2034</td>
</tr>
<tr>
<td>Tank AW-101 Group A Mitigation Complete</td>
<td>10/2032</td>
<td>8/2033</td>
</tr>
<tr>
<td>Tank SY-103 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>1/2025</td>
</tr>
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5-63
Table 5-14. Scenario 2 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Pretreatment/Treatment</th>
<th>Key Mission Metrics</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 2 – Early DFHLW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DST Retrieval Completes</td>
<td>11/2062</td>
<td>11/2057</td>
</tr>
<tr>
<td></td>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td></td>
<td>DFHLW Operations</td>
<td>N/A</td>
<td>12/2024 – 11/2033</td>
</tr>
<tr>
<td></td>
<td>TWCS Capability Start</td>
<td>6/2032</td>
<td>6/2023</td>
</tr>
<tr>
<td></td>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td></td>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
</tr>
<tr>
<td></td>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2023</td>
</tr>
<tr>
<td></td>
<td>HLW Vitrification Facility Operations</td>
<td>12/2033 – 8/2063</td>
<td>12/2033 – 7/2058</td>
</tr>
<tr>
<td></td>
<td>WTP Initial Plant Operations</td>
<td>12/2036</td>
<td>12/2027</td>
</tr>
<tr>
<td></td>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>8/2058</td>
</tr>
<tr>
<td></td>
<td>IHS Module 1 Need Date</td>
<td>5/2034</td>
<td>12/2024</td>
</tr>
<tr>
<td></td>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>4/2029</td>
</tr>
<tr>
<td></td>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>8/2031</td>
</tr>
<tr>
<td></td>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047 – 8/2065</td>
<td>8/2031 – 9/2060</td>
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<td></td>
<td>All HLW Shipped Offsite</td>
<td>8/2065</td>
<td>9/2060</td>
</tr>
<tr>
<td></td>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>N/A</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
CWC = Central Waste Complex.  
DFHLW = direct-feed high-level waste.  
DFLAW = direct-feed low-activity waste.  
DST = double-shell tank.  
ETF = Effluent Treatment Facility.  
HLW = high-level waste.  
HSF = Hanford Shipping Facility.  
IDF = Integrated Disposal Facility.  
IHS = interim Hanford storage.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
LERF = Liquid Effluent Retention Facility.  
N/A = not applicable.  
PT = Pretreatment.  
SST = single-shell tank.  
TPA = Tri-Party Agreement.  
TWCS = tank waste characterization and staging.  
WMA = waste management area.  
WRF = waste receiving facility.  
WTP = Waste Treatment and Immobilization Plant.

Figure 5-36 shows the operating schedule for major facilities and processes in Scenario 2.
Figure 5-36. Scenario 2 – Operating Schedule for Major Facilities/Processes.
5.2.3.2 Cost

The annual and cumulative lifecycle cost profiles are presented and compared with the Baseline Case in Figure 5-37. The cost profile is similar to the Baseline Case, with a few notable differences. The cumulative lifecycle cost is $104 billion ($196 billion escalated) versus $111 billion ($231 billion escalated) for the Baseline Case, with $6 billion ($34 billion escalated) cost savings realized from completing the mission over 5 years earlier. However, Scenario 2 requires increased funding prior to startup of the integrated WTP to support DFHLW operation—the incremental cost of DFHLW through the end of FY 2033 is estimated at $4.7 billion, and the capital costs for the TWCS capability and HLW Vitrification Facility are accelerated by 9 years within this timeframe. Note that capital cost for the WTP facilities, including the HLW Vitrification Facility, is not included in the lifecycle cost analysis, but operating costs are. The cost of offsite IHLW canister disposal is also not included.

Eliminating the supplemental TRU waste treatment process from the flowsheet results in a combined capital and operations cost savings of $190 million over the 11 years from FY 2026 through 2037; however, the cost of operating the integrated WTP and the LAW supplemental treatment process for the additional 7 months required to treat the potential CH-TRU waste escalated to 2058 is estimated at $800 million.

For the purposes of this cost analysis, the operating cost for the HLW Vitrification Facility is assumed to be 36 percent of the operating cost of the integrated WTP. Consistent with the other System Plan (Rev. 8) cases, the operating cost for the LAW Vitrification Facility and the EMF is 40 percent of the operations cost for the integrated WTP. Therefore, the operating cost for DFLAW and DFHLW is a combined 76 percent of the integrated WTP operating cost.
5.2.3.3 Mission Flowsheet Results

Including early DFHLW in the flowsheet drives earlier completion dates for the SST retrievals and tank waste treatment, while improving level-loading (i.e., a more constant rate over the course of the mission) of tank farms operations, including SST retrievals, evaporator campaigns, and DST transfers over the course of the mission. This approach comes at the expense of increased tank farms operations during the timeframe of DFHLW operations. The following subsections present the detailed mission flowsheet results for each system in Scenario 2 compared to the Baseline Case.

5.2.3.3.1 Single-Shell Tank Retrievals

The historical and projected SST retrieval progress, as measured by the volume of original waste remaining in the SSTs as a function of time, is presented in Figure 5-38. Since the near-term retrieval assumptions for this scenario were not changed from the Baseline Case, the completion of tank waste retrievals in the C Tank Farm and A/AX Tank Farms is the same as the Baseline Case, finishing in August 2017 and November 2022, respectively. The retrieval of S/SX Farm tanks begin approximately 1 year later in Scenario 2 due to the space required in the 200 East Area DSTs for receiving DFHLW effluent and preparing DFHLW feed, with the retrieval progress catching up as DFHLW generates additional space for retrieved solids in the 200 East Area DSTs.
Beginning in 2031, the Baseline Case retrieval progress again outpaces Scenario 2 due to the inclusion of the supplemental TRU waste treatment process in the Baseline Case flowsheet. However, when DFHLW operations end and the PT Facility starts up, the Scenario 2 retrieval progress pulls ahead of the Baseline Case permanently as the remaining DFHLW effluent is concentrated, and the space generated through DFHLW is fully realized. Even with removal of the supplemental TRU waste treatment process from the flowsheet, the SST retrievals complete over 3 years earlier than the Baseline Case.

Figure 5-39 shows the sequence and timing of the SST retrievals over the course of the RPP mission versus the Baseline Case. The dark-colored bands indicate the active SST retrievals and the light-colored bands indicate the delays in the SST retrievals (i.e., the difference in the modeled retrieval duration and the assumed minimum retrieval duration). Figure 5-39 shows many of the same trends as Figure 5-38. For example, early DFHLW appears to increase the level-loading of the SST retrievals over the mission, as indicated by the relatively constant slope of retrieval bars after the integrated WTP starts in 2033. This results from the frequent delays in the late 2030s (which occur in the Baseline Case because retrievals are restricted by the high solids levels in the SY Tank Farm DSTs) being eliminated. As a result, the tank waste retrievals in S/SX Tank Farms complete 4 years earlier, after starting about 1 year later in Scenario 2. The retrieval delay time after the retrievals of A/AX Tank Farms is reduced by 29 percent versus the Baseline Case (Note that if the supplemental TRU waste treatment process is included in the flowsheet, the delay time is reduced by 42 percent).
SST retrievals differ from the Baseline Case in timing and also in sequence. In the Baseline Case, the sequence of the SST retrievals from the tanks in the S/SX Tank Farms is optimized to reduce the amount of sludge retrieved to the DSTs during DFLAW operations prior to the startup of the integrated WTP. In Scenario 2, the model was permitted to choose the sequence of the SST retrievals from the S/SX Tank Farms to maintain continuity of feed to the DFLAW and DFHLW processes. As a result, higher-sludge SSTs were retrieved during this period. In addition, to support a continuing supply of sludge for HLW feed after startup of the integrated WTP, the 200 East Area WRF (and four simultaneous retrievals) starts 1 year earlier in Scenario 2.
Figure 5-39. Scenario 2 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
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5.2.3.3.2 Double-Shell Tank Space Management

The utilization of DST space over the course of the mission in Scenario 2 is depicted in Figure 5-40, and the amount of available space in the DSTs in Scenario 2 versus the Baseline Case is presented in Figure 5-41. Even with the flowsheet changes and DST closure completing 5 years earlier than in the Baseline Case, DST space utilization is similar to the Baseline Case. The main differences are:

- A larger amount of available DST space is maintained during DFHLW operations in Scenario 2, which represents the space buffer required for preparing DFHLW feed in the DSTs.
- The limited available DST space in the mid-2040s in the Baseline Case is mitigated in Scenario 2 by lower required water additions for solids mitigation (26 Mgal over the mission versus 37 Mgal).
- The DST waste volume is drawn down and the DSTs closed earlier than in the Baseline Case.

Figure 5-40. Scenario 2 – Double-Shell Tank Space Utilization.
Comparisons to the Baseline Case of the annual and mission cumulative DST transfers and DST slurry transfers (including WRF-to-DST transfers) are presented in Figure 5-42 and Figure 5-43, respectively. The DST operations-intensive nature of direct-feed treatment results in a significant increase in DST transfers during DFHLW operations. This leads to a cumulative increase of approximately 350 DST transfers and 100 DST slurry transfers over the mission and represents an acceleration of the need to complete a significant number of annual DST slurry transfers. Note that although the number of required DST transfers increases, the increase occurs in a way that equalizes the annual DST transfers better over the mission duration.
Figure 5-42. Scenario 2 Comparison – Double-Shell Tank Transfers.

Figure 5-43. Scenario 2 Comparison – Double-Shell Tank Slurry Transfers.
5.2.3.3.3 **242-A Evaporator**

The demand for the 242-A Evaporator over the course of the mission, in terms of annual campaigns, cumulative feed volume, and cumulative waste volume reduction (WVR) versus the Baseline Case, is shown in Figure 5-44.

Although 11 Mgal less water is added for solids mitigation and 3.7 Mgal of LAWPS cesium eluate is directed into DFHLW feed in Scenario 2, the 242-A Evaporator is required to process an additional 24 Mgal of feed. This is driven by several factors:

- 16 Mgal of dilute DFHLW effluent must be blended in the DSTs and concentrated by the 242-A Evaporator during DFHLW operations.
- 5 Mgal of additional dilute supernatant liquid is retrieved to the DSTs from the SSTs that was retrieved to the supplemental TRU waste treatment process in the Baseline Case.
- Fewer HLW feed batches to the PT Facility. The HLW feed batches to the PT Facility typically serve as an outlet for dilute supernatant liquid (average of 3.2 M Na). In Scenario 2, DFHLW feed batches, which do not include a similar amount of supernate, replace a portion of the HLW feed batches to the PT Facility.

In addition, with the 242-A Evaporator operations end date closely coupled to the SST retrievals end date, 242-A Evaporator operations complete in 2054, 3 years earlier than the Baseline Case.

![Figure 5-44. Scenario 2 Comparison – 242-A Evaporator Operation.](image-url)
With the increased feed volume and shortened operating duration, the average number of annual 242-A Evaporator campaigns increases to 6.7 per year, approximately two more than the Baseline Case. During DFHLW operations, the DFHLW effluent return stream pushes the average number of annual 242-A Evaporator campaigns to 7.8, approximately three more than over the same period in the Baseline Case. However, the increased level-loading of the SST retrievals over the mission, combined with the inclusion of early DFHLW and reduced solids mitigation water, partially flattens the peaks and valleys in the demand for the 242-A Evaporator and makes the mission more level-loaded with respect to annual 242-A Evaporator campaigns. Peak demand for the 242-A Evaporator in Scenario 2 occurs in 2050 and equates to 125 days of hot operations. In comparison, the peak demand in the Baseline Case occurs in 2045 and equates to 152 days of hot operations.

Because much of the additional water processed by the 242-A Evaporator would have been evaporated elsewhere in the Baseline Case flowsheet, the impact to LERF is minimal (a total increase of less than 2 Mgal over the course of the mission).

5.2.3.3.4 Waste Feed Delivery
The strategy for preparing and staging feed to the LAWPS is altered slightly for Scenario 2. During DFHLW operations, dilute DFHLW effluent is used for dilution of LAW feed batches to the LAWPS, when possible, to reduce the demand on the 242-A Evaporator. Because the dilute DFHLW effluent contains a small amount of sodium, LAWPS batches diluted with DFHLW effluent are often not diluted to the 5.6 M Na target and averaged 6.3 M Na over all of the DFLAW. After DFLAW operations end, LAW feed to the LAWPS continues to be staged simultaneously in two DSTs to support the anticipated higher demand for LAW pretreatment. Feed from the LAWPS to the LAW Vitrification Facility is screened against the ICD-30 waste acceptance criteria. All waste acceptance criteria that can be screened for direct-LAW feed are met, with the exception of the TRU-to-Na ratio, which is exceeded by 12 percent for one campaign in 2027, and the uranium-235 (U-235) concentration, which is exceeded by up to 35 percent for two campaigns in 2029 and 2030. (Section 5.1.3.3.5 describes waste acceptance criteria that can be screened using model data.) The direct-LAW feed in violation of the TRU and fissile uranium waste acceptance criteria was sourced from supernate decanted off the top of HLW solids (from which the radionuclides of concern were washed) from the TWCS capability.

The ICD-19 waste acceptance criteria that can be screened are met for LAW feed to the PT Facility and are met for HLW feed to the PT Facility, with the exception of maximum solids concentration. The ICD-19 maximum solids concentration is exceeded by DFHLW feed batches prepared during DFHLW operations, which are then fed to the PT Facility. This potential issue can be mitigated by transitioning from preparing DFHLW feed to preparing HLW feed prior to the end of DFHLW operations.

DFHLW feed batches are prepared in the TWCS tanks by the following process:

1. Transfer slurry at a nominal 10 wt% solids from the 200 East Area DSTs equipped with two mixer pumps to fill the TWCS tank
2. Allow the solids to settle from the slurry, and decant the supernatant liquid to the 200 East Area DSTs.

3. Repeat steps (1) and (2).

4. Dilute the settled solids in the TWCS tank to a nominal 20 wt% solids. Diluent is selected based on the following order of preference: (a) LAWPS cesium eluate, (b) dilute DFHLW effluent, (c) raw water.

Figure 5-45 shows the bulk volume composition of DFHLW feed delivered from the TWCS capability to the HLW Vitrification Facility, including the 550-gal portion of the post-transfer flush directed into the melter feed preparation vessels. No waste acceptance criteria exist for DFHLW feed; however, the DFHLW feed that is delivered in Scenario 2 meets the ICD-19 waste acceptance criteria that can be screened (for HLW feed to the PT Facility), with the exception of maximum solids concentration, which was exceeded by design.

The specific sequence of feeds, including the primary sludge source, diluent liquid, and predicted glass information (based on the ORP 2013 HLW GFM) is provided in Table 5-15. Sludges fed through the DFHLW process were specifically selected to expedite immobilization of...
radiological hazard (curies) and then to target retrieved sludges (rather than precipitated salts), which yield high WOL without the need for washing or leaching. However, the predicted WOL trends downward over the course of DFHLW operation as the most desirable sludge is consumed. For diluent, the majority of DFHLW feed batches are diluted with LAWPS cesium eluate; raw water is only used for preparing the first three feed batches prior to sufficient eluate volume being available in the receiver DST, and dilute DFHLW effluent is used only occasionally.

Table 5-15. Scenario 2 – Early Direct-Feed High-Level Waste Feed Sequence. (2 pages)

<table>
<thead>
<tr>
<th>Batch #</th>
<th>Delivery date</th>
<th>Volume (gal)</th>
<th>Solids (wt%)</th>
<th>Primary sludge source(s)</th>
<th>Diluent</th>
<th>Predicted glass driver(s)</th>
<th>Predicted WOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12/2024</td>
<td>439,000</td>
<td>20%</td>
<td>AY-102</td>
<td>Raw water</td>
<td>Nepheline, viscosity maximum</td>
<td>55%</td>
</tr>
<tr>
<td>2</td>
<td>10/2025</td>
<td>399,000</td>
<td>20%</td>
<td>A Farm, AY-101</td>
<td>Raw water</td>
<td>Nepheline, viscosity maximum</td>
<td>56%</td>
</tr>
<tr>
<td>3</td>
<td>5/2026</td>
<td>323,000</td>
<td>21%</td>
<td>A Farm, AZ-101</td>
<td>Raw water</td>
<td>Sulfur, viscosity minimum</td>
<td>51%</td>
</tr>
<tr>
<td>4</td>
<td>12/2026</td>
<td>411,000</td>
<td>20%</td>
<td>AX Farm, AZ-102</td>
<td>LAWPS cesium eluate</td>
<td>Sulfur, nepheline</td>
<td>55%</td>
</tr>
<tr>
<td>5</td>
<td>7/2027</td>
<td>415,000</td>
<td>17%</td>
<td>C Farm via AN-106</td>
<td>LAWPS cesium eluate</td>
<td>Nepheline, viscosity maximum</td>
<td>58%</td>
</tr>
<tr>
<td>6</td>
<td>12/2027</td>
<td>407,000</td>
<td>18%</td>
<td>C Farm via AN-106</td>
<td>DFHLW effluent</td>
<td>Nepheline, viscosity maximum</td>
<td>58%</td>
</tr>
<tr>
<td>7</td>
<td>6/2028</td>
<td>419,000</td>
<td>17%</td>
<td>C Farm via AN-106</td>
<td>LAWPS cesium eluate</td>
<td>Nepheline, viscosity maximum</td>
<td>58%</td>
</tr>
<tr>
<td>8</td>
<td>11/2028</td>
<td>412,000</td>
<td>17%</td>
<td>C Farm via AN-106</td>
<td>LAWPS cesium eluate</td>
<td>Nepheline, viscosity maximum</td>
<td>58%</td>
</tr>
<tr>
<td>9</td>
<td>4/2029</td>
<td>420,000</td>
<td>17%</td>
<td>C Farm via AN-106</td>
<td>LAWPS cesium eluate</td>
<td>Nepheline, viscosity maximum</td>
<td>58%</td>
</tr>
<tr>
<td>10</td>
<td>9/2029</td>
<td>403,000</td>
<td>18%</td>
<td>C Farm via AN-101</td>
<td>DFHLW effluent</td>
<td>Sulfur, nepheline, viscosity minimum</td>
<td>52%</td>
</tr>
<tr>
<td>11</td>
<td>3/2030</td>
<td>415,000</td>
<td>18%</td>
<td>C Farm via AN-101</td>
<td>LAWPS cesium eluate</td>
<td>Sulfur, nepheline, viscosity minimum</td>
<td>49%</td>
</tr>
<tr>
<td>12</td>
<td>8/2030</td>
<td>405,000</td>
<td>18%</td>
<td>C Farm via AN-101</td>
<td>DFHLW effluent</td>
<td>Sulfur, nepheline, viscosity minimum</td>
<td>44%</td>
</tr>
<tr>
<td>13</td>
<td>2/2031</td>
<td>413,000</td>
<td>17%</td>
<td>C Farm via AN-101</td>
<td>LAWPS cesium eluate</td>
<td>Sulfur, nepheline, viscosity minimum</td>
<td>45%</td>
</tr>
<tr>
<td>14</td>
<td>8/2031</td>
<td>425,000</td>
<td>19%</td>
<td>S Complex</td>
<td>LAWPS cesium eluate</td>
<td>Nepheline, viscosity maximum</td>
<td>46%</td>
</tr>
<tr>
<td>15</td>
<td>2/2032</td>
<td>418,000</td>
<td>17%</td>
<td>C Farm via AN-101</td>
<td>LAWPS cesium eluate</td>
<td>Sulfur, nepheline, viscosity minimum</td>
<td>50%</td>
</tr>
<tr>
<td>16</td>
<td>7/2032</td>
<td>420,000</td>
<td>17%</td>
<td>S Complex</td>
<td>LAWPS cesium eluate</td>
<td>Nepheline, viscosity maximum</td>
<td>47%</td>
</tr>
<tr>
<td>17</td>
<td>12/2032</td>
<td>429,000</td>
<td>19%</td>
<td>S Complex</td>
<td>DFHLW effluent</td>
<td>Nepheline, viscosity maximum</td>
<td>43%</td>
</tr>
</tbody>
</table>
Table 5-15. Scenario 2 – Early Direct-Feed High-Level Waste Feed Sequence. (2 pages)

<table>
<thead>
<tr>
<th>Batch #</th>
<th>Delivery date</th>
<th>Volume (gal)</th>
<th>Solids (wt%)</th>
<th>Primary sludge source(s)</th>
<th>Diluent</th>
<th>Predicted glass driver(s)</th>
<th>Predicted WOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>8/2033</td>
<td>235,000</td>
<td>20%</td>
<td>S Complex</td>
<td>LAWPS cesium eluate</td>
<td>Nephteline, PCT, viscosity maximum</td>
<td>37%</td>
</tr>
</tbody>
</table>

DFHLW = direct-feed high-level waste.  PCT = product consistency test.
LAWPS = Low-Activity Waste Pretreatment System.

5.2.3.3.5 Waste Treatment and Immobilization

This section discusses waste treatment and immobilization in Scenario 2 versus the Baseline Case. Table 5-16 summarizes the amounts of immobilized product for the LAW and HLW Vitrification Facilities and for LAW supplemental treatment (for which product volume is estimated for both a vitrified and potential grouted immobilized waste form).

Table 5-16. Scenario 2 Comparison – Waste Treatment Product Summary.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 2 – Early DFHLW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>8/2058</td>
</tr>
<tr>
<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
<td>7,800</td>
<td>11,400</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>23,600</td>
<td>34,300</td>
</tr>
<tr>
<td></td>
<td>Waste loading</td>
<td>44%</td>
<td>46%</td>
</tr>
<tr>
<td>Total ILAW (glass)</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>92,600</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>518,000</td>
<td>510,000</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na$_2$O)</td>
<td>22%</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>MT sodium reporting to ILAW</td>
<td>84,100</td>
<td>79,100</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>45,300</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>249,400</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na$_2$O)</td>
<td>23%</td>
<td>22%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass)</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>47,300</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>233,600</td>
<td>260,600</td>
</tr>
<tr>
<td></td>
<td>Waste Loading (Na$_2$O)</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Volume (yd$^3$)</td>
<td>118,400</td>
<td>132,100</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (grout)</td>
<td>Product (yd$^3$)</td>
<td>419,200</td>
<td>469,500</td>
</tr>
<tr>
<td></td>
<td>Waste Na$_2$O equivalent (%)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Potential CH-TRU Waste</td>
<td>Number of packages</td>
<td>8,396</td>
<td>N/A</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  LAW = low-activity waste.  MT = metric ton.  DFHLW = direct-feed high-level waste.  WTP = Waste Treatment and Immobilization Plant.  IHLW = immobilized high-level waste.  ILAW = immobilized low-activity waste.
Early DFHLW results in an increase of 3,600 IHLW canisters (+46 percent) versus the Baseline Case because a portion of solids that would have been dissolved by washing and leaching in the PT Facility and immobilized as ILAW in the Baseline Case are instead immobilized as IHLW. In addition, some of the LAW treatment load is shifted from the LAW Vitrification Facility to LAW supplemental treatment due to the need to treat approximately the same amount of LAW feed in a LAW treatment duration, which is shortened by 5 years.

The tank farms radioactive inventory over the course of the mission for Scenario 2 compared to the Baseline Case is depicted in Figure 5-46. Note that the figure accounts for radioactive decay of the starting inventory over time—the remaining radioactivity is decayed to the date reported. The general trend is that the tank farms radioactive inventory decreases as waste is delivered to the WTP and radioactive decay proceeds. The main difference versus the Baseline Case is that HLW treatment begins earlier, immobilizing 52 percent of the IHLW curies prior to the startup of HLW treatment in the Baseline Case. As in the Baseline Case, nearly all immobilized radioactivity is segregated to the IHLW product, which contains 98 percent of the immobilized curies.

5.2.3.3.5.1 Direct-Feed Treatment

The combined DFLAW and DFHLW tank waste flowsheet is in effect for the 10 years immediately preceding startup of the PT Facility. As in the Baseline Case, DFLAW operations are occurring over this entire period. However, in Scenario 2, the DFHLW flowsheet is in effect
for the 9 years immediately preceding startup of the PT Facility, overlapping with DFLAW operations. The following observations are made regarding this 9-year period of DFHLW operations:

- Represents 27 percent of the HLW treatment duration or 24 percent of the theoretical HLW treatment capacity when accounting for the ramp-up.
- 4,700 IHLW canisters are produced (41 percent of the mission-total IHLW production).
- 51 percent average IHLW WOL (46 percent overall average). The primary IHLW driver during DFHLW is sulfur solubility followed by the probability of nepheline formation.
- 83 MCi of radioactivity is immobilized (52 percent of the mission-total immobilized, assuming a decay date of January 1, 2008).
- 7,640 MT of solids are delivered to the TWCS capability and fed to the HLW Vitrification Facility (22 percent of the mission-total solids delivered to the TWCS capability).
- 5.9 Mgal of tank waste is removed from the DSTs: 2.2 Mgal of sludge (including interstitial supernatant and the supernatant heel in the TWCS tanks) and 3.7 Mgal of LAWPS cesium eluate from the DST receiver.

DFHLW operations also generate 22 Mgal of dilute effluent, which includes (see Figure 5-47):

- 9.7 Mgal of offgas condensate from the SBS and WESP systems in the HLW Vitrification Facility (this volume includes 5 M caustic soda added for neutralization of this stream).
- 5.6 Mgal from water and chemicals used for IHLW canister decontamination and drained into the plant wash system.
- 4.2 Mgal from flush water following transfers between the TWCS capability and HLW Vitrification Facility (a portion of the flush following transfers into the melter feed preparation vessels in the HLW Vitrification Facility is directed into the feed and is not included in the flush water volume).
- 2.5 Mgal of 7.5 M sodium nitrite added to protect the carbon steel tanks in the TWCS capability (and eventually the DSTs) from pitting corrosion resulting from the halides in the DFHLW effluent. The corrosion mitigation strategy is based on data from SRNL-STI-2015-00506, SRNL Report for Tank Waste Disposition Integrated Flowsheet: Corrosion Testing.
Of the 22 Mgal of dilute effluent generated through DFHLW (Figure 5-47), 21 Mgal are eventually returned to the 200 East Area DSTs (including 5 Mgal used for dilution of DFLAW feed to the LAWPS), with 1 Mgal recycled into the DFHLW feed. This equates to 3.6 gal of dilute effluent returned to the 200 East Area DSTs for each of the 5.9 Mgal fed forward to DFHLW. However, by blending and concentrating the dilute effluent using the 242-A Evaporator, the 21 Mgal is reduced to as little as 2.2 Mgal, a fractional WVR of nearly 90 percent. This means that the impact to the DST space of DFHLW coupled with 242-Evaporator operations is a net gain of only 200 kgal, if the LAWPS cesium eluate is assumed to be blended and concentrated in the 242-A Evaporator if not included with the DFHLW feed.

If the LAWPS cesium eluate is not assumed to be blended and concentrated if not included with the DFHLW feed, there is a net gain of 3.7 Mgal. Therefore, the main benefit of DFHLW to DST space management comes from removing solids from the DSTs (not removing waste volume), which allows for greater continuity of the SST retrievals and the removal of restrictive reductions in the DST operating volumes tied to high solids levels. DFHLW also removes the LAWPS cesium eluate from the DST system, preventing the reprocessing of the cesium eluate that occurs in the Baseline Case.

A flowchart of the major process streams (including volumes) for the Scenario 2 combined direct-feed flowsheet is provided in Figure 5-48, with stream totals spanning the period from
startup of the TWCS capability (June 30, 2023) to startup of the integrated WTP (December 31, 2033).

Considering coupled operation of the DFLAW, DFHLW, and the 242-A Evaporator, the Scenario 2 combined direct-feed flowsheet generates 13.2 Mgal of additional DST space compared to only operation of the 242-A Evaporator. A net 10,000 MT of waste sodium is treated between the DFLAW and DFHLW processes—10,900 MT treated through DFLAW and 1,800 MT treated through DFHLW versus 800 MT returned from the DFLAW process (EMF returns and LAWPS cesium eluate) and 1,800 MT returned from the DFHLW process (corrosion-mitigated HLW effluent).
Figure 5-48. Scenario 2 – Process Stream Flowchart.
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### 5.2.3.3.5.2 Pretreatment Throughput

The average throughput of the PT Facility is 1,120 MT as-delivered solids and 2,100 MT Na waste per year. Compared to the Baseline Case of 1,060 MT as-delivered solids and 2,120 MT Na waste per year, there is a small, but notable increase in solids throughput. This increase is partially due to starting the PT Facility with the HLW Vitrification Facility fully ramped and LAW supplemental treatment available, and partially due to an increased average effectiveness in reducing the volume of solids in the PT Facility ultrafiltration system via washing, caustic leaching, and oxidative leaching (because solids that did not benefit as much from these processes were preferentially fed during DFHLW operations).

Use of the LAWPS to pretreat LAW feed after startup of the integrated WTP increased due to the shortened LAW treatment duration, with 30 Mgal of supernate at 5.6 M Na fed over 18 years of operations—12 Mgal more than in the Baseline Case over 20 years of operations.

### 5.2.3.3.5.3 Glass Production

Figure 5-49 provides a comparison of the HLW Vitrification Facility IHLW canister production in Scenario 2 to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case IHLW canister production. The HLW Vitrification Facility starts up 9 years prior to the Baseline Case in the DFHLW operations mode. During DFHLW operations, IHLW canister production is at 96 percent of the theoretical maximum (4,870 IHLW canisters over 9 years of DFHLW operations).

![Graph](image-url)
When the integrated WTP starts up on December 31, 2033 and DFHLW operations end, IHLW production closely resembles the Baseline Case, averaging a rate of 2.23 MTG/day versus the theoretical maximum at 70 percent TOE of 5.25 MTG/day. As in the Baseline Case, the throughput of the PT Facility is more limiting to the HLW treatment rate than the capacity of the HLW Vitrification Facility (Section 5.1.3.3.6 provides additional information). 11,400 IHLW canisters are eventually produced, an increase of 3,600 (+46 percent) compared to the Baseline Case. The increase in IHLW product occurs because a portion of the solids, which would have been dissolved by washing and leaching in the PT Facility and immobilized as ILAW in the Baseline Case, are instead immobilized as IHLW during DFHLW operations.

Even without washing and leaching 22 percent of the as-delivered HLW feed solids (fed to the TWCS capability) during DFHLW operations, there was no significant reduction in mission-total ILAW container production. The reduction in caustic additions from not leaching was partially offset by the sodium added for corrosion control of the DFHLW effluent returned to tank farms, additional supernate retrieved from the potential CH-TRU waste SSTs, and slightly lower average sodium oxide loading of the ILAW product.

Figure 5-50 provides a comparison of the LAW Vitrification Facility ILAW container production to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case LAW Vitrification Facility ILAW container production.

Figure 5-50. Scenario 2 Comparison – Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production.
Production of ILAW containers from the LAW Vitrification Facility is similar to the Baseline Case, with two notable distinctions. First, approximately 6,400 fewer ILAW containers are produced by the LAW Vitrification Facility because some of the LAW treatment load is shifted to LAW supplemental treatment due to the need to treat approximately the same amount of LAW feed, in a LAW treatment duration that is shortened by 5 years. Second, ILAW container production is slightly (about seven percent) higher during DFLAW because feed batches, which were diluted with DFHLW effluent, were often above the 5.6 M Na target for DFLAW feed and averaged 6.3 M Na over all DFLAW. This partially mitigated the issue of the ILAW production rate being limited by the amount of water in the melter feed during DFLAW operations.

Figure 5-51 provides a comparison of the Scenario 2 LAW supplemental treatment ILAW container production to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case LAW supplemental treatment ILAW container production. LAW supplemental treatment starts 1 year earlier in Scenario 2 to support operation of the HLW Vitrification Facility at its full ramp rate with second-generation melters and to accommodate shortening the LAW treatment duration to match the earlier completion of HLW treatment. LAW supplemental treatment production is closer to its assumed capacity at 70 percent TOE of 42 MTG/day than the Baseline Case (average rate of 29.0 MTG/day versus 22.2 MTG/day for the Baseline Case), supported by the increased use of LAWPS to provide supplemental LAW pretreatment capacity after startup of the PT Facility (30 Mgal fed over 18 years versus 18 Mgal over 20 years in the Baseline Case). Larger LAW supplemental treatment capacities were modeled, but demonstrated no significant benefit to the major mission metrics.

Figure 5-51. Scenario 2 Comparison – Immobilized Low-Activity Waste Supplemental Treatment Production.
5.2.3.4  Opportunities

Because Scenario 2 represents a new and substantially different flowsheet, the results can be improved by refining the flowsheet and applying lessons learned from the modeling of Scenario 2 (and Scenarios 3 and 11). Although Scenario 2 as-modeled presents an opportunity to bring in the dates for the SST retrieval completion and tank waste treatment completion by 3 and 5 years, respectively (6 and 6 years, respectively, if the supplemental TRU waste treatment process is included in the flowsheet), this section offers opportunities that have the potential to increase the benefits of including early DFHLW in the flowsheet.

In Scenario 2, there is a demonstrated capability of the DFHLW process to feed the HLW Vitrification Facility at a rate supporting its operation at up to 5.25 MTG/day. After PT Facility startup, the HLW Vitrification Facility is operated at an average of 42 percent of this rate for the duration of the mission because of the rate-limiting solids throughput of the PT Facility (Sections 5.1.3.3.6 and 5.2.3.3.5.3 provide additional information). Therefore, an opportunity exists to “fill-in” the space between the theoretical and actual IHLW production curves after PT Facility startup by supplementing HLW feed from the PT Facility with direct-HLW feed from the TWCS capability, analogous to how LAW supplemental treatment is supplemented by feed from the LAWPS in the Baseline Case flowsheet. Because the HLW Vitrification Facility and TWCS capability will already be constructed (including the ability to operate in a direct-feed mode) and operating during this timeframe, this type of operation does not require a significant increase in capital or operational expenditure. However, a larger tankage capacity in the TWCS capability may be needed to support staging two types of HLW feed, and developing a design that includes multiple feed sources piped to the melter feed preparation vessels may be challenging. Continued use of the DFHLW process also provides a potential outlet for hard-to-handle solids that cannot be delivered to the PT Facility, but could be accepted by the HLW Vitrification Facility.

In the “hybrid” HLW feed flowsheet described in the preceding paragraph, 4.89 percent of the as-delivered solids is potentially treated per year after startup of the PT Facility, completing HLW treatment in 25 years (9 years of DFHLW operations, and 16 years of hybrid operations). This is based on the average treatment rates in Scenario 2 of 3.2 percent of mission-total as-delivered solids per year for the PT Facility feeding the HLW Vitrification Facility, and 0.6 percent of the mission-total as-delivered solids per year for each MTG/day of HLW vitrification capacity dedicated to treating DFHLW feed. The average excess capacity of 3.0 MTG/day in the HLW Vitrification Facility after the PT Facility startup is assumed to be used for vitrification of DFHLW feed.

The hybrid HLW flowsheet can potentially be improved by optimizing which solids are direct-fed and which are pretreated. However, a hybrid HLW flowsheet will increase the mission-total IHLW canister production compared to Scenario 2, potentially to around 15,000 canisters. The increase in IHLW product occurs because a portion of solids that would have been washed and leached in the PT Facility and immobilized as ILAW in Scenario 2 are instead fed directly to the HLW Vitrification Facility and immobilized as IHLW. Other factors, such as LAW treatment or the SST retrievals, may be more limiting to the mission duration than HLW treatment in this flowsheet. Additional modeling is recommended to evaluate this scenario further.
Another opportunity to optimize the flowsheet is to perform solids washing and/or caustic leaching of the DFHLW feed solids in the TWCS capability. Solids washing will lower the mission-total IHLW canister production by reducing the amount of supernate and soluble salts fed to the HLW Vitrification Facility during DFHLW operations. The TWCS capability is the preferred location for solids washing due to its enhanced mixing capability and the proximity of dilute DFHLW effluent, which could be used for the wash in place of water, eliminating a potential increase in demand for the 242-A Evaporator. Because the PT Facility is still included in the Scenario 2 flowsheet, reprecipitation of sparingly soluble salts from the wash solution is not a large concern because those salts could be reprocessed in the PT Facility and treated as LAW.

A potential opportunity presented by DFHLW that is not realized in modeling is that the TOE for the HLW Vitrification Facility will likely exceed the TOE for the integrated WTP, giving an advantage to flowsheets including DFHLW versus the baseline. Per Assumption A1.3.1.3, the TOE of the integrated WTP is modeled at 72 percent based on the most recent WTP OR assessment (24590-WTP-RPT-PE-12-002), while the LAW and HLW Vitrification Facilities are modeled at the contract minimum TOE of 70 percent. However, the TOE of the HLW Vitrification Facility is predicted to be 83.3 percent by the same assessment. Therefore, because Scenario 2 demonstrates the ability of the tank farms to feed the HLW Vitrification Facility at its assumed theoretical maximum rate, increasing this rate will potentially raise the throughput of the DFHLW process by nearly 20 percent. This opportunity does not exist for DFLAW because the TOE of the LAW Vitrification Facility is predicted to be 71.2 percent, barely distinguishable from the currently modeled 70 percent. Because the throughput of the ultrafiltration system in the PT Facility is far more limiting to the HLW treatment rate in the baseline flowsheet than the HLW Vitrification Facility capacity, even at 70 percent TOE, the Baseline Case will be unaffected by this change.

Finally, there is an opportunity to optimize modeling and potentially the operation of DFHLW by refining the GFMs to better predict glass formulations for projected DFHLW feed compositions. For example, the ORP 2016 HLW GFM demonstrated a significant improvement in IHLW WOL over the ORP 2013 HLW GFM (used in Scenario 2) when applied to DFHLW feeds in Scenario 3 (see Section 5.3).

5.2.3.5 Risks

There are several new risks associated with Scenario 2 that have the potential to reduce the benefits of including early DFHLW in the flowsheet or threaten the feasibility of the scenario.

- Scenario 2 depends on design (including resolution of outstanding technical issues), construction, and commissioning of the TWCS capability being completed in less than 6 years and the HLW Vitrification Facility being completed in approximately 7 years.

- The cost of DFHLW operation, estimated to be an incremental cost of $4.9 billion through the end of FY 2033, has the potential to threaten available funding for completion of the PT Facility. If the PT Facility (or a similar set of capabilities) is not included in the flowsheet, the mission could potentially be extended.
- Scenario 2 accelerates the need for a federal geological repository for secure permanent disposal of the IHLW product. Based on a 4,000 IHLW canister capacity for the IHS Facility, the repository will be needed by 2031 versus 2047 for the Baseline Case. If the availability of the repository cannot be accelerated, the IHS Facility will need to be expanded.

- Coupling between DFHLW and tank farms, especially the need for tank farms space to receive DFHLW effluents, makes sustained DFHLW operation vulnerable to extended outages of the 242-A Evaporator or additional DSTs failing, among other potential issues.

- Pipe routing changes required to support DFHLW operations may complicate design of the WTP Facility. Examples of required changes include adding pipe routings from the TWCS capability to the melter feed preparation vessels, from the effluent collection vessels in the HLW Vitrification Facility to the TWCS capability, and other potential routing changes to divert flush water from the melter feed preparation vessels.

- The chemical composition of DFHLW feed, particularly the increased concentrations of volatile sulfate and halides, may decrease the TOE in the HLW Vitrification Facility by shortening the service life of the HLW melters or components of the HLW melters (e.g., bubblers), and may require some redesign. Material upgrades in the HLW Vitrification Facility offgas system may also be required.

- The lack of established waste acceptance criteria for DFHLW feed and the lack of a well-defined flowsheet for the entire DFHLW process (including timing of the DST upgrades) means that the feasibility of the projected DFHLW feed sequence in Scenario 2, which the results depend on, is uncertain.
5.3 SCENARIO 3 – EARLY DIRECT-FEED HIGH-LEVEL WASTE WITH NO WASTE TREATMENT AND IMMOBILIZATION PLANT PRETREATMENT FACILITY

5.3.1 Objective/Planning Bases

Scenario 3 (DFHLW with no PT Facility) evaluates the impacts of eliminating the PT Facility and the supplemental treatment process from the Scenario 2 flowsheet, leaving DFLAW and DFHLW as the only waste treatment processes. As in Scenario 2, the HLW Vitrification Facility hot start occurs on December 31, 2024, and WTP initial plant operations are achieved on December 31, 2027, both 9 years earlier than required by the Amended Consent Decree (2016). The basis for this accelerated start date is a reasonable engineering projection of 7 years for startup of the HLW Vitrification Facility in DFHLW mode. This time allows for engineering studies, final design and construction of a feed receipt vessel (or vessels) near the HLW Vitrification Facility (i.e., the TWCS capability), and completion of facility construction. Table 5-17 identifies the baseline assumptions from Appendix A that were modified for Scenario 3.

Scenario 3 also includes one sensitivity scenario, Scenario 3A, which is the same as Scenario 3 in all assumptions, with the exception that the ORP 2016 enhanced LAW and HLW GFMs (PNNL-25835) were used for determining the composition of the immobilized waste products produced by the LAW and HLW Vitrification Facilities, respectively (Assumptions A1.3.4.9 and A1.3.3.6).

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 3 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.6.2</td>
<td>To support early DFHLW operation, the TWCS capability will be available to receive HLW feed starting on June 30, 2023</td>
</tr>
<tr>
<td>A1.3.1.6</td>
<td>DFHLW production of IHLW in the HLW Vitrification Facility will begin on December 31, 2024, after completion of hot commissioning.</td>
</tr>
<tr>
<td>A1.3.3.2</td>
<td>The theoretical maximum HLW Vitrification Facility capacity will be ramped as follows, consistent with the acceleration of the facility start date:</td>
</tr>
<tr>
<td>Starting on</td>
<td>Rate (MTG/day)</td>
</tr>
<tr>
<td>12/31/2024</td>
<td>3.0</td>
</tr>
<tr>
<td>12/31/2025</td>
<td>4.0</td>
</tr>
<tr>
<td>9/30/2027</td>
<td>4.2</td>
</tr>
<tr>
<td>12/31/2029</td>
<td>5.25</td>
</tr>
<tr>
<td>A1.2.3.17</td>
<td>To support DFHLW operation, HLW feed batches will be delivered directly from the TWCS capability to the HLW Vitrification Facility.</td>
</tr>
<tr>
<td>A1.3.1.8</td>
<td>To support DFHLW operation, effluent – including HLW offgas (SBS and WESP) condensate, IHLW canister decontamination chemicals, and flush water – is returned from the HLW Vitrification Facility to the TWCS capability.</td>
</tr>
</tbody>
</table>
### Table 5-17. Scenario 3 – Assumptions Altered from the Baseline Case. (2 pages)

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 3 Assumption</th>
</tr>
</thead>
</table>
| A1.2.6.1                   | To support DFHLW operations, the TWCS capability will have the following additional functionalities:  
|                            | • Concentration of solids by decanting the supernate to tank farms  
|                            | • Dilution of HLW feed solids (using water) to a concentration of 20 wt% for transfer to the HLW Vitrification Facility  
|                            | • Concentration and recycle of dilute effluent from the HLW Vitrification Facility (evaporation capability assumed equivalent to the FEP evaporator in the PT Facility) |
| A1.2.3.4                   | To support early DFHLW operation, the sequence of SSTs retrieved from the S and SX Tank Farms will be chosen to maintain a constant feed for DFHLW treatment and for DFLAW treatment. |
| A1.3.2                     | All LAW feed is pretreated in the LAWPS and all HLW feed is delivered directly to the HLW Vitrification Facility from the TWCS capability; the PT Facility is not modeled. |
| A1.4.1                     | All LAW is treated in the LAW Vitrification Facility; the proposed LAW supplemental treatment process is not modeled. |
| A1.4.2                     | All potential CH-TRU tank waste is retrieved through the WRFs to the DST system and eventually treated in the WTP; the proposed supplemental TRU waste treatment facility is not modeled. |

CH-TRU = contact-handled transuranic.  
DFHLW = direct-feed high-level waste.  
DFLaw = direct-feed low-activity waste.  
DST = double-shell tank.  
FEP = feed evaporator process.  
HLW = high-level waste.  
IHLW = immobilized high-level waste.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
MTG = metric ton of glass.  
PT = pretreatment.  
SBS = submerged bed scrubber.  
SST = single-shell tank.  
TRU = transuranic.  
TWCS = tank waste characterization and staging.  
WESP = wet electrostatic precipitator.  
WRF = Waste Receiving Facility.  
WTP = Waste Treatment and Immobilization Plant.

### 5.3.2 Flowsheet Description

The simplified flowsheet for Scenario 3 is presented in Figure 5-52. The flowsheet differs from the Baseline Case in several ways. The PT Facility and LAW supplemental treatment (or similar capabilities) are no longer included in the flowsheet; all HLW feed is delivered from the TWCS capability and treated in the HLW Vitrification Facility, and all LAW feed is pretreated in the LAWPS and vitrified in the LAW Vitrification Facility. To support direct-feed operation of the HLW Vitrification Facility, the functionality of the TWCS capability was also changed from the Baseline Case to better support DFHLW operations.
Scenario 3 – Early Direct Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment

Figure 5-52. Scenario 3 – Simplified Flowsheet.

Legend

Tank Farms

WTP

Sup. Treatment

Other

N/A (Comparative to the Baseline Case)

New (Comparative to the Baseline Case)

Acronyms

CWC: Central Waste Complex

DST: double-shell tank

ETF: Effluent Treatment Facility

HLW: high-level waste

HSF: Hanford Shipping Facility

IHS: Interim Hanford Storage

LAW: low-activity waste

LERF: Liquid Effluent Retention Facility

MT: metric ton

SST: single-shell tank

TBD: to be determined

TRU: transuranic

WTP: Hanford Tank Waste Treatment and Immobilization Plant

For illustrative purposes only: The flowsheet presented here has been simplified for presentation purposes.
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In the Baseline Case, the TWCS capability performs the functions of receiving, staging (including supporting sampling), and delivering slurry from the 200 East Area DSTs to the WTP. In this DFHLW flowsheet, the TWCS capability must also support fractionation of the as-received slurry into a solids-heavy fraction, which is fed forward to the HLW Vitrification Facility, and a supernatant liquid fraction, which is returned to the 200 East Area DSTs. This is modeled as a settle-decant process; however, added technology (e.g., filtration), may be needed to support this function. After the fractionation is completed, the solids-heavy fraction is diluted in the TWCS capability to support transfer to the HLW Vitrification Facility (LAWPS cesium eluate from the 200 East Area DSTs is the preferred diluent).

Once diluted, the prepared slurry is staged, sampled, and transferred directly to the feed preparation vessels in the HLW Vitrification Facility from the TWCS capability as DFHLW feed. The preparation process for DFHLW feed is described in Section 5.3.3.3.4.

Dilute effluent from the HLW Vitrification Facility is routed to the TWCS capability for the duration of the mission. In the TWCS tanks, the dilute effluent is combined with cesium eluate from the LAWPS and concentrated in an evaporator (assumed to be equivalent to the feed evaporator process [FEP] evaporator in the PT Facility). These concentrated evaporator bottoms are blended back into the HLW feed in a recycle loop, and the evaporator secondary liquid effluent is routed to the LERF and treated in the ETF.

Independent of other changes to the scenario flowsheet, the supplemental TRU waste treatment process was removed from the flowsheet. The 11 SSTs containing potential CH-TRU waste were instead retrieved through the WRFs to the DSTs and eventually treated in the WTP.

### 5.3.3 Analysis

#### 5.3.3.1 Schedule Performance

The key mission activity dates for Scenario 3 and Scenario 3A, compared with the Baseline Case, are included in Table 5-18. Additionally, Figure 5-53 shows the operating schedule for major facilities and processes in Scenario 3. Compared to the Baseline Case and with the exception of facility start dates that were modified as input assumptions (see Section 5.3.1), the resulting differences in the operating schedule for Scenario 3 include:

- The mission end date (treat all tank waste) occurs in November 2126, 63 years later than in the Baseline Case. Compared to the Baseline Case, the HLW treatment duration is 71 years longer (101 years total). Similarly, the DST completion occurs in September 2116, 54 years later than in the Baseline Case.
- LAW treatment completes in July 2081, nearly 18 years later than the Baseline Case.
- SST retrievals complete in December 2064, 8 years later than the Baseline Case.
- Driven by an SST retrieval schedule that is accelerated during the 2020s and early 2030s, the need date for the 200 West Area WRF is September 2036, approximately 4 years earlier than the Baseline Case.
Compared to Scenario 3, Scenario 3A demonstrated a significant improvement in the end dates for LAW and HLW treatment (and therefore the mission), which completed 11 years and 31 years earlier, respectively. However, Scenario 3A did not demonstrate a significant difference from Scenario 3 when comparing more near-term mission metrics, up to and including the completion of the SST retrievals, which completed less than 1 year earlier.

Table 5-18. Scenario 3 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metrics</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 3 – Early DFHLW with No PT Facility (2013 GFMs)</th>
<th>Scenario 3A – Early DFHLW with No PT Facility (2016 GFMs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete C Tank Farm Retrievals (existing TPA 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
<td>5/2022</td>
<td>5/2022</td>
<td>5/2022</td>
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Table 5-18. Scenario 3 Comparison – Key Mission Activity Dates. (2 pages)

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<th>Scenario 3 – Early DFHLW with No PT Facility (2013 GFMs)</th>
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CH-TRU = contact-handled transuranic.  
CWC = Central Waste Complex.  
DFHLW = direct-feed high-level waste.  
DFLAW = direct-feed low-activity waste.  
ETF = Effluent Treatment Facility.  
GFM = glass formulation model.  
HLW = high-level waste.  
HSF = Hanford Shipping Facility.  
IDF = Integrated Disposal Facility.  
IHS = Interim Hanford Storage.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
LERF = Liquid Effluent Retention Facility.  
N/A = not applicable.  
PT = Pretreatment.  
SST = single-shell tank.  
TPA = Tri-Party Agreement.  
TWCS = tank waste characterization and staging.  
WMA = waste management area.  
WRF = Waste Receiving Facility.  
WTP = Waste Treatment and Immobilization Plant.
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### Figure 5-53. Scenario 3 – Operating Schedule for Major Facilities/Processes.

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Scenario 3 – Early Direct Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment

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5.3.3.2 Cost

The annual and cumulative lifecycle cost profiles are presented and compared with the Baseline Case in Figure 5-54. The cumulative lifecycle cost is $151 billion ($768 billion escalated), versus $111 billion ($231 billion escalated) for the Baseline Case. There is $22 billion in cost savings through the Baseline Case treatment completion date (November 2063), with the savings realized from the avoidance of LAW supplemental treatment capital costs and the PT Facility and LAW supplemental treatment operations costs. However, the mission continues an additional 63 years and costs $40 billion ($537 billion escalated) more than the Baseline Case. The annual cost drops sharply after 2081, when LAW treatment is completed and the LAWPS and LAW Vitrification Facility are permanently shut down.

In Scenario 2, early DFHLW added $4.7 billion in cumulative cost through the end of FY 2033, while in Scenario 3, the incremental cost of early DFHLW is offset by the avoidance of LAW supplemental treatment capital costs during the same period. As a result, the cumulative cost of Scenario 3 is $2 billion lower than the Baseline Case through the end of FY 2033. However, the capital cost for the TWCS capability is accelerated by 9 years within this timeframe, and the addition of an evaporator and 316L stainless steel tank liners to the TWCS capability increases the capital cost by $330 million prior to June 2023.

Note that the capital cost for the WTP facilities, including the PT Facility and HLW Vitrification Facility, is not included in the lifecycle cost analysis, however operating costs are. The cost of offsite IHLW canister disposal is also not included.

Figure 5-54. Scenario 3 Comparison – Lifecycle Cost Profile.
For the purposes of this cost analysis, the operating cost for the HLW Vitrification Facility is assumed to be 36 percent of the operating cost of the integrated WTP. Consistent with the other System Plan (Rev. 8) cases, the operating cost for the LAW Vitrification Facility and the WTP EMF is 40 percent of the operations cost for the integrated WTP. Therefore, the combined operational cost for DFLAW and DFHLW is 76 percent of the operating cost for the integrated WTP. To account for the addition of an evaporator to the TWCS capability, the average annual cost of operating the 242-A Evaporator was added to the operating cost for the TWCS capability. This results in the operating cost of the TWCS capability being increased 150 percent over the Baseline Case.

5.3.3.3 Mission Flowsheet Results
Removing the PT Facility and LAW supplemental treatment from the mission flowsheet prolongs the mission by decades and increases the production of IHLW by forcing a large fraction of waste treated as LAW in the Baseline Case to be treated as HLW. The direct-feed treatment also increases the burden on tank farms operations by complicating waste feed delivery, resulting in a significant increase in the amount of DST transfers and 242-A Evaporator campaigns. The following subsections present the detailed mission flowsheet results for each system in Scenario 3 compared to the Baseline Case.

5.3.3.3.1 Single-Shell Tank Retrievals
Figure 5-55 shows the historical and projected SST retrieval progress, as measured by the volume of original waste remaining in the SSTs, as a function of time. Since the near-term retrieval assumptions for this scenario were not changed from the Baseline Case, the completion of the retrievals of C Tank Farm and A/AX Tank Farms are the same as the Baseline Case, finishing in August 2017 and November 2022, respectively. The retrieval of S/SX Tank Farms begin approximately 1 year later in Scenario 3 due to the space required in the 200 East Area DSTs for preparing DFHLW feed; however, the retrieval progress catches up with and eventually surpasses the Baseline Case as DFHLW treatment, coupled with the TWCS evaporator, generates additional space for retrieved solids in the 200 East Area DSTs. When the supplemental TRU treatment process and then the integrated WTP and LAW supplemental treatment start up in the early 2030s in the Baseline Case, the Baseline Case retrieval progress permanently outpaces Scenario 3—completing 8 years earlier.

Compared to the Baseline Case, the SST retrievals are slower, but more level-loaded (i.e., the rate of the SST waste retrieval is more constant) due to a near-constant rate of waste treatment after DFHLW starts up in 2024. Compared to Scenario 3 (2013 GFMs), Scenario 3A (2016 GFMs) exhibits a similar retrieval progress profile. Scenario 3A progress outpaces Scenario 3 between 2050 and 2057, with the gap diminishing by the time the SST retrievals complete for both scenarios in 2064.
Figure 5-55. Scenario 3/3A Comparison – Single-Shell Tank Retrieval Progress.

Figure 5-56 shows the sequence and timing of the SST retrievals over the course of the mission versus the Baseline Case. The dark-colored bands indicate the active SST retrievals, and the light-colored bands indicate delays in the SST retrievals (i.e., the difference in the modeled retrieval duration and the assumed minimum retrieval duration). Figure 5-56 shows many of the same trends as Figure 5-55. The retrieval delay time after the retrievals of A/AX Tank Farms is increased by 46 percent versus the Baseline Case. This is driven by the rate that space is generated through treatment being poorly matched to the potential rate of the SST retrieval (because of the treatment throughput is on average lower in Scenario 3 over the course of the mission).

The SST retrievals differ from the Baseline Case in timing and also in sequence. In the Baseline Case, the sequence of the SST retrievals from S/SX Tank Farms is optimized to reduce the amount of sludge retrieved to the DSTs during DFLAW operations prior to startup of the integrated WTP. As in Scenario 2, the model was permitted in Scenario 3 to choose the sequence of SST retrievals from S/SX Tank Farms to maintain continuity of feed to the DFLAW and DFHLW processes. As a result, higher-sludge SSTs were retrieved during this period.
Scenario 3 – Early Direct-Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment

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Scenario 3 – Early Direct Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment

Figure 5-56. Scenario 3 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
Scenario 3 – Early Direct Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment
5.3.3.3.2  Double-Shell Tank Space Management

The utilization of DST space over the course of the mission is depicted in Figure 5-57, and the amount of available space in the DSTs in Scenarios 3 and 3A versus the Baseline Case is presented in Figure 5-58. The DST space utilization is essentially within the range of the Baseline Case through the end of four simultaneous SST retrievals in 2057, with an extended drawdown of the DST waste volume at the end of the mission. This elongated drawdown is due to (1) the longer gap between the completion of the 200 East Area SST retrievals and the 200 West Area SST retrievals, and (2) the rate of waste treatment slowing at the end of the mission (see Section 5.3.3.3.5 for more information). As in Scenario 2, a larger amount of DST space is maintained during the 2020s, which represents the space buffer required for preparing DFHLW feed in the DSTs.

Scenario 3A (2016 GFM) exhibits similar behavior to Scenario 3 (2013 GFM); however, the final drawdown of the DST waste volume at the end of the mission is shortened by approximately 30 years due to the 2016 HLW GFM predicting better waste treatment throughput during this period (Section 5.3.3.3.5 provides additional information).

Figure 5-57. Scenario 3 – Double-Shell Tank Space Utilization.
Comparisons to the Baseline Case of the annual and mission cumulative DST transfers and DST slurry transfers (including WRF to DST transfers) are presented in Figure 5-59 and Figure 5-60, respectively. The DST operations-intensive nature of direct-feed treatment results in a significant increase in DST transfers over the mission. This leads to a cumulative increase of approximately 1,700 DST transfers and 250 DST slurry transfers over the mission and represents an acceleration of the need to complete a significant number of annual DST slurry transfers (due to the earlier start date for HLW treatment). Although the DST transfers are spread out over a significantly longer mission duration, there is still a substantial increase in the number of required DST transfers during the period of DST operations in the Baseline Case.
Scenario 3 – Early Direct Feed High-Level Waste with No Waste Treatment and Immobilization Plant Pretreatment.

Figure 5-59. Scenario 3 Comparison – Double-Shell Tank Transfers.

Figure 5-60. Scenario 3 Comparison – Double-Shell Tank Slurry Transfers.
Figure 5-61 show the demand for the 242-A Evaporator over the course of the mission in terms of annual campaigns, cumulative feed volume, and cumulative WVR versus the Baseline Case. The demand for the 242-A Evaporator is much higher than the Baseline Case. The mission-total feed volume is 311 Mgal and the mission-total WVR is 154 Mgal, 51 percent and 55 percent higher than the Baseline Case, respectively.

With the demand spread out over an additional 14 years of 242-A Evaporator operations, the increased mission-total demand does not equate to a proportional increase in annual demand, and the average number of annual evaporator campaigns remains roughly the same as the Baseline Case (approximately 5.9 versus 5.5 for the Baseline Case). Peak demand for the 242-A Evaporator occurs in 2055 and equates to 161 days of hot operations. Near-peak demand for the 242-A Evaporator is sustained over a 5-year period between from 2053 through 2057, when the 242-A Evaporator operates at an average of 144 days of hot operations annually. In comparison, the peak demand in the Baseline Case occurs in 2045 and equates to 152 days of hot operations.

The increase in 242-A Evaporator demand is driven by three primary factors:

1. With no waste feed evaporator in the DFLAW flowsheet, the 242-A Evaporator must be operated more aggressively to concentrate LAW feed when DFLAW is the only LAW treatment process. In the Baseline Case, 99 Mgal of supernatant liquid at an average of 3.7 M Na is delivered to the PT Facility (as either LAW feed or the liquid fraction of
HLW feed)—this feed must be concentrated using the 242-A Evaporator to a minimum of 5.6 M Na.

2. 58 Mgal of water is added to the DSTs for solids mitigation, 21 Mgal more than the Baseline Case. More aggressive operation of the 242-A Evaporator leads to more solids precipitating from evaporator bottoms. This process creates a positive feedback loop where more water is added for solids mitigation (equivalent to targeted in-tank solids washing), which must then be evaporated.

3. 5 Mgal of additional dilute supernatant liquid is retrieved to the DSTs from SSTs that were retrieved to the supplemental TRU treatment process in the Baseline Case. This additional supernatant liquid must be concentrated by the 242-A Evaporator prior to treatment.

5.3.3.3.4 Waste Feed Delivery

The process for delivering LAW feed from the 200 East Area DSTs to the LAWPS is unchanged from the Baseline Case. Feed from the LAWPS to the LAW Vitrification Facility are screened against the ICD-30 waste acceptance criteria. All waste acceptance criteria that can be screened for direct LAW feed (see Section 5.1.3.3.5 for waste acceptance criteria that can be screened using model data) are met for the 90 Mgal of feed delivered prior to 2072, with the exception of the maximum TRU-to-sodium ratio and maximum U-235 concentration, which are exceeded by 140 percent and 72 percent, respectively, for one feed campaign in 2027 and by three percent and two percent, respectively, for another feed campaign in 2029. After 2072, during cleanout of the DST system, approximately 7 Mgal of direct LAW feed is delivered, which falls significantly below the minimum sodium molarity and exceeds the maximum ratios for fluoride and sulfate concentration to sodium concentration. For this 7 Mgal, the average sodium concentration is 2.7 M and the average ratios of fluoride and sulfate-to-sodium are 0.120 and 0.083, respectively.

DFHLW feed batches are prepared in the TWCS tanks by the following process:

1. Transfer slurry at a nominal 10 wt% solids from the 200 East Area DSTs equipped with two mixer pumps to fill the TWCS tank
2. Allow the solids to settle from the slurry, and decant the supernatant liquid to the 200 East Area DSTs
3. Repeat steps (1) and (2)
4. Blend in any available concentrated HLW effluent
5. Dilute the settled solids in the TWCS tank using raw water to a nominal 20 wt% solids.49

49 Per 24590-WTP-RPT-PT-02-005, 20 wt% is the concentration target for HLW solids in the WTP PT Facility ultrafiltration system. The required infrastructure is assumed to be constructed to support delivering DFHLW feed from the TWCS capability to the WTP HLW Vitrification Facility at this concentration.
During final cleanout of the DSTs and when LAW treatment is completed, DFHLW feed batches are prepared in the TWCS tanks by the following simplified process:

1. Transfer in any available concentrated HLW effluent, up to half of the volume of the TWCS tank
2. Transfer slurry at up to 10 wt% solids from the 200 East Area DSTs equipped with two mixer pumps to fill the TWCS tank.

Solids fed through the DFHLW process were not washed, with the exception of precipitated salts, which were washed once through the solids mitigation process prior to delivery to the TWCS capability. As in Scenario 2, sludges fed through the DFHLW process were specifically selected to expedite immobilization of radiological hazard (curies). No waste acceptance criteria exist for DFHLW feed; however, the DFHLW feed that is delivered meets the ICD-19 waste acceptance criteria\(^{50}\) that can be screened (for HLW feed to the PT Facility), with the exceptions of minimum pH for a handful of feed batches (as low as 11.2 versus the minimum of 12) and maximum solids concentration, which was exceeded by design.

5.3.3.3.5 Waste Treatment and Immobilization

This section discusses waste treatment and immobilization in Scenarios 3 and 3A versus the Baseline Case. Table 5-19 summarizes the amount of immobilized product for the LAW and HLW Vitrification Facilities. The removal of HLW solids pretreatment from the flowsheet forces a large fraction of waste treated as LAW in the Baseline Case to be treated as HLW in Scenario 3, resulting in a large increase in IHLW production and coupled decrease in ILAW production.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 3 – Early DFHLW with No PT Facility (2013 GFMs)</th>
<th>Scenario 3A – Early DFHLW with No PT Facility (2016 GFMs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>11/2126</td>
<td>7/2095</td>
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<td>WTP IHLW</td>
<td>Product (canisters)</td>
<td>7,800</td>
<td>63,600</td>
<td>43,400</td>
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<td>MT of product</td>
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<td>190,900</td>
<td>130,100</td>
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<td>Total ILAW (glass)</td>
<td>Product (containers)</td>
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<td>MT sodium reporting to ILAW</td>
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<td>46,400</td>
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\(^{50}\) The ICD-19 waste acceptance criteria reflect the WTP PT Facility design and safety basis, which may not fully bound the WTP HLW Vitrification Facility design and safety basis.
Table 5-19. Scenario 3 Comparison – Waste Treatment Product Summary. (2 pages)

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<thead>
<tr>
<th>Facility</th>
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<th>Scenario 1 – Baseline Case</th>
<th>Scenario 3 – Early DFHLW with No PT Facility (2013 GFMs)</th>
<th>Scenario 3A – Early DFHLW with No PT Facility (2016 GFMs)</th>
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<td>MT</td>
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<td>WTP</td>
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</table>

DFHLW operations enable the HLW Vitrification Facility to be operated at its full 70 percent TOE capacity; however, 63,600 IHLW canisters are produced—an increase of over 700 percent relative to the Baseline Case. This drives the HLW treatment duration to 101 years and extends the completion of tank waste treatment to 2126. 58,700 ILAW containers are produced, 38 percent less than the Baseline Case. A benefit realized in Scenario 3A from using the 2016 GFMs (compared to Scenario 3 using 2013 GFMs) is that the mission-total IHLW canister count is reduced 32 percent to 43,400 and the mission-total ILAW container count is reduced 14 percent to 50,400.

Figure 5-62 depicts the tank farms radioactive inventory over the course of the mission for Scenario 3 compared to the Baseline Case. The figure accounts for radioactive decay of the starting inventory over time—the remaining radioactivity is decayed to the date it is reported. The general trend is that the tank farms radioactive inventory decreases as waste is delivered to the WTP and radioactive decay proceeds. The main differences versus the Baseline Case are that HLW treatment begins earlier, immobilizing 49 percent of the IHLW curies prior to startup of HLW treatment in the Baseline Case, and the rate of curie immobilization decreases relative to the Baseline Case as the fraction of salt in the DFHLW feed increases towards the end of the mission. Between the Baseline Case treatment completion date (November 2063) and the Scenario 3 treatment completion date (November 2126), an incremental 1,000,000\(^{51}\) Ci are immobilized; in the last 50 years of treatment in Scenario 3, an incremental 400,000\(^{51}\) Ci are immobilized. As in the Baseline Case, nearly all immobilized radioactivity is segregated to the IHLW product, which contains 99 percent of the immobilized curies.

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\(^{51}\) Decayed to the Scenario 3 treatment completion date, November 2126.
5.3.3.3.5.1 Direct-Feed Treatment
The DFLAW and DFHLW processes are the only tank waste treatment processes in the Scenario 3 flowsheet. DFLAW treatment begins in 2023 and continues until 2081 with the same flowsheet as in the Baseline Case. DFHLW treatment (including the TWCS capability with an added evaporator) begins in 2024 and continues for the duration of the mission, until 2126. A flowchart of the major process streams, including volumes, for the Scenario 3 flowsheet is provided in Figure 5-63.

DFLAW treatment processes a total of 96 Mgal of feed at a nominal 5.6 M Na concentration. LAW feed from the 200 East Area DSTs is pretreated in the LAWPS and vitrified in the LAW Vitrification Facility (along with 8 Mgal of dilute LAW effluent concentrated in the WTP EMF and blended into the melter feed). This equates to a gross 45,400 MT Na waste treated, or a net 43,400 MT Na waste treated when considering 6 Mgal of corrosion-mitigated dilute effluent at 4 M Na returned from the WTP EMF to the DST system. Excluding periods after 2065 when LAW feed is not available, there is a net sodium treatment rate of 890 MT Na waste per year treated by the DFLAW process, 42 percent of the Baseline Case waste sodium throughput from the PT Facility.

DFHLW treatment processes a total of 41,600 MT of solids delivered to the TWCS capability and then vitrified in the HLW Vitrification Facility (along with 11 Mgal of LAWPS cesium eluate and dilute HLW effluent concentrated in the TWCS capability and blended into the DFHLW feed batches). The as-delivered solids are increased by 30 percent over the Baseline
Case due to an increase in precipitated solids from more aggressive use of the 242-A Evaporator to prepare LAW feed for treatment via the DFLAW process. The solids fed through the DFHLW process were not washed, with the exception of precipitated salts, which were washed once through the solids mitigation process prior to delivery to the TWCS capability. Over the course of the mission, an average of 410 MT of as-delivered solids are treated per year by the DFHLW process, 39 percent of the Baseline Case as-delivered solids throughput from the PT Facility.

HLW treatment throughput (in terms of as-delivered solids mass treated) decreases over the course of the mission. The amount of as-delivered solids processed annually by DFHLW operations through the Baseline Case completion date is 890 MT (11/14/2063; this period includes the ramp-up of the HLW Vitrification Facility to the full rate with second-generation melters), while only 130 MT of as-delivered solids are processed annually over the last 40 years of DFHLW operation. This decrease in HLW treatment throughput is driven by changing feed composition—at the end of the mission, retrieved sludge has been depleted, and HLW feed mainly comprises sparingly soluble salts, which are high in sulfate. This problem is exacerbated by the recycle of HLW effluent that allows volatile sulfate to build up in the feed, severely limiting throughput (Section 5.3.3.3.5.4 provides additional detail). However, for most of the mission, the recycle of HLW effluent does not have a large impact on HLW treatment throughput.
Figure 5-63. Scenario 3 – Process Stream Flowchart.

Legend

Acronyms

DST double-shell tank
ETF Effluent Treatment Facility
HLW high-level waste
LAW low activity waste
LERF Liquid Effluent Retention Facility
Mgal million gallons
SBSS submerged bed scrubber
SST single-shell tank
TOC Tank Operations Contractor
TWCS tank waste characterization and staging
WESP wet electrostatic precipitator
WTP Waste Treatment and Immobilization Plant

For illustrative purposes only: The figure has been simplified omitting some secondary waste, recycle streams, facility residuals, and process-forming chemicals. Results are rounded.
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5.3.3.3.5.2 **Glass Production**

Figure 5-64 compares the HLW Vitrification Facility IHLW canister production in Scenario 3 to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case IHLW canister production. DFHLW operations use the full capacity of the HLW Vitrification Facility (5.25 MTG/day for second-generation melters at 70 percent TOE) by eliminating the PT Facility ultrafiltration process – the rate-limiting step for HLW treatment in the Baseline Case (see Section 5.1.3.3.6) – from the flowsheet. Over the HLW treatment duration, IHLW canister production is at more than 99 percent of the theoretical maximum production capacity.

By the time HLW treatment completes in 2126, 63,600 IHLW canisters are produced—an increase of over 700 percent compared to the Baseline Case. The increase in IHLW canisters is partially because a portion of solids (aluminum, phosphate, and sulfate are the primary species of concern) that would have been dissolved by washing and leaching and immobilized as ILAW in the Baseline Case are instead immobilized as IHLW through DFHLW operations. The build-up of volatile sulfate in the feed from the recycle of HLW offgas, which contributes to limiting IHLW WOL to half of the Baseline Case IHLW WOL, also contributes to the increase.

The increase in IHLW production eventually outweighs the benefits gained from operating the HLW Vitrification Facility at full capacity, and the HLW treatment duration is increased by a factor of 3.4 times versus the Baseline Case.

**Figure 5-64. Scenario 3 Comparison – Immobilized High-Level Waste Production.**
The trend in IHLW production for Scenario 3A (2016 GFM) is nearly the same as for Scenario 3 (2013 GFM), with IHLW production at the full capacity of the HLW Vitrification Facility for the entire HLW treatment duration. However, Scenario 3A ends 31 years earlier, with 32 percent less IHLW canisters produced. This difference is due to the 2016 HLW GFM yielding better WOL, especially at the end of the mission.

Figure 5-65 compares the LAW Vitrification Facility ILAW container production in Scenario 3 to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case ILAW container production. Through the end of DFLAW in the Baseline Case, ILAW container production is nearly identical to the Baseline Case, with the rate of ILAW container production limited by the amount of water in the feed per Assumption A1.3.4.12 in both Scenario 3 and the Baseline Case. However, after startup of the PT Facility in the Baseline Case, ILAW container production matches the theoretical maximum production capacity (21 MTG/day), while ILAW container production in Scenario 3 continues to be limited by the amount of water in the feed. This is because the treated LAW evaporation process system in the PT Facility concentrates the feed to the LAW Vitrification Facility, while the DFLAW flowsheet contains no capability to concentrate the pretreated waste feed.

Compared to the Baseline Case, there is 38 percent less total ILAW containers produced in Scenario 3 due primarily to the elimination of solids washing and leaching (especially the elimination of caustic soda additions for solids leaching). Although LAW supplemental treatment is not included in Scenario 3, the LAW Vitrification Facility produces more ILAW containers over a longer treatment duration. The additional ILAW container production in the Baseline Case is absorbed by LAW supplemental treatment, which accounts for 45 percent of the Baseline Case LAW treatment.

Figure 5-65. Scenario 3 Comparison – Immobilized Low-Activity Waste Production.
The trends in ILAW production for Scenario 3A (2016 GFMs) are nearly the same as for Scenario 3 (2013 GFMs), with ILAW production consistently limited by the amount of water in the feed and no feed outages until DST cleanout. However, Scenario 3A ends 11 years earlier, with 14 percent less ILAW containers produced. This difference is due to the 2016 LAW GFM yielding better WOL throughout the mission.

5.3.3.3.5.3 Glass Drivers – Scenario 3 (2013 Glass Formulation Models)

The ORP 2013 GFMs (documented in PNNL-22631) consist of a collection of glass property composition models created to develop a nonconservative set of constraints and property models that can be used to estimate the amounts of IHLW and ILAW produced at Hanford. In the Baseline Case, and all System Plan (Rev. 8) scenarios with the exception of sensitivities tested in Scenarios 1B and 3A, glass is assumed to be formulated using the ORP 2013 GFMs per Assumptions A1.3.4.9 and A1.3.3.6.

Figure 5-66 shows the glass drivers (i.e., the waste loading constraint estimated to be most limiting to WOL) for the HLW Vitrification Facility IHLW canister production, as a function of calendar year and the number of batches limited. Average WOL as a function of calendar year is also presented. The average WOL for the IHLW product is 22 percent, compared to 44 percent for the Baseline Case. The most common glass drivers are sulfur solubility (60 percent of feed batches), probability of nepheline formation (21 percent of feed batches), and maximum phosphorous oxide loading (15 percent of feed batches).
All of these drivers, which reduce the average WOL compared to the Baseline Case, are attributable to removing washing and leaching of HLW feed solids from the flowsheet. Sulfur and phosphate, typically occurring in the solid phase as kogarkoite (Na₃FSO₄) and natrophosphate (Na₇F(PO₄)₂·19H₂O), respectively, are sparingly soluble species that are effectively removed through water washing and are never limiting to WOL of the IHLW product in the Baseline Case. Though nepheline is limiting to a small portion of HLW feed batches in the Baseline Case, the problem is exacerbated in Scenario 3 as nepheline ((Na, K)AlSiO₄) is a sodium-potassium-aluminum-silicon compound, and the amount of these species in the HLW feed solids is substantially reduced through water washing and/or caustic leaching.

Nepheline is often limiting to WOL early in DFHLW treatment and is generally correlated with high-aluminum feed and relatively high WOL. Phosphate is often limiting during the 2040s and 2050s as high-phosphate solids are retrieved from the B and T Complexes. Sulfur, though often limiting at various times throughout the mission, is the near-exclusive glass driver after the SST retrievals complete in 2064. When the sludge retrieved from the SSTs is fed through the DFHLW process, the remaining solids contain a large fraction of precipitated salts, including kogarkoite. When a large fraction of the sulfur fed to the HLW Vitrification Facility is volatilized in the HLW melter, captured in the offgas condensate, and recycled into the HLW feed, sulfur builds up in the feed, creating a positive feedback loop that severely limits WOL of the IHLW product over the last approximately 40 years of the mission. The WOL of the IHLW product is on average five percent during that period.
Figure 5-67 shows the glass drivers for the LAW Vitrification Facility ILAW container production, as a function of calendar year and the number of batches limited.

Average sodium oxide loading and total WOL as a function of calendar year are also presented. The average WOL for the ILAW product is 19 percent, compared to 22 percent for the Baseline Case. The glass drivers are alkali (sodium and potassium) content (48 percent of feed batches), alkali and sulfur content (21 percent of feed batches), halide (chloride and fluoride) content (21 percent of feed batches), and sulfur content (10 percent of feed batches). The majority of the sulfur-limited feed is the low-sodium feed delivered after 2065.

The WOL of the ILAW product is lower than the Baseline Case due to the elimination of chemical additions (especially caustic soda) for solids leaching. These chemical additions diluted the ratio of volatile sulfur and halides to sodium in the feed, and these volatiles limit WOL for 52 percent of LAW feed batches in Scenario 3.

5.3.3.3.5.4 Glass Drivers – Scenario 3A (2016 Glass Formulation Models)

Similar to the ORP 2013 GFMs (PNNL-22631), the ORP 2016 GFMs (PNNL-25835) consist of a collection of glass property composition models created to develop a nonconservative set of constraints and property models that can be used to estimate the amounts of IHLW and ILAW produced at Hanford. However, the 2016 GFMs, which are used in Scenario 3A, incorporate advancements realized from data and lessons learned from an additional 200 glasses tested since the creation of the 2013 GFMs.
Figure 5-68 shows the glass drivers for the HLW Vitrification Facility IHLW canister production, as a function of calendar year and the number of batches limited. Average WOL as a function of calendar year is also presented.

Figure 5-68. Scenario 3A – Immobilized High-Level Waste Glass Drivers.

The average WOL for the IHLW product is 34 percent, a significant improvement compared to 22 percent for Scenario 3. The most common glass drivers are the same as for Scenario 3: sulfur solubility (61 percent of feed batches), maximum phosphorous oxide loading (22 percent of feed batches), and probability of nepheline formation (8 percent of feed batches). The significant improvement in WOL is realized primarily from an increase in projected sulfur solubility over the 2013 HLW GFM. For Scenario 3A, the average sodium oxide and total WOL following completion of the SST retrievals (approximated as after 2064) are 2.1 percent and 25 percent, respectively, compared with 0.9 percent and 15 percent for Scenario 3.

Figure 5-69 shows the glass drivers for the LAW Vitrification Facility ILAW container production, as a function of calendar year and the number of batches limited. Average sodium oxide loading and total WOL as a function of calendar year are also presented. The average WOL for the ILAW product is 22 percent, a significant improvement compared to 19 percent for Scenario 3. The glass drivers are alkali content (61 percent of feed batches), alkali and sulfur content (34 percent of feed batches), sulfur content (5 percent of feed batches), and halide content (1 percent of feed batches). The significant improvement in WOL is realized primarily from an increase in permissible halide loading over the 2013 LAW GFM.
5.3.3.3.5 Liquid Effluent Retention Facility and Effluent Treatment Facility

Over the mission, 631 Mgal of secondary liquid effluent was routed to the LERF and treated in the ETF—an 83 Mgal increase over the Baseline Case. However, because the mission is over twice the length of the Baseline Case, the annual demand on these facilities is less.

The 631 Mgal of secondary liquid effluent includes 206 Mgal from the 242-A Evaporator, 205 Mgal from the TWCS capability, and 220 Mgal from the WTP EMF (see Figure 5-63, page 5-119). Reductions in secondary liquid from eliminating the supplemental TRU treatment process and reducing the amount of LAW effluent produced (from producing fewer ILAW containers) are outweighed by increased effluent volumes from the 242-A Evaporator and from an increased volume of HLW effluent (from producing more IHLW canisters), which is evaporated in the TWCS capability. In the Baseline Case, the PT Facility also takes advantage of process condensate recycles to reduce the volume of secondary liquid effluent, an opportunity that does not exist in the Scenario 3 flowsheet.

5.3.3.4 Opportunities

Because Scenario 3 represents the first effort to define and model a full-mission flowsheet with DFLAW and DFHLW as the only tank waste treatment processes, the results can be improved by refining the flowsheet and applying lessons learned from the modeling of Scenario 3 (and Scenario 11). This section offers opportunities that have the potential to improve the results of
the Scenario 3 flowsheet, bringing the completion dates for SST retrievals and tank waste treatment closer to the dates in the Baseline Case.

Opportunities to improve the flowsheet arise from adding capabilities in tank farms to enhance separation of the LAW and HLW feed fractions of the tank waste prior to treatment. The most desirable capability in achieving this goal is the ability to reassign the volatile sulfate and halides in the concentrated HLW effluent to LAW feed (instead of HLW feed). This can be achieved by blending the concentrated HLW effluent (from the TWCS capability) with LAW feed, potentially at the front end of LAWPS (the filtered solids are returned to the TWCS capability and blended into HLW feed). Incorporating this flowsheet change reduces or even eliminates the extended end-of-mission drawdown of the DSTs, driving lower HLW treatment throughput from the buildup of recycled volatilized sulfur in the feed. This capability is the most significant difference between Scenario 3 and Scenario 11 (Section 5.11), which reduces mission-total IHLW canister production by 56 percent versus Scenario 3 (HLW treatment duration is reduced proportionately to 46 years compared to 101 years in Scenario 3). If implemented, the LAWPS cesium eluate will likely be returned to tank farms (as in the Baseline Case) and blended into the HLW feed by transferring from tank farms to the TWCS capability, similar to Scenario 2. The capability should probably be retained in the flowsheet to recycle concentrated HLW effluent into the HLW feed to be used for high-radioactivity effluent and to maintain decoupling of LAW and HLW treatment.

Another opportunity to optimize the flowsheet is to perform solids washing and/or caustic leaching of the HLW feed solids in the TWCS capability. This added capability will lower the mission-total IHLW canister production by reducing the amount of supernate and soluble salts fed to the HLW Vitrification Facility. The TWCS capability is the preferred location for solids washing due to its enhanced mixing capability and the ease of adding functionality supporting washing and leaching (since the TWCS capability is not yet designed or built). Decantate from the washing and/or leaching processes could be blended with the dilute HLW effluent, concentrated in the TWCS evaporator, and blended with LAW feed, potentially at the front end of LAWPS (as described in the preceding paragraph). Additions of caustic soda or heating of the transfer lines may be required to prevent significant reprecipitation of sparingly soluble salts from the concentrated wash solution.

Note that if the potential improvements in the two preceding paragraphs are implemented, the mission duration will likely be limited by the capacity of the LAW Vitrification Facility to immobilize LAW, and if additional LAW treatment capacity is added, by the capacity of the LAWPS to pretreat LAW feed. For this reason, additional LAW feed pretreatment capacity and additional LAW treatment capacity may be desirable.

Another opportunity to improve the Scenario 3 flowsheet is to reincorporate supplemental treatment of the potential CH-TRU tank waste (this is included in the Baseline Case flowsheet). Past modeling has demonstrated that supplemental TRU treatment can eliminate 6 to 12 months of the treatment duration and brings the SST retrieval completion date forward by as much as several years. Extrapolating 6 to 12 months to the lower treatment throughput in Scenario 3, supplemental TRU treatment may shorten the treatment mission by over 2 years.
A potential opportunity presented by DFHLW that is not realized in modeling is that the TOE for the HLW Vitrification Facility will likely exceed the TOE for the integrated WTP, giving an advantage to flowsheets including DFHLW versus the baseline. Per Assumption A1.3.1.3, the TOE of the integrated WTP is modeled at 72 percent based on the most recent WTP OR assessment (24590-WTP-RPT-12-002), while the LAW and HLW Vitrification Facilities are modeled at the contract minimum TOE of 70 percent. However, the TOE of the HLW Vitrification Facility is predicted to be 83.3 percent by the same assessment. Therefore, because Scenario 2 demonstrates the ability of the tank farms to feed the HLW Vitrification Facility at its assumed theoretical maximum rate, increasing this rate will potentially raise the throughput of the DFHLW process by nearly 20 percent. This opportunity does not exist for DFLAW because the TOE of the LAW Vitrification Facility is predicted to be 71.2 percent, barely distinguishable from the currently modeled 70 percent. Because the throughput of the ultrafiltration system in the PT Facility is far more limiting to the HLW treatment rate in the baseline flowsheet than the HLW Vitrification Facility capacity, even at 70 percent TOE, the Baseline Case will be unaffected by this change.

Finally, there is an opportunity to optimize modeling and potentially the operation of DFHLW by refining GFMs to better predict glass formulations for projected DFHLW feed compositions. For example, ORP 2016 GFMs demonstrated a significant improvement in WOL over the ORP 2013 GFMs (used in Scenario 3) when applied to direct HLW and LAW feeds in Scenario 3A.

5.3.3.5 Risks

There are several new risks associated with Scenario 3, including risks related to the startup and effectiveness of DFHLW and risks associated with increased modeling uncertainty for this scenario. In addition, risks associated with the aging infrastructure, tanks, and facilities are exacerbated since the mission is 63 years longer. Risks that are new to Scenario 3 include:

- Because soluble species are typically not washed or leached in the Scenario 3 flowsheet, the amount of IHLW produced is dependent on the amount of solids precipitated from the supernate in the tank farms. Therefore, the modeling results are highly dependent on tank farms processes, which are more variable than the set linear flowsheet of the PT Facility and the solubility modeling. As a result, the amount of uncertainty in the Scenario 3 results is much higher than for the Baseline Case, and likely for the other modeled System Plan (Rev. 8) scenarios.\(^{52}\)

- Scenario 3 depends on design (including resolution of outstanding technical issues), construction, and commissioning of the TWCS capability being completed in less than 6 years and the HLW Vitrification Facility being completed in approximately 7 years.

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\(^{52}\) Several studies have evaluated the efficacy of the ISM concerning tank waste. RPP-RPT-58434, *Evaluation of the Integrated Solubility Model Pitzer Parameters*, compared ISM predictions to tank waste simulants at 25°C, 45°C, and 60°C. In RPP-RPT-53089, *Evaluation of the HTWOS Integrated Solubility Model Predictions*, ISM predictions were also compared to existing boil-down and saltcake dissolution data for tank waste. While the ISM does an adequate job of predicting solubility, phosphate salts (which are often limiting to WOL in IHLW in Scenario 3) are a noted area of concern.
Because the mission length is limited by the HLW treatment duration, any delay in startup will result in an equal increase in mission length.

- For the last approximately 40 years of treatment, the GFM predicts an average WOL of five percent for the IHLW product. Because the glass formulation predicted by the GFMs represents the maximum WOL based on the model constraints, the WOL achieved operationally is often several percent lower. Therefore, the amount of glass produced from the Scenario 3 HLW feeds may be higher than predicted by the model, extending the mission.

- At the end of the mission, there is nearly 2 Mgal of concentrated HLW effluent remaining in the TWCS capability that was generated after the completion of the DST operations (i.e., when there was no remaining feed to blend with the effluent). The disposition of this waste stream remains an uncertainty.

- Scenario 3 accelerates the need for a federal geological repository for secure permanent disposal of the IHLW product. Based on a 4,000 IHLW canister capacity for the IHS Facility, the repository will be needed by 2031 versus 2047 for the Baseline Case. If the availability of the repository cannot be accelerated, the IHS Facility will need to be expanded. The repository will also need to have the capacity to accept 63,600 IHLW canisters.

- Pipe routing changes required to support DFHLW operation may complicate design of the WTP Facility. Examples of required changes include adding pipe routings from the TWCS capability to the melter feed preparation vessels, from the effluent collection vessels in the HLW Vitrification Facility to the TWCS capability, and other potential routing changes to divert flush water from the melter feed preparation vessels.

- The chemical composition of DFHLW feed, particularly the increased concentrations of volatile sulfate and halides that build up in the offgas recycle, may decrease the TOE in the HLW Vitrification Facility by shortening the service life of the HLW melters or components of the HLW melters (e.g., bubblers), and may require some redesign. Material upgrades in the HLW Vitrification Facility offgas system may also be required.

- The lack of established waste acceptance criteria for DFHLW feed and the lack of a well-defined flowsheet for the entire DFHLW process (including timing of DST upgrades) means that the feasibility of the projected DFHLW feed sequence in Scenario 3, which the results depend on, is uncertain.
5.4 SCENARIO 4 – RISK-INFORMED SINGLE-SHELL TANK RETRIEvals

5.4.1 Objective/Planning Bases

The purpose of Scenario 4 (Risk-Informed SST Retrievals) is to evaluate the associated cost and mission completion benefits of retrieving 98 percent of the remaining Hanford SST waste radioactivity (Ci) without retrieving all of the SSTs. Table 5-20 identifies the baseline assumptions from Appendix A that were modified for Scenario 4.

Table 5-20. Scenario 4 – Assumptions Altered from the Baseline Case.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 4 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.3.11</td>
<td>49 SSTs, including 11 potential CH-TRU waste SSTs, will not be retrieved. These SSTs have less than or equal to the same amount of radioactivity that has already been left as residual in a retrieved tank (C-106).</td>
</tr>
<tr>
<td>A1.2.3.18</td>
<td>The 11 SSTs planned for CH-TRU waste processing will not be retrieved. These SSTs have less than or equal to the same amount of radioactivity that has already been left as residual in a retrieved tank (C-106).</td>
</tr>
<tr>
<td>A1.4.2.1</td>
<td>There will not be a supplemental TRU waste treatment facility, as no CH-TRU waste SSTs will be retrieved.</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic. TRU = transuranic. SST = single-shell tank.

There are 49 SSTs, including 11 potential CH-TRU waste tanks, that were selected to remain unretrieved based on the radioactivity of the residual in Tank C-106 (131,600 Ci decayed to January 2008), which has completed retrieval. These 49 SSTs each have total radioactivity levels approximately the same or less than Tank C-106. The SSTs to remain unretrieved are listed in Table 5-21.


<table>
<thead>
<tr>
<th>Single-Shell Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-102 BX-107 T-109 TX-113</td>
</tr>
<tr>
<td>B-103 BX-108 T-110 TY-101</td>
</tr>
<tr>
<td>B-104 BX-111 T-111 TY-102</td>
</tr>
<tr>
<td>B-105 BX-112 T-112 TY-104</td>
</tr>
<tr>
<td>B-106 SX-113 T-201 TY-106</td>
</tr>
<tr>
<td>B-107 T-101 T-202 U-101</td>
</tr>
<tr>
<td>B-108 T-102 T-203 U-104</td>
</tr>
<tr>
<td>B-109 T-103 T-204 U-112</td>
</tr>
<tr>
<td>B-112 T-104 TX-103 U-201</td>
</tr>
<tr>
<td>B-201 T-105 TX-107 U-202</td>
</tr>
<tr>
<td>B-202 T-106 TX-108 U-203</td>
</tr>
<tr>
<td>B-203 T-108 TX-109 U-204</td>
</tr>
<tr>
<td>B-204</td>
</tr>
</tbody>
</table>
This scenario is a first look to determine the impact(s) on the mission from not retrieving some SSTs, without consideration of all the risks posed by leaving specific constituents of concern in the tanks. If this initiative is pursued, other criteria for determining the potential SSTs to remain unretrieved should be considered, such as long-lived soluble radionuclides, radioactive cesium and/or technetium content, RCRA metals (e.g., arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver), or tank integrity considerations. The results of this scenario can be used as a starting point from which more detailed risk-informed approaches can be developed.

5.4.2 Flowsheet Description
The simplified flowsheet diagram for Scenario 4 is shown in Figure 5-70. The flowsheet differs from the Baseline Case in that the supplemental CH-TRU waste treatment process is not required, since the potential CH-TRU waste SSTs are not retrieved.

5.4.3 Analysis
5.4.3.1 Schedule Performance
Figure 5-71 shows the operating schedule for the SST retrievals and the treatment facilities in Scenario 4, and Table 5-22 lists the key mission activity dates compared to the Baseline Case. The LAW Vitrification Facility operates for 38 years, compared to 40 years for the Baseline Case, while the PT Facility and HLW Vitrification Facility operate for 28 years, compared to 30 years for the Baseline Case. The mission is essentially 2 years shorter in Scenario 4 versus the Baseline Case. This difference directly relates to a reduction in feed to the integrated WTP in Scenario 4 compared to the Baseline Case due to retrieving fewer SSTs. Although the SST retrievals completed 6 years earlier in Scenario 4 compared to the Baseline Case, the mission only completed 2 years earlier, because WTP throughput is limiting.
Figure 5-70. Scenario 4 – Simplified Flowsheet.
### Figure 5-71. Scenario 4 – Operating Schedule for Major Facilities/Processes.

#### Regulatory
- WMA C Closed (M-045-83)
- Five Retr. Completed (D-16B-03)
- A-103 Retrived (M-045-15)
- Nine Addl Retr. Completed (D-16B-02)
- C-Farm Retr; Completed (D-16B-01)

#### Storage/Retrieval
- CST (Slurry)
- CST (Supernatant)
- East Area WRF
- West Area SST Ret.
- SY-103
- AN-104
- AN-103
- AW-103
- AN-105

#### Pretreatment/Treatment
- LAWPS
- DRE/AR Operations
- LAW Hot Comm. Complete (D-00A-09)
- WTP LAW Verification Facility Operations
- WTP Hot Start (D-00A-17)
- TWCS Capability
- HLW Hot Comm. Complete (D-00A-04)
- WTP HLW Verification Facility Operations
- PT Hot Comm. Complete (D-00A-16)
- WTP Initial Plant Operations (D-00A-01)
- Input – WTP Initial Plant Operations
- LAW Support, Treatment Facility Operations

#### Disposal
- IHS Module 1
- IHS Module 2
- IHS Operations
- HSF Operations
- HLW Shipped Offsite

**Legend**
- Regulatory Due Date
- Regulatory Projected Completion
- Start
- Complemented
- Completed
- HLW Shipped Offsite
- Group A Mitigation Completed
- Insert Date
- Summary Task
- Tank Farms
- WTP
- Supplemental Treatment
- Other
As shown in Table 5-22, the regulatory mission metrics for Scenario 4 are identical to those of the Baseline Case, as are the DFLAW metrics. Not retrieving 49 SSTs does not impact the mission metrics prior to the completion of DFLAW operations because those SSTs are either potential CH-TRU waste tanks or are not retrieved until after the end of DFLAW operations. Other key mission activity dates for Scenario 4, compared with the Baseline Case, are included in Table 5-22.

Table 5-22. Scenario 4 Comparison – Key Mission Activity Dates. (2 pages)
### Table 5-22. Scenario 4 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 4 – Risk-Informed SST Retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP Initial Plant Operations</td>
<td>12/31/2036</td>
<td>12/31/2036</td>
</tr>
<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>N/A</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>7/2061</td>
</tr>
<tr>
<td>IDF Operations</td>
<td>10/2023 – 10/2068</td>
<td>10/2023 – 1/2066</td>
</tr>
<tr>
<td>IHS Facility Operations</td>
<td>1/2034 – 10/2063</td>
<td>1/2034 – 6/2061</td>
</tr>
<tr>
<td>IHS Module 1 Need Date</td>
<td>12/2033</td>
<td>1/2034</td>
</tr>
<tr>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>4/2042</td>
</tr>
<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047 – 12/2065</td>
<td>2/2047 – 8/2063</td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
<td>8/2063</td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>N/A</td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>2/2047</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
CWC = Central Waste Complex.  
DFLAW = direct-feed low-activity waste.  
ETF = Effluent Treatment Facility.  
HLW = high-level waste.  
HSF = Hanford Shipping Facility.  
IDF = Integrated Disposal Facility.  
IHS = Interim Hanford Storage.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
LERF = Liquid Effluent Retention Facility.  
N/A = not applicable.  
PT = Pretreatment.  
SST = single-shell tank.  
TPA = Tri-Party Agreement.  
TWCS = tank waste characterization and staging.  
WMA = waste management area.  
WRF = Waste Receiving Facility.  
WTP = Waste Treatment and Immobilization Plant.

#### 5.4.3.2 Cost

Figure 5-72 shows the lifecycle cost profile for Scenario 4 versus the Baseline Case, along with the escalated cost profiles in the background. The total lifecycle cost estimated for Scenario 4 is $103 billion versus $111 billion for the Baseline Case.

A reduction in the total lifecycle cost over the Baseline Case was anticipated for Scenario 4 since 49 SSTs remain unretrieved. In addition to retrieval costs, 11 potential CH-TRU waste SSTs are not retrieved, which eliminates the need for the supplemental CH-TRU waste treatment process. Not retrieving 38 SSTs otherwise retrieved to the DSTs and treated in the WTP in the Baseline Case results in less waste to be treated through WTP and a shorter mission duration, which translates to reduced costs.

The cost profiles for the Baseline Case and Scenario 4 are nearly identical until 2040, when the profiles begin to deviate. The impact of not retrieving 38 SSTs is not seen until later in the mission, when the SSTs removed from the retrieval pool are retrieved in the Baseline Case. Thereafter, the cost profile for Scenario 4 generally tracks with the Baseline Case, but with some
cost savings realized after 2050 from retrieving fewer SSTs. The majority of the cost savings for Scenario 4 over the Baseline Case are attributed to completing waste treatment and closing tank farms more than 2 years earlier.

Figure 5-72. Scenario 4 Comparison – Lifecycle Cost Profile.

A cost savings of $1.4 billion is realized in Scenario 4 between 2033 and 2058 by not retrieving 38 non-CH-TRU waste SSTs. Although not perceptible in Figure 5-72, elimination of the supplemental CH-TRU waste treatment process and its operations results in a savings of $190 million over 11 years, from 2026 through 2037. In addition, not retrieving the 11 potential CH-TRU waste SSTs results in a cost savings of $300 million between 2029 and 2037, which is also not easily seen in Figure 5-72.

The total escalated cost for Scenario 4 is $205 billion versus $231 billion for the Baseline Case.

5.4.3.3 Mission Flowsheet Results
The model run indicates that leaving 49 SSTs unretrieved results in the SST retrievals completing 6 years earlier for Scenario 4 than for the Baseline Case (see Table 5-22). However, the total mission duration for Scenario 4 is only 2 years shorter than the Baseline Case. This supports the conclusion that the mission duration is limited by the treatment facility throughput and not by SST retrieval completion. The 2-year reduction in mission duration compared to the Baseline Case reflects a reduction in the amount of waste to be processed by not retrieving the
49 SSTs listed in Table 5-21. A further breakdown of the results is provided in the following subsections.

5.4.3.3.1 Single-Shell Tank Retrievals

Figure 5-73 shows the SST retrieval sequence and timing for Scenario 4 compared to the Baseline Case. Since the potential CH-TRU waste SST retrievals do not impact the DSTs or vitrification processes, and Scenario 4 does not include potential CH-TRU waste retrievals, the potential CH-TRU waste tanks are not included in Figure 5-73 for the Baseline Case. The SST retrievals to DSTs follow the same order in Scenario 4 and the Baseline Case until October 2034, when Tank S-107 is chosen for retrieval in Scenario 4 compared to Tank BY-111 for the Baseline Case. Even with changes in retrieval order and some SSTs remaining unretrieved in Scenario 4, the shape of the retrieval curves for the Baseline Case and Scenario 4 remain nearly identical through 2042. From this point onward, the SSTs are retrieved more slowly in Scenario 4 when compared to the Baseline Case, causing the retrieval curves to deviate. The SSTs left unretrieved in Scenario 4 represent relatively small-volume, short-duration retrievals with limited impact to the DST system. These low-impact retrievals inflate the number of SSTs retrieved over time in the Baseline Case when compared to Scenario 4. Scenario 4 still completes the mission earlier than the Baseline Case, because there are fewer tanks to be retrieved. In Scenario 4, the SST retrievals complete in October 2050, 6 years earlier than in the Baseline Case.

Note that the dark bands on the plots indicate when retrieval of the SST is occurring and the lighter colors indicate when the SST is not being retrieved.
Figure 5-73. Scenario 4 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
The number of SSTs retrieved each year for Scenario 4 compared to the Baseline Case is shown in Figure 5-74. Scenario 4 averages two SST retrievals per year and the Baseline Case averages 2.4 SST retrievals through 2041. Starting in 2042, Scenario 4 averages 3.6 retrievals per year versus an average of 4.7 retrievals per year for the Baseline Case. This difference is reflected in the “Cumulative Number of Completed Retrievals” in Figure 5-74, where the total retrievals for Scenario 4 and the Baseline Case begin to deviate more in 2042. The same point of departure is seen in Figure 5-73.

Figure 5-74. Scenario 4 Comparison – Total Single-Shell Tank Retrievals Completed per Calendar Year (Excluding Potential Contact-Handled Transuranic Waste Tanks).
Figure 5-75 shows the historical and projected SST retrieval progress, as measured by the approximate volume of original waste remaining in the SSTs as a function of time. The potential CH-TRU waste SST retrievals are not included in the Baseline Case in this plot to provide a more direct comparison to Scenario 4, which does not include retrieval of potential CH-TRU waste tanks. The average volume retrieved from the SSTs per year is approximately the same as the Baseline Case until Scenario 4 retrievals complete in 2050. Because there are 38 fewer SSTs retrieved, the as-retrieved waste volume is reduced by 25 Mgal versus the Baseline Case. Leaving non-CH-TRU waste SSTs unretrieved in Scenario 4 results in approximately 3.8 Mgal more waste remaining in the SSTs than in the Baseline Case at the end of retrievals. The potential CH-TRU waste SSTs are included in the residual shown for both the Baseline Case and Scenario 4 in this figure, although they were retrieved in the Baseline Case. The actual residual volume remaining in the SSTs in the Baseline Case is approximately 300 kgal.

Figure 5-75. Scenario 4 Comparison – Single-Shell Tank Retrieval Progress (Excluding Potential Contact-Handled Transuranic Waste Tanks).
5.4.3.3.2 Double-Shell Tank Space Management

The utilization of DST space during the waste treatment mission for Scenario 4 is shown in Figure 5-76. The figure depicts the total DST capacity, total volume of waste, and allocations of headspace for purposes other than waste storage (see Table 5-5 in Section 5.1.3.3.2 for the DST space allocation descriptions).

During the DFLAW period (2023 to 2033), DST usage in Scenario 4 is essentially identical to the DST usage in the Baseline Case. Once the TWCS capability starts up in 2032, followed by the integrated WTP in late 2033 and the LAW supplemental treatment facility in late 2034, the available DST space begins to increase, providing space for tank mitigations. The available DST volume reaches a maximum of approximately 9 Mgal in 2038.

Figure 5-76. Scenario 4 – Double-Shell Tank Space Utilization.

Between 2038 and 2046, the inputs into the DSTs outpace the waste volume removed by treatment due to the increase in SST retrieval volume and increased dissolution of precipitated 

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53 The total DST capacity line reflects existing and planned increases in the maximum operating volume of the 241-AP Tank Farm DSTs.
solids (i.e., solids mitigation) additions. After 2046, the available DST space increases after the SST retrievals complete, and then begins to decline as the DSTs close.

The available DST space for Scenario 4 and the Baseline Case are shown in Figure 5-77. Scenario 4 exhibits the same trend as the Baseline Case; however, due to the reduction in SST retrieved volume and changes in SST retrieval sequencing, the magnitude of the available space peaks and valleys differs. In both Scenario 4 and the Baseline Case, the average available DST space over the mission is approximately 5 Mgal.

Figure 5-77. Scenario 4 Comparison – Double-Shell Tank Available Space.

When the ISM was introduced to the model in System Plan (Rev. 7), excess solids were precipitated in the DSTs from 242-A Evaporator operations, potentially creating Group A tanks and limiting the use of the DSTs. Solids mitigation involves dissolution of excess precipitated solids in water to prevent creation of Group A tanks.
Figure 5-78 shows the projected DST transfers for Scenario 4 versus the Baseline Case. In Scenario 4, approximately 1,800 DST transfers are predicted to occur, compared to approximately 2,200 in the Baseline Case. This result of approximately 400 fewer transfers is expected as less waste is retrieved in Scenario 4, resulting in fewer DST transfers. The majority of the difference can be attributed to 220 fewer DST-to-DST transfers, 160 fewer WRF-to-DST transfers, and 20 fewer DST-to-TWCS transfers.

Through 2041, the average number of DST transfers per year is approximately the same; there are 30 DST transfers per year in Scenario 4 compared to 32 DST transfers per year in the Baseline Case. From 2042 to the completion of the mission, there are an average of 53 DST transfers per year in Scenario 4 versus an average of 68 DSTs per year in the Baseline Case. This difference reflects the impact of fewer SST retrievals for Scenario 4 compared to the Baseline Case after 2042, as discussed in Section 5.4.3.3.1.

Figure 5-78. Scenario 4 Comparison – Projected Double-Shell Tank Transfer Demand per Calendar Year.

The transfers into the DST system primarily consist of the retrieved SST waste and a variety of other additions from miscellaneous Hanford facility waste generators, returns during DFLAW operations, water and chemical additions resulting from mitigation of special DST waste, flushes, dilutions, solids mitigation, and the DST closure activities. Figure 5-79 summarizes the approximately 180 Mgal of additions to the DSTs over the mission per calendar year. The volume of additions to the DSTs peak between the years of 2041 and 2050 due to the increase in as-retrieved SST waste and the solids mitigation water additions.
Table 5-23 compares the Scenario 4 and Baseline Case DST additions. Scenario 4 results in 39 Mgal fewer additions than in the Baseline Case. The majority of this savings (65 percent or 25 Mgal) is from retrieving fewer SSTs to the DSTs. The remaining 35 percent (13 Mgal) is from a reduction in the amount of water required to dissolve precipitated solids (solids mitigation).

5.4.3.3.3 Waste Receiving Facilities

In Scenario 4, the B-Complex WRF is projected to be used from 2035 to 2051 and the T-Complex WRF is projected to be used from 2038 through 2048. In the Baseline Case, the B-Complex WRF is projected to be used from 2035 to 2057 and the T-Complex WRF from 2040 to 2050. The shorter durations and earlier
completion dates for Scenario 4 reflect that there are 38 fewer SSTs retrieved to the DSTs than in the Baseline Case.

5.4.3.3.4 242-A Evaporator

Figure 5-80 shows the projected demand on the 242-A Evaporator over the waste treatment mission for Scenario 4 compared to the Baseline Case. In Scenario 4, 182 242-A Evaporator campaigns are required to process about 163 Mgal of waste, reducing the stored volume by about 76 Mgal for the mission duration. In the Baseline Case, 230 campaigns were required to process approximately 206 Mgal of waste, reducing the stored volume by about 99 Mgal. The 43 Mgal reduction in 242-A Evaporator feed for Scenario 4 correlates to the 25 Mgal reduction in as-retrieved waste additions to the DSTs plus the resulting 13 Mgal reduction in solids mitigation water additions, when compared to the Baseline Case (see Table 5-23).

The 242-A Evaporator averages 5.1 campaigns per year over the mission in Scenario 4 versus 5.5 for the Baseline Case; however, 242-A Evaporator operations end 6 years earlier in Scenario 4 due to reduced retrievals. The 242-A Evaporator operations peak between 2041 and 2050, when the average increases to nine campaigns per year with a maximum of 17 campaigns in 2047. The evaporator peaks at 140 days of hot operations in 2047. In contrast, the Baseline Case peaks at 152 days of hot operations.

5.4.3.3.5 Waste Feed Delivery

Scenario 4 meets the ICD-30 feed screening criteria for DFLAW and the ICD-19 feed screening criteria for the LAW Vitrification Facility. However, this scenario does not meet the ICD-19
criteria for the U-fissile-to-U-total ratio in three percent of the feed to the HLW Vitrification Facility. This information can be used to identify blending actions for mitigating the issue if this scenario is implemented.

5.4.3.3.6 Waste Treatment and Immobilization
The Scenario 4 treatment assumptions are the same as the Baseline Case, with the exception of the removal of the supplemental CH-TRU waste treatment process. In addition, in Scenario 4, less waste requires treatment due to leaving the SSTs unretrieved, which results in treatment completing 2 years earlier than in the Baseline Case.

Figure 5-81 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 the radioactive decay over time of the starting inventory. Scenario 4 and Baseline Case operations are essentially identical through DFLAW.

When the HLW Vitrification Facility begins operations, the rate at which the tank farms curies are processed increases for both Scenario 4 and the Baseline Case. However, the rate at which the curies are processed is greater for Scenario 4 than the Baseline Case because low-curie SSTs are not being retrieved, allowing the high-curie tanks to be retrieved earlier. Only 1.5 million curies remain unretrieved in the 49 SSTs, which is barely noticeable in Figure 5-81.
Figure 5-82 shows the simple sodium balance for Scenario 4. There are 78,300 MT of sodium reporting to the ILAW in Scenario 4 compared to 84,100 MT of sodium reporting to the ILAW in the Baseline Case. For both the Baseline Case and Scenario 4, 57 percent of the sodium is from waste and 43 percent is added throughout the process. The majority of the sodium is added in the PT Facility for caustic leaching and to keep aluminum in solution.

The total sodium reporting to ILAW is lower in Scenario 4 compared to the Baseline Case due to fewer SSTs being retrieved, which contain 3,400 MT of sodium. In addition to no longer immobilizing the sodium contained in those tanks, sodium additions are reduced, because the sludge from those tanks is no longer leached in the WTP facilities.
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Figure 5-82. Scenario 4 – Simple Sodium Balance.
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5.4.3.3.6.1 Direct-Feed Waste Treatment

Leaving 49 SSTs unretrieved in Scenario 4 does not impact DFLAW operations relative to the Baseline Case, because the retrieval of those tanks either occurs after DFLAW operations end or are potential CH-TRU waste tanks that are not treated through the LAWPS or the integrated WTP.

5.4.3.3.6.2 Pretreatment Throughput

An average pretreatment throughput of 2,060 MT waste sodium/year and 1,030 MT as-delivered solids/year is achieved in Scenario 4. By comparison, the Baseline Case achieves an average of 2,120 MT waste sodium/year and 1,070 MT as-delivered solids/year. The total pretreatment waste sodium throughput in the Baseline Case is 63,600 MT, compared to 56,800 MT in Scenario 4. Approximately 3,400 MT of sodium remains in the 38 SSTs that were not retrieved to DSTs, which accounts for 50 percent of the difference between the waste sodium in Scenario 4 versus the Baseline Case. As discussed in Section 5.4.3.3.6, approximately 57 percent on average of the sodium reporting to ILAW is from tank waste and 43 percent is added throughout the process, so the remaining difference in pretreatment sodium throughput is due to sodium additions in the tank farms and PT Facility.

The total as-delivered pretreatment solids throughput for the Baseline Case is 31,900 MT, compared to 28,100 MT for Scenario 4. Leaving the SSTs unretrieved results in approximately 3,800 MT less as-delivered solids in Scenario 4 compared to the Baseline Case.

5.4.3.3.6.3 Glass Production

The Scenario 4 glass production metrics are compared against the Baseline Case metrics in Table 5-24. The IHLW and ILAW waste loadings are the same in both Scenario 4 and the Baseline Case; however, in Scenario 4, the IHLW canister production is eight percent less than the Baseline Case. The same trend can be seen with total ILAW container production, which is approximately nine percent less in Scenario 4 than in the Baseline Case. Since the waste loading is approximately the same for the glass, the reduction in containers and canisters relates directly to the reduction in waste sodium and as-delivered solids treated in Scenario 4 when compared to the Baseline Case. Not retrieving the 38 non-CH-TRU waste SSTs results in a 12 percent reduction in solids in the feed to the PT Facility. This reduction in solids fed to the HLW Vitrification Facility (10 percent on a post-leach basis) is consistent with an eight percent reduction in IHLW canisters. The reduction in solids is not expected be identical to the reduction in HLW canisters, as the composition of the solids will impact waste loading.

In addition to a reduction in the as-delivered solids to the PT Facility, not retrieving the 38 non-CH-TRU waste SSTs results in a 3,400 MT (7 percent) reduction in the amount of sodium retrieved from the SSTs. Thus there is a seven percent reduction in the amount of sodium in the ILAW and a nine percent reduction in the number of ILAW containers. As with IHLW, the reduction in sodium is not expected to be identical to the reduction in ILAW containers, as the composition of the LAW feed will impact waste loading.
Table 5-24. Scenario 4 Comparison – Waste Treatment Product Summary.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 4 – Risk Informed SST Retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>7/2061</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>48,400</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>266,700</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass)</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>37,100</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>233,600</td>
<td>204,400</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>21%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Volume (cubic meters)</td>
<td>118,400</td>
<td>103,600</td>
</tr>
<tr>
<td>Total ILAW</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>85,500</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>517,900</td>
<td>471,100</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>MT sodium reporting to LAW</td>
<td>84,100</td>
<td>78,300</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (grout)</td>
<td>Grout product (yd³)</td>
<td>419,200</td>
<td>389,400</td>
</tr>
<tr>
<td></td>
<td>Waste Na₂O equivalent (%)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
<td>7,800</td>
<td>7,200</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>23,600</td>
<td>21,700</td>
</tr>
<tr>
<td></td>
<td>Waste loading</td>
<td>44%</td>
<td>43%</td>
</tr>
</tbody>
</table>

IHLW = immobilized high-level waste.  
ILAW = immobilized low-activity waste.  
LAW = low-activity waste.  
SST = single-shell tank.  
WTP = Waste Treatment and Immobilization Plant.

Figure 5-83 compares the projected IHLW production for Scenario 4 and the Baseline Case against the net capacity assumption for both cases from the HLW Vitrification Facility. Figure 5-84 and Figure 5-85 do likewise for the projected LAW and LAW supplemental treatment production, respectively. In Scenario 4, as in the Baseline Case, the net capacities of the HLW Vitrification Facility, LAW Vitrification Facility, and LAW supplemental treatment facility are each assumed to be 70 percent of their respective design capacities (see assumptions in Appendix A for additional details).

The net capacity assumption is the same for both cases, so the net capacity lines in Figure 5-83 are overlaid. With the Baseline Case producing more IHLW than Scenario 4, the mission is longer, which is reflected in the gray extension of the theoretical net capacity line.

In Scenario 4, the HLW throughput is slightly higher than the Baseline Case early in production, indicating that more HLW feed is available in Scenario 4 on startup of the HLW Vitrification Facility. After that, the production curves for Scenario 4 and the Baseline Case essentially parallel one another until just prior to the end of the mission in Scenario 4, when the rate of HLW glass production declines. Scenario 4 HLW glass production completes approximately
2 years prior to completion in the Baseline Case. There is less HLW to process through the HLW Vitrification Facility in Scenario 4 than the Baseline Case from not retrieving 38 SSTs.

Figure 5-83. Scenario 4 Comparison – Projected Immobilized High-Level Waste Production.
The projected WTP ILAW production for Scenario 4 and the Baseline Case against the net capacity assumption for both cases is shown in Figure 5-84. The net capacity assumption is the same for both cases, so the net capacity lines are overlaid. With the Baseline Case producing more ILAW than Scenario 4, the mission is longer, which is reflected by the gray extension of the theoretical net capacity line.

The actual throughput for Scenario 4 and the Baseline Case are identical, so the lines are overlaid, much the same as the theoretical capacity lines. With the Baseline Case producing more glass than Scenario 4, the mission is also about 2 years longer, which is reflected in the blue extension of the actual throughput line.

Figure 5-85 compares the projected LAW supplemental treatment facility ILAW production for Scenario 4 and the Baseline Case against the theoretical capacity assumption for both cases. The theoretical capacity assumption is the same for both cases, so the theoretical capacity lines are overlaid. With the Baseline Case producing more ILAW (at the LAW supplemental treatment facility) than Scenario 4, the mission is longer, which is reflected by the gray extension of the theoretical net capacity line.

The actual LAW supplemental treatment throughput for Scenario 4 and the Baseline Case are nearly identical until 2051. In 2052 for Scenario 4 and 2053 for the Baseline Case, the LAWPS shuts down and the SST retrievals are complete or nearly complete. At this point, LAW supplemental treatment throughput decreases because the only source of feed is the PT Facility.
5.4.3.3.6.4 Supplemental Immobilization – Grout

If feed to the LAW supplemental treatment facility is grouted rather than vitrified, there will be approximately 389,400 yd$^3$ of grout with approximately eight percent equivalent Na$_2$O loading for Scenario 4. This is compared to 37,100 LAW glass containers, which is equivalent to 103,600 yd$^3$ of glass with a waste loading of 22 percent Na$_2$O.

For the Baseline Case, 419,200 yd$^3$ of grout with an eight percent equivalent Na$_2$O loading will be produced, compared to 42,400 LAW glass containers, which is equivalent to 118,400 yd$^3$ of glass with 21 percent Na$_2$O loading.

The reduced amount of grout that produced in Scenario 4 compared to the Baseline Case is consistent with the reduction in retrieved sodium, as discussed in Section 5.4.3.3.6.3.

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55 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 2.7924 yd$^3$ of ILAW per container.
5.4.3.3.6.5 Liquid Effluent Retention Facility

In Scenario 4, there is a 72 Mgal reduction in the amount of radioactive dangerous liquid effluent predicted to be treated by ETF compared to the Baseline Case. Table 5-25 shows the distribution of feed sources to LERF over the mission for Scenario 4 compared to the Baseline Case.

Table 5-25. Scenario 4 Comparison – Distribution of Feed to the Liquid Effluent Retention Facility.

<table>
<thead>
<tr>
<th>Source Facility</th>
<th>Scenario 1 – Baseline Case (Mgal)</th>
<th>Scenario 4 (Mgal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>242-A Evaporator condensate</td>
<td>133</td>
<td>102</td>
</tr>
<tr>
<td>WTP EMF</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>LAW supplemental treatment to LERF</td>
<td>170</td>
<td>153</td>
</tr>
<tr>
<td>WTP to LERF</td>
<td>194</td>
<td>174</td>
</tr>
<tr>
<td>Supplemental TRU waste</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>547</strong></td>
<td><strong>475</strong></td>
</tr>
</tbody>
</table>

EMF = Effluent Management Facility.
LAW = low-activity waste.
LERF = Liquid Effluent Retention Facility.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

The 72 Mgal reduction is due to a 31 Mgal reduction in 242-A Evaporator condensate, an approximate 17 Mgal reduction in secondary waste from the LAW supplemental treatment facility, a 20 Mgal reduction in secondary waste from the integrated WTP, and a 4 Mgal reduction in condensate from supplemental TRU waste treatment, as Scenario 4 does not include a separate supplemental TRU waste treatment process.

5.4.3.3.6.6 Potential Contact-Handled Transuranic Treatment

In Scenario 4, unlike the Baseline Case, the potential CH-TRU waste SSTs are not retrieved and the supplemental CH-TRU treatment is not needed.

5.4.3.3.7 Impacts on Closure Activities

The cost profile estimates the closure dates from the SSTs and DSTs by driving a schedule, reflecting the baseline and closure strategies and logic, with the individual SST retrieval dates and DST final use dates projected by the TOPSim model. In the Baseline Case, all SSTs are projected to be retrieved by December 2056 and closed by February 2061. In Scenario 4, SST retrievals are projected to be complete by October 2050 and closed by December 2054.

Therefore, in Scenario 4, the SSTs are retrieved and closed 6 years earlier than in the Baseline Case because 49 SSTs are not retrieved. An implicit assumption in Scenario 4 is that the 49 SSTs are closed as-is. The risks associated with this assumption are addressed in Section 5.4.3.5.

After the completion of the bulk retrieval of the last SST, the critical path includes tank-specific and WMA closure activities. Note that although the SSTs complete retrieval and are closed 6 years earlier in Scenario 4 compared to the Baseline Case, the DSTs complete retrieval and closure only 2 years earlier in Scenario 4 compared to the Baseline Case. This is because the HLW treatment is throughput-limited, and the duration of the mission is highly dependent on the quantity and composition of the solids to be treated. As stated in Section 5.4.3.3.6, not retrieving the waste in 38 non-CH-TRU waste SSTs results in an eight percent reduction in the quantity of IHLW canisters. Operating the HLW Vitrification Facility over 30 years results in an approximate 2-year reduction in mission duration.
5.4.3.4 Opportunities

In Scenario 4, earlier retrieval of higher-risk SSTs (in terms of radioactivity) reduces the impact of potential SST breaches. In addition, the cost of the mission is reduced by $26 billion due to not retrieving 49 SSTs with low radioactivity, including 11 potential CH-TRU waste tanks, and because the supplemental CH-TRU waste treatment is not needed.

Additional opportunities to explore the impact of risk-informed SST retrievals on the mission duration and cost, similar to Scenario 4, exist such as:

- The potential to reduce the number of WRF tanks could be explored, as many of the B and T Farm SSTs are not being retrieved in Scenario 4, although the impact on the lifecycle cost would be small (<0.01 percent).
- The potential exists to expand the SST selection criteria:
  - Include more tanks to reduce treatment mass
  - Select tanks that reduce or eliminate LAW supplemental treatment
  - Include partial retrieval of the SSTs.
- The potential exists to revise the SST selection criteria:
  - Select tanks based on composition of key radionuclides such as long-lived soluble radionuclides, cesium, or technetium
  - Select tanks based on composition of RCRA metals or other chemicals of concern.

5.4.3.5 Risks

In Scenario 4, 11 potential CH-TRU waste and 38 non-CH-TRU waste SSTs are assumed to remain unretrieved and can be closed as-is. The waste volumes remaining in the tanks pose a risk in that the tanks will likely require special considerations and processes to meet land disposal requirements and for safely closing those tanks. A Scenario 4 assumption is that no additional cost or time will be required to close the tanks.

In total, 1.4 Mgal and 30,000 Ci remain in the potential CH-TRU waste SSTs, and 3.8 Mgal and 1.45 million curies remain in the 38 non-CH-TRU waste SSTs. Of the 49 SSTs that were not retrieved in this scenario, Tank TX-113 has the greatest volume (640 kgal) and Tank TX-103 has the highest curie count (139,000 Ci). In total, the 49 SSTs contain 1.48 million curies (decayed to January 1, 2008).
5.5 SCENARIO 5 – ACCELERATED RETRIEVAL COMPLETION

5.5.1 Objective/Planning Bases

The objective of Scenario 5 (Accelerated Retrieval Completion) is to complete all SST waste retrievals by June 2047. The target date of June 2047 was agreed to as being the midpoint between the current TPA milestone date of December 31, 2040 (M-045-70) and the anticipated target date for retrieval completion in the Baseline Case (RPP-RPT-60302, Summary of Meeting Minutes for ORP-11242, Revision 8, River Protection Project System Plan, Process Development). The pathway to accomplish this was to determine the number of new DSTs required and their associated timing and placement within the mission duration. The basis for Scenario 5 is the same as the Baseline Case except for a change in DST operations. Table 5-26 identifies the baseline assumptions from Appendix A that were modified for Scenario 5.

Table 5-26. Scenario 5 – Assumptions Altered from the Baseline Case.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 5 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.2.1</td>
<td>New DSTs (in multiples of four) in operation on June 2028 (based on a decision to build in June 2020 and an 8-year lead time) (ORP-11242, Rev. 6,* Section 10.6).</td>
</tr>
<tr>
<td></td>
<td>Additional DSTs (in multiples of four) to be placed in operation every 5 years after June 2028 based on retrieval needs to complete all retrievals by June 2047.</td>
</tr>
<tr>
<td>A1.2.2.2</td>
<td>New DSTs will have an operating volume of 1.25 Mgal each.</td>
</tr>
</tbody>
</table>


DST = double-shell tank.

The new DSTs discussed in this scenario are equipped with dual mixer pumps without incremental insertion capability, slurry pumps, and decant pumps, and have an operating capacity of 1.25 Mgal each. The new DSTs are connected to the DST transfer system by three transfer lines (each presumably constructed of 3-inch 304L stainless steel in 6-inch carbon steel) and a new diversion box that intercepts the transfer lines from the nearest valve pit. The new DSTs will be located in the 200 West Area and/or the 200 East Area.

5.5.2 Flowsheet Description

The simplified flowsheet diagram for Scenario 5 is the same as that shown in Figure 5-1 (Section 5.1) for the Baseline Case. There are no changes to the flowsheet, with the exception of new, additional DSTs within the 200 West Area and/or the 200 East Area tank farms, already pictured in the Baseline Case diagram within the tank farms.

5.5.3 Analysis

5.5.3.1 Schedule Performance

Figure 5-86 shows the operating schedule for the SST retrievals and the treatment systems in this accelerated retrieval completion scenario, and Table 5-27 lists the key mission activity dates compared to the Baseline Case.
Scenario 5 – Accelerated Retrieval Completion

Figure 5-86. Scenario 5 – Operating Schedule for Major Facilities/Processes.

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>16</th>
<th>2021</th>
<th>2026</th>
<th>2031</th>
<th>2036</th>
<th>2041</th>
<th>2046</th>
<th>2051</th>
<th>2056</th>
<th>2061</th>
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<tbody>
<tr>
<td>Regulatory</td>
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<tr>
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</tbody>
</table>

Legend
- Regulatory Due Date
- Regulatory Projected Completion
- Start
- Completed
- Completions
- Group A Mitigation Completed
- NDA Date
- Summary Task
- Tank Farms
- Supplemental Treatment
- WTP
- Other Contractor

2026 WMA C Closed (M-045-83)
- Modelled - WMA C Closed (M-045-83)
- Five Retr. Completed (D-168-03)
- Modelled - Five Retr. Completed (D-168-03)
- A-103 Retr. Completed (M-045-15)
- Nine Add'l Retr. Completed (D-168-02)
- Modelled - Nine Add'l Retr. Completed (D-168-02)
- C-Farm Retr. Completed (D-168-01)
- Modelled - C-Farm Retr. Completed (D-168-03)
Scenario 5 – Accelerated Retrieval Completion

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### Table 5-27. Scenario 5 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metrics</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 5 – Accelerated Retrieval Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete C Tank Farm Retrievals (existing TPA 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td>Complete Five Additional SST Retrievals (existing Consent Decree 12/31/2020)</td>
<td>4/2019</td>
<td>4/2019</td>
</tr>
<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
<td>5/2022</td>
<td>5/2022</td>
</tr>
<tr>
<td>Complete Tank A-103 retrieval (existing TPA 9/30/2022)</td>
<td>11/2022</td>
<td>11/2022</td>
</tr>
<tr>
<td>WMA C Closed (existing TPA 6/30/2019)</td>
<td>6/2028</td>
<td>6/2028</td>
</tr>
<tr>
<td><strong>Storage/Retrieval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 East Area WRF Operational</td>
<td>1/2035</td>
<td>1/2033</td>
</tr>
<tr>
<td>200 West Area WRF Operational</td>
<td>4/2040</td>
<td>8/2033</td>
</tr>
<tr>
<td>200 West Area SST Retrievals Complete</td>
<td>4/2055</td>
<td>9/2046</td>
</tr>
<tr>
<td>200 East Area SST Retrievals Complete</td>
<td>12/2056</td>
<td>3/2046</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Supernate)</td>
<td>9/2025</td>
<td>9/2025</td>
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<tr>
<td>Cross-Site Transfer Line Activated (Slurry)</td>
<td>7/2025</td>
<td>7/2025</td>
</tr>
<tr>
<td>Start of Four Simultaneous Retrievals</td>
<td>1/2035</td>
<td>1/2033</td>
</tr>
<tr>
<td>Tank AN-103 Group A Mitigation Complete</td>
<td>9/2032</td>
<td>6/2026</td>
</tr>
<tr>
<td>Tank AN-104 Group A Mitigation Complete</td>
<td>6/2025</td>
<td>6/2025</td>
</tr>
<tr>
<td>Tank AN-105 Group A Mitigation Complete</td>
<td>1/2033</td>
<td>12/2029</td>
</tr>
<tr>
<td>Tank AW-101 Group A Mitigation Complete</td>
<td>10/2032</td>
<td>6/2029</td>
</tr>
<tr>
<td>Tank SY-103 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>10/2023</td>
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<tr>
<td><strong>Pretreatment/Treatment</strong></td>
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<tr>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>TWCS Capability Start</td>
<td>6/2032</td>
<td>6/2032</td>
</tr>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
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<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
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<tr>
<td>HLW Vitrification Facility Operations</td>
<td>12/2033 – 8/2063</td>
<td>12/2033 – 2/2064</td>
</tr>
<tr>
<td>WTP Initial Plant Operation</td>
<td>12/31/2036</td>
<td>12/2036</td>
</tr>
<tr>
<td>Potential CH-TRU Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2036</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>3/2064</td>
</tr>
</tbody>
</table>
The differences in the key mission metrics from the Baseline Case are largely due to the addition of three new DST farms:

- Twelve new DSTs in the 200 West Area in 2028
- Twelve DSTs in the 200 East Area in 2033
- Eight new DSTs in the 200 East Area in 2038.

The addition of new DSTs enables earlier retrievals in the B and T Complex tank farms, which brings forward the operational need dates for the 200 East and 200 West Area WRFs. All SST retrievals are completed by September 2046, compared to December 2056 in the Baseline Case. The 200 East Area SSTs are retrieved by March 2046 (compared to December 2056 in the baseline), and 200 West Area SSTs are retrieved by September 2046 (compared to April 2055).

While the SST-retrieved waste is available earlier in the DSTs for waste treatment operations, the treatment mission duration for Scenario 5 is nearly the same as the Baseline Case, even though the SST retrievals are completed 10 years earlier than the baseline. This is primarily because the mission duration is limited by treatment throughput. Interim storage onsite is similar to the Baseline Case, and offsite shipping operations and the need date for the federal geological repository deviate slightly from the Baseline Case (2049 in Scenario 5 versus 2047 in the Baseline Case).
The 242-A Evaporator is shut down 8 years earlier in Scenario 5, compared to the Baseline Case (2049 versus 2057), due to accelerated SST retrievals and additional DST space. The completion dates for Group A mitigation tanks are also provided in the table, and are each within 2 years of the respective Baseline Case completion dates. The date for the “Start of Four Simultaneous Retrievals” is approximately 2 years earlier in Scenario 5 (2033 versus 2035) due to the availability of DST space for the retrieved SST waste.

5.5.3.2 Cost

Figure 5-87 shows the lifecycle cost profile for this scenario compared to the Baseline Case. The total lifecycle cost estimated for Scenario 5 is $117 billion ($239 billion escalated), while the Baseline Case is $111 billion ($231 billion escalated)—almost four percent higher than the Baseline Case. The largest difference is the construction, operation, and closeout of the new DSTs required for this scenario occurring in the years 2020 to 2035. The total cost for 12 new DSTs in the 200 West Area is estimated to be $4 billion (escalated), of which approximately $700 million is required for operations, and $300 million is required for tank and farm closures. The total cost for 20 new DSTs in the 200 East Area is estimated to be $10 billion (escalated), with approximately $2 billion for operations and $460 million for tank and farm closures. However, Scenario 5 contains a reduction of $3 billion (escalated) in base operations costs and $3 billion (escalated) in the SST retrieval and closure costs due to the completion of the SST retrievals 10 years earlier, in the years 2048 to 2061.
The costs for new DSTs in this scenario were based on an estimate developed originally as part of the Project W-236 (Cost to Construct New DST Farm) in the 1993/1994 timeframe. The estimate was updated in 2015 to include 304L stainless steel materials of construction and a full tank farm weather-enclosure building with an overhead maintenance crane. However, current design and construction technologies will be considered for any new DSTs constructed on the Hanford Site. While the timeline for SST retrievals is accelerated in this scenario by the addition of new DSTs, the assumptions on the SST retrieval rates and simultaneous retrievals remain the same as the Baseline Case (see Assumption A1.2.3.3), which includes no more than two simultaneous retrievals per area, not including the SSTs containing potential CH-TRU waste.

5.5.3.3 Mission Flowsheet Results

The Scenario 5 results show that accelerated SST retrievals can be accomplished before June 2047 with the construction of 32 new DSTs, 12 in the 200 West Area and 20 in the 200 East Area. The approach used to determine the number, timing, and location of new DSTs required was a process of trial-and-error with a variety of tank configurations (multiples of four tanks in either the 200 East Area or the 200 West Area in 2028, 2033, 2038, or 2043), with the target being the SST retrieval completion date on or before June 2047. The first set of DSTs was determined to be required in the 200 West Area in 2028, where two-thirds of the SST volume is located. After that, no additional DSTs are needed in the 200 West Area, although up to 20 new DSTs are required in 200 East Area to meet the SST retrieval target date, while retaining the same assumptions for the retrieval rate and simultaneous retrievals as the Baseline Case. While retrieval of all the SSTs can be accelerated by 10 years, the mission duration is slightly longer, which leads to the conclusion that the RPP mission duration is limited by treatment throughput and not by SST retrieval capabilities. The results are described in more detail in the following subsections.

5.5.3.3.1 Single-Shell Tank Retrievals

The SST retrieval sequence is shown in Figure 5-88 for Scenario 5 and compared with the Baseline Case. The dark bands on the plots indicate when retrieval of the SST is occurring, and the lighter colors indicate when the SST is not being retrieved. This figure shows that Scenario 5 eliminates most of the delay time after 2028 when the first set of new DSTs become operable, leading to a 62 percent less delay time than the Baseline Case.\textsuperscript{56} There is some delay time evident in Scenario 5 between 2033 and 2035 for two tanks in B Tank Farm; however, this was found to be a lack of optimization in the model where the retrieval was slated for a specific DST and was therefore required to wait for availability of that DST. Further optimization of the model may reduce the delay times even more in this scenario.

\textsuperscript{56} The delay time is considered after 241-A and 241-AX Tank Farms retrievals have been completed.
Figure 5-88. Scenario 5 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
Figure 5-89 and Figure 5-90 show the number of SSTs retrieved each year in comparison with the Baseline Case. The total number of SST retrievals and the volume of retrieved waste are the same for both cases; in Scenario 5, retrievals are accelerated by 10 years due to the addition of new DSTs. Figure 5-89 shows the number of SST retrievals by year for both the Baseline Case and Scenario 5, and Figure 5-90 shows the SST retrieval progress as the total SST waste volume remaining in the SSTs over time. The progress for both scenarios are the same until 2028, when the first new DSTs are placed into operation. After the new DSTs begin operating, retrievals are accelerated until the SST retrievals are completed, 10 years earlier than the Baseline Case.

Figure 5-89. Scenario 5 Comparison – Total Single-Shell Tanks Retrieved per Calendar Year.
5.5.3.3.2 Double-Shell Tank Space Management

Managing DST space is essential to accomplishing the SST retrieval target date of June 2047. The addition of new DSTs supports this objective. In this scenario, the first new DST farm consists of 12 tanks located in the 200 West Area that are fully integrated with the rest of the DST transfer system. The 200 West Area was chosen for the first new DSTs because the SSTs in this area contain approximately two-thirds of the remaining retrieval volume and take longer to retrieve. The new farm is scheduled to be operational July 1, 2028. The new DST farm project activities are assumed to begin in 2020 and include an estimated 8 years of design, construction, and commissioning (ORP-11242, Rev. 6, Section 10.6). The next new DST farm consists of 12 tanks located in the 200 East Area. This second farm is fully integrated with the rest of the DST transfer system and is scheduled to be operational July 1, 2033. The third new farm adds an additional eight tanks in the 200 East Area. This farm is fully integrated with the rest of the DST transfer system and is scheduled to be operational July 1, 2038.

Figure 5-91 shows the utilization of the existing and new DST space for the waste treatment mission in this scenario. The figure shows the total DST capacity, total volume of waste, and various allocations of headspace for purposes other than waste storage (see Table 5-4 [Section 5.1.3.3.2] for DST space allocation descriptions). The total capacity is initially 32 Mgal from the existing DSTs and 31 Mgal when Tank AY-102 retrieval is completed. As the new DSTs begin operating, the capacity increases by approximately 15 Mgal in 2028 (first set of new DSTs), then increases about another 15 Mgal in 2033 (second set of new DSTs), and about another 10 Mgal in 2038 (third set of new DSTs), to a maximum of 71 Mgal. The DST closures
begins around 2042, and from that point on, the available DST space is reduced as the DSTs are closed and removed as available space.

Figure 5-91. Scenario 5 – Double-Shell Tank Space Utilization.

Figure 5-92 shows just the available space portion of the DSTs for Scenario 5 compared to the Baseline Case. In Scenario 5, the “peaks” in the figure point to the new DSTs becoming operable in 2028, 2033, and 2038. The downsides of the peaks show the new DSTs filling up and subsequently emptying just as quickly as waste is transferred to the WTP for treatment. From 2028 through 2041, the DST available space appears to be above that necessary to achieve the goal of this scenario. However, Figure 5-93, Figure 5-94, and Figure 5-95 show the new DSTs are continually filled and emptied; therefore, the abundance of available DST space is in appearance only. Figure 5-93 shows the first set of new DSTs in the 200 West Area in 2028. Figure 5-94 shows the next set of new DSTs in the 200 East Area in 2033, and Figure 5-95 shows the last set of new DSTs in the 200 East Area in 2038.
Figure 5-92. Scenario 5 Comparison – Double-Shell Tank Available Space.
Figure 5-93. Scenario 5 – First New Set of Double-Shell Tanks in the 200 West Area in 2028.
Figure 5-94. Scenario 5 – Second New Set of Double-Shell Tanks in the 200 East Area in 2033.
Figure 5-95. Scenario 5 – Third New Set of Double-Shell Tanks in the 200 East Area in 2038.
Numerous DST transfers occur to support staging of feed for the LAWPS and the WTP, the cross-site transfer lines, and other DSTs. Figure 5-96 shows the numbers of DST transfers in Scenario 5 compared to the Baseline Case. There are 337 more DST-to-DST transfers in Scenario 5, resulting in a 15 percent increase from the Baseline Case. A breakdown of the types of transfers in this scenario and comparisons to the Baseline Case are provided in Table 5-28. The majority of additional DST transfers in Scenario 5 are DST-to-DST transfers, likely due to the 32 new DSTs and the necessity of moving waste among the DSTs to meet the accelerated SST retrieval completion target date.

Figure 5-96. Scenario 5 Comparison – Double-Shell Tank Transfers.
## Table 5-28. Scenario 5 Comparison – Double-Shell Tank Transfers.

<table>
<thead>
<tr>
<th>Transfer</th>
<th>Baseline Case</th>
<th>Scenario 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Transfers</td>
<td>Percentage of Total</td>
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<tr>
<td>DST to WTP</td>
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<td>0.9</td>
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<tr>
<td>DST to TWCS</td>
<td>199</td>
<td>9.1</td>
</tr>
<tr>
<td>DST to DST (Cross-Site)</td>
<td>145</td>
<td>6.6</td>
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<tr>
<td>WRF to DST</td>
<td>652</td>
<td>29.7</td>
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<tr>
<td>DST to DST</td>
<td>1,180</td>
<td>53.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,196</strong></td>
<td><strong>53.7</strong></td>
</tr>
</tbody>
</table>

DST = double-shell tank.  
TWCS = tank waste characterization and staging.  
WRF = Waste Receiving Facility.  
WTP = Waste Treatment and Immobilization Plant.

### 5.5.3.3 Waste Receiving Facilities

For Scenario 5, the B-Complex WRF in the 200 East Area has a start date of 2033, approximately 2 years earlier than the Baseline Case. The T-Complex WRF in the 200 West Area has a start date of 2033, 7 years earlier than the Baseline Case. The WRFs are required earlier to meet the accelerated retrieval schedule in this scenario.

### 5.5.3.4 242-A Evaporator

Figure 5-97 shows the projected demand on the 242-A Evaporator over the waste treatment mission for Scenario 5, compared to the Baseline Case. The 242-A Evaporator is expected to process about 188 Mgal of waste, reducing the stored volume by about 87 Mgal for the mission duration—only 12 percent less than the Baseline Case. There is an average of 6.2 campaigns per year over the mission for Scenario 5, compared to an average of 5.5 campaigns per year for the Baseline Case. However, 242-A Evaporator operations end 8 years sooner in Scenario 5, thus lowering the processed volume compared to the Baseline Case. The 242-A Evaporator operations peak between 2037 and 2045, when the average increases to 12 campaigns per year, with a maximum of 17 campaigns per year after all 32 new DSTs have started operating and SST retrievals are continuing. The evaporator peaks at 144 days of hot operations in 2045. In contrast, the Baseline Case peaks at 152 days of hot operations. Scenario 5 has more available DSTs, and therefore, uses the 242-A Evaporator slightly less due to a reduced amount of mitigation water added to the DSTs to precipitate solids. In this scenario, approximately 20 Mgal of water are added for solids mitigation, compared to 37 Mgal of water in the Baseline Case—a reduction of 47 percent.
5.5.3.3.5 Waste Treatment and Immobilization

This section presents the production metrics of the WTP for Scenario 5 and compares the metrics to those for the Baseline Case. Table 5-29 shows that Scenario 5 is the same as the Baseline Case in the timing and duration and associated product output of waste treatment operations. Therefore, waste treatment operations are largely unaffected by the acceleration in the SST retrievals due to the construction of new DSTs.

Table 5-29. Scenario 5 Comparison – Waste Treatment Product Summary. (2 pages)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 5 – Accelerated Retrieval Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>3/2064</td>
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<tr>
<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
<td>7,800</td>
<td>8,000</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>23,600</td>
<td>24,200</td>
</tr>
<tr>
<td></td>
<td>Waste loading</td>
<td>44%</td>
<td>43%</td>
</tr>
<tr>
<td>Total ILAW</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>93,900</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>518,000</td>
<td>517,500</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>MT sodium reporting to LAW</td>
<td>84,100</td>
<td>83,300</td>
</tr>
</tbody>
</table>
### Table 5-29. Scenario 5 Comparison – Waste Treatment Product Summary. (2 pages)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 5 – Accelerated Retrieval Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>52,000</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>286,700</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment ILAW (glass)</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>41,900</td>
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<tr>
<td></td>
<td>MT of product</td>
<td>233,600</td>
<td>230,800</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Volume (yd³)</td>
<td>118,400</td>
<td>117,000</td>
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<tr>
<td>LAW Supplemental Treatment (grout)</td>
<td>Product (yd³)</td>
<td>419,200</td>
<td>412,600</td>
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<tr>
<td></td>
<td>Waste Na₂O equivalent (%)</td>
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<td>8</td>
</tr>
<tr>
<td>CH-TRU Waste</td>
<td>Number of packages</td>
<td>8,396</td>
<td>8,396</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
IHLW = immobilized high-level waste.  
ILAW = immobilized low-activity waste.  
LAW = low-activity waste.  
MT = metric ton.  
WTP = Waste Treatment and Immobilization Plant.

Figure 5-98 depicts the tank farms radioactive inventory over the course of the mission for Scenario 5, compared to the Baseline Case. Note that the figure accounts for radioactive decay of the starting inventory over time—the remaining radioactivity is decayed to the date it is reported. The general trend is that the tank farms radioactive inventory decreases as waste is delivered to the WTP and radioactive decay proceeds. The trend in tank farms radioactive inventory over the mission is mostly indistinguishable from the Baseline Case. Because the mission is treatment-limited, expediting the SST retrievals does not expedite the rate that radioactivity is immobilized (although the radioactivity is moved into RCRA-compliant DST storage earlier). As in the Baseline Case, nearly all immobilized radioactivity is segregated to the IHLW product, which contains 98 percent of the immobilized curies.
5.5.3.3.5.1 Glass Production

Figure 5-99 compares the projected IHLW production for Scenario 5 and the Baseline Case against the theoretical capacity assumption for both cases from the HLW Vitrification Facility. The theoretical capacity assumption is the same for both cases, so the theoretical capacity lines are overlaid for both scenarios on the plot. The glass production rate from Scenario 5 follows the Baseline Case closely, with little deviation. The resulting canisters of IHLW produced is effectively the same as the Baseline Case, about 8,000 canisters.
Figure 5-99. Scenario 5 – Projected Immobilized High-Level Waste Glass Production.

Figure 5-100 compares the projected ILAW production for Scenario 5 and the Baseline Case against the theoretical capacity assumption from the LAW Vitrification Facility. The theoretical capacities of the WTP facilities are assumed to be 70 percent of their respective design capacities, as explained in the Baseline Case. The theoretical lines for both scenarios are overlaid on top of each other, as there is no deviation. For the projected ILAW, the line exactly mirrors the Baseline Case, both expecting to produce about 52,000 ILAW containers. This is due to the same amount of tank waste retrieved from the SSTs, and the same waste treatment operations for both scenarios.
The LAW supplemental treatment facility immobilizes the excess pretreated LAW feed from the LAWPS, provided there is feed available, and excess pretreated LAW feed from the WTP. Because this is excess LAW feed, there are times of slowdown, when there is not enough feed for the supplemental treatment facility to operate at its maximum capacity. Figure 5-101 shows the projected ILAW production from the supplemental treatment facility in this scenario compared to the Baseline Case. The figure shows that due to the accelerated SST retrievals in this scenario, there is an abundance of feed to the supplemental treatment facility from 2040 through 2049. Starting in 2050, glass production in the supplemental treatment facility slows considerably as there is less feed available (more feed was processed earlier through the facility). From 2050 through 2064, the average rate of glass production drops to 9 MTG/day. The supplemental treatment facility in Scenario 5 and the Baseline Case is sized with four melters for a total capacity of 42 MTG/day (after 70 percent TOE, see Assumption A1.4.1.5). While Scenario 5 has more feed earlier than the Baseline Case, both end up with approximately the same volume of containers at about the same time.
5.5.3.3.5.2 **Supplemental Immobilization – Grout**

If the feed to LAW supplemental treatment is grouted, rather than vitrified, there will be approximately 412,600 yd\(^3\) of grout with approximately eight percent equivalent Na\(_2\)O loading for Scenario 5. This is compared to 42,000 LAW glass containers, which is equivalent to 117,000 yd\(^3\) of glass\(^57\) with a waste loading of 21 percent Na\(_2\)O.

For the Baseline Case, 419,200 yd\(^3\) of grout with an eight percent equivalent Na\(_2\)O loading will be produced, compared to 42,400 LAW glass containers, which is equivalent to 118,400 yd\(^3\) of glass with 21 percent Na\(_2\)O loading.

5.5.3.3.6 **Impacts on Closure Activities**

With the SSTs retrieved earlier in Scenario 5, all of the SST tank farms in the 200 East and West Areas can be closed from 6 to 11 years earlier than in the Baseline Case. The largest impact on closure activities is the cleanout and closure of 32 additional DSTs. The initial closure of the existing DSTs begins in 2050 and continues through 2069. Closure of the new DSTs in the 200 West Area is from 2050 to 2054, while closure of the new DSTs in the 200 East Area starts in 2062 through 2066. The closures of DST tank farms are comparable to the Baseline Case, closing around the same time due to the treatment-limiting throughput of WTP.

\(^{57}\) 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 2.7924 yd\(^3\) of ILAW per container.
5.5.3.4 Opportunities

The management of DST space is one of the key issues and uncertainties in the Baseline Case because the PMB assumes that improvements in DST space management will support the projected SST retrieval schedule (see Section 5.1.3.3.2). The DST space management in this scenario is improved by the increased storage capacity offered from the construction of additional DSTs. This increased available DST space allows for rapid transfers and the flexibility to easily stage evaporator campaigns while keeping the DST receiver tanks empty and allowing continued SST retrievals. This approach is what eliminates most of the SST retrieval delay time seen in the Baseline Case. Given the assumed minimum SST retrieval durations, there can be little to no added delay due to waiting for DST space availability after 2028 in this scenario, if the target SST retrieval completion date is to be met.

This scenario could be considered a contingency planning scenario. Having the new DSTs provides operational flexibility and risk reduction during the RPP mission. Retrieving the SSTs as soon as possible reduces the risk of future leaks to the environment while allowing closure of the SST WMAs and, thereby, reducing the risk of past leaks. The potential for future leaking of the current, aging DSTs could seriously affect SST retrievals if no new DSTs are available. This is especially true in the 200 West Area, where there are currently only three DSTs. Finally, if there is significant delay or reduction in waste treatment, the SST retrievals can still be completed, tank waste can be stored in new DSTs with improved longevity, and a large fraction of the risk to human health and the environment will have been eliminated.

Another opportunity with the construction of new DSTs is the flexibility of location within the respective 200 East or 200 West Areas. In this scenario, the model places the new DSTs relatively close to existing DST farms. An opportunity exists to site the new 200 East Area DSTs closer to the B Complex and the new 200 West Area DSTs closer to the T Complex so that construction of the WRFs can be eliminated and the new DSTs can be used in that capacity. This approach has the potential to reduce the lifecycle cost of Scenario 5 by over $588 million.

The last DST tank farm to be constructed on the Hanford Site was AP Tank Farm (1982 to 1986), which is in the 200 East Area. The costs for new DSTs in this scenario were based on an estimate developed originally as part of the Project W-236 (Cost to Construct New DST Farm) in the 1993/1994 timeframe and escalated more than 20 years. The estimate was updated in 2015 to include 304L stainless steel materials of construction and a full tank farm weather enclosure building with an overhead maintenance crane. An opportunity in this scenario is to evaluate new technology and improvements in DST design and infrastructure to better suit the current understanding of RPP mission needs. There are also more regulations now regarding construction and operations than in the past, so a new design can incorporate up-to-date requirements for increased safety of workers and the public. The construction and regulatory environment is different now versus the early 1990s. Factors based on “estimator judgment” were used to approximate those impacts. While this cost basis is a risk, there is an opportunity in Scenario 5 to provide a detailed estimate for new DSTs based on current information.

The 242-A Evaporator operates less aggressively in this scenario because of additional DST space and less required solids mitigation water. This slight reduction in operations can help mitigate the impact of interruptions or outages on 242-A Evaporator operations. A future
opportunity in this scenario is to operate the 242-A Evaporator more aggressively, or at least as much as the Baseline Case, which will potentially reduce the number of new DSTs required to achieve the target date for the SST retrieval completion.

In Scenario 5, the strategy for providing tank waste to the vitrification facilities is the same as the Baseline Case. This allows for a more accurate comparison of the goal to achieve accelerated SST retrieval completion. **Intentional blending** of the tank waste for feed delivery has the potential to provide a more consistent feed for delivery to the waste treatment facilities, which can be accomplished in this scenario due to the flexibility of having additional DST space (e.g., more waste available, ability to move and blend feed of different waste types for consistency). The result of a more consistent, blended waste feed to the WTP could result in higher waste loading in the glass, producing fewer glass canisters and containers.

Finally, during the years of low glass production due to less available feed, several LAW supplemental treatment facility melters could potentially be shutdown, saving on electrical costs for the facility after 2050. As currently modeled, the total production of LAW supplemental treatment ILAW containers in this scenario is effectively the same as in the Baseline Case; however, the LAW supplemental treatment facility production rate is significantly reduced in the last approximately 10 years in this scenario.

5.5.3.5 **Risks**

The largest risks with Scenario 5 is the cost and schedule constraints and potential for delays in the construction of 32 new DSTs. The decision to construct the new DSTs must be made in 2020 to allow sufficient time for permitting, design, and construction by the specified operating date of July 1, 2028, which must be met to complete the SST retrievals by June 2047. In addition, with another 12 DSTs to be constructed and operational in the 200 East Area by 2033 and then another eight by 2038, capital and operating budgets must remain in place. Another risk concerning the new DSTs is the additional costs and time required to maintain RCRA compliance, meet maintenance and surveillance requirements, and cleanout and close the 32 new DSTs. While the results show that the mission duration is largely unaffected, unforeseen delays and complications will multiply with 32 additional DSTs when compared to the Baseline Case. In addition, as discussed in Section 5.5.3.4, the cost estimate for the construction of the new DSTs is based on unknown and aged historical references.
5.6 SCENARIO 6 – TRI-PARTY AGREEMENT COMPLIANT

5.6.1 Objective/Planning Bases

The objective of Scenario 6 (TPA Compliant) is to calculate the SST retrieval and treatment capacities required to meet the TPA milestones for retrieving all SST waste by December 31, 2040 and treating all tank waste by December 31, 2047. The calculations completed to evaluate Scenario 6 are documented in RPP-RPT-60174, Calculation Report for Scenario 6 of ORP-11242, Office of River Protection System Plan. This scenario calculates the average SST retrieval rate required to complete the SST retrievals by the TPA milestone date. Four sensitivity analyses are explored to examine a potential range of the new DSTs required to support completion of SST retrievals by the TPA milestone date through changing different variables related to retrievals.

This scenario also explores the extent to which pretreatment and HLW and LAW treatment throughputs need to be increased to treat all tank waste by the TPA milestone date. The majority of assumptions that form the planning basis for this scenario are the same as the Baseline Case. Table 5-30 identifies the baseline assumptions from Appendix A that were modified for Scenario 6.

Table 5-30. Scenario 6 – Assumptions Altered from the Baseline Case.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 6 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.2.1 New DSTs (in multiples of four) are in operation by January 1, 2028.</td>
<td></td>
</tr>
<tr>
<td>A1.2.3.3 Simultaneous retrieval constraints resulting from infrastructure or operational considerations are not enforced.</td>
<td></td>
</tr>
<tr>
<td>A1.3.3.2 There is no ramp-up for the HLW Vitrification Facility. The facility operates 5 years at a maximum rate of 4.2 MTG/day, and 9 years at a maximum rate of 5.25 MTG/day.</td>
<td></td>
</tr>
<tr>
<td>A1.3.4.5 There is no ramp-up for the LAW Vitrification Facility. The facility operates 24 years at a maximum rate of 21.0 MTG/day.</td>
<td></td>
</tr>
<tr>
<td>N/A All SST waste is retrieved by December 31, 2040.</td>
<td></td>
</tr>
<tr>
<td>N/A All tank waste treatment is complete by December 31, 2047.</td>
<td></td>
</tr>
<tr>
<td>DST = double-shell tank.</td>
<td>N/A = not applicable.</td>
</tr>
<tr>
<td>HLW = high-level waste.</td>
<td>SST = single-shell tank.</td>
</tr>
<tr>
<td>LAW = low-activity waste.</td>
<td>WTP = Waste Treatment and Immobilization Plant.</td>
</tr>
<tr>
<td>MTG = metric ton of glass.</td>
<td></td>
</tr>
</tbody>
</table>

All of the new DSTs discussed herein would be equipped with dual mixer pumps without incremental insertion capability, slurry pumps, and decant pumps, and would have an operating capacity of 1.25 Mgal each. They would be connected to the DST transfer system by three transfer lines (each presumably constructed of 3-inch 304L stainless steel in 6-inch carbon steel) and a new diversion box that would intercept transfer lines from the nearest valve pit. The new DSTs would be located in the 200 West Area and/or the 200 East Area.

While these new DSTs represent a significant change to site infrastructure, their construction is assumed to not require any technology development as the most recently constructed tank farm, AP Tank Farm, will likely serve as a primary template for design of the new farms.
5.6.2 Flowsheet Description

The simplified flowsheet diagram for Scenario 6 is the same as that shown in Figure 5-1 (Section 5.1.2) for the Baseline Case. There are no changes to the flowsheet; new, additional DSTs are within the 200 West Area and/or the 200 East Area tank farms that are pictured in the Baseline Case diagram.

5.6.3 Analysis

This section evaluates the results of Scenario 6 modeling. The schedule and mission flowsheet results are presented in the subsections below.

5.6.3.1 Schedule Performance

Table 5-31 details a comparison of the key mission activity dates between the Baseline Case and Scenario 6. This scenario was not modeled using TOPSim; therefore, many mission metric dates are not evaluated. Treatment start dates and supporting infrastructure availability are consistent with the Baseline Case.

Table 5-31. Scenario 6 Comparison – Key Mission Activity Dates.

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 6 – TPA Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete C Tank Farm Retrievals (existing Consent Decree 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td><strong>Storage/Retrieval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SST Retrievals Complete</td>
<td>12/2056</td>
<td>12/2040</td>
</tr>
<tr>
<td><strong>Pretreatment/Treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>TWCS Capability Start</td>
<td>6/2032</td>
<td>6/2032</td>
</tr>
<tr>
<td>PT Facility Operations</td>
<td>12/2033 – 11/2063</td>
<td>12/2033 – 12/2047</td>
</tr>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
</tr>
<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>HLW Vitrification Facility Operations</td>
<td>12/2033 – 8/2063</td>
<td>12/2033 – 12/2047</td>
</tr>
<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2036</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>12/2047</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.
DFLAW = direct-feed low-activity waste.
HLW = high-level waste.
LAW = low-activity waste.
LAWPS = Low-Activity Waste Pretreatment System.
PT = pretreatment.
SST = single-shell tank.
TPA = Tri-Party Agreement.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.
5.6.3.2  Cost
A lifecycle cost profile was not performed for this scenario as the scenario was not modeled using TOPSim.

5.6.3.3  Mission Flowsheet Results
The calculations completed for Scenario 6 indicate that the average SST retrieval rate needs to be accelerated by 1.7 times the average SST retrieval rate observed in the Baseline Case. The calculations also reveal that treatment capacities need to be doubled. In addition, treating all tank waste is limited by the LAW treatment capacity and, under the Baseline Case configuration, would not be possible to accomplish by the TPA milestone date of December 31, 2047. Table 5-32 shows a comparison of the key calculation results between the Baseline Case and Scenario 6. The following subsections present the detailed mission flowsheet results for each system evaluated in this scenario and for each of the sensitivity analyses.

Table 5-32. Scenario 6 Comparison – Key Results.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 6 – TPA Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST retrieval completion</td>
<td>12/2056</td>
<td>12/2040</td>
</tr>
<tr>
<td>WTP treatment completion</td>
<td>11/2063</td>
<td>12/2047</td>
</tr>
<tr>
<td>Average as-retrieved SST waste retrieval rate (Mgal/year)</td>
<td>3.4</td>
<td>5.7</td>
</tr>
<tr>
<td>Average 242-A Evaporator (campaigns/year)</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Average Na PT* Facility throughput (MT/year)</td>
<td>2,115</td>
<td>4,540</td>
</tr>
<tr>
<td>Average solids throughput (MT/year)</td>
<td>1,060</td>
<td>2,280</td>
</tr>
<tr>
<td>Average IHLW throughput (MTG/day)</td>
<td>2.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Average ILAW throughput (MTG/day)</td>
<td>35.5</td>
<td>59.1</td>
</tr>
</tbody>
</table>

* Represents the PT Facility design requirement that the facility has a treatment capacity to process 2,620 MT waste sodium per year. In this context, waste sodium is defined in the WTP Contract to include sodium in the delivered LAW feed, 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.

5.6.3.3.1  Single-Shell Tank Retrievals
Table 5-33 lists the average yearly retrieval rate required to retrieve all remaining SSTs by December 31, 2040 compared to the corresponding yearly average retrieval rate for the Baseline Case. Scenario 6 will need to retrieve the 121 remaining SSTs 16 years earlier than the retrieval completion date observed for the Baseline Case. SSTs containing potential CH-TRU waste are excluded from the remaining SSTs to be retrieved in this scenario because those SSTs are successfully retrieved to supplemental treatment prior to the TPA milestone date in the Baseline Case.
Table 5-33. Scenario 6 Comparison – Single-Shell Tank Retrievals.

<table>
<thead>
<tr>
<th>SST Retrieval Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 6 – TPA Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST retrievals complete</td>
<td>12/2056</td>
<td>12/2040</td>
</tr>
<tr>
<td>Number of SST retrievals remaining on 1/1/2018 (excluding potential CH-TRU waste)</td>
<td>121</td>
<td>121</td>
</tr>
<tr>
<td>Average number of SST retrievals per year</td>
<td>3.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Original SST waste (Mgal)</td>
<td>26.5</td>
<td>26.5</td>
</tr>
<tr>
<td>As-retrieved SST waste (Mgal)</td>
<td>131</td>
<td>131</td>
</tr>
<tr>
<td>Average original SST waste per year (Mgal/year)</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Average as-retrieved SST waste per year (Mgal/year)</td>
<td>3.4</td>
<td>5.7</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic. TPA = Tri-Party Agreement. SST = single-shell tank.

The average effective rate of the SST retrievals calculated for Scenario 6 is 1.7 times the average effective SST retrieval rate observed for the Baseline Case. The average retrieval rate calculated for Scenario 6 may be feasible, as the total minimum retrieval duration (taking into account the minimum retrieval duration for each SST and assuming no more than four simultaneous retrievals total, regardless of area) will take approximately 13 years. However, this timeframe assumes a consistent retrieval rate for the duration, which is likely not feasible due to the DST space limitations early in the mission.

Scenario 6 assumes that any new DSTs built will be available on January 1, 2028, and until that time, DST space is limited, resulting in fewer SST retrievals until the new DSTs become available. Therefore, the average SST retrieval rate for the first 10 years (2018 to 2027) will be much lower than the average presented in Table 5-33, which requires an increase in the average retrieval rate for the remaining 13 years (2028 to 2040). Assuming the DST space available prior to 2028 is equal to the available DST space on January 1, 2018 (4.6 Mgal), the average as-retrieved volume retrieval rate required for the first 10 years is 1.3 Mgal/year, and after 2027 increases to 9.1 Mgal/year. These theoretical retrieval rates for Scenario 6 are depicted with the Baseline Case annual completed retrievals in Figure 5-102. Based on the Baseline Case SST retrieval sequence, 13 SSTs will be retrieved in the first 10 years. The remaining 108 SSTs will then have to be retrieved in the last 13 years to meet the TPA milestone for completing retrievals. The increased rate of retrievals required, when considering early limitations in the DST space, significantly decreases the likelihood of achieving retrieval completion by the TPA milestone date without changing the current SST retrieval constraints regarding the number of simultaneous retrievals.
### 5.6.3.3.2 Double-Shell Tank Space Management

The ability to achieve accelerated retrieval rates is dependent on the DST space available to support the retrievals. The amount of available DST space at any given time throughout the mission depends primarily on 242-A Evaporator operations (to concentrate dilute waste contained in the DST system), treatment operations (to send waste forward from the DST system for treatment activities), and various waste and/or water additions to the DST system (e.g., for flushes, waste returns during DFLAW operations, mitigation activities). To determine the number of new DSTs required to support completing the SST retrievals by the TPA milestone date, the following sensitivity analyses were evaluated with varying assumptions to understand the factors that most contribute to creating available space in the DST system:

- **Scenario 6a** – No concentration of as-retrieved SST waste, no credit for treatment
- **Scenario 6b** – Concentrate as-retrieved SST waste, no credit for treatment
- **Scenario 6c** – No concentration of as-retrieved SST waste, credit for treatment through December 31, 2040
- **Scenario 6d** – Concentrate as-retrieved SST waste, credit for treatment through December 31, 2040.
Table 5-34 summarizes the results for each of the sensitivity analyses. The total as-retrieved waste received into the DST system is approximately 131 Mgal. The post-evaporative volume of the received SST waste (assuming concentration to 1.43 SpG using the 242-A Evaporator) is approximately 44.4 Mgal. The analyses take into account the DST space that is available as of January 15, 2018 (observed in the Baseline Case). The sensitivity analyses also assume that any new DSTs will be available to receive waste starting on January 1, 2028.

Table 5-34. Scenario 6 Sensitivities – Results Summary.

<table>
<thead>
<tr>
<th>Sensitivity Metric</th>
<th>Scenario 6a – Pre-Evaporator – No Treatment Credit</th>
<th>Scenario 6b – Post-Evaporator – No Treatment Credit</th>
<th>Scenario 6c – Pre-Evaporator – with Treatment Credit</th>
<th>Scenario 6d – Post-Evaporator – with Treatment Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total as-retrieved SST waste (Mgal)</td>
<td>131</td>
<td>44.4</td>
<td>131</td>
<td>44.4</td>
</tr>
<tr>
<td>Additions to DSTs through 12/31/2056 (Mgal)</td>
<td>27</td>
<td>64.2</td>
<td>45.2</td>
<td>82.5</td>
</tr>
<tr>
<td>Available DST space on 1/15/2018 (Mgal)</td>
<td>4.6</td>
<td>4.6</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Volume treated through 12/31/2040 (Mgal)</td>
<td>-</td>
<td>-</td>
<td>50.7</td>
<td>50.7</td>
</tr>
<tr>
<td>Additional DST space required after 12/31/2027 (Mgal)</td>
<td>153.6</td>
<td>104</td>
<td>121.1</td>
<td>71.5</td>
</tr>
<tr>
<td>Additional DSTs required to support retrievals</td>
<td>123</td>
<td>84</td>
<td>97</td>
<td>58</td>
</tr>
<tr>
<td>Number of DST four-packs required</td>
<td>31</td>
<td>21</td>
<td>25</td>
<td>15</td>
</tr>
</tbody>
</table>

*The volume treated comprises waste transfers from DSTs to the LAWPS, the TWCS capability, and the PT Facility.

DST = double-shell tank.
LAWPS = Low-Activity Waste Pretreatment System.
PT = pretreatment.
SST = single-shell tank.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

To account for other activities affecting DST space during SST retrievals, additions to the DST system relevant to each of the sensitivities is included in the evaluation. Additions to the DSTs are based on the results from the Baseline Case. Since the SST retrievals are completed in December 2056 in the Baseline Case, the waste additions to the DSTs up to that time are included, as the same additions are assumed to occur during the SST retrievals for these analyses. Table 5-35 presents the types and amounts of additions introduced into the DST system through December 2056 for the Baseline Case, and which additions are included or excluded for the sensitivities analyzed.
Table 5-35. Scenario 6 Sensitivities – Volume of Double-Shell Tank Additions.

<table>
<thead>
<tr>
<th>Addition Type</th>
<th>Scenario 6a – Pre-Evaporator – No Treatment Credit</th>
<th>Scenario 6b – Post-Evaporator – No Treatment Credit</th>
<th>Scenario 6c – Pre-Evaporator – with Treatment Credit</th>
<th>Scenario 6d – Post-Evaporator – with Treatment Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste generators (Mgal)</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>Special DST waste mitigation (Mgal)</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Sludge dilution (Mgal)</td>
<td>8.8</td>
<td>8.8</td>
<td>8.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Flushes (Mgal)</td>
<td>13.1</td>
<td>13.1</td>
<td>13.1</td>
<td>13.1</td>
</tr>
<tr>
<td>Solids mitigation (Mgal)</td>
<td>-</td>
<td>37.3</td>
<td>-</td>
<td>37.3</td>
</tr>
<tr>
<td>LAWPS/WTP EMF additions and returns (Mgal)</td>
<td>-</td>
<td>-</td>
<td>18.2</td>
<td>18.2</td>
</tr>
<tr>
<td><strong>Total Additions (Mgal)</strong></td>
<td><strong>27</strong></td>
<td><strong>64.2</strong></td>
<td><strong>45.2</strong></td>
<td><strong>82.5</strong></td>
</tr>
</tbody>
</table>

DST = double-shell tank.

EMF = Effluent Management Facility.

LAWPS = Low-Activity Waste Pretreatment System.

Solids mitigation additions are not included in the total additions to the DST system in Scenarios 6a and 6c because the water added is primarily for solids mitigation resulting from waste concentrated using the 242-A Evaporator, and these sensitivity analyses omit 242-A Evaporator use. Similarly, the LAWPS and WTP EMF additions and returns are not included in the total additions for Scenarios 6a and 6b because these sensitivities assume no treatment activities.

The first two sensitivities (Scenarios 6a and 6b) assume that no treatment activities occur during the SST retrievals, so SST waste is entering the DST system and no waste is leaving the DST system for treatment. The primary difference between the first two sensitivities, depicted in Figure 5-103 and Figure 5-104, respectively, is that Scenario 6a evaluates the DST space required to receive the as-retrieved waste on a pre-evaporative basis, while Scenario 6b evaluates the DST space required to receive the as-retrieved waste assuming that the 242-A Evaporator is available as needed to concentrate the waste received (to a SpG of 1.43).

The second set of sensitivity analyses (Scenarios 6c and 6d) conservatively take into account treatment activities that occur during the SST retrievals through December 31, 2040. Similar to the first two sensitivities, the primary difference between the second two sensitivities, depicted in Figure 5-105 and Figure 5-106, respectively, is that Scenario 6c evaluates the DST space required to receive the as-retrieved waste on a pre-evaporative basis, and Scenario 6d on a post-evaporative basis.

Results from the sensitivity analyses illustrate that the availability of the 242-A Evaporator, combined with the space generated by waste treatment, plays a vital role in reducing the number of new DSTs required to support the SST retrievals. When neither of these space-creating factors is included in the flowsheet, as in Scenario 6a, 31 four-packs of new DSTs are required to support SST retrievals. The number of new DST four-packs is reduced by half when the
242-A Evaporator and treatment are included in the flowsheet. Therefore, based on the sensitivities analyzed, sensitivity Scenario 6d results in the least amount of new DSTs (60 or 15 four-packs) that are needed to support completing the SST retrievals by the TPA milestone date of December 31, 2040.

Figure 5-103. Scenario 6 Sensitivity 6a – Double-Shell Tank Additions.
Figure 5-104. Scenario 6 Sensitivity 6b – Double-Shell Tank Additions.

Figure 5-105. Scenario 6 Sensitivity 6c – Double-Shell Tank Additions.
5.6.3.3.3 242-A Evaporator

The 242-A Evaporator operates for 23 years in Scenario 6 to support continued SST retrievals. Table 5-36 illustrates that an average of approximately three additional campaigns per year over the average campaigns per year observed for the Baseline Case are needed to concentrate the as-retrieved SST waste during retrieval operations for Scenario 6. However, the average number of annual campaigns does not consider near-term DST space limitations. When space limitations for the first 10 years are considered, the average number of campaigns, after new DSTs become available, must increase to accommodate the increased SST retrieval rate required. The annual number of campaigns required after 2027 increases to 13.7 campaigns per year to support concentrating the as-retrieved SST waste.
Table 5-36. Scenario 6 Comparison – 242-A Evaporator Operations.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 6 – TPA Compliant</th>
<th>Scenario 6 – Considering Early DST Space Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average annual WVR (Mgal/year)</td>
<td>2.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.0&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average WVR per campaign (gal/campaign)</td>
<td>439,000</td>
<td>439,000</td>
<td>439,000</td>
</tr>
<tr>
<td>Average annual campaigns (campaigns/year)</td>
<td>5.5</td>
<td>8.6</td>
<td>13.7</td>
</tr>
</tbody>
</table>

<sup>a</sup> 242-A Evaporator operating years = 40 (2018–2057)
<sup>b</sup> 242-A Evaporator operating years to support SST retrievals = 23 (2018–2040)
<sup>c</sup> 242-A Evaporator operating years to support SST retrievals = 13 (2028–2040)

DST = double-shell tank.  
SST = single-shell tank.  
TPA = Tri-Party Agreement.  
WVR = waste volume reduction.

Figure 5-107 provides a graphical representation of the annual campaigns for the Baseline Case compared to the weighted averages calculated for Scenario 6. The lower average number of 242-A Evaporator campaigns prior to 2028 calculated for Scenario 6 compared to the Baseline Case, and the difference in total accumulated WVR, is attributed to the evaporator concentrating other dilute waste in the Baseline Case that is not included in the calculations for Scenario 6. Assuming a typical campaign has a processing time of 10 days to 2 weeks requires the 242-A Evaporator to operate approximately 137 to 192 days per year for the last 13 years to support SST retrievals. This approach may not be feasible due to the RCRA permit limit of a maximum 182 hot operating days per year.
5.6.3.3.4 Waste Treatment and Immobilization

This section presents the production metrics of the integrated WTP for Scenario 6 and discusses the mission duration drivers.

5.6.3.3.4.1 Pretreatment Throughput

To meet the TPA milestone of December 31, 2047 to treat all tank waste, the WTP will need to process all waste sodium in 24 years, and all as-delivered solids will need to be processed in 14 years. This processing rate equates to a 16-year acceleration in treatment completion compared to the Baseline Case completion date of 2063. Table 5-37 presents average throughput amounts for sodium and solids (excluding initial facility ramp-ups) for the Baseline Case and Scenario 6.

The average PT Facility sodium throughput (assuming the same LAWPS sodium throughput) will need to be more than doubled versus the average in the Baseline Case. The sodium throughput calculated exceeds the PT Facility design capacity of 2,620 MT waste sodium per year by 73 percent. Similarly, the results show that the solids throughput will also need to be more than doubled to process all solids by the TPA milestone. The increased solids throughput calculated is over two times the PT Facility design capacity of 860 MT of as-delivered feed solids per year.
Table 5-37. Scenario 6 Comparison – Sodium and Solids Throughput.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 6 – TPA Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average sodium throughput, PT Facility only&lt;sup&gt;a&lt;/sup&gt; (MT/year)</td>
<td>2,115&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4,540</td>
</tr>
<tr>
<td>Total average sodium throughput&lt;sup&gt;b&lt;/sup&gt; (MT/year)</td>
<td>2,020</td>
<td>3,440</td>
</tr>
<tr>
<td>Average solids throughput (MT/year)</td>
<td>1,060&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2,280</td>
</tr>
</tbody>
</table>

<sup>a</sup> Represents the PT Facility design requirement that the facility has a treatment capacity to process 2,620 MT waste sodium per year. 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.

<sup>b</sup> Includes sodium sent to the PT Facility and the LAWPS.

<sup>c</sup> Average excludes initial ramp-up of associated facilities.

The treatment capacities calculated for Scenario 6 do not support treating all tank waste by December 31, 2047. There may be an opportunity to make up for limited treatment capacity by starting facilities earlier, which may also decrease the total number of additional DSTs needed. However, the facility start dates in the current Amended Consent Decree (2016) do not support the on-time completion of TPA milestones.

5.6.3.3.4.2 Glass Production

Table 5-38 shows the average production rates for IHLW and ILAW for Scenario 6 and the Baseline Case. Weighted average theoretical throughput rates were also calculated for Scenario 6. The theoretical IHLW throughput is calculated by multiplying the first generation melter rate by the number of years the HLW Vitrification Facility operates at that rate, adding that to the product of second-generation melters and the number of years the facility operates at that rate, then dividing by the total number of treatment years. A similar method was used to calculate the theoretical weighted throughput for the combined production rates of the LAW Vitrification Facility and the LAW supplemental treatment facility.

Table 5-38. Scenario 6 Comparison – Average Glass Production.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 6</th>
<th>Scenario 6 – Theoretical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average IHLW production (MTG/day)</td>
<td>2.2</td>
<td>4.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Average combined ILAW production (MTG/day)</td>
<td>35.5</td>
<td>59.1</td>
<td>43.8</td>
</tr>
</tbody>
</table>

The average rate required for IHLW production is more than twice the average rate observed in the Baseline Case, and the average rate required for ILAW production is greater than the theoretical rate. The Baseline Case uses four melters for the LAW supplemental treatment facility operating at a net capacity of 42 MTG/day. To accommodate the increased LAW throughput, the LAW supplemental treatment facility will need to have seven melters operating
at a net capacity of 73.5 MTG/day. Therefore, given the Baseline Case facility ILAW production capacities and the Amended Consent Decree assumed start dates, treating all tank waste by the TPA milestone date is not possible.

5.6.3.3.5 Impacts on Closure Activities
The largest impact to closure activities for Scenario 6 is the cleanout and closure of a minimum of 60 additional DSTs.

5.6.3.4 Opportunities
The primary opportunity related to the results and associated risks observed in Scenario 6 is to renegotiate the TPA milestones dates to align more closely with current planning and the Amended Consent Decree (2016) dates.

5.6.3.5 Risks
The primary risks with Scenario 6 are the cost and schedule constraints and the potential for delays in the construction of 60 new DSTs. The decision to construct the new DSTs must be made in 2020 to allow sufficient time for permitting, design, and construction by the specified starting date of January 1, 2028 (similar to the risk discussion for Scenario 5, Section 5.5.3.5), which must be met to support completing the SST retrievals by the TPA milestone date of December 31, 2040. Another risk associated with the new DSTs is the additional costs and time required to maintain RCRA compliance and to clean out and close the 60 new DSTs.

Other risks associated with meeting the TPA milestone date for completing SST retrievals are (1) the ability to retrieve SST waste at the rate needed when additional DSTs become available, without affecting key SST retrieval constraints, and (2) the ability of the 242-A Evaporator to support the increased SST retrieval rates without exceeding the RCRA permit maximum hot operating days per year.

The primary risk associated with meeting the TPA milestone for treating all tank waste by December 31, 2047, is the ability of the treatment facilities (PT Facility, HLW and LAW Vitrification Facilities, and the LAW supplemental treatment facility) to support the increased treatment capacities required assuming the current facility start dates under the Amended Consent Decree (2016).
5.7 SCENARIO 7 – REDUCED THROUGHPUT

5.7.1 Objective/Planning Bases

The purpose of Scenario 7 (Reduced Throughput) is to evaluate the impacts of lower-than-anticipated waste retrieval and treatment rates on the mission. This scenario also consists of two sensitivity runs that evaluate each aspect separately:

- Scenario 7A – Reduced Retrieval Rates Only
- Scenario 7B – Reduced Treatment Throughput Rates Only.

For Scenario 7, the SST retrieval durations were increased by a factor of 2.5,\(^{58}\) and the WTP facilities and LAW supplemental treatment rates were adjusted to 50 percent of design capacity instead of 70 percent as in the Baseline Case. Table 5-39 identifies the baseline assumptions from Appendix A that were modified for Scenario 7.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 7 Assumption</th>
<th>Applied to Scenario 7A</th>
<th>Applied to Scenario 7B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.1.1.5</td>
<td>The SST minimum retrieval durations were increased by a factor of 2.5 for all SSTs after A/AX Tank Farms instead of a factor of 1.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A1.3.1.3</td>
<td>The integrated TOE of the WTP is assumed to be 50% instead of 70%.</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>A1.3.3.2</td>
<td>The HLW Vitrification Facility ramp rates were adjusted to reach a maximum of 50% TOE:</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Starting on</td>
<td>Rate (MTG/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/2033</td>
<td>2.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/2034</td>
<td>2.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/2036</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/2038</td>
<td>3.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1.3.4.5</td>
<td>The LAW Vitrification Facility ramp rates were adjusted to reach a maximum of 50% TOE:</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Starting on</td>
<td>Rate (MTG/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/2021</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/31/2022</td>
<td>13.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/31/2023</td>
<td>15.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{58}\) The value of 2.5 is based on a comparison of the predicted durations from RPP-PLAN-40145, Rev. 6 (the revision that was current prior to retrieval completion) and actual durations for Tanks 241-C-101, 241-C-102, 241-C-104, 241-C-105, 241-C-107, and 241-C-112.
Table 5-39. Scenario 7 – Assumptions Altered from the Baseline Case. (2 pages)

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 7 Assumption</th>
<th>Applied to Scenario 7A</th>
<th>Applied to Scenario 7B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.4.1.5</td>
<td>The LAW supplemental treatment facility ramp rate was adjusted to a maximum of 50% TOE:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 12/31/2034 – 50% of Baseline Case 100% rate, which is 30 MTG/day.</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLW</td>
<td>high-level waste.</td>
</tr>
<tr>
<td>LAW</td>
<td>low-activity waste.</td>
</tr>
<tr>
<td>MTG</td>
<td>metric ton of glass.</td>
</tr>
<tr>
<td>SST</td>
<td>single-shell tank.</td>
</tr>
<tr>
<td>TOE</td>
<td>total operating efficiency.</td>
</tr>
<tr>
<td>WTP</td>
<td>Waste Treatment and Immobilization Plant.</td>
</tr>
</tbody>
</table>

5.7.2 Flowsheet Description

The simplified flowsheet diagram for Scenario 7 is the same as that shown in Figure 5-1 (Section 5.1.2) for the Baseline Case. In Scenario 7, the retrieval rates and treatment rates are reduced; however, the flowsheet remains the same as the Baseline Case.

5.7.3 Analysis

5.7.3.1 Schedule Performance

Figure 5-108 shows the operating schedule for SST retrievals and the treatment facilities for Scenario 7, and Table 5-40 lists the key mission activity dates. The LAW Vitrification Facility operates for 57 years, compared to 40 years for the Baseline Case, while the PT Facility and HLW Vitrification Facility operate for 47 years, compared to 30 years for the Baseline Case. The SST retrievals and mission lengths are 17 years longer in Scenario 7 versus the Baseline Case. The extended operations and mission in Scenario 7 compared to the Baseline Case relate directly to the increase in SST retrieval durations, coupled with the reduction in treatment throughput.
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Figure 5-108. Scenario 7 – Operating Schedule for Major Facilities/Processes.
Table 5-40. Scenario 7 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 7 – Reduced Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete C Tank Farm Retrievals (existing Consent Decree 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td>Complete Five Additional SST Retrievals (existing Consent Decree 12/31/2020)</td>
<td>4/2019</td>
<td>4/2019</td>
</tr>
<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
<td>5/2022</td>
<td>5/2022</td>
</tr>
<tr>
<td>Complete A-103 (existing TPA 9/30/2022)</td>
<td>11/2022</td>
<td>11/2022</td>
</tr>
<tr>
<td>WMA C Closed (existing TPA 6/30/2019)</td>
<td>6/2028</td>
<td>6/2028</td>
</tr>
<tr>
<td><strong>Storage/Retrieval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 East Area WRF Operational</td>
<td>1/2035</td>
<td>1/2035</td>
</tr>
<tr>
<td>200 West Area WRF Operational</td>
<td>4/2040</td>
<td>12/2042</td>
</tr>
<tr>
<td>200 West Area SST Retrievals Complete</td>
<td>4/2055</td>
<td>3/2074</td>
</tr>
<tr>
<td>200 East Area SST Retrievals Complete</td>
<td>12/2056</td>
<td>4/2065</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Supernate)</td>
<td>9/2025</td>
<td>1/2026</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Slurry)</td>
<td>7/2025</td>
<td>11/2025</td>
</tr>
<tr>
<td>Start of Four Simultaneous Retrievals</td>
<td>1/2035</td>
<td>1/2035</td>
</tr>
<tr>
<td>Tank AN-103 Group A Mitigation Complete</td>
<td>9/2032</td>
<td>9/2032</td>
</tr>
<tr>
<td>Tank AN-104 Group A Mitigation Complete</td>
<td>6/2025</td>
<td>11/2025</td>
</tr>
<tr>
<td>Tank AN-105 Group A Mitigation Complete</td>
<td>1/2033</td>
<td>3/2034</td>
</tr>
<tr>
<td>Tank AW-101 Group A Mitigation Complete</td>
<td>10/2032</td>
<td>8/2033</td>
</tr>
<tr>
<td>Tank SY-103 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td><strong>Pretreatment/Treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>TWCS capability Start</td>
<td>6/2032</td>
<td>6/2032</td>
</tr>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
</tr>
<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>HLW Vitrification Facility Operations</td>
<td>12/2033 – 8/2063</td>
<td>12/2033 – 12/2080</td>
</tr>
<tr>
<td>WTP Initial Plant Operations</td>
<td>12/2036</td>
<td>N/A59</td>
</tr>
<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2042</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>3/2081</td>
</tr>
</tbody>
</table>

59 This scenario never meets 70 percent of design capacity required for WTP initial plant operations.
Table 5-40. Scenario 7 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 7 – Reduced Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>LERF/ETF Operations</td>
<td>1/2016 – 12/2065</td>
<td>1/2016-4/2082</td>
</tr>
<tr>
<td>IHS Module 1 Need Date</td>
<td>12/2033</td>
<td>8/2034</td>
</tr>
<tr>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>10/2045</td>
</tr>
<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047</td>
<td>11/2052</td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
<td>3/2083</td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>1/2031</td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>11/2052</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.
CWC = Central Waste Complex.
DFLAW = direct-feed low-activity waste.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHS = Interim Hanford Storage.
LAW = low-activity waste.
LAWPS = Low-Activity Waste Pretreatment System.
LERF = Liquid Effluent Retention Facility.
PT = Pretreatment.
SST = single-shell tank.
TPA = Tri-Party Agreement.
TWCS = tank waste characterization and staging.
WMA = waste management area.
WRF = Waste Receiving Facility.
WTP = Waste Treatment and Immobilization Plant.

5.7.3.2 Cost

Figure 5-109 shows the lifecycle cost profile for Scenario 7 versus the Baseline Case. The total lifecycle unescalated cost estimated for Scenario 7 is $148 billion ($417 billion escalated) versus 111 billion ($231 billion escalated) for the Baseline Case. The longer mission in Scenario 7 results in an increase associated with the additional years of operations. The cost profile is nearly the same as the Baseline Case until the end of the Baseline Case treatment completion (2063), and then, as Scenario 7 continues, the costs for the additional years of operations is incurred.
5.7.3.3  Mission Flowsheet Results

The following subsections present the detailed mission flowsheet results for each system in Scenario 7 compared to the Baseline Case.

5.7.3.3.1  Single-Shell Tank Retrievals

The SSTs are projected to be retrieved by March 2074 for Scenario 7, which is 17 years longer than in the Baseline Case. Figure 5-110 shows the historical and projected SST retrieval progress as measured by the volume of original waste remaining in the SSTs as a function of time. Since the near-term retrieval assumptions for this scenario were not changed from the Baseline Case, the completion of C Tank Farm and A/AX Tank Farms are the same as the Baseline Case, finishing in August 2017 and November 2022, respectively. After retrievals in A/AX Tank Farms are completed and the cross-site slurry receiver becomes available in 2025, the Scenario 7 retrieval progress begins to deviate from the Baseline Case. As the mission continues, the retrieval progress for this scenario continues to diverge from the Baseline Case as a result of the longer SST retrieval durations and reduced treatment rates.
Figure 5-110. Scenario 7 Comparison – Single-Shell Tank Retrieval Progress.

Figure 5-111 shows the timing of SST retrievals grouped by farm for Scenario 7, compared to the Baseline Case. In Scenario 7, the gap between the end of 200 East and 200 West Area retrievals is increased to 11 years compared to 4 months in the Baseline Case. This increase in the delta between the completions of the two areas results from the later years of the mission becoming retrieval-limited and the already lengthy U Tank Farm retrievals taking 2.5 times longer in Scenario 7. Since the model is constrained to two simultaneous retrievals per area (four total), when one area is completed, the total number of simultaneous retrievals is cut in half. If there is a large gap between the retrieval completions of the 200 East and 200 West Areas, there is a greater impact to the SST retrieval rate than if the two areas were more synchronized.
Figure 5-111. Scenario 7 Comparison – Single-Shell Tank Retrieval Gantt Chart.

Figure 5-112 shows the sequence and timing of each SST retrieval during the RPP mission for Scenario 7 compared to the Baseline Case. The light-colored bands indicate delays in the SST tank retrievals. Scenario 7 has 25 percent less delay time than the Baseline Case, which is attributed to more available DST space as the mission progresses, creating fewer delays for SST retrievals. This increase in available DST space in Scenario 7, compared to the Baseline Case, is the net result of a better balance between the reduced SST retrieval rate, which increases available DST space, and the reduced treatment rate, which decreases the available DST space. The DST space management for Scenario 7 is summarized in Section 5.7.3.3.2.
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Figure 5-112. Scenario 7 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
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5.7.3.3.2 Double-Shell Tank Space Management

The DSTs for Scenario 7 are projected to operate 17 years longer than in the Baseline Case. Figure 5-113 depicts the utilization of DST space through the completion of the waste treatment mission for Scenario 7. The figure shows the total DST capacity, total volume of waste, and various allocations of headspace for purposes other than waste storage (see Table 5-4 in Section 5.1.3.3.2). Similar to the Baseline Case, during the DFLAW period (2023–2033), the amount of space created by treatment is typically filled with the incoming waste volume from special DST waste mitigations and SST retrievals. When the TWCS capability starts up in 2032, followed by the integrated WTP in late 2033 and the LAW supplemental treatment facility in late 2034, available DST space begins to increase, providing space to mitigate special DST wastes and to continue retrieving the SSTs. Between 2036 and 2049, the waste inputs into the DSTs and the amount of waste removed by treatment are roughly balanced; however, from 2050 to 2053 there is a brief reduction in available DST space as a result of increased water additions used to mitigate precipitated DST solids (i.e., solids mitigation). During this time, 13 Mgal of solids mitigation water is added. After 2053, DST space increases for the remaining 27 years of the mission. The large step-change of available space in 2065 is the result of completing the 200 East Area SST retrievals, with nine DSTs closed that are assumed to no longer be needed. The remaining DSTs are closed between the years 2074 and 2078, after retrievals in the 200 West Area are competed.

Figure 5-113. Scenario 7 – Double-Shell Tank Space Utilization.

The DST available space for Scenario 7 compared to the Baseline Case is shown in Figure 5-114. The available DST space tracks nearly the same as the Baseline Case until 2042.
As the mission continues after 2042, there is approximately 10 years in Scenario 7 where the treatment throughput and the retrieval rate are balanced and the net available space is relatively constant. Then from 2052 to 2054, there is a brief dip in the available DST space (due to additional solids mitigation water additions discussed above) prior to a large increase in the amount of available DST (up to 18 Mgal). This large increase is a result of the treatment throughput outpacing the rate of SST retrievals.

Figure 5-114. Scenario 7 Comparison – Double-Shell Tank Available Space.

Numerous transfers occur between DSTs to support staging of feed for treatment (both the LAWPS and the integrated WTP) and receipt of the retrieved SST waste. Figure 5-115 shows the comparison of the DST transfers for Scenario 7 and the Baseline Case. Both the Baseline Case and Scenario 7 predict that approximately 2,200 total DST transfers will occur over the course of the RPP mission. In Scenario 7, however, the average number of transfers per year is reduced since the transfers are spread out over a mission that is 17 years longer than the Baseline Case. The Baseline Case averaged 47 transfers per year, while Scenario 7 averaged 36 transfers per year. The peak years for DST transfers are near the end of the mission in both the Baseline Case (2055) and Scenario 7 (2065), which coincide with completion of retrievals in the first 200 Area (East or West) and the closure of several DSTs.
The total amount of DST additions for Scenario 7 is 7 Mgal less than the Baseline Case (212 Mgal and 219 Mgal, respectively). The small reduction in DST additions for Scenario 7 is almost entirely due to less dilution water needed to meet the cross-site slurry transfer solid concentration requirement. In the Baseline Case, the solids in Tanks SY-102 and SY-103 build up to the upper limit of 200 inches several times; where in Scenario 7, this only occurs once. Since the Baseline Case is more treatment limited (i.e., the rate of incoming SST retrieval volume is higher than the rate of volume being removed by treatment) than Scenario 7, the available DST space for the cross-site slurry receipts is more restrictive and results in periodic solids build up in 200 West Area slurry receivers (Tanks SY-102 and SY-103).

5.7.3.3.3 Waste Receiving Facilities
In Scenario 7, the B-Complex WRF is projected to operate from 2037 to 2065, 7 years longer than the Baseline Case (operating from 2036 to 2057). The T-Complex WRF is projected to be used for 23 years, from 2043 to 2066, in Scenario 7 compared with only 10 years of operations in the Baseline Case (2040 to 2050).

5.7.3.3.4 242-A Evaporator
Figure 5-116 shows that in Scenario 7 the 242-A Evaporator is estimated to process 11 Mgal less dilute waste compared to the Baseline Case (5 percent less volume) but operates for 17 years longer. This small reduction in feed coupled with the large increase in years of operation results in the average number of annual 242-A Evaporator campaigns in Scenario 7 being reduced to
3.7, compared to 5.5 in the Baseline Case. The longer operational window also corresponds to a reduction in the peak number of campaigns in Scenario 7 compared to the Baseline Case—12 versus 17, respectively.

Figure 5-116. Scenario 7 Comparison – Projected Operations of the 242-A Evaporator.

5.7.3.3.5 Waste Treatment and Immobilization

This section discusses the waste treatment and immobilization results for Scenario 7 versus the Baseline Case. Table 5-41 summarizes the amounts of immobilized product for the supplemental TRU treatment process, LAW and HLW Vitrification Facilities, and supplemental treatment facility (for which the amount is reported as a glass and a grouted product). The metrics show that even with the 17-year increase in mission length, there is little change in the total product produced for Scenario 7 compared to the Baseline Case. The results for each facility are discussed in more detail in the sections that follow.

Table 5-41. Scenario 7 Comparison – Waste Treatment Product Summary. (2 pages)
### Table 5-41. Scenario 7 Comparison – Waste Treatment Product Summary. (2 pages)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 7 – Reduced Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ILAW (glass)</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>95,400</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>518,000</td>
<td>525,600</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>MT sodium reporting to LAW</td>
<td>84,100</td>
<td>84,900</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>49,800</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>274,400</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>22%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment Facility (glass)</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>45,600</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>233,600</td>
<td>251,200</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>21%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Volume (yd³)</td>
<td>118,400</td>
<td>127,300</td>
</tr>
<tr>
<td>LAW Supplemental Treatment Facility (grout)</td>
<td>Product (yd³)</td>
<td>419,200</td>
<td>461,500</td>
</tr>
<tr>
<td></td>
<td>Waste Na₂O equivalent (%)</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

| Potential CH-TRU Waste | Number of packages | 8,396 | 8,396 |

CH-TRU = contact-handled transuranic.  
IHLW = immobilized high-level waste.  
ILAW = immobilized low-activity waste.  
LAW = low-activity waste.  
WTP = Waste Treatment and Immobilization Plant.

Figure 5-117 compares the decrease in radioactivity of the tank farms inventory as waste is delivered to the various waste treatment and immobilization facilities for the Baseline Case and Scenario 7. The scenarios are identical until the start of the fully integrated WTP (post-DFLAW). When the HLW Vitrification Facility begins operations, the rate of curie removal for Scenario 7 is slightly less than the Baseline Case due to the reduced capacity of the facility.
5.7.3.3.5.1 Direct-Feed Waste Treatment

During the 10-year DFLAW period, 30 percent less dilute feed is sent through the LAWPS and 30 percent less ILAW is produced in Scenario 7 compared to the Baseline Case. This decrease results from the reduction of the LAW Vitrification Facility throughput from 70 percent of the design capacity for the Baseline Case to 50 percent in Scenario 7. During DFLAW operations, there is a gain of 9 Mgal of DST space created in Scenario 7 compared to 12.7 Mgal in the Baseline Case. Table 5-42 compares the volume metrics of DFLAW operations for Scenario 7 and the Baseline Case.

Table 5-42. Scenario 7 Comparison – Summary of Direct-Feed Low-Activity Waste Operations Volume Metrics. (2 pages)

<table>
<thead>
<tr>
<th>Stream Name</th>
<th>Baseline Case (Mgal)</th>
<th>Scenario 7 (Mgal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original DST waste treated by DFLAW</td>
<td>13.2</td>
<td>8.9</td>
</tr>
<tr>
<td>Dilution water additions to DSTs</td>
<td>7.8</td>
<td>6.1</td>
</tr>
<tr>
<td>Total diluted feed to LAWPS</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>Cesium IX returns to tank farms</td>
<td>3.7</td>
<td>2.7</td>
</tr>
<tr>
<td>WTP EMF returns to tank farms</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Water Additions to LAW Vitrification Facility</td>
<td>23</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 5-42. Scenario 7 Comparison – Summary of Direct-Feed Low-Activity Waste Operations Volume Metrics. (2 pages)

<table>
<thead>
<tr>
<th>Stream Name</th>
<th>Baseline Case (Mgal)</th>
<th>Scenario 7 (Mgal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water additions to WTP EMF</td>
<td>7.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Post-evaporator returns to tank farms</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Amount sent to LERF from WTP EMF</td>
<td>46</td>
<td>35</td>
</tr>
<tr>
<td>Net DST space created from DFLAW operations</td>
<td>12.7</td>
<td>8.6</td>
</tr>
</tbody>
</table>

DFLAW = direct-feed low-activity waste.  
DST = double-shell tank.  
EMF = Effluent Management Facility.  
IX = ion exchange.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
LERF = Liquid Effluent Retention Facility.  
WTP = Waste Treatment and Immobilization Plant.

5.7.3.3.5.2 Pretreatment Throughput

In Scenario 7, an average of 1,360 MT Na waste per year and 680 MT as-delivered solids per year is treated compared to the Baseline Case, which averaged 2,120 MT Na waste per year and 1,070 MT as-delivered solids per year. In Scenario 7, the PT Facility operates 57 percent longer (47 years versus 30 years), but processes roughly the same amount of sodium and solids, which reduces the amount of waste processed on an annual basis.

5.7.3.3.5.3 Glass Production

Figure 5-118 shows the glass production for the ILAW and IHLW for Scenario 7. For the majority of the mission in Scenario 7, the glass production is continuous; however, between the years of 2068 through 2074, there are lapses in production due to a reduction in the available feed. This lapse indicates that the mission has become retrieval-limited at this point. In this period, the WTP feed sources consist of a few DST closures and the remaining retrievals in the U Tank Farm, which are not sufficient for continuous feed to the integrated WTP. After the 200 West Area retrievals complete (2074), the remaining DST are closed and provide a surge of feed through the end of treatment.
Figure 5-118. Scenario 7 – Projected Immobilized Waste Production.

Figure 5-119 compares the projected IHLW production for Scenario 7 to the Baseline Case. Figure 5-120 and Figure 5-121 show the ILAW production of the LAW Vitrification Facility and LAW supplemental treatment facility, respectively. These graphs depict the Scenario 7 assumption where the theoretical capacity of the HLW and LAW Vitrification Facilities are reduced to 50 percent of their respective design capacities compared to 70 percent for the Baseline Case. The IHLW and ILAW production lines for Scenario 7 are shifted proportionally from the theoretical line, compared to the Baseline Case. The Baseline Case is always treatment-limited and the IHLW and ILAW production lines in the HLW and LAW Vitrification Facilities, respectively, are typically continuous.

As discussed previously, in Scenario 7, there is a 6-year period starting in 2068 where the mission becomes retrieval-limited, and insufficient feed to the integrated WTP results in breaks in production. The supplemental treatment facility production also has insufficient feed beginning in 2068 and little production through the end of the mission, as the final DST cleanout does not generate enough waste to keep the supplemental treatment facility adequately fed.
Scenario 7 – Reduced Throughput

Figure 5-119. Scenario 7 Comparison – Projected Immobilized High-Level Waste Production.

Figure 5-120. Scenario 7 Comparison – Projected Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production.
5.7.3.3.5.4 Liquid Effluent Retention Facility

Scenario 7 discharged approximately 590 Mgal of liquid effluent to LERF, slightly more than the Baseline Case, which discharged approximately 550 Mgal. Table 5-43 compares the amount of discharge to LERF from each of the sources for Scenario 7 and the Baseline case. Table 5-43 shows that, while there is less volume discharged from the 242-A Evaporator and the WTP EMF, there is a larger increase in the volume discharged from the LAW supplemental treatment facility and the integrated WTP, resulting from the extended operation of the offgas caustic scrubbers. The caustic scrubbers in the LAW Vitrification Facility offgas and LAW supplemental treatment facility offgas systems are modeled with a constant quench water addition. Since these unit operations operate longer in Scenario 7 than the Baseline Case, there is an increase in water additions and, consequently, output to LERF.
Table 5-43. Scenario 7 Comparison – Liquid Effluent Retention Facility Discharges.

<table>
<thead>
<tr>
<th>Discharge</th>
<th>Baseline Case (Mgal)</th>
<th>Scenario 7 (Mgal)</th>
<th>Delta (Mgal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>242-A Evaporator condensate</td>
<td>133</td>
<td>126</td>
<td>-6</td>
</tr>
<tr>
<td>WTP EMF condensate</td>
<td>30</td>
<td>21</td>
<td>-10</td>
</tr>
<tr>
<td>LAW supplemental treatment condensate</td>
<td>170</td>
<td>214</td>
<td>44</td>
</tr>
<tr>
<td>WTP condensate</td>
<td>210</td>
<td>224</td>
<td>14</td>
</tr>
<tr>
<td>Supplemental TRU waste condensate</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>547</strong></td>
<td><strong>589</strong></td>
<td><strong>42</strong></td>
</tr>
</tbody>
</table>

EMF = Effluent Management Facility  
LAW = low-activity waste.  
TRU = transuranic.  
WTP = Waste Treatment and Immobilization Plant.

5.7.3.3.5.5 Potential Contact-Handled Transuranic Treatment

In both Scenario 7 and the Baseline Case, processing the potential CH-TRU tank waste is projected to begin in January 2031. However, due to the longer SST retrieval rates in Scenario 7, processing is extended 3 years—operating for 11 years compared to 5 years in the Baseline Case. With the extended operations, the maximum and average treatment rates are reduced in Scenario 7 as follows:

- Maximum 2,100 gal/day of slurry versus 5,300 gal/day of slurry in the Baseline Case
- Average of 1,350 gal/day of slurry versus 3,000 gal/day of slurry in the Baseline Case.

Scenario 7 and the Baseline Case both indicate that processing this waste will produce 8,400 drums of packaged waste, which will be stored at the CWC (see Section 3.4.1) pending final disposition.

5.7.3.3.6 Disposal, Storage, and Shipping

The schedule for the disposal, storage, and shipping of immobilized waste products is extended in Scenario 7, compared to the Baseline Case, due to the longer mission duration. The detailed storage, shipping, and disposal dates compared to the Baseline Case are summarized in Table 5-40, and the Scenario 7 schedule is provided in Figure 5-108.

5.7.3.3.7 Closure

The closure dates for Scenario 7 are 17 years later than in the Baseline Case, which are reflected in the cost estimate discussed in Section 5.7.3.2.
5.7.3.4 Opportunities
Scenario 7 illustrates the balance between the SST retrieval rate and the treatment rate. If SST retrievals are too slow, the treatment facilities have insufficient feed and production is reduced. If treatment throughput is too slow, available DST space is reduced and SST retrievals are delayed. The following opportunities exist to reduce the cost and/or schedule with respect to Scenario 7:

- Optimize SST retrievals to promote level loading of retrievals over the course of the mission while maintaining feed to the WTP
- Shut down the supplemental treatment facility earlier and/or reduce the size, with little impact to the RPP mission
- Place the individual WTP facilities on standby for a period of time towards the end of the mission when there is insufficient feed to maintain production
- Strategically close the DSTs to minimize the WTP feed outages
- Shut down the LAWPS earlier when demand is diminished.

5.7.3.5 Risks
The risks associated with Scenario 7 are the same as the Baseline Case; however, the risks associated with the aging infrastructure, tanks, and facilities are exacerbated since the mission is 17 years longer.

5.7.3.6 Sensitivity Scenarios
The purpose of the two Scenario 7 sensitivity cases is to isolate two assumption changes, the increased SST retrieval durations and the reduced treatment throughput, to assess the relative impact of each change on the different RPP mission systems. The two sensitivity scenarios are:

- Scenario 7A – Reduced SST throughput sensitivity, reduced retrieval rates only
- Scenario 7B – Reduced WTP throughput sensitivity, reduced treatment rates only.

The results of the two sensitivity scenarios are presented in the following subsections.

5.7.3.6.1 Analysis
The mission metrics for the two sensitivity scenarios are compared to the results of Scenario 7 and the Baseline Case in Table 5-44. The impact of each change to the various RPP mission systems is discussed in the subsequent subsections.

Table 5-44. Scenario 7 Comparison – Mission Metrics for Scenarios 7, 7A, and 7B. (2 pages)

<table>
<thead>
<tr>
<th>Item</th>
<th>Baseline Case</th>
<th>Scenario 7 – Reduced Throughput</th>
<th>Scenario 7A – Reduced SST Throughput</th>
<th>Scenario 7B – Reduced WTP Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 East Area SST retrievals complete</td>
<td>12/2056</td>
<td>4/2065</td>
<td>10/2057</td>
<td>12/2061</td>
</tr>
<tr>
<td>200 West Area SST retrievals complete</td>
<td>4/2055</td>
<td>3/2074</td>
<td>9/2071</td>
<td>6/2061</td>
</tr>
<tr>
<td>All SST retrievals complete</td>
<td>12/2056</td>
<td>3/2074</td>
<td>9/2071</td>
<td>12/2061</td>
</tr>
</tbody>
</table>
Table 5-44. Scenario 7 Comparison – Mission Metrics for Scenarios 7, 7A, and 7B. (2 pages)

<table>
<thead>
<tr>
<th>Item</th>
<th>Baseline Case</th>
<th>Scenario 7 – Reduced Throughput</th>
<th>Scenario 7A – Reduced SST Throughput</th>
<th>Scenario 7B – Reduced WTP Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>DST retrievals complete</td>
<td>11/2062</td>
<td>1/2080</td>
<td>1/2076</td>
<td>3/2075</td>
</tr>
<tr>
<td>Delta (years from Baseline Case)</td>
<td>N/A</td>
<td>+17</td>
<td>+15</td>
<td>+5</td>
</tr>
<tr>
<td>Treatment complete</td>
<td>11/2063</td>
<td>3/2081</td>
<td>12/2076</td>
<td>4/2076</td>
</tr>
<tr>
<td>Delta (years from Baseline Case)</td>
<td>N/A</td>
<td>+17</td>
<td>+13</td>
<td>+12</td>
</tr>
<tr>
<td>IHLW canisters</td>
<td>7,800</td>
<td>7,800</td>
<td>7,800</td>
<td>7,800</td>
</tr>
<tr>
<td>ILAW containers (WTP)</td>
<td>51,600</td>
<td>49,800</td>
<td>54,200</td>
<td>49,200</td>
</tr>
<tr>
<td>ILAW containers (Supplemental Treatment Facility)</td>
<td>42,400</td>
<td>45,600</td>
<td>42,600</td>
<td>45,700</td>
</tr>
<tr>
<td>Total ILAW containers</td>
<td>94,000</td>
<td>95,400</td>
<td>96,800</td>
<td>94,900</td>
</tr>
<tr>
<td>Percent from LAW Supplemental Treatment Facility</td>
<td>45%</td>
<td>48%</td>
<td>44%</td>
<td>48%</td>
</tr>
<tr>
<td>Potential CH-TRU waste package</td>
<td>8,396</td>
<td>8,396</td>
<td>8,396</td>
<td>8,396</td>
</tr>
<tr>
<td>ETF solids drums</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
</tr>
</tbody>
</table>

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

5.7.3.6.1.1 **Single-Shell Tank Retrievals**

The completion of SST retrievals for Scenario 7 is 17 years longer than in the Baseline Case. Figure 5-122 graphically depicts the SST retrieval progress for each of the Scenario 7 runs and the Baseline Case. Comparing the SST completion dates of the sensitivity scenarios indicates that the increase in SST retrieval durations affect the retrieval progress considerably more than the reduction in treatment rate. Scenario 7A (with only the SST retrieval rate reduced) extends SST retrievals by 15 years; while in Scenario 7B (with only the treatment rate reduced), SST retrievals are extended by 5 years.
Table 5-45 shows the SST retrieval times and delays for the Baseline Case, Scenario 7, and the sensitivity scenarios. For Scenario 7, there is 25 percent less delay time than the Baseline Case. This reduction in SST retrieval delays in Scenario 7 compared to the Baseline Case is the net result of a better balance between the reduced SST retrieval rate, which increases the available DST space and the reduced treatment rate, which decreases the available DST space.

Table 5-45. Scenario 7 Comparison – Single-Shell Tank Retrieval Delays.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Baseline Case</th>
<th>Scenario 7 – Combined Throughput Reductions</th>
<th>Scenario 7A – Reduced SST Throughput</th>
<th>Scenario 7B – Reduced WTP Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total minimum retrieval time&lt;sup&gt;a&lt;/sup&gt; (years)</td>
<td>53.6</td>
<td>133.9</td>
<td>133.9</td>
<td>53.6</td>
</tr>
<tr>
<td>Total modeled retrieval time (years)</td>
<td>90.2</td>
<td>161.5</td>
<td>143.1</td>
<td>109.6</td>
</tr>
<tr>
<td>Total delay (years)</td>
<td>36.6</td>
<td>27.6</td>
<td>9.2</td>
<td>56.1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Minimum retrieval durations are the projected durations from RPP-PLAN-40145 (SS-1647), for the Baseline Case and Scenario 7B and 2.5 times the RPP-PLAN-40145 (SS-1647), durations for Scenario 7 and Scenario 7A. These estimates exclude retrievals in C, A, and AX Tank Farms.

Note: Total retrieval times and delay times presented above are the sum of all SST retrieval durations as if retrieved in series. Actual mission results use concurrent retrievals, resulting in shorter retrieval time.

SST = single-shell tank. WTP = Waste Treatment and Immobilization Plant.
As demonstrated in Scenario 7A, the reduced SST retrieval rates alone result in little retrieval delay since the waste treatment processes are extracting waste from the DSTs at a faster rate than retrievals are backfilling the tanks. This creates a large amount of available DST space, resulting in fewer conflicts for waste receipts from the SST retrievals.

Conversely, in Scenario 7B, in which the treatment rate is reduced but the retrieval rates are the same as the Baseline Case, the SST retrieval rate outpaces the rate at which treatment extracts the waste and creates a reduction in the available DST space, resulting in more SST retrieval delays.

If the treatment rate outpaces the retrieval rate, the mission becomes retrieval-limited and the difference in the 200 East and West Area SST retrieval completions widens. In Scenario 7, the end of the mission is retrieval-limited, and the 200 East Area retrievals complete 11 years before the 200 West Area, compared to the Baseline Case, which only has a 4-month gap and is almost entirely treatment-limited. Scenario 7A is even more retrieval-limited, with the 200 East Area retrievals completing 14 years earlier than the 200 West Area. Scenario 7B, on the other hand, is entirely treatment-limited, and the 200 East and 200 West Areas end within 5 months of each other.

5.7.3.6.1.2 Available Double-Shell Tank Space

As discussed in Section 5.7.3.3.2, the available DST space in Scenario 7 tracks nearly the same as the Baseline Case until 2042. However, as the mission progresses in Scenario 7, there is a large amount of available DST space that is a result of treatment outpacing retrievals. Figure 5-123 illustrates the impact of each of the Scenario 7 changes on available DST space. In Scenario 7A, the treatment rate outpaces the retrieval rate earlier than in Scenario 7, making DST space available sooner. In Scenario 7B, the available DST space has a similar trend to the Baseline Case, except the mission is extended due to reduced treatment rates.
5.7.3.6.1.3 242-A Evaporator Operations – Scenario 7 Sensitivities

The sensitivity scenarios show the impact of the reduced SST retrieval rate and reduced treatment throughput on the 17-year extension to 242-A Evaporator operations compared to the Baseline Case. Table 5-46 summarizes 242-A Evaporator operations in terms of total feed, WVR, average and maximum number of annual campaigns, and the last year of operation for the Baseline Case and each of the Scenario 7 scenarios. The 11-Mgal reduction in evaporator feed in Scenario 7 is mainly due to slower retrieval rates, rather than a reduction in treatment throughput. While the 242-A Evaporator demand, in terms of volume, is less in all of the Scenario 7 scenarios (compared to the Baseline Case), the largest difference is seen in Scenario 7A. In Scenario 7A, there is 46 Mgal less evaporator feed than in the Baseline Case, which is due to the large amount of available DST space and results in less demand on the 242-A Evaporator.
Table 5-46. Scenario 7 Comparison – 242-A Evaporator Operations Summary.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Feed (Mgal)</th>
<th>Total WVR (Mgal)</th>
<th>Average Campaigns per Year</th>
<th>Maximum Annual Campaigns</th>
<th>Last Year of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Case</td>
<td>204</td>
<td>99</td>
<td>5.5</td>
<td>17</td>
<td>2057</td>
</tr>
<tr>
<td>Scenario 7</td>
<td>193</td>
<td>94</td>
<td>3.7</td>
<td>12</td>
<td>2074</td>
</tr>
<tr>
<td>Scenario 7A</td>
<td>158</td>
<td>77</td>
<td>3.2</td>
<td>8</td>
<td>2070</td>
</tr>
<tr>
<td>Scenario 7B</td>
<td>202</td>
<td>97</td>
<td>4.9</td>
<td>14</td>
<td>2062</td>
</tr>
</tbody>
</table>

WVR = waste volume reduction.

5.7.3.6.1.4 Treatment – Glass Production

As noted in Section 5.7.3.3.5.3, the glass production facilities have insufficient feed for several years towards the end of treatment when, in Scenario 7, the mission becomes retrieval-limited. This balance between retrievals and treatment becomes even clearer when comparing the production plots for the sensitivity scenarios. Figure 5-124 through Figure 5-129 show the production of IHLW, ILAW from the WTP, and ILAW from the LAW supplemental treatment facility for Scenarios 7A and 7B.

In Scenario 7A, there are 12 years when the integrated WTP has insufficient feed, compared to 6 years in Scenario 7. Although the Scenario 7A retrievals are delayed and the treatment rate is not changed, there is a longer period that the mission is treatment-limited compared to Scenario 7. In Scenario 7B (as in the Baseline Case), the mission is always treatment-limited because the WTP vitrification facilities have sufficient feed to continue production.

The supplemental treatment facility production curves for Scenario 7A show an extended period (nearly 20 years) at the end of the mission when there are lapses in feed, further showing that this sensitivity case is retrieval-limited near the end of the mission. In Scenario 7B, the supplemental treatment facility has sufficient feed until the last 10 years, which show a reduced production rate due to less available LAW feed as the mission completes.
Figure 5-124. Scenario 7A – Waste Treatment and Immobilization Plant Immobilized High-Level Waste Production.

Figure 5-125. Scenario 7B – Waste Treatment and Immobilization Plant Immobilized High-Level Waste Production.
Figure 5-126. Scenario 7A – Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production.

Figure 5-127. Scenario 7B – Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production.

Figure 5-128. Scenario 7A – Supplemental Treatment Immobilized Low-Activity Waste Production.

Figure 5-129. Scenario 7B – Supplemental Treatment Immobilized Low-Activity Waste Production.
5.8 SCENARIO 8 – EARLY U TANK FARM RETRIEVALS

5.8.1 Objective/Planning Bases

The objective of the Scenario 8 (Early U Tank Farm Retrievals) is to determine the effects to the SST retrieval schedules, DST space availability, glass loading, and RPP mission metrics when the U Tank Farm is retrieved as the next farm after the retrievals of A and AX Tank Farms. The basis for Scenario 8 is the same as the Baseline Case except for a change in the SST retrieval sequencing. Table 5-47 identifies the baseline assumption from Appendix A that was modified for Scenario 8.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 8 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.3.4</td>
<td>SST retrievals: Start U Tank Farm as the next set of retrievals after A and AX Tank Farms, with the goal of continuity of SST retrievals.</td>
</tr>
</tbody>
</table>

SST = single-shell tank.

5.8.2 Flowsheet Description

The simplified flowsheet diagram for Scenario 8 is the same as that shown in Figure 5-1 (Section 5.1.2) for the Baseline Case.

5.8.3 Analysis

5.8.3.1 Schedule Performance

Figure 5-130 shows the operating schedule for SST retrievals and the treatment systems in Scenario 8, and Table 5-48 lists the key mission activity dates compared to the Baseline Case. Because the changes in this scenario only involve a change in sequence of the SST retrievals, the operating schedule dates are similar to the Baseline Case, with minor differences.

- SST retrievals are completed 1.5 years earlier than in the Baseline Case.
- The 200 West Area WRF is not operational until almost 3 years after the operational date in the Baseline Case.
- Mitigation of two Group A tanks (AN-103 and AW-101) is completed 4 years earlier than in the Baseline Case.
- Mitigation of one Group A tank (AN-105) is completed 1.5 years earlier than in the Baseline Case.

The mission duration is approximately the same as the Baseline Case, completing only 6 months later. All other dates are about the same, aligning within approximately 1 year of the Baseline Case.
Figure 5-130. Scenario 8 – Operating Schedule for Major Facilities/Processes.
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Table 5-48. Scenario 8 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metrics</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 8 – Early U Tank Farm Retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete C Tank Farm Retrievals (existing TPA 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td>Complete Five Additional SST Retrievals (existing Consent Decree 12/31/2020)</td>
<td>4/2019</td>
<td>4/2019</td>
</tr>
<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
<td>5/2022</td>
<td>5/2022</td>
</tr>
<tr>
<td>Complete Tank A-103 Retrieval (existing TPA 9/30/2022)</td>
<td>11/2022</td>
<td>11/2022</td>
</tr>
<tr>
<td>WMA C Closed (existing TPA 6/30/2019)</td>
<td>6/2028</td>
<td>6/2028</td>
</tr>
<tr>
<td><strong>Storage/Retrieval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Supernate)</td>
<td>9/2025</td>
<td>9/2025</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Slurry)</td>
<td>7/2025</td>
<td>7/2025</td>
</tr>
<tr>
<td>200 West Area SST Retrievals Complete</td>
<td>4/2055</td>
<td>9/2053</td>
</tr>
<tr>
<td>200 East Area SST Retrievals Complete</td>
<td>12/2056</td>
<td>6/2055</td>
</tr>
<tr>
<td>200 West Area WRF Operational</td>
<td>4/2040</td>
<td>12/2042</td>
</tr>
<tr>
<td>200 East Area WRF Operational</td>
<td>1/2035</td>
<td>1/2035</td>
</tr>
<tr>
<td>Start of Four Simultaneous Retrievals</td>
<td>1/2035</td>
<td>7/2036</td>
</tr>
<tr>
<td>Tank AN-103 Group A Mitigation Complete</td>
<td>9/2032</td>
<td>9/2028</td>
</tr>
<tr>
<td>Tank AN-104 Group A Mitigation Complete</td>
<td>6/2025</td>
<td>6/2025</td>
</tr>
<tr>
<td>Tank AN-105 Group A Mitigation Complete</td>
<td>10/2032</td>
<td>10/2028</td>
</tr>
<tr>
<td>Tank AW-101 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>Tank SY-103 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>DST Retrieval Complete</td>
<td>11/2062</td>
<td>6/2063</td>
</tr>
<tr>
<td>** Pretreatment/Treatment**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>TWCS Capability Start</td>
<td>6/2032</td>
<td>6/2032</td>
</tr>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
</tr>
<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2036</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>5/2064</td>
</tr>
</tbody>
</table>
Table 5-48. Scenario 8 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metrics</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 8 – Early U Tank Farm Retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHS Module 1 Need Date</td>
<td>12/2033</td>
<td>5/2034</td>
</tr>
<tr>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>1/2043</td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>8/2047</td>
</tr>
<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047 – 11/2063</td>
<td>8/2047 – 6/2066</td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
<td>6/2066</td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>1/2031</td>
</tr>
</tbody>
</table>

5.8.3.2 Cost

Scenario 8 only differs from the Baseline Case in the sequence of the SST retrievals. The lifecycle cost for Scenario 8, compared to the Baseline Case, is provided in Figure 5-131. This figure shows only slight variation in the cost profile and cumulative cost. All other treatment operations remain the same as the Baseline Case. The cost for this scenario is $112 billion ($233 billion escalated), slightly higher than the Baseline Case cost of $111 billion ($231 billion escalated).
5.8.3.3 Mission Flowsheet Results

The model run results show that there is no significant deviation to the mission schedule and cost retrieving tanks in U Tank Farm earlier than in the Baseline Case because the RPP mission is limited by treatment throughput and not by the SST retrieval capabilities or sequence. The results are discussed in more detail in the following subsections.

5.8.3.3.1 Single-Shell Tank Retrievals

Figure 5-132 compares the SST retrieval sequence for Scenario 8 and the Baseline Case. The dark bands on the plots indicate when retrieval of the SST is occurring, and the lighter colors indicate when the SST is not being retrieved. In this scenario, the first three tanks selected to be retrieved from the U Tank Farm are Tanks U-101, U-112, and U-104. These three SSTs contain the smallest quantity of waste and have the least impact on DST storage space. These tanks were also selected to accelerate the development and deployment of retrieval and leak assessment technologies needed for problematic tanks, as these first three tanks are assumed leakers. The retrieval order for the remaining SSTs in U Tank Farm was determined by model logic. This figure shows that Scenario 8, by retrieving the longer retrieval duration tanks in U Tank Farm after the retrieval of tanks in the A and AX Tank Farms, leads to seven percent less delay time than the Baseline Case. Less delay time enables retrieval completion of all SSTs 18 months earlier in this scenario compared to the Baseline Case. In addition, full closure of all SST farm complexes completes 18 months earlier than the Baseline Case.
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Figure 5-132. Scenario 8 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
Table 5-49 compares the difference in retrieval metrics from October 2023 to February 2031, the time of retrievals in U Tank Farm in Scenario 8. During this period, more SSTs are fully retrieved in this scenario (16 U Tank Farm SSTs) than in the Baseline Case (the first eight SSTs from S and SX Tank Farms). However, there is 12 percent less volume of original SST waste retrieved from the 16 tanks in the U Tank Farm compared to the eight tanks in the 241S and SX Tank Farms. While the volume of as-retrieved waste is higher in Scenario 8, this may be attributed to more dilution due to the higher volume of retrieved solids in the U Tank Farm tanks (167,000 gal versus 71,000 gal in the Baseline Case), and the retrieval methods required for complete retrieval of the SSTs. Because of the more dilute as-retrieved liquid volume in Scenario 8, the post-evaporator retrieved volume of Scenario 8 is 20 percent less than the Baseline Case. For purposes of risk reduction, the total radioactivity of the retrieved waste is estimated to be slightly higher in Scenario 8 compared to the Baseline Case.

Between 2023 and 2031, the SST retrievals in the Baseline Case were selected to target primarily saltcake waste, which can be dissolved and fed through the DFLAW treatment process. As Table 5-49 shows, the amount of saltcake retrieved from the SSTs in U Tank Farm is comparable to that retrieved in the Baseline Case from SSTs in the S and SX Tank Farms. However, the U Tank Farm SSTs contain more sludge mixed with the saltcake; 17 percent of the waste volume retrieved between 2023 and 2031 from the U Tank Farm is sludge, compared to only 3.5 percent from the SSTs chosen in the S and SX Tank Farms. Retrieval of sludge waste during this time is not preferred because the waste has to be stored in the DST system until the HLW Vitrification Facility begins operating.

Table 5-49. Scenario 8 Comparison – Retrieved Waste Metrics from October 2023 to February 2031.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 8 – Early U Farm Retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of SSTs completely retrieved</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Volume of original waste of SSTs retrieved</td>
<td>3.0 Mgal</td>
<td>2.9 Mgal</td>
</tr>
<tr>
<td>Volume of original waste as saltcake</td>
<td>2.9 Mgal</td>
<td>2.4 Mgal</td>
</tr>
<tr>
<td>Volume of original waste as sludge</td>
<td>0.1 Mgal</td>
<td>500 kgal</td>
</tr>
<tr>
<td>Volume of as-retrieved waste</td>
<td>12.8 Mgal</td>
<td>15.8 Mgal</td>
</tr>
<tr>
<td>Volume of retrieved solids</td>
<td>0.07 Mgal</td>
<td>0.17 Mgal</td>
</tr>
<tr>
<td>Volume of post-evaporator retrieved waste</td>
<td>5.6 Mgal</td>
<td>4.5 Mgal</td>
</tr>
<tr>
<td>Total radioactivity of the completely retrieved SSTs(^a)</td>
<td>3.5 MCi</td>
<td>4.6 MCi</td>
</tr>
</tbody>
</table>

\(^a\) Decay date of January 1, 2008, for comparison purposes only.

SST = single-shell tank.

---

\(^{60}\) Note that during the time period of October 2023 to February 2031, three additional SSTs are in the process of being retrieved in the Baseline Case, but not completed.

Many criteria such as these have triggered evaluations on various retrieval sequences in mission planning. In 2015, an analysis was performed to compare the SST retrieval sequences and look at defining the next set of SSTs to be retrieved after those in the A and AX Tank Farms to provide adequate feed to support the site cleanup mission (RPP-RPT-58854, Future Tank Retrievals Alternatives Analysis). Based on the criteria and alternatives evaluated at that time, the preferred alternative selected was retrieving the S and SX Tank Farms next. Further mission planning has evolved since then to potentially warrant reevaluation of the SST farm retrieval sequence order.

Figure 5-133 shows the number of SST retrievals by year for both the Baseline Case and Scenario 8, and Figure 5-134 shows the SST retrieval progress of the total SST waste volume remaining in the SSTs by calendar year. The progress for both scenarios are similar, with Scenario 8 completing all SST retrievals 1.5 years earlier than the Baseline Case.

Figure 5-133. Scenario 8 Comparison – Total Single-Shell Tanks Retrieved per Calendar Year.
5.8.3.3.2 Double-Shell Tank Space Management

Figure 5-135 shows the utilization of DST space through completion of the waste treatment mission in Scenario 8. The figure shows the total DST capacity, total volume of waste, and various allocations of headspace for purposes other than waste storage (see Table 5-4 in Section 5.1.3.3.2). The profile is similar to the Baseline Case, as the only difference is the sequence of the SST retrievals. For better comparison to the Baseline Case, Figure 5-136 shows just the available space portion of the DSTs for Scenario 8 and the Baseline Case. The first difference is in 2023, when Scenario 8 begins SST retrievals in U Tank Farm and the Baseline Case begins SSTs retrievals in S and SX Tank Farms. Because the retrieval rate for the SSTs in the U Tank Farm is slower compared to tanks in the S and SX Tank Farms (i.e., less volume can be retrieved over time), there is more available DST space in the time period of 2023 to 2031. The comparable time in the Baseline Case for U Tank Farm retrievals is 2048 to 2055.
Figure 5-135. Scenario 8 – Double-Shell Tank Space Utilization.

Figure 5-136. Scenario 8 Comparison – Double-Shell Tank Available Space.
Numerous DST transfers occur to support staging of feed for the LAWPS and the integrated WTP, the cross-site transfer lines, and other DSTs. Figure 5-137 shows the number of DST transfers in Scenario 8 compared to the Baseline Case. While the distribution of DST transfers over the years varies slightly, the total number of DST transfers is the same as the Baseline Case.

![Figure 5-137. Scenario 8 Comparison – Double-Shell Tank Transfers.](image)

### 5.8.3.3.3 Waste Receiving Facilities
For Scenario 8, the B-Complex WRF in the 200 East Area has a start date of 2035, the same as the Baseline Case. The T-Complex WRF in the 200 West Area has a start date of 2042, 2 years later than the Baseline Case caused by the later retrievals of the T Complex SSTs in this scenario.

### 5.8.3.4 242-A Evaporator
Figure 5-138 shows the projected demand on the 242-A Evaporator over the waste treatment mission for Scenario 8, along with a comparison to the Baseline Case. The 242-A Evaporator is expected to process about 200 Mgal of waste, reducing the stored volume by about 100 Mgal for the mission duration, about the same as the Baseline Case. There is an average of five campaigns per year averaged over the mission, the same as the Baseline Case. The 242-A Evaporator operations end 13 months earlier in Scenario 8, which corresponds to the 18-month earlier completion of SST retrievals. The 242-A Evaporator operations have several peak years between 2043 and 2053 when the average increases to 11 campaigns per year, with a maximum number of 17 campaigns in 2053. The 242-A Evaporator peaks at 143 days of hot operations in the peak year of 2053. In contrast, the Baseline Case peaks at 152 days of hot operation.
Scenario 8 has a more even distribution of evaporator campaigns over the mission duration when compared to the Baseline Case. This starts with an increase in evaporator campaigns (over the Baseline Case) between 2027 and 2031, with the earlier retrievals of tanks in the U Tank Farm and their higher solids content. There is a reduction in the amount of water added to the DSTs to mitigate solids, resulting in additional available DST space. In this scenario, approximately 29 Mgal of water are added for solids mitigation compared to 37 Mgal of water in the Baseline Case—a reduction of 23 percent.

5.8.3.3.5 Waste Feed Delivery

The waste feed delivery feed screening for Scenario 8 was evaluated and found to be the same as the Baseline Case. No parameters other than the sequence of the SST retrievals were changed, and the waste feed does not vary between Scenario 8 and the Baseline Case.

5.8.3.3.6 Waste Treatment and Immobilization

This section presents the production metrics of the integrated WTP for Scenario 8 and compares the metrics to those for the Baseline Case. All detailed programmatic and technical assumptions for the integrated WTP in this scenario are the same as the Baseline Case (provided in Section A1.3). Table 5-50 shows that Scenario 8 is the same as the Baseline Case in regards to timing, duration, and product output of waste treatment operations.
Table 5-50. Scenario 8 Comparison – Waste Treatment Product Summary.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 8 – Early U Tank Farm Retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>5/2064</td>
</tr>
<tr>
<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
<td>7,800</td>
<td>7,800</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>23,600</td>
<td>23,400</td>
</tr>
<tr>
<td></td>
<td>Waste loading</td>
<td>44%</td>
<td>45%</td>
</tr>
<tr>
<td>Total ILAW</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>94,800</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>517,900</td>
<td>521,900</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>MT sodium reporting to LAW</td>
<td>84,100</td>
<td>84,800</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>52,400</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>288,400</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass)</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>42,400</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>233,600</td>
<td>233,500</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>Volume (yd³)</td>
<td>118,400</td>
<td>118,400</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (grout)</td>
<td>Product (yd³)</td>
<td>419,200</td>
<td>419,500</td>
</tr>
<tr>
<td></td>
<td>Waste Na₂O equivalent (%)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Potential CH-TRU Waste</td>
<td>Number of packages</td>
<td>8,396</td>
<td>8,396</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
IHLW = immobilized high-level waste.  
ILAW = immobilized low-activity waste.  
LAW = low-activity waste.  
MT = metric ton.  
WTP = Waste Treatment and Immobilization Plant.  

The waste curies immobilized over time are approximately the same as in the Baseline Case, as shown in Figure 5-139. The LAW Vitrification Facility is assumed to begin full operations on December 31, 2023. The PT Facility and HLW Vitrification Facility are assumed to be fully operational on December 31, 2033, the same as the Baseline Case. Waste treatment is projected to be completed in April 2064.
5.8.3.3.6.1 **Pretreatment Throughput**

The pretreatment throughput in this scenario is the same as the Baseline Case and presented in Section 5.1.3.3.6.2.

5.8.3.3.6.2 **Glass Production**

Figure 5-140 shows the projected IHLW production versus the theoretical capacity for Scenario 8 in comparison to the Baseline Case. The theoretical capacity assumption is the same for both cases, so the theoretical capacity lines are overlaid for both scenarios on the plot. The glass production rate from Scenario 8 follows the Baseline Case closely, with little deviation. The resulting canisters of IHLW produced is essentially the same as the Baseline Case, approximately 7,800 canisters.
Figure 5-140. Scenario 8 Comparison – Projected Immobilized High-Level Glass Production.

Figure 5-141 shows the projected ILAW production from the LAW Vitrification Facility for Scenario 8 in comparison to the Baseline Case. The theoretical capacities of all the WTP facilities are each assumed to be 70 percent of their respective design capacities, as explained in the Baseline Case. Again, the theoretical lines for both scenarios are overlaid on top of each other, as there is no deviation. For the projected ILAW production, the line exactly mirrors the Baseline Case, both expecting to produce about 52,000 ILAW containers.
The LAW supplemental treatment facility vitrifies the pretreated LAW from the LAWPS after startup of the integrated WTP and excess pretreated LAW from the WTP. The LAW supplemental treatment facility in the Baseline Case and in this case, is sized with four melter, which equates to a total theoretical capacity of 42 MTG/day (after 70 percent TOE, see Assumption A1.4.1.5). Because this is excess LAW treatment capacity, there are times when there is not enough feed for the LAW supplemental treatment facility to operate at its maximum theoretical capacity. Figure 5-142 shows the projected ILAW production from the LAW supplemental treatment facility in Scenario 8 compared to the Baseline Case. The sequence of SST retrievals is evident in the LAW supplemental treatment facility ILAW production comparison, as the glass production amounts vary over time from that in the Baseline Case. However, at the end of the mission, the same amount of containers are produced in both scenarios.
5.8.3.3.6.3  *Supplemental Immobilization – Grout*

If feed to the LAW supplemental treatment facility is grouted rather than vitrified, there will be approximately 419,200 yd$^3$ of grout, with approximately eight percent equivalent Na$_2$O loading for Scenario 8. This is compared to 42,400 LAW glass containers (from the LAW supplemental treatment facility), which is equivalent to 118,400 yd$^3$ of glass with a waste loading of 21 percent Na$_2$O.\(^{62}\) These metrics are the same as that produced in the Baseline Case.

5.8.3.3.7  *Impacts on Closure Activities*

In this scenario, closure activities of the SST WMAs can be completed earlier compared to the Baseline Case. Since the SSTs are retrieved earlier in Scenario 8, the U Tank Farm is projected to be closed 8 years earlier than the next farm retrieved after A and AX Tank Farms (S Tank Farm) in the Baseline Case. The completion of all SST tank farm closures is projected to occur 1.5 years earlier than in the Baseline Case. The closure of the DST farms is comparable to the Baseline Case, projected to be closed about the same time due to the treatment-limiting throughput of the WTP.

\(^{62}\) The volume of the ILAW containers is 626 gal and, when filled to 90 percent, the containers each hold 564 gallons of ILAW. This amount is equivalent to 2.7924 yd$^3$ of ILAW per container.
5.8.3.4 Opportunities
An opportunity associated with early retrieval of U Tank Farm tanks is the ability to initiate closure activities in one WMA 8 years earlier than the Baseline Case. During the period of U Tank Farm retrievals in Scenario 8, 16 SSTs are fully retrieved compared to eight SSTs in the same time span in the Baseline Case (S and SX Tank Farms). In addition, many SSTs in the U Tank Farm are assumed leakers and are therefore retrieved earlier in the mission, thus potentially reducing environmental risk. As discussed in Section 5.8.3.3.1, retrieving the SSTs from the U Tank Farm earlier in the mission is favorable at a time when the DST space is most limited, as retrieval of these tanks is slow. Balancing the retrieval rate with the DST space allocations can improve the timing of SST retrievals and thus reduce some of the delay time experienced in the Baseline Case.

Delaying retrieval of S and SX Tank Farms provides a potential opportunity to blend the high-phosphate B Complex waste with the retrieved waste from S and SX Tank Farms SSTs after 2031. In the Baseline Case, the B Complex and T Complex SSTs are retrieved in parallel, and both are high in phosphate. This blending may provide better consistency of feed for delivery to the integrated WTP; however, this approach may change the quantities of immobilized waste produced.

5.8.3.5 Risks
Early retrieval of tanks in U Tank Farm that are assumed leakers can cause cost and schedule delays if unforeseen difficulties arise with the development and deployment of retrieval and leak assessment technologies. In contrast, the Baseline Case does not retrieve any assumed leakers in the same time span from October 2023 to February 2031 (during DFLAW operations).

Another risk in earlier retrieval of U Tank Farm SSTs is in the composition of the retrieved tank wastes. With the modeled retrieval order in Scenario 8, there is more sludge retrieved earlier than in the Baseline Case retrieval order (500 Kgal versus 106 Kgal in the years 2023 to 2031). This additional sludge can potentially slow down retrievals due to the allowable sludge levels in the already limited DST storage system, causing cost and schedule delays. These delays can then impact DFLAW operations in Scenario 8, by compromising the continuity of LAW feed. This risk may be minimized by further optimization of the U Tank Farm retrieval order.

Current mission planning and funding is in place to retrieve the waste in S and SX Tank Farms after A and AX Tank Farms. To accomplish Scenario 8, planning and funding will have to be redirected to get the infrastructure in place (installation of diversion boxes and transfer lines) to retrieve U Tank Farm SSTs after A and AX Tank Farms. The transfer lines and diversion box/valve pit for U Tank Farm retrievals are the same transfer line system that will connect the T-Complex WRFs with SY Tank Farm. Therefore, for mission efficiency, this infrastructure will need to be in place earlier than planned in the Baseline Case.
5.9 SCENARIO 9 – OFFSITE EFFLUENT TREATMENT

5.9.1 Objective/Planning Bases

The purpose of Scenario 9 (Offsite Effluent Treatment) is to evaluate the opportunity for treating the LAW Vitrification Facility and LAW supplemental treatment facility effluents offsite and disposing of the waste at the IDF (or other disposal site) to quantify the benefits to glass loading, DST space, and waste treatment throughput over the duration of the mission. In Scenario 9, the following changes were made to the modeling assumptions to route the offgas recycle streams to the LAW Vitrification Facility and LAW supplemental treatment melters.

Table 5-51 identifies the baseline assumptions from Appendix A that were modified in Scenario 9. Treatment and disposal of the effluent is not specifically modeled; however, the volumes and component concentrations are used to estimate offsite treatment and disposal costs. The offsite treatment and disposal cost assumptions are discussed in Section 5.9.3.2.

Table 5-51. Scenario 9 – Assumptions Altered from the Baseline Case. (2 pages)

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 9 Assumption</th>
<th>Change Note</th>
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</thead>
<tbody>
<tr>
<td>A1.3.2.3</td>
<td>The PT Facility will be configured so that a portion of concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to a supplemental treatment facility as feed. The treated LAW concentrate tank feeds the LAW Vitrification Facility as its first priority, with excess going to a supplemental treatment facility.</td>
<td>Deleted the sentence: This is downstream of the point to which the condensate from the LAW SBS/WESP systems recycled, so the feed to a supplemental treatment facility will include a proportional fraction of recycled condensate from both LAW facilities.</td>
</tr>
<tr>
<td>A1.3.4.4</td>
<td>For the duration of the mission, the effluent from the LAW Vitrification Facility offgas SBS and caustic scrubber effluent will be routed to the WTP EMF.</td>
<td>This was previously only applicable to DFLAW operations.</td>
</tr>
<tr>
<td>A1.3.5.1</td>
<td>For the duration of the mission, the WTP EMF will receive the effluent from the LAW Vitrification Facility SBS, WESP, caustic scrubber, and plant wash system.</td>
<td>This was previously only applicable to DFLAW operations.</td>
</tr>
<tr>
<td>A1.3.5.3</td>
<td>Of the SBS/WESP effluent sent to the WTP EMF, 2 vol% will be collected in an accumulation vessel to account for WTP EMF evaporator outages. This volume was estimated as an average based on the analysis in RPP-RPT-59257.a This effluent will not be chemically adjusted for corrosion control.</td>
<td>This stream was previously returned to tank farms and chemically adjusted for corrosion control.</td>
</tr>
<tr>
<td>A1.3.5.4</td>
<td>The WTP EMF will operate for the duration of the mission. When the PT Facility begins operations, the WTP EMF will not be shut down.</td>
<td>This was previously only applicable to DFLAW operations and was shut down when the PT Facility started.</td>
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<tr>
<td>A1.3.5.7</td>
<td>For the WTP EMF evaporator concentrate, 100% is collected in an accumulation vessel to simulate offsite treatment.</td>
<td>This was previously recycled to the LAW Vitrification Facility feed tank.</td>
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<tr>
<td>A1.3.5.8</td>
<td>The fraction of effluent to account for WTP EMF evaporator outages will not be mitigated for corrosion control.</td>
<td>This stream was previously adjusted for corrosion control prior to being returned to the tank farms.</td>
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</tbody>
</table>
### Table 5-51. Scenario 9 – Assumptions Altered from the Baseline Case. (2 pages)

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 9 Assumption</th>
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<tr>
<td>A1.3.5.9</td>
<td>There is no effluent returned to the LAW Vitrification Facility.</td>
<td>This previously identified blending of the effluent returned to the LAW Vitrification Facility with incoming LAW feed.</td>
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<tr>
<td>N/A</td>
<td>The LAW supplemental treatment facility SBS and WESP liquid effluent is sent to an accumulation vessel after being concentrated in the second LAW evaporation process.</td>
<td>Not specified in Appendix A</td>
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</table>


DFLAW = direct-feed low-activity waste. PT = pretreatment. EMF = Effluent Management Facility. SBS = submerged bed scrubber. LAW = low-activity waste. WESP = wet electrostatic precipitator. N/A = not applicable. WTP = Waste Treatment and Immobilization Plant.

#### 5.9.2 Flowsheet Description

The simplified flowsheet diagram for Scenario 9 is shown in Figure 5-143. The yellow highlighted lines indicate the additions to the Baseline Case flowsheet. The LAW Vitrification Facility SBS and WESP recycle streams are routed to the WTP EMF for the entire mission and not recycled back to the LAW feed. Concentrate from the WTP EMF is sent to an accumulation vessel to quantify the effluent sent to offsite treatment and disposal. The portion of dilute WTP EMF returns, sent to the tank farms in the Baseline Case, is instead added to the accumulation vessel. The concentrated SBS/WESP recycle stream from LAW supplemental treatment is also sent to the accumulation vessel to quantify the effluent for offsite treatment and disposal.

#### 5.9.3 Analysis

##### 5.9.3.1 Schedule Performance

Figure 5-144 (page 5-258) shows the operating schedule for SST retrievals and the treatment facilities for Scenario 9, and Table 5-52 (page 5-259) lists the key mission activity dates compared to the Baseline Case. The mission duration is nearly the same as the Baseline Case, completing 6 months earlier. The operating schedule dates for Scenario 9 are similar to the Baseline Case, with the following key differences:

- SST retrievals complete 1 year earlier than the Baseline Case.
- The 200 West Area WRF is required to support retrievals in the T and TX Tank Farms 2 years earlier than the Baseline Case.
- Tanks AN-103 and AW-101 Group A mitigations are completed 7 years earlier than the Baseline Case.
- 242-A Evaporator shuts down nearly 2 years earlier than the Baseline Case.
Figure 5-143. Scenario 9 – Simplified Flowsheet.
Figure 5-144. Scenario 9 – Operating Schedule for Major Facilities/Processes.

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<td>Tank AN-104 Group A Mitigation Complete</td>
<td>6/2025</td>
<td>4/2025</td>
<td></td>
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<tr>
<td>Tank AN-105 Group A Mitigation Complete</td>
<td>1/2033</td>
<td>11/2032</td>
<td></td>
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<tr>
<td>Tank AW-101 Group A Mitigation Complete</td>
<td>10/2032</td>
<td>12/2025</td>
<td></td>
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<tr>
<td>Tank SY-103 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>10/2023</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2023</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TWCS Capability Start</td>
<td>6/2032</td>
<td>6/2032</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
<td></td>
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<tr>
<td>WTP Initial Plant Operations</td>
<td>12/2036</td>
<td>12/2036</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2036</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>5/2063</td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>
Table 5-52. Scenario 9 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Disposal</th>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 9 – Offsite Effluent Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHS Facility Operations</td>
<td>1/2034 – 10/2063</td>
<td>1/2034 – 4/2063</td>
<td></td>
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<tr>
<td>IHS Module 1 Need Date</td>
<td>12/2033</td>
<td>5/2034</td>
<td></td>
</tr>
<tr>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>7/2042</td>
<td></td>
</tr>
<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047</td>
<td>12/2046</td>
<td></td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
<td>6/2065</td>
<td></td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>1/2031</td>
<td></td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>12/2046</td>
<td></td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  LAWPS = Low-Activity Waste Pretreatment System.
CWC = Central Waste Complex.  LERF = Liquid Effluent Retention Facility.
DFLAW = direct-feed low-activity waste.  PT = Pretreatment.
ETF = Effluent Treatment Facility.  SST = single-shell tank.
HLW = high-level waste.  TPA = Tri-Party Agreement.
HSF = Hanford Shipping Facility.  TWCS = tank waste characterization and staging.
IDF = Integrated Disposal Facility.  WMA = waste management area.
IHS = Interim Hanford Storage.  WRF = Waste Receiving Facility.
LAW = low-activity waste.  WTP = Waste Treatment and Immobilization Plant.

5.9.3.2 Cost

The lifecycle cost for Scenario 9, with a comparison to the Baseline Case, is provided in Figure 5-145. This scenario finishes 6 months earlier with the unescalated cost being approximately $1 billion less, totaling $110 billion ($227 billion escalated). The cost is about the same, because the additional cost associated with sending the effluent offsite for treatment and disposal is offset by a reduction resulting from earlier completion of SST retrievals, less ILAW containers produced, and earlier mission completion.

The unescalated cost for the offsite effluent treatment is approximately $450 million. For Scenario 9, approximately $7 million in upfront costs are assumed to be associated with regulatory permitting, management, and procurement activities for liquid effluent transportation. These costs are spread over 5 years beginning in FY 2019. For the purpose of providing a conservative cost estimate, the treated effluent is assumed to be disposed of offsite rather than at the IDF. The cost of sending the effluent offsite for treatment is based on the following:

- The effluent meets Class C waste limits.
- The effluent is shipped as a liquid to Perma-Fix Northwest in Richland, Washington for solidification.
- The solidified product is shipped to Waste Control Specialists in Texas for disposal.
5.9.3.3 Mission Flowsheet Results

The following subsections present the detailed mission flowsheet results for each system in Scenario 9 compared to the Baseline Case.

5.9.3.3.1 Single-Shell Tank Retrievals

The SSTs are projected to be retrieved by December 2055 in Scenario 9, which is 1 year earlier than in the Baseline Case. Figure 5-146 shows the historical and projected SST retrieval progress, measured by the volume of original waste remaining in the SSTs as a function of time. Figure 5-147 shows the number of SST retrievals per calendar year. Since the near-term retrieval assumptions for this scenario were not changed from the Baseline Case, the completion of C Tank Farm and A and AX Tank Farms retrievals are the same as the Baseline Case, finishing in August 2017 and November 2022, respectively. After retrievals are completed in A and AX Tank Farms, Scenario 9 retrieves four more SSTs during DFLAW operations than the Baseline Case because more DST space is available from eliminating the dilute returns from the WTP EMF to the tank farms and treatment throughput has increased. As the mission continues, the retrieval rates are approximately the same for Scenario 9 and the Baseline Case; however, these improvements enable SST retrievals to complete 1 year earlier.

Figure 5-148 shows that the timing of SST retrievals in Scenario 9 is similar to the Baseline Case, with an approximate four percent less delay associated with the Scenario 9 retrievals compared to the Baseline Case. As discussed above, this slight improvement results from an increase in available DST space due to the elimination of WTP EMF returns and improved throughput of LAW treatment resulting from routing the recycle streams to melter feed.
Figure 5-146. Scenario 9 Comparison – Single-Shell Tank Retrieval Progress.

Figure 5-147. Scenario 9 Comparison – Total Single-Shell Tanks Retrieved per Calendar Year.
Figure 5-148. Scenario 9 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
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5.9.3.3.2 Double-Shell Tank Space Management

The DSTs in Scenario 9 are projected to operate for nearly the same duration as in the Baseline Case. Figure 5-149 depicts the utilization of DST space through the completion of the waste treatment mission for Scenario 9, which is similar to the Baseline Case (Figure 5-8, Section 5.1.3.3.2). The figure shows the total DST capacity, total volume of waste, and various allocations of headspace for purposes other than waste storage (see Table 5-4, Section 5.1.3.3.2).

Figure 5-149. Scenario 9 – Double-Shell Tank Space Utilization.

Figure 5-150 compares the available space in the DSTs in Scenario 9 to the Baseline Case. The available DST space tracks nearly the same as the Baseline Case, except near the end of retrievals (from 2050 to 2055) when the peaks are approximately 2 Mgal higher in Scenario 9. This difference is due to the increased LAW and supplemental treatment throughput from improved waste loading in the glass.

During DFLAW operations, there is no significant difference in available space between Scenario 9 and the Baseline Case, even though 1 Mgal of DFLAW returns were eliminated and there is a 2 Mgal increase in the DFLAW throughput. The elimination of these returns and increased throughput enables the receipt of additional retrieved SST waste and earlier mitigation of Group A wastes.

Numerous transfers occur between DSTs to support staging of feed for treatment (for LAWPS and the WTP) and receipt of the retrieved SST waste. Figure 5-151 shows a similar trend for the number of DST transfers per year in Scenario 9 and the Baseline Case. Both scenarios predict that approximately 2,200 DST transfers will occur during the RPP mission.
Figure 5-150. Scenario 9 Comparison – Double-Shell Tank Available Space.

Figure 5-151. Scenario 9 Comparison – Double-Shell Tank Transfers.
5.9.3.3.3 Waste Receiving Facilities

In Scenario 9, the B-Complex WRF is projected to operate from 2035 to 2056, which is 1 year less than the Baseline Case that projected operating the WRF from 2035 to 2057. For Scenario 9, the T-Complex WRF is projected to operate for 13 years (2038 to 2051) compared to 10 years of operation in the Baseline Case (2040 to 2050).

5.9.3.3.4 242-A Evaporator

Figure 5-152 shows that 242-A Evaporator operations for Scenario 9 and the Baseline Case are similar. The 242-A Evaporator is expected to process about 199 Mgal of waste, reducing the stored volume by about 97 Mgal for the mission duration—two percent less than the Baseline Case. The average number of campaigns per year is 5.7 for Scenario 9 and 5.5 for the Baseline Case; however, evaporator operations end nearly 2 years earlier in this scenario. The 242-A Evaporator peaks in Scenario 9 at 141 days of hot operations in 2043, while the Baseline Case peaks at 152 days of hot operations. In this scenario, the evaporator demand is slightly less than the Baseline Case as a result of eliminating the WTP EMF returns to the tank farms and increased treatment throughput.

Figure 5-152. Scenario 9 Comparison – Projected Operations of the 242-A Evaporator.

5.9.3.3.5 Waste Treatment and Immobilization

This section discusses the integrated WTP results for Scenario 9 versus the Baseline Case. Table 5-53 summarizes the amounts of immobilized product for the supplemental TRU treatment facility, LAW and HLW Vitrification Facilities, and LAW supplemental treatment facility. The metrics show that removing the offgas recycle to the LAW Vitrification Facility Facility and the
LAW supplemental treatment facility melters reduces the number of ILAW containers by nine percent, or by 8,300 containers. The results for each facility are discussed in the subsections that follow.

### Table 5-53. Scenario 9 Comparison – Waste Treatment Product Summary.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 9 – Offsite Effluent Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>5/2063</td>
</tr>
<tr>
<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
<td>7,800</td>
<td>7,800</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>23,600</td>
<td>23,600</td>
</tr>
<tr>
<td></td>
<td>Waste loading</td>
<td>44%</td>
<td>45%</td>
</tr>
<tr>
<td>Total ILAW (glass)</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>85,700</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>518,000</td>
<td>472,000</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>22%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>MT sodium reporting to LAW</td>
<td>84,100</td>
<td>82,500</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>51,200</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>282,000</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>22%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (glass)</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>34,500</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>233,600</td>
<td>190,000</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>21%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Volume (yd³)</td>
<td>118,400</td>
<td>96,300</td>
</tr>
<tr>
<td>LAW Supplemental Treatment (grout)</td>
<td>Product (yd³)</td>
<td>419,200</td>
<td>395,000</td>
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<tr>
<td></td>
<td>Waste Na₂O equivalent (%)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Potential CH-TRU Waste</td>
<td>Number of packages</td>
<td>8,396</td>
<td>8,396</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
IHLW = immobilized high-level waste.  
ILAW = immobilized low-activity waste.  
LAW = low-activity waste.  
MT = metric ton.  
WTP = Waste Treatment and Immobilization Plant.

Figure 5-153 compares the decrease in radioactivity of the tank farms inventory as waste is delivered to the various waste treatment and immobilization facilities for the Baseline Case and Scenario 9. The scenarios are nearly identical except for a small improvement in HLW production that results from less LAW being fed through the PT Facility, which slightly improves the PT Facility filtration rate (discussed in Section 5.9.3.3.5.2).
5.9.3.5.1 Direct-Feed Waste Treatment

During the 10-year DFLAW period, 8 vol% more dilute feed is processed through the LAWPS and 230 (two percent) more ILAW containers are produced in Scenario 9 compared to the Baseline Case. Table 5-54 presents a comparison of the DFLAW volume metrics for Scenario 9 and the Baseline Case. During DFLAW operations, there is a net 14.5 Mgal of DST space created in Scenario 9 compared to 12.7 Mgal in the Baseline Case. The extra waste volume processed during DFLAW operations is a result of better waste loading in the ILAW from eliminating the offgas recycle stream to the melters.

Table 5-54. Scenario 9 Comparison – Summary of Direct-Feed Low-Activity Waste Operations Volume Metrics. (2 pages)

<table>
<thead>
<tr>
<th>Stream Name</th>
<th>Scenario 1 – Baseline Case (Mgal)</th>
<th>Scenario 9 – Offsite Effluent Treatment (Mgal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original DST waste treated by DFLAW</td>
<td>13.2</td>
<td>14.7</td>
</tr>
<tr>
<td>Dilution water additions to DSTs</td>
<td>7.8</td>
<td>8.1</td>
</tr>
<tr>
<td>Total diluted feed to LAWPS</td>
<td>21</td>
<td>22.8</td>
</tr>
<tr>
<td>Cesium IX returns to tank farms</td>
<td>3.7</td>
<td>4.2</td>
</tr>
<tr>
<td>WTP EMF returns to tank farms</td>
<td>1.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Water addition to LAW Vitrification Facility</td>
<td>23</td>
<td>23</td>
</tr>
</tbody>
</table>
Table 5-54. Scenario 9 Comparison – Summary of Direct-Feed Low-Activity Waste Operations
Volume Metrics. (2 pages)

<table>
<thead>
<tr>
<th>Stream Name</th>
<th>Scenario 1 – Baseline Case (Mgal)</th>
<th>Scenario 9 – Offsite Effluent Treatment (Mgal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water addition to WTP EMF</td>
<td>7.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Post evaporator DFLAW returns to tank farms&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Amount sent to LERF from WTP EMF</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Net DST space created in DFLAW</td>
<td>12.7</td>
<td>14.5</td>
</tr>
</tbody>
</table>

<sup>a</sup> Post evaporator returns to the tank farms is the sum of the cesium IX returns and the WTP EMF returns concentrated to a SpG of 1.43.

DFLAW = direct-feed low-activity waste.

DST = double-shell tank.

EMF = Effluent Management Facility.

IX = ion exchange.

LAW = low-activity waste.

LAWPS = Low-Activity Waste Pretreatment System.

LERF = Liquid Effluent Retention Facility.

SpG = specific gravity.

WTP = Waste Treatment and Immobilization Plant.

5.9.3.3.5.2 Pretreatment Throughput

In Scenario 9, an average of 2,100 MT Na waste per year and 1,080 MT as-delivered solids per year is treated which is nearly the same as the Baseline Case, which averages 2,120 MT Na waste per year and 1,070 MT as-delivered solids per year. There is 2 Mgal (11 percent) less LAW feed delivered to the PT Facility LAW feed receipt tanks over the mission as a result of increased DFLAW and LAW supplemental treatment throughputs, which draws more LAW feed through the LAWPS instead of the PT Facility. The amount of HLW feed delivered to the PT Facility is the same as the Baseline Case.

5.9.3.3.5.3 Glass Production

Figure 5-154 shows that the IHLW production for Scenario 9 is nearly the same as the Baseline Case. The slight improvement in production is due to less LAW being fed through the PT Facility (as discussed above), which slightly improves the PT Facility filtration rate.

Figure 5-155 depicts the ILAW production for the LAW Vitrification Facility for Scenario 9 and the Baseline Case. The WTP ILAW production rate is identical for Scenario 9 and the Baseline Case. Figure 5-156 compares the ILAW production (from LAW supplemental treatment) for Scenario 9 and the Baseline Case. There are 19 percent fewer containers produced in Scenario 9 compared to the Baseline Case (34,530 versus 42,400). The reduction in containers is a result of better waste loading in the ILAW from eliminating the offgas recycle stream in this scenario. The waste loading and glass drivers are discussed below.
leakers.

The deployment of retrieval and leak assessment technologies needed for problematic tanks, as these first three tanks are assumed to be above the Baseline Case because the RPP mission is limited by treatment throughput and not by the SST retrieval cap.

1.1.3.3 Comparison

The mission schedule and cost for Scenario 8 is provided in Figure 8 only differs from the Baseline Case in the sequence of the SST retrievals. This scenario identifies the waste produced since the year of the Baseline Case. The waste production is approximately the same as the Baseline Case, completing only 6 months earlier than in the Baseline Case. SST retrievals are completed 1.5 years earlier than in the Baseline Case.

Figure 5-154. Scenario 9 Comparison – Projected Immobilized High-Level Waste Production.

Figure 5-155. Scenario 9 Comparison – Projected Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production.
5.9.3.3.5.4 **Glass Drivers**

The ILAW drivers are impacted in Scenario 9 due to the elimination of the melter offgas recycle stream. When the melter offgas condensate from the SBS and WESP are recycled, volatile components such as chlorine, fluorine, iodine, sulfur, technetium, and cesium tend to concentrate in the melter feed. Increased concentrations of sulfur and halides (Cl\(^-\), F\(^-\), I\(^-\)) reduce the sodium oxide and WOL in the glass. For the Baseline Case, the ILAW from LAW supplemental treatment contains a greater amount of the melter offgas recycle from the supplemental treated LAW evaporation process system and a portion of the treated LAW evaporation process system. This increase in the recycle stream results in an increase of sulfur-constrained batches (sulfur rule and combined alkali plus sulfur rule\(^{63}\)) and an increase in the halide-constrained glass. In Scenario 9, waste loading is increased since the melter offgas recycle stream is eliminated, reducing the volatile components (which decreases waste loading).

Figure 5-157 and Figure 5-158 show the major WTP ILAW drivers over the mission for Scenario 9 and the Baseline Case. Figure 5-159 and Figure 5-160 show the major ILAW drivers (from LAW supplemental treatment) for Scenario 9 and the Baseline Case.

\(^{63}\) The 2013 GFM (PNNL-22631) defines the sulfur content rule as \(w_{\text{SO}_3} < 1.5\%\) and the alkali and sulfur content rule as \(w_{\text{Na}_2O} + 0.66 \times w_{\text{K}_2O} \leq 33.94 - 11.69 \times w_{\text{Na}_3}\). Where \(w_x\) is the weight percent of component \(x\) in the glass.
Figure 5-157. Scenario 9 – Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Glass Drivers.

Figure 5-158. Baseline Case – Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Glass Drivers.
Figure 5-159. Scenario 9 – Supplemental Treatment Vitrification Drivers.

Figure 5-160. Baseline Case – Supplemental Treatment Vitrification Drivers.
Table 5-55 summarizes the glass driver percentages for ILAW from the WTP and LAW supplemental treatment for both cases. Eliminating the recycle stream in Scenario 9 results in 20 percent more of the batches being alkali-only (Na$_2$O and K$_2$O) constrained and less of the batches constrained by sulfur and halides. This reduction in sulfur- and halide-limited glass batches increases the Na$_2$O loading and waste loading by one percent (23 and 28 percent, respectively). Eliminating the recycle streams has a greater impact on the ILAW from LAW supplemental treatment than the WTP glass since the supplemental ILAW has greater amounts of melter offgas recycle from the supplemental facility offgas and a portion of the WTP offgas. The LAW supplemental treatment Na$_2$O and waste loadings increased by two percent compared to the Baseline Case, while the WTP ILAW loadings changed by only 0.4 percent. The glass formulation loading rules are described in PNNL-22631.

The IHLW drivers for Scenario 9 are essentially the same as the Baseline Case, with the primary glass drivers being T2%-spinel and nepheline discriminator.

Table 5-55. Scenario 9 Comparison – Summary of Combined Immobilized Low-Activity Waste Glass Drivers and Na$_2$O Loading.

<table>
<thead>
<tr>
<th>Glass Drivers and Waste Loadings</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 9 – Offsite Effluent Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total ILAW</td>
<td>LAW</td>
</tr>
<tr>
<td>Alkali content (Na$_2$O, K$_2$O)</td>
<td>55.8%</td>
<td>67.9%</td>
</tr>
<tr>
<td>Alkali and sulfur content (Na$_2$O, K$_2$O, SO$_3$)</td>
<td>33.6%</td>
<td>25.3%</td>
</tr>
<tr>
<td>Halide conservative rule 1 (Cl$^-$, F$^-$, Cr$_2$O$_7^-$, K$_2$O, SO$_3$)</td>
<td>7.6%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Sulfur content (SO$_3$)</td>
<td>3.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Average Loading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Na$_2$O loading</td>
<td>22.3%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Average WOL</td>
<td>26.5%</td>
<td>27.4%</td>
</tr>
</tbody>
</table>

GFM = glass formulation model.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
WOL = waste oxide loading.
WTP = Waste Treatment and Immobilization Plant.

5.9.3.4 Effluent to Offsite Summary

Scenario 9 predicts that 180 kgal per year, totaling 7 Mgal of offgas condensate, will require offsite treatment and disposal. Table 5-56 summarizes the volume contribution from the three sources to offsite effluent: WTP EMF concentrated bottoms, WTP EMF dilute returns (resulting from WTP EMF downtimes), and LAW supplemental treatment concentrated bottoms. The majority of the volume sent offsite is from the WTP EMF (78 percent) and the remaining is from LAW supplemental treatment (22 percent). The LAW supplemental treatment contribution is smaller because the effluent is being concentrated to a higher SpG than the WTP EMF streams. The average sodium molarity of the combined WTP EMF streams is 2.6 M (3.8 M for
concentrated bottoms and 0.08 M for dilute) compared to the LAW supplemental treatment stream, which is concentrated to a sodium molarity of 7.6 M.

Table 5-56. Scenario 9 – Offsite Effluent Volumes.

<table>
<thead>
<tr>
<th>Source</th>
<th>Volume (kgal)</th>
<th>Volume Percent</th>
<th>Average SpG</th>
<th>Average Sodium Molarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP EMF bottoms to offsite</td>
<td>3,800</td>
<td>53%</td>
<td>1.17</td>
<td>3.8</td>
</tr>
<tr>
<td>Dilute WTP EMF returns to offsite</td>
<td>1,800</td>
<td>25%</td>
<td>1.01</td>
<td>0.08</td>
</tr>
<tr>
<td>Supplemental treatment bottoms to offsite</td>
<td>1,500</td>
<td>22%</td>
<td>1.24</td>
<td>7.6</td>
</tr>
<tr>
<td>Combined total offsite effluent</td>
<td>7,100</td>
<td>100%</td>
<td>1.14</td>
<td>3.7</td>
</tr>
</tbody>
</table>

EMF = Effluent Management Facility.  
SpG = specific gravity.  
WTP = Waste Treatment and Immobilization Plant.

The operating assumptions for the WTP EMF evaporators and the LAW supplemental treatment facility were not changed in this scenario, although the target evaporation concentration(s) will typically be optimized to match the selected treatment and disposal option.

All nuclear facilities, whether a utility or a disposal site, have to comply with NRC regulations. Classes of wastes are detailed in 10 CFR 61.55 and enforced by the NRC. The classes include Class A, B, and C, with Class A being the least hazardous. As the waste class and hazard increase, the regulations established by the NRC require progressively greater controls to protect the health and safety of the public and environment. The classification for Hanford LLW, which includes a mixture of radionuclides, is determined by the sum-of-fractions rule, which is the fraction of each nuclide’s concentration divided by the appropriate limit and adding the resulting values. The sum must be less than one to meet the classification.

The offsite effluents in Scenario 9 were evaluated against 10 CFR 61.55 waste classification categories A, B, and C, and the comparisons are presented in Table 5-57 and Table 5-58. The combined average of the offsite effluent streams exceeds the Class A limits. Exceeding the Table 1 Class A limit results in the effluent not being eligible for Class B categorization. The combined effluent meets the Class C designation, with the average sum-of-fractions being 0.22. Tc-99, americium-241 (Am-241), and Sr-90 are the main constituents that cause the Class A limits to be exceeded.

Table 5-57. Scenario 9 – Summary of Offsite Effluent Comparison to Nuclear Regulatory Commission 10 CFR 61.55 Table 1 Limits. (2 pages)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Units</th>
<th>Limit</th>
<th>Average Concentration</th>
<th>Class A Fraction of Limit</th>
<th>Class C Fraction of Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-14</td>
<td>Ci/m³</td>
<td>8</td>
<td>0.0E+00</td>
<td>0.0E+00</td>
<td>0.0E+00</td>
</tr>
<tr>
<td>Ni-59</td>
<td>Ci/m³</td>
<td>220</td>
<td>8.3E-05</td>
<td>3.8E-06</td>
<td>3.8E-07</td>
</tr>
<tr>
<td>Tc-99</td>
<td>Ci/m³</td>
<td>3</td>
<td>5.6E-01</td>
<td>1.9E+00</td>
<td>1.9E-01</td>
</tr>
<tr>
<td>I-129</td>
<td>Ci/m³</td>
<td>0.08</td>
<td>3.6E-04</td>
<td>4.5E-02</td>
<td>4.5E-03</td>
</tr>
<tr>
<td>Pu-241</td>
<td>µCi/g</td>
<td>3500</td>
<td>1.4E-01</td>
<td>4.0E-04</td>
<td>4.0E-05</td>
</tr>
</tbody>
</table>

5-276
Table 5-57. Scenario 9 – Summary of Offsite Effluent Comparison to Nuclear Regulatory Commission 10 CFR 61.55 Table 1 Limits. (2 pages)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Units</th>
<th>Limit</th>
<th>Average Concentration</th>
<th>Class A (^{b}) Fraction of Limit</th>
<th>Class C Fraction of Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cm-242</td>
<td>ηCi/g</td>
<td>20000</td>
<td>3.3E-03</td>
<td>1.6E-06</td>
<td>1.6E-07</td>
</tr>
<tr>
<td>Alpha &gt; 5 years</td>
<td>ηCi/g</td>
<td>100</td>
<td>3.0E+00</td>
<td>3.0E-01</td>
<td>3.0E-02</td>
</tr>
<tr>
<td>Sum of Fractions</td>
<td></td>
<td></td>
<td></td>
<td>2.2</td>
<td>0.22</td>
</tr>
</tbody>
</table>


\(^{b}\) If the concentration does not exceed 0.1 times the value in Table 1, the waste is Class A.

\(D = \) nano or \(10^{-9}\)

Table 5-58. Scenario 9 – Summary of Offsite Effluent Comparison to Nuclear Regulatory Commission 10 CFR 61.55 Table 2 Limits.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Units</th>
<th>Col. 1 Class A</th>
<th>Col. 2 Class B</th>
<th>Col. 3 Class C</th>
<th>Average Concentration</th>
<th>Class A Fraction of Limit</th>
<th>Class C Fraction of Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>Ci/m³</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>2.7E-04</td>
<td>6.8E-06</td>
<td>0</td>
</tr>
<tr>
<td>Co-60</td>
<td>Ci/m³</td>
<td>700</td>
<td>0</td>
<td>0</td>
<td>5.0E-06</td>
<td>7.1E-09</td>
<td>0</td>
</tr>
<tr>
<td>Ni-63</td>
<td>Ci/m³</td>
<td>3.5</td>
<td>70</td>
<td>700</td>
<td>5.3E-03</td>
<td>1.5E-03</td>
<td>7.6E-06</td>
</tr>
<tr>
<td>Sr-90</td>
<td>Ci/m³</td>
<td>0.04</td>
<td>150</td>
<td>7000</td>
<td>2.0E-01</td>
<td>5.1E+00</td>
<td>2.9E-05</td>
</tr>
<tr>
<td>Cs-137</td>
<td>Ci/m³</td>
<td>1</td>
<td>44</td>
<td>4600</td>
<td>5.1E-02</td>
<td>5.1E-02</td>
<td>1.1E-05</td>
</tr>
<tr>
<td>Nuclides &lt;5 years with Y-90 and Ba-137m</td>
<td>Ci/m³</td>
<td>700</td>
<td>0</td>
<td>0</td>
<td>1.3E+02</td>
<td>1.9E-01</td>
<td>0</td>
</tr>
<tr>
<td>Sum of Fractions</td>
<td></td>
<td>5.4</td>
<td>4.8E-05</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Figure 5-161 shows the summary of the offsite effluent by batch. All of the batches originating from the WTP EMF meet the waste designation, and 93 percent of the batches from the LAW supplemental treatment facility bottoms meet the Class C requirement.
All of the batches from the LAW supplemental treatment facility could meet the Class C requirements if this stream is not evaporated as aggressively. The liquid effluent, when treated to the final disposal form (e.g., cast stone), will be diluted further, thus adding additional conservatism to the Scenario 9 projections.

While the waste meets the concentration limits for Class C waste disposal, there are potential issues disposing of the treated waste at the IDF or offsite disposal facilities due to the amount of Tc-99. Past PA studies64 that focused on groundwater protection have shown that Tc-99 in various waste forms disposed of in the IDF will be the primary dose contributor to the IDF performance. Tc-99 is problematic due to its long half-life (213,000 years), complex redox chemistry, high solubility, and volatility at high temperatures. During the glass melting process, a fraction of the Tc-99 volatilizes from the glass melter and is captured in the offgas treatment system. In the Baseline Case, the offgas condensates are recycled back through pretreatment and sent to the LAW Vitrification Facility and supplemental treatment as LAW feed, which increases the retention of Tc-99 in the LAW glass. In Scenario 9, this recycle stream (and the majority of Tc-99) is sent for offsite treatment instead of being captured in the glass. Figure 5-162 shows the distribution of the approximately 26,000 Ci of Tc-99 sent from the tank farms to the various treatment products in Scenario 9.

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5.9.3.5 **Opportunities**

In Scenario 9 there are opportunities to change the volume and/or classification of the effluent to be shipped offsite by evaporating the effluent to meet the desired concentration target. For example, if the target were to meet 85 percent of the Class C limit, the combined effluent stream could be concentrated by 75 percent more to meet this target value. Less volume sent offsite for treatment could potentially reduce the treatment and disposal costs. However, the effluent could meet Class A requirements, if the effluent stream is not evaporated as aggressively or at all; while the volume increases, the per gallon disposal cost for Class A is less. A cost-benefit analysis of the various options will need to be completed to determine the best approach.

A concern with the disposal of the treated melter offgas effluent (especially at the IDF) is the amount of long-lived radionuclides such as Tc-99 and the potential to leach to the groundwater. There are various alternatives that have been evaluated over the years to remove the Tc-99 either in the waste prior to vitrification or in the melter offgas stream. The DOE Office of Environmental Management has established a technetium management program plan (SRNL-STI-2016-00712, *Technetium Management Program Plan*). This plan captures the principal technetium-related DOE needs and opportunities, and the approach that will be used to resolve them. Several tasks are outlined to explore the opportunities to address this issue.

Since the recycle is not returned to the LAW supplemental treatment facility feed, the amount of containers produced is reduced in Scenario 9, suggesting an opportunity to reduce the number of LAW supplemental treatment facility melters. In addition, the melter and offgas equipment life will potentially increase as the corrosive halides and sulfates are reduced by eliminating the melter offgas recycle stream. Another potential opportunity is to refine the current glass formulation without the recycle contributions and improve waste loading even further.
Scenario 9 makes use of the existing WTP EMF for the entire mission, while in the Baseline Case the WTP EMF is not used after DFLAW operations. Continuing to use an existing facility adds value and provides a better return on investment.

5.9.3.6 Risks

There are several risks associated with Scenario 9 that could impede its success. The key risks include the following:

- **Regulatory risks**: There are potential issues associated with a new NEPA analysis, with a modification to the existing ROD in the TC & WM EIS to allow offsite treatment and onsite or offsite disposal of the effluent stream. There are also risks associated with receiving approval of exemptions in accordance with DOE O 435.1 for treatment and disposal of the waste at facilities other than the DOE site where the waste is generated.

- **Transportation risks**: Shipping LLW offsite may face opposition from offsite stakeholders. In addition, there are risks associated with the truck or trailer availability and/or filling the vehicles.

- **Offsite treatment facility risks**: There are risks associated with potential delays and operational readiness of the selected offsite treatment facility (e.g., Perma-Fix Northwest) such that the facility is not able to support the demand. Delays and obstacles could result from issues with construction and permitting.

- **Onsite or offsite disposal facility risks**: There is a potential risk that the selected disposal facility will be unavailable and/or cannot support the demand.

- **Waste acceptance criteria risks**: There is a potential that the effluent will not meet the waste acceptance criteria for offsite shipping and/or that the final treated waste form does not meet the offsite disposal waste acceptance criteria.

- **Accuracy of predictive tools**: Capture of key radionuclides Tc-99, iodine-129 (I-129), Sr-90, and Am-241 within the melter glass product may vary from the current baseline and could have an adverse effect on disposal of the offgas stream.
5.10 SCENARIO 10 – RETRIEVAL CONTINGENCY

5.10.1 Objective/Planning Bases

The objective of Scenario 10 (Retrieval Contingency) is to determine the number of new DSTs and their associated timing required to maintain the Baseline Case SST retrieval completion date of December 2056, assuming a 5-year delay to DFLAW operations and WTP startup. Table 5-59 identifies the baseline assumptions from Appendix A that were modified for Scenario 10.

Table 5-59. Scenario 10 – Assumptions Altered from the Baseline Case.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 10 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.2.1</td>
<td>New DSTs will be added in multiples of four and operational June 2028 (based on a decision to build in June 2020 and an 8-year lead-time). Additional DSTs, added in four-packs, are to be placed in operation every 5 years after June 2028 based on retrieval needs to meet the Baseline Case retrieval completion date of December 2056.</td>
</tr>
<tr>
<td>A1.2.2.2</td>
<td>New DSTs will have an operating volume of 1.25 Mgal each.</td>
</tr>
<tr>
<td>A1.2.5.1</td>
<td>The LAWPS will be operational on 10/1/2028.</td>
</tr>
<tr>
<td>A1.2.5.2</td>
<td>The final transfer from the LAWPS to the LAW Vitrification Facility should occur by 11/30/2038.</td>
</tr>
<tr>
<td>A1.3.1.7</td>
<td>The PT Facility will be operational by 12/31/2038.</td>
</tr>
<tr>
<td>A1.3.3.2</td>
<td>The HLW Vitrification Facility will be operational on 12/31/2038.</td>
</tr>
<tr>
<td>Starting on</td>
<td>Rate (MTG/day)</td>
</tr>
<tr>
<td>12/31/2038</td>
<td>3.0</td>
</tr>
<tr>
<td>12/31/2039</td>
<td>4.0</td>
</tr>
<tr>
<td>9/30/2041</td>
<td>4.2</td>
</tr>
<tr>
<td>12/31/2043</td>
<td>5.25</td>
</tr>
<tr>
<td>A1.3.4.5</td>
<td>The LAW Vitrification Facility will be operational on 12/31/2028.</td>
</tr>
<tr>
<td>Starting on</td>
<td>Rate (MTG/day) (hot commissioning will not specifically be modeled):</td>
</tr>
<tr>
<td>12/31/2028</td>
<td>9.0</td>
</tr>
<tr>
<td>7/31/2029</td>
<td>18.0</td>
</tr>
<tr>
<td>7/31/2030</td>
<td>21.0</td>
</tr>
<tr>
<td>A1.2.6.2</td>
<td>The TWCS capability will be operational 6/30/2037 (18 months prior to hot commissioning of the HLW Vitrification Facility).</td>
</tr>
<tr>
<td>A1.4.1.6</td>
<td>The LAW supplemental treatment facility will be operational on 12/31/2039.</td>
</tr>
</tbody>
</table>

In this scenario, the new DSTs will be equipped with dual mixer pumps (without incremental insertion capability), slurry pumps, and decant pumps, and will have an operating capacity of 1.25 Mgal each. The pumps will be connected to the DST transfer system by three transfer lines (each presumably constructed of 3-inch 304L stainless steel in 6-inch carbon steel) and a new...
diversion box that will intercept transfer lines from the nearest valve pit. The new DSTs will be located in the 200 West Area and/or the 200 East Area.

While the new DSTs represent a significant change to site infrastructure, construction is assumed to not require any technology development, as the most recently constructed tank farm, AP Tank Farm, will likely serve as a template for the design and cost bases of the new farms. The assumptions on SST retrieval rates and simultaneous retrievals remain the same as the Baseline Case (see Assumption A1.2.3.3), which includes no more than two retrievals per area at the same time, excluding potential CH-TRU waste SSTs.

5.10.2 Flowsheet Description
The simplified flowsheet diagram for Scenario 10 is the same as that shown in Figure 5-1 (Section 5.1.2) for the Baseline Case.

5.10.3 Analysis
5.10.3.1 Schedule Performance
Figure 5-163 shows the operating schedule for SST retrievals and the treatment systems in Scenario 10, and Table 5-60 lists the key mission activity dates compared to the Baseline Case.

The differences in the key mission metrics from the Baseline Case are due to the following:

- 5-year delay in DFLAW and WTP startup
- Addition of eight new DSTs in the 200 West Area in June 2028
- Addition of four new DSTs in the 200 East Area in June 2033.

In Scenario 10, the addition of eight new DSTs in the 200 West Area in 2028 supports the 200 West Area SST retrieval completion by November 2054 even with a 5-year delay, compared to April 2055 in the Baseline Case. The addition of four new DSTs in 200 East Area in 2033 supports the East Area SST retrieval completion by November 2055, compared to December 2056 in the Baseline Case.

For Scenario 10, the B-Complex WRF in the 200 East Area has a start date of June 2033, approximately 2 years earlier than the Baseline Case. The T-Complex WRF in the 200 West Area starts about the same as the Baseline Case in July 2040. The 200 East Area WRF is required earlier to accelerate SST retrievals in this scenario.

Due to the 5-year delay in the DFLAW Program and startup of the integrated WTP, the treatment mission completes 5 years later than the Baseline Case in December 2068. Even with this 5-year delay, the SST retrievals complete 1 year earlier than the Baseline Case due to the addition of the new DSTs.

Compared to the Baseline Case, the 242-A Evaporator will shut down 1 year earlier (June 2056 versus April 2057), due to accelerated SST retrievals and additional DST space, which compensates for the 5-year delay caused by late startup of DFLAW operations and the integrated
WTP. To help accelerate SST retrievals, this scenario starts four simultaneous retrievals in June 2033 versus January 2035.

Even with a 5-year delay in DFLAW and WTP operations, the completion dates for Group A tank mitigations are each within 2 years of the Baseline Case, as all remaining Group A tank mitigations will occur when the new DSTs are added in the 200 East Area in 2033.
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Figure 5-163. Scenario 10 – Operating Schedule for Major Facilities/Processes.

### Regulatory
- WMA C Closed (M-045-83)
- Modeled - Five Retr. Completed (D-168-03)
- Modeled - Five Retr. Completed (D-168-03)
- A-103 Retrieved (M-045-15)
- Modeled - A-103 Retrieved (M-045-15)
- Nine Add'l Retr. Completed (D-168-02)
- Modeled - Nine Add'l Retr. Completed (D-168-02)
- C-Farm Retr. Completed (D-168-01)
- Modeled - C-Farm Retr. Completed (D-168-01)

### Storage/Retrieval
- CST (Slurry) - CST (Supernatant)
- New DSTs 1
- East Area WRF
- AN-103
- AN-105
- AN-104

### Pretreatment/Treatment
- Input - WTP LAW LH VI, Hot Comm.
- WTP LAW LH VI, Hot Comm.
- TWCS Capability
- Input - WTP LH VI, Hot Comm.
- Input - WTP PT Hot Comm.
- WTP LH VI, Hot Comm.
- PT Hot Comm. Complete (D-00A-16)
- Input - WTP Initial Plant Operations
- Potential CH-TRU Facility Operations

### Disposal
- CWC
- IHS Module 1
- IHS Module 2
- HLW Shipped Offsite

### Legend
- Regulatory Due Date
- Regulatory Projected Completion
- Start
- Completed
- Completed Farm Retrieval
- Group A Mitigation Completed
- Start Date
- Summary Tank
- Tank Fills
- WRF
- Supplemental Treatment
- Other
Table 5-60. Scenario 10 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 10 – Retrieval Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete C Tank Farm Retrievals (existing Consent Decree 3/31/2024)</td>
<td>8/2017</td>
<td>8/2017</td>
</tr>
<tr>
<td>Complete Five Additional SST Retrievals (existing Consent Decree 12/31/2020)</td>
<td>4/2019</td>
<td>4/2019</td>
</tr>
<tr>
<td>Complete Nine Additional SST Retrievals (existing Consent Decree 3/31/2024)</td>
<td>5/2022</td>
<td>5/2022</td>
</tr>
<tr>
<td>Complete Tank A-103 (existing TPA 9/30/2022)</td>
<td>11/2022</td>
<td>11/2022</td>
</tr>
<tr>
<td>WMA C Closed (existing TPA 6/30/2019)</td>
<td>6/2028</td>
<td>6/2028</td>
</tr>
<tr>
<td>New DSTs Operational – 200 West Area</td>
<td>N/A</td>
<td>6/2028</td>
</tr>
<tr>
<td>New DSTs Operational – 200 East Area</td>
<td>N/A</td>
<td>6/2033</td>
</tr>
<tr>
<td>200 West Area WRF Operational</td>
<td>4/2040</td>
<td>7/2040</td>
</tr>
<tr>
<td>200 East Area WRF Operational</td>
<td>1/2035</td>
<td>6/2033</td>
</tr>
<tr>
<td>200 West Area SST Retrievals Complete</td>
<td>4/2055</td>
<td>11/2054</td>
</tr>
<tr>
<td>200 East Area SST Retrievals Complete</td>
<td>12/2056</td>
<td>11/2055</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Supernate)</td>
<td>9/2025</td>
<td>9/2025</td>
</tr>
<tr>
<td>Cross-Site Transfer Line Activated (Slurry)</td>
<td>7/2025</td>
<td>7/2025</td>
</tr>
<tr>
<td>Start of Four Simultaneous Retrievals</td>
<td>4/2039</td>
<td>6/2033</td>
</tr>
<tr>
<td>Tank AN-103 Group A Mitigation Complete</td>
<td>9/2032</td>
<td>6/2033</td>
</tr>
<tr>
<td>Tank AN-104 Group A Mitigation Complete</td>
<td>6/2025</td>
<td>10/2023</td>
</tr>
<tr>
<td>Tank AN-105 Group A Mitigation Complete</td>
<td>1/2033</td>
<td>7/2033</td>
</tr>
<tr>
<td>Tank AW-101 Group A Mitigation Complete</td>
<td>10/2032</td>
<td>7/2033</td>
</tr>
<tr>
<td>Tank SY-103 Group A Mitigation Complete</td>
<td>10/2023</td>
<td>10/2023</td>
</tr>
<tr>
<td>LAWPS Start</td>
<td>10/2023</td>
<td>10/2028</td>
</tr>
<tr>
<td>TWCS Capability Start</td>
<td>6/2032</td>
<td>6/2037</td>
</tr>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2038</td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2028</td>
</tr>
<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2038</td>
</tr>
<tr>
<td>WTP Initial Plant Operations</td>
<td>12/31/2036</td>
<td>12/31/2041</td>
</tr>
<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2036</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>12/2068</td>
</tr>
</tbody>
</table>
Table 5-60. Scenario 10 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 10 – Retrieval Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>LERF/ETF Operations</td>
<td>1/2016 – 12/2065</td>
<td>10/2016 – 1/2070</td>
</tr>
<tr>
<td>IHS Facility Operations</td>
<td>1/2034 – 10/2063</td>
<td>12/2038 – 12/2068</td>
</tr>
<tr>
<td>IHS Module 1 Need Date</td>
<td>12/2033</td>
<td>5/2039</td>
</tr>
<tr>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>4/2048</td>
</tr>
<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047 – 12/2065</td>
<td>1/2054 – 11/2071</td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
<td>1/2071</td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>1/2031</td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>1/2054</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
CWC = Central Waste Complex.  
DFLAW = direct-feed low-activity waste.  
DST = double-shell tank.  
ETF = Effluent Treatment Facility.  
HLW = high-level waste.  
HSF = Hanford Shipping Facility.  
IDF = Integrated Disposal Facility.  
IHS = Interim Hanford Storage.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
LERF = Liquid Effluent Retention Facility.  
PT = Pretreatment.  
SST = single-shell tank.  
TPA = Tri-Party Agreement.  
TWCS = tank waste characterization and staging.  
WMA = waste management area.  
WRF = Waste Receiving Facility.  
WTP = Waste Treatment and Immobilization Plant.

5.10.3.2 Cost

Figure 5-164 shows the lifecycle cost profile for this scenario compared to the Baseline Case. Although the cost profile for Scenario 10 and the Baseline Case are similar, the impact is evident of the 5-year delay in the start of treatment on the lifecycle cost profile for Scenario 10.

The total unescalated lifecycle cost estimated for Scenario 10 is $116 billion, four and one-half percent higher than the Baseline Case cost of $111 billion.

The total cost of construction, operations, and closure for eight new DSTs in the 200 West Area is estimated to be $3.1 billion. The total cost for four new DSTs in the 200 East Area is estimated to be $1.9 billion, including operations and closure.65

The total escalated cost for Scenario 10 is $266 billion versus $231 billion for the Baseline Case.

---

65 The costs for new DSTs in this scenario were based on an estimate developed originally as part of the Project W-236 (Cost to Construct New DST Farm) in the 1993/1994 timeframe. The estimate was updated in 2015 to include 304L stainless steel materials of construction and a full tank farm weather-enclosure building with an overhead maintenance crane.
5.10.3.3 Mission Flowsheet Results

The Scenario 10 results indicate that, even with a 5-year delay in the start of treatment, the Baseline Case SST retrieval completion date of December 2056 can be met with the addition of new DSTs. To complete SST retrievals by December 2056, 12 new DSTs are required: eight in the 200 West Area in 2028 and four in the 200 East Area in 2033. While the SST retrieval durations are the same as the Baseline Case, treatment completes 5 years later in this scenario, corresponding to the 5-year delay in the start of treatment. This leads to the conclusion that the RPP mission duration is limited by treatment throughput and not by SST retrieval capabilities. Further breakdown of the results is provided in the following subsections.

5.10.3.3.1 Single-Shell Tank Retrievals

Figure 5-165 provides a comparison of the SST retrieval sequence for Scenario 10 and the Baseline Case. The green and dark-blue bands on the plots indicate when retrieval of the SST is occurring, and the yellow and light-blue colors indicate when the SST is not being retrieved (i.e., delay time). The impact on SST retrievals of the 5-year treatment delay (December 2023 to December 2028) can be seen in the figure. Tanks S-105 and S-109 are started just prior to the delay, but do not complete retrieval until after the delay is over, 5 years later. Addition of the new DSTs in 2028 and 2033 results in a seven percent less SST retrieval delay time in Scenario 10 after treatment starts. This improvement is enough to meet the Baseline Case SST retrieval completion date of December 2056.
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Figure 5-165. Scenario 10 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
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Figure 5-166 shows the number of SSTs retrieved each year in Scenario 10 compared to the Baseline Case. The total number of SSTs retrieved is the same in both scenarios, as is the number of SSTs retrieved until the end of 2023, when the 5-year treatment delay in Scenario 10 begins. The treatment delay also causes a 5-year delay in retrievals because the DSTs are full.

Figure 5-166. Scenario 10 Comparison – Total Single-Shell Tanks Retrieved per Calendar Year.
Retrieval efficiency is improved in Scenario 10 by the addition of new DSTs in 2028 and 2033, which reduces the delay in retrieval time and supports completion of retrievals by December 2056. Figure 5-167 shows the reduction in the original SST waste volume as the tanks are retrieved for Scenario 10 and the Baseline Case. The total volume of retrieved waste is essentially the same in both scenarios.

![Figure 5-167. Scenario 10 Comparison – Single-Shell Tank Retrieval Progress.](image)

5.10.3.3.2 Double-Shell Tank Space Management

The number of new tanks that will be needed was determined by a process of elimination with a variety of tank configurations (multiples of four tanks in 200 East Area in 2028 and 200 West Area in 2033), with the target being the SST retrieval completion date on or before December 2056. Four tanks in 200 West Area and eight tanks in 200 East Area were initially modeled, but this configuration did not meet the December 2056 SST retrieval completion date. Because more waste resides in the 200 West Area, the number of new DSTs added in 2028 in 200 West Area was increased to eight. This configuration was found to meet the SST retrieval completion date; however, the tanks in the 200 East Area were underutilized, indicating that the number of new DSTs could be reduced to four while still meeting the Baseline Case SST completion date. On implementation of this configuration in the model, an SST retrieval completion date of November 2055 was obtained.

Through December 2023, pre-DFLAW operations in Scenario 10 are identical to the Baseline Case, with the exception of Tank AN-104 mitigation, which is completed in October 2023.
compared to June 2025 in the Baseline Case. Then DFLAW operations are delayed until 2028 because of the 5-year delay in treatment. During the delay, between 2023 and 2028, there are no SST retrievals, DST transfers, or 242-A Evaporator campaigns because no space is available in the DSTs for operations until treatment begins.

Space management in the DSTs is essential to completing retrievals of the SSTs by December 2056. The addition of new DSTs in this scenario supports this objective. The first new DST farm consists of eight tanks located in the 200 West Area that are fully integrated with the rest of the DST transfer system. The 200 West Area was chosen for the first new DSTs because the SSTs in this area contain approximately two-thirds of the remaining retrieval volume and take longer to retrieve. The new farm is operational in June 2028. The next new DST farm, operational in June 2033, consists of four tanks located in the 200 East Area, which are also fully integrated with the rest of the DST transfer system.

Figure 5-168 shows the utilization of the existing and new DSTs over the course of the mission in this scenario. The figure shows the total DST capacity, total volume of waste, and various allocations of headspace for purposes other than waste storage (see Table 5-4 in Section 5.1.3.3.2). The total capacity is initially 32 Mgal from the existing DSTs and is 31 Mgal when Tank AY-102 retrieval is completed. As the first set of new DSTs is available for use, the DST capacity increases by approximately 10 Mgal in 2028, then increases another 5 Mgal in 2033 when the second set of new DSTs becomes operational. Closure of the DSTs begins in 2051, and from that point on, the available DST space is reduced as the tanks are closed and no longer available.

Figure 5-168. Scenario 10 – Double-Shell Tank Space Utilization.
The new tanks add approximately 15 Mgal of DST space. In Figure 5-168, only 4 to 13 Mgal of new DST space appears to be used before DST closure begins. However, Figure 5-169 and Figure 5-170 show that the new DSTs are continually filled and emptied, and spend a significant amount of time at least partially full.

Figure 5-169. Scenario 10 – New Set of Double-Shell Tanks in the 200 West Area in 2028.

Figure 5-171 shows the available DST space in Scenario 10 compared to the Baseline Case. The peaks in 2028 and 2033 point to the new DSTs becoming operable. The downsides of the peaks depict the new DSTs filling up almost immediately after the tanks become available. Between 2030 and 2043, the additional space created by the new DSTs is well-used and the available space is about the same as the Baseline Case. Starting in 2043 as SST retrievals complete, the shapes of the curves for Scenario 10 and the Baseline Case are nearly the same; however, the curve for Scenario 10 reflects the additional space from the 12 extra DSTs. In both scenarios, the available space declines at the end of the mission as the DSTs close.
Numerous DST transfers support staging of feed for the LAWPS, WTP, and LAW supplemental treatment facility. As shown in Figure 5-172, the total number of DST transfers in both cases and the transfers over time are nearly the same. Transfers into the DST system consist mostly of the retrieved SST waste and a variety of other additions from miscellaneous Hanford facility waste.
generators, returns during DFLAW operations, water and chemical additions resulting from mitigation of special DST wastes, flushes, dilutions, solids mitigation, and DST closure activities. Approximately 200 Mgal of additions to the DSTs are made over the duration of the mission, which represents a reduction of approximately ten percent compared to the Baseline Case. The majority of the decrease in added volume is due to a 14-Mgal reduction in solids mitigation water additions. Since there is more available DST space in this scenario, not as much waste needs to be concentrated by the 242-A Evaporator, thus reducing the need for solids mitigation.

Figure 5-172. Scenario 10 Comparison – Double-Shell Tank Transfers.

5.10.3.3.3 Waste Receiving Facilities
The addition of new DSTs enables earlier retrievals in the B Complex, which accelerates the operational need date for the 200 East Area WRF from January 2035 for the Baseline Case to June 2033. The 200 West Area WRF is needed about the same time that the facility is needed in the Baseline Case, indicating that T Complex retrievals occur during the same period in both scenarios.

5.10.3.3.4 242-A Evaporator
Figure 5-173 shows the projected demand on the 242-A Evaporator over the course of the mission compared to the Baseline Case. The 242-A Evaporator processes about 180 Mgal of dilute waste, 12 percent less than the Baseline Case. The average number of annual campaigns per year is approximately the same in Scenario 10 versus the Baseline Case at 5.4 versus 5.5 campaigns per year, respectively. The reduction in feed volume is directly related to the
addition of new DSTs, which reduces the need to use the evaporator to create DST space as aggressively as in the Baseline Case.

The maximum number of 242-A Evaporator campaigns in 1 year is 15, compared to 17 in the Baseline Case. The 242-A Evaporator peaks at 127 days of hot operations during the peak year of 2049. In contrast, the Baseline Case peaks at 152 days of hot operations.

Figure 5-173. Scenario 10 Comparison – Projected Operations of the 242-A Evaporator.

5.10.3.3.5 Waste Feed Delivery
Scenario 10 meets all ICD-19 feed screening criteria\textsuperscript{66} for the LAW and HLW Vitrification Facilities, and the ICD-30 criteria for the U-235 concentration 99 percent of the time for feed to the LAWPS during DFLAW operations. This information can be used to identify actions for mitigating issues if this scenario is implemented as the baseline.

5.10.3.3.6 Waste Treatment and Immobilization
This section presents the production metrics of the integrated WTP for Scenario 10 and compares the metrics to those for the Baseline Case. Table 5-61 shows that Scenario 10 is the same as the Baseline Case in timing, duration, and product output of waste treatment operations. Therefore,

\textsuperscript{66} Items not modeled and reported include feed receipt temperature, feed viscosity, slurry rheology, critical velocity, particle size, particle hardness, separable organics, and PCB concentration.
waste treatment operations are relatively unaffected by the acceleration in SST retrievals due to the construction of the new DSTs.

Table 5-61. Scenario 10 Comparison – Waste Treatment Product Summary.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 10 – Retrieval Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
<td>11/2063</td>
<td>12/2068</td>
</tr>
<tr>
<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
<td>7,800</td>
<td>7,800</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>23,600</td>
<td>23,600</td>
</tr>
<tr>
<td></td>
<td>Waste loading</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>Total ILAW</td>
<td>Product (number of containers)</td>
<td>94,000</td>
<td>95,800</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>517,900</td>
<td>527,900</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na$_2$O)</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>WTP ILAW</td>
<td>Product (number of containers)</td>
<td>51,600</td>
<td>51,900</td>
</tr>
<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>285,700</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na$_2$O)</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>LAW Supplemental Treatment</td>
<td>Product (number of containers)</td>
<td>42,400</td>
<td>44,000</td>
</tr>
<tr>
<td>(glass)</td>
<td>MT of product</td>
<td>233,600</td>
<td>242,200</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na$_2$O)</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Volume (yd$^3$)</td>
<td>118,000</td>
<td>122,800</td>
</tr>
<tr>
<td>LAW Supplemental Treatment</td>
<td>Grout product (yd$^3$)</td>
<td>419,200</td>
<td>430,500</td>
</tr>
<tr>
<td>(grout)</td>
<td>Waste Na$_2$O equivalent (%)</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

IHLW = immobilized high-level waste. MT = metric ton.
ILAW = immobilized low-activity waste. WTP = Waste Treatment and Immobilization Plant.
LAW = low-activity waste.

Figure 5-174 shows the decrease in radioactivity in the tank farms inventory as waste is delivered to the various waste treatment and immobilization facilities. The graph includes the radioactive decay over time of the starting inventory. The decline in curies during DFLAW operations is predominantly due to decay, so the 5-year delay in the start of DFLAW in Scenario 10 does not noticeably change the rate of tank farms curie decline, but does extend the curve for 5 years. HLW Vitrification Facility operations also start 5 years later than the Baseline Case, so the rapid decrease in curies associated with HLW treatment occurs 5 years later. After HLW vitrification starts, the curies are removed from the tank farms faster in Scenario 10, as SST retrievals are accelerated to meet the Baseline Case SST retrieval date.
5.10.3.3.6.1 Direct-Feed Waste Treatment
The DFLAW flowsheet is in effect for 10 years prior to the PT Facility starting up. In those 10 years, 21 Mgal of LAW at a target concentration of 5.6 M Na is sent to the LAWPS, where the waste is pretreated and sent to the LAW Vitrification Facility. During DFLAW operations, approximately 11,100 containers of ILAW are produced (61,200 MTG), which is approximately 12 percent of the total ILAW estimated for the mission (95,800 total ILAW containers). These results are nearly identical to the Baseline Case.

5.10.3.3.6.2 Pretreatment Throughput
The waste sodium and as-delivered solids are approximately the same in Scenario 10 as in the Baseline Case because the same waste is processed in both scenarios. An average pretreatment throughput of 2,030 MT Na waste per year and 1,090 MT as-delivered solids per year is achieved in Scenario 10. By comparison, the Baseline Case achieves an average of 2,120 MT Na waste per year and 1,070 MT as-delivered solids per year. The slight difference between the two scenarios is due to differences in blending as the waste is retrieved and transferred between DSTs.

5.10.3.3.6.3 Glass Production
Figure 5-175 compares the projected HLW glass production for Scenario 10 and the Baseline Case against the theoretical capacities of the HLW Vitrification Facility for both scenarios. Although treatment is delayed by 5 years, the glass production rate closely mirrors that of the
Baseline Case. The resulting number of IHLW canisters produced is the same as the Baseline Case, about 7,800 canisters.

Figure 5-175. Scenario 10 Comparison – Projected Immobilized High-Level Glass Production.

Figure 5-176 shows the projected ILAW production, compared to the Baseline Case, against the theoretical capacities of the LAW Vitrification Facility for both scenarios. Production of ILAW mirrors the Baseline Case, just delayed by 5 years, and results in about 52,000 containers.
The LAW supplemental treatment facility immobilizes excess pretreated LAW feed from the PT Facility and the LAWPS, provided there is feed available. Because the facility only processes excess LAW feed, there are times of slowdown, when there is not enough feed for the facility to operate at maximum capacity. Figure 5-177 shows the projected ILAW production from the LAW supplemental treatment facility compared to the Baseline Case. The figure shows that Scenario 10 operates significantly closer to the theoretical treatment capacity than the Baseline Case. This is due to having more space available for SST retrievals with the addition of new DSTs, which increases the quantity of feed available for treatment. In 2058, Scenario 10 ILAW production slows abruptly as retrievals of the SSTs are complete and the LAWPS has shut down. The remaining feed to the LAW supplemental treatment facility at this point is only the excess LAW from the PT Facility. The Baseline Case exhibits the same behavior, although less abruptly since the SST retrievals are more evenly distributed over the treatment mission. Scenario 10 produces slightly more glass (44,000 containers) than the Baseline Case (42,400 containers) over the same 30-year duration. The waste blending is somewhat different in Scenario 10 due to the changes in the retrieval order of the SSTs, DST-to-DST transfers resulting from implementation of the 5-year delay, and the addition of new DSTs. The differences in blending account for the variance in containers produced between Scenario 10 and the Baseline Case.
5.10.3.3.6.4 Supplemental Immobilization – Grout

If the feed to the supplemental treatment facility is grouted rather than vitrified, there will be approximately 423,500 yd$^3$ of grout, with approximately eight percent equivalent Na$_2$O loading. This is compared to 44,000 LAW glass containers (produced at the LAW supplemental treatment facility), which is equivalent to 123,000 yd$^3$ of glass$^{67}$ with a waste loading of 22 percent Na$_2$O.

For the Baseline Case, 419,200 yd$^3$ of grout with an eight percent equivalent Na$_2$O loading will be produced compared to 42,400 LAW glass containers, which is equivalent to 118,000 yd$^3$ of glass with 21 percent Na$_2$O loading.

5.10.3.3.7 Impacts on Closure Activities

In Scenario 10, the largest impact on closure activities is the cleanout and closure of 12 additional DSTs. The initial closure of the existing DSTs begins in 2051 and continues through 2067. Closure of DSTs in the 200 West Area completes in 2059, while closure of the DSTs in the 200 East Area completes in 2067. In the Baseline Case, 200 West Area DSTs close in 2056 and 200 East Area DSTs close in 2062. The DSTs complete closure 5 years later than the Baseline Case. This reflects the 5-year delay and the mission being treatment-limited.

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$^{67}$ The volume of the ILAW containers is 626 gal and, when filled to 90%, the containers hold 564 gal of ILAW per container, which is equivalent to 2.7924 yd$^3$ of ILAW per container.
5.10.3.4 Opportunities

There are a number of benefits associated with the construction of new DSTs on the Hanford Site. New DSTs provide operational flexibility and risk reduction during the RPP mission. The potential for future leaking DSTs could seriously affect mission cost and duration. If insufficient DST space is available, the SST retrieval durations will increase because less DST space is available to receive SST waste and to stage feed for delivery to the treatment facilities. This is most evident in the 200 West Area, where there are currently only three DSTs. The new DSTs also support earlier completion of the SST retrievals than would be possible without additional tanks, which reduces the likelihood, and therefore impact, of potential SST integrity issues.

The 242-A Evaporator operations are less aggressive in this scenario compared to the Baseline Case because the additional DST space, created by the addition of 12 new DSTs, reduces the need for evaporation to create DST space. The reduced reliance on the 242-A Evaporator can help mitigate the impact of interruptions or outages in evaporator operations, which slows SST retrieval progress.

In Scenario 10, the strategy for providing tank waste to the vitrification facilities is the same as the Baseline Case. However, intentional blending of the tank waste for feed delivery has the potential to reduce the amount of glass produced. This process can be accomplished to some degree in Scenario 10, due to the flexibility created by the addition of 15 Mgal of DST space.

Another opportunity from the construction of new DSTs is the flexibility of location within the respective 200 East or 200 West Areas. In this scenario, the new DSTs were placed relatively close to existing DST farms. The new 200 East Area DSTs could be positioned closer to the B Tank Farm and the new 200 West Area DSTs could be located closer to the T Tank Farm so that construction of the WRFs can be eliminated and the new DSTs can be used in that capacity. This has the potential of reducing the lifecycle cost of Scenario 10 by over $660 million (escalated).

The last DST farm to be constructed on the Hanford Site was AP Tank Farm in the 200 East Area (1982 and 1986). The costs for new DSTs in this scenario were based on an estimate developed originally as part of the Project W-236 (Cost to Construct New DST Farm) in the 1993/1994 timeframe. The estimate was updated in 2015 to include 304L stainless steel materials of construction and a full tank farm weather-enclosure building with an overhead maintenance crane. An opportunity exists in this scenario to evaluate new technologies and improvements in the DST design and infrastructure to better suit the current understanding of mission needs. There are also more regulations now regarding construction and operations than in the past, so a new design can incorporate up-to-date requirements for increased safety of workers and the public. The construction and regulatory environment is different now versus the early 1990s. Factors based on “estimator judgment” were used to approximate those impacts. While this cost basis is a risk, there is an opportunity in Scenario 10 to provide a detailed (and potentially more accurate) estimate for new DSTs based on current information.

5.10.3.5 Risks

The management of DST space is one of the key issues and uncertainties in the Baseline Case because the PMB assumes that improvements in DST space management will support the
projected SST retrieval schedule (see Section 5.1.3.3.2). The need for aggressive DST space management is mitigated in this scenario by the increased storage capacity offered from the construction of additional DSTs. This increased available DST space enables transfers with fewer delays and the flexibility to stage evaporator campaigns more easily, while continuing SST retrievals. The additional DSTs eliminate a significant amount of the SST retrieval delay time seen in the Baseline Case after 2028.

In Scenario 10, the 12 new DSTs will cost approximately $7 billion (escalated). In addition, the 5-year treatment delay, which extends the mission for 5 years (completing in 2074), will cost an additional $28 billion due to cost escalation as mission completion is extended into the future. Further delays become more expensive, as escalation increases every year the mission is delayed. If the mission is delayed an additional 5 years, completing in 2079, escalation will contribute another $40 billion to the mission cost. Note that this increase reflects pure escalation and does not include the cost to maintain the tank farms or treatment systems in the interim. Starting with a factor of one in 2018, the escalation increases to 5.04 by 2074 and 5.80 by 2079. The estimated yearly escalation factor is approximately 1.03, which is based on a yearly inflation rate of 2.86 percent. In this scenario, the eight new DSTs in the 200 West Area will need to be operable by June 2028, and the four new DSTs in the 200 East Area will need to be operable by June 2033 to prevent further delays.

The decision to construct the new DSTs must be made by 2020 to allow sufficient time for permitting, design, and construction by the specified operating date of June 2028. In addition, with another four DSTs to be constructed and operational in the 200 East Area by June 2033, capital and operating budgets must remain in place. The new DSTs in the 200 East and 200 West Areas are needed to meet the SST retrieval completion date of December 2056.

Due to the 5-year delay in completing the mission, there are additional risks posed by the continued aging of tanks, treatment facilities, and associated infrastructure. There is increased risk that DSTs past the end of their lifecycle could fail and that the mission could be further slowed by increasing maintenance needs in aging treatment facilities.

As discussed in Section 5.10.3.4, the cost estimate for the construction of the new DSTs is based on unknown and aged historical references, and there is a risk that new DSTs could cost more than estimated for use in this scenario.
5.11 SCENARIO 11 – DIRECT-FEED HIGH-LEVEL WASTE WITH LIQUIDS–ONLY WASTE TREATMENT AND IMMOBILIZATION PLANT PRETREATMENT FACILITY

5.11.1 Objective/Planning Bases
Scenario 11 evaluates the impacts to the mission of using a flowsheet, which includes full-mission DFHLW operations with the PT Facility operated as liquids-only. The PT Facility receives LAW feed from tank farms and processes the effluents from the LAW and HLW Vitrification Facilities. Entrained solids captured in the ultrafilters and the concentrated cesium eluate are sent to the HLW Vitrification Facility. Table 5-62 identifies the baseline assumptions from Appendix A that were modified for Scenario 11.

Table 5-62. Scenario 11 – Assumptions Altered from the Baseline Case.

<table>
<thead>
<tr>
<th>Baseline Case Assumption #</th>
<th>Scenario 11 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.2.6.1</td>
<td>The TWCS capability will have the additional functionalities of concentrating solids by decanting the supernatant liquid to the tank farms and diluting solids to a concentration of 20 wt% for transfer to the WTP.</td>
</tr>
<tr>
<td>A1.3.2.1</td>
<td>The TWCS capability will send HLW feed directly to the HLW feed blending vessel (HLP-VSL-00028) in the PT Facility.</td>
</tr>
<tr>
<td>A1.3.2</td>
<td>All PT Facility operations involving HLW sludge washing and leaching are removed from the flowsheet; the PT Facility is modeled as a “liquids-only” facility and will handle LAW feed and the effluent from the WTP vitrification facilities.</td>
</tr>
<tr>
<td>A1.4.1.4</td>
<td>The LAWPS shuts down permanently after DFLAW operations complete (LAWPS is not used as a source of additional feed to the LAW supplemental treatment facility).</td>
</tr>
</tbody>
</table>

DFLAW = direct-feed low-activity waste. PT = pretreatment.
HLW = high-level waste. TWCS = tank waste characterization and staging.
LAW = low-activity waste. WTP = Waste Treatment and Immobilization Plant.
LAWPS = Low-Activity Waste Pretreatment System.

5.11.2 Flowsheet Description
The simplified flowsheet for Scenario 11 is presented in Figure 5-178. The flowsheet differs from the Baseline Case in several ways. The HLW feed is delivered directly from the TWCS capability to the HLP feed blending vessel (HLP-VSL-00028) in the PT Facility instead of the HLP feed receipt vessel (HLP-VSL-00022), bypassing the PT Facility ultrafiltration system entirely. In addition, in support of direct-feed operation of the HLW Vitrification Facility, the functionality of the TWCS capability was changed from the Baseline Case to better support DFHHLW operation.

In the Baseline Case, the TWCS capability performs the functions of receiving, staging (including sampling), and delivering slurry from the 200 East Area DSTs to the WTP. However, in this DFHHLW flowsheet, the TWCS capability must also support separation of the as-received slurry into a solids-heavy fraction, which is fed forward to the HLW Vitrification Facility, and a supernatant liquid fraction, which is returned to the 200 East Area DSTs. This is modeled as a settle-decant process; however, added technology, such as filtration, may be desirable or required to support this function. After the separation is completed, the solids-heavy fraction is diluted.
with water in the TWCS capability to support transfer of the waste to WTP. When diluted, the prepared DFHLW feed slurry is staged, sampled, and transferred directly from the TWCS capability to the HLP feed blending vessel in the PT Facility.

By removing the solids washing and leaching functions, the PT Facility can dedicate more capacity to pretreating LAW feed from tank farms, and LAWPS is no longer needed in the flowsheet as a source of supplemental pretreated LAW feed to LAW supplemental treatment. Instead, the LAWPS is shut down permanently after the completion of DFLAW operations. The removal of the solids washing and leaching functions from the PT Facility, coupled with the removal of LAWPS as a source of supplemental pretreated LAW feed, enables the LAW supplemental treatment to be sized at half the capacity as in the Baseline Case (21 MTG/day equivalent versus 42 MTG/day equivalent at 70 percent TOE).
Figure 5-178. Scenario 11 – Simplified Flowsheet.
5.11.3 Analysis

5.11.3.1 Schedule Performance

Table 5-63 lists the key mission activity dates for Scenario 11 compared with the Baseline Case, and Figure 5-179 includes the operating schedule for SST retrievals and the treatment systems for this scenario.

Notable differences between the dates for Scenario 11 and the Baseline Case are:

- Total mission duration approximately 16 years longer
- SST retrievals complete nearly 6 years later
- 242-A Evaporator operates 10 years longer.

Table 5-63. Scenario 11 Comparison – Key Mission Activity Dates. (2 pages)
### Table 5-63. Scenario 11 Comparison – Key Mission Activity Dates. (2 pages)

<table>
<thead>
<tr>
<th>Key Mission Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 11 – DFHLW w/Liquids-Only WTP PT Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>LAW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2023</td>
<td>12/2023</td>
</tr>
<tr>
<td>HLW Vitrification Facility Hot Commissioning Completes</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>HLW Vitrification Facility Operations</td>
<td>12/2033 – 8/2063</td>
<td>12/2033 – 9/2079</td>
</tr>
<tr>
<td>WTP Initial Plant Operations</td>
<td>12/2036</td>
<td>12/2036</td>
</tr>
<tr>
<td>Potential CH-TRU Waste Treatment Facility Operations</td>
<td>1/2031 – 1/2036</td>
<td>1/2031 – 1/2036</td>
</tr>
<tr>
<td>Treatment Completion</td>
<td>11/2063</td>
<td>9/2079</td>
</tr>
<tr>
<td><strong>Disposal</strong></td>
<td></td>
<td></td>
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<tr>
<td>IHS Facility Operations</td>
<td>1/2034 – 10/2063</td>
<td>1/2034 – 9/2079</td>
</tr>
<tr>
<td>IHS Module 1 Need Date</td>
<td>12/2033</td>
<td>12/2033</td>
</tr>
<tr>
<td>IHS Module 2 Need Date</td>
<td>10/2042</td>
<td>4/2038</td>
</tr>
<tr>
<td>HSF Offsite Shipping Operations</td>
<td>8/2047 – 12/2065</td>
<td>8/2040 – 10/2081</td>
</tr>
<tr>
<td>All HLW Shipped Offsite</td>
<td>12/2065</td>
<td>10/2081</td>
</tr>
<tr>
<td>CWC Need Date</td>
<td>1/2031</td>
<td>1/2031</td>
</tr>
<tr>
<td>Federal Geological Repository Need Date</td>
<td>8/2047</td>
<td>8/2040</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  
CWC = Central Waste Complex.  
DFHLW = direct-feed high-level waste.  
DFLAW = direct-feed low-activity waste.  
ETF = Effluent Treatment Facility.  
HLW = high-level waste.  
HSF = Hanford Shipping Facility.  
IDF = Integrated Disposal Facility.  
IHS = Interim Hanford Storage.  
LAW = low-activity waste.  
LAWPS = Low-Activity Waste Pretreatment System.  
LERF = Liquid Effluent Retention Facility.  
PT = Pretreatment.  
SST = single-shell tank.  
TPA = Tri-Party Agreement.  
TWCS = tank waste characterization and staging.  
WMA = waste management area.  
WRF = Waste Receiving Facility.  
WTP = Waste Treatment and Immobilization Plant.
### Scenario 11 – Operating Schedule for Major Facilities/Processes

**Calendar Year**

| 16 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 | 2055 | 2056 | 2057 | 2058 | 2059 | 2060 | 2061 | 2062 | 2063 | 2064 | 2065 | 2066 | 2067 | 2068 | 2069 | 2070 | 2071 | 2072 | 2073 | 2074 | 2075 | 2076 | 2077 | 2078 | 2079 | 2080 | 2081 | 2082 | 2083 | 2084 | 2085 | 2086 |
|----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

**Regulatory**

- WMAC Closed (M-045-83)
- Modeled - WMAC Closed (M-045-83)
- Closed - WMAC Closed (M-045-83)
- Five Retr: Completed (D-168-03)
- Five Retr: Completed (D-168-03)
- A-103 Retr: Completed (M-045-15)
- Modeled - A-103 Retr: Completed (M-045-15)
- Modeled - Nine Add Ret: Completed (D-168-02)
- Modeled - Nine Add Ret: Completed (D-168-02)
- C-Farm Retr: Completed (D-168-01)
- Modeled - C-Farm Retr: Completed (D-168-01)

**Storage/Retrieval**

- CST (Starns) → CST (Supernatant)
- East Area WRF
- West Area WRF
- AN-304 AW-101
- AN-105
- AN-103

**Pretreatment/Treatment**

- LAWPS
  - WTP LAW Hot Comm.
  - TWES Capability
  - WTP HLW Hot Comm.
  - WTP PT Hot Comm.

**Disposal**

- CIVC
  - IHS Module 1
  - IHS Module 2
  - HSP Operations
  - LLW Shipped Offsite
  - IHS Operations

**Legend**

- Regulatory Rule Change
- Regulatory Projected Compliance Start
- Completed
- Completed (A-103 Planned to Complete)
- Revised Date
- Summary Table
- U.S.
- ORP
- Supplemental Treatment

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*Figure 5-179.* Scenario 11 – Operating Schedule for Major Facilities/Processes.
5.11.3.2 Cost

The annual and cumulative lifecycle cost profiles are presented and compared with the Baseline Case in Figure 5-180. The escalated cumulative lifecycle cost is $136 billion ($369 billion escalated), versus $111 billion ($231 billion escalated) for the Baseline Case. There is $7 billion in cost savings through the Baseline Case treatment completion date (November 2063), with the savings realized from the smaller required LAW supplemental treatment capacity. The capital and operational expense for LAW supplemental treatment is assumed to be 70% of the Baseline Case values (based on the heuristic that cost scales with the square root of capacity). However, the mission continues an additional 16 years, ultimately costing $25 billion ($139 billion escalated) more than the Baseline Case. (Note: Capital cost for the WTP facilities is not included in the lifecycle cost analysis. The cost of offsite IHLW canister disposal is also not included.)

![Figure 5-180. Scenario 11 Comparison – Lifecycle Cost Profile.](image)

5.11.3.3 Mission Flowsheet Results

Removing the washing/leaching capability provided by the PT Facility from the flowsheet extends the mission and increases the production of IHLW by forcing a large fraction of waste treated as LAW in the Baseline Case to be treated as HLW. Direct-feed treatment also increases the burden on tank farms operations by complicating waste feed delivery, resulting in a significant increase in the amount of DST transfers and, to a lesser extent, 242-A Evaporator campaigns. The following subsections present the flowsheet results for each system in Scenario 11 compared to the Baseline Case.
5.11.3.3.1 Single-Shell Tank Retrievals

The remaining SST waste volume is plotted versus time in Figure 5-181. The retrieval rates in Scenario 11 are nearly the same as in the Baseline Case through about 2035. Even though the total available DST space increases over the 9 years following 2035 (see Figure 5-183 and Figure 5-184 in Section 5.11.3.3.2), the retrieval rate slows because additional SST retrievals required the solids level limit to be exceeded in some DSTs. This is a result of slower solids treatment compared to the Baseline Case. After 2044, the rate of retrieval, indicated by the decrease in SST waste volume remaining, is similar to the Baseline Case. The last SST is retrieved in August 2062, approximately 6 years later than in the Baseline Case.

Figure 5-181. Scenario 11 Comparison – Single-Shell Tank Retrieval Progress.

A comparison of the SST retrieval sequence is shown in Figure 5-182. The dark-green and dark-blue bands on the plots indicate when retrieval of the SST is occurring, and the light green and light-blue colors indicate when the SST is not being retrieved (i.e., delay time). The retrieval delay time after the retrievals of A/AX Tank Farms is increased by 38 percent versus the Baseline Case because slower SST retrievals are needed to prevent excessive solids buildup in the DSTs.
Figure 5-182. Scenario 11 Comparison – Single-Shell Tank Retrieval Sequence and Timing.
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5.11.3.3.2 Double-Shell Tank Space Management

Figure 5-183 shows the utilization of DST space through completion of the DST operations. The figure shows the total DST capacity, total volume of waste, and various allocations of headspace (see Table 5-4 in Section 5.1.3.3.2). Plotting the available DST space (grey area in Figure 5-183) allows a comparison with the Baseline Case, which is illustrated in Figure 5-184. After the startup of the WTP in Scenario 11, more DST space is available than in the Baseline Case because the LAW treatment capacity is oversized relative to the HLW treatment capacity (see also Section 5.11.3.3.6).

Figure 5-183. Scenario 11 – Double-Shell Tank Space Utilization.

Comparisons of Scenario 11 to the Baseline Case of the annual and mission cumulative DST transfers (including WRF to DST transfers) are presented in Figure 5-185. The DST operations-intensive nature of direct-feed treatment causes a significant increase in DST transfers over the mission. This leads to a cumulative increase of approximately 950 DST transfers. Although the DST transfers are spread out over a longer mission duration, there is still a substantial increase in the number of required DST transfers during the period of DST operations compared to the Baseline Case.
Figure 5-184. Scenario 11 Comparison – Double-Shell Tank Available Space.

Figure 5-185. Scenario 11 Comparison – Double-Shell Tank Transfers.
5.11.3.3.3 Waste Receiving Facilities
In Scenario 11, the B-Complex WRF is projected to be used from 2035 to 2062, and the T-Complex WRF is projected to be used from 2044 through 2058. In the Baseline Case, the B-Complex WRF is projected to be used from 2035 to 2057 and the T-Complex WRF from 2040 to 2050. The longer operating durations and later completion dates for Scenario 11 reflect the slower SST retrievals.

5.11.3.3.4 242-A Evaporator
Figure 5-186 shows the demand for the 242-A Evaporator over the course of the mission in terms of annual campaigns, cumulative feed volume, and cumulative WVR versus the Baseline Case. The demand for the 242-A Evaporator is slightly higher in Scenario 11 than the Baseline Case. The mission-total feed volume is 219 Mgal and the mission-total WVR is 107 Mgal, six percent and eight percent higher than the Baseline Case, respectively.

However, because the demand is spread out over an additional 10 years of 242-A Evaporator operations (ending in 2067), the increased mission-total demand does not equate to a proportional increase in annual demand, with an average of 4.7 annual evaporator campaigns (compared to 5.5 for the Baseline Case). Peak demand for the 242-A Evaporator occurs in 2053 and equates to 118 days of hot operations. The high demand in 2034 results from shutting down DFLAW operations and concentrating the remaining dilute effluents and feed, which equates to 97 days of hot operations. In the Baseline Case, the peak demand occurs in 2045 and equates to 152 days of hot operations.

Figure 5-186. Scenario 11 Comparison – 242-A Evaporator Operation.
The increase in 242-A Evaporator demand is driven by the need to concentrate LAW feed to the PT Facility to a sodium concentration of at least 4 M (the minimum for LAW feed per the WTP Contract). In the Baseline Case, 78 Mgal of dilute supernatant liquid at an average sodium molarity of 3.2 is delivered to the PT Facility as the liquid fraction of HLW feed—this feed must be concentrated using the 242-A Evaporator to a minimum sodium molarity of 4. This is partially mitigated by operating the evaporator less aggressively after 2034 because there is no need to concentrate feed to a minimum sodium molarity of 5.6 to be fed to the LAWPS, and the DST space (for supernatant liquid) is not constraining to SST retrieval rates. Due to the less aggressive operation of the 242-A Evaporator, there are only 20 Mgal of water additions for solids mitigation—17 Mgal less than the Baseline Case.

5.11.3.3.5 Waste Feed Delivery

The process for delivering LAW feed from the 200 East Area DSTs to the LAWPS is unchanged from the Baseline Case. Feed from the LAWPS to the LAW Vitrification Facility is screened against the ICD-30 waste acceptance criteria. All waste acceptance criteria that can be screened for direct-LAW feed (see Section 5.1.3.3.5) are met, with the exception of the maximum TRU to sodium ratio and maximum U-235 concentration, which are exceeded by seven percent and two percent, respectively, for the last partial DFLAW feed campaign in 2033.

The process for delivering LAW feed from the 200 East Area DSTs to the PT Facility is unchanged from the Baseline Case. However, during final cleanout of the DSTs, when all LAW feed DSTs in the 200 East Area have been closed, supernatant decants from the TWCS capability are delivered directly to the LAW feed receipt vessels in the PT Facility (approximately 2 Mgal total). A period for staging and sample analysis for LAW feed delivered directly from the TWCS capability to the PT Facility is not explicitly modeled, but presumably could occur in the (1) DST originally containing the supernatant liquid, (2) TWCS tank, or (3) LAW feed receipt vessel in the PT Facility. LAW feed delivered from the 200 East tank farms to the PT Facility is screened against the ICD-19 waste acceptance criteria. All waste acceptance criteria that can be screened for LAW feed (see Section 5.1.3.3.5) are met for all LAW feed delivered to the PT Facility. Note that 11 Mgal of the LAW feed near the end of the mission, during DST cleanout, was delivered at a sodium concentration under 4 M (average: 2.4 M). The minimum sodium concentration for LAW feed per the WTP Contract is 4 M, although this is not an ICD-19 criterion for waste acceptance.

DFHLW feed batches are prepared in the TWCS tanks by the following process:

1. Transfer slurry at a nominal 10 wt% solids from the 200 East Area DSTs equipped with two mixer pumps to fill the TWCS tank.

2. Allow the solids to settle from the slurry, and decant the supernatant liquid to the 200 East Area DSTs. During final cleanout of the DSTs, when all LAW feed DSTs in the 200 East Area have been closed, supernatant decants from the TWCS capability are delivered directly to the LAW feed receipt vessels in the PT Facility.

3. Repeat steps (1) and (2).
4. Blend in any available concentrated HLW effluent.
5. Dilute the settled solids in the TWCS tank using raw water to a nominal 20 wt% solids.\(^{68}\)

Solids fed through the DFHLW process were not washed, with the exception of precipitated salts, which were washed once through the solids mitigation process prior to delivery to the TWCS capability. No waste acceptance criteria exist for DFHLW feed; however, because DFHLW is delivered to the HLP feed blending vessel (HLP-VSL-00028) in the PT Facility, ICD-19 waste acceptance criteria (for HLW feed to the PT Facility) may still apply. The DFHLW feed that is delivered meets all ICD-19 waste acceptance criteria that can be screened (see Section 5.1.3.3.5 for waste acceptance criteria that can be screened using model data), with the exceptions of (1) criticality safety limit (CSL) 8.2 (fissile uranium to total uranium for the solids), which was exceeded by less than one percent for a single feed campaign in 2034 comprising Tank AW-105 solids, and (2) maximum solids concentration, which was exceeded by design.

5.11.3.3.6 Waste Treatment and Immobilization

This section discusses waste treatment and immobilization in Scenario 11 versus the Baseline Case. Table 5-64 summarizes the amounts of immobilized product for the LAW and HLW Vitrification Facilities and for LAW supplemental treatment (product volume is estimated for a vitrified and a potential grouted immobilized waste form). Because Scenario 11 removes the pretreatment of HLW solids from the flowsheet, forcing a large fraction of waste treated as LAW in the Baseline Case to be treated as HLW, a large increase in IHLW production and coupled decrease in ILAW production occurs.

DFHLW operations enables the HLW Vitrification Facility to be operated at its full 70 percent TOE capacity. However, 27,800 IHLW canisters are produced, an increase of 256 percent relative to the Baseline Case, driving the HLW treatment duration to 46 years and extending the completion of tank waste treatment to 2079. A total of 69,200 ILAW containers are produced, 26 percent less than the Baseline Case. In addition, some of the LAW treatment load is shifted from LAW supplemental treatment due to the need to treat a lesser amount of waste sodium in a LAW treatment duration that is increased by 16 years. Because of the decreased amount of sodium to be treated and the load shift, LAW supplemental treatment is sized at half the capacity modeled in the Baseline Case. This reduction in capacity was determined to have no significant impact on the results during modeling of the scenario.

\(^{68}\) Per 24590-WTP-RPT-PT-02-005, 20 wt% is the concentration target for HLW solids in the WTP PT Facility ultrafiltration system. The required infrastructure is assumed to be constructed to support delivering DFHLW feed from the TWCS capability to the WTP HLW Vitrification Facility at this concentration.
Table 5-64. Scenario 11 Comparison – Waste Treatment Product Summary.

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<tr>
<th>Facility</th>
<th>Metric</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 11 – DFHLW w/Liquids-Only WTP PT Facility</th>
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</thead>
<tbody>
<tr>
<td>Waste Treatment</td>
<td>Completion date</td>
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<td>9/2079</td>
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<td>WTP IHLW</td>
<td>Product (number of canisters)</td>
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<td></td>
<td>MT of product</td>
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<td></td>
<td>Waste loading</td>
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<td>38%</td>
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<td>WTP ILAW</td>
<td>Product (number of containers)</td>
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<td>44,700</td>
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<tr>
<td></td>
<td>MT of product</td>
<td>284,300</td>
<td>246,300</td>
</tr>
<tr>
<td></td>
<td>Waste loading (Na₂O)</td>
<td>23%</td>
<td>19%</td>
</tr>
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<td>LAW Supplemental Treatment (glass)</td>
<td>Product (number of containers)</td>
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<tr>
<td></td>
<td>MT of product</td>
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</tr>
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<td></td>
<td>Waste loading (Na₂O)</td>
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<td>15%</td>
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<td>Volume (yd³)</td>
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<td>Total ILAW</td>
<td>Product (number of containers)</td>
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<td>MT of product</td>
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<td>Waste loading (Na₂O)</td>
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<tr>
<td>Potential CH-TRU Waste</td>
<td>Number of packages</td>
<td>8,400</td>
<td>8,400</td>
</tr>
</tbody>
</table>

CH-TRU = contact-handled transuranic.  MT = metric ton.
IHHLW = immobilized high-level waste.  PT = Pretreatment.
ILAW = immobilized low-activity waste.  WTP = Waste Treatment and Immobilization Plant.
LAW = low-activity waste.

Figure 5-187 compares the tank farms radioactive inventory over the mission duration for Scenario 11 and the Baseline Case. The figure accounts for radioactive decay of the starting inventory over time—the remaining radioactivity is decayed to the date reported. The trend shown is that the tank farms radioactive inventory decreases as waste is delivered to the WTP and radioactive decay proceeds. This trend in tank farms radioactive inventory over the mission is similar to the Baseline Case, although the rate of curie immobilization decreases relative to the Baseline Case as the fraction of salt in the DFHLW feed increases towards the end of the mission. As in the Baseline Case, nearly all immobilized radioactivity is segregated to the IHLW product, which contains 98 percent of the immobilized curies.
5.11.3.3.6.1 Direct-Feed Treatment

DFHLW is the only HLW treatment process in the Scenario 11 flowsheet. DFHLW treatment begins in 2033 and continues for the duration of the mission, until 2079. DFLAW, prior to startup of the PT Facility, is nearly unchanged from the Baseline Case (10,000 MT of waste sodium treated) and does not overlap DFHLW treatment; therefore, DFLAW is not discussed further in this scenario. Note that the LAWPS does not act as a source of supplemental pretreated, direct LAW feed to the LAW supplemental treatment process in Scenario 11.

DFHLW treatment processes a total of 38,800 MT of solids delivered to the TWCS capability and then vitrified in the HLW Vitrification Facility (along with 1,700 MT of filtered solids from the PT Facility ultrafiltration process and 165 kgal of cesium eluate from the PT Facility cesium IX process). The as-delivered solids are increased by 21 percent over the Baseline Case due to more precipitated solids from the increased use of the 242-A Evaporator to prepare LAW feed for delivery to the PT Facility. The solids fed through the DFHLW process were not washed, with the exception of precipitated salts, which were washed once through the solids mitigation process prior to delivery to the TWCS capability. Over the course of the mission, an average of 850 MT of as-delivered solids are treated per year by the DFHLW process, 80 percent of the PT Facility as-delivered solids throughput in the Baseline Case.
5.11.3.3.6.2 Pretreatment Throughput

The average waste sodium throughput of the PT Facility is 780 MT Na waste per year. Compared to the Baseline Case (2,120 MT Na waste per year), there is a large (64 percent) decrease in waste sodium throughput. This decrease occurs even after the LAWPS is shut down permanently following the completion of DFLAW operations and is no longer a source of supplemental pretreated LAW feed to LAW supplemental treatment (8,800 MT Na waste is pretreated by the LAWPS after DFLAW operations in the Baseline Case).

The following factors contribute to the decrease in the waste sodium throughput of the PT Facility in Scenario 11:

- In the Baseline Case, 30,400 MT Na is added to the PT Facility for washing and leaching solids. These chemical additions are eliminated in Scenario 11.

- The PT Facility operates 16 years longer (a 53 percent increase) compared to the Baseline Case. Even if the amount of waste sodium pretreated was equal to the Baseline Case, a 35 percent decrease is expected in annual throughput because the sodium is pretreated over a longer duration.

- 6,000 MT Na waste is sent forward with the direct-HLW feed, bypassing pretreatment in the PT Facility.

In this scenario, 35,800 MT Na waste is pretreated in the PT Facility versus 63,500 MT Na waste in the Baseline Case. Figure 5-188 presents the simple sodium balance for Scenario 11.
Figure 5-188. Scenario 11 – Simple Sodium Balance.

### Acronyms
- **CWC**: Central Waste Complex
- **HLW**: high-level waste
- **LAW**: low-activity waste
- **MT**: metric ton
- **TBD**: to be determined
- **TRU**: transuranic
- **WTP**: Hanford Tank Waste Treatment and Immobilization Plant

For illustrative purposes only: The mass balance has been simplified omitting some secondary waste, recycle streams, facility residuals, and glass-forming chemicals. Results are rounded.
5.11.3.3.6.3 Glass Production

Figure 5-189 compares IHLW canister production from the HLW Vitrification Facility in Scenario 11 to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case. DFHLW operations use the full capacity of the HLW Vitrification Facility (5.25 MTG/day for second-generation melters at 70 percent TOE) by eliminating the PT Facility ultrafiltration process from the flowsheet, which is the rate-limiting step for HLW treatment in the Baseline Case (see Section 5.1.3.3.6). Over the HLW treatment duration, IHLW canister production is at more than 98 percent of the theoretical maximum production capacity.

By the time HLW treatment completes in 2079, 27,800 IHLW canisters are produced—an increase of 256 percent compared to the Baseline Case. The increase in IHLW canisters is partially because a portion of solids (aluminum, phosphate, and sulfate are the primary species of concern) that would have been washed and leached in the PT Facility and immobilized as ILAW in the Baseline Case are instead immobilized as IHLW through DFHLW operations. Therefore, HLW treatment is the rate-limiting step for the completion of tank waste treatment in Scenario 11.

Figure 5-189. Scenario 11 Comparison – Immobilized High-Level Waste Production.

Figure 5-190 compares the total ILAW container production (LAW Vitrification Facility and LAW supplemental treatment) to the theoretical maximum production capacity at 70 percent TOE and to the Baseline Case (LAW Vitrification Facility). Even after halving the LAW supplemental treatment capacity, the capacity for LAW treatment is greater than the demand or the availability of LAW feed. This lack of LAW feed occurs throughout the mission, becoming
more apparent after the completion of SST retrievals in 2062. Driven by the removal of solids washing and leaching from the flowsheet, there is a large increase in the amount of IHLW canisters produced (becoming the driver for the treatment duration) and a coupled decrease in ILAW container production—therefore, less ILAW containers are produced over the longer treatment duration. As a result, the capacity of the flowsheet to pretreat and treat LAW feed is oversized compared to the capacity to treat HLW feed. These effects can also be observed in the DST space utilization plot (Figure 5-183); after startup of the PT Facility, the DST supernatant volume is drawn down significantly as LAW feed is rapidly treated, while the DST slurry volume remains relatively stable.

Although it often appears that no ILAW containers are being produced, some amount is continually being produced from the HLW effluent. For example, between 2066 and 2071, 436 ILAW containers are produced.

5.11.3.6.4 Glass Drivers

The ORP 2013 GFM (PNNL-22631) consist of a collection of glass property composition models created to develop a nonconservative set of constraints and property models that can be used to estimate the amounts of IHLW and ILAW produced at Hanford.

Figure 5-191 shows the glass drivers (i.e., the waste loading constraint estimated to be most limiting to WOL) for IHLW canister production at the HLW Vitrification Facility, as a function of calendar year and the number of batches delivered. The average WOL as a function of
calendar year is also presented. The average WOL for the IHLW product is 38 percent, compared to 44 percent for the Baseline Case. The most common glass drivers are probability of nepheline formation (38 percent of feed batches), maximum P₂O₅ loading (35 percent of feed batches), and sulfur solubility (12 percent of feed batches). The IHLW drivers as a percentage of the batches limited are presented in Figure 5-192 and Figure 5-193 for Scenario 11 and the Baseline Case, respectively.

All of these drivers, which reduce the average WOL compared to the Baseline Case, are attributable to removing washing and leaching of HLW feed solids in the PT Facility from the flowsheet. Sulfur and phosphate, typically occurring in the solid phase as kogarkoite (Na₃FSO₄) and natrophosphate (Na₇F(PO₄)₂·19H₂O), respectively, are sparingly soluble species that are effectively removed through water washing and are never limiting to WOL of the IHLW product in the Baseline Case. Though nepheline is limiting to a small portion of HLW feed batches in the Baseline Case, the problem is exacerbated in Scenario 11 as nepheline ((Na, K)AlSiO₄) is a sodium-potassium-aluminum-silicon compound, and the amount of these species in the HLW feed solids is substantially reduced through water washing and/or caustic leaching. Note that sulfur solubility is a less common glass driver compared to Scenario 3 (12 percent versus 60 percent of feed batches) due to not recycling volatilized sulfur in the HLW effluent back into the HLW feed.

Figure 5-191. Scenario 11 – Immobilized High-Level Waste Glass Drivers.
Figure 5-192. Scenario 11 – Percentage of Each Immobilized High-Level Waste Glass Driver.

Figure 5-193. Baseline Case – Percentage of Each Immobilized High-Level Waste Glass Driver.
The glass drivers for ILAW container production as a function of calendar year and the number of batches limited is presented in Figure 5-194. Average sodium oxide loading and total WOL as a function of calendar year are also presented. The average WOL for the ILAW product is 17 percent, compared to 22 percent for the Baseline Case. The glass drivers are:

- Alkali (sodium and potassium) content (35 percent of feed batches)
- Alkali and sulfur content (25 percent of feed batches)
- Halide (chloride and fluoride) content (25 percent of feed batches)
- Sulfur content (19 percent of feed batches).

The majority of the sulfur-limited feed is the low-sodium feed delivered near the end of the mission, during DST cleanout. The ILAW drivers as a percentage of the batches limited are presented in Figure 5-195 and Figure 5-196 for Scenario 11 and the Baseline Case, respectively.

The WOL of the ILAW product is lower than the Baseline Case due to the elimination of chemical additions, especially caustic soda, which would have occurred in the PT Facility for solids leaching. These chemical additions diluted the ratio of volatile sulfur and halides to sodium in the feed, and these volatiles limit WOL for 65 percent of LAW feed batches in Scenario 11 compared to 44 percent in the Baseline Case. This also represents an increase over Scenario 3, where 52 percent of batches are limited by volatiles due to the ability to send more dilute LAW feed (and HLW effluent) to the PT Facility than what can be fed through the DFLAW process.

Figure 5-194. Scenario 11 – Immobilized Low-Activity Waste Glass Drivers.
Figure 5-195. Scenario 11 – Percentage of Each Immobilized Low-Activity Waste Glass Drivers.

Figure 5-196. Baseline Case – Percentage of Each Immobilized Low-Activity Waste Glass Drivers.
5.11.3.4 Opportunities

Because Scenario 11 represents the first effort to define and model full-mission DFHLW coupled with a liquids-only PT Facility, the results can be improved by refining the flowsheet and applying lessons learned from the modeling of Scenario 11. The following opportunities have the potential to improve the results of the flowsheet, potentially bringing the completion dates for SST retrievals and tank waste treatment even earlier than the dates in the Baseline Case:

- Take advantage of the reduced coupling between HLW treatment and the PT Facility to start DFHLW operations earlier. This approach has the added complication of returning effluent from the HLW Vitrification Facility to tank farms, as in Scenario 2.

- Incorporate solids washing and/or caustic leaching of the HLW feed solids in the TWCS capability to reduce the amount of supernate and soluble salts fed to the HLW Vitrification Facility, which will lower the mission-total IHLW canister production. The TWCS capability is the preferred location for solids washing due to its enhanced mixing capability and because the added functions supporting washing and leaching can easily be added (as the TWCS capability is not yet designed or built).

- Evaluate the feasibility of sending additional LAW feed to the PT Facility at concentrations below 4 M Na. This approach will (1) reduce mission IHLW canister production by preventing precipitation of sparingly soluble salts from 242-A Evaporator bottoms and (2) reduce the demand on the 242-A Evaporator. If washing of HLW feed solids is incorporated into the flowsheet, re-precipitation of salts is a concern for the concentrate produced from the wash solution. The FEP evaporator in the PT Facility can be used to concentrate LAW feed; however, this function is not included as a part of the baseline flowsheet for the WTP.

- Eliminate LAW supplemental treatment. This action could come at the expense of delaying SST retrievals and likely will not be possible if flowsheet changes are made to expedite the completion of HLW treatment.

- The underutilization of the LAW treatment capacity and DST space suggests expediting SST retrievals may be possible by creating additional deep sludge DSTs.

- Revise the current GFM to refine the projected DFHLW feed compositions (Scenario 3A demonstrates that the ORP 2016 GFM provides an increase in WOL for projected DFHLW compositions).

- A potential DFHLW opportunity not realized in modeling is that the TOE for the HLW Vitrification Facility will likely exceed the TOE for the integrated WTP. Per Assumption A1.3.1.3, the TOE of the integrated WTP is modeled at 72 percent based on the most recent WTP OR assessment (24590-WTP-RPT-PE-12-002), while the LAW and HLW Vitrification Facilities are modeled at the contract minimum TOE of 70 percent. However, the TOE of the HLW Vitrification Facility is predicted to be 83.3 percent by the same assessment. Therefore, because Scenario 2 demonstrates the capability of the tank farms to feed the HLW Vitrification Facility at its assumed theoretical maximum rate, increasing this rate will potentially raise the throughput of the DFHLW process by nearly 20 percent.
5.11.3.5 Risks

There are several new risks associated with Scenario 11, including risks associated with increased modeling uncertainty for this scenario. In addition, risks associated with the aging infrastructure, tanks, and facilities are exacerbated since the mission is 16 years longer. Risks that are new to Scenario 11 include:

- Because soluble species are typically not washed or leached in the Scenario 11 flowsheet, the amount of IHLW produced is dependent on the amount of solids precipitated from the supernate in the tank farms. Therefore, the modeling results are highly dependent on tank farms processes, which are more variable than the set linear flowsheet of the PT Facility and the solubility modeling. As a result, the amount of uncertainty in the Scenario 11 results is much higher than for the Baseline Case, and likely for the other modeled System Plan 8 scenarios, with the notable exception of Scenario 3.\(^69\)

- Scenario 11 requires a federal geological repository for secure permanent disposal of the IHLW product that is capable of accepting at least 27,800 IHLW canisters.

- Pipe routing changes required support DFHLW operation may complicate design of the HLW Vitrification Facility. Examples of required changes include adding pipe routings from the TWCS capability to the melter feed preparation vessels, from the effluent collection vessels in the HLW Vitrification Facility to the TWCS capability, and potentially other routing changes to divert flush water from the melter feed preparation vessels.

- The chemical composition of DFHLW feed, particularly the increased concentrations of volatile sulfate and halides, may decrease the TOE in the HLW Vitrification Facility by shortening the service life of the HLW melters or components of the HLW melters (e.g., bubblers), and may require some redesign. Material upgrades in the HLW Vitrification Facility offgas system may also be required.

- Because the glass formulation predicted by the GFM represents the maximum WOL based on the model constraints, the WOL achieved operationally is often several percent lower. Therefore, the amount of glass produced from the Scenario 11 HLW feeds may be higher than predicted by the model, extending the mission.

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\(^69\) Several studies have evaluated the efficacy of the ISM concerning tank waste. RPP-RPT-58434 compared ISM predictions to tank waste simulants at 25°C, 45°C, and 60°C. In RPP-RPT-53089, ISM predictions were also compared to existing boil-down and saltcake dissolution data for tank waste. While the ISM does an adequate job of predicting solubility, phosphate salts (which are often limiting to WOL in IHLW in Scenario 3) are a noted area of concern.
6.0 SCENARIO COMPARISON

Escalated and unescalated lifecycle cost profiles were created for all scenarios except Scenario 6. Figure 6-1 provides a comparison of the unescalated lifecycle costs for each scenario. The capital costs associated with WTP construction are not included. Individual lifecycle cost profiles for each scenario are provided in their respective analysis discussions in Section 5.0.

Figure 6-1. Unescalated Lifecycle Cost Comparison.

The lifecycle cost comparison shows that total lifecycle costs are closely correlated with total mission durations due to operations costs and escalation in the later years of the mission. Scenario 3 had the longest mission duration and thus the highest lifecycle cost. Scenarios 2 and 4 had the shortest mission durations and thus the lowest lifecycle costs. The lifecycle cost for Scenario 4 was approximately $1 billion less than Scenario 2 despite a slightly longer mission duration because of reduced expenditures relating to SST retrievals.

The planned start dates for the WTP waste processing facilities are pivotal to long-term costs and schedules. Not only do the costs directly associated with the WTP facilities increase when start dates are delayed (caused by escalation), the costs associated with supporting facilities also increase for the same reason because their construction and operations schedules are tied to the dates the WTP facilities are needed.
In addition to lifecycle cost, the scenario performance against legal milestones was assessed. Resultant quantities of immobilized waste products and associated waste loading were calculated, which helped predict when storage, shipping, and disposal facilities are needed. The model results also forecasted when key activities could occur, such as mitigation of special DST wastes (e.g., buoyant displacement gas release event [BDGRE], saltcake, complexed concentrate waste), and when other supporting facilities would be needed (e.g., the WRFs). Table 6-1 summarizes these findings for each scenario.
### Table 6-1. Comparison of Key Scenario Results.

<table>
<thead>
<tr>
<th>Index</th>
<th>Scenario 1 – Baseline Case</th>
<th>Scenario 2 – Early DFHLW</th>
<th>Scenario 3 – Early DFHLW with No PT Facility</th>
<th>Scenario 4 – Risk-Informed Retrievals</th>
<th>Scenario 5 – Accelerated Retrieval Completion</th>
<th>Scenario 6 – TRU Compliant</th>
<th>Scenario 7 – Reduced Throughput</th>
<th>Scenario 8 – Early U Tank Farm</th>
<th>Scenario 9 – Offsite Effluent</th>
<th>Scenario 10 – Retrieval Contingency</th>
<th>Scenario 11 – DFHLW with Liquids-Only WTP PT Facility</th>
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<tbody>
<tr>
<td>Cost</td>
<td>Unescalated Lifecycle Cost, FY 2017 to End of Mission</td>
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<td>$104B</td>
<td>$151B</td>
<td>$103B</td>
<td>$117B</td>
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<td>$148B</td>
<td>$112B</td>
<td>$110B</td>
<td>$116B</td>
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<td>1/2034</td>
<td>9/2036</td>
<td>1/2035</td>
<td>1/2033</td>
<td>N/A</td>
<td>1/2035</td>
<td>1/2035</td>
<td>1/2035</td>
<td>6/2033</td>
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<tr>
<td></td>
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<td>6/2036</td>
<td>2/2036</td>
<td>11/2038</td>
<td>7/2040</td>
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<td>12/2042</td>
<td>4/2038</td>
<td>7/2040</td>
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<td></td>
<td>Close all DSTs (M-042-00A)</td>
<td>11/2062</td>
<td>11/2057</td>
<td>9/2051</td>
<td>7/2060</td>
<td>3/2063</td>
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<td>N/A</td>
<td>1/2036</td>
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<td>1/2036</td>
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<td></td>
<td>HLW Glass Canisters</td>
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<td>7,800</td>
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<td>HLW Glass Waste Oxide Loading</td>
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<td>43%</td>
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<td>Total ILW Containers</td>
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<td>85,700</td>
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<td>21%</td>
<td>19%</td>
<td>22%</td>
<td>22%</td>
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<td>42,700</td>
<td>34,300</td>
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<td>78,300</td>
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<td>86,000</td>
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<td>Potential TRU Tank Waste Drums</td>
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<td>N/A</td>
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<td>8,400</td>
<td>8,400</td>
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<tr>
<td></td>
<td>LAU Supplemental Treatment Projected Grout Volume (yd³)</td>
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<td>389,400</td>
<td>412,000</td>
<td>N/A</td>
<td>461,500</td>
<td>419,500</td>
<td>395,000</td>
<td>430,500</td>
</tr>
</tbody>
</table>

DFHLW = direct-feed high-level waste. ILAW = immobilized low-activity waste. PT = pretreatment. WMA = waste management area.


FY = fiscal year. MT = metric ton. TRU = transuranic. WTP = Waste Treatment and Immobilization Plant.
7.0 RISK AND OPPORTUNITY MANAGEMENT/CONTINGENCY PLANNING

This section outlines the key risks associated with the Baseline Case and with the contingency planning for the six risks identified in TPA Milestone M-062-40.

7.1 RISKS ASSOCIATED WITH THE BASELINE CASE

The Baseline Case defined by Appendix A and presented in this System Plan includes a number of challenges that need to be successfully addressed to reach the desired performance for the mission. ORP has a comprehensive risk management program to address these challenges that 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 that is used to track the risks, potential impacts, and associated mitigating actions. Key risks associated with the Baseline Case are summarized below. The risk registers provide a more comprehensive discussion of the risks.

The key risks associated with the Baseline Case include:

- Uncertainty in tank waste chemical/radionuclide inventory and particle size distribution
- Uncertainty in predicted waste solubility and partitioning
- Uncertainty in the ability of the 242-A Evaporator to meet mission demand
- Uncertainty in the SST retrieval waste compositions, retrieval durations, and as-retrieved waste volumes
- Ability to maintain sufficient space in the DST system, and the ability of the DST system to maintain adequate waste feed to the WTP treatment facilities
- Delayed startup of DFLAW and/or the WTP
- Delayed startup of the IHS Facility and/or HSF
- Infrastructure availability
- Ability of waste feed to meet the WTP waste acceptance criteria
- Ability to activate the cross-site transfer line and successfully perform cross-site transfers
- Ability of LAWPS to meet required throughput, and ability of the pretreated waste to meet the DFLAW waste acceptance criteria
- Uncertainty in the scope of the supplemental treatment capability and the ability to implement the scope
- Ability to implement the TWCS capability, and the ability of TWCS to meet required throughput rates
- Ability to start up the supplemental CH-TRU waste facility and WRFs on time, and the ability of these facilities to meet required throughputs
ORP performs contingency planning using a formal risk and opportunity management process (TFC-PLN-39). However, Section 7.0 is not intended to provide as much detail as the WTP or WRPS risk and opportunity management plans, and the section does not provide an all-inclusive mission contingency plan. Section 7.0 is a compilation of the contingency measures that were identified and considered in System Plan (Rev. 8), with a focus on Milestone M-062-40 requirements.
7.2.1 Single-Shell Tank Integrity
Milestone M-062-40 language:

The [System] Plan will identify and consider possible contingency measures to address the following risks:

- Results from SST integrity evaluations.

7.2.1.1 Identification of Possible Contingency Measures
If results from the SST integrity evaluations indicate a change in tank integrity status, possible contingency measures might include:

- Continuing the SSTIP (all scenarios)
- Transferring waste from a leaking tank to a WRF or DST for temporary storage (all scenarios)
- Permitting, designing, constructing, and operating new DSTs (Scenarios 5, 6, and 10)
- Modifying the sequence of SST retrievals (Scenarios 2, 3, 8, and 11)
- Leaving some SSTs unretrieved (Scenario 4).

7.2.1.2 Consideration of Possible Contingency Measures
The scope of all System Plan (Rev. 8) scenarios incorporates the current results of the SSTIP (Section 3.1.1), which provides for monitoring and inspection of the Hanford SSTs to identify tanks that may be experiencing liquid intrusion or a leak. Waste retrieval operations involve the addition of some liquid to the tank to mobilize the waste. However, retrieval methods for each tank are selected based, in part, on the integrity of the tank. Retrieval technologies that require less water are expected to be deployed in tanks where the risk of a leak is higher. This approach incorporates the results of the SST integrity evaluations in waste retrieval planning and execution in accordance with the milestone and is included in the modeling for the System Plan.

All model scenarios include design, construction, and operation of WRFs in the 200 East and 200 West Areas. These WRFs could be used to provide temporary storage for waste retrieved from a leaking tank.

Scenarios 5, 6, and 10 estimated the number of new DSTs required to achieve predefined SST retrieval completion goals. Scenario 5 (Section 5.5) examined the number of new DSTs required to accelerate SST retrievals to complete in 2047, given the Baseline Case treatment assumptions. Scenario 6 (Section 5.6) estimated the number of new DSTs required to accelerate SST retrievals to complete by 2040, with and without credit for waste treatment and 242-A Evaporator support. Scenario 10 (Section 5.10) examined the number of new DSTs required to maintain the Baseline Case SST retrieval schedule given a 5-year delay in WTP startup. Although the primary purpose of these scenarios was not to evaluate the impact of the SST integrity, adding new DSTs to the flowsheet can reduce the impact of the SST integrity issues because the added tanks provide an outlet for removing waste from the SSTs, in most cases sooner than would otherwise be possible.
The major trade-off of this option is that the lifecycle cost increased in all cases, due to the additional cost of the new DSTs and no improvement to the treatment completion date.

Scenarios 2, 3, and 8 incorporated the SST retrieval sequences that were modified from the Baseline Case as part of their analyses. Scenarios 2 and 3 (Sections 5.2 and 5.3) favored sludge waste in S and SX Tank Farms to support early HLW treatment operations rather than the saltcake waste favored by the Baseline Case. Scenario 8 (Section 5.8) examined retrieving U Tank Farm SSTs during DFLAW rather than S and SX Tank Farm SSTs retrieved in the Baseline Case during this period. The results of these scenarios can inform decisions on the SST farm and tank sequences that pertain to DST space impacts and influences on the waste treatment feed streams, in the event that SST integrity issues necessitate modification to those sequences.

Scenario 4 (Section 5.4) incorporated a risk-based approach to SST retrievals in which some SSTs were not retrieved based on the curie content of the waste. Similar approaches could be taken in consideration of SST integrity and the risks to human health and the environment of retrieving certain SSTs versus leaving the waste in place.

7.2.1.3 Status of Contingency Measures
Possible loss of tank integrity is a known risk and is addressed by the Risk and Opportunities Management Program. Sections 3.1.1 and 3.1.2 provide additional information on the SSTIP and DSTIP, respectively, which are ongoing programs.

The addition of new DSTs as a contingency measure will require detailed engineering analysis in compliance with DOE O 413.3B. The decision to construct new tanks needs to be made at least 8 years prior to the operational need date to allow sufficient time for permitting, design, construction, and startup testing.

Accelerating the installation of waste retrieval equipment on an emergent leaking tank, and accelerating the schedule for executing retrieval activities for that tank, will likely be dependent on the project budget and resources available at that time. This activity may not be cost-effective because much of the infrastructure upgrades (e.g., ventilation systems) required for a retrieval are shared amongst all tanks in the SST farms and would need to be maintained for future retrievals.

7.2.2 Retrievals Take Longer
Milestone M-062-40 language:

The [System] Plan will identify and consider possible contingency measures to address the following risks:

• If retrievals take longer than originally anticipated and there is a potential impact to the schedule for retrieving specified tanks under this agreement.

7.2.2.1 Identification of Possible Contingency Measures
This risk focuses on the time required to retrieve 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. At that point, deployment of a different, more suitable technology should be considered.

### 7.2.2.2 Consideration of Possible Contingency Measures

A variety of waste retrieval technologies have been deployed in C Tank Farm (discussed in Section 4.2.1). Several tanks were only successfully retrieved after two or three different technologies were deployed. This situation is indicative of the complexity of the waste and is likely to be repeated as retrieval operations move into other tank farms.

All cases use the latest revision of RPP-PLAN-40145, as the plan identifies waste depths per SST over which each of the identified retrieval technologies is anticipated to be successful. The latest plan also incorporates lessons learned from SST retrievals in C Tank Farm, which generally increased the minimum durations for the SST retrievals modeled in the System Plan (Rev. 8) scenarios.

Scenario 4 shortened the total duration of SST retrievals by applying a risk-based approach in which waste was left in selected SSTs. Scenarios 7 and 7a (Section 5.7) analyzed the mission impact of increased SST retrieval durations over the Baseline Case. Scenario 8 (Section 5.8) achieved an accelerated SST retrieval completion by modifying the SST retrieval sequence to better align with DST space availability.

### 7.2.2.3 Status of Contingency Measures

As more information becomes available from SST retrievals, RPP-PLAN-40145 will be updated to enhance the ability to achieve successful retrievals. This information will be integrated into future System Plan revisions, with consideration of available resources, physical limitations in the tank farms, and available receipt capacity within the DST system.

### 7.2.3 Double-Shell Tank Space

Milestone M-062-40 language:

> The [System] Plan will identify and consider possible contingency measures to address the following risks:

- *If DST space is not sufficient or is not available to support continued retrievals on schedule.*

### 7.2.3.1 Identification of Possible Contingency Measures

If existing DST space is not sufficient, possible contingency measures might include:

- Sending potential CH-TRU waste to a supplemental treatment facility and not to the DST system (all scenarios except 2, 3, and 4)
- Permitting, designing, constructing, and operating new DSTs (Scenarios 5, 6, and 10)
- Modifying the sequence of SST retrievals (Scenarios 2, 3, 8, and 11)
- Leaving some SSTs unretrieved (Scenario 4)
Reducing or eliminating effluent returns to the DST system from DFLAW operations (Scenarios 2, 3, and 9)

- Accelerating HLW treatment and startup of the TWCS capability (Scenarios 2 and 3)
- Revisiting current fill limits in the DSTs (all scenarios).

7.2.3.2 Consideration of Possible Contingency Measures

In the Baseline Case, the potential CH-TRU waste currently stored in 11 SSTs is retrieved and treated in a proposed supplemental TRU waste treatment facility, and then disposed of offsite. If implemented, this disposition path will enable approximately 1,265 kgal of waste (HNF-EP-0182) to be treated outside of the DST system, thereby not impacting the limited DST space.

Scenarios 5, 6, and 10 evaluate constructing and operating varying numbers of new DSTs to support SST retrievals. These scenarios show that SST retrievals will be accelerated over the Baseline Case if additional DSTs are available. Constructing new DSTs also reduces the impact of potential DST leaks in the future, which further reduces available DST space and adversely affects SST retrievals.

Modifying the sequence of the SST retrievals can alleviate DST space limitations. By executing long-duration retrievals when DST space is limited, such as in Scenario 8, the SST retrievals are better aligned with DST space availability, resulting in less overall delay. Optimizing the relative amounts of sludge and saltcake waste retrieved to the DST system, based on available solids capacity, also ensures that adequate feed is available for the HLW and LAW treatment processes. With early HLW treatment in Scenarios 2 and 3, more sludge waste was retrieved to the DST system earlier than in the Baseline Case.

Retrieving less SST waste reduces the demand on the DST and treatment systems. A risk-based approach to the SST retrievals, as explored in Scenario 4, can achieve this while still addressing the majority of the hazard posed by the waste. Reducing effluent returns to the DST system also reduces the demand. Scenarios 2 and 3 use the TWCS capability for receiving LAWPS cesium eluate and blending it with HLW feed, rather than storing the eluate in the DST system. Scenario 9 examines the impact of sending LAW offgas effluent offsite for treatment rather than back to the DSTs during DFLAW operations.

In addition, DST space will be created faster by accelerating startup of the treatment facilities. Scenarios 2 and 3 accelerated HLW treatment, which showed a complimentary acceleration in SST retrievals when the additional DST space was realized.

All cases added more than 70 inches of settled solids to Tanks SY-102 and SY-103 for S and SX Tank Farm waste retrievals. Adding more settled solids to some DSTs than is currently allowed may be possible. However, this approach will require evaluation within the boundaries of the Waste Compatibility Program, with consideration of emergency space requirements and additional future expenses related to the purchase, installation, operation, and eventual decommissioning of incrementally insertable mixer pumps.
7.2.3.3 Status of Contingency Measures
Design of the proposed supplemental TRU waste treatment facility was placed on standby in 2005. Resumption of project activities will require additional resources. Additional information on the supplemental TRU waste treatment facility is provided in Section 3.3.1.

The addition of new DSTs as a contingency measure will require detailed engineering analysis in compliance with DOE O 413.3B. The decision to construct new tanks may need to be made as much as 8 years prior to the operational need date to allow sufficient time for permitting, design, construction, and startup testing.

Future SST retrieval sequences are periodically evaluated and plans are developed as the next retrievals approach. Information from the SSTIP can prompt reevaluation of the SST retrieval sequence.

Implementing a risk-based retrieval approach and/or sending secondary effluent offsite requires buy-in from the regulators and stakeholders and are in the conceptual stage at this time. Further analysis is required before either of these concepts can be implemented.

Enabling higher settled solids volumes in additional DSTs will be subject to mixing and tank integrity studies, physical limitations within the tank farms, and available receipt capacity within the DST system.

7.2.4 Delayed Waste Treatment and Immobilization Plant Cold Commissioning
Milestone M-062-40 language:

The [System] Plan will identify and consider possible contingency measures to address the following risks:

- If any portion of the WTP does not initiate cold commissioning on schedule.

7.2.4.1 Identification of Possible Contingency Measures
Contingency measures for a delay in WTP cold commissioning are identified with regard to the impact on hot commissioning, if the delay cascades to affect the WTP hot start (see Section 7.2.5.1).

7.2.4.2 Consideration of Possible Contingency Measures
See Section 7.2.5.2.

7.2.4.3 Status of Contingency Measures
See Section 7.2.5.3.
7.2.5 Delayed Waste Treatment and Immobilization Plant Hot Start

Milestone M-062-40 language:

The [System] Plan will identify and consider possible contingency measures to address the following risks:

- If any portion of the WTP does not complete hot start on schedule.

7.2.5.1 Identification of Possible Contingency Measures

If any portion of the WTP does not complete hot start on schedule, possible contingency measures include:

- Implementing direct-feed flowsheets (all scenarios)
- Improving the HLW and LAW GFMs (Scenarios 1B and 3A)
- Permitting, designing, constructing, and operating new DSTs (Scenarios 5, 6, and 10)
- Sending potential CH-TRU waste to a supplemental treatment facility and not to the DST system (all scenarios except 2, 3, and 4)
- Leaving some SSTs unretrieved (Scenario 4).

7.2.5.2 Consideration of Possible Contingency Measures

All scenarios analyzed in System Plan (Rev. 8) incorporated a DFLAW flowsheet that enables LAW treatment to begin without hot start of the PT Facility, substantially reducing risk. A DFHLW flowsheet could also be implemented, as examined in Scenarios 2, 3, and 11, which bypasses or eliminates the PT Facility for HLW treatment. In the event that the HLW or the LAW Vitrification Facilities are delayed, improving the GFMs (Scenarios 1B and 3A) will enable more waste to be treated within the same melter capacity limitations, providing the opportunity to make up lost treatment time. Improvement in the GFMs was especially valuable in conjunction with the DFHLW flowsheet where the HLW feed is not leached (Scenario 3A). While the direct-feed flowsheets can mitigate the risk posed by the PT Facility, the flowsheets do not mitigate risks associated with the vitrification facilities.

In the event that one of the vitrification facilities is delayed, constructing and operating new DSTs, as examined in Scenarios 5, 6, and 10, can enable the SST retrievals and the DST waste mitigations to continue; however, constructing new DSTs will be costly. Eliminating or reducing inputs to the DSTs system can also mitigate risks associated with the vitrification facilities and reduce the number of new DSTs required. For example, sending potential CH-TRU waste to a supplemental treatment system eliminates approximately 1.265 Mgal of waste that would otherwise be handled in the DST system and treated at the WTP. Risk-based approaches to the SST retrievals, as in Scenario 4, have the potential to reduce the waste volume that must be stored and treated even more than supplemental CH-TRU waste treatment.
7.2.5.3 Status of Contingency Measures

The DFLAW flowsheet is currently being implemented. Section 4.0 provides the status of facilities that will be used for DFLAW operations. Potential options for a DFHLW flowsheet are being evaluated, and the results will help define the scope of the TWCS capability. Development of advanced GFMs continues. Advanced GFMs started with the 2013 models introduced in System Plan (Rev. 7), and have been updated to the 2016 models analyzed in Scenarios 1B and 3A. Additional testing data will be incorporated, with the goal of creating models that can be implemented in the field.

The addition of new DSTs as a contingency measure will require detailed engineering analysis in compliance with DOE O 413.3B. The decision to construct new tanks may need to be made as much as 8 years prior to the operational need date to allow sufficient time for permitting, design, construction, and startup testing.

The supplemental CH-TRU waste treatment project is currently on hold (see Section 3.3.14.0) pending available funding. Risk-based SST retrieval approaches are conceptual and will require further analysis and buy-in from regulators and stakeholders before being implemented.

7.2.6 Waste Treatment and Immobilization Plant Treatment Rates

Milestone M-062-40 language:

The [System] Plan will identify and consider possible contingency measures to address the following risks:

- If operation of the WTP does not meet treatment rates that are adequate to complete retrievals under the schedule in this agreement. For example, the contingency measures will address estimated pretreatment facility throughput as affected by ultrafiltration capacity and oxidative leaching requirements.

7.2.6.1 Identification of Possible Contingency Measures

If operation of the WTP does not meet anticipated treatment rates, contingency measures might include:

- Implementing direct-feed flowsheets (all scenarios)
- Implementing a supplemental treatment facility for liquid waste (all scenarios except 3 and 3A)
- Improving the HLW and LAW GFMs (Scenarios 1B and 3A)
- Permitting, designing, constructing, and operating new DSTs (Scenarios 5, 6, and 10)
- Sending potential CH-TRU waste to a supplemental treatment facility and not to the DST system (all scenarios except 2, 3, and 4)
- Leaving some SSTs unretrieved (Scenario 4).
7.2.6.2 **Consideration of Possible Contingency Measures**

Scenario 7b evaluates the mission impacts if anticipated treatment rates are not met. Implementing the direct-feed flowsheets allows the PT Facility to be bypassed or eliminated, which avoids any delays associated with the facility. Analysis of the System Plan (Rev. 8) model scenarios showed that solids processing in the PT Facility limits the rate that HLW can be treated. Therefore, implementing a DFHLW flowsheet, as evaluated in Scenarios 2, 3, and 11, could enable HLW treatment to occur at a higher rate. The HLW treatment is also limited by the ability of the WTP to treat the LAW byproduct. Implementing a supplemental treatment facility, in the form of a vitrification or grout process, will provide another option for LAW processing, enabling better performance of the HLW Vitrification Facility.

In the event that the anticipated melter throughput cannot be achieved, using improved GFM models (e.g., the 2016 models evaluated in Scenarios 1B and 3A) could increase the WOL, enabling more waste to be treated per unit amount of glass produced.

Reducing the total volume of waste that requires treatment at the WTP can also help mitigate the risk of lower than anticipated treatment rates. Sending potential CH-TRU waste to a supplemental CH-TRU waste treatment facility reduces the waste volume sent to the WTP and also provides parallel processing capabilities. Implementing a risk-based SST retrieval approach (Scenario 4) reduces the waste volume sent to the WTP and the strain on the DST system that could occur due to lower than anticipated treatment rates.

Conversely, increasing the capacity of the DST system by constructing new DSTs also provides a means to continue SST retrievals in the event that the amount of waste removed from the system by treatment is less than expected.

7.2.6.3 **Status of Contingency Measures**

With the exception of constructing a supplemental treatment facility for liquid waste, the contingency measures are the same as those listed in Section 7.2.5, with the status provided in Section 7.2.5.3. Constructing a supplemental treatment facility for liquid waste is included in the RPP mission baseline and is assumed to be operational in 2034. However, the project is still awaiting a decision on the technology that will be used, and the capacity is still being evaluated. Other flowsheets being considered, such as DFHLW, may affect the required capacity or the need for a supplemental treatment capability.
8.0 REFERENCES


References

ORP-11242
Rev. 8


RPP-RPT-52791, 2015, Tank Farm Transfer System Fitness-for-Service Erosion and Corrosion Basis, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.


ORP-11242
Rev. 8


*Washington State Environmental Policy Act.*


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APPENDIX A
MODEL STARTING ASSUMPTIONS
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Appendix A – Model Starting Assumptions

TERMS

Acronyms

BBI  best-basis inventory
BDGRE  buoyant displacement gas release event
BOF  balance of facilities
CD  Critical Decision
CERCLA  Comprehensive Environmental Response, Compensation, and Liability Act
Cs  cesium
CSL  criticality safety limit
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
EIS  environmental impact statement
EMF  Effluent Management Facility
EPA  U.S. Environmental Protection Agency
ETF  Effluent Treatment Facility
FY  fiscal year
GFM  glass formulation model
HFFACO  Hanford Federal Facility Agreement and Consent Order
HGR  hydrogen generation rate
HIHTL  hose-in-hose transfer line
HLW  high-level waste
HPH  high-level waste canister pour handling
HSF  Hanford Shipping Facility
HTWOS  Hanford Tank Waste Operations Simulator
ICD  interface control document
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
LAWPS  Low-Activity Waste Pretreatment System
LERF  Liquid Effluent Retention Facility
LLW  low-level waste
LWA  Land Withdrawal Act
MLLW  mixed low-level waste
MUST  miscellaneous underground storage tank
Na  sodium
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>NEPA</td>
<td>National Environmental Policy Act</td>
</tr>
<tr>
<td>ORP</td>
<td>U.S. Department of Energy, Office of River Protection</td>
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<tr>
<td>PMB</td>
<td>performance measurement baseline</td>
</tr>
<tr>
<td>PNNL</td>
<td>Pacific Northwest National Laboratory</td>
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<tr>
<td>PT</td>
<td>pretreatment</td>
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<tr>
<td>Pu</td>
<td>plutonium</td>
</tr>
<tr>
<td>RH-TRU</td>
<td>remote-handled transuranic</td>
</tr>
<tr>
<td>RL</td>
<td>U.S. Department of Energy, Richland Operations Office</td>
</tr>
<tr>
<td>RPP</td>
<td>River Protection Project</td>
</tr>
<tr>
<td>SALDS</td>
<td>State-Approved Land Disposal Site</td>
</tr>
<tr>
<td>SBS</td>
<td>submerged bed scrubber</td>
</tr>
<tr>
<td>SRNL</td>
<td>Savannah River National Laboratory</td>
</tr>
<tr>
<td>SST</td>
<td>single-shell tank</td>
</tr>
<tr>
<td>TEDF</td>
<td>Treated Effluent Disposal Facility</td>
</tr>
<tr>
<td>TOC</td>
<td>Tank Operations Contractor</td>
</tr>
<tr>
<td>TOE</td>
<td>total operating efficiency</td>
</tr>
<tr>
<td>TPA</td>
<td>Tri-Party Agreement</td>
</tr>
<tr>
<td>TRU</td>
<td>transuranic</td>
</tr>
<tr>
<td>TRUM</td>
<td>transuranic mixed</td>
</tr>
<tr>
<td>TWCS</td>
<td>tank waste characterization and staging</td>
</tr>
<tr>
<td>TWINS</td>
<td>Tank Waste Information Network System</td>
</tr>
<tr>
<td>U</td>
<td>uranium</td>
</tr>
<tr>
<td>WESP</td>
<td>wet electrostatic precipitator</td>
</tr>
<tr>
<td>WIPP</td>
<td>Waste Isolation Pilot Plant</td>
</tr>
<tr>
<td>WMA</td>
<td>waste management area</td>
</tr>
<tr>
<td>WOL</td>
<td>waste oxide loading</td>
</tr>
<tr>
<td>WRF</td>
<td>Waste Receiving Facility</td>
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<tr>
<td>WRPS</td>
<td>Washington River Protection Solutions, LLC</td>
</tr>
<tr>
<td>WTP</td>
<td>Waste Treatment and Immobilization Plant</td>
</tr>
</tbody>
</table>
Units

°C   degrees Celsius
°F   degrees Fahrenheit
Ci   curie
ft   feet
ft³  cubic feet
g   gram
gal  gallon
kg   kilogram
kgal thousand gallons
L   liter
lb   pound
m³  cubic meter
Mgal million gallons
mL  milliliter
MT  metric ton
MTG  metric tons of glass
vol%  volume percent
wt%  weight percent
A1.0 MODEL STARTING ASSUMPTIONS

The following set of key assumptions defines the Model Starting Assumptions for System Plan (Rev. 8).

Table A-1. Regulatory Commitments. (2 pages)

<table>
<thead>
<tr>
<th>Milestone #</th>
<th>Regulation</th>
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<tbody>
<tr>
<td>D-00A-01</td>
<td>Amended Consent Decree</td>
<td>Achieve Initial Plant Operations for the Waste Treatment and Immobilization Plant</td>
<td>12/31/2036</td>
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<tr>
<td>D-00A-02</td>
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<td>HLW Vitrification Facility Construction Substantially Complete</td>
<td>12/31/2030</td>
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<tr>
<td>D-00A-03</td>
<td>Amended Consent Decree</td>
<td>Start HLW Vitrification Facility Cold Commissioning</td>
<td>6/30/2032</td>
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<tr>
<td>D-00A-04</td>
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<td>HLW Vitrification Facility Hot Commissioning Complete</td>
<td>12/31/2033</td>
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<tr>
<td>D-00A-05</td>
<td>Amended Consent Decree</td>
<td>Laboratory Construction Substantially Complete</td>
<td>12/31/2012 (COMPLETED)</td>
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<tr>
<td>D-00A-06</td>
<td>Amended Consent Decree</td>
<td>Complete Methods Validations</td>
<td>6/30/2032</td>
</tr>
<tr>
<td>D-00A-07</td>
<td>Amended Consent Decree</td>
<td>LAW Vitrification Facility Construction Substantially Complete</td>
<td>12/31/2020</td>
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<tr>
<td>D-00A-08</td>
<td>Amended Consent Decree</td>
<td>Start LAW Vitrification Facility Cold Commissioning</td>
<td>12/31/2022</td>
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<tr>
<td>D-00A-09</td>
<td>Amended Consent Decree</td>
<td>LAW Vitrification Facility Hot Commissioning Complete</td>
<td>12/31/2023</td>
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<tr>
<td>D-00A-12</td>
<td>Amended Consent Decree</td>
<td>Steam Plant Construction Complete</td>
<td>12/31/2012 (COMPLETED)</td>
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<tr>
<td>D-00A-13</td>
<td>Amended Consent Decree</td>
<td>Complete Installation of Pretreatment Feed Separation Vessels FEP-SEP-00001A/1B</td>
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<tr>
<td>D-00A-14</td>
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<td>PT Facility Construction Substantially Complete</td>
<td>12/31/2031</td>
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<tr>
<td>D-00A-15</td>
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<td>Start PT Facility Cold Commissioning</td>
<td>12/31/2032</td>
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<tr>
<td>D-00A-16</td>
<td>Amended Consent Decree</td>
<td>PT Facility Hot Commissioning Complete</td>
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<tr>
<td>D-00A-17</td>
<td>Amended Consent Decree</td>
<td>Hot Start of Waste Treatment Plant</td>
<td>12/31/2033</td>
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<tr>
<td>D-00A-18</td>
<td>Amended Consent Decree</td>
<td>Complete Structural Steel Erection Below Elevation 56 ft in PT Facility</td>
<td>12/31/2009 (COMPLETED)</td>
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<tr>
<td>D-00A-19</td>
<td>Amended Consent Decree</td>
<td>Complete Elevation 98 ft Concrete Floor Slab Placements in PT Facility</td>
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<td>D-00A-20</td>
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<td>D-00A-21</td>
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<td>Complete Construction of Structural Steel to Elevation 37 ft in HLW Vitrification Facility</td>
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<td>D-16B-01</td>
<td>Amended Consent Decree</td>
<td>Complete retrieval of tank wastes from the following remaining SSTs in WMA C: C-102, C-105, and C-111.</td>
<td>3/31/2024</td>
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Table A-1. Regulatory Commitments. (2 pages)

<table>
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<th>Milestone #</th>
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<tr>
<td>D-16B-02</td>
<td>Amended Consent Decree</td>
<td>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 9 SSTs and advise Ecology accordingly.</td>
<td>3/31/2024</td>
</tr>
<tr>
<td>D-16B-03</td>
<td>Amended Consent Decree</td>
<td>Of the 12 SSTs referred to in B-1 and B-2, complete retrieval of tank wastes in at least five.</td>
<td>12/31/2020</td>
</tr>
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</table>

DOE = U.S. Department of Energy.
HLW = high-level waste.
LAW = low-activity waste.
PT = Pretreatment.
WMA = waste management area.

A1.1 KEY ASSUMPTIONS

The following subsections outline the best available key starting assumptions for the TOPSim, consistent with the proposed System Plan (Rev. 8) Baseline Case. Assumptions may change in the time prior to actual modeling of the System Plan (Rev. 8) scenarios. Any changes to these assumptions will be approved by the U.S. Department of Energy (DOE), Office of River Protection (ORP), and reflected in the System Plan document.

A1.1.1 Model Starting Assumption Alignment

The Model Starting Assumptions for System Plan (Rev. 8) align with the following items.

A1.1.1.1 The schedule given in the Amended Consent Decree (2016, 2:08-CV-5085-RMP Document 222) for treatment facility start dates and processing rates.

A1.1.1.2 The current Hanford Tank Waste Treatment and Immobilization Plant (WTP) flowsheet (24590-WTP-RPT-PT-02-005, Flowsheet Bases, Assumptions, and Requirements).


A1.1.1.5 Minimum tank retrieval durations from SVF-1647, “SVF-1647 Rev 7 Calculation of the SST Retrieval Volumes and Durations.xlsx,” which includes the retrieval duration factors (efficiencies) listed in RPP-40545, Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning, Table G.7-1, with a multiplier of 1. Modeled minimum durations of AX and A Tank Farm single-shell tank (SST) retrievals are at least 1.5 times the durations given in SVF-1647.

A1.1.1.6 The 2013 low-activity waste (LAW) and high-level waste (HLW) glass formulation models (GFM) (PNNL-22631, Glass Property Models and Constraints for Estimating the Glass to be Produced at Hanford by Implementing Advanced Glass Formulation Efforts).
A1.1.7 Direct-feed LAW (DFLAW) operations prior to the Pretreatment (PT) Facility and HLW Vitrification Facility startups.

A1.1.8 Near-term operations consistent with the Multi-Year Operating Plan\(^{70}\) (WRPS-1603955, “WRPS Multi-Year Operating Plan, Revision 5, FY 2017 – FY 2022”).

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 (Rev. 353), Waste Tank Summary Report for Month Ending May 31, 2017, with pending changes as agreed to with the Washington State Department of Ecology (Ecology), ORP, and the Tank Operations Contractor (TOC).

A1.2.1.2 Timely approval is assumed to be received to support interim closure (tank isolation and filling with grout) of each SST sometime after retrieval of that tank is complete, as further defined in RPP-PLAN-40761, Integrated Single-Shell Tank Waste Management Area Closure Plan. Although cost and schedule information for closure activities is reflected in the performance measurement baseline (PMB), closure activities are not modeled.

A1.2.1.3 Timely approval is assumed to be received to support full closure of each tank farm after all tanks in that farm are closed.

A1.2.2 Double-Shell Tanks

A1.2.2.1 The 28 double-shell tanks (DST) are described in HNF-EP-0182. The DSTs are assumed to remain fully operational for the duration of the waste treatment mission, with the exception of DST AY-102 which will remain out of service after completion of retrieval by March 4, 2017 (Settlement Agreement [2014], PCHB-14-041c).

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 AP Tank Farm tanks, except Tank AP-102 is increased to 454 inches (1.2465 Mgal). The “normal operating limits” for all AP Tank Farm tanks, with the exception of Tanks AP-102 and AP-106, have already been increased to 454 inches.

Tank AP-106 is assumed to successfully pass the in-service leak testing required to use this increased operating level, as outlined in the Multi-Year Operating Plan (WRPS-1603955). DST AP-102 will not have its operating level increased due to flammable gas limitations.

\(^{70}\) Revision 5 of the Multi-Year Operating Plan reflects the state of the system prior to impacts caused by tank vapors issues and prior to the fiscal year (FY) 2017 continuing resolution.
A1.2.2.3 The volume of DST space allocated for tank farm emergencies and emergency returns from the WTP (per 24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed* [ICD-19]) is 1.265 Mgal (HNF-3484, *Double-Shell Tank Emergency Pumping Guide*). This space may be distributed among multiple DSTs. Headspace in Group A DSTs is not credited toward the emergency space requirement.

A1.2.2.4 No DST space will be reserved for non-emergency returns of pretreated LAW to the DST system. No DST space will be reserved for non-emergency returns of liquid effluents to the DST system other than those planned for DFLAW.

A1.2.2.5 Insoluble solids retrieved from the SSTs are assumed to settle 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%.

A1.2.2.6 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 buoyant displacement gas release event [BDGRE] criteria). For mission planning purposes, the following simplified proxy limits will be used:

- Existing BDGRE controls are assumed to apply to the DSTs containing an accumulation of settled salts.
- Restrictions on the use of currently existing Group A tanks will continue to be followed for those tanks until the waste has been retrieved.
- The depth of settled sludge accumulated in Tanks AN-101 and AN-106 will be maintained less than 300 inches in accordance with WRPS-1403027, “Contract Number DE-AC27-08RV14800, Washington River Protection Solutions LLC Proposed Control of Sludge Depth in AN-101 and AN-106.”
- The depth of settled sludge accumulated in the other DSTs will be maintained less than 200 inches based on incremental mixer pump limitations. Total solids accumulation will be maintained less than 200 inches in tanks that contain a mixture of sludge and salt or other waste restrictions. Tanks not used for accumulating retrieved solids will be limited to 70 inches of solids, the maximum amount that can be mobilized using two mixer pumps without variable insertion capability.

A1.2.2.7 The waste blending and segregation controls in the feed control list (HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*, Table A-1) will be followed. The waste blending, required to address each issue in Table A-1, may differ from the current controls and will be addressed in the scenario analysis where changes are required.
A1.2.2.8 The strontium and transuranic (TRU) constituents will be removed from the Envelope C supernate currently stored in Tanks AN-102 and AN-107 in the DST system using strontium nitrate and sodium permanganate strikes based on the in-tank precipitation process described in RPP-PLAN-51288, *Development Test Plan for Sr/TRU Precipitation Process*.

A1.2.2.9 The blending strategy concept described in RPP-RPT-43828, *Refined Use of AN Farm for C Farm Single-Shell Tank Retrieval*, is assumed to successfully mitigate the uranium enrichment issues with Tank C-104 solids that have been retrieved to Tank AN-101.

A1.2.2.10 Blending of high zirconium waste currently stored in Tanks AW-103 and AW-105, as outlined in HNF-4219, *Alternatives Generation and Analysis for Phase I High-Level Waste Feed Tanks Selection*, will be modeled by metering this waste into HLW feed to the WTP.

A1.2.2.11 Mitigation of tanks designated as Group A will be performed based on the strategy defined in 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*.

A1.2.2.12 During DFLAW operations, the following DSTs will be dedicated to supporting the DFLAW flowsheet:

- Tank AP-107: Low-Activity Waste Pretreatment System (LAWPS) feed tank
- Tanks AP-103 and AP-108: LAWPS feed staging tanks
- Tank AP-105: The WTP Effluent Management Facility (EMF) effluent receipt tank (for returns to the tank farms)
- Tank AW-106: LAWPS cesium eluate receipt tank.

A1.2.2.13 DST AW-102 is dedicated as the 242-A Evaporator feed tank for the entire mission. *Bottoms* from the 242-A Evaporator may only be sent to DSTs in the AW and AP Tank Farms.

A1.2.2.14 All cross-site *slurry* transfers from the 200 West Area are delivered to DST AN-104 and are subject to the available receipt capacity of the tank. There is an initiative identified to relax this constraint by providing the capability cross-site slurry transfers to other DSTs, but the initiative is subject to funding availability and is not currently planned modeled.

A1.2.2.15 DST AP-102, which is receiving the solids retrieved from Tank AY-102, is the dedicated HLW *hot commissioning* tank per Feed Control List item #2 (HNF-SD-WM-OCD-015, Table A-1).

A1.2.2.16 Double-shell tank AP-106 is the dedicated receipt DST for the SST retrieval waste from A Tank Farm, per RPP-RPT-57042, *Decision Report for the Disposition of*
Sludge from Tank 241-AY-102 and the 241-A/241-AX Farm Tanks. This tank may be repurposed after A Tank Farm retrievals are completed.

A1.2.2.17 DST AZ-102 is the dedicated receipt tank for the SST retrieval waste from AX Tank Farm, per RPP-RPT-57042. This tank may be repurposed after AX Tank Farm retrievals are completed.

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.

A1.2.3.2 The modeling goal for sequencing the retrieval of SST waste is to minimize the waste treatment mission duration, which is asserted to significantly reduce the risk to human health and the environment, by attempting to provide sufficient HLW or LAW feed to keep the limiting facilities operating at or near assumed capacity and by maintaining as high an average waste oxide loading (WOL) of the limiting facility product as reasonably achievable. In addition, the sequencing should be operationally tractable.

A1.2.3.3 The retrieval of the SSTs will be sequenced using a staggered, overlapping farm-by-farm approach, described in RPP-PLAN-40145, which considers the following:

- Simultaneous retrieval constraints resulting from infrastructure or operational considerations.
- Retrieval technologies and performance, including learning curves and anticipated difficulty in retrieval based on unique tank and waste conditions.
- Available DST space.
- 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.
- Retrieving the A/AX Tank Farms tanks after completion of retrieving the tanks in C Tank Farm.
- Using dedicated receiver tanks for A/AX Tank Farm retrievals. The DSTs selected for retrievals of A/AX Tank Farms listed in RPP-PLAN-40145 have been superseded by RPP-RPT-57042.

A1.2.3.4 Although not specifically planned in RPP-RPT-40145, the SSTs in the S and SX Tank Farms will be the next SSTs retrieved after completion of the AX and A Tank Farm retrievals, based on RPP-RPT-58854, Future Tank Retrievals Alternatives.
Analysis. SSTs containing primarily saltcake will be retrieved first to provide additional feed for DFLAW and to limit the amount of sludge stored in the DSTs prior to startup of the HLW Vitrification Facility. These SSTs will be retrieved into the DSTs in the SY Tank Farm.

A1.2.3.5 On completion of AX and A Tank Farm SST retrievals, the following activities will occur, as DST space allows, prior to starting the SST retrievals in 200 West Area:

- Group A mitigation of DST AN-104, to prepare the tank as the 200 East Area receiver of cross-site slurry transfers
- Activation of the cross-site supernate transfer line, to allow supernate to be transferred to 200 East Area
- Group A mitigation of the DST SY-103, to prepare the tank as an SST retrieval receipt tank
- Activation of the cross-site slurry transfer line, to ensure a path exists for transferring retrieved solids to the 200 East Area.

Required operational dates of the cross-site slurry and supernate transfer lines will be provided as a model output.

A1.2.3.6 The sludge depth in Tanks SY-102 and SY-103 will be limited to 200 inches during 200 West Area SST retrievals. However, sludge will be transferred to the 200 East Area when space allows, maintaining levels as low as possible in 200 West Area tanks.

A1.2.3.7 Waste retrieved from B Complex (B, BX, and BY Tank Farms), not including non-high-level radioactive waste consistent with TRU waste (see Assumption A1.2.3.3), will be transferred to a tank in the B Complex Waste Receiving Facility (WRF), with supernate routed back and forth from the WRF tank to the SST as required. Retrieved waste will be transferred from the WRF tank to DST storage via new double-encased hose-in-hose transfer line (HIHTL) or stainless steel lines (RPP-PLAN-40145).

A1.2.3.8 Waste retrieved from T Complex (T, TX, and TY Tank Farms), not including waste handled as non-high-level radioactive waste consistent with TRU waste (see Assumption A1.2.3.3), will be transferred to a tank in the T-Complex WRF, with supernate routed back and forth from the WRF tank to the SST as required. Retrieved waste will be transferred from the WRF tank to DST storage via new double-encased HIHTLs or stainless steel lines (RPP-PLAN-40145).

A1.2.3.9 Each WRF will consist of six tanks, each tank with a 150,000-gal operating volume, along with all needed ancillary equipment per 82400-99-076, “Documentation for SST Retrieval Scope in Phase II.”

A1.2.3.10 The B and T-Complex WRFs are assumed to be available as needed to support continuity of retrievals. The need dates for the WRFs will be provided as a model output.
A1.2.3.11 All other SSTs (except those specifically retrieved into WRFs or those handled as non-high-level radioactive waste consistent with TRU waste) will be retrieved directly into the DST system.

A1.2.3.12 During retrieval of waste from the SSTs to the DST system, sodium hydroxide and sodium nitrite will be added, as needed, so that the as-retrieved liquid phase composition satisfies the DST waste chemistry limits given in Tables 3-7 and 3-8 of HNF-SD-WM-OCD-015. Caustic additions for intra-DST transfers and for depletion of caustic over time are not modeled.

A1.2.3.13 For LAW feed staged for delivery to the PT Facility from a DST, allow a minimum of 210 days for waste mixing, sampling, and qualification (180 days for qualification per ICD-19 and 30 days to mix and sample the feed) to verify compliance with permits and the safety authorization basis before delivery to the WTP. This time is applied starting when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.

A1.2.3.14 A minimum of 194 days is allocated for waste feed sampling and qualification in a DST prior to the waste being delivered to the LAWPS. Of the 194 days, 14 days is for mixing and sampling of the tank, and 180 days is allocated to certifying that the waste can be accepted by the LAWPS. The first batch of LAWPS feed will be qualified in DST AP-107, while subsequent batches will be qualified in either Tank AP-103 or AP-108, and then delivered to Tank AP-107.

A1.2.3.15 During full WTP operations, deliveries of feed to the WTP will be timed and sequenced to balance the production of HLW glass and LAW glass.

A1.2.3.16 The use of the DSTs to receive retrieved SST waste, manage stored waste, and stage and deliver feed to the WTP in RPP-40149 (Volumes I to III) incorporates information from RPP-PLAN-40145. Revision 2 of RPP-40149 covers full mission DST utilization, while Revision 3 covers aspects associated with DFLAW operations. Key aspects of RPP-40149 include:

- Planned configuration of each DST.
- Timing of upgrades to each DST (based on outputs from the model).
- Entrained solids concentrations or quantities for supernatant liquid transfers.
- The maximum settled solids level that can be effectively mobilized and well mixed using two mixer pumps without incremental insertion capability is 70 inches.
- Mixer pumps with incremental insertion capability (12 ft vertical stroke) can accommodate settled solid layers up to 200 inches, mixing in 70-inch increments.

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71 A waste certification time of 180 days is conservatively assumed based on certifying waste for the WTP, per ICD-19. The average time required to certify waste for the LAWPS is expected to be shorter based on optimization opportunities that are being evaluated.
• Deep sludge tanks with more than 200 inches of settled solids (specifically, DST 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 A and AX Tank Farms SSTs, the goal is to minimize the creation of additional DSTs with more than 70 inches of settled solids.

• During normal operations, mixer pumps will not be operated with less than 72 inches of waste in the tank for deliveries of HLW feed to the tank waste characterization and staging (TWCS) capability to ensure well-mixed feed.

• During normal operations, mixer pumps will not be operated with less than 36 inches of waste in the tank for DST-to-DST transfers to prevent damage to the pumps.

• When used to stage HLW solids, the DSTs in AZ and AY Tank Farms will each be limited to a maximum of nine complete fill-mix-empty cycles to avoid fatigue damage to in-tank components, not including the final DST cleanout (Leonard 2010). This enabling assumption is not explicitly modeled; however, the model results will be compared to the assumption.

• With the possible exception of the LAW hot commissioning feed, all LAW transfers from the tank farms to the WTP originate in a subset of AP Tank Farm tanks and are transferred through a dedicated LAW feed line, thereby minimizing HLW solids in the LAW transfers to the WTP (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”).

• When a slurry transfer from a deep sludge DST occurs, a 30-day delay will be imposed prior to a subsequent slurry transfer from the same source tank to allow for equipment installation.

A1.2.3.17 All HLW batches will be delivered to the TWCS capability for sampling/qualification and subsequent feeding to the PT Facility.
A1.2.3.18 The residual waste remaining in the SSTs and DSTs after retrieval is complete will be estimated as follows:72, 73, 74

- The residual inventory in a 200-series SST will be best-basis inventory (BBI) data for that SST where waste retrieval actions have already been completed, when that information is available, or will be estimated as 25 ft\(^3\) of residual containing 83 wt\% water-washed solids with liquids at 5E-4 times the concentration (mole/L) of the bulk as-retrieved supernate.
- The residual waste inventory in a 100-series SST will be BBI data for that SST where waste retrieval actions have already been completed, when that information is available, or will be estimated as 300 ft\(^3\) of residual containing 83 wt\% water-washed solids with liquids at 5E-4 times the concentration (moles/liter) of the bulk as-retrieved supernate.
- DSTs: Residual waste is rinsed three times (if \(\geq\) 300 ft\(^3\) solids) or two times (if \(<\) 300 ft\(^3\) solids) with 10 kgal of water. The liquid is decanted after each rinse. The final residual waste volume is less than or equal to 300 ft\(^3\).75

A1.2.3.19 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.

A1.2.4 Tank Farm Waste Evaporator (242-A)

A1.2.4.1 The 242-A Evaporator will be available, as needed, to support the SST retrievals and to help maintain the sodium concentration in the delivered feed within WTP feed specifications. The evaporator will not be available during scheduled maintenance outages.

A1.2.4.2 A 90-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. After the start of DFLAW operations, the sampling and analysis period is decreased to 60 days based on the assumption that

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72 The residual volumes are conservatively assumed to be the maximum allowed by the *Hanford Federal Facility Agreement and Consent Order – Tri Party Agreement (TPA)* (Ecology et al. 1989), adjusted downward for a nominal 20% estimating uncertainty (per RPP-37110, *Computer/CAD Modeling System Test Results*), until better estimates can be developed. The residual volume estimate is not meant to define the limits of any particular retrieval technology nor replace the procedures established in Appendix H of the TPA.

73 The weight percent solids and liquid remaining in the residual is based on an informal review of post-retrieval waste volume estimates for Tanks 241-C-103, 241-C-106, 241-S-112, 241-C-201, 241-C-202, 241-C-203, and 241-C-204 (Sasaki 2008).

74 The reduction in liquid-phase concentration relative to the pre-rinse composition is based on rinsing the 100-series residual with three rinses, each of 10,000 gal, and on rinsing the 200-series residual with three rinses, each of 833 gal. The pre-rinse composition is assumed to equal the bulk as-retrieved liquid phase composition. These are placeholder assumptions until better estimates are developed.

75 The 300 ft\(^3\) DST residual volume is a simplifying assumption that is consistent with SST residual waste requirements and is not based on any evaluation of DST waste retrieval capability.
the 222-S Laboratory will work 24 hours/day to support DFLAW (WRPS-1605091, “Evaporator Sampling”).

A1.2.4.3 The 242-A Evaporator processes waste at a slurry rate of 30-70 gal/minute, between a minimum waste volume reduction of 15 percent and a maximum boil-off rate of 40 gal/minute.

A1.2.4.4 The maximum waste volume reduction per campaign may not exceed 57 percent.

A1.2.4.5 Dilute waste will be concentrated until the waste reaches a bulk specific gravity of 1.43 g/mL; feed will not be evaporated if it will achieve less than a 15 percent waste volume reduction at 1.43 g/mL or at 80 percent of the maximum cesium-137 (Cs-137) limit.

A1.2.4.6 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 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 waste volume reduction to account for the vacuum system steam jets.

A1.2.4.7 The 242-A Evaporator will be exclusively fed from DST AW-102. The fill height of this DST is limited to 390 inches to maintain buffer space for operational upsets of the evaporator.

A1.2.5 Low-Activity Waste Pretreatment System

A1.2.5.1 The LAWPS will receive liquid waste from the tank farms beginning October 1, 2023. This system will be the only source of LAW feed to the LAW Vitrification Facility until the PT Facility begins operation.

A1.2.5.2 The LAWPS will discontinue routine LAW deliveries to the LAW Vitrification Facility 1 month before the PT Facility begins hot commissioning to allow for piping reconfiguration. LAWPS will serve as an auxiliary source of LAW feed for the **LAW supplemental treatment** facility for the remainder of the mission.

A1.2.5.3 Waste staged for delivery to the LAWPS will be consistent with RPP-RPT-58649, *Waste Acceptance Criteria for the Low-Activity Waste Pretreatment System*, waste acceptance criteria. For modeling purposes, waste will be staged with a target sodium molarity of 5.6 (RPP-RPT-57120, *Low Activity Waste Pretreatment System (TSL01) Conceptual Design Report*) and a Cs-137 molarity less than 4.21E-05 (RPP-RPT-58649). Other acceptance criteria constraints are not specifically modeled, but can be assessed from the model results.

A1.2.5.4 For modeling purposes, cross-flow filtration will be assumed to remove 100 percent of entrained solids from the LAWPS feed.
A1.2.5.5 For modeling purposes, the two ion-exchange (IX) columns operate in series at a waste flow rate of 10 gal/minute; 99.99 percent of the Cs-137 in the feed is removed by the column (RPP-RPT-57120).

A1.2.5.6 The IX resin is replaced after 30 loading/elution cycles. Resin disposal is not modeled, but the volume of spent resin generated is tracked.

A1.2.5.7 Ion-exchange column eluate is accumulated in a cesium product tank and held for a minimum of 2 days to allow for neutralization and sampling, prior to being returned to the tank farms.

A1.2.5.8 Pretreated waste is held in three LAW staging tanks for a minimum of 4 days prior to being delivered to the LAW Vitrification Facility, to allow for confirmation sampling.\(^{76}\)

A1.2.6 Tank Waste Characterization and Staging

A1.2.6.1 The TWCS capability will perform the functions described in 13-ORP-0286, “Request for Approval of the Justification of Mission Need for a Tank Waste Characterization Staging Capability [Update]” (June 2015), including:

- Mitigate the pretreatment 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 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 ICD-19 particle size criterion
- Enable the waste feed to meet the WTP waste acceptance criteria
- Reduce the potential need for design changes to the PT 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 the WTP operations

\(^{76}\) Based on 1 day for sampling and 3 days for analysis. The analysis consists of Cs-137, total organic carbon, pH, and TRU. Analyses of a limited set of analytes are routinely performed at the 222-S Laboratory in similar turnaround times (WRPS-1402857, “Preliminary Sample Size for the Cs Product and Treated Lag Storage Vessel”).
• Accommodate operational upsets and reduce the likelihood of the HLW feed being returned to the tank farms.

For modeling purposes, the TWCS capability consists of six 500,000-gal tanks that are used for staging HLW feed for delivery to the PT Facility.

A1.2.6.2 The TWCS capability will be available to receive HLW starting on June 30, 2032.

A1.2.6.3 A minimum of 190 days\textsuperscript{77} are allocated to mixing/sampling each TWCS tank of HLW staged for delivery to the PT Facility.

A1.2.6.4 The TWCS capability will be the only source of HLW feed delivered to the PT Facility.

A1.2.6.5 Transfer line flush volumes for transfers from the TWCS capability to the PT Facility will be based on a TWCS capability location consistent with Site 5 from RPP-54688, \textit{One System Consolidated Waste Management Facility Site Evaluation}, 15 acres of greenfield located between the 200 East Area tank farms and the HLW Vitrification Facility.

A1.2.6.6 All HLW batches delivered to the WTP should be no greater than 145,000 gal, including line flushes (per ICD-19) and contain between 10 and 200 g of unwashed solids per liter of slurry (DE-AC27-01RV14136, \textit{Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant}). In addition, HLW batches target a maximum of 10 wt\% of undissolved solids to meet mixing constraints in the HLW feed receipt tank (per pulse-jet mixer operating constraints as defined in 24590-WTP-MRR-PET-10-001, \textit{WTP Mission Assessment of the Design and Operating Changes Expected to Resolve PJM Mixing in PT Vessels}).

\textbf{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.

\textbf{A1.3.1 General}

\textbf{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.

\textsuperscript{77} 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 tank having a diameter of 44 ft and being designed specifically for mixing and sampling. Since no formal design has been proposed, a detailed estimate of the actual time required is not available. The remaining 180 days is the minimum time that must be allowed for analysis of a waste acceptance sample per ICD-19.
A1.3.1.2 The balance of facilities (BOF), 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.

A1.3.1.3 The integrated total operating efficiency (TOE) of the WTP is assumed to be 70 percent (known as the integrated facility availability in DE-AC27-01RV14136). 78

A1.3.1.4 Hot commissioning for the LAW Vitrification Facility will complete by December 2023. Hot commissioning for the PT Facility and HLW Vitrification Facility will complete by December 2033 (Amended Consent Decree [2016, 2:08-CV-5085-RMP] Milestones D-00A-04, D-00A-09, and D-00A-16). Detailed hot commissioning plans, however, are not explicitly modeled.

A1.3.1.5 Production of ILAW in the LAW Vitrification Facility (via DFLAW) will begin at the end of December 2023, after completion of hot commissioning.

A1.3.1.6 Production of IHLW in the HLW Vitrification Facility will begin at the end of December 2033, after completion of hot commissioning.

A1.3.1.7 Per the Amended Consent Decree (2016) Milestone D-00A-17, hot start of the WTP will begin on or before December 31, 2033, and continue until the end of the treatment mission.

A1.3.1.8 The WTP is assumed to not return any waste streams or wastewater back to the DST system, except for that returned during DFLAW operations.

A1.3.1.9 The technical issues previously identified in several design oversight reviews, external reviews, and a comprehensive independent review either have been resolved or are assumed to be resolved without adverse impact to the assumed performance of or the schedule for the WTP. Notwithstanding technical issue resolution, the current version of ICD-19 is assumed for current mission planning purposes.

A1.3.1.10 The delivered feed and internal WTP material flows and accumulations are assumed to be consistent with the WTP authorization basis. 79

A1.3.1.11 Waste temperatures are not modeled. The temperature of LAW feed delivered to the WTP is assumed to be less than 120°F; the temperature of HLW feed delivered to the WTP is assumed to be less than 150°F per ICD-19. The minimum waste

78 This assumption is implemented by a reduction in LAW and HLW melter rates (Assumptions A1.3.3.2 and A1.3.4.5) and throttling of the WTP PT Facility rate (Assumption A1.3.2.11) such that the plant availability for the WTP approximates the results of 24590-WTP-RPT-PE-12-002, 2012 WTP Operations Research Assessment.

79 It is assumed that the integrated management process for ICD-19, 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. For example, the feed control list (HNF-SD-WM-OCD-015, Table A-1) already requires blending of the solids in DST 241-AZ-101 to reduce the hydrogen generation rate (HGR) and blending of the solids in SST 241-C-104 to reduce the concentration of 233U.
Appendix A – Model Starting Assumptions

A1.3.1.12 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 7, “Waste Feed Acceptance Criteria,” from ICD-19. 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.
- Table 5, “Treated LAW Feed Acceptance Criteria,” from 24590-WTP-ICD-MG-01-030, ICD 30 – Interface Control Document for Direct LAW Feed (ICD-30), for direct LAW feed delivered from the LAWPS.

A1.3.1.13 The basis for 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. Flowsheet and operating mode modifications will be approved by ORP, as needed, to implement the other assumptions in this System Plan. Additional details for modeling are in 24590-WTP-MDD-PR-01-002, Dynamic (G2) Model Design Document. The following modifications have been made:

- Both HLW Vitrification Facility melter and offgas trains have been combined into one train, with throughput equivalent to two trains.
- Both 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.
- The WTP process-sample hold times are not modeled.

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80 Based on previous feed screening, some delivered feed is expected to fall outside of the screening criteria and may require multiple iterations with ORP, Bechtel National, Inc., and WRPS over several years to fully define an acceptable set of feed requirements and to update the process strategy in RPP-40149-VOL1 to ensure that projected feed batches comply with the final waste acceptance criteria.

81 The subset comprises maximum bulk density, minimum slurry pH, maximum solids wt% (LAW feed only), maximum solids g/L (HLW feed only), maximum LAW feed unit dose, maximum HLW feed unit dose, maximum total organic carbon (TOD), maximum plutonium (Pu) to metals loading ratio (criticality safety limit [CSL] 8.1), maximum Pu to metals loading ratio (CSL 8.4), maximum uranium (U) fissile to U total (CSL 8.2 liquid), maximum U fissile to U total (CSL 8.2 solid), maximum Pu concentration of liquids (CSL 8.3), maximum sodium (Na) molarity, maximum hydrogen generation rate (HGR) (LAW), and maximum HGR (HLW). Screening for these parameters is currently performed by SVF-2455, “SVF-2455_R0_WTP DQO Feed Screening.xlsm.”
- Aqueous and solid phase densities use the tank farms basis rather than the WTP basis.
- The TOE includes downtime for major facility equipment changeout (e.g., LAW and HLW melters).
- The glass formulation process is performed using the 2013 GFMs rather than the WTP GFMs.
- The vessels associated with BOF are not specifically modeled; however, the various cold chemicals are modeled.
- The HLW canister decontamination system is not modeled; however, the chemical additions resulting from this process are accounted for.
- The LAW carbon dioxide system used for LAW container decontamination is not modeled.
- The WTP Analytical Laboratory is not modeled.
- The impurities associated with chemical additions and the moisture content of the glass formers are not modeled.
- The rheology of the melter feed is not adjusted.
- The entrainment of glass oxides in the offgas and subsequent recycle streams are not modeled.

A1.3.2 Pretreatment Facility

A1.3.2.1 When the WTP requests delivery of HLW feed, the HLW feed receipt tanks at the WTP will have sufficient space to receive no greater than 145,000 gal (549 m³) of HLW feed, including associated transfer line flushes from the DST system without interruption, per ICD-19, Section 2.2.4.2.

A1.3.2.2 When the WTP requests delivery of LAW feed, the LAW feed receipt tanks at the WTP will have sufficient space to receive a nominal 1.125 Mgal of feed (including flushes) from the DST system without interruption, to avoid deliveries of small batches tying up a DST for extended periods.\(^8\)

A1.3.2.3 The PT Facility will be configured so that a portion of concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to a LAW supplemental treatment facility as feed. This is downstream of the point to which the condensate from the LAW submerged bed scrubber (SBS)/wet electrostatic precipitator (WESP) systems is recycled, so the feed to a LAW supplemental treatment facility will include a proportional fraction of recycled condensate from both LAW facilities. The treated LAW concentrate tank feeds the LAW Vitrification Facility as its first priority, with excess going to a LAW supplemental treatment facility.

\(^8\) DE-AC27-01RV14136 requires that 1.5 Mgal of space is provided to receive and store LAW feed from the DST system. Space allocated from receiving feed is 1.125 Mgal, while the remaining 0.375 Mgal is reserved for storage.
A1.3.2.4 The pretreatment configuration will reflect 24590-WTP-MDD-PR-01-002, which operates the ultrafiltration process and cesium IX system at 45°C.

A1.3.2.5 The ultrafiltration process will operate in the “back-end” leaching mode. Back-end leaching is defined as caustic leaching in the ultrafiltration feed vessels (UFP-VSL-00002A/B) as opposed to front-end leaching, where caustic leaching occurs in the ultrafiltration preparation vessels (UFP-VSL-00001A/B).

A1.3.2.6 For planning purposes, all of the solids in each ultrafilter feed batch will be fully caustic leached.

A1.3.2.7 The extent of sludge dissolved by caustic leaching is defined by the integrated solubility model (ISM), as 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 leach process that removes chromium from the HLW sludge will be implemented in the ultrafilter process system per 24590-WTP-RPT-PT-02-005. The oxidative leach process will only be applied to HLW feed batches containing at least 0.5 wt% chromium.

A1.3.2.9 The IX resin is replaced after 10 elution/regeneration cycles (24590-WTP-RPT-PT-02-005). The number of times the cesium IX resin is replaced will be tracked.

A1.3.2.10 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.

A1.3.2.11 The modeled throughput of the PT Facility is throttled to account for the integrated facility availability described in Assumption A1.3.1.3.

A1.3.3 High-Level Waste Vitrification Facility

A1.3.3.1 Hot commissioning is not specifically modeled and is assumed to be accounted for in the modeled ramp-up of the facility.

A1.3.3.2 The net HLW Vitrification Facility capacity will be ramped as follows:

<table>
<thead>
<tr>
<th>Starting on</th>
<th>Rate (MTG/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/31/2033</td>
<td>3.0</td>
</tr>
<tr>
<td>12/31/2034</td>
<td>4.0</td>
</tr>
<tr>
<td>9/30/2036(^{83})</td>
<td>4.2(^{84})</td>
</tr>
<tr>
<td>12/31/2038</td>
<td>5.25</td>
</tr>
</tbody>
</table>

\(^{83}\) This date is selected such that the Amended Consent Decree (2016) 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 Milestone D-00A-01 by December 31, 2036.

\(^{84}\) DE-AC2-701RV14136, Section C.7(b), “Waste Treatment Capacity Requirements,” specifies that the WTP HLW Vitrification Facility will support a combined design capacity of 6 MTG/day with the original two melters and 7.5 MTG/day with two replacement melters, with a minimum integrated TOE of 70 percent. The capability of the
A1.3.3.3 The average bulk density of immobilized HLW (IHLW) will be 2.66 kg/L at 20°C; the average density of the molten glass used in the melter will be 2.40 kg/L.  

A1.3.3.4 The mass of glass contained in a filled IHLW canister will be estimated using an average bulk density of 2.66 kg/L (24590-WTP-RPT-PT-02-005, Section 4.2.3.6).

A1.3.3.5 On the average, each canister of IHLW will be filled to 39.8 ft$^3$ (1.127 m$^3$) and will contain an average of 3.00 MT of HLW glass.

A1.3.3.6 The composition, properties, and WOL of HLW glass will be estimated using the 2013 GFM documented in PNNL-22631.

A1.3.3.7 For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals. For planning purposes, the allowable glass-forming chemicals are: Al$_2$O$_3$, B$_2$O$_3$, CaO, Fe$_2$O$_3$, Li$_2$O, MgO, Na$_2$O, SiO$_2$, TiO$_2$, ZnO, and ZrO$_2$.

A1.3.3.8 One HLW melter is assumed to be replaced every 2.5 years on average and contains approximately 823 gal (110 ft$^3$) of glass. The time required to changeout spent HLW melters is not explicitly modeled; however, the replacement of spent melters is already accounted for in the net production capacity assumptions.

A1.3.3.9 The HLW melter production rate may be affected by the composition of feed batches delivered in accordance with 24590-WTP-MCR-PE-13-0023, Variable HLW Melt Rate. Specifically, if feed batches are too dilute, the production rate will be reduced to account for energy lost to evaporation.

A1.3.4 Low-Activity Waste Vitrification Facility

A1.3.4.1 Hot commissioning is not specifically modeled and is assumed to be accounted for in the modeled ramp-up of the facility.

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WTP HLW Vitrification Facility to support this increase is evaluated in 24590-HLW-RPT-PE-07-001, High Level Waste Vitrification Plant Capacity Enhancement Study.

85 These requirements are based on crucible density data and estimated volume percent void content per 24590-WTP-RPT-PT-02-005, Section 4.2.3.6 and 4.2.3.2, respectively.

86 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 Appendix C of 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.

87 This is based on filling a canister with 3/8-inch thick walls to 95 percent fill (1.127 m$^3$) of glass with a bulk density of 2.66 kg/L.

88 This assumes two melters, each with a 5-year minimum design life per 24590-HLW-3PS-AE00-T0001, Engineering Specification for High Level Waste Melters. The volume of glass in the melter is assumed to reflect the 25-inch heel remaining after the maximum pour and includes an allowance for increased volume caused by corrosion of the refractory (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.
A1.3.4.2 The LAW Vitrification Facility will receive all of its feed from the PT Facility when the PT Facility begin operations.

A1.3.4.3 Prior to PT Facility operation (i.e., during DFLAW operations), the LAW Vitrification Facility will receive LAW feed exclusively from the LAWPS.

A1.3.4.4 During DFLAW operations, the effluent from the LAW Vitrification Facility offgas SBS and caustic scrubber effluent will be routed to the WTP EMF.

A1.3.4.5 The net LAW Vitrification Facility capacity will be ramped as follows:

<table>
<thead>
<tr>
<th>Starting on</th>
<th>Rate (MTG/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/31/2023</td>
<td>9.0</td>
</tr>
<tr>
<td>7/31/2024</td>
<td>18.0</td>
</tr>
<tr>
<td>7/31/2025</td>
<td>21.0&lt;sup&gt;89&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

A1.3.4.6 The average bulk density of immobilized LAW (ILAW) will be 2.58 kg/L at 20°C; the average density of the molten glass will be 2.45 kg/L.<sup>90</sup>

A1.3.4.7 The mass of glass contained in a filled ILAW container will be estimated using an average bulk density of 2.58 kg/L (24590-WTP-RPT-PT-02-005, Section 3.2.3.7).

A1.3.4.8 On the average, each package of ILAW will be filled to 564 gal (75 ft<sup>3</sup>)<sup>91</sup> and will contain 5.51 MT of LAW glass.<sup>92</sup>

A1.3.4.9 The total sodium loading of LAW glass from pretreated feed will be determined using the 2013 LAW GFM (PNNL-22631).

A1.3.4.10 For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals. For planning purposes, the allowable glass-forming chemicals are: Al<sub>2</sub>O<sub>3</sub>, B<sub>2</sub>O<sub>3</sub>, CaO, Fe<sub>2</sub>O<sub>3</sub>, Li<sub>2</sub>O, MgO, Na<sub>2</sub>O, SiO<sub>2</sub>, TiO<sub>2</sub>, ZnO, and ZrO<sub>2</sub>.

A1.3.4.11 One LAW melter is assumed to be replaced every 2.5 years on average and contains approximately 1,875 gal (251 ft<sup>3</sup>) of glass.<sup>93</sup> The time required to change out spent LAW melters is not explicitly modeled, however, the replacement of spent melters

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<sup>89</sup> This rate assumes two LAW melters, each 15 MTG/day designed at a 70 percent TOE. 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 TOE of 70 percent.

<sup>90</sup> This is based on crucible density data and estimated volume percent void content per 24590-WTP-RPT-PT-02-005, Section 3.2.3.2 and 3.2.3.7, respectively.

<sup>91</sup> DE-AC27-01RV14136, Section C, Specification 2, Section 2.2.2.5, requires that the packages will be filled to at least 90 percent of the volume of an empty package; the corresponding volume is obtained from 24590-WTP-RPT-PT-02-005, Section 3.2.3.7.

<sup>92</sup> This is based on filling a package to 90 percent (2.135 m<sup>3</sup>) of glass with a bulk density of 2.58 kg/L.

<sup>93</sup> This assumes two melters, each with a 5-year minimum design life per 24590-LAW-3PS-AE00-T0001, Engineering Specification for Low Activity Waste Melters. The volume of glass in the melter does not include an allowance for increased volume 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 melter with “cold” glass prior to removal from service.
is already accounted for in the net production capacity assumptions. In addition, spent melters will be managed and disposed of at the Integrated Disposal Facility (IDF) as mixed low-level waste (MLLW).

A1.3.4.12 The LAW melter production rate may be affected by the composition of feed batches delivered in accordance with 24590-WTP-MCR-PE-13-0024, Variable LAW Melt Rate. Specifically, if feed batches are too dilute, the production rate will be reduced to account for energy lost to evaporation.

A1.3.5 Effluent Management Facility

A1.3.5.1 During DFLAW operations, the WTP EMF will receive effluent from the LAW Vitrification Facility SBS, WESP, caustic scrubber, and plant wash system.

A1.3.5.2 The WTP EMF flowsheet consists of a feed tank, an evaporator, a condenser, and evaporator concentrate and condensate tanks.

A1.3.5.3 Of the SBS/WESP effluent sent to the WTP EMF, 2 vol% will be returned to the tank farms to account for WTP EMF evaporator outages. This volume was estimated as an average based on the analysis in RPP-RPT-59257, Evaluation of EMF Evaporator Down Time Returns to Tank Farms.

A1.3.5.4 The WTP EMF will only operate during DFLAW. When the PT Facility begins operations, the WTP EMF will be shut down.

A1.3.5.5 The WTP EMF evaporator concentrates SBS effluent to a target specific gravity of 1.2, a Cl⁻ concentration of 2 wt%, or a Cs-137 concentration of 1.9E-04 Ci/L, whichever is reached first (24590-WTP-MRR-PENG-16-001, DFLAW 100% Recycle Using 2013 Glass Model).

A1.3.5.6 The WTP EMF evaporator overheads and caustic scrubber effluent are sent to the Liquid Effluent Retention Facility (LERF)/Effluent Treatment Facility (ETF).

A1.3.5.7 Of the WTP EMF evaporator concentrate, 100 percent is recycled to the LAW Vitrification Facility feed tank.

A1.3.5.8 The fraction of effluent returned to the tank farms is mitigated for corrosion control using the algorithm described in SRNL-STI-2015-00506, SRNL Report for Tank Waste Disposition Integrated Flowsheet: Corrosion Testing.

A1.3.5.9 The effluent returned to the LAW Vitrification Facility is blended with incoming LAW feed such that the amount of effluent recycled to LAW vitrification per batch is minimized.
A1.4 SUPPLEMENTAL TREATMENT

A1.4.1 Low-Activity Waste Supplemental Treatment Facility

A1.4.1.1 For the purposes of this System Plan, LAW supplemental treatment capacity is assumed to be provided by a LAW supplemental treatment facility, located in the 200 East Area adjacent to the WTP.

A1.4.1.2 The LAW supplemental treatment facility is not assumed to consist of a particular treatment technology. Instead, technology will be analyzed based on the volume and amount of sodium it processes, with estimated amounts of various proposed immobilized waste forms (e.g., glass, grout) reported. For modeling purposes, the LAW supplemental treatment facility will be a vitrification facility with the same design and GFMs as the LAW Vitrification Facility. Waste product quantities will be specified in terms of immobilized glass and a grout waste form.

A1.4.1.3 The LAW supplemental treatment facility will receive “excess” pretreated LAW from the PT Facility per Assumption A1.3.2.3.

A1.4.1.4 The LAW supplemental treatment facility will receive pretreated LAW from the LAWPS during full WTP operations, as availability and capacity permits.

A1.4.1.5 The net capacity of a LAW supplemental treatment facility will be selected with the goal that the combined LAW treatment capacity will be large enough so as to not drive the mission duration.

A1.4.1.6 Hot commissioning of the LAW supplemental treatment facility is not specifically modeled. No ramp-up of the facility is currently assumed. Instead, the facility is modeled as an additional treatment capacity available as needed to ensure that LAW treatment is not limiting HLW treatment. The LAW supplemental treatment need date and average/surge capacity will be estimated as an output of the model. For comparability to the WTP, the treatment capacity is specified in terms of an immobilized glass waste form (MTG/day).

A1.4.2 Supplemental Non-High-Level Radioactive Waste Treatment

A1.4.2.1 Per the lifecycle PMB, the supplemental non-high-level radioactive waste (consistent with TRU waste as defined in the Waste Isolation Pilot Plant [WIPP] Land Withdrawal Act [Public Law 102-579]) treatment and packaging process will be available in 2031. This date may be changed based on analysis of budget and resource constraints.

A1.4.2.2 The supplemental non-high-level radioactive waste (consistent with TRU waste as defined in the WIPP Land Withdrawal Act) treatment and packaging process will treat a maximum of 8,040 gal (1,075 ft³) 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 TOE (RPP-21970, CH-TRUM WPU&SE 11-Tank Material Balance, Section 3.0).
A1.4.2.3 The SSTs assumed to contain non-high-level radioactive sludge consistent with TRU (as defined in the WIPP Land Withdrawal Act) waste are [B-201, B-202, B-203, B-204], [T-201, T-202, T-203, T-204], T-111, T-110, and T-104, in the stated order except that the tank order within the [brackets] can be changed to match the order reflected in the PMB (RPP-21970, Sections 3.0 and 5.0, Assumption 2).

A1.4.2.4 The supplemental waste treatment and packaging system for tanks containing non-high-level radioactive waste consistent with TRU waste will first be located near B Tank Farm and then moved to T Tank Farm. There will be a minimum 10-day outage between tanks and a minimum 180-day outage to move equipment between farms.

A1.4.2.5 Waste previously assumed to be remote-handled transuranic (RH-TRU) 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 at the WTP together with the HLW (Harp 2008).

A1.4.2.6 The process flowsheet for the treatment of non-high-level radioactive waste consistent with TRU waste is described in the material balance for the waste tanks. The flowsheet is assumed to use the “dry batch mode” (RPP-21970). The process flowsheet contains two dryers that are modeled as one continuous dryer of equivalent treatment capacity.

A1.4.2.7 The dried waste product from the packaging process for the non-high-level radioactive waste consistent with TRU waste is assumed to be packaged in 55-gal drums containing no more than 620 lb of product per drum (RPP-21970).

A1.4.2.8 Although not explicitly modeled, the drums for non-high-level radioactive waste consistent with TRU waste are assumed to be stored onsite at the Central Waste Complex (CWC) until final disposition of the waste has been determined.

A1.4.2.9 Liquid effluent will either be transferred to the LERF via tank truck 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.

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 200 Area Treated Effluent Disposal Facility (TEDF) will be driven by the needs of the waste treatment mission and are assumed to be available when needed.

A1.5.1.2 If the treatment mission requires a new secondary liquid waste treatment facility or that changes be made to the ETF, LERF, SALDS, or TEDF or the associated operating plans, ORP is assumed to successfully drive the changes.
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.

A1.5.1.4 The LERF consists of three basins, each with an operating volume of 7.8 Mg (HNF-SD-WM-SAD-040, Liquid Effluent Retention Facility Final Hazard Category Determination), which are used to provide lag storage of liquid effluent. For planning purposes, only two of the basins will be allocated to support the waste treatment mission; the third basin will be reserved for Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) effluents.

A1.5.1.5 The ETF will be modeled as a black box. The partitioning of feed into solid waste and treated effluent will be approximated per HNF-4573, Liquid Effluent Retention Facility Basin 44 Process Test Post-Report, Appendix A. Chemicals (e.g., those for bulking or stabilization of the solid waste form) will not be tracked.

A1.5.1.6 The SALDS will not be modeled.

A1.5.1.7 The 200 Area TEDF will not be modeled.

A1.5.2 Central Waste Complex

A1.5.2.1 The 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.

A1.5.2.2 The packaged non-high-level radioactive waste consistent with TRU waste is assumed to be stored at the CWC until final disposition of the waste has been determined.

A1.5.2.3 Costs for disposing of non-high-level radioactive waste consistent with TRU waste from CWC are a flat rate, regardless of storage duration, and are assumed to be the same as the costs for disposing of the waste directly from the packaging facility.

A1.5.3 Interim Hanford Storage


A1.5.3.2 The IHS Facility will be located in the 200 East Area in the proximity of the 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 geologic storage (RPP-23674).

A1.5.3.3 The need date for the IHS Facility will be the date on which the first radioactive HLW canister leaves the WTP (see Assumption A1.5.3.6).

A1.5.3.4 The first 2,000-canister IHS module is assumed to be available when needed.

A1.5.3.5 The second 2,000-canister IHS module is assumed to be available 1.5 years in advance of the projected need date (RPP-23674).

A1.5.3.6 The following factors will be considered when determining the time between when a HLW canister is poured and when the canister must be shipped out of the WTP to the IHS Facility.

- The HLW canister pour handling (HPH) system canister cooling rack provides 24 positions for placement of canisters (24590-HLW-3YD-HPH-00001, System Description for HLW System HPH Canister Pour Handling, Section 6.2.1.4). This capacity does not constrain HLW production. Instead, this capacity provides information to identify when the IHS Facility and Hanford Shipping Facility (HSF) are required.

- The HLW canister storage cave in WTP has 46 storage rack slots (24590-HLW-3YD-HEH-00001, System Description for the HLW System HEH Canister Export Handling), but one slot under the viewing window is designated for canister grapple recovery. This capacity does not constrain HLW production. Instead, this capacity provides information to identify when the IHS Facility and HSF are required.

A1.5.3.7 The disposition of nonconforming canisters has not yet been determined.

A1.5.3.8 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 (RPP-23674). This capacity does not constrain HLW production. Instead, this capacity provides information to identify when the IHS Facility and HSF are required.

A1.5.4 Hanford Shipping Facility

A1.5.4.1 The HSF, which provides the capability for shipping HLW canisters to a potential national repository, will be located in the 200 East Area. 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 (RPP-23674).

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 either to continue to build additional canister storage modules or to construct the HSF. For planning purposes, the outcome of this decision is assumed to be that the HSF will be constructed and HLW canisters are
shipped to an offsite final disposal alternative (see Section A1.5.5) rather than building additional IHS 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 A1.5.3.8. 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 a year’s worth of available capacity to decouple receipt of WTP canisters from shipping to a national repository. This capacity does not constrain HLW production. Instead, this capacity provides information to identify when the IHS Facility and HSF are required.

A1.5.5 Final Disposal Alternative

A1.5.5.1 The final disposal alternative for HLW glass canisters is assumed to be at an unidentified offsite national repository.

A1.5.5.2 The final disposal alternative is assumed to have the same waste acceptance criteria as the Yucca Mountain national repository waste acceptance criteria. The HLW GFM (PNNL-22631) is assumed to result in canisters that meet the waste acceptance criteria of the final disposal alternative.

A1.5.6 Integrated Disposal Facility

A1.5.6.1 The IDF is assumed will be operational when needed and will provide permanent disposal for the ILAW, other MLLW, and low-level waste (LLW).

A1.5.6.2 Per the PMB, the IDF will receive LAW glass packages from the WTP; solid waste from the TOC and WTP, including spent LAW melters;\(^\text{94}\) 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).

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 users.

\(^{94}\) The final disposition of spent HLW melters has not yet been determined. The many alternatives in DOE/EIS-0391, Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington, assume that these spent HLW melters will be packaged in an overpack and stored at the IHS until the melters can be removed for disposition and final disposal. 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.
A.1.5.7 222-S Laboratory

A.1.5.7.1 The laboratory services required to support waste characterization for TOC projects and operations are assumed to be available and provided in a timely manner.

A.1.5.7.2 Any required facility life-extension upgrades will be aligned with the PMB.

A.1.5.7.3 The 222-S Laboratory is assumed to transfer 5 kgal/year of waste (see Assumption A1.6.1.3) to the tank farms before the startup of the WTP, and 10 kgal/year thereafter.

A.1.5.8 Waste Encapsulation and Storage Facility

A.1.5.8.1 Cesium and strontium capsules are assumed to be dispositioned outside of the WTP and tank farm facilities by the DOE Richland Operations Office (RL).

A.1.5.9 Waste Isolation Pilot Plant

A.1.5.9.1 Permitting and operational requirements to accept the Hanford non-high-level radioactive waste consistent with TRU waste that is planned to be disposed at WIPP will not impact the schedule’s critical path.

A.1.5.10 Other Hanford Site Facilities

A.1.5.10.1 Sludge generated from cleanup of the Hanford K Basins is assumed to be dispositioned by RL outside of the WTP and tank farms facilities.

A.1.5.10.2 The T Plant Facility is assumed to transfer a one-time 15 kgal of waste circa 2025 (see Assumption A1.6.1.3) to the tank farms as part of its deactivation. The transfer will include a flush equal to 22 vol% of the waste transferred.

A.1.5.10.3 Waste from the retrieval of the miscellaneous underground storage tanks (MUST) (see Assumption A1.6.1.3) 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 Lifecycle Schedule with this information.

A.1.6 CROSS-CUTTING ASSUMPTIONS

A.1.6.1 General

A.1.6.1.1 The decay date used for reporting all radionuclides is January 1, 2008, unless explicitly stated otherwise (RPP-33715, Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operation Simulator Model – 2016 Update).

A.1.6.1.2 In general, the inventory for tanks with waste intrusive activities are updated in the Tank Waste Information Network System (TWINS) once per quarter. The tank inventory update for System Plan (Rev. 8), was completed by:
• Downloading the solid and liquid inventory from TWINS for each tank as of March 2016.
• Downloading the Enraf waste volume data for each tank as of February 2016.
• Making adjustments to assign specific compounds to or make improvements in the solid/liquid allocation of bound hydroxide and oxygen.
• Making adjustments to speciate aluminum and chromium into specific compounds based on RPP-RPT-47306, Waste Type Analysis for Aluminum Leachability Estimates of All Non-Retrieved Hanford Tank Wastes, and WTP-RPT-117, Oxidative-Alkaline Leaching of Washed 241-SY-102 and 241-SX-101 Tank Sludges, respectively.
• Tanks with waste intrusive activities since the effective date for each tank are then reviewed, and any transfers completed after the effective date for each tank in the downloaded inventory and the demarcation date are included as historical transfers.

A1.6.1.3 Estimates of the inventory for the MUSTs, the waste resulting from deactivation of other Hanford facilities, and operation of the 222-S Laboratory are provided in RPP-33715.

A1.6.1.4 All solubility activities (including water wash and caustic leaching) will be modeled using the ISM, as described in RPP-RPT-50703 and RPP-RPT-58972.

A1.6.1.5 For modeling purposes, the approximations to waste chemistry in the tank farms are described in HNF-3157, Best-Basis Wash and Leach Factor Analysis, and RPP-21807, Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator.

A1.6.1.6 Liquid density and specific gravity will be estimated using the correlations described in RPP-14767, Hanford Tank Waste Operations Simulator Specific Gravity Model – Derivation of Coefficients and Validation.

A1.6.1.7 For modeling purposes, solid particulate density is assumed to be a constant 3 g/mL per RPP-9805, Values of Particle Size, Particle Density, and Slurry Viscosity to Use in Waste Feed Delivery Transfer System Analysis.

A1.6.1.8 The portion of total organic carbon from oxalate will be tracked as oxalate rather than total organic carbon to avoid double-counting and will not be further speciated. However, for modeling purposes, the remaining total organic carbon will be treated as carbon when it enters the WTP to allow for reaction stoichiometry.

A1.6.1.9 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., supernate, dissolved salts, mobilized solids) being transferred. This is a simplifying assumption required for a tractable model.
A1.6.1.10 Permit preparation activities of external agencies are not modeled and do not impact timing of modeled activities.

A1.6.1.11 The model scenario is assumed to be consistent with and bounded by the outcome of the National Environmental Policy Act of 1969 (NEPA) process.

A1.6.1.12 The model scenario is assumed to be consistent with and bounded by the appropriate facility authorization basis.

A1.6.1.13 When appropriate, Critical Decision (CD)-2 must be approved before regulatory approval of permits can begin. A range of 33 to 36 months is assumed for permitting activities (McDonald 2013). Note: Permitting activities are not explicitly modeled; these activities will be tracked manually.
A2.0 REFERENCES


Appendix A – Model Starting Assumptions


A-30
Appendix A – Model Starting Assumptions


RPP-37110, 2008, Computer/CAD Modeling System Test Results, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.


Appendix A – Model Starting Assumptions


APPENDIX B

LIFECYCLE COST MODEL SCENARIO RESULTS SUMMARIES
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The following figures were generated from the Lifecycle Cost Model results generated from the System Plan, Rev. 8, modeling in TOPSim. 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. In addition, the following items apply to the figures in this section and should be taken into consideration:

1) The results are based on fiscal year, which differs from the calendar year results reported elsewhere.

2) The results are from the Lifecycle Cost Model, which may differ slightly from the TOPSim model results.

3) For the aforementioned reasons, the results cannot be directly compared to the scenario results in the report, but provide a summary of the cost basis used for each scenario.

4) Unless specifically defined in the Lifecycle Cost Model results, D&D is assumed to occur five years following the completion of operations of a facility.
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Figure B-1. Baseline Case – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-1. Baseline Case – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-2. Scenario 2 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-2. Scenario 2 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-3. Scenario 3 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-3. Scenario 3 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-4. Scenario 4 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-4. Scenario 4 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-5. Scenario 5 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-5. Scenario 5 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-6. Scenario 7 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-6. Scenario 7 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-7. Scenario 8 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-7. Scenario 8 – Lifecycle Cost Model Results Summary. (2 Pages)
## Figure B-8. Scenario 9 – Lifecycle Cost Model Results Summary. (2 Pages)

### Appendix B

#### Lifecycle Cost Model Scenario Results Summaries

- **ORP:** ORP-11242 Rev. 8

### Key Projections

<table>
<thead>
<tr>
<th>Major Facility Markups</th>
<th>LEAP</th>
<th>ORP</th>
<th>LCE</th>
<th>Supplemental Treatment</th>
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<td>LEAP</td>
<td>ORP</td>
<td>LCE</td>
<td>Supplemental Treatment</td>
<td></td>
</tr>
</tbody>
</table>

### Base Operations

- **244 A Evaporator Campaigns**
- **201 to G10 Transfers**
- **MAA C Closure**
- **MAA A/M Closure**
- **MAA A/M Closure**

### IGT Network/Closure AMM/UA

- **245 A Evaporator Campaigns**
- **245 A Evaporator Campaigns**
- **245 A Evaporator Campaigns**

### IGT Network/Closure AMM/UA

- **MAA L/X Closure**
- **MAA L/X Closure**
- **MAA L/X Closure**

### IGT Network/Closure AMM/LH/PY

- **9 Complex TRU and Miscellaneous**
- **9 Complex TRU and Miscellaneous**
- **9 Complex TRU and Miscellaneous**

### Acronyms

- **ORP:** Operation and Recovery Plan
- **LCE:** Lifecycle Cost Estimate
- **LEAP:** Long-Term Energy Access Planning
- **ORP:** Operation and Recovery Plan
- **LCE:** Lifecycle Cost Estimate
- **LEAP:** Long-Term Energy Access Planning

### Notes

- The results presented in this figure differ from the original and annual reports because the results from the ORP-11242 Rev. 8 are updated to reflect the current year's data.

### Legend

- **Regulatory Milestones:**
  - Activity Start
  - Activity Complete
  - Facility Start Date
- **Facility Milestones:**
  - Competitor Milestones
  - Tank Retrieval Complete
  - CFT Transfer
  - Evaporator Campaign
  - 94 H/C Collection
  - LAH Handover Complete
  - Tank Farms
  - LAH Supplemental Treatment
- **Summary Task:**
Figure B-8. Scenario 9 – Lifecycle Cost Model Results Summary. (2 Pages)
**Figure B-9. Scenario 10 – Lifecycle Cost Model Results Summary.**

### Key Projections

- Major Facility Startup
- Supplemental K-TRU Transfers
- B Complex AMR

### Base Operations

- 242 A Evaporator Campaigns
- DST to DST Transfers

### Infrastructure Upgrades

- Rev DST Anode Mat (RA)
- Rev DST Anode Mat (RA)

### ORP - 11242 Rev. 8

### Notes

1. The results presented herein reflects the assumption of normalized operation.
2. The results presented herein reflect the assumption of a line facility in which the ORP-11242 Rev. 8.
3. The results presented herein reflect the assumption of a line facility in which the ORP-11242 Rev. 8.
4. For the above-normalized results, the cost is normalized to the period of operation.
5. The results presented herein reflect the assumption of a line facility in which the ORP-11242 Rev. 8.
6. For the above-normalized results, the cost is normalized to the period of operation.
7. The results presented herein reflect the assumption of a line facility in which the ORP-11242 Rev. 8.

### Legend

- Regulatory Milestones
- Activity Start
- Activity Complete
- Facility Start Date
- Competition Milestones
- Tank Statement Complete
- DST Transfer
- Evaporator Campaign
- HIF/IR Campaigns
- LEU Core Reels
- Tank Fills
- LEU Supplemental Treatment

### Acronyms

- ORP
- Rev.
- AMR
- DST
- RA
- B
- RA
- TRU
- D1
- M1
- M2
- M3
- N/A
- TOE
- KRTU
- TRU
- NTRU
- D1<br>
Figure B-9. Scenario 10 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-10. Scenario 11 – Lifecycle Cost Model Results Summary. (2 Pages)
Figure B-10. Scenario 11 – Lifecycle Cost Model Results Summary. (2 Pages)