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ORP-11242
Revision 6

RIVER PROTECTION PROJECT SYSTEM PLAN

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

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

Approved for Public Release;
Further Dissemination Unlimited

River Protection Project System Plan

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Office of River Protection

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HISTORY SHEET

Revision	Date	Reason for Revision	Revised by
0	August 2002	Initial Issuance	K. R. Wells
1	April 2003	Reflect proposed changes and additions to the Waste Treatment Processes & Facilities to accelerate mission completion	K. R. Wells
2	September 2003	Reflect a Target Case which depicts the mission based on how ORP expects the WTP to perform and a Stretch Case which depicts the mission if significant increases in both WTP and non-WTP LAW treatment performance are realized.	P. J. Certa
3	May 2008	Reflects a Reference Case which depicts a mission scenario based on beginning full WTP operations in 2019, in conjunction with supplemental LAW treatment and supplemental TRU packaging. Generally aligned with key features of the FY 2007 baseline.	P. J. Certa
3A	July 2008	Incorporate comments from the Office of Management and Budget	P. J. Certa
4	September 2009	Reflects a Baseline Case consistent with the Performance Management Baseline. An Initial Planning Case consistent with the Interim and draft Performance Measurement Baseline under the new Tank Operations Contract and an Unconstrained Case are used to evaluate program impacts against assumed “success criteria.”	M. N. Wells
5	November 2010	Reflects a Baseline Case, which provides the technical basis for the Performance Measurement Baseline; and a Sensitivity Case in which all potential TRU tank waste is processed through WTP.	M. N. Wells
6	October 2011	Reflects a Baseline Case, which provides the technical basis for the Performance Measurement Baseline; and nine additional scenarios jointly selected by ORP and Ecology to meet the requirements of HFFACO Milestone M-062-40.	M. N. Wells

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), Office of River Protection (ORP) manages the River Protection Project (RPP). The RPP mission is to retrieve and treat Hanford's tank waste and close the tank farms to protect the Columbia River. As a result, ORP is responsible for the retrieval, treatment, and disposal of approximately 55 million gallons (Mgal)[1] of radioactive waste contained in the Hanford Site waste tanks and closure[2] of all the tanks and associated facilities.

This version of the RPP System Plan (Rev. 6) is a major update of the previous revision, System Plan (Rev. 5), issued November 2010. This revision of the System Plan (1) provides the technical basis, by means of the Baseline Case (Case 1), for updates to the Tank Operations Contract (TOC) Performance Measurement Baseline (PMB), and (2) presents the results for the scenarios (Cases 2 – 10) selected by ORP and Washington State Department of Ecology (Ecology) in accordance with the *Hanford Federal Facility Agreement and Consent Order* (HFFACO)[3] milestone M-062-40. Consequently, this revision of the System Plan contains significantly more modeling results and analyses than previous revisions. Additional information, such as cost and schedule data for each scenario relative to the Baseline Case, has also been included in this revision as required by that milestone.

The Baseline Case describes how the RPP mission could be achieved given an underlying set of technical and programmatic assumptions. The Baseline Case shows how the tank farms, together with the Waste Treatment and Immobilization Plant (WTP), a second low-activity waste (LAW) vitrification facility, and the potential contact-handled transuranic (CH-TRU) tank waste treatment process, could retrieve and treat the Hanford tank waste with an estimated life-cycle cost of $59.9 billion, contingent on successful resolution of the key issues and uncertainties. The Baseline Case and all of the other scenarios project that the Hanford tank waste would be treated by 2047.

The key issues and uncertainties related to the Baseline Case are summarized in this executive summary (page ES-13) and expanded on in Section 7.0 of this document. A summary of targeted success criteria and Baseline Case results can be found in Table ES-1 (presented in the Results section of this executive summary), with more detailed results reported in Section 5.0.

ORP performs contingency planning using the risk management process. HFFACO milestone M-062-40 requires that the System Plan identify and consider possible contingency measures to address six specific risks. These risks and their possible contingency measures are identified and considered in Section 11.0.

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[1] This is the total volume of tank waste as of October 2010 from HNF-EP-0182, *Waste Tank Summary Report for Month Ending September 30, 2010* (Rev. 270). The total volume of tank waste fluctuates over time because water and chemicals may be added to the tanks as part of certain waste retrieval processes to facilitate waste retrieval; water is also removed by the waste evaporator.

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

[3] Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Cases 2 - 10 represent the scenarios selected by ORP and Ecology for partial completion of HFFACO milestone M-062-40, as documented in letter 10-TPD-148.[4] Starting with the Baseline Case, each of the scenarios changes some of the underlying assumptions in order to evaluate the impacts of those changes upon the treatment mission. Changes in the key issues and uncertainties introduced by the changed assumptions were identified and are included with the results of the corresponding scenarios in Section 10.0. A summary of results for Cases 2 - 10 is provided in Table ES-2 (presented in the Results section of this executive summary), with more detailed results presented in Section 10.0. The scenarios showed varying degrees of success in meeting the targeted success criteria for the Baseline Case and their own scenario-specific goals (see Table ES-1 for a summary of the success criteria).

Background

The current ORP strategy[5] for completing the RPP mission involves a number of interrelated activities. ORP will reduce risk to the environment posed by tank wastes by:

- Retrieving the waste from the single-shell tanks (SST) to double-shell tanks (DST) and delivering the waste to the WTP.
- Constructing and operating the WTP, which will safely treat the high-level waste (HLW) fraction contained in the tank farms. A portion of the LAW fraction separated from the HLW fraction in the WTP will be immobilized in the WTP LAW Vitrification Facility.[6]
- Developing and deploying supplemental treatment capability, currently depicted as a second LAW vitrification facility in the Baseline Case, to safely treat the remainder of the LAW fraction not immobilized by the WTP LAW Vitrification Facility.
- Developing and deploying supplemental pretreatment capability as needed.
- Developing and deploying treatment and packaging capability for potential TRU tank waste interim storage at the Central Waste Complex pending determination of the final disposal pathway.[7]

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[4] Brockman, D. A., and J. A. Hedges, 2010, "Partial Completion of Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Interim Milestone M-062-40, to Submit a System Plan to Washington State Department of Ecology (Ecology) Describing the Disposition of All Tank Waste Managed by the U.S. Department of Energy (DOE), Office of River Protection (ORP), Including 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," (Letter 10-TPD-148 to D. A. Faulk, Program Manager, Office of Environmental Cleanup, Hanford Project Office, U.S. Environmental Protection Agency, October 28), U. S. Department of Energy, Office of River Protection, and Washington State Department of Ecology Nuclear Waste Program, Richland, Washington.

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

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

[7] The strategy includes options for (1) disposing of the packaged potential TRU tank waste offsite, or (2) treating the potential TRU waste through the WTP and disposing the waste as IHLW.

- Deploying interim storage capacity for the immobilized high-level waste (IHLW) pending determination of the final disposal pathway.[8]
- Disposing of packaged immobilized low-activity waste (ILAW) onsite at the Integrated Disposal Facility.
- Closing the SST and DST tank farms, ancillary facilities, and associated waste management and treatment facilities.
- Optimizing the overall mission by resolution of technical and programmatic uncertainties; upgrading the tank farms to provide a steady, well-balanced feed to the WTP; and performing trade-offs of the required amount and type of supplemental treatment and pretreatment, and the amount of IHLW and ILAW.

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

The HFFACO, also known as the Tri-Party Agreement (TPA), was signed by DOE, Ecology, and the 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 Ecology negotiated new and revised HFFACO milestones, along with new milestones in a Consent Decree to be 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.[9] One of the new HFFACO milestones, M-062-40, requires ORP to prepare a System Plan every three years with its own specific set of requirements. The scope of the System Plan was expanded compared to previous revisions to address the requirements of the new HFFACO milestone M-062-40.

Purpose

The System Plan establishes a Baseline Case that is used as the technical basis for the budget and schedule baseline documented in the TOC PMB. The Baseline Case describes how the RPP mission could be achieved given an underlying set of assumptions. The Baseline Case demonstrates the interactions among several key technical aspects of the RPP mission, including SST retrieval, 242-A Evaporator campaigns, DST space management waste feed delivery, SST and DST closure, total processed sodium, supplemental LAW treatment capacity, mission duration, WTP pretreatment throughput, and HLW glass formulation.[10] The Baseline Case also provides an estimated life-cycle cost and conveys the key issues and uncertainties of the mission for the given set of underlying assumptions.

The results and analysis of the Baseline Case are used in continued integration with ongoing refinements of (1) the TOC PMB; (2) plans for waste feed delivery, SST retrieval, and supplemental LAW treatment; and (3) the hot commissioning and campaign plans for the WTP.

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[8] ORP planning with regard to final disposal of IHLW is subject to recognition of uncertainties with regard to an assumed, planned off-site geologic repository.

[9] Consent Decree, 2010, *State of Washington v. DOE*, Case No. 08-5085-FVS (October 25), Eastern District of Washington.

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

Identification of areas that might require decisions or benefit from resolution of issues and uncertainties allows ORP to further improve its risk mitigation strategy.

As required by HFFACO milestone M-062-40, the System Plan describes the disposition of all tank waste managed by ORP, presents results from several scenarios[11] selected by Ecology and ORP, and identifies and considers possible contingency measures. Appendix D provides a crosswalk of milestone M-062-40 language with specific sections in this System Plan.

Results

The Baseline Case shows how the WTP, together with a second LAW facility and the potential TRU tank waste treatment process, could treat the Hanford tank waste by 2043, with approximately 25 years of WTP operations and an estimated life-cycle cost of $59.9 billion. All SST waste retrievals are projected to be completed in 2039. All schedule-based success criteria are projected to be met, with the exception that the completion date of all SST farm closures is projected to be about nine months late. Future work to improve the closure completion date will analyze the SST retrieval sequencing logic, retrieval infrastructure, SST farm closure requirements currently being developed, and other applicable parameters to make better use of the available DST space near the end of the mission. A reconciliation of technical and schedule assumptions for the duration of hard heel removal activities is also necessary. A simplified flowsheet for the Baseline Case is shown in Figure ES-1.

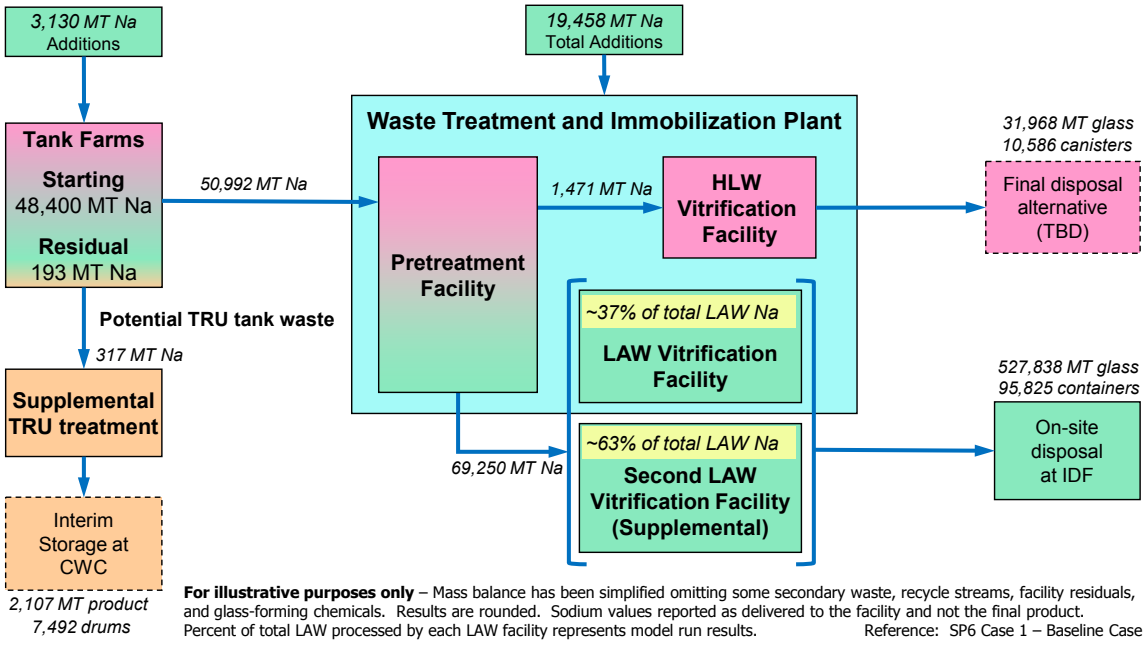

Figure ES-1. Simplified Flowsheet for Baseline Case

A comparison of the results for the System Plan (Rev. 5) Baseline Case, the System Plan (Rev. 6) Baseline Case, and Cases 2 - 10 is summarized in Table ES-1. A comparison of the System Plan (Rev. 6) Baseline Case and Cases 2 - 10 to the mission metric success criteria is shown in Figure ES-2.

[11] Partial completion of the milestone (selection of scenarios for this version of the System Plan) is documented in letter 10-TDP-148 (Brockman and Hedges 2010).

Table ES-1. System Plan (Rev. 6) Highlights

Metric (milestone)	Success criteria	System Plan (Rev. 5): Baseline Case	System Plan (Rev. 6) Scenarios									
			Case 1: Baseline Case	Case 2: TRU waste to WTP	Case 3: FBSR for supplemental treatment	Case 4: WTP delay with increased vitrification	Case 5: 2020 Vision One System	Case 6: WTP delay with new DST farm	Case 7: Enhanced tank waste strategy	Case 8: Accelerated retrieval	Case 9: Early U Farm closure	Case 10: Slow SST retrievals
Life-cycle cost, FY 1997 to end of mission	$61.5B	–	$59.9 B	**$61.6 B**	$58.1 B	**$66.0 B**	$58.0 B	**$68.7 B**	$57.3 B	**$62.8 B**	$59.6 B	$60.8 B
Meets near-term funding targets through 2015	$2,750M	–	$2,440 M	$2,400 M	**$3,226 M**	$2,314 M	$2,705 M	$2,450 M	**$3,377 M**	$2,413 M	$2,442 M	$2,439 M
Meets near-term funding profile through 2015	Note a	–	✓	✓	X	✓	✶	✓	X	✓	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	7/13/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	1/23/2014
Start five additional SST retrievals (B-3)	12/31/2017	2/9/2015	7/23/2017	7/23/2017	9/16/2017	7/2017	**9/9/2018**	7/23/2017	9/16/2017	7/23/2017	5/21/2017	7/27/2017
Close WMA C (M-045-83)	6/30/2019	6/28/2019	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	9/20/2017	12/16/2020	12/16/2020	11/4/2019	**7/17/2024**	4/21/2020	8/25/2021	10/24/2019	12/16/2020	8/15/2020	1/17/2021
Complete all SST retrievals (M-045-70)	12/31/2040	10/13/2039	9/8/2039	9/25/2040	11/3/2038	**8/14/2043**	9/14/2038	**7/24/2042**	9/9/2037	3/27/2040	9/7/2038	10/4/2040
Close all SSTs (M-045-00)	1/31/2043	**9/29/2043**	**10/5/2043**	**10/20/2044**	12/2/2042	**9/11/2047**	10/9/2042	**8/20/2046**	10/4/2041	**4/21/2044**	10/2/2042	**10/31/2044**
Treat all tank waste (M-062-00)	12/31/2047	8/26/2045	4/23/2043	5/13/2044	8/13/2041	3/27/2046	8/26/2041	3/16/2047	10/4/2039	6/7/2045	1/17/2043	10/16/2043
Close all DSTs (M-042-00A)	9/30/2052	9/15/2049	3/18/2048	6/1/2049	8/7/2046	2/17/2051	7/30/2046	3/21/2052	12/18/2045	5/31/2050	1/17/2048	10/22/2048
Complete potential TRU tank waste packaging	–	6/26/2023	7/13/2023	–	7/13/2023	7/13/2023	7/13/2023	7/13/2023	7/13/2023	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	33,654	31,968	34,884	31,056	31,512	30,721	31,304	28,205	37,137	31,875	31,995
HLW glass canisters	–	10,713	10,586	11,552	10,284	10,435	10,173	10,366	9,340	12,298	10,555	10,595
HLW glass waste oxide loading	–	37.6%	36.9%	35.3%	37.8%	37.7%	38.4%	38.3%	41.2%	36.3%	36.6%	37.0%
LAW glass mass (MTG)	–	415,430	527,838	533,110	152,045	523,479	520,966	525,433	0	527,819	526,269	523,693
LAW glass containers	–	75,419	95,825	96,782	27,602	95,034	94,577	95,389	0	95,822	95,540	95,073
LAW glass sodium oxide loading	–	17.2%	17.8%	17.7%	19.92%	17.9%	18.0%	17.8%	0	17.9%	18.0%	17.9%
Sodium reporting to LAW glass (MT)	–	53,058	69,659	70,109	22,474	69,657	69,689	69,487	0	70,018	70,136	69,499
FBSR product (MT)	–	–	–	–	620,099	–	–	–	912,751	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–	–	46,380	–	–	–	68,507	–	–	–
LiHT by-product (MT)	–	20,201	–	–	–	–	–	–	–	–	–	–
Potential TRU tank waste drums	–	7,491	7,492	–	7,492	7,492	7,492	7,492	7,492	–	7,491	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. X – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric ton.
MTG = metric tons of glass.
SST = single-shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

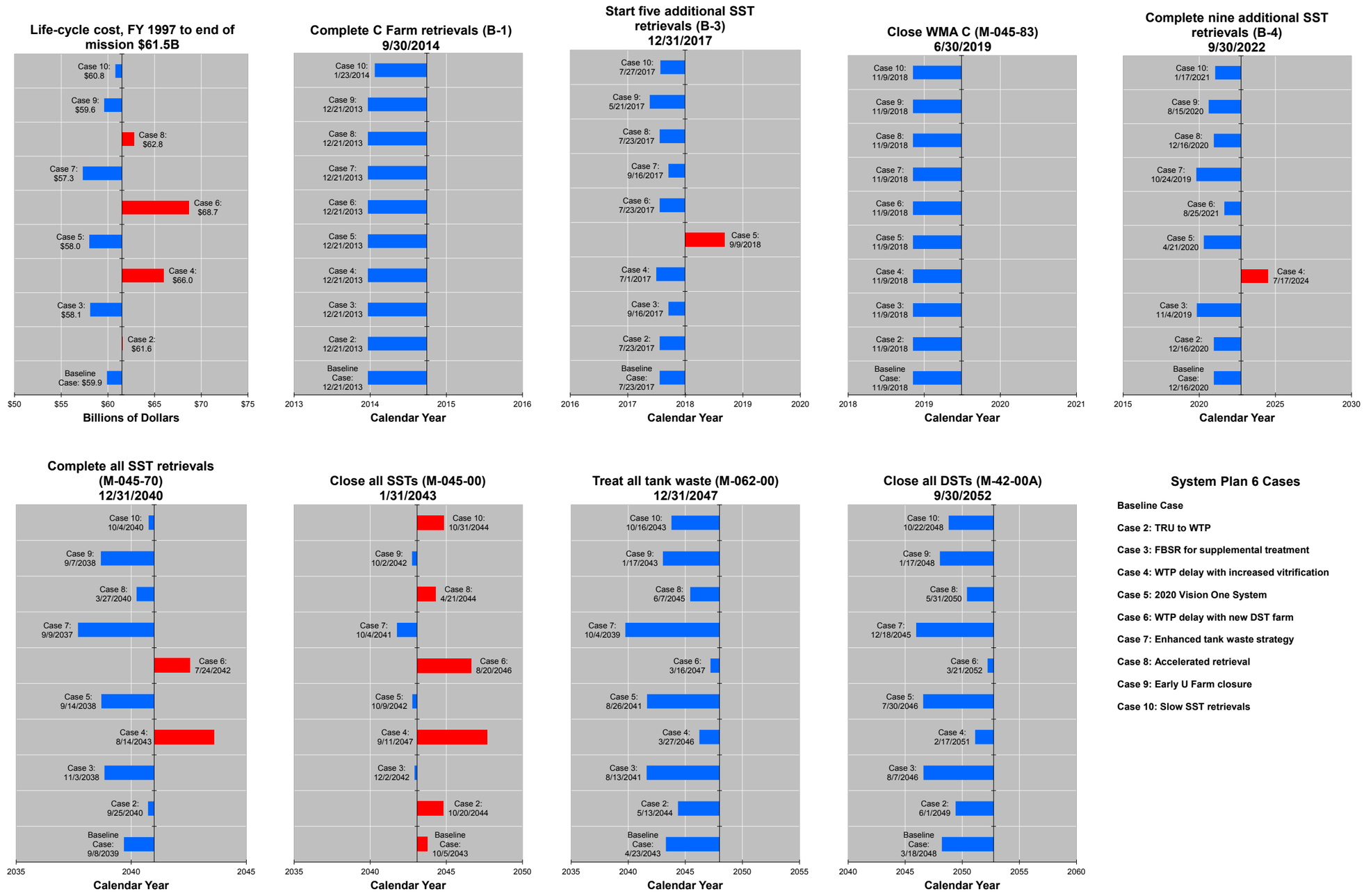

Figure ES-2. Comparison of System Plan Cases to Mission Milestones

Detailed system descriptions for Cases 2 - 10 are included in Section 10.0, along with a detailed analysis of the results. Table ES-2 shows the intended purpose of each of the scenarios and brief summary observations on the results when compared to the Baseline Case.

Table ES-2. Summary Results for Cases 2 – 10 (3 pages)

Case No.	Scenario Title	Purpose	Observations
2	TRU waste to WTP	Show impacts of treating all potential TRU tank waste at WTP as HLW	The additional waste treated at the WTP caused an increase in the number of HLW canisters, an increase in WTP treatment duration, and an associated increase in life-cycle cost.
3	FBSR for supplemental treatment	Deploy FBSR as an alternative to a second LAW vitrification facility	The supplemental pretreatment and treatment capacity added for Case 3 facilitated an earlier completion of SST retrievals, earlier SST and DST closures, and shorter treatment duration. The costs to install and operate the alternative supplemental treatment system were offset by the elimination of a second LAW vitrification facility and by the decreased mission length. The sodium management of Case 3 could be optimized to further reduce the demand on the WTP Pretreatment Facility and improve the utilization of the supplemental pretreatment and treatment systems. When compared on a volume basis, the FBSR product is 2.4 times the volume of LAW glass for the same amount of sodium processed. The accelerated schedule necessary for a 2018 deployment of fluidized bed steam reformers carries significant risks.
4	WTP delay with +10% vitrification capacity	Evaluate how well a 10% increase in overall vitrification capacity offsets all/part of the impact of the uniform 4-year delay in WTP startup	Increased vitrification capacity only recovered about one year from the 4-year delay in WTP startup. As such, SST retrievals and closures, DST closures, and the end of treatment all occur years behind the Baseline Case, resulting in an increased life-cycle cost. The 10% additional vitrification capacity may exceed the mechanical handling capabilities of the HLW Vitrification Facility.
5	2020 Vision One System	Show impacts of phased turnover of WTP facilities	Starting LAW treatment earlier than the Baseline Case had beneficial impacts on the mission, allowing SST retrievals and closures, DST closures, and end of treatment all to occur ahead of the Baseline Case. Competing demands for DST space early in the mission caused milestone B-3, "Start five additional SST retrievals," to be missed by about nine months. The additional costs of providing supplemental pretreatment and supporting early LAW treatment were more than offset by the cost savings due to shorter mission duration. Despite a 13.5-month outage in HLW production caused by DST space constraints, all tank waste was treated approximately 20 months earlier than the Baseline Case.

Table ES-2. Summary Results for Cases 2 – 10 (3 pages)

Case No.	Scenario Title	Purpose	Observations
6	WTP delay with new DST farm	Evaluate how well a new DST farm offsets the impact of a uniform 4-year delay in WTP startup	The 4-year delay in startup of WTP causes a nearly 4-year delay in the end of treatment, even with a new DST farm. While the additional DST farm allows SST retrievals to be completed with less than a 4-year delay, the milestone is still missed. The increased mission duration due to delayed treatment increases the life-cycle cost considerably.
7	Enhanced tank waste strategy	Use of transformational technologies that may shorten mission schedule by 7 years and reduce life-cycle cost by $16 billion	Replacing the WTP LAW Vitrification Facility and a second LAW facility with eight fluidized bed steam reformers fed by both of the WTP pretreatment and supplemental pretreatment processes accelerated the treatment end date by 3.5 years compared to the Baseline Case and 6 years compared to the PMB. All other success criteria were met; typically in advance of the Baseline Case. The scenario goal of shortening the mission by 7 years and saving $16 billion when compared to the PMB were only partially met (6 years and $4.3 billion were saved). Significant savings were achieved through the 3.5-year treatment duration reduction relative to the Baseline Case. The sodium management of Case 7 could be optimized to further reduce demand on the WTP Pretreatment Facility and improve the use of the supplemental pretreatment and treatment systems. The accelerated schedule necessary for a 2018 deployment of fluidized bed steam reformers carries significant risks. When compared on a volume basis, the FBSR product is 2.4 times the volume of LAW glass for the same amount of sodium processed. The enhanced HLW glass model and the increased LAW immobilization capacity allow waste to be staged through the DST system more rapidly than the Baseline Case. As a result, both the HLW and LAW facilities experience SST retrieval-limited outages during the mission.
8	Accelerated SST retrievals	Show effect on mission duration using alternate SST retrieval approach	All mission success criteria were met by Case 8, with the exception of the SST closure date, and the treatment end date was more than 2 years later than the Baseline Case. The increased treatment duration was due to the additional waste sent to the WTP from potential CH-TRU waste tanks (the starting point for Case 8 was Case 2). Less-than-optimal blending of the potential CH-TRU tank waste (due to timing of retrievals and waste diversity available) caused more HLW glass to be produced. Staging waste in sound SSTs allowed SST retrievals to complete earlier than for Case 2, which also treated potential CH-TRU waste at the WTP. SSTs are not currently approved to receive consolidated waste and there is significant risk that the effort needed to demonstrate that selected SSTs are fit-for-use; implement any required engineering, operational, or administrative controls; and support an accelerated SST retrieval permitting schedule would not support a 2020 project start.

Table ES-2. Summary Results for Cases 2 – 10 (3 pages)

Case No.	Scenario Title	Purpose	Observations
9	Early U Farm closure	Show impacts of beginning U Farm retrievals instead of A Farm for the nine retrievals after C Farm	All mission success criteria were met by Case 9 and the results are similar to those for the Baseline Case. The treatment end date is 2 months earlier than the Baseline Case, with a $300 million reduction in life-cycle cost. The total volume of waste retrieved from SSTs during 2020 to 2025 in Case 9 exceeds that of the Baseline Case due to the creation of additional deep sludge tanks to use more DST space.
10	Slow SST retrievals	Show impacts on the baseline of increasing the minimum retrieval durations for SSTs	All mission success criteria were met by Case 10, with the exception of the SST closure date. The results are similar to those for the Baseline Case. The 25% slower SST retrievals in the near-term can be tolerated due to schedule contingency built into the early retrieval schedules, which allows for a reasonable increase in the duration of one retrieval to avoid impacting the following retrieval.

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
FBSR = fluidized bed steam reforming.
HLW = high-level waste.
LAW = low-activity waste.
PMB = performance measurement baseline.
SST = single-shell tank.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

A detailed analysis of the Baseline Case results is provided in Section 5.0. The following is a discussion of the highlights.

For most of the waste treatment mission, the duration of the Baseline Case is driven by the HLW vitrification capacity, followed by the total LAW vitrification capacity and WTP pretreatment capacity. In the early years, through 2030, the waste treatment mission is primarily driven by the total LAW vitrification capacity from both the WTP LAW Vitrification Facility and a second LAW facility, which limits the amount of HLW that can be pretreated and prepared for vitrification. If the risks associated with achieving the assumed SST retrieval rates or the ability of the DST system to prepare and delivery feed are realized, those systems might become the mission duration drivers.

Additionally, the WTP Pretreatment (PT) Facility may be running in the vicinity of its achievable capacity for feed solids and waste sodium during much of the mission (Section 5.6.2.2 provides further details). If the Baseline Case exceeds the achievable WTP PT Facility capacities, the mission duration may increase or supplemental pretreatment capacity may be required. The capabilities of the WTP are being evaluated and documented per TPA milestone M-062-49, which states, in part, that DOE is to "submit a report to Ecology…which demonstrates that the WTP is designed to accomplish…pretreat[ing] 100% of retrievable tank waste…"

The addition of supplemental pretreatment to the mission would reduce the demand on the WTP PT Facility, which may (1) mitigate the potential capacity shortfall, and (2) allow for reducing the sodium demand on WTP pretreatment to better accommodate pretreatment of solids and potentially keep the HLW glass production closer to the theoretical production curve.

The SSTs are projected to be retrieved by October 2039, with the C Farm retrievals being completed in December 2013. The management of DST space, up until all facilities have reached their full net capacities, is critical to maintaining the progress of SST retrievals. After the retrieval of C Farm, minimal DST space is available to support additional SST retrievals, and three evaporator campaigns are needed to make space for retrieving waste from the nine additional SSTs. The schedule for retrieving waste from the nine additional tanks for the System Plan (Rev. 6) Baseline Case has been delayed compared to the schedule for the same tanks in the System Plan (Rev. 5) Baseline Case, mitigating some of the schedule issues[12] raised in the System Plan (Rev. 5) Baseline Case.

Three SST retrievals are started in late 2023 or early 2024, only to sit idle until the WTP frees up enough tank space for them to continue and finish in mid-2026. The start of these retrievals would probably be rescheduled after sufficient DST space is made available by operation of the WTP.

The DST space needed to adequately stage, sample, and blend solids for delivery to the WTP is still under evaluation. As the waste feed delivery strategy is refined, the timing of the nine additional SST retrievals may need to be reevaluated. A more detailed discussion of DST space management is provided in Section 5.5.2.1.

The WTP LAW Vitrification Facility is projected to treat about 37 percent of the pretreated LAW from the WTP PT Facility, while a second LAW facility is projected to treat about 63 percent. In previous System Plans, the combined LAW glass production (two WTP LAW Facility melters plus six melters in a second LAW facility) was selected to allow for the potential acceleration of the treatment end date resulting from full use of the available HLW treatment capacity. However, in System Plan (Rev. 6), this approach of balancing the LAW and HLW capacities was thought to result in oversizing the second LAW facility (two WTP LAW Facility melters plus eight melters in the second LAW facility), so the same capacity determined by System Plan (Rev. 5) was used. This also maintains consistency with the PMB, while the Supplemental Treatment and Immobilization Program determines the needed capacity.

Waste treatment is projected to be completed in 2043 for the Baseline Case, with a total of 10,586 canisters of HLW glass and 95,825 containers of LAW glass produced. The mass of HLW glass for System Plan (Rev. 6) is 5 percent less than for System Plan (Rev. 5), but the difference in the HLW canister count is only 1 percent. The reason that the glass mass and canister count did not change by the same percentage is that the ⅜-in. walled canister used in System Plan (Rev. 6) holds slightly less glass (3.02 MT)[13] than the thin-walled (10-gauge nominal) (3.14 MT) assumed for System Plan (Rev. 5).

[12] In System Plan (Rev. 5), the timing of the retrievals from the A and AX Farms was driven primarily by available DST tank space and minimum retrieval durations. Proper allowances for the time needed to upgrade infrastructure and install the retrieval systems were not included in System Plan (Rev. 5), but are included in System Plan (Rev. 6).

[13] Canister filling details are provided in Appendix B, Assumption B3.3.3.7.

A number of changes occurred between System Plan (Rev. 5) and System Plan (Rev. 6) that impacted the mass of HLW glass produced, including:

- Flowsheet changes (removing the Aluminum Removal Facility and implementing the WTP PT Facility "equipment alternative"[14])
- Implementation of an additional intentional blending strategy
- Minor changes in incidental blending
- A modeling change in the handling of vessel heels in the WTP.

Cumulatively, these changes reduced the HLW glass mass by the 5 percent discussed above. Additional details are provided in Section 5.10.2.

The projected number of LAW containers for the Baseline Case increased by 27 percent (from 75,419 to 95,825 containers) relative to the System Plan (Rev. 5) Baseline Case. The increase was due to several interrelated causes, primarily from the removal of the Aluminum Removal Facility from the RPP mission baseline, which was only partially offset by implementing the WTP pretreatment equipment alternative. Additionally, partitioning assumptions for the LAW melter were updated, and the sludge washing efficiency was improved for the ultrafiltration system.

Assumptions

Selected Baseline Case assumptions from System Plan (Rev. 5) are summarized and compared to selected Baseline Case assumptions for System Plan (Rev. 6) in Table ES-3. Detailed assumptions are provided in Appendix B.

The two largest changes in assumptions were the removal of the Aluminum Removal Facility for supplemental LAW treatment and the implementation of the WTP equipment alternative flowsheet changes in pretreatment to mitigate solids precipitation in the ion-exchange feed.

System Plan (Rev. 6) adopted a HLW canister with ⅜-in. thick walls, which holds about 3.02 MTG/canister instead of the thin-walled (10-gauge nominal) HLW canister (3.14 MTG/canister) used for System Plan (Rev. 5).

A different approach was taken to determine the supplemental LAW treatment capacity, maintaining the same size (six melters yielding 63 MTG/day net) used in System Plan (Rev. 5).

[14] A description of the WTP PT Facility "equipment alternative" is provided in Appendix B, Assumption B3.3.2.4.

Table ES-3. Comparison of Selected Baseline Case Assumptions

Item	System Plan (Rev. 5) Baseline Case	System Plan (Rev. 6) Baseline Case
Projected funding	PMB RPP-09-002[a] as updated	PMB as of March 2011
Supplemental LAW treatment	Second WTP LAW vitrification facility: Start 2022	Second WTP LAW vitrification facility: Start 2022
Supplemental TRU tank waste treatment	Potential TRU tank waste interim stored in Central Waste Complex	Potential TRU tank waste interim stored in Central Waste Complex
WTP normal operations	12/2019	12/2019
Sodium and aluminum management	Aluminum Removal Facility	WTP equipment alternative
SST retrieval sequence	Staggered, overlapping, farm-by-farm (logistically favorable) RPP-PLAN-40145, Rev. 1[b]	Staggered, overlapping, farm-by-farm (logistically favorable) RPP-PLAN-40145, Rev. 2[c]
SST retrieval rates	New technology for assumed leakers Updated operating shifts and learning curves per SVF-1647, Rev. 3B[d]	New technology for assumed leakers Updated operating shifts and learning curves per SVF-1647, Rev. 3D[e]
WTP feed screening	Screened for Specification 7, 8, HGR and criticality	Screened for Specification 7, 8, HGR and criticality
HLW canisters	3.14 MTG/canister (10-gauge nominal)	3.02 MTG/canister (⅜-in. thick wall)
HLW capacity	4.2 MTG/day net, then 5.25 MTG/day net with second generation melter	4.2 MTG/day net, then 5.25 MTG/day net with second generation melter
LAW capacity (WTP)	21 MTG/day net	21 MTG/day net
Supplemental LAW treatment capacity	Second LAW facility sized as needed (≈63 MTG/day)	Second LAW facility sized consistent with the current project work (≈ 63 MTG/day)
Glass formulation models	HLW: 2009 GFM[f] LAW: 2004 DOE model[g,h]	HLW: 2009 GFM[f] LAW: 2004 DOE model[g,h]

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

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

[c] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

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

[e] SVF-1647, 2011, "Single-Shell Tank Retrieval Assumptions for Mission Modeling," Rev. 3D, Washington River Protection Solutions, LLC, Richland, Washington.

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

[g] D-03-DESIGN-004, 2003, *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*, WTP Engineering Division, U.S. Department of Energy, Office of River Protection, Richland, Washington.

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

DOE = U.S. Department of Energy.
GFM = glass formulation model.
HGR = hydrogen generation rate.
HLW = high-level waste.
LAW = low-activity waste.
MTG = metric tons of glass.
PMB = performance measurement baseline.
SST = single-shell tank.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

Key Issues and Uncertainties

The System Plan provides "single-value" estimates for key mission metrics (e.g., the treatment end date and quantity of glass produced) and the timing of various events. These estimates are "single-value" in that they do not reflect the uncertainty and variability within the underlying assumptions and calculations.

Some of the assumptions used for the Baseline Case present issues and uncertainties that need to be successfully addressed to further reduce ORP's risk associated with achieving the desired performance for the RPP mission. The issues and uncertainties identified for the Baseline Case will assist ORP in the management of the programmatic and technical risks associated with the waste treatment mission. Selected key issues and uncertainties are summarized below.

- **Individual SST retrieval durations** – The range of operating efficiencies for SST retrievals, after C Farm is retrieved, is assumed to be improved by a factor of two[15] in the Baseline Case over the expected performance based on past experience, process records, laboratory test results, technology development testing, inspections of tanks, and best engineering judgment.
- **DST space management** – If DST space is not properly managed or if sludge-specific flammable gas controls are more restrictive than assumed, there could be a detrimental effect on SST retrieval timing and waste feed delivery capabilities.
- **Waste feed delivery capabilities** – The Baseline Case assumes that a DST can be adequately mixed, sampled, and qualified in 210 days, and adequately delivered in successive deliveries that continue to meet feed qualifications. The Baseline Case also assumes that the DST system will support the timely staging and preparation of those feed batches.
- **WTP pretreatment capacity** – The Baseline Case assumes that the WTP PT Facility will support the assumed net HLW and LAW vitrification capacities and that no additional "throttle" internal to the WTP PT Facility is needed beyond maintaining flowsheet fidelity.
- **Effluent Treatment Facility treatment capabilities** – The Baseline Case assumes that secondary waste processing facilities will have the capacity and capabilities required to handle all of the secondary liquid waste generated during the treatment mission.
- **Operations and maintenance capabilities** – The Baseline Case assumes that the programmatic, organizational, and cultural changes needed to accommodate the step change in the pace of operations (from a sustained average of 1.4 to nine SST retrieval completions per year and from a sustained average of 11 to 91 DST transfers per year) will be successfully implemented.
- **Glass formulation and vitrification capabilities** – The Baseline Case assumes that the waste loadings projected by the assumed glass formulation models can be achieved using the projected variable feed without reduction in the assumed vitrification rates.

[15] For perspective, the expected total operating efficiencies (before the 2x multiplier) range from 21 to 34 percent. With the multiplier, they would need to range from 42 to 68 percent.

- **Potential CH-TRU tank waste disposition** – The Baseline Case assumes that the potential CH-TRU tank waste will be packaged beginning in April 2018. Prerequisites may include the Tank Closure and Waste Management Environmental Impact Statement (TC & WM EIS) Record of Decision (ROD), a formal waste determination, Resource Conservation and Recovery Act[16] (RCRA) permits for the packaging facility and for interim storage at the Central Waste Complex, and identification of the final disposition of the packaged waste.

These key issues and uncertainties are discussed in more detail, together with potential mitigating actions, in Section 7.0.

Path Forward

The key issues and uncertainties associated with the Baseline Case and its underlying assumptions must be carefully considered when interpreting results and in making changes to the TOC PMB. While the Baseline Case projects that many activities may be completed earlier than their success criteria or milestones, there is considerable technical and programmatic uncertainty. Efforts currently being pursued by ORP to address issues with the underlying assumptions and reduce the technical and programmatic uncertainty include the following:

- Accelerating the decisions for providing the required supplemental LAW treatment and pretreatment capacity
- Evaluating alternatives for providing additional LAW treatment capacity
- Accelerating the startup of LAW treatment (either the WTP LAW Vitrification Facility or a second LAW facility) to decrease the required size of the supplemental LAW vitrification facility and to increase DST space availability during the critical period between 2018 and 2022
- Evaluating and implementing options to improve management of DST space
- Demonstrating how existing or new retrieval technologies can achieve the higher total operating efficiencies (shorter durations) than currently realized to support sustained waste feed delivery and uninterrupted WTP operations
- Performing an analysis of equipment reliability, availability, and maintainability of the integrated RPP flowsheet using the Washington River Protection Solutions, LLC (WRPS) operations research model;[17] identifying the equipment pinch-points and operational limitations that need to be addressed to ensure a successful mission
- Incorporating new HLW and LAW glass data into glass formulation models for both system planning and production purposes; continued improvement and evaluation of glass formulation models with consideration of waste incorporation, melter throughput, and tolerance to variable feed composition

[16] *Resource Conservation and Recovery Act of 1976 (RCRA)*, 42 USC 6901, et seq.

[17] This WRPS-authored model (see Section 4.2.1) currently focuses on the waste feed delivery systems and interactions with the WTP. The contractually required operations research model of the WTP, authored by Bechtel National, Inc., is a more detailed model that focuses only on WTP operating without tank farms interactions.

- Refining understanding of the solubility of aluminum and other key components in the tank waste to reduce the uncertainty with the amount of sodium that needs to be treated and the required capacities of supplemental treatment and pretreatment
- Completing the final waste determination of potential CH-TRU tank waste, and determining its final disposition to facilitate implementation of packaging operations.

Coda

The Baseline Case, together with due consideration of the key issues and uncertainties, provides the technical basis for changes to the PMB. Consistent with the emerging outcome of key decisions and risk mitigating activities, a future baseline might be synthesized using the best risk-mitigating features of the other scenarios explored in this System Plan.

Soon after WTP commissioning and until the late 2020s, SST retrievals are limited due to DST space availability. It is recognized that alternative strategies are needed to sustain SST retrievals at a stable pace to retain experience and operations proficiency, while reducing the predicted bow-wave later in the mission.

Over the next year, WRPS is scheduled to complete an equipment reliability, availability, and maintainability analysis of the integrated RPP flowsheet using the WRPS operations research model. The results of this study will identify equipment pinch-points and operational limitations that will need to be addressed to ensure a successful mission. The flowsheet modeling and analysis to-date assumes that the project will achieve a significantly increased pace of operations (over six times the current SST retrieval activity and over eight times the current DST transfer activity) that does not exist today.

Over the next six years, and prior to WTP operations, the infrastructure projects and operational improvements must be implemented to support successful execution of the System Plan. Without these improvements, there is considerable risk to completing the treatment of all tank waste by the dates reflected in this System Plan (2043).

An area for focus in a future revision of the System Plan will be to account for equipment and operational limitations that can be expected during the tank farms waste retrieval, feed delivery, and WTP pretreatment operations. Currently, the System Plan assumes that many of these systems are available upon demand, without impacts from equipment failures or lack of availability, staff availability, or abnormal field and weather conditions. Experience has shown that SST retrievals present unique challenges that cannot always be foreseen. This experience provides the basis for determining the required performance of SST retrievals, and as experience is gained with new retrieval technologies, adjustments will be made to reflect the lessons learned.

This version of the System Plan incorporates the design and limited operational changes to the WTP that have been developed thus far to address the performance of mixing systems in the WTP PT Facility. As the WTP documented safety analysis is finalized and the operational strategy is fully developed, additional controls may be put in place that could impact the mission.

Future System Plans will take these risks and opportunities into consideration. The overall goal is to identify and implement the necessary systems and programs required to achieve all of the TPA and Consent Decree commitments at the lowest technical and programmatic risk, while protecting the public and the environment.

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TERMS

ALARA	as low as reasonably achievable
AMS	articulating mast system
ARRA	*American Recovery and Reinvestment Act of 2009*
ATL	Advanced Technologies and Laboratories International, Inc.
BBI	Best-Basis Inventory
BCR	baseline change request
BDGRE	buoyant displacement gas release event
BNI	Bechtel National, Inc.
BOF	balance of facilities
CD	critical decision
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CH-TRU	contact-handled transuranic
CLIN	contract line item number
CSL	criticality safety limit
CWC	Central Waste Complex
CXP	cesium ion-exchange process
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DSA	documented safety analysis
DST	double-shell tank
Ecology	Washington State Department of Ecology
EFRT	External Flowsheet Review Team
EIS	environmental impact statement
EM	U.S. Department of Energy, Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FBSR	fluidized bed steam reforming
FCCF	Feed Characterization and Certification Facility
FY	fiscal year
G	Guide
GCS	gas characterization system
GFM	glass formulation model
HAMTC	Hanford Atomic Metal Trades Council
HEPA	high-efficiency particulate air

HFFACO	Hanford Federal Facility Agreement and Consent Order
HGR	hydrogen generation rate
HLW	high-level waste
HSF	Hanford Shipping Facility
HTRH	hard-to-remove heel
HTWOS	Hanford Tank Waste Operations Simulator
HVAC	heating, ventilation, and air conditioning
ICD	interface control document
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
IHS	interim Hanford storage
ILAW	immobilized low-activity waste
IMUST	inactive miscellaneous underground storage tank
IX	ion exchange
LAW	low-activity waste
LCM	life-cycle cost model
LERF	Liquid Effluent Retention Facility
LiHT	lithium hydrotalcite
LLW	low-level waste
M	Manual
MAR	mission analysis report
MARS	mobile arm retrieval system
MTG	metric ton of glass
MUST	miscellaneous underground storage tank
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
O	Order
OB/ND	optical basicity/nepheline discriminator
OCRWM	Office of Civilian Radioactive Waste Management
OR	operations research
ORP	U.S. Department of Energy, Office of River Protection
PA	performance assessment
PMB	performance measurement baseline
PMR	permit modification request
PNNL	Pacific Northwest National Laboratory
PT	pretreatment
PUREX	Plutonium-Uranium Extraction (Plant)

RA	Recovery Act (also referred to as ARRA)
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
REDOX	Reduction-Oxidation (Plant)
RL	U.S. Department of Energy, Richland Operations Office
RMF	rotary microfiltration
RMP	risk management plan
ROD	Record of Decision
RPP	River Protection Project
SALDS	State-Approved Land Disposal Site
SBS	submerged bed scrubber
SCIX	small-column ion exchange
SHMS	standard hydrogen monitoring system
SpG	specific gravity
SST	single-shell tank
SSTIP	single-shell tank integrity project
TC & WM	Tank Closure and Waste Management
TEDF	Treated Effluent Disposal Facility
TOC	Tank Operations Contract
TOE	total operating efficiency
TPA	Tri-Party Agreement
TRL	technology readiness level
TRU	transuranic
TWINS	Tank Waste Information Network System
TWRS	tank waste remediation system
WBS	work breakdown structure
WD	waste determination
WESF	Waste Encapsulation and Storage Facility
WFD	waste feed delivery
WFE	wiped-film evaporator
WIPP	Waste Isolation Pilot Plant
WIR	waste incidental to reprocessing
WMA	waste management area
WMA C	Waste Management Area C
WOL	waste oxide loading
WRF	waste retrieval facility
WRPS	Washington River Protection Solutions, LLC
WTP	Waste Treatment and Immobilization Plant

1.0 INTRODUCTION

At the Hanford Site, 55 million gallons of nuclear waste are stored in aging underground tanks, threatening the Columbia River.

One of the world's largest environmental cleanup projects is underway at the Hanford Site in Washington State. A fully integrated system of waste storage, treatment, and disposal facilities is in varying stages of design, construction, operation, or future planning. These facilities are needed to complete the U.S. Department of Energy's (DOE) mission to protect the Columbia River, the largest river system in the Pacific Northwest. Many challenges must be met to achieve site cleanup and closure.[18]

DOE has two federal offices at Hanford—the DOE Office of River Protection (ORP), which is responsible for cleanup of Hanford Site tank waste, and the DOE Richland Operations Office (RL), which is responsible for nuclear waste and facility cleanup, and overall management of the Hanford Site. Each DOE office oversees separate contracts held by various government contractors.

1.1 HANFORD SITE BACKGROUND

The 586-mi^2 Hanford Site is located along the Columbia River in southeastern Washington State (Figure 1-1) and is home to the world's first plutonium production complex. Beginning with the Manhattan Project and throughout the Cold War, Hanford played a pivotal role in providing nuclear materials for the nation's defense program. However, more than 40 years of plutonium production also yielded a challenging nuclear waste legacy—approximately 55 million gallons (Mgal) of radioactive and chemically hazardous wastes are stored in 177 underground tanks located on Hanford's Central Plateau. Of the 177 tanks, seven tanks have been retrieved, three have been retrieved to the limits of technology, and two are currently in retrieval status.

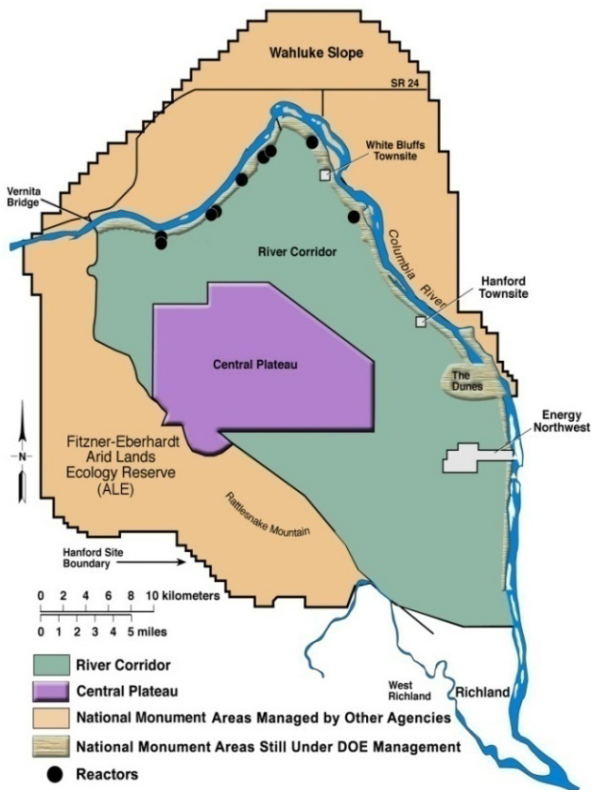


Figure 1-1. Hanford Site Map

The waste composition varies widely, necessitating a variety of unique waste retrieval and treatment methods. In addition, 149 of these tanks are decades past their design life. Some tanks are known or are assumed to have leaked, contaminating the soil and groundwater;

[18] Selected terms are hyperlinked to definitions provided in the Glossary in Appendix A.

the contamination from this and other sources is progressing towards the Columbia River. Today, under the direction of DOE, Hanford contractors are performing one of the world's largest environmental cleanup projects and face many overlapping technical, regulatory, and financial challenges.

1.2 RIVER PROTECTION PROJECT SYSTEM PLAN PURPOSE

The successful management of the River Protection Project (RPP) by ORP requires:

- Careful coordination of multiple government contractors that are responsible for the design, construction, operation, and maintenance of the RPP facilities and support services
- Integration with the Plateau Remediation Contractor and the Mission Support Contractor under RL
- Regulatory administration and oversight by the Washington State Department of Ecology (Ecology) and U.S. Environmental Protection Agency (EPA)
- Assuring transparency with stakeholders, including the Hanford Advisory Board, Indian Nations, and general public.

The primary purpose of this document, hereinafter referred to as the System Plan (Rev. 6), is to provide a basis, in the form of an operating scenario, for the alignment of program costs, scope, and schedules from upper-tier contracts to individual facility operating plans. The current operating scenario is hereinafter referred to as the Baseline Case. System Plan (Rev. 6) also serves to define the issues that must be resolved by ORP to ensure the success of the cleanup mission. Mitigating actions and plans to address these issues, including a summary of selected technology development initiatives, are also included in this plan. It is important to note that strategic planning is ongoing; therefore, the System Plan will be revised periodically to reflect recent progress, current plans, responses to emergent issues, changes in the regulatory environment, and budgeting constraints.

This particular revision of the System Plan also serves a secondary purpose, to explore selected operating scenarios in support of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO, Ecology et al. 1989) milestone M-062-40. In accordance with this milestone, ten cases (including the Baseline Case and nine alternatives) were jointly defined by DOE and Ecology, and modeled in the Hanford Tank Waste Operations Simulator (HTWOS). The results of these model runs are documented in this System Plan. Additional details are provided in Section 1.3, "Success Criteria;" Section 1.9, "Scenarios;" Section 2.2, "RCRA, CERCLA, and Hanford Federal Facility Agreement and Consent Order;" Section 10.0, "Selected Scenarios," and Appendix B, "Key Assumptions and Success Criteria."

1.3 SUCCESS CRITERIA

Success criteria are metrics that are used to determine how well a scenario meets overall mission goals or requirements. For System Plan (Rev. 6), the success criteria comprise schedule- and cost-based metrics (see Appendix B, Section B2.0, "Success Criteria"). The cost-based success criteria also include near-term funding targets, which are addressed in Section 5.3, "Highlights," for the System Plan (Rev. 6) Baseline Case and in Sections 10.x.4, "Cost and Schedule Impacts," for each of the other scenarios (where x represents the case number).

Table 1-1 compares the System Plan (Rev. 5) Baseline Case, the System Plan (Rev. 6) Baseline Case, and the other System Plan (Rev. 6) cases in terms of the success criteria and other important quantities.

Although each case is intended to meet the success criteria, there is no guarantee that each criterion will be met. During system analysis, the timing of certain activities, assumed facility capacities, or other process variables in the System Plan (Rev. 6) Baseline Case may be shifted as needed to satisfy the success criteria, even if this requires deviation from other programmatic assumptions, including deviating from the funding guidance. However the assumptions for Cases 2 – 10 were not adjusted when the results did not meet the success criteria, since the intended purpose of Cases 2 – 10 was to identify impacts of the specified changes to Baseline Case assumptions.

The success criteria that were used in the development of previous System Plan revisions (Rev. 4 and 5) originated as proposed milestones that were included in a draft Consent Decree and HFFACO change package associated with litigation that was still pending at that time. To support planning in the interim, DOE adopted some of those proposed milestones as proxies for approved milestones. Upon resolution of the litigation,[19] the proposed dates were approved, thereby establishing new milestones. These milestones were subsequently incorporated into the Tank Operations Contract (TOC) performance measurement baseline (PMB) and System Plan (Rev. 6).

[19] The finalized Consent Decree in *State of Washington v. DOE*, Case No. 08-5085-FVS, was entered into the U.S. District Court for the Eastern District of Washington on October 25, 2010. By agreement of the parties, the related HFFACO change package became effective on that date.

Table 1-1. System Plan (Rev. 6) Highlights

Metric (milestone)	Success criteria	System Plan (Rev. 5): Baseline Case	System Plan (Rev. 6)									
			Case 1: Baseline Case	Case 2: TRU waste to WTP	Case 3: FBSR for supplemental treatment	Case 4: WTP delay with increased vitrification	Case 5: 2020 Vision One System	Case 6: WTP delay with new DST farm	Case 7: Enhanced tank waste strategy	Case 8: Accelerated retrieval	Case 9: Early U Farm closure	Case 10: Slow SST retrievals
Life-cycle cost, FY 1997 to end of mission	$61.5 B	–	$59.9 B	**$61.6 B**	$58.1 B	**$66.0 B**	$58.0 B	$68.7 B	$57.3 B	$62.8 B	$59.6 B	$60.8 B
Meets near-term funding targets through 2015	$2,750M	–	$2,440 M	$2,400 M	**$3,226 M**	$2,314 M	$2,705 M	$2,450 M	**$3,377 M**	$2,413 M	$2,442 M	$2,439 M
Meets near-term funding profile through 2015	Note a	–	✓	✓	X	✓	✶	✓	X	✓	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	7/13/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	12/21/2013	1/23/2014
Start five additional SST retrievals (B-3)	12/31/2017	2/9/2015	7/23/2017	7/23/2017	9/16/2017	7/2017	**9/9/2018**	7/23/2017	9/16/2017	7/23/2017	5/21/2017	7/27/2017
Close WMA C (M-045-83)	6/30/2019	6/28/2019	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	9/20/2017	12/16/2020	12/16/2020	11/4/2019	**7/17/2024**	4/21/2020	8/25/2021	10/24/2019	12/16/2020	8/15/2020	1/17/2021
Complete all SST retrievals (M-045-70)	12/31/2040	10/13/2039	9/8/2039	9/25/2040	11/3/2038	**8/14/2043**	9/14/2038	**7/24/2042**	9/9/2037	3/27/2040	9/7/2038	10/4/2040
Close all SSTs (M-045-00)	1/31/2043	**9/29/2043**	**10/5/2043**	**10/20/2044**	12/2/2042	**9/11/2047**	10/9/2042	**8/20/2046**	10/4/2041	**4/21/2044**	10/2/2042	**10/31/2044**
Treat all tank waste (M-062-00)	12/31/2047	8/26/2045	4/23/2043	5/13/2044	8/13/2041	3/27/2046	8/26/2041	3/16/2047	10/4/2039	6/7/2045	1/17/2043	10/16/2043
Close all DSTs (M-042-00A)	9/30/2052	9/15/2049	3/18/2048	6/1/2049	8/7/2046	2/17/2051	7/30/2046	3/21/2052	12/18/2045	5/31/2050	1/17/2048	10/22/2048
Complete potential TRU tank waste packaging	–	6/26/2023	7/13/2023	–	7/13/2023	7/13/2023	7/13/2023	7/13/2023	7/13/2023	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	33,654	31,968	34,884	31,056	31,512	30,721	31,304	28,205	37,137	31,875	31,995
HLW glass canisters	–	10,713	10,586	11,552	10,284	10,435	10,173	10,366	9,340	12,298	10,555	10,595
HLW glass waste oxide loading	–	37.6%	36.9%	35.3%	37.8%	37.7%	38.4%	38.3%	41.2%	36.3%	36.6%	37.0%
LAW glass mass (MTG)	–	415,430	527,838	533,110	152,045	523,479	520,966	525,433	0	527,819	526,269	523,693
LAW glass containers	–	75,419	95,825	96,782	27,602	95,034	94,577	95,389	0	95,822	95,540	95,073
LAW glass sodium oxide loading	–	17.2%	17.8%	17.7%	19.92%	17.9%	18.0%	17.8%	0	17.9%	18.0%	17.9%
Sodium reporting to LAW glass (MT)	–	53,058	69,659	70,109	22,474	69,657	69,689	69,487	0	70,018	70,136	69,499
FBSR product (MT)	–	–	–	–	620,099	–	–	–	912,751	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–	–	46,380	–	–	–	68,507	–	–	–
LiHT by-product (MT)	–	20,201	–	–	–	–	–	–	–	–	–	–
Potential TRU tank waste drums	–	7,491	7,492	–	7,492	7,492	7,492	7,492	7,492	–	7,491	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. X – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric ton.
MTG = metric tons of glass.
SST = single-shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

1.4 PRIME CONTRACTS

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

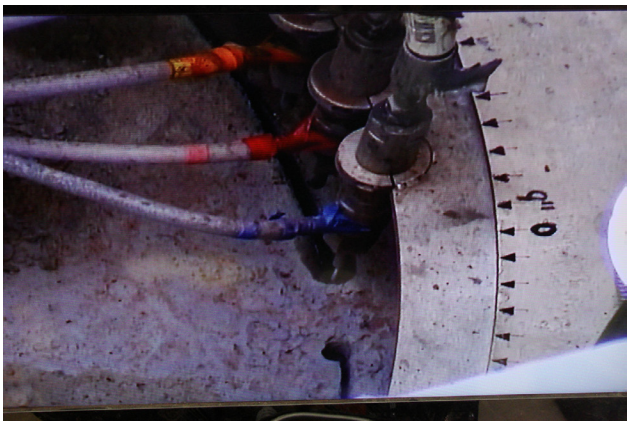
- The Tank Operations Contract (TOC) (DE-AC27-08RV14800), held by Washington River Protection Solutions, LLC (WRPS), includes the construction, operation, and maintenance activities necessary to store, retrieve, and transfer tank wastes; provide supplemental pretreatment for tank waste; provide treatment,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

1.5 RECENT ACCOMPLISHMENTS

A number of important advancements have recently been made in the tank farms, particularly in the single-shell tank (SST) C Farm:

- A 55-in. diameter hole was safely cut into the center of the concrete dome of Tank C-107, and a new riser and shield plug were installed in December 2010 (Figure 1-2). The successful completion of this task represented several important "firsts" for Hanford.
  - It was the first use of high-pressure water infused with fine-grit garnet to create an opening in a Hanford waste tank. Although this concrete-cutting technique is common in the construction industry, it had never been deployed in a waste tank environment before. Extensive preparations were conducted, including multiple rehearsals using a mock-up to ensure risks were minimized.
  - The 55-in. diameter hole is the largest ever cut into a Hanford waste tank.
  - A new 47-inch diameter riser was installed in the dome.
  - Ground-penetrating radar was used to locate the steel rebar embedded in the concrete dome. This data guided the placement of anchor bolts needed to support the weight of the shield plug during and after cutting.

  Some obsolete equipment from within and near the tank was also removed as part of this scope of work. A new, larger riser was needed to accommodate installation of the mobile arm retrieval system (MARS) to support waste retrieval (described in more detail below).



A 55-in. diameter hole was cut in the top of Tank C-107 through 15 in. of concrete and steel rebar.

A new 48-in. riser was installed in December 2010.

Figure 1-2. Cutting Tank C-107 Dome and Riser Installation

- Design and assembly of a deployable MARS unit was completed in early 2011. The design incorporates lessons learned from the full-scale demonstration of a MARS unit at the Cold Test Facility in 2010 (Figure 1-3). This transformational technology is expected to be able to access all areas inside the tank, including access around obstacles; it is also expected to be able to break up hardened waste heels, thus precluding the need to use separate equipment to finish waste retrieval in the tank. The first installation of a MARS unit in a waste tank was made in Tank C-107 in July 2011, with startup and testing planned for August and September 2011.
- Waste retrieval from Tank C-104, originally started in January 2010, succeeded in removing approximately 195 thousand gallons (kgal) (75 percent of the waste inventory) before being interrupted by a transfer pump failure in receipt Tank AN-101. That pump was replaced.

  Waste retrievals were set to resume when an obstruction was discovered directly below the variable-height slurry pump in Tank C-104. This prevented the pump from being lowered as needed to continue waste retrieval. The obstruction was determined to be a piece of obsolete equipment that had fallen to the bottom of the tank.

  To move the obstruction in Tank C-104, WRPS personnel modified the articulating mast system (AMS), an existing piece of hardware that was originally procured for other waste retrieval uses, and equipped it with a shovel-like device, two high-pressure water nozzles, and a forked plate. These modifications enabled the AMS to reach around the obstruction and move it out of the way.

Figure 1-3. Mobile Arm Retrieval System Testing at the Cold Test Facility

The modified AMS (Figure 1-4) was installed in Tank C-104 in November 2010, and was successfully operated in December 2010 to move the obstruction. Waste retrieval operations resumed briefly in February 2011, but were suspended because of an AN-101 supernate pump failure. The pump was replaced. Approximately 98 percent of the tank's waste was removed before retrieval was halted when the limit of technology was reached for the modified sluicing equipment.

Figure 1-4. Articulating Mast Retrieval System Installed in Tank C-104 to Remove Obstruction

- Efforts to retrieve the hard-to-remove heel in Tank C-108 are in progress. Sluicing equipment was deployed in Tank C-108, removing all but about 6,800 gal of waste.
- Bulk waste retrieval from Tank C-111 began with modified sluicing on September 15, 2010. However, this method proved to be ineffective, and had removed only about 300 gal of waste when retrieval operations were halted in November 2010, with approximately 32 kgal of waste remaining. Sampling of the remaining hard heel is scheduled to begin in November 2011.
- The Tank C-110 hard heel was sampled in 2010; a decision is pending on which technology to deploy for heel removal.
- Tank C-112 construction is in progress to install equipment necessary to perform waste retrieval starting in October 2011.

Significant progress has also been made in other areas:

- The 242-A Evaporator facility completed ten major upgrade projects in fiscal year (FY) 2010 and conducted two evaporator campaigns in September and October 2010 to reclaim approximately 480 kgal of space in the double-shell tank (DST) system.
- Tank operating specifications define the maximum fill level of each tank. The level-rise modification project field work was successfully completed in AP Farm. New instrumentation, including level detectors and leak detection systems, were installed in six of the eight DSTs in AP Farm. (The same work was previously completed for the first two tanks, AP-103 and AP-108.) The new instrumentation will allow AP Farm to safely store approximately 100 kgal of additional waste in each tank, for a total storage capacity increase of approximately 800 kgal. In-service leak checks are required to confirm proper operation at the higher inventory levels; tests for Tanks AP-104 and AP-105 are planned in FY 2011. Field tests for the remaining four tanks will be scheduled in the future.

- Remote visual inspections of 12 SSTs were completed in FY 2010; the structural integrity of all 12 tanks was deemed satisfactory. Additional details are provided in Section 3.1.1.
- In 2011, plans are being developed to obtain and test a vertical core from the entire depth of the sidewall of an SST. Additional details are provided in Section 3.1.1.
- SY Farm transfer line upgrades are in progress (Figure 1-5). Eight underground, pipe-in-pipe transfer lines that no longer meet regulatory requirements are being removed and replaced by four new lines and four refurbished lines. More than 700 linear feet of piping will be replaced. The non-compliant lines are being disposed of onsite at the Environmental Restoration Disposal Facility (ERDF). As of February 2011, six of the eight lines have been removed. The project is expected to be completed by the end of September 2011.

Figure 1-5. SN 280 Transfer Line Removed from SY Farm

- Installation of the TY Farm interim moisture barrier was completed in September 2010 (Figure 1-6). The barrier is made of high-density asphalt, and covers all six TY Farm tanks. The barrier is designed to prevent precipitation from percolating into the soil and potentially pushing contaminants further into the soil or the water table. Instead, precipitation collected on the barrier is directed outside the farm to an evaporation basin, which is lined with a geo-membrane to prevent leaks. The basin was filled with soil and planted with native grasses to take up moisture. Monitoring of the completed barrier during the first three months after it was installed revealed that the barrier succeeded in redirecting approximately 215 kgal of runoff away from the farm. The TY Farm barrier is the second of six planned; the first was installed in T Farm in 2008.

Figure 1-6. TY Farm Interim Barrier with Well Covers in Place

- *American Recovery and Reinvestment Act of 2009* (ARRA) funds totaling $326 million were allocated to ORP and WRPS to improve facilities that handle liquid waste. Thirty separate projects were undertaken to improve a variety of tank farm facilities and infrastructure systems. Six ARRA projects have been completed; the rest will finish in FY 2011. Additional details are provided in Section 3.1.9.

- Vadose zone program activities have been focused on (1) supporting Waste Management Area[20] C (WMA C), (2) improving soil characterization data for a number of WMAs, and (3) supporting placement of interim surface barriers. Additionally, significant technology development and field implementation efforts, particularly with regard to direct-push boreholes and surface geophysical exploration, are in progress.
- The 222-S Laboratory provides support to the tank farms for routine operations and for technology development needs. The facility is also undergoing extensive upgrades to improve its ability to support the additional needs projected for tank farms operations over the next several decades as tank waste characterization, retrievals, and feed preparation activities increase.

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

1.6 RECENT PLANNING IMPROVEMENTS

Long-range planning for the Waste Treatment Complex is a multifaceted, iterative process. Each revision of the System Plan builds on the best strategies identified in previous plans, thereby increasing planning confidence. Several important planning improvements identified during or after the development of System Plan (Rev. 5) have been incorporated in the planning basis for the Revision 6 Baseline Case.

- The overall configuration of the RPP system has been updated to reflect current plans, as depicted in Figure 1-7. In accordance with DOE direction (Triay 2010), the Aluminum Removal Facility has been removed.
- The System Plan is integrated with three key RPP documents. These documents were updated as part of the System Plan (Rev. 6) effort:
  - RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*, provides the strategy for removing radioactive and chemical wastes from the SSTs. This document includes the basis for detailed SST retrieval assumptions, waste volumes and durations for each tank, and a logical methodology for selecting the best waste retrieval process for deployment in a given SST, based on the tank's structural integrity, design attributes, and other considerations. This System Plan is integrated with RPP-PLAN-40145.[21] Additional details are provided in Section 3.1.1.

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

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

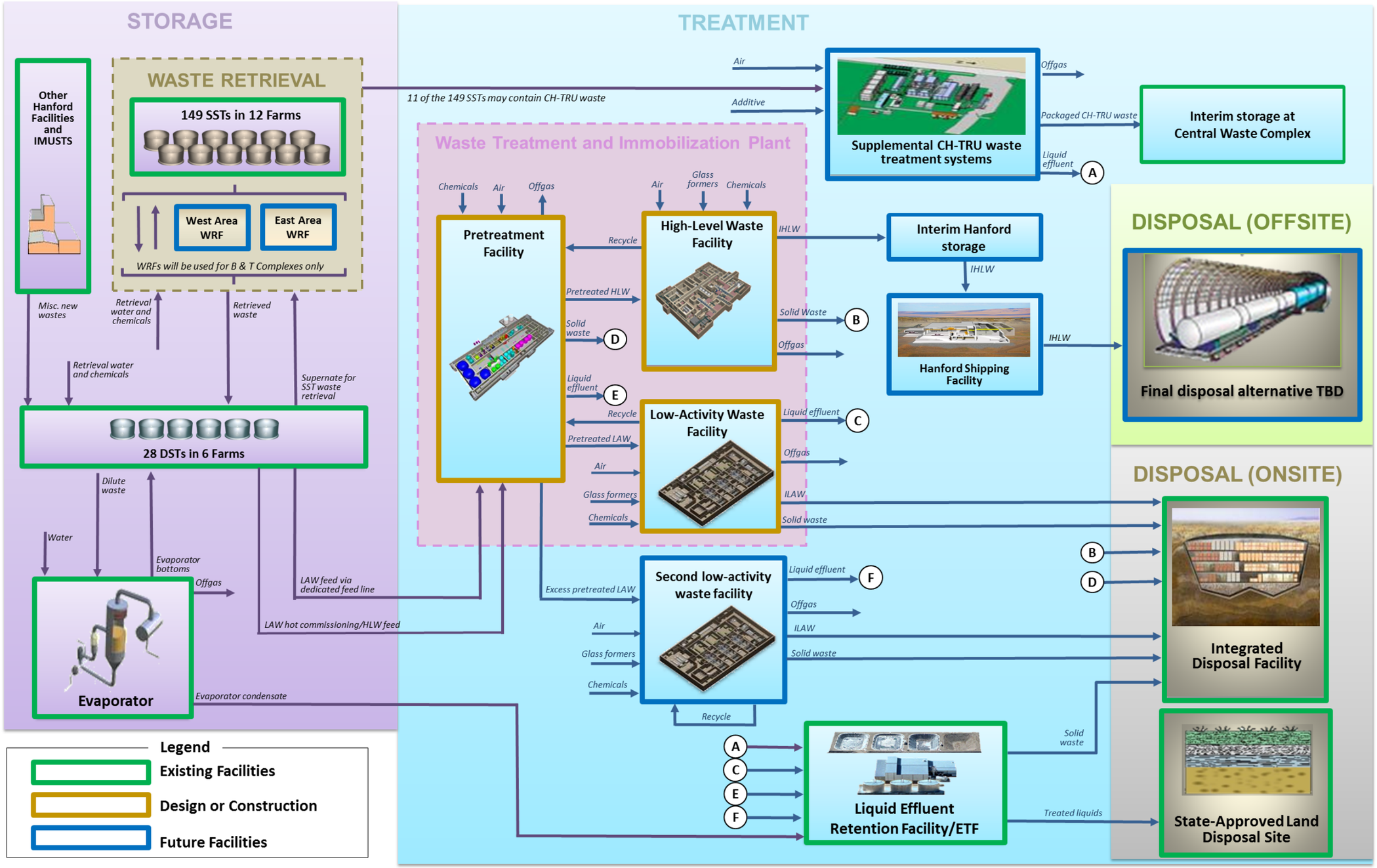


Figure 1-7. Simplified Process Flow Diagram

- RPP 40149, *Integrated Waste Feed Delivery Plan*, Volumes 1 and 2:
  - RPP-40149-VOL1, *Integrated Waste Feed Delivery Plan: Volume 1 – Strategy*, defines the strategy to provide optimized and reliable feed of retrieved waste from the tank farms to the WTP or other treatment facilities. RPP-40149-VOL1 provides an integrated systems approach to waste retrieval, treatment, and delivery, consistent with the hardware baseline established in RPP-PLAN-50117, *Waste Feed Delivery Projects Plan*, in which existing DST farm conditions were evaluated to document the current status of site infrastructure and storage/retrieval systems. This System Plan is integrated with RPP-40149. Additional details are provided in Sections 3.1.2 and 5.5.2.2.
  - RPP-40149-VOL2, *Integrated Waste Feed Delivery Plan: Volume 2 – Campaign Plan*, provides more detailed plans for the first seven campaigns for delivery of feed to the WTP, evaluates the projected feed for the entire mission for systematic issues, and identifies future refinements.

- TFC-PLN-39, *Risk Management Plan* (RMP), describes the systematic process used by WRPS to assess and manage project risks within the RPP program. This RMP supports prudent and effective project management through minimization of risk and maximization of opportunities inherent in the TOC life-cycle scope, schedule, and cost baseline. The RMP quantifies the schedule and cost uncertainties for the baseline based on a probabilistic evaluation of residual risks after mitigation. Risks and opportunities currently associated with the RPP program are addressed in this System Plan. For each risk or opportunity identified, attendant assumptions, issues and uncertainties, and potential mitigating actions are also articulated. The next revisions of the RMP will first bring it into alignment with System Plan (Rev. 5) and then incorporate the results of the System Plan (Rev. 6). Additional details are provided in Section 7.0.
- The HTWOS model was significantly upgraded and the model improvements are reflected in this System Plan. Additional details are provided in Section 4.1.1. Improvements include:
  - SST waste retrieval plans were aligned[22] with RPP-PLAN-40145 and SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3D.xlsx'."
  - DST functions were aligned[22] with RPP-40149 and anticipated field constraints and improvements. RPP-40149 was developed and is expected to be issued in parallel with the System Plan (Rev. 6).
  - The 242-A Evaporator campaign logic was improved.

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

- Several new facilities and technologies were added to the HTWOS model to facilitate the evaluation of proposed additions or changes to the RPP mission, including construction of a dedicated LAW feed delivery line to WTP, a feed characterization and certification facility, supplemental pretreatment in the form of rotary microfiltration (RMF) and small-column ion exchange (SCIX), supplemental treatment in the form of fluidized bed steam reforming (FBSR), and a new DST farm.
- The waste treatment processing facility flowsheet used by HTWOS was updated to more closely align with the current WTP facility design and operating modes, including the WTP Pretreatment (PT) Facility equipment alternative.
- The 2009 glass formulation model (GFM) was augmented by the optical basicity/nepheline discriminator (OB/ND) GFM to optionally allow for enhanced formulation of HLW glass. In System Plan (Rev. 6), the 2009 GFM for HLW was used for all cases except Case 7, which used the OB/ND model for HLW glass. The DOE 2004 GFM was used for LAW in all System Plan (Rev. 6) cases.

- A new life-cycle cost model (LCM) is being developed to support the near-term and life-cycle cost impacts of proposed operational and flowsheet changes within the RPP system. The new LCM was used to develop the cost profiles for Cases 2 – 10.
- During the development of System Plan (Rev. 6), additional RPP documents have been revised or newly created as part of a systems engineering approach to mission planning. These documents include, but are not limited to:
  - RPP–RPT-41742, *River Protection Project Mission Analysis Report* (MAR) – Defines the mission objectives, identifies the top-level functions needed to accomplish the mission, and specifies the requirements that must be met to achieve those functions.
  - RPP-46506, *Decision Framework – Key Decisions Required to Achieve the RPP Mission* – Developed to document the technical decisions that must be made and the projects that must be executed to meet program schedules and HFFACO milestones. This document will be updated as the RPP mission evolves, decisions are made, and the need for new decisions emerges. The role of RPP-46506 in the system planning process is discussed in Sections 1.8 and 8.0.
  - RPP-PLAN-43988, *WRPS Technology Development Roadmap* – Identifies technology gaps in the RPP system and highlights ongoing technology development activities that have been undertaken to close those gaps, including initiatives that may, if successful, accelerate RPP mission completion. A listing of select technologies is provided in Section 6.0.

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

1.7 CONVENTIONS

This section explains the more important conventions used in this System Plan and considerations in interpreting results.

1.7.1 Reference Dates

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

- ORP approved the key assumptions and success criteria (Appendix B) on February 1, 2011 (Fletcher 2011a) and the System Plan annotated outline on February 11, 2011 (Fletcher 2011b). ORP approved the revised assumptions on May 16, 2011 (Fletcher 2011c).
- February 1, 2011 is the demarcation between completed[23] historical and projected activities in the System Plan (Rev. 6).
- The starting point for cost and schedule estimates and scope is the PMB as of March 27, 2011 (the end of fiscal March 2011).
- The description of the RPP system status is current as of February 1, 2011.
- October 1, 2010 is the effective date for the current inventory of tank waste (RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operations Simulator Model – 2011 Update*).
- The status (integrity and contents) of the waste tanks is current as of September 2010 (HNF-EP-0182, *Waste Tank Summary Report for Month Ending September 30, 2010*, Rev. 270).
- The decay date for reporting radionuclides is January 1, 2008, unless stated otherwise.

1.7.2 Scenario Optimization

The Baseline Case is optimized in the sense that it has undergone successive refinements over several years with the goal of meeting the success criteria, supporting near-term operational needs, and reducing overall technical and programmatic risk. Refinements reflect the year-to-year evolution of assumptions and for this specific System Plan, the adjustments to the SST retrieval sequence and waste feed delivery (WFD) strategy, both within the degrees of freedom afforded by the approved assumptions.

It was recognized, while framing the scenarios to be evaluated against the Baseline Case in this System Plan, that these scenarios would not be optimized to the same degree as the Baseline Case, although the use of the DSTs was debottlenecked to the extent possible within the time allocated for preparation of this document. The technical evaluation of the scenarios has provided the opportunity for significant insight into the behavior of the RPP mission through comparison of assumptions, results, and issues for selected mission scenarios.

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

1.7.3 Reporting

In Appendix B, the general convention is to use the same units and precision as the source documents. This is done to improve traceability and to avoid unnecessary propagation of rounding errors.

In the rest of the document, results are reported to "full" precision, generally to the nearest day for calendar events, nearest $100,000 for costs, and to the nearest whole unit for other quantities (metric ton [MT] or metric ton 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 HTWOS and LCM model results, spreadsheets, figures, tables, and text.

The reported precision does not reflect the underlying accuracy or uncertainties in technical and programmatic assumptions and modeling methodology. As a result, an activity is underway to examine the sensitivity of mission metrics, as estimated by HTWOS, to various input assumptions. Because system modeling is a continuous improvement activity, results of this effort may be applied in future HTWOS improvements or interpretation of scenario results.

1.8 SYSTEM PLANNING PROCESS

Revisions of the System Plan are closely linked to revisions of the TOC PMB (Figure 1-8). At the outset of developing each new System Plan, planning guidance and direction from ORP are incorporated into the key assumptions for the new Baseline Case. Upon ORP approval of the assumptions, the scope of the System Plan is defined. Integration with other key documents and HTWOS modeling and analysis begin.

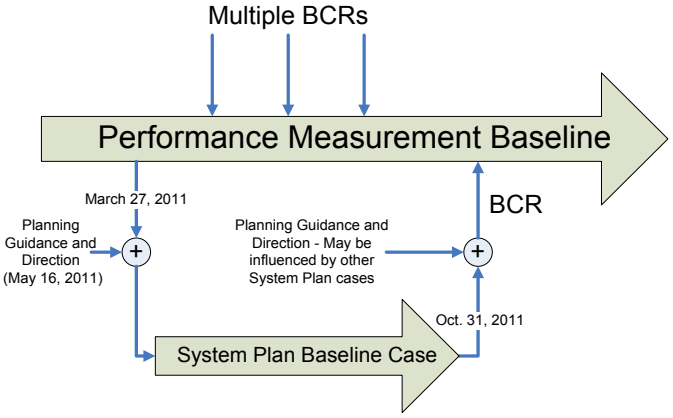


Figure 1-8. System Plan Supports Performance Measurement Baseline

In the meantime, other baseline change requests (BCR) may be proposed, approved, and incorporated in the PMB. However, these BCRs *do not* impact the ongoing system planning effort currently underway.

Upon completion of the current System Plan, Baseline Case results are reviewed. These results, along with emergent planning guidance and direction related to funding, schedule, or other matters, are captured in one or more new BCRs for incorporation into the PMB. Subsequently, other BCRs also may be incorporated in the PMB until the completion of this iteration of the System Plan, at which point the entire cycle starts over. In this way, alignment between the PMB and the System Plan is maintained.

Figure 1-9 and Figure 1-10 take a closer look at what goes into the System Plan Baseline Case as described in Figure 1-8. Figure 1-9 illustrates the information flow of the System Plan, showing only the flow of information into and through the document; it does not show the feedback and iteration that takes place throughout document preparation.

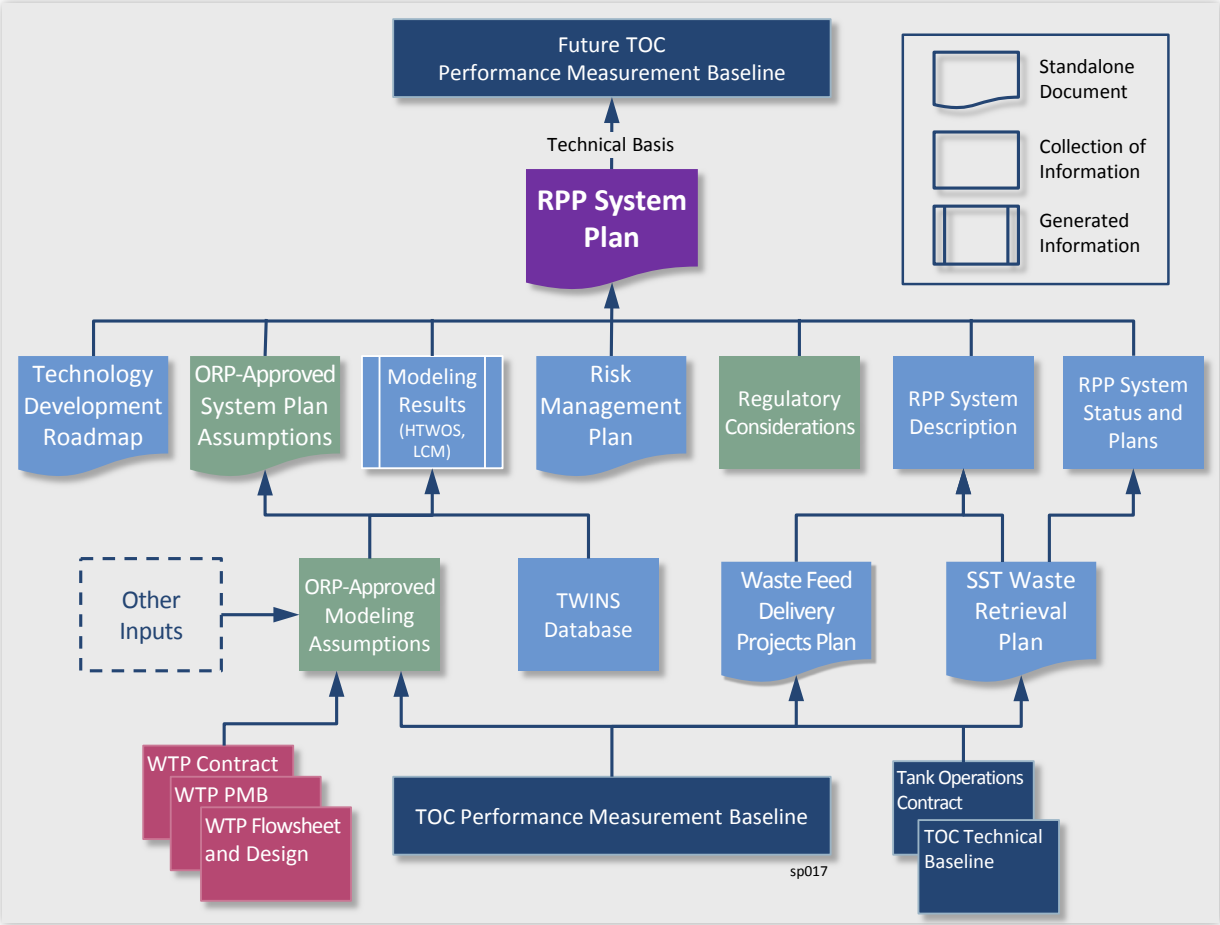


Figure 1-9. River Protection Project System Planning

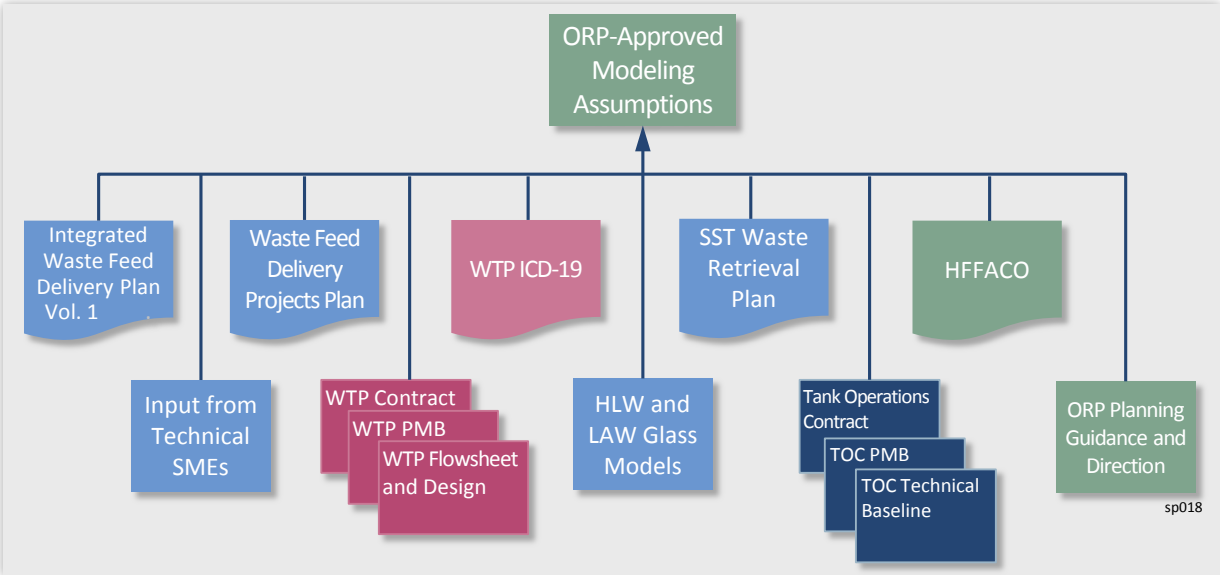


Figure 1-10. System Plan Modeling Assumptions

Inputs are broken down into three groups: (1) standalone documents, (2) information collected from several sources, and (3) generated information. Each of these groups is represented by a different shape on the diagram. Figure 1-10 takes a similar approach to focus on the ORP-approved modeling assumptions, as they are a major contributor to the System Plan. Within this section, terms in **bold** refer to items shown on the figure.

Beginning at the bottom of Figure 1-9 and moving upwards provides a generalized flow of information into the System Plan and on to future revisions of the PMB. Through the **WTP Contract** and **Tank Operations Contract**, ORP establishes its expectations for the contractor to provide safe, compliant, cost-effective, and energy-efficient services for a specific scope of work. At Hanford, this scope includes the storage, retrieval, and treatment of tank wastes; storage and disposal of treated wastes; and closure of tank farm WMAs to protect the Columbia River. The ORP contractors each prepare and maintain a PMB (the **WTP PMB** and **TOC PMB**) to align the cost, scope, and schedule of the work to be completed.

The **WTP Flowsheet and Design** describes the process that will take place within the facilities currently under construction, and the **TOC Technical Baseline** describes the current and planned technical operations in the tank farms. All of these sources of information feed into other documents such as the **SST Retrieval Plan**, the **Waste Feed Delivery Projects Plan** (previously the Integrated Waste Feed Delivery Plan), and the **ORP-Approved Modeling Assumptions**.

The **ORP-Approved Modeling Assumptions** identify the inputs for the modeling efforts related to the System Plan. The assumptions were created based on input from several sources in addition to the sources stated previously (shown in Figure 1-10) and will be explained later in this section. The Tank Waste Information Network System (**TWINS**) **Database** is comprised of waste characterization data taken from the Best-Basis Inventory (BBI),[24] which is the preferred database for waste characterization at Hanford, including wash and leach factors and other supplemental characterization data. The approved modeling assumptions and the **TWINS Database** information flow up into the modeling tools used for system planning, HTWOS and the LCM, and the program integration aspects of the System Plan.

The **Waste Feed Delivery Projects Plan** and the **SST Retrieval Plan** are sources of information for the **RPP System Description**, which provides a description of the RPP system as a whole, and the **RPP System Status and Plans**, which provides information to the System Plan about the current state of the RPP facilities.

There are several primary sources of input into the System Plan, as indicated by Figure 1-9. Some of the inputs are standalone documents; others are collections of information, both preexisting and generated, that are brought together for the purpose of the System Plan. Brief descriptions of each of these inputs are as follows.

- **Technology Development Roadmap** – Outlines the methods required to meet the mission schedule and success criteria dates, and discusses strategies that are being investigated to accelerate mission completion.

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

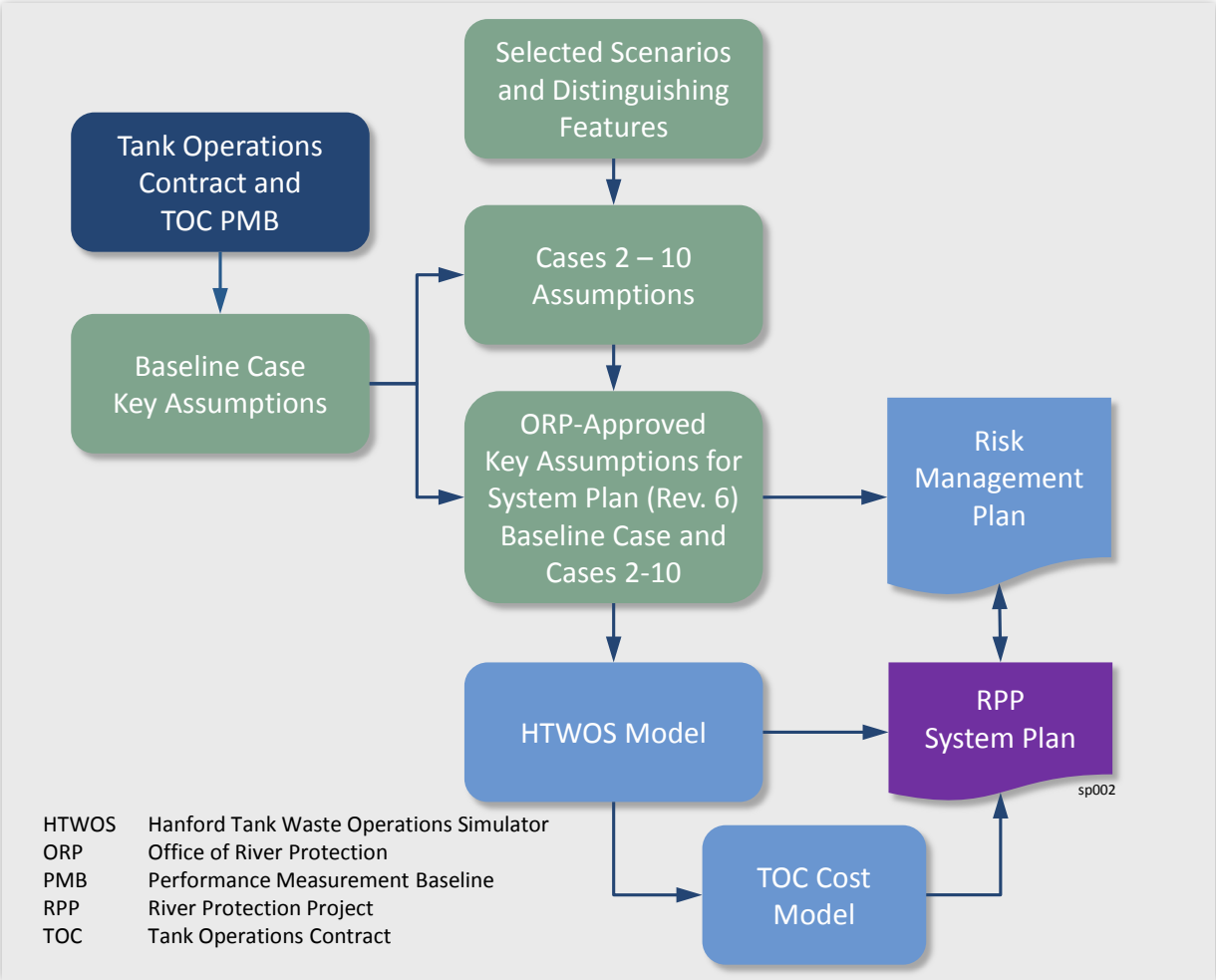
- **ORP-Approved System Plan Assumptions** – Provide direct ORP input to system planning via their formal approval (Fletcher 2011a and 2011c) of the key assumptions and success criteria; these assumptions are formulated prior to this System Plan revision and included in the modeling.
- **Modeling Results** – Provide the HTWOS and the LCM results that are generated, collected, analyzed, and interpreted for presentation within the System Plan.
- **Risk Management Plan** – Includes the results of a risk assessment associated with the TOC PMB.
- **Regulatory Considerations** – Provide a collection of specific regulations and DOE Orders that play key roles in determining the actions DOE will pursue.
- **RPP System Description** – Provides a description of the purpose and history of the RPP system.
- **RPP System Status and Plans** – Present current events, recent accomplishments, and future plans of the RPP system.

Upon completion, the System Plan provides the technical basis for future changes to the TOC PMB.

Figure 1-10 further identifies the inputs in the **ORP-Approved Modeling Assumptions**; the list is not all inclusive but does represent the major inputs. The inputs to these assumptions not discussed previously are as follows:

- **WTP ICD-19** (24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed*) – Establishes interface requirements for the delivery of feed from the tank farms to the WTP.
- **Integrated Waste Feed Delivery Plan Vol. 1** – Defines how the DSTs will be used to stage and deliver feed to the WTP.
- **HFFACO** – Provides success criteria for the completion of the RPP mission.
- **HLW and LAW Glass Models** – Provide the methodology for selecting the chemical components that need to be added to a waste stream to make a suitable glass based on the waste stream composition.
- **Input from Technical Subject Matter Experts** – Provide input regarding current project status and plans affecting the modeled systems.
- **ORP Planning Guidance and Direction** – Provide input that reflects current programmatic and budgetary expectations.

A similar, but simplified, version of this planning process was implemented to evaluate the nine additional cases developed in support of HFFACO Milestone M-062-40, as depicted in Figure 1-11.



The planning process used for Baseline Case was simplified and adapted to reflect the unique characteristics of Cases 2 – 10.

Figure 1-11. River Protection Project System Planning (Non-Baseline Scope)

For Cases 2 – 10, the **Baseline Case Key Assumptions** were used in conjunction with the **Selected Scenarios and Distinguishing Features** of each case to develop **Cases 2 – 10 Assumptions.** The Baseline Case key assumptions were assumed to apply to all cases, except as noted in the case-specific subsections of Appendix B, to accommodate the unique features of each case. This approach produces a reasonably consistent basis for later comparison of the results of each case relative to the Baseline Case. ORP approved the key assumptions for both the Baseline Case and Cases 2 – 10 in a single transmittal (Fletcher 2011a).[25] The assumptions were then incorporated in the HTWOS model. Technical results produced by HTWOS are reflected directly in the System Plan. Schedule results produced by HTWOS are further evaluated in the TOC cost model to calculate expected life-cycle costs for all cases, which are also reflected in this System Plan. The System Plan also has an iterative relationship with the RMP (TFC-PLN-39), in that risks already identified in the RMP are addressed in the System Plan and evaluation of new cases may provide insight into new risks, which are then reflected in the RMP.

[25] Revised key assumptions were approved by ORP on May 16, 2011 (Fletcher 2011c).

The contents of this System Plan reflect the input of ORP, Ecology, WRPS, and BNI. A series of meetings were held in which ORP and Ecology selected the scenarios to be evaluated in support of HFFACO milestone M-062-40 (RPP-48228, *Selected Scenarios for RPP System Plan, Revision 6*). Separate meetings with ORP were used to frame the scope of the Baseline Case and to establish the ORP-approved key assumptions and success criteria (Appendix B). WRPS had the overall lead in preparation of the System Plan, which includes performing the mission modeling, developing more detailed tank farms planning assumptions, and integrating the Baseline Case with the SST Waste Retrieval Plan (RPP-PLAN-40145) and associated spreadsheet (SVF-1647), Integrated WFD Plan (RPP-40149), RMP (TFC-PLN-39), Decision Framework (RPP-46506), and the life-cycle PMB. In accordance with ORP direction, key features of the process flowsheet and modeling assumptions for the WTP and certain feed screening criteria developed by BNI were adopted, as were the WTP facility status updates.

1.9 SCENARIOS

During the period of July 28 to October 27, 2010, key personnel from ORP and Ecology, supported by WRPS, met numerous times to discuss the scenarios to be selected for evaluation under HFFACO milestone M-062-40, which states, in part:

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

On October 27, 2010, ORP and Ecology decided to model the five highest priority scenarios as selected by each agency[26] for the System Plan (Rev. 6), for a total of ten cases. Figure 1-12 illustrates the relationships among the ten scenarios; Cases 2 – 7, 9, and 10 are all variations of the Baseline Case; Case 8 is a variation of Case 2. Additional details describing the scope of the Baseline Case and Cases 2 - 10 are summarized in Table 1-2 (page 1-21).

Modeling of the ten cases began by defining several HTWOS updates, which established a starting point for the rest of the HTWOS modeling in the System Plan.[27] The HTWOS updates reflect planning and guidance from ORP, and model maintenance and programmatic improvements. The starting point for the HTWOS updates was the key assumptions from System Plan (Rev. 5), and then the updates were successively incorporated into HTWOS. These HTWOS updates provided the foundation for building the **Baseline Case**, which is the technical basis for the budget and schedule baseline documented in the RPP PMB.

The scenarios selected by ORP and Ecology were subsequently assigned corresponding case numbers for ease of tracking during modeling and to be consistent with established System Plan nomenclature (i.e., Scenario 2 was renamed Case 2, etc.).

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[26] Section 10.0, Figure 10-1, identifies which agency chose each scenario.

[27] HTWOS updates and the model configuration used for the System Plan are described in RPP-17152, *Hanford Tank Waste Operations Simulation (HTWOS) Version 6.61 Model Design Document*.

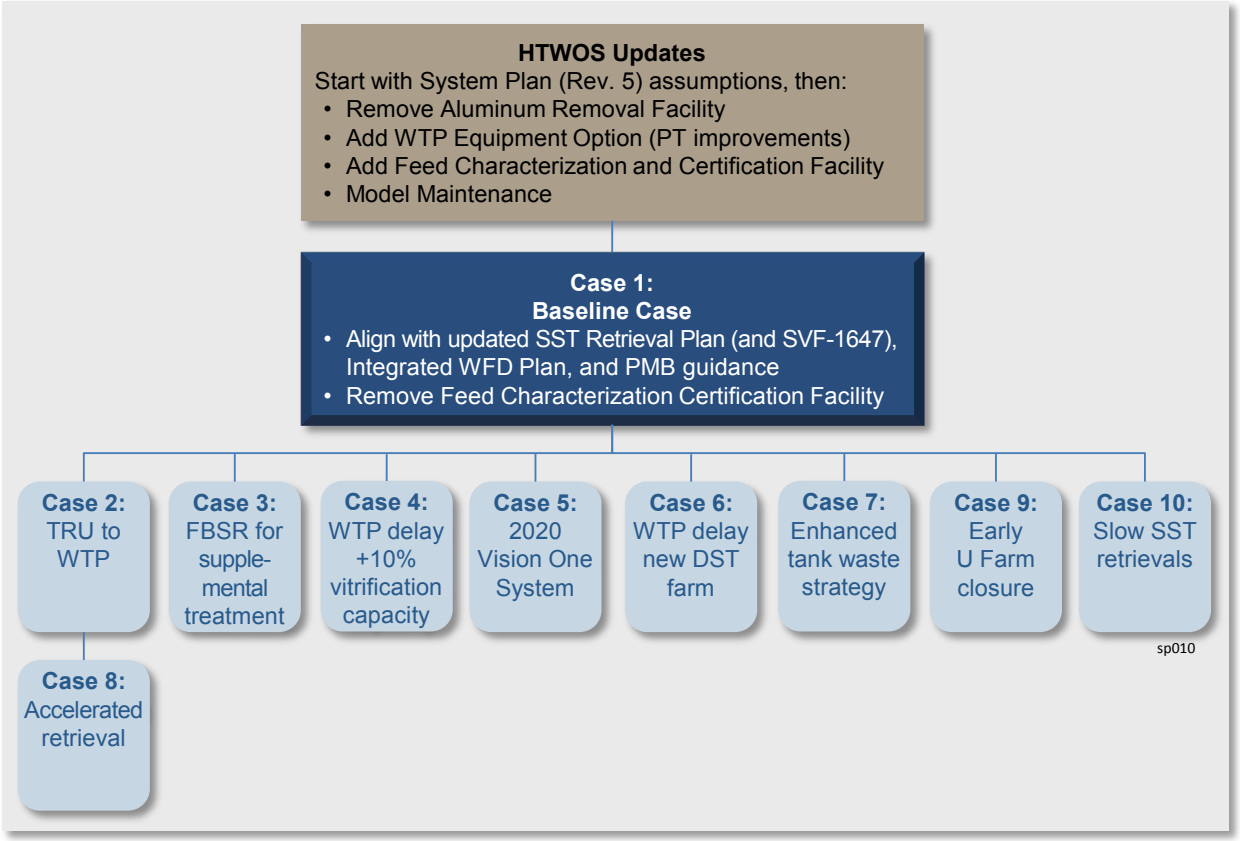

Figure 1-12. Candidate Scenarios

For the purposes of system planning, the scope of the Baseline Case in each System Plan is defined by ORP-approved assumptions, which generally remain unchanged during the HTWOS modeling process. However, ORP planning guidance is subject to change during that time. Therefore, the BCR process is used as necessary to align System Plan results with then-current ORP planning guidance for the next System Plan.

Table 1-2. Scenarios Summary Description

Scenario number	Scenario title	Purpose	Description
1	System Plan (Rev. 6) Baseline Case	Establish technical basis for budget and schedule baseline documented in the PMB	Eliminate the Aluminum Removal Facility. Add the WTP equipment alternative (pretreatment changes include processing at higher temperatures to mitigate solids precipitation using less NaOH). Incorporate model maintenance updates. Integrate with next planned updates of Integrated WFD Plan[a] and SST Retrieval Plan.[b] Update starting tank inventory. DOE 2004 LAW glass GFM used for all cases; 2009 GFM for HLW glass used for all cases except Case 7.
2	TRU waste to WTP	Show impacts of treating all "potential TRU" tank waste at WTP	All "potential TRU" tank waste will be treated at the WTP as HLW.
3	FBSR for supplemental treatment	Deploy FBSR as an alternative to second LAW facility	The FBSR replaces a second LAW facility for supplemental treatment. Monolithic waste form from FBSR will be disposed at IDF. WTP LAW Vitrification Facility begins operation January 1, 2020. The number of FBSRs will be estimated based on the total required LAW treatment capacity, the WTP LAW Facility vitrification capacity, and estimated net capacity of a single FBSR. Supplemental pretreatment uses SCIX/RMF (number to match net FBSR capacity). The first FBSR starts January 1, 2018, with each additional FBSR coming online nine months apart.
4	WTP delay with increased vitrification capacity	Evaluate how well 10% increase in overall vitrification capacity offsets all or part of the impact of a uniform 4-year delay in WTP startup	Increase the WTP HLW, LAW, and second LAW facility capacities by 10% each relative to the WTP "delay scenario."
5	2020 Vision One System[c]	Show impacts and effects of phased turnover of WTP facilities	Begin making LAW glass in 2016 (compared to 2018 in the Baseline Case) with the WTP LAW Vitrification Facility, processing one package of LAW glass/day. Use supplemental pretreatment (SCIX/RMF) until the WTP PT Facility is available; RMF in Tank AP-105 riser (solids discharge to Tank AP-105); SCIX in Tank AP-107 riser (cesium eluate to Tank AP-107); pretreated LAW staged in three existing 15,000-gal tanks, then delivered via HIHTL to the WTP LAW Vitrification Facility. Secondary liquid waste from the WTP LAW Vitrification Facility is returned to tank farms until the ETF upgrades are completed.
6	WTP delay with new DST farm	Evaluate how well a new DST farm offsets all or part of the impact of a uniform 4-year delay in WTP startup	Create new DST farm (no more than eight 1 Mgal tanks) in 200 East Area to allow SST retrieval to remain on schedule; equip each tank with dual mixer pumps (without incremental insertion capability), slurry pumps, and decant pumps. New DST farm becomes operational on September 30, 2020.
7	Enhanced tank waste strategy	Use of transformational technologies may shorten mission schedule by seven years and reduce life-cycle cost by $16 billion	Eliminate both WTP LAW Vitrification and second LAW vitrification facilities – all LAW treated with FBSRs. The number of FBSRs to be estimated from the total required LAW treatment capacity needed to support mission completion seven years early. Supplemental pretreatment using at-tank SCIX/RMF. First FBSR starts January 1, 2018. Monolithic waste form disposal at IDF. Enhanced HLW glass model (PNNL-19372[d]) using optical basicity/nepheline discriminator; increase HLW capacity to support mission completion seven years early (not exceeding 1.5 times System Plan [Rev. 6] Baseline Case).
8	Accelerated SST retrievals	Show effect on mission duration using alternate SST retrieval approach	Stage T Farm waste into sound SSTs in TX Farm. Start T Complex WRF construction and operation two years earlier than System Plan (Rev. 6) Baseline Case. Use one or more WFEs connected to T Complex WRF to support waste staging.
9	Early U Farm closure	Show impacts of beginning retrievals in U Farm instead of A Farm for the nine retrievals after C Farm	After C Farm, retrieve the four AX Farm tanks and five U Farm tanks (U-101, -104, -110, -112, -106).
10	Slow SST retrievals	Show impacts on baseline of increasing the minimum retrieval durations for the SSTs	Increase the minimum retrieval durations for each SST by 25% for all retrievals starting between January 1, 2011 and January 1, 2021.

[a] RPP-40149, 2011, *Integrated Waste Feed Delivery Plan*, Volumes 1 and 2, Rev. 2 Draft, Washington River Protection Solutions, LLC, Richland, Washington.

[b] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[c] The title of this scenario, "2020 Vision One System," has changed slightly from the original title, "2020 Vision." The new title reflects minor changes to detailed assumptions that were made to align the System Plan (Rev. 6) HTWOS model analysis of Case 5 with the "2020 Vision One System" business proposal recently submitted to ORP by BNI and WRPS, and to distinguish Case 5 from other workscope being managed by DOE-EM also using the "2020 Vision" title. The upper-tier framing assumptions did not change. Therefore, the "2020 Vision One System" is still representative of ORP's and Ecology's agreed-upon scenario as described in letter 10-TPD-148, from ORP and Ecology to EPA (Brockman and Hedges 2010).

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

DOE = U.S. Department of Energy.
DST = double-shell tank.
EM = U.S. Department of Energy, Office of Environmental Management.
ETF = Effluent Treatment Facility.
FBSR = fluidized bed steam reformer.
GFM = glass formulation model.
HIHTL = hose-in-hose transfer line.
HLW = high-level waste.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
PMB = performance measurement baseline.
PT = pretreatment.
RMF = rotary microfiltration.
SCIX = small column ion exchange.
SST = single-shell tank.
TRU = transuranic.
WFD = waste feed delivery.
WFE = wiped-film evaporator.
WRF = waste retrieval facility.
WTP = Waste Treatment and Immobilization Plant.

1.10 LIFE-CYCLE COST ANALYSIS

The LCM uses the TOC PMB[28] as of March 27, 2011 (see Section 1.7.1 and Figure 1-8) as the starting point for all scenarios. The TOC PMB is comprised of the scope, schedule, and cost for all authorized baseline activities. Because several scenarios involve new facilities or system configurations that would require additional workscope, some supplemental scenario-specific cost estimates were necessary. These estimates, time-phased with a schedule, were developed by estimators, project managers, or knowledgeable staff, and were incorporated into an LCM schedule for the appropriate scenario using placeholder WBS elements. The new scope estimates are all considered rough order of magnitude, and relied on information obtained from existing reports and studies, sketches and reference drawings, historical cost data (costs escalated to current year as applicable), scaling of baseline data, and estimator judgment.

With the exception of the supplemental scenario-specific estimates that were added for major scope additions, no attempt was made to change or improve the estimating accuracy of activities in the TOC PMB or to deviate from the existing set of estimating assumptions. Additionally, the funded management reserve and unfunded contingency totals were assumed to be held constant to the values reported in Assumption B2.1.5 (Appendix B) and were not recalculated for each scenario.

The LCM schedule for each scenario represents the unique dates and durations of activities projected by the HTWOS results. Predecessor project activities are moved in the schedule to coincide with the start of operations from HTWOS results, and successor activities begin immediately after operation completion. 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 HTWOS results, and not constraints, the LCM produces zero-float schedules. This approach is useful in demonstrating the schedule fluctuations resulting from different technical assumptions, but risk analysis and confirmation of availability of resources and funds would be required before using LCM schedules for anything other than comparative analysis.

All costs have been escalated to the projected year of occurrence, so life-cycle costs reported for each scenario have escalation included. Further details of the life-cycle cost analysis of the System Plan (Rev. 6) scenarios are provided in RPP-RPT-50187, *System Plan Rev. 6 Lifecycle Cost Analysis*.

1.11 PATH FORWARD

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

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[28] The TOC PMB includes Project Baseline Summary (PBS) ORP-0014, "Radioactive Liquid Tank Waste Stabilization and Disposition Project," and HQ-HLW-0014X, "Radioactive Liquid Tank Waste Stabilization and Disposition – Storage Operations Awaiting Geologic Repository." Scope and costs associated with WTP engineering, procurement, construction, and commissioning from PBS ORP-0060, "Waste Treatment and Immobilization Plant," is excluded from the TOC PMB, the LCM analyses, and this System Plan.

2.0 REGULATORY ENVIRONMENT

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

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

2.1 NATIONAL ENVIRONMENTAL POLICY ACT

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

2.1.1 Tank Waste Remediation System, Final Environmental Impact Statement

In 1996, DOE and Ecology co-authored DOE/EIS-0189, *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (TWRS EIS). This EIS evaluated a range of alternatives to manage and dispose of radioactive, hazardous, and mixed wastes stored in the Hanford tanks. In 1997, DOE published the TWRS EIS Record of Decision (ROD). Three TWRS EIS supplemental analyses were subsequently published in 1997, 1998, and 2001; however, the 1997 ROD was not modified.

2.1.2 Draft Tank Closure and Waste Management Environmental Impact Statement

On October 30, 2009 DOE issued the Notice of Availability for DOE/EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*[29] (TC & WM EIS). The TC & WM EIS will form the basis for making decisions about Hanford Site cleanup, including the following:

- Retrieval, treatment, and disposal of waste from 149 SSTs and 28 DSTs and closure of the SST system
- Final decontamination and decommissioning of the Fast Flux Test Facility, a nuclear test reactor

[29] Ecology is a cooperating agency with DOE. Therefore, the TC & WM EIS satisfies Washington State Environmental Policy Act requirements, and supports permits that will be needed under its hazardous waste program.

- Disposal of Hanford's waste and other DOE sites' low-level waste (LLW) and mixed LLW.

Upon issuance of the final EIS, and no sooner than 30 days thereafter, DOE may issue a ROD and publish it in the Federal Register.

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

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

An EIS is written more broadly than a specific project baseline and because it looks at how a program could evolve into the future, it covers more aspects than what might be in the tank farms baseline at any given time. The System Plan may evaluate some cases that are different than the EIS. Once a ROD is written, the tank farms baseline may need to be modified to align with the ROD.

2.1.3 Environmental Assessment for the 242-A Evaporator

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

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

The liquid and solid mixed (i.e., radioactive and hazardous) waste in the Hanford underground storage tanks includes hazardous wastes that are subject to the *Resource Conservation and Recovery Act of 1976* (RCRA). RCRA regulates hazardous waste from the point of generation through storage, treatment, and ultimate disposal. Many aspects of Hanford Site operations are governed by various RCRA permits. EPA's RCRA implementing regulations also include minimum technological requirements (e.g., secondary containment) that apply to management of hazardous wastes. The state of Washington, via Ecology, has been authorized by the EPA to administer a state hazardous waste management program in lieu of the federal hazardous waste management program, as set forth in the *Revised Code of Washington* (RCW) 70.105.130, "Department's Powers as Designated Agency under Federal Act." In turn, Ecology regulates hazardous waste pursuant to RCW 70.105, "Hazardous Waste Management," and Washington Administrative Code (WAC) 173-303, "Dangerous Waste Regulations."

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

Hanford is also subject to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), also referred to as "Superfund." CERCLA provides broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Some tanks are known to have leaked and some are assumed to have leaked because contamination has been found in the ground near them. However, some of this contamination may have come from leaks in tank farms piping or tank overfills. Beginning in the 1950s, more than 1 Mgal of liquid radioactive tank waste may have been inadvertently released into the environment, contaminating the soil and groundwater. Other wastes originally planned for tank containment were released to conserve tank space. In addition, approximately 440 billion gallons of low-level liquid wastes have been disposed to Hanford Site soils. The extent of the environmental contamination at Hanford prompted the EPA to include four areas of the Hanford Site on its National Priorities List, making the Hanford Site subject to the CERCLA response action requirements (including removal and remedial actions) for hazardous substance releases or threatened releases.

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

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

Between 2007 and 2009, as a result of a lawsuit filed by the state of Washington, DOE and the Ecology negotiated new and revised HFFACO milestones, along with new milestones in a Consent Decree to be filed in federal district court. Both the Consent Decree (08-5085-FVS) and HFFACO changes became effective on October 25, 2010, the date the Consent Decree was entered into federal court. HFFACO and Consent Decree milestones for cleanup activities are fundamental to long-range planning for ORP, and are incorporated in the TOC PMB. Selected HFFACO and Consent Decree milestones are used as success criteria during system planning (additional information is provided in Section 1.3).

2.3 DOE O 435.1 AND PREPARATIONS FOR FACILITY CLOSURE

The objective of DOE O 435.1, *Radioactive Waste Management*,[30] is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. Specific and detailed requirements are further defined in the accompanying DOE M 435.1-1, *Radioactive Waste Management Manual*, and DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*.

2.3.1 Definition of High-Level Waste

DOE M 435.1-1 embraces the definition of HLW as presented in the *Nuclear Waste Policy Act of 1982* (NWPA), as amended, which was intended to provide DOE with a basis for determining when wastes were, or were not, HLW.[31]

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

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

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

2.3.2 Waste Incidental to Reprocessing

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

Given the very large mass of chemical waste in tanks across the DOE complex, DOE collaborated with the U.S. Nuclear Regulatory Commission (NRC) staff to identify approaches DOE could use to classify waste streams that are not HLW based on their innately low radionuclide concentrations or incidental contamination, and also as appropriate, to classify large volumes of decontaminated chemical waste containing relatively low radionuclide concentrations, or LAW that could be disposed of without needing the protection of a geologic repository. Wastes that meet these criteria can, under certain circumstances, be classified as not HLW and are referred to as waste incidental to reprocessing (WIR).

[30] DOE is currently updating DOE O 435.1.

[31] For purposes of consistency and conservatism, all wastes stored in the Hanford tank farms are managed as HLW, which means that these wastes are subject to the highest health and safety protocols.

The NRC and DOE developed three criteria (paraphrased below) that identify the evaluation process DOE could use to decontaminate tank wastes and ascertain the wastes would be then suitable for disposal as LLW. Those criteria are:

1. Key radionuclides (i.e., those that are most significant to near-term or long-term human health and safety) must be removed to the maximum technical and economical extent practical.[32]

2. Waste must meet safety requirements comparable to Title 10, *Code of Federal Regulations*, Part 61 (10 CFR 61), "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives."

3. Wastes must be solidified and the radionuclide concentrations within the solidified wastes must be within 10 CFR 61.55 Class C concentration limits.

The essence of these three criteria is that if the radionuclides are removed so that the wastes are no longer "highly radioactive," and if the decontaminated wastes then meet NRC or DOE equivalent regulatory requirements for disposal as a LLW, DOE can determine the waste to be LLW and manage it accordingly. The radionuclides that are removed are combined with the HLW and vitrified.[33]

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

In addition, as described in Section 2.2, some residual waste, including hard-to-remove heels, the contaminated tank itself, and associated contaminated components, will remain after bulk waste retrieval is complete in accordance with the HFFACO. Additionally, these residuals may be stabilized and disposed in place if (1) the residual waste can be determined to be WIR pursuant to the DOE M 435.1-1 WD process, and (2) landfill closure for tanks is supported by the TC & WM EIS ROD. To support future SST farm closure operations, a WD is expected to be necessary for each of the seven SST WMAs.[34] Current estimates indicate that it may take 24-36 months to issue each WD. The scope of the WD for each WMA will be comprehensive, and will include tank residuals, pipeline residuals, and equipment abandoned in place.

Wastes that are retrieved from tanks will be filtered in the WTP PT Facility to remove insoluble materials, including ^{90}Sr and transuranic (TRU) isotopes, and then treated by ion exchange to remove cesium isotopes. Decontamination of waste heels in tanks occurs during the retrieval process, which both removes most of the wastes from the tanks and also washes the heel materials to remove much of the soluble radioactivity.

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

[33] The NWPA specifies geologic disposal for all spent nuclear fuel HLW.

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

DOE analyzes the wastes treated by either approach to ascertain that the second and third WIR criteria will be met (i.e., that the treated wastes can be safely disposed of as LLW). The second criterion, in particular, assures that the calculated doses to maximally exposed individuals following disposal and to humans that inadvertently intrude into the disposal site would be no higher than is allowed by NRC regulations for LLW sites.

2.3.3 Performance Assessment for Waste Management Area C

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

HHFACO Appendix I, Section 2.5, requires the development of a PA for the SST system and the development of a PA for each WMA. The PAs will address the post-closure, long-term risk to human health and the environment presented by residual waste, equipment, and contaminated soil. The PAs will address both radionuclides and hazardous chemicals, and incorporate applicable requirements, including performance requirements defined by RCW 70.105, RCRA, *Clean Water Act of 1972*, *Safe Drinking Water Act of 1974*, *Atomic Energy Act of 1954*, and any other performance requirements that might be "applicable or relevant and appropriate requirements" under CERCLA. Successful closure of each WMA will require a systems approach to address all of these elements.

The first WMA to be closed will be WMA C. HFFACO milestone M-045-83 calls for closure of WMA C in 2019. Facilities to be addressed in the closure of WMA C include 16 SSTs, a catch tank, seven diversion boxes, a vault containing four tanks, and about six miles of pipelines. In addition, WMA C corrective measures associated with existing soil and groundwater contamination must be performed. These corrective measures have been divided into two phases, which are being executed concurrently. The first phase includes the retrieval of waste from SSTs in C Farm, and the catch tank and four tanks in the 244-CR vault. The second phase of corrective measure investigations is underway in WMA C, per RPP-PLAN-39114, *Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C*, provided through HFFACO milestone M-045-61. This work involves characterization of past releases to the soil using borehole logging, soil sampling, and soil electrical resistivity evaluations. Characterization results are combined with historic information regarding releases, and conceptualizations of contamination fate and transport are being developed. In addition, potential methods for soil remediation are being evaluated to support the development of a Phase 2 RCRA Facility Investigation/Corrective Measures Study for WMA C (HFFACO milestone M-045-61, due December 31, 2014). Additional investigations are planned for assessing and determining disposition of ancillary equipment within the tank farms through actual demonstrations and technical evaluations (HFFACO milestones M-045-80 and M-045-81).

Development of the WMA C PA document is underway via a series of technical exchanges with staff from DOE, NRC, EPA, and Ecology. Other participants include the Tank Operations Contractor (WRPS), the Oregon Department of Energy, several Tribal Nations, members of the Hanford Advisory Board, and other stakeholders.

Technical discussions allow for the identification and clarification of specific technical questions related to: (1) conceptual models and alternatives, (2) exposure scenarios, and (3) specific data and parameter values that will be needed to support development and implementation of the numerical model calculations used in the PA. The completed PA will support related WDs, RCRA closure plans, and CERCLA RODs, which will be needed to close some Hanford facilities. The initial planning session was conducted in February 2009. Nine working sessions have been held to-date; a total of 13 are currently planned. Final numerical modeling for the PA has been deferred until after completion of the TC & WM EIS, per DOE direction. It is anticipated that the PA will be completed in late 2012.

2.4 DOCUMENTED SAFETY ANALYSIS

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

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

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

RPP-13033, *Tank Farms Documented Safety Analysis*, and the associated HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*, document the safety basis for tank farms.

The 222-S Laboratory and 242-A Evaporator each have their own DSA and technical safety requirements. The evaporator DSA and technical safety requirement revisions will be completed in 2012.

Per DOE-STD-1189-2008, *Integration of Safety into the Design Process*, the hazards presented by any new operation will need to be evaluated early in the project, and the design features and controls to address those hazards will be integrated into the design. This type of analysis is currently in progress for two planned activities in the tank farms.

- Mixer pumps will be installed in most DSTs. However, operation of these mixer pumps is not currently authorized in the tank farms DSA (RPP-13033), and will require a hazards evaluation, accident analysis, development of controls, and development of a DSA amendment to authorize their operation.

- Implementation of updated buoyant displacement gas release event (BDGRE) controls specific to sludge waste is not currently authorized in the tank farms DSA (RPP-13033), and will require a hazards evaluation, accident analysis, development of controls, and development of a DSA amendment to authorize their operation.

Any other new operations (e.g., supplemental treatment or pretreatment) will also be required to meet DOE-STD-1189-2008.

3.0 STATE OF THE RIVER PROTECTION PROJECT SYSTEM

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

A fully integrated system of RPP waste storage, treatment, and disposal facilities is in varying stages of design, construction, operation, or future planning. In addition to the facilities highlighted in Figure 1-7, this section addresses waste retrieval from SSTs and DSTs, miscellaneous underground storage tanks (MUST), inactive miscellaneous underground storage tanks (IMUST),[35] waste transfer systems, the 242-A Evaporator, Vadose Zone Integration Program, ARRA-funded projects, various supplemental treatment facilities, WTP, and other interfacing facilities. Current events and recent accomplishments are also described.

3.1 STORAGE

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

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

Table 3-1. Tank Farms Waste Volumes

Tank type	200 East Area	200 West Area	Total
Single-shell tanks			
Sludge	4.0 Mgal	5.4 Mgal	9.4 Mgal
Saltcake	6.2 Mgal	13.8 Mgal	20.0 Mgal
Supernate	46 kgal	41 kgal	87 kgal
Subtotal	10.2 Mgal	19.3 Mgal	29.5 Mgal
Double-shell tanks			
Sludge	1.7 Mgal	0.2 Mgal	1.9 Mgal
Saltcake	3.0 Mgal	0.6 Mgal	3.6 Mgal
Supernate	18.8 Mgal	1.6 Mgal	20.4 Mgal
Subtotal	23.5 Mgal	2.4 Mgal	25.9 Mgal
Total	33.7 Mgal	21.7 Mgal	55.4 Mgal

Note: Data is current as of the Best-Basis Inventory effective date, consistent with Best-Basis Inventory input to the Hanford Tank Waste Operations Simulator. Summary volumes include the volume of retained gas but do not include the IMUST inventory. Totals may not sum correctly from individual contributors due to rounding.

IMUST = inactive miscellaneous underground storage tank.
kgal = thousand gallons.
Mgal = million gallons.

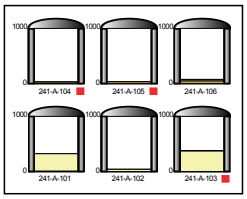
[35] MUSTs and IMUSTs are collectively referred to as IMUSTs in this plan (described further in Section 3.1.3).

Note: Data is current as of the Best-Basis Inventory effective date, consistent with Best-Basis Inventory input to the Hanford Tank Waste Operations Simulator.

Figure 3-1. 200 West Tank Waste Contents

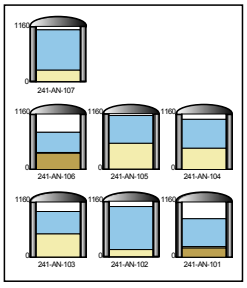
A-Tank Farm- Constructed 1953-1955
6 @1,000 Kgal Tank Capacity, Single-Shell

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



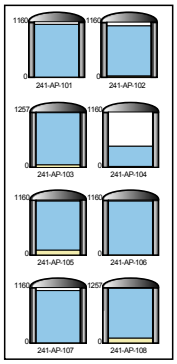
AN-Tank Farm- Constructed 1977-1980
7 @1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AN-101	195	31	581
241-AN-102	0	154	894
241-AN-103	0	486	475
241-AN-104	0	443	606
241-AN-105	0	536	589
241-AN-106	338	17	426
241-AN-107	0	241	848



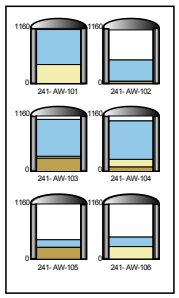
AP-Tank Farm- Constructed 1982-1986
6 @1,160 Kgal Tank Capacity, Double-Shell
2 @1,257 Kgal Tank Capacity, Double-Shell

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



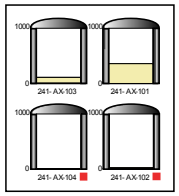
AW-Tank Farm- Constructed 1976-1980
6 @1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AW-101	0	396	737
241-AW-102	52	0	444
241-AW-103	280	40	769
241-AW-104	97	157	809
241-AW-105	248	0	162
241-AW-106	0	269	196



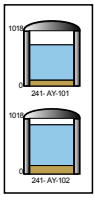
AX-Tank Farm- Constructed 1963-1965
4 @1,000 Kgal Tank Capacity, Single-Shell

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



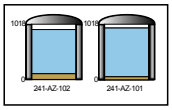
AY-Tank Farm- Constructed 1968-1970
2 @1,018 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AY-101	105	0	653
241-AY-102	151	0	749



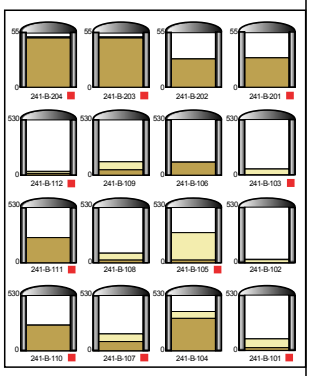
AZ-Tank Farm- Constructed 1970-1974
2 @1,018 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AZ-101	52	0	894
241-AZ-102	105	0	814



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

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

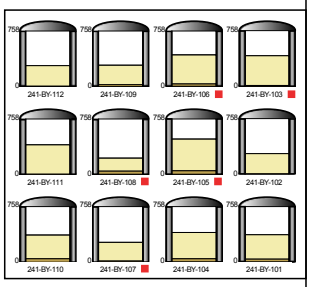


BX- Tank Farm- Constructed 1946-1947
12 @530 Kgal Tank Capacity, Single-Shell

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

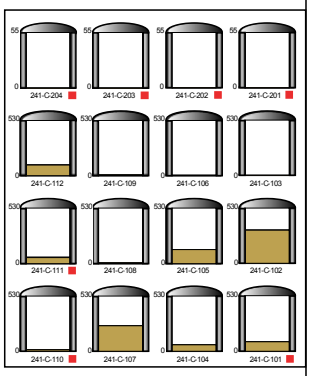
BY-Tank Farm- Constructed 1948-1949
12 @758 Kgal Tank Capacity, Single-Shell

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



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

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-C-101 ■	88	0	0
241-C-102	316	0	0
241-C-103	2	0	0
241-C-104	64	0	0
241-C-105	132	0	0
241-C-106	3	0	0
241-C-107	247	0	0
241-C-108	7	0	0
241-C-109	8	0	1
241-C-110 ■	17	0	0
241-C-111 ■	57	0	3
241-C-112	104	0	0
241-C-201 ■	0	0	0
241-C-202 ■	0	0	0
241-C-203 ■	0	0	0
241-C-204 ■	0	0	0



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

Data Derived From Waste Tank Summary Report Dated 9/30/2010

M.J. Rodgers
washington river protection solutions
\\AP012\CHARDOC$\All By Staff\Member\Rodgers\Bank Figures\200 East Bank Profile 093010.pdf

Note: Data is current as of the Best-Basis Inventory effective date, consistent with Best-Basis Inventory input to the Hanford Tank Waste Operations Simulator.

Figure 3-2. 200 East Tank Waste Contents

3.1.1 Single-Shell Tanks

Status: Existing (interim stabilized/retrievals in progress)

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

To provide assurance that any future SST loss of integrity can be detected, Hanford has monitored SST integrity for years. Monitoring activities include dome deflection surveys, SST integrity assessment (RPP-10435, *Single-Shell Tank System Integrity Assessment Report*), photo and video archives of dome interiors, leak history archives, and a variety of surveillance methods, including liquid observation wells, drywell monitoring, material balances during retrieval, transfer route monitoring, waste surface level measurements, and leak detection during waste retrieval. In addition, tank farms personnel use high-resolution resistivity leak detection and monitoring systems for most SSTs during retrieval operations. This system was first demonstrated on Tank S-102 and has since been deployed on six C Farm tanks. Surface geophysical exploration technologies have been demonstrated in many of the SST farms; this method allows personnel to identify areas of higher conductivity in the soil but does not quantify leak volumes. Transfer routes are monitored for radioactivity, toxic vapor releases, and visual indications of a possible leak. A formal tank leak assessment process is also in place, using approved tank operating procedures.

Because the oldest SSTs are more than 60 years old, and knowing that completion of SST waste retrieval is still decades away, a new SST Integrity Program was developed in 2009 to identify those activities needed to extend the life of the tanks. An expert panel was convened and met twice in 2009 to address SST integrity concerns. From these two meetings, the panel identified 33 recommendations, documented in RPP-RPT-43116, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project*, for implementation of an enhanced SST integrity project (SSTIP). The panel focused on four key elements for the tank integrity project: (1) confirmation of tank structural integrity, (2) assessment of the likelihood of future tank liner degradation, (3) leak identification and prevention, and (4) mitigation of contaminant migration. Some of the panel's recommendations were recently converted into new HFFACO milestones. Several significant efforts have been completed or are in progress in support of the SSTIP:

- In 2010, as part of the SST Integrity Program, remote visual inspections were conducted in 12 SSTs. The 12 tanks are a diverse group, representing eight different farms. The inspections included both sound tanks and tanks that are known or suspected to have leaked in the past; six are located in 200 East Area, and six are in 200 West Area. The inspections were conducted by lowering a radiation tolerant pan-tilt-zoom camera through a riser, which allows the visible concrete above the tank liner to be examined. Special attention was paid to the upper haunch area, and the apex of the tank dome. Based on the review of the in-tank videos, structural integrity of the 12 tanks was deemed satisfactory (RPP-RPT-48194, *Fiscal Year 2010 Visual Inspection Report for Single-Shell Tanks*).

- In 2011, plans are being developed to obtain and test a vertical core from the entire depth of the sidewall of an SST. The intent is to perform coring of the tank sidewall through the haunch, down the full height of the SST sidewall, and into, but not through, the wall footing. A similar effort was completed in 1981 on SST SX-115. Obtaining this new core will provide additional information on the present condition of SST concrete. The results of laboratory tests on the core will be compared to earlier laboratory analyses, and compared to predicted values used in finite element models for evaluating the condition and integrity of the SSTs. Tank A-106 has been selected for sidewall coring. Concrete degradation is linked with elevated temperature, and the high-heat history of Tank A-106 is expected to provide a bounding case for evaluation. Sidewall coring is tentatively expected to occur in FY 2013 (RPP-PLAN-47370, *Sidewall Core Drilling Plan for the Single-Shell Tank 241-A-106 Sidewall Coring Project*).
- Investigative work employing the process described in RPP-32681, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*, has concluded that 44 of the 67 SSTs previously designated as assumed leakers have probably been miscategorized because of spills and overflows that were not the results of liner breaches. This conclusion is subject to tank-by-tank formal confirmation via TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. To-date, the eight assumed leakers reevaluated using this process have been judged to be sound or that leakage occurred above the current waste level in the tank. This enables the waste in these five tanks to be retrieved by more efficient processes.
- Other investigative work to identify common factors for liner failures has revealed two areas of interest:
  - In several of the SX Farm tanks, the solid waste was leached with REDOX (Reduction-Oxidation) Facility condensate to recover the sodium nitrate for reuse within the REDOX Facility. The original supernate was transferred out of the tanks, which inadvertently removed the protective sodium nitrite. The tanks were subsequently backfilled with fresh process condensate, which leached the sodium nitrate out of the resident sludge, creating a sodium nitrate-rich supernate. With the nitrite gone, the steel liners were subjected to nitrate-induced stress corrosion cracking. All five of the sodium nitrate-leached tank liners failed.
  - The ductile-to-brittle transition temperature of the steel alloy used to construct the SX Farm may have played a role in the failures of eight tanks there. This farm was constructed during 1954 and 1955. For a two-week period during that winter, the ambient air temperature was well below the ductile-to-brittle transition temperature for those liners. In theory, any sharp impacts, such as dropped tools or equipment bumps, that occurred during this period could have created micro-fractures in the liners that later were susceptible to failure, especially during nitrate leaching or high-temperature thermal cycling. The six tanks at the north end of the farm were backfilled with soil at that time, and none of those leaked. However, the nine tanks at the southern end of the farm were not backfilled, and eight of those later leaked.

3.1.1.1 Single-Shell Tank Waste Retrieval Process Fundamentals

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

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

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

- During the **bulk retrieval phase**, the waste slurry concentration is approximated as a constant value. The bulk retrieval phase begins at the start of retrieval and ends when the cumulative waste slurry concentration begins to show a definite decline as retrieval progresses.
- The **transition phase** begins when the bulk retrieval phase ends. In the transition phase, the waste slurry concentration steadily declines as the remaining waste volume in the tank is reduced. The transition phase ends when the waste slurry concentration is reduced to the point at which retrieval with the current equipment is no longer effective.
- The **hard-to-remove heel** (HTRH) **phase** begins when transition ends. If HTRH retrieval is required, equipment is installed and HTRH removal begins. The waste slurry concentration during HTRH retrieval begins at a specified concentration and reduces steadily as remaining waste in the tank is reduced until the HTRH retrieval process is no longer effective.

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

3.1.1.2 Accelerated Single-Shell Tank Retrieval Initiative

WRPS previously proposed an initiative to address retrieval programmatic risks and to accelerate retrieval activities in the SST system. The initiative includes accelerated retrieval of the A and AX Farm tanks to AY and AZ DSTs and six of the SX Farm tanks to an S Farm SST. Due to limited DST space available to accommodate these retrievals and the WTP operating schedule, a large bow-wave is reflected in the Baseline Case that must be worked off in the 2025 to 2040 timeframe, requiring completion of a sustained average of nine retrievals per year.

By accelerating these retrievals and staging the retrieved waste in approved SSTs, the bow-wave and associated programmatic risks might be significantly reduced. ORP approved a BCR to move forward with accelerated A/AX Farm retrievals to AY and AZ DSTs. SSTs are not currently approved to receive waste and further development of the regulatory approach and strategy for interim staging of tank waste in SSTs has not been initiated.

3.1.1.3 Single-Shell Tank Waste Retrieval Progress To-Date

Waste retrieval from SSTs is in progress. Retrieval operations have been completed in seven SSTs (Table 3-2) and three SSTs have been retrieved to the limits of deployed technologies[36] (Table 3-3). Waste retrieval activities in FY 2010-2011 have been focused on retrieving Tanks C-104, C-108, and C-111 (Table 3-4) and readying Tanks C-107, and C-112 for retrieval (Table 3-5). Five remaining C Farm tanks are scheduled to be retrieved next (Table 3-5).

Tank S-102 retrieval was stopped prematurely in July 2007 due to an above-grade waste spill. Since then, Tank S-102 has been in "retrieval" mode. However, in June 2010, WRPS informed ORP that Tank S-102 meets the interim stabilization criteria, so the tank has been returned to "storage" status (Sax 2010). The System Plan assumes that the retrieval of Tank S-102 will be completed in FY 2023.

Table 3-2. Tanks with Retrieval Operations Complete

Tank	Retrieval completion date	*Waste Inventory Changes*[a]				Technology deployed
		Waste volume removed (gal)	Waste volume remaining (gal)	Curies[a] removed (Ci)	Curies[a] remaining (Ci)	
C-106	12/31/2003	194,000	2,800	7,135,000	132,000	Modified sluicing and oxalic acid dissolution
C-203	3/24/2005	2,500	100	600	500	Vacuum retrieval
C-202	8/11/2005	1,200	100	1,700	1,000	Vacuum retrieval
C-201	3/23/2006	600	100	500	500	Vacuum retrieval
C-103	8/23/2006	70,000	2,500	2,745,000	20,000	Modified sluicing
C-204	12/11/2006	1,300	100	100	300	Vacuum retrieval
S-112	3/2/2007	612,000	2,400	584,000	0	Saltcake dissolution and modified sluicing
Totals:		**881,600**	**8,100**	**10,466,900**	**154,300**	

[a] Data reference SVF-2175, 2011, "Single Shell Tank Retrieval Summary FY11 Q2.xlsx," Rev. 0, which calculates the total curies and volumes retrieved from single-shell tanks into double-shell tanks as of March 31, 2011. Radionuclides are decay corrected to January 1, 2008.

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

Table 3-3. Tanks Retrieved to the Limits of Deployed Technologies

Tank	Retrieval start date	*Waste Inventory Changes*[a]				Technology deployed
		Waste volume removed to-date (gal)	Waste volume remaining (gal)	Curies removed to-date (Ci)	Curies remaining (Ci)	
C-108	12/20/2006	59,000	6,800	139,000	13,000	Modified sluicing
C-109	6/19/2007	56,000	7,800	766,000	2,000	Modified sluicing
C-110	9/22/2008	161,000	17,200	30,000	3,000	Modified sluicing
Totals:		**276,000**	**31,800**	**935,000**	**18,000**	

[a] Data reference SVF-2175, 2011, "Single Shell Tank Retrieval Summary FY11 Q2.xlsx," Rev. 0, which calculates the total curies and volumes retrieved from single-shell tanks into double-shell tanks as of March 31, 2011. Radionuclides are decay corrected to January 1, 2008.

Table 3-4. Tanks In Progress

Tank	Retrieval start date	*Waste Inventory Changes*[a]				Technology to be deployed (bulk/heel method)
		Waste volume removed to-date (gal)	Waste volume remaining (gal)	Curies removed to-date (Ci)	Curies remaining (Ci)	
C-104[b]	1/08/2010	233,000	25,700	751,000	299,000	Modified sluicing
C-111[c]	9/14/2010	300	32,200	TBD	TBD	TBD
Totals:		**233,300**	**57,900**	**TBD**	**TBD**	

[a] Data reference SVF-2175, 2011, "Single Shell Tank Retrieval Summary FY11 Q2.xlsx, Rev. 0, which calculates the total curies and volumes retrieved from single-shell tanks into double-shell tanks as of March 31, 2011. Radionuclides are decay corrected to January 1, 2008.

[b.] Per WRPS-1102627 (Dunning 2011), bulk retrieval of Tank C-104 was completed on June 17, 2011, with an ending waste volume of 4,710 gal. Data reflects the status of Tank C-104 at the reference date (see Section 1.7.1) used for System Plan (Rev. 6) preparation, which pre-dated completion of Tank C-104 retrieval.

[c] Tank C-111 modified sluicing operations were completed on November 4, 2010. The remaining waste will be retrieved using hard-to-remove heel retrieval technology (specific method TBD). (Dunning, A. B., 2010, "Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Completion of Performance Based Incentive 2.14, Fee Bearing Milestone PBI-2.14.3, 'Complete Bulk Retrieval of Tank 241-C-111' – Request for Incremental Fee Approval," [Letter WRPS-1003927 and enclosure to S.E. Bechtol, Contracting Officer, U.S. Department of Energy, Office of River Protection, December 28], Washington River Protection Solutions, LLC, Richland, Washington.) Curie data for Tank C-111 will be updated in the BBI upon completion of heel retrieval.

BBI = Best-Basis Inventory. TBD = to be determined.

Table 3-5. Tanks Next In Line

Tank	Scheduled started date	*Waste Inventory Changes*[a]				Technology to be deployed (bulk/heel method)
		Waste volume removed to-date (gal)	Waste volume remaining (gal)	Curies removed to-date (Ci)	Curies remaining (Ci)	
C-107	9/10/2011	–	253,000	–	4,097,000	New riser, mobile arm retrieval sluicing system/none
C-112	10/1/2011	–	104,000	–	1,343,000	Modified sluicing and in-tank vehicle
C-102	11/1/2012	–	316,000	–	108,000	Modified sluicing and in-tank vehicle
C-101	6/1/2012	–	88,000	–	124,000	New riser, mobile arm retrieval vacuum system/none[b]
C-105	7/1/2013	–	132,000	–	939,000	New riser, mobile arm retrieval vacuum system/none[b]
Totals:		**–**	**893,000**	**–**	**6,611,000**	

[a] Data reference SVF-2175, 2011, "Single Shell Tank Retrieval Summary FY11 Q2.xlsx, Rev. 0, which calculates the total curies and volumes retrieved from single-shell tanks into double-shell tanks as of March 31, 2011. Radionuclides are decay corrected to Jan. 1, 2008.

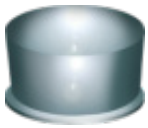
[b] The regulator-approved retrieval technology for these tanks is currently the mobile retrieval system.

3.1.1.4 Single-Shell Tank Closure

Detailed descriptions of closure plans for Hanford facilities are still under development and are beyond the purview of this document. The Baseline Case assumes that each SST will be interim-closed in accordance with Appendix B, Assumption B3.2.1.2, followed by full closure in accordance with Appendix B, Assumption B3.2.1.3. Final closure of each SST and associated WMA is assumed to be completed within about five years after the last SST from that farm is retrieved. Closure will be conducted in accordance with applicable regulatory requirements.

3.1.2 Double-Shell Tanks

Status: Operational



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

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

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

- Conducting DST integrity assessments (e.g., ultrasonic and video examinations) and documenting results for use in subsequent inspections
- Conducting DST waste chemistry sampling and adjustments for corrosion mitigation
- Performing DST waste chemistry corrosion optimization studies to quantify the best waste chemistry parameters to minimize DST corrosion, while adding as few chemicals to the waste as possible
- Developing and installing in-tank corrosion probes for DSTs with new or revised corrosion control limits
- Performing DST structural analysis and studies for thermal, operating, and seismic loads
- Performing in-service leak testing needed to raise the operating levels of AP Farm tanks from 1.144 Mgal to 1.2465 Mgal (see Appendix B, Assumption B3.2.2.2)
- Conducting periodic testing, evaluation, and certification of DST support equipment (e.g., waste transfer lines, valve pits, etc.).

Effective and efficient management of the storage space available in the DSTs is essential to the success of the RPP mission. The theoretical total capacity of the 28 DSTs is 32.3 Mgal. Projections of how the DSTs are used over time are illustrated in Figure 5-7 (Section 5.5.2).

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

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

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

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

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

Another consideration in operating the DSTs is managing waste containing high concentrations of phosphates. Wastes containing phosphates pose a high risk of solids precipitation and/or gelling during transfer, after evaporation and cooling, or during mixing with the waste in the receiver tank. This could (and has in the past) lead to formation of plugs in waste transfer lines or could cause significant difficulties during evaporator operations. It is asserted that a tank containing phosphate gel might retain flammable gases leading to a gas release event of a different mechanism than a BDGRE (RPP-23584, *Safety Evaluation of Waste Gel in the Tank Farms*). Because of these issues, controls for the transfer of phosphate wastes are provided by HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*. These phosphate waste transfer controls are not currently explicitly modeled for life-cycle mission modeling purposes.

Two DSTs, Tanks AN-102 and AN-107, currently store waste that includes high concentrations of complexed ^{90}Sr and TRU in the supernate. These two components must be precipitated out of solution prior to vitrification to avoid having those components report to the WTP LAW Vitrification Facility. Although the WTP PT Facility has the capability to do the precipitation step there, the current plan is to precipitate the ^{90}Sr /TRU in-situ in the DST system. The precipitated ^{90}Sr and TRU is incidentally blended with other HLW solids and will be vitrified at the WTP.

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

3.1.3 Inactive/Miscellaneous Underground Storage Tanks

Status: Operational/Inactive

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

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

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

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

In support of upcoming retrieval and closure activities anticipated in C Farm and A Farm, WRPS is planning activities to address Tank C-301, a catch tank in C Farm. A BCR will be submitted to allow core sampling of this tank in FY 2011.

Tank A-350 is a surface water collection tank in A Farm. Recently, the pump in Tank A-350 was replaced, the liquid inside was removed, and the tank was isolated from the diversion boxes. Further closure actions are under consideration.

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

3.1.4 Waste Transfer Systems

Status: Operational

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

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

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

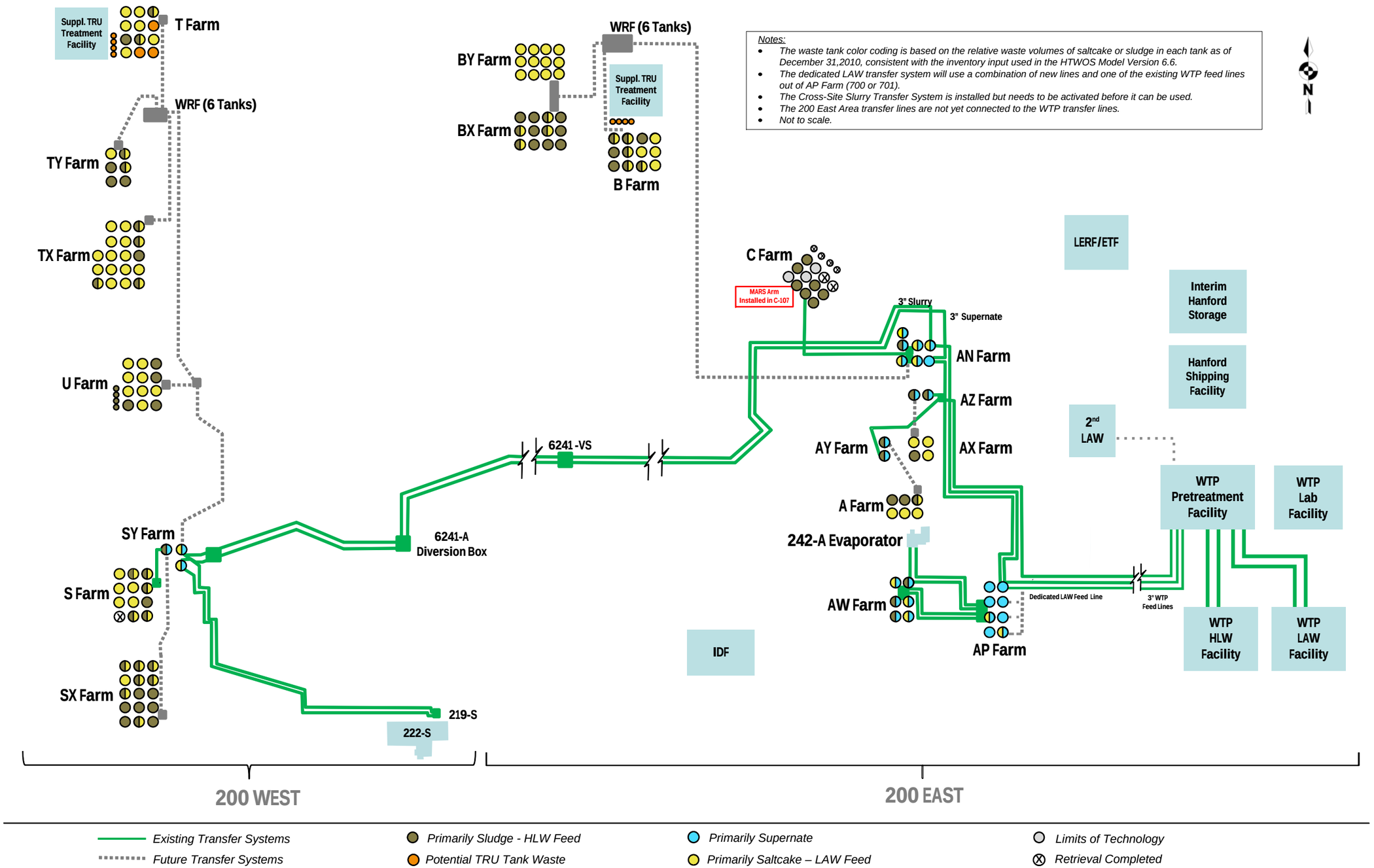


Figure 3-3. Hanford Tank Cleanup Status and Waste Transfer System

3.1.5 Waste Retrieval Facilities

Status: Proposed

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

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

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

The mission of the B Complex WRF potentially includes an enhanced WRF concept, also referred to as a Feed Characterization and Certification Facility (FCCF), in which the basic WRF capabilities would be augmented to include mixing, blending, sampling, and filtration of retrieved waste to provide a more uniform feed to WTP (RPP-RPT-44860, *Mission Analysis Report Waste Feed Delivery Projects East Area Waste Retrieval Facility*). Sampling of the blended wastes at the WRF would support the certification of feed batches to WTP, in accordance with ICD-19 (24590-WTP-ICD-MG-01-019) requirements. Further work on the FCCF is on hold pending direction from ORP.

3.1.6 242-A Evaporator

Status: Operational

The primary mission of the 242-A Evaporator (Figure 3-4) is to support tank farm waste storage by reducing dilute waste volume. Evaporator availability is essential to the success of the RPP mission to continue SST waste retrievals and to adjust the sodium levels to meet WTP feed requirements. The evaporator operates on a campaign basis, using the time between campaigns to implement facility upgrades as necessary. The 242-A Evaporator has a final status RCRA Part B permit.

Figure 3-4. 242-A Evaporator Facility

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

3.1.7 Waste Encapsulation and Storage Facility

Status: Operational

WESF, adjacent to the west end of B Plant, was constructed in 1974 to encapsulate and store cesium and strontium that were separated from the Hanford Site's tank waste. Approximately one-third of the cesium and strontium contained in the original tank waste was previously removed and incorporated into capsules. The cesium waste is stored as a chloride salt and is double-contained in 316L stainless-steel capsules with maximum outer dimensions of 21 in. long by 3 in. in diameter. Due to integrity concerns, a small number of cesium capsules have been sealed within an additional 316L stainless-steel containment boundary, called a Type W overpack, with maximum outer dimensions of 21.225 in. long by 3.25 in. in diameter. The strontium waste is stored as a fluoride salt and is double-contained. The inner strontium capsule is made of Hastelloy C-276 and the outer capsule is made of 316L stainless steel, with maximum outer dimensions of 20.1 in. long by 2.625 in. in diameter. WESF provides for safe storage and monitoring of the capsules under water in pool cells. WESF is an interim status RCRA facility.

The current inventory at WESF consists of 1,335 cesium capsules and 601 strontium capsules. The capsules contain approximately 106 MCi of radioactivity,[37] including daughter products. This represents approximately 60 percent of the curies stored in 200 East and 200 West Areas combined. The management of WESF and the disposition of the cesium and strontium capsules is the responsibility of RL, which had planned on disposal of the capsules at the proposed Yucca Mountain nuclear waste repository.

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

A decision as to the continuing viability of direct disposal will be made under HFFACO milestone M-092-05 (circa 2017). This allows sufficient time for ORP to make the necessary changes to the WTP to receive and vitrify the contents of the capsules, and for RL to build a de-encapsulation and conditioning facility.

[37] Note that the decay date for this activity is May 1, 2010.

The System Plan (Rev. 6) Baseline Case assumes that the capsules will not require processing at WTP (Appendix B, Assumption B3.5.8.1). However, the WTP contract provides for the ability to receive and vitrify the capsules contents as HLW, after appropriate conditioning, if processing of the capsules is determined to be required for final disposition. Therefore, WESF is not shown on the simplified process flow diagram, nor is the treatment of the capsule contents modeled.

3.1.8 Vadose Zone Program

Status: Operational

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

The first step in vadose zone remediation is achieving high-quality site characterization data. However, commercially available technologies are not always suitable for as-is deployment in the complex environment of the Hanford tank farms. For example, traditional soil characterization methods rely on drilling boreholes to obtain soil samples for laboratory analysis, but the complexity and expense of drilling in contaminated soil dictate the development of methods more suitable to the Hanford tank farm setting. Successful adaptation of existing technologies has led to recent advancements in soil characterization tools and groundwater monitoring and protection that will enable ORP to better understand, mitigate, and treat existing contamination plumes (Figure 3-5).

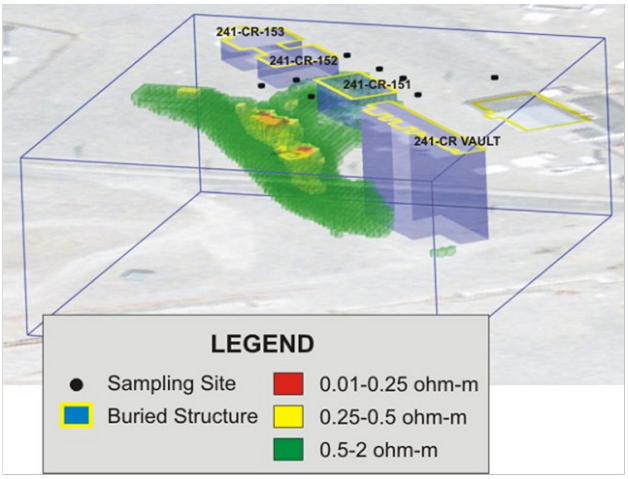


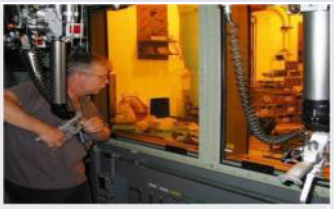
Figure 3-5. Subsurface Contamination Plume

Recent vadose zone program activities have focused on providing support for planned WMA C closure in 2019 (discussed in Section 2.3.3), characterizing a number of areas for the placement of interim surface barriers, installation of the TY Farm interim surface barrier (discussed in Section 1.5), and several significant technology development and field implementation efforts. Additional details are provided in System Plan (Rev. 5), Section 3.1.9.

3.1.9 Recovery Act Projects

Passage of the ARRA, also referred to as the Recovery Act (RA), provided a unique opportunity to significantly reduce life-cycle costs by making near-term investments in core mission activities. ORP received $326 million for use in FY 2010 and FY 2011 to improve facilities that handle liquid waste. ARRA funds were allocated to support 30 subprojects in five categories, as summarized in Table 3-6.

Table 3-6. Recovery Act Projects

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

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

All 30 RA projects were started by June 1, 2010. As of February 28, 2011, six projects have been completed. The remaining 24 RA projects still in progress are scheduled to be completed on or before September 30, 2011.

3.2 TREATMENT

3.2.1 Supplemental Transuranic Treatment Facility

Status: Early Design

Twenty tanks (17 SSTs and three DSTs) have been evaluated by the Tank Operations Contractor as containing waste that DOE could potentially designate as TRU waste based on analytical reports that identified the origins of the waste in those tanks. In all cases, the justification for the wastes being candidates for disposition as TRU waste is based on the sludge in the tanks originating from processes that do not fall within the NWPA definition of HLW (see Section 2.3.1), and the wastes containing alpha-emitting TRU radionuclides in concentrations defined as TRU waste in the *Waste Isolation Pilot Plant Land Withdrawal Act*. Of those 20 tanks, 11 SSTs contain contact-handled (CH) waste and nine contain remote-handled waste. DOE has not taken steps to formally designate the waste as TRU, but could do so after the TC & WM EIS ROD is issued.

The Baseline Case assumes that eleven SSTs will be handled as potential CH-TRU tank waste and that waste will 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.[38]

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

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

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[38] Final disposition of the treated potential CH-TRU tank waste could be disposal at WIPP near Carlsbad, New Mexico. To do so, DOE would need to submit a WIPP RCRA Part B permit Class III permit modification request (PMR) to the New Mexico Environment Department for approval. Waste that is approved via the PMR process for disposal at WIPP would 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 PMR approval to dispose of this waste at WIPP, or if the PMR is denied, that waste could be blended with other Hanford sludge waste and processed in the WTP as HLW. This option was explored in Case 2 and is discussed in Section 10.2.

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

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

The technical and programmatic assumptions for the potential TRU tank waste treatment system are included in Appendix B, Section B3.4.2.

3.2.2 Waste Treatment and Immobilization Plant

Status: Design and Construction

The WTP (Figure 3-6) is currently being designed and built by BNI. There are five main facilities within the WTP project: the PT Facility, HLW Vitrification Facility, LAW Vitrification Facility, dedicated Analytical Laboratory, and the balance of facilities (BOF), which includes supporting infrastructure systems such as air, water, electrical, power, fire protection, and others. As of February 2011, construction of the WTP is 57 percent complete.

Figure 3-6. Hanford Waste Treatment and Immobilization Plant

The WTP will generate secondary solid and liquid waste streams. The secondary solid waste (e.g., spent LAW melters, spent ion-exchange resin, HEPA filters, carbon absorbers, silver mordenite columns) is assumed to be disposed of in the IDF (see Section 3.4.1). A disposal path for spent HLW melters has not yet been identified (see Table 7-8, Item 7.8-10). The secondary liquid waste is assumed to be treated at the ETF (see Section 3.2.4). More detailed planning assumptions are provided in Appendix B.

The current status of the WTP facilities is briefly described in the subsections that follow. Recent changes in project controls accounting resulted in changes in the calculation of percent complete statistics. The figures reflected below more accurately represent actual status, and are not directly comparable to figures reported in System Plan (Rev. 5).

3.2.2.1 Pretreatment Facility

The WTP PT Facility will receive both HLW feed and LAW feed from the tank farms. Specific pretreatment processes include concentration, ultrafiltration, caustic and oxidative leaching, and subsequent separation of the waste into two streams: a HLW fraction for treatment at the HLW Vitrification Facility, and a LAW fraction for treatment at the LAW Vitrification Facility.

The WTP PT Facility also has the capability to precipitate complexed ^{90}Sr and TRU elements to avoid having those constituents partition to LAW. These complexed wastes would have to be segregated from other streams during pretreatment, and the precipitate intentionally blended with pretreated HLW sludge that is high in ^{89}Sr content to force the ^{90}Sr to precipitate. However, implementing this process in the ultrafiltration feed vessels was expected to cause a delay of approximately six to 24 months in HLW processing, since those same vessels are also used for sludge processing (RPP-RPT-48340, *Evaluation of Alternative Strontium and Transuranic Separation Processes*). Therefore, current plans are to precipitate the strontium and TRU elements in the DST system prior to transferring the waste to WTP. Additional details are provided in Appendix B, Assumption B3.2.2.9.

In 2010, ORP selected the "equipment alternative" to resolve anticipated post-filtration precipitation issues in the PT Facility (Williams 2010). The potential for solids to form after ultrafiltration was initially identified during a flowsheet assessment of the effect of External Flowsheet Review Team (EFRT) issue M-12 modifications performed in 2007. Subsequent large-scale laboratory testing confirmed that solids may form at this juncture. The downstream cesium ion-exchange process system (CXP) is designed for solids-free liquid, so the presence of solids in post-ultrafiltration permeates posed a significant issue. Primary concerns included accumulation of solids in vessels designed for solid-free liquids, difficulty operating the ion-exchange (IX) columns, accumulation of solids and possible plugging of downstream process lines, potential carryover of ^{137}Cs in excess of the LAW stream limits, and enhanced corrosion or maloperation in the cesium nitric acid recovery process system evaporator. Post-filter precipitation was determined to be influenced by four distinct factors: temperature, kinetics, the common ion effect, and chemical reactions, all of which must be balanced to minimize and mitigate solids precipitation in the CXP system.

The equipment alternative was developed to fully address the precipitation issue using equipment changes, mostly to piping, without altering the black cell vessels. The new arrangement provides mixing and temperature control for all filtrate vessels with a pumped recycle loop that allows representative sampling and a broad range of IX column pumping capability.

It also retains the baseline flowsheet ability for either up-front or back-end caustic leaching. In particular, the changes:

- Eliminate 99 percent of precipitates by first heating waste passing through the ultrafiltration system, then diluting with water and hydroxide as needed
- Add polish filtration just before the IX columns
- Swap the functions of two vessels (with piping changes) so that all filtrate vessels have pulse jet mixers and can tolerate precipitates
- Install piping to combine four previously separate vessels into one recirculation loop for inventory control, temperature control, sampling, and broader IX column pumping range.

These changes were also implemented in the HTWOS model in support of System Plan (Rev. 6). Additional information about the HTWOS model is provided in Section 4.0. Additional details about the equipment alternative are provided in 24590-WTP-RPT-PET-09-004, *Recommendation of Alternative to Mitigate Solids Precipitation in Ion Exchange Feed*.

As of the end of February 2011, the WTP PT Facility is approximately 46 percent complete. The near-term schedule forecast is:

Complete PT Facility design: April 8, 2015

Complete PT Facility construction: February 22, 2016

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

Figure 3-7. High-Level Waste Canister (left) and Low-Activity Waste Container (right)

3.2.2.2 High-Level Waste Vitrification Facility

The WTP HLW Vitrification Facility will immobilize the HLW fraction of the waste in glass, which is poured into HLW stainless-steel canisters (Figure 3-7). Each HLW canister will have ⅜-in. thick walls, and will hold 3.02 metric tons of glass (MTG) on average. The filled immobilized high-level waste (IHLW) canisters will be transferred to interim Hanford storage (IHS), and then transported to an off-site geologic repository for disposal. As of February 2011, the HLW Vitrification Facility is approximately 52 percent complete.

The near-term schedule forecast for the WTP HLW Vitrification Facility is:

Complete HLW Vitrification Facility design:	July 6, 2015
Complete HLW Vitrification Facility construction:	May 26, 2016

3.2.2.3 Low-Activity Waste Vitrification Facility

The WTP LAW Vitrification Facility will immobilize approximately 37 percent of the LAW fraction of the waste in glass (Section 3.2.3), which is poured into LAW stainless-steel packages (Figure 3-7). Each LAW package will hold 5.51 MTG on average. The filled ILAW containers are assumed to be transferred to the on-site IDF for disposal, consistent with final decisions to be reached in the TC & WM EIS ROD. As of February 2011, the LAW Vitrification Facility is approximately 64 percent complete. The near-term schedule forecast is as follows:

Complete LAW Vitrification Facility design:	September 18, 2008 (actual)
Complete LAW Vitrification Facility construction:	October 29, 2014

3.2.2.4 Analytical Laboratory

The WTP Analytical Laboratory and BOF will provide operational support to the PT, HLW, and LAW facilities. As of the end of February 2011, the Analytical Laboratory is approximately 46 percent complete. The near-term schedule forecast is as follows:

Complete Analytical Laboratory design:	June 17, 2013
Complete Analytical Laboratory construction:	December 16, 2013

3.2.2.5 Balance of Facilities

The WTP includes 20 support facilities, including the Glass Former Facility and collectively referred to as the BOF, which provide various utilities and other functions to support the PT, HLW, and LAW facilities (see Appendix B, Assumption B3.3.1.2). As of the end of February 2011, the BOF is nearly 46 percent complete. The near-term schedule forecast is as follows:

Complete BOF design:	October 9, 2015
Complete BOF construction:	January 25, 2016

3.2.3 Supplemental Treatment / Second Low-Activity Waste Facility

Status: Future Facility

System Plan (Rev. 6) assumes that a second LAW vitrification facility will be the outcome of the current Supplemental Treatment and Immobilization Program. However, alternative technologies are currently under consideration.

For years, the RPP baseline has relied on the WTP HLW Vitrification Facility processing capacity to “pace” the RPP mission; that is, the HLW Vitrification Facility capacity determines the overall length of the RPP mission, and all supporting activities are required to finish within the same timeframe. Annual costs to operate the RPP system are expected to be approximately $1 billion per year, so a strong financial incentive exists to complete the overall mission as soon as possible.

However, the WTP LAW Vitrification Facility capacity alone was never intended to treat the entire inventory of Hanford LAW waste in the same timeframe as the HLW can be treated. The WTP LAW Vitrification Facility will treat approximately 37 percent of the LAW waste; additional capacity was always envisioned to treat the remaining 63 percent.

Although work related to supplemental treatment needs had begun previously, the Supplemental Treatment and Immobilization Program was formalized via direction from DOE Office of Environmental Management (EM) in January 2011 (Triay 2011). This program is divided into two subprojects, one each for treatment and immobilization.

The supplemental treatment project will evaluate the need to provide additional pretreatment capacity to facilitate mission acceleration and reduce mission life-cycle costs. LAW treatment must provide the means to remove solids and remove cesium. Technologies initially considered for solids removal include cross-flow filtration and RMF. Technologies initially considered for cesium removal include caustic side solvent extraction, IX, and fractional crystallization.

The supplemental immobilization project will evaluate potential immobilization technologies to convert the treated LAW into an immobilized form suitable for disposal at the IDF; one preferred technology and one alternate (backup) technology will be selected. Technologies initially considered for immobilization included joule-heated melter vitrification (which is already planned for use in the WTP LAW Vitrification Facility, and is assumed to be the technology deployed in a second LAW facility), cast stone, FBSR, and bulk vitrification.

The supplemental treatment and supplemental immobilization projects have their own schedule, each following the CD process (Table 3-7). CD-0, justification of mission need, was approved in January 2011 (Triay 2011). Both projects are currently working towards CD-1, alternative selection, with the remainder of their project schedules planned to support startup of the chosen technologies by 2018.

This revision of the System Plan assumes the second (supplemental) LAW vitrification facility will begin routine operations on October 1, 2022 (Appendix B, Assumption B3.4.1.6). This is one year later than the System Plan (Rev. 4) assumed startup date, which served as the basis for the second LAW facility schedule in the PMB. For the purposes of modeling the life-cycle cost and schedule for the System Plan (Rev. 6) Baseline Case, activities in the PMB associated with the second LAW facility were delayed by one year (consistent with the LCM methodology of delaying project schedules to as-late-as possible, see Section 1.10).

Table 3-7. Supplemental Treatment and Immobilization Project Schedules

Milestone	Date
Supplemental Treatment Project	
CD-0 approval	January 2011
CD-1 approval	September 2011
CD-2 approval	December 2012
CD-3 approval	August 2014
CD-4 approval	July 2017
Start operations	January 2018
Supplemental Immobilization Project	
CD-0 approval	January 2011
CD-1 approval	September 2012
CD-2 approval	March 2014
CD-3 approval	July 2015
CD-4 approval	January 2018
Start operations	November 2018

CD = critical decision.

Therefore, the supplemental treatment and immobilization schedule used for the Baseline Case cost and schedule analysis is consistent with the PMB (which includes CD-2 through CD-4 for a second LAW facility), but is delayed by one year.

The Baseline Case assumes that the flowsheet for a second (supplemental) LAW vitrification facility would be similar to the flowsheet for the LAW Vitrification Facility currently being constructed by the WTP project. Based on the assumptions used for the Baseline Case, the design capacity of the second LAW facility was selected as six 15 MTG/day melters (90 MTG/day total) yielding a net capacity of 63 MTG/day after application of a 70 percent total operating efficiency (see Section 5.6.3.1 for a discussion on how this capacity was selected). This capacity is three times the WTP LAW Vitrification Facility capacity. The new facility would be designed, constructed, and operated separately from the WTP LAW Vitrification Facility.

The required capacities of the supplemental treatment and immobilization projects will be determined with consideration of technical and programmatic uncertainties (e.g., the amount of sodium in the pretreated LAW) and opportunities (e.g., potential improvements in LAW glass formulation).

3.2.4 Liquid Effluent Retention Facility/Effluent Treatment Facility

Status: Operational

The LERF, shown in Figure 3-8, is designed to store 242-A Evaporator process condensate and other dilute liquid waste streams for treatment at the 200 East Area ETF. The ETF provides for the collection, treatment, and storage of low-level mixed wastes and the disposal of treated wastes meeting applicable state and federal permit requirements. The LERF/ETF has a final status RCRA Part B permit.

In addition to the waste streams already being collected, treated, and disposed at LERF/ETF, liquid effluent secondary wastes generated during waste treatment operations (WTP, supplemental LAW treatment, and supplemental treatment of potential TRU tank waste) will be sent to ETF for treatment and disposal, either as liquids at the State-Approved Land Disposal Site (SALDS) or as a solidified waste form at the IDF. A new solidification treatment unit has been proposed for the ETF, which would produce an acceptable waste form for disposal at IDF. However, there are significant uncertainties (see Table 7-8, Item 7.8-16) associated with the projected characterization and predicted groundwater impacts of these secondary waste streams.

In 2008, ORP requested that the DOE Office of Waste Processing (EM-21) sponsor a workshop for developing a roadmap to outline the steps necessary to design the secondary waste form. Workshop participants included representatives from DOE, EPA, Ecology, NRC, Oregon Department of Energy private consultants, and technical experts from DOE national laboratories and academia.

Figure 3-8. Liquid Effluent Retention Facility/Effluent Treatment Facility

The participants focused on three areas: regulatory drivers, waste composition, and waste forms. Their efforts culminated in a roadmap of proposed actions (PNNL-18196, *Hanford Site Secondary Waste Roadmap*) necessary to address regulatory and performance requirements, waste composition, preliminary waste form screening, waste form development, process design and support, and validation. Successful implementation of the roadmap will lead to the selection of a compliant, low-cost waste form for disposal of secondary wastes. Candidate waste forms are currently being tested to determine their capabilities for waste loading, retention of contaminants, and compliance with IDF waste acceptance criteria.

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

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

3.3 STORAGE ONSITE AND SHIPPING

3.3.1 Interim Hanford Storage

Status: Future

IHS will receive and temporarily store canisters of IHLW, with the IHLW canisters subsequently retrieved and transported to the Hanford Shipping Facility (HSF) in preparation for shipment to a national repository. Initially, IHS will provide storage for 4,000 canisters, which would support WTP operations through March 2031. Additional modules, each with a 2,000-canister capacity, can be built as needed until reaching its maximum capacity of 16,000 canisters. This expansion capability mitigates the risk associated with the uncertainty regarding the availability of a national repository.

IHS will be located in 200 East Area. Four possible alternatives for storing the canisters are being evaluated:

- Below-grade storage vaults, similar to those used at the Savannah River Site
- Open-rack storage similar to the storage bay at the WTP HLW Vitrification Facility
- Outdoor dry-cask storage similar to spent-fuel storage at nuclear power plants
- Retrofitting the existing Canister Storage Building in 200 East Area.

The preferred alternative will be identified in FY 2011. Conceptual design is scheduled to be completed in FY 2012, with the IHS becoming operational in November 2018. The technical and programmatic assumptions for IHS are included in Appendix B.

3.3.2 Hanford Shipping Facility

Status: Future Facility

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

3.3.3 Central Waste Complex

Status: Operational

The CWC in the 200 West Area provides compliant interim storage for containerized LLW and mixed LLW pending on-site disposal, and solid TRU waste awaiting treatment and pending determination of final disposition. The CWC began waste management operations in August 1988 and is an interim status RCRA facility.

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

The CWC is not modeled in HTWOS, however, the costs associated with the staging, storage, and loading of shipments of potential CH-TRU tank waste is addressed by the PMB and the LCM. It is assumed to provide, to the extent practical, permitted waste storage and characterization for the potential TRU tank waste that may be packaged by the supplemental TRU treatment system.

3.4 DISPOSAL ONSITE

3.4.1 Integrated Disposal Facility

Status: Construction Complete (200 East Area)

The IDF is planned to be operational on September 28, 2018, per the current PMB. Consistent with final decisions reached based on the analyses in the TC & WM EIS and documented in the ROD, the IDF would provide on-site disposal of:

- ILAW[39] from WTP
- Mixed waste generated through waste operations

[39] ORP will seek a treatability variance for the ILAW waste stream pursuant to 40 CFR 268, "Land Disposal Restrictions."

- Other LLW
- Spent or failed LAW and HLW melters[40] from the WTP
- Alternative ILAW forms (e.g., those generated from bulk vitrification, if implemented, or by the ETF).

The Tank Operations Contractor will provide transport of spent or failed melters and ILAW packages from the WTP to the IDF. The initial phase of the IDF has been constructed; however, final decisions about using the IDF for ILAW disposal, or whether to construct an IDF in the 200 West Area, will not be made until the final TC & WM EIS has been issued and a ROD is published. The Hanford Facility RCRA permit will require modification, as it currently only addresses disposal of ILAW packages and roll-off boxes from bulk vitrification.

The IDF (Figure 3-9) is located in the 200 East Area, southwest of the Plutonium-Uranium Extraction (PUREX) Plant. The facility consists of a single landfill with two separate, expandable cells that would be used if and when the additional capacity is needed. One cell (Cell 1) is permitted as a RCRA Subtitle C landfill system and designed in accordance with Washington Dangerous Waste Regulations; this cell may receive dangerous and/or hazardous waste, specifically mixed LLW. This waste includes the ILAW from WTP and bulk vitrification, the spent or failed melters, and ETF secondary waste. The other cell (Cell 2) would not receive dangerous and/or hazardous waste; it would receive only LLW. Both cells include a double-liner system, leachate collection and removal systems, and a leak-detection system. Key issues and uncertainties associated with the IDF are included in Section 7.0, Table 7-8. The technical and programmatic assumptions for the IDF are included in Appendix B.

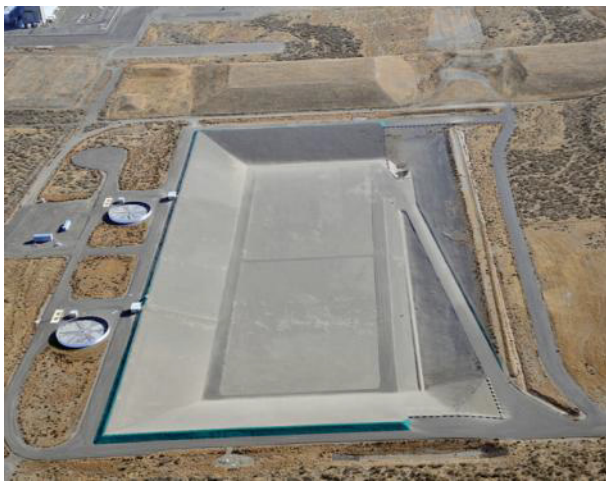

Figure 3-9. Integrated Disposal Facility

3.4.2 State Approved Land Disposal Site

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

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

[40] Final disposition of HLW melters has not been determined. The TC&WM EIS assumes storage of the HLW melters onsite pending a WIR determination, which will be required when they are taken out of service (see Appendix B, Assumption B3.5.6.2).

3.4.3 Environmental Restoration Disposal Facility

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

Figure 3-10. The Environmental Restoration Disposal Facility Trench Layout

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

ERDF operations began in July 1996. The facility is designed as a multi-cell burial trench that can be expanded over time to add more cells. Initially only two cells (Cells 1 and 2) were constructed. Four additional cells (Cells 3 through 6) have been constructed since operations began, and there are plans to build four more cells during the future operation of the facility. Additional cells beyond these ten may also be added in the future as needed. The trench layout is shown in Figure 3-10. ERDF is projected to receive up to 5,960,000 m^3 (7,800,000 yd^3) of waste when all ten cells have been built.

3.5 DISPOSAL OFFSITE

3.5.1 Potential Transuranic Tank Waste

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

3.5.2 Final High-Level Waste Disposal Alternative

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

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

3.6 222-S LABORATORY

Figure 3-11. 222-S Laboratory

The 222-S Laboratory is a full-service analytical facility located in 200 West Area that handles highly radioactive samples (Figure 3-11). Organic, inorganic, and radio-chemistry analyses are performed on a wide variety of air, liquid, soil, tank waste, and biota samples. The laboratory provides support for a variety of essential tank farm activities, including tank-to-tank transfers, corrosion rate studies, and chemical testing to support tank corrosion inhibition, and input to the engineering specifications for each 242-A Evaporator campaign. The 222-S Laboratory also studies the physical and chemical characteristics of waste necessary to enable waste retrievals, provides data to support tank closure requirements, and supports the vadose zone program. In addition, 222-S Laboratory maintains the ability to analyze low-level and non-radioactive samples in support of developmental and industrial hygiene activities. A small business contractor (ATL) provides a service for routine analytical support at the laboratory.

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

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

3.7 WASTE FEED INTERFACE

The most significant interface associated with the work described in this System Plan is the WTP feed delivery interface. Timely, efficient, and compliant delivery of waste feed from the tank farms to the WTP is the key interface component affecting the success of the ORP mission. Several activities are in progress to strengthen this interface and further ensure smooth operations:

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

- A dedicated feed line for delivery of LAW feed to WTP is now planned. This line will physically isolate the AP Farm LAW feed staging tanks from any cross-connection to transfer lines used for HLW. This arrangement will preclude a human error (misrouting) that could have sent HLW to the WTP PT Facility LAW feed receipt tanks, ensuring that no additional solids become entrained in the LAW feed.
- An FCCF has been proposed and may be included in future planning efforts, pending direction from ORP. The FCCF would provide vessels designed specifically to support waste mixing, blending, sampling, and filtration of retrieved wastes to provide more uniform feed to WTP.
- A Waste Feed Interface Project Team has been created, comprised of key personnel from ORP, WRPS, URS, and BNI. Their charter is to identify and plan for the resolution of any technical, administrative, or operational gaps that would interfere with the preparation, sampling, characterization, qualification, and timely delivery of HLW and LAW feed to the WTP.
- WRPS and BNI have jointly proposed a 2020 Vision One System strategy to support DOE's request for an integrated approach to begin LAW tank waste treatment in 2016 and to achieve WTP initial plant operations by 2022 to meet the Consent Decree (08-5085-FVS) commitments. This strategy includes alignment of contracts, incentives, resources, projects, and funding profiles to meet these objectives. An initial technical approach was developed for the proposal to balance LAW and HLW tank waste processing prior to availability of supplemental LAW treatment capacity in 2022. Case 5 further refines this technical approach and provides results than can be directly compared with the Baseline Case. DOE is currently reviewing the proposal and rough-order-of-magnitude cost estimate submitted by WRPS and BNI on March 21, 2011 (Spencer and Russo 2011).

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4.0 MODELING TOOLS

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

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

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

Two dynamic models are at the heart of flowsheet planning for the RPP system. WRPS uses the HTWOS model, a dynamic event-simulation model programmed using the G2[41] programming language, to track the waste as it moves through storage, retrieval, feed staging, and multiple treatment processes from the present day until the end of the RPP mission. The HTWOS model forecasts the outcomes of various proposed operating scenarios, including the quantities and composition of the primary and secondary waste streams, the timing of key process steps, life-cycle system mass balances, and mission end dates. BNI uses the WTP Dynamic (G2) model to evaluate WTP facility equipment utilization, unit operations and plant performance, and to support process and facility design decisions, integration with the tank farms, and other activities.

Two operations research (OR) models are also planned or in use. WRPS is currently developing a detailed WFD OR model using WITNESS[42] software, which will address equipment reliability, availability, and maintainability for the DSTs, the 242-A Evaporator, and the waste transfer systems leading to WTP. As part of that effort, a simplified OR model of the WTP is being developed and integrated with the WFD OR model to allow evaluation of the effects of equipment failures on the combined WFD/WTP system. Results from this model will support operational planning, and the model is expected to be in use by the end of 2011. BNI maintains an OR model of the WTP, also using WITNESS, which simulates WTP operations. The BNI model is used to estimate the availability of the WTP systems.

A TOC LCM is also being developed. It will electronically link the HTWOS output database to schedule and cost-processing software to generate life-cycle cost reports, which will allow ORP to analyze the impact of technical or programmatic changes on RPP budget profiles and projected life-cycle costs and schedules. The new LCM tool was used to support portions of System Plan (Rev. 6).

4.1 DYNAMIC MODELS

4.1.1 Hanford Tank Waste Operations Simulator Model

The HTWOS model is a dynamic flowsheet simulation and mass balance model developed for ORP using the commercially available Gensym[43] Corporation G2 software.

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

The HTWOS model is currently maintained and operated by the WRPS Mission Analysis and Strategic Planning organization. HTWOS is used to:

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

The overall configuration of the major systems actively modeled in HTWOS for this System Plan is consistent with Figure 1-7 (Section 1.6), and includes:

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

HTWOS also has the ability to model[44] the following systems to explore potential changes to the Baseline Case:

- FCCF to support staging, sampling, and delivery of HLW feed to the WTP
- Supplemental treatment in the form of FBSR
- Supplemental pretreatment in the form of RMF and SCIX
- A new eight-tank DST farm.

The HTWOS model incorporates about 790 waste treatment vessels and operations, and unenumerated transfer and routing system segments. Model execution time for a full mission run is currently about eight hours. The initial waste inventory is established by the BBI, a compilation of tank waste data derived from historical process records and laboratory analysis. The BBI is updated quarterly and encompasses 25 chemical constituents and 46 radionuclides, plus numerous supplemental analytes. This data is compiled in TWINS, along with water wash and caustic leach factors and solubility correlations (details are provided in Appendix B, Section B3.6). The current data is loaded into HTWOS before starting each planning effort.

[44] Modules for several other facilities and processes, including fractional crystallization, the full ETF flowsheet, a demonstration bulk vitrification system, the bulk vitrification system, the East and West supplemental treatment plants, and an interim pretreatment facility have been used in the past, and could be reactivated if needed in the future.

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

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

Results from the model can be used to prepare flowsheets and mass balances for the entire mission or for parts of the mission. An overview of general input categories, case-specific input categories, and results categories are provided in Figure 4-1 (page 4-5). Of particular importance is the generation of the WTP feed vector, which describes the feed that the tank farms will be providing to WTP under the conditions modeled. The number of batches in a feed vector varies depending on the scenario being modeled, but generally is in the range of 300-400 batches for the overall mission. In general, each feed batch contains waste from several SSTs and DSTs. Feed vector details for each batch include the DST source (the specific DST) where the batch is staged immediately prior to transfer to WTP, the total waste volume, weight percent solids, waste feed composition data, leach factors, and other information. The feed vector can be used as input to the WTP Dynamic (G2) model. Additional information on the WTP Dynamic (G2) model is provided in Section 4.1.2.

From late 2010 through 2011, WRPS personnel implemented significant upgrades to HTWOS. These upgrades improved (1) the alignment between the model and current tank farm operating plans, (2) the alignment between the model and the WTP flowsheet, and (3) the capabilities of the model. Many aspects of HTWOS were affected, including the following.

- SST waste retrieval plans modeled in HTWOS are aligned with the assumptions, guidelines, and recommendations for SST retrieval planning described in RPP-PLAN-40145 and spreadsheet SVF-1647. These guidelines include the retrieval technologies, tank sequencing strategy, waste retrieval methods, as-retrieved waste volumes, minimum retrieval durations, and chemical additions for near-term SST retrievals.
- The 242-A Evaporator campaign logic has been modified to:
  - Ensure that the evaporator operates to produce at least 30 gal of slurry (concentrated bottoms) per minute when operating
  - Remove the requirements to perform a “cold run,” if the interval between evaporator campaigns exceeds 11 months.

- HTWOS dynamically assigns allowable functions (e.g., dilute receivers or HLW feed staging) to DSTs based on installed equipment, established operating criteria, equipment capabilities, and evolving system demands. The functional flow block diagram for the operation of the DSTs has been improved to better simulate many areas of DST operations and to simulate proposed future constraints or improvements.
  - The function or role of each DST will be defined by the capabilities of its installed equipment, in accordance with RPP-40149. In addition, the availability of each tank for service will be determined by its construction schedule for equipment installation and its current waste inventory.
  - A dedicated LAW feed line was added and the model constrained to provide all LAW feed, except for the hot commissioning feed, from a subset of the AP Farm tanks to minimize the amount of HLW solids in the LAW feed transfers to the WTP.
  - Solids entrainment assumptions for supernate transfers were updated based on a review of RPP-RPT-49362, *Entrained Solids in Double-Shell Tank Transfers*.
  - Constraints were added to the model to minimize the formation of deep sludge tanks and to impose time constraints associated with the incremental insertion of mixer pumps when removing solids from a deep sludge tank.
  - Improvements in the operation of the DSTs have also increased the degree of sludge blending, both incidental and intentional, using only the existing tank space. This is expected to increase the waste oxide loading and reduce melter feed variability, thereby reducing the total mass of glass predicted, which in turn shortens the waste treatment project duration and reduces life-cycle costs.
- In HTWOS, the WTP flowsheet (equipment configuration, capacities, chemical reactions and extents, operating modes and logic, process splits and decontamination factors) used for mission modeling was updated to better reflect the planned WTP flowsheet, and to match naming conventions between the two models. Certain simplifications and changes from the WTP flowsheet were made, as discussed in Appendix B.
- The model and supporting software were modified to improve its fidelity and reliability, and to resolve a variety of minor modeling issues.
- The model was modified to facilitate the evaluation of the following proposed additions or changes to the mission:
  - Construction of a dedicated LAW feed delivery line to WTP
  - Use of an FCCF[45]
  - Supplemental treatment in the form of FBSR
  - Supplemental pretreatment in the form of RMF and SCIX
  - Construction of a new DST farm.

[45] An FCCF was initially included as a model improvement in HTWOS, but during early System Plan (Rev. 6) development, it was removed from the Baseline Case to maintain consistency with the PMB, and to avoid unacceptable near-term cost impacts. The FCCF remains a potential mitigating action for mixing and sampling risks.

The 2009 GFM in HTWOS was updated to optionally allow for enhanced formulation of HLW glass using the glass composition and glass property constraints from PNNL-19372, *Glass Composition Constraint Recommendations for Use in Life-Cycle Mission Modeling*. This enhanced GFM supplements the nepheline discriminator with an optical basicity limit.[46]

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

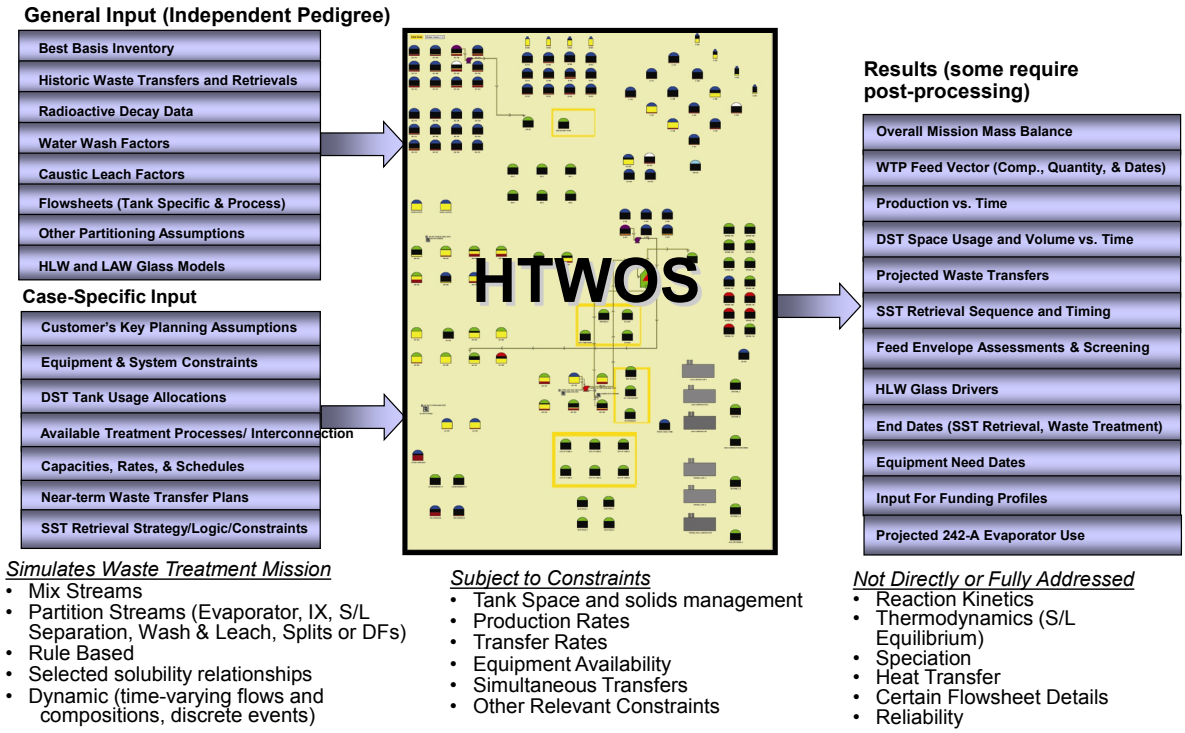

Figure 4-1. Hanford Tank Waste Operations Simulator

Detailed descriptions of the key assumptions and success criteria used to develop this System Plan are provided in Appendix B. RPP-17152, *Hanford Tank Waste Operations Simulation (HTWOS) Version 6.61 Model Design Document*, documents how these assumptions were incorporated into the HTWOS model and provides more detailed modeling assumptions and descriptions of how the model works.

4.1.2 Waste Treatment and Immobilization Plant Dynamic Model (G2)

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

- Evaluate WTP tank and equipment utilization, unit operation, and plant performance
- Predict reagent demand
- Evaluate WTP process and facility design

[46] A GFM is a collection of empirical property correlations and their associated limits and a set of model validity and solubility limits. Given a pretreated HLW feed, the GFM can predict the amount and composition of the resulting HLW glass. This information assists in predicting mission duration and long-term disposal requirements.

- Support preoperational planning assessments
- Support technical integration with the tank farms regarding waste feed staging
- Support product and secondary waste acceptance activities.

In addition to the WTP feed vector from HTWOS, input to the WTP Dynamic model includes vessel volumes, pump flow rates, chemical reagents, sampling turnaround times, and appropriate research and technology data (e.g., filter flux data and melter off-gas data). Output data includes waste batch delivery predictions; volume history data, with plots for each vessel; sodium molarity and weight percent solids for each process vessel; cumulative mass transfer for every process stream; cumulative glass production; and waste loading and limiting constituents of glasses. These data are interpreted to determine utilization rates for chemical reagents, process condensate, and demineralized water; utilization of cesium IX resin; utilization of mineral glass formers; the volume and composition of pretreated LAW and LAW submerged bed scrubber recycle to a second (supplemental) LAW facility; and the volume and composition of waste water discharge.

Additional information about the WTP Dynamic G2 model is provided in 24590-WTP-MDD-PR-01-002, *Dynamic (G2) Model Design Document*, and the underlying process flowsheet described in 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements*.

4.2 OPERATIONS RESEARCH MODELS

4.2.1 Waste Feed Delivery Operations Research Model

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

The WFD OR model is being created using WITNESS, a commercial off-the-shelf process simulation software developed by the Lanner Group. The WFD system specifically includes the 28 DSTs, the 242-A Evaporator, and numerous waste transfer lines, pump pits, valve pits, jumpers and valves; in all, over 600 system components are represented. The availability data for the various systems and equipment has been derived from actual operating experience at Hanford, from similar experience at Savannah River Site, and from generic reliability databases when no indigenous source could be found.

Model development is proceeding in phases:

- **Phase 1** – The initial version of the WFD OR model, Phase 1, was developed to repeat the DST waste transfers as predicted by a simplified version of the HTWOS model run for the System Plan (Rev. 4) Unconstrained Case. By repeating the HTWOS sequence of events, the WFD OR model was able to incorporate most of the assumptions that form the basis for the HTWOS model run. This phase was completed in September 2009.

- **Phase 2** – In addition to modeling equipment failures, the Phase 2 OR model includes restoration times and then estimates the effects of failures on mission duration. Bottleneck analyses have been performed to identify those systems that contribute the most to mission delays. These systems are waste transfer pumps, waste transfer lines, and waste transfer jumpers. This information will be used to update WFD maintenance systems and potential designs to improve their reliability and availability. WITNESS is used to simulate equipment failures based on the reliability assumptions for each piece of equipment to estimate the impact on the WFD system. The reliability and restoration data is a combination of Hanford-specific data, applicable Savannah River Site data, and generic data chosen by examination of Hanford operating experience. Phase 2 was completed in August 2010 (RPP-RPT-45827, *Phase 2 Waste Feed Delivery Operations Research [OR] Model Assessment Report*).
- **Phase 3** – The Phase 3 model improves on the Phase 2 model by removing the excessive conservatism of the Phase 2 model, which was the result of the simplified WFD model used in Phase 2. Like the previous two model versions, this model also uses an HTWOS transfer list as the basis for all waste movements. However, significant improvements to the model include the following.
  - Waste transfers within the WFD system are able to reorder themselves, within limits based on equipment availability.
  - Multiple, simultaneous waste transfers are able to occur, provided no limiting conditions are present, which is consistent with the HTWOS model input.
  - Waste transfers are able to utilize any available waste transfer route.
  - When applicable, waste transfers are able to reroute mid-transfer in response to an equipment failure.
  - Time constraints in the WFD system are explicitly modeled.
  - WTP processing, albeit simple, is modeled and includes equipment reliability based on published BNI data.

These changes will provide a more accurate prediction of the impacts of equipment failures. The inherent flexibility of the waste transfer system will be better used in this model. Additionally, equipment failures in either the WTP or WFD system will impact both the WTP and WFD system in this model. The Phase 3 effort is scheduled for completion by the end of FY 2011.

In FY 2012, the Phase 3 model is planned to be enhanced to include personnel resource constraints, impacts due to planned maintenance (including outages), and updates to the system plan assumptions. Sensitivity runs will be used to evaluate the expected effects of various actions to improve system availabilities, providing valuable input into operations and maintenance system improvement planning.

4.2.2 Waste Treatment and Immobilization Plant Operations Research Model

BNI maintains an OR model of the WTP as part of the WTP statement of work, as outlined in the WTP contract (DE-AC27-01RV14136). Similar to the WRPS WFD OR model, the BNI WTP OR model also uses Lanner's WITNESS software. The BNI model simulates WTP operations, including the PT, HLW, and LAW facilities, the Analytical Laboratory, and the Glass Former Facility, and is used to estimate the availability of these systems.

4.3 TANK OPERATIONS CONTRACT LIFE-CYCLE COST MODEL

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

Two separate software programs, HTWOS and Primavera Enterprise Project Portfolio Management[47] (P6), are used jointly to predict cost impacts. HTWOS defines the operating scenario by simulating field operations like waste transfers, retrievals, evaporator operations, and waste treatment processes. P6 tracks project resources, costs, and schedules, including earned value metrics, milestone dates, work breakdown structure (WBS) summaries, and other project management tools.

Each program serves its intended purpose well, but prior to development of the LCM, using them in tandem to predict life-cycle cost impacts was a time-consuming and error-prone manual process. The length of time required for generation of scenario input, completion of HTWOS model runs, and multiple iterations with P6 to generate a schedule with escalated costing data did not facilitate timely evaluation of life-cycle cost and schedule impacts. An automated link between the two programs would not only expedite the process, but it would also necessitate reconciliation of assumptions (both models incorporate RPP-specific assumptions, but there was previously no protocol for confirming that the assumptions in one model were fully consistent with the assumptions in the other model), and provide more reliable results generated from a verified and validated system.

In June 2010, a contract was awarded to develop and deploy an LCM tool that will create an electronic link between HTWOS and P6. The LCM model was developed in parallel with System Plan (Rev. 6) production, which allowed the new model to be used to support some of the planning efforts reflected in System Plan (Rev. 6). The Baseline Case cost profile was first generated using the manual process mentioned above, and then using the LCM. The two sets of results were compared to validate the new model. Once validated, the LCM was used to generate schedules and cost profiles for the nine remaining cases. All schedule and cost data presented in System Plan (Rev. 6) were generated by the LCM, as opposed to the manual process.

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

5.0 BASELINE CASE MODELING RESULTS

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

This section describes and evaluates the mission scenario based on the Baseline Case assumptions, and provides the technical basis for future revisions of the PMB and detailed plans and strategies. After a brief discussion of highlights and observations, the results for the Baseline Case are presented and organized according to the simplified process flow diagram in Figure 1-7 (Section 1.6) and the discussion in Section 3.0.

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

5.1 ASSUMPTION CHANGES FROM SYSTEM PLAN (REV. 5)

Many of the assumptions for the Baseline Case are the same as those used in the Baseline Case in the System Plan (Rev. 5). The more notable changes from these assumptions are described below.

Programmatic Assumption Changes

- The schedule for the IDF was delayed approximately eight years, adopting a just-in-time approach.
- The schedule for DST and infrastructure upgrades and the specific equipment and functions planned for each DST were aligned with RPP-40149-VOL1 (Strategy).
- One DST was dedicated to receive waste retrieved from the A Farm tanks; a separate DST was dedicated to receive AX Farm waste.
- The Aluminum Removal Facility was removed from the RPP mission flowsheet.
- The certification of 242-A Evaporator operators can be maintained without having to perform a cold run within 11 months of a waste campaign (see Appendix B, Assumption B3.2.4.2, and footnote 117.)
- A dedicated transfer line was used to deliver all the LAW feed to the WTP, with the exception of the first batch of hot commissioning feed.

Technical Assumption Changes

- The model for the WTP was realigned to the WTP flowsheet and design as represented by 24590-WTP-RPT-PT-02-005, except where superseded by the “equipment alternative” modification discussed in 24590-WTP-RPT-PET-09-004 or by other approved assumptions.
- SST retrieval assumptions were updated.
- The assumed solids handling capabilities and limitations during routine operation of the DST system were updated and aligned with RPP-40149, including:
  - Operational controls to minimize solids entrainment in supernate transfers

  - Operational controls for managing the accumulation of HLW solids to support waste retrievals from the C, A and AX Farms (i.e., manage the formation of deep sludge tanks)
  - Operational controls to minimize the formation of additional deep sludge tanks after the completion of waste retrieval from the A and AX Farms
  - Operational constraints associated with the incremental insertion of mixer pumps as required
  - An operational constraint for a minimum slurry rate of 30 gpm for the 242-A Evaporator.
- An intentional blending strategy called blind blending was implemented to reduce HLW glass mass and feed variability.
- A new approach was used to calculate the necessary capacity of a second LAW facility (Section 5.6.3.1 provides additional details).

Modeling Methodology Changes

- A TOC LCM was developed to prepare estimates of the schedule, life-cycle cost, and cost profiles for modeled scenarios.
- The process of transferring tank waste inventory data from TWINS into the HTWOS model was automated and streamlined.

5.2 METHODOLOGY

The detailed mission scenario for the Baseline Case was developed from a series of approximately 250 trial runs, resulting in about 80 documented HTWOS model runs. HTWOS Version 6.01 was first updated with the Baseline Case technical and programmatic assumptions provided in Appendix B, Section B3.0, and incorporated a number of modeling improvements. Then a series of iterations and alignments were performed, including:

- Aligning with near-term operational plans (SST retrievals, evaporator operation, DST transfers)
- Establishing the “bootstrap transfers” needed to prepare and stage the initial HLW feed batches for delivery to the WTP
- Establishing the capacity of a second LAW facility
- “Debottlenecking” the system by:
  - Adjusting the use of the DSTs over time to balance the supply of HLW and LAW feed to the WTP, while backfilling the newly freed DST space with waste from SST retrievals
  - Adjusting the SST retrieval schedule.

The verified model and the scenario resulting from the above series of runs became the final System Plan (Rev. 6) Baseline Case, and were subsequently released as HTWOS Version 6.61 (RPP-17152).

A summary of the model run requests for the Baseline Case, along with a listing of the associated spreadsheets and other results, is provided in RPP-RPT-48681, *Hanford Tank Waste Operations Simulator Model Data Package for the River Protection Project System Plan Rev. 6 Cases*, for traceability. These include reference to the corresponding WTP feed vectors, feed screening spreadsheets, and more detailed life-cycle mass balances.

5.3 HIGHLIGHTS

Table 1-1 (Section 1.3) summarizes and compares the key results from the Baseline Case with the other nine cases in terms of success criteria and other key metrics. Table 5-1 provides an overview of near-term funding for the Baseline Case.

Figure 5-1 shows the life-cycle cost profile for the Baseline Case and compares it to the PMB cost profile. Overall, the total life-cycle cost estimated for the Baseline Case is about the same as the total life-cycle cost in the PMB.

Table 5-1. Near-Term Funding Targets versus Results for the Baseline Case

Fiscal year	Target[a] ($M)	Case 1[a] ($M)
2011	410	394
2012	510	485
2013	510	462
2014	610	478
2015	710	621
Total	**2,750**	**2,440**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

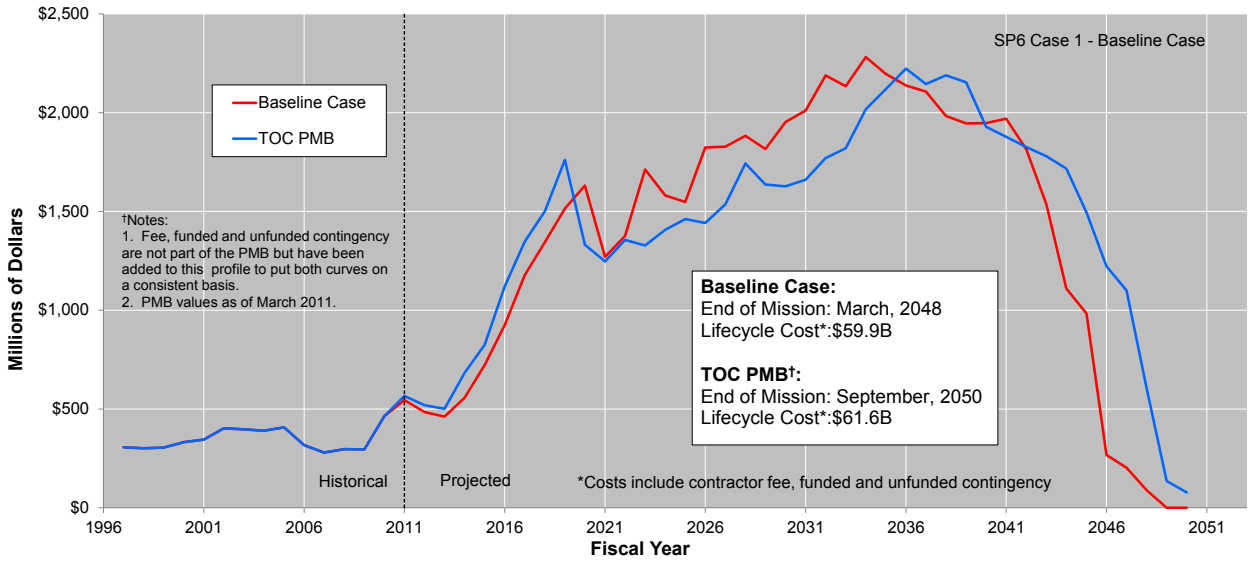

Figure 5-1. Life-Cycle Cost Profile for the Baseline Case

The differences in the life-cycle cost profiles are due to the following:

- The mission is completed about two years earlier in the Baseline Case, reducing the total life-cycle cost by $1.7 billion compared to the PMB.
- The increased costs for the Baseline Case in FY 2021 through FY 2036 result from an acceleration of the SST retrieval schedule when compared to the SST retrieval schedule used in the PMB, increases in the costs for the different retrieval technologies (e.g., the estimated costs for application of the MARS technology to retrieve wastes from selected SSTs), an added cost for a dedicated LAW feed line to the WTP, and from assigning costs to the DST-to-WTP feed transfers in the Baseline Case cost estimate. The acceleration in the SST retrieval schedule in the Baseline Case results from improvements in SST retrieval technology and in the management of DST space.
- Additional differences in how the costs are spread during the mission resulted from the use of different scheduling assumptions for the Baseline Case. Different scheduling assumptions were used to automate the preparation of the schedule and associated life-cycle costs for all the cases modeled in the System Plan (Rev. 6) document. In general, these assumptions moved the end of precursor project activities to coincide with the start of operations from HTWOS results, and terminated management and operations activities consistent with the operational completion dates from HTWOS.

Figure 5-2 provides a simple sodium mass balance for the Baseline Case.

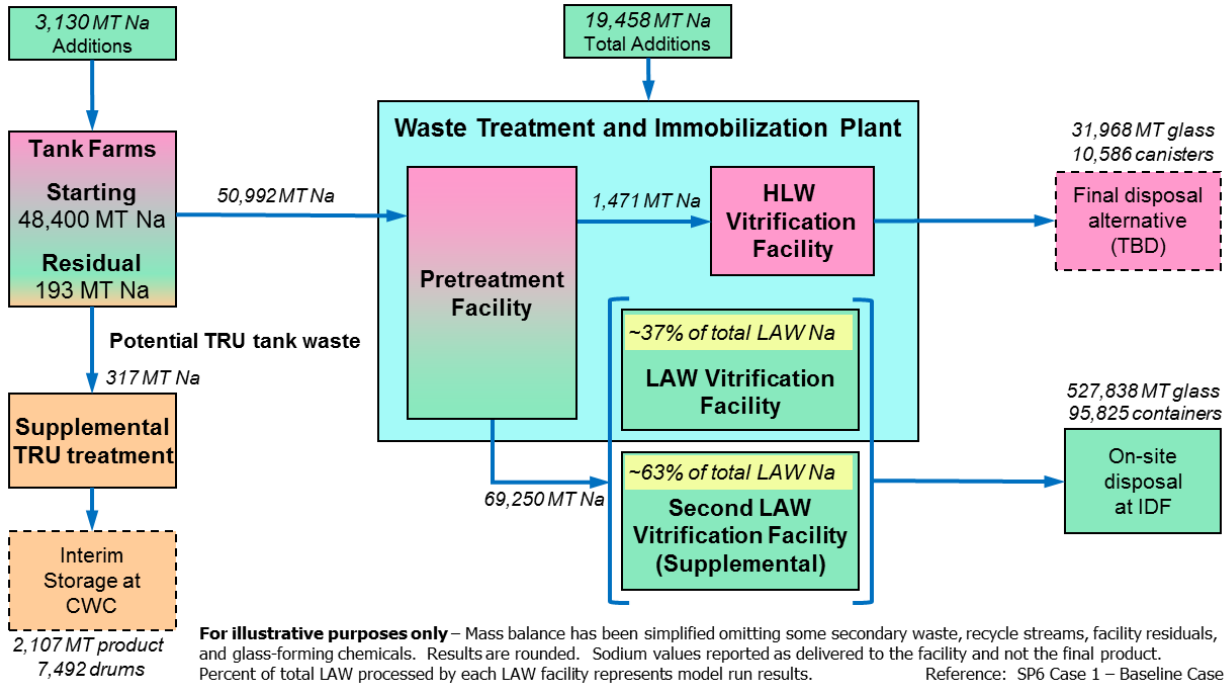

Figure 5-2. Simple Mass Balance for the Baseline Case

For the ease of the reader, start dates for several operating facilities have been included in Table 5-2.

Table 5-2. Key Start Dates

Facility	Facility available date (date of first use if different)
WTP hot commissioning Pretreatment HLW LAW	 6/11/2018 9/29/2018 8/18/2018
WTP routine operations	12/31/2019
B Complex WRF	7/2/2019 (11/26/2023)
T Complex WRF	6/30/2020 (7/21/2030)
242-A Evaporator	Active
Second LAW facility	10/1/2022
Potential CH-TRU tank waste processing	4/2/2018
Effluent Treatment Facility	Active
Interim Hanford storage	11/21/2018 (11/24/2019)
Hanford Shipping Facility	(6/14/2029)
Central Waste Complex	Active (4/5/2018)
Integrated Disposal Facility	9/28/2018

CH-TRU = contact handled transuranic.
HLW = high-level waste.
LAW = low-activity waste.
WRF = waste retrieval facility.
WTP = Waste Treatment and Immobilization Plant.

5.4 OBSERVATIONS

The Baseline Case is projected to meet all of the success criteria, with the exception of TPA milestone M-045-00, Complete Closure of All SST Farms. As in System Plan (Rev. 5), the date on which closure of all SSTs is completed is projected to be missed by slightly under a year. This is discussed further in Section 5.5.9.1.

For most of the waste treatment mission, the duration of the Baseline Case is driven by the HLW vitrification capacity, followed by the total LAW vitrification capacity and WTP pretreatment capacity. As discussed in Section 5.6.2.2, the modeled capacity of the Baseline Case may be at or near the pretreatment capacity for feed solids and may be at or above the pretreatment capacity for waste sodium. If the Baseline Case exceeds the achievable WTP PT Facility capacities, then the mission duration may increase or supplemental pretreatment capacity may be required.

In the early years, through 2030, the waste treatment mission is primarily driven by the total LAW vitrification capacity from both the WTP LAW Vitrification Facility and second LAW facility, which limits the amount of HLW that can be pretreated and prepared for vitrification. There may be periods between 2025 and 2030 during which the WTP PT Facility is limiting.

The management of DST space, up until all facilities have reached their full net capacities, is critical in maintaining progress with SST retrievals. After the retrieval of C Farm, waste must be staged to and concentrated in the 242-A Evaporator to make enough DST space to support the retrieval of the nine additional SSTs. A more detailed discussion of DST space management is provided in Section 5.5.2.1.

5.5 STORAGE

5.5.1 Single-Shell Tanks

The SSTs are projected to be retrieved by October 2039, with the C Farm retrievals being completed in December 2013.[48] Figure 5-3 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.

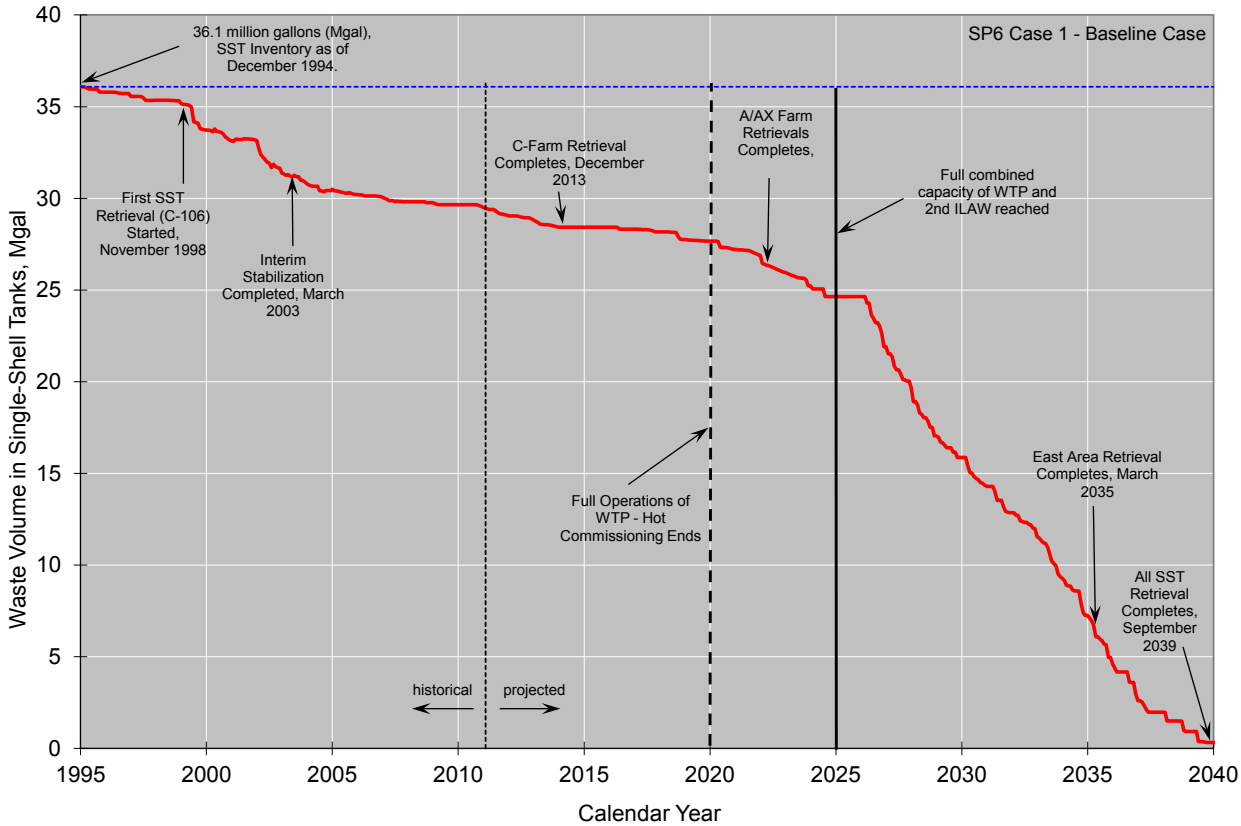

Figure 5-3. Overall Single-Shell Tank Retrieval Progress

As discussed in Section 5.5.2.1, the available DST space must be carefully managed to support SST retrievals between 2015 and 2020, and possibly through 2025. In addition, there is uncertainty in meeting the projected retrieval completion date for the nine additional SSTs (currently assumed to be from A and AX Farms).

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

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

Figure 5-4 shows the number of retrievals that were completed or are projected to be completed during each calendar year. During the execution of the mission, the number of retrievals averages about 1.4 per year in the near-term period (through 2013), slightly more than doubles to an average of three per year between 2015 and 2025, and then increases significantly after 2025 (approximately triples to an average of nine per year), when all treatment facilities are online at their full capacity. It may be possible to smooth out the peaks to the annual average values by carefully adjusting the detailed SST retrieval assumptions, or (pending approval by Ecology) by staging retrieved SST waste into sound, fit-for-use SSTs, as was explored in Section 10.8.

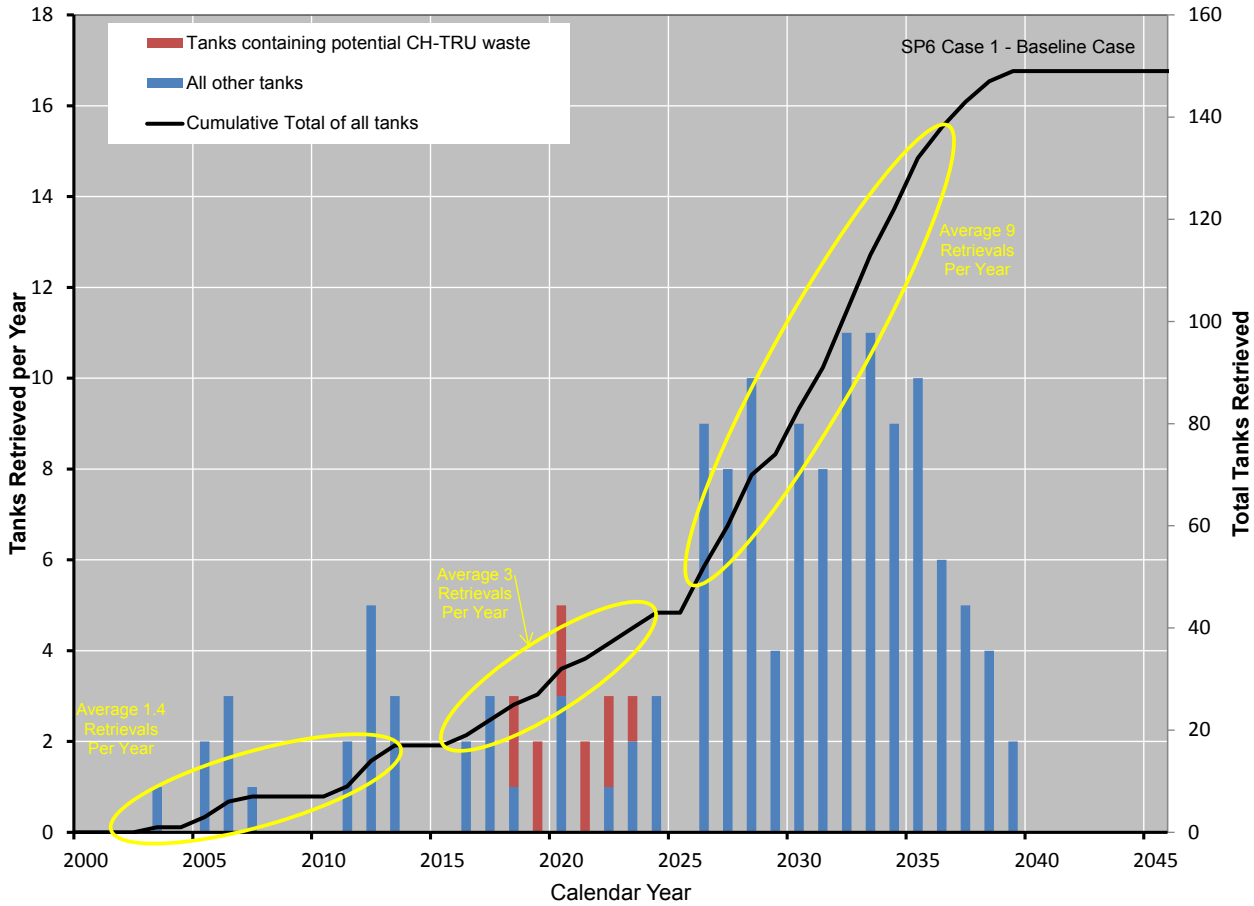

Figure 5-4. Single-Shell Tank Retrievals Completed Each Calendar Year

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

In the System Plan (Rev. 6) Baseline Case, an increase in the minimum-heel volume in DSTs containing HLW solids has increased the effectiveness of incidental blending, and the use of blind blending (a form of intentional blending) has contributed to further reductions in the HLW glass mass (see Section 5.6.2.5 for a discussion of the improvements). Even with these improvements, additional intentional blending scenarios using the farm-based retrieval approach may be examined in the future to attempt to further reduce the amount of HLW glass and the variability of HLW feed.

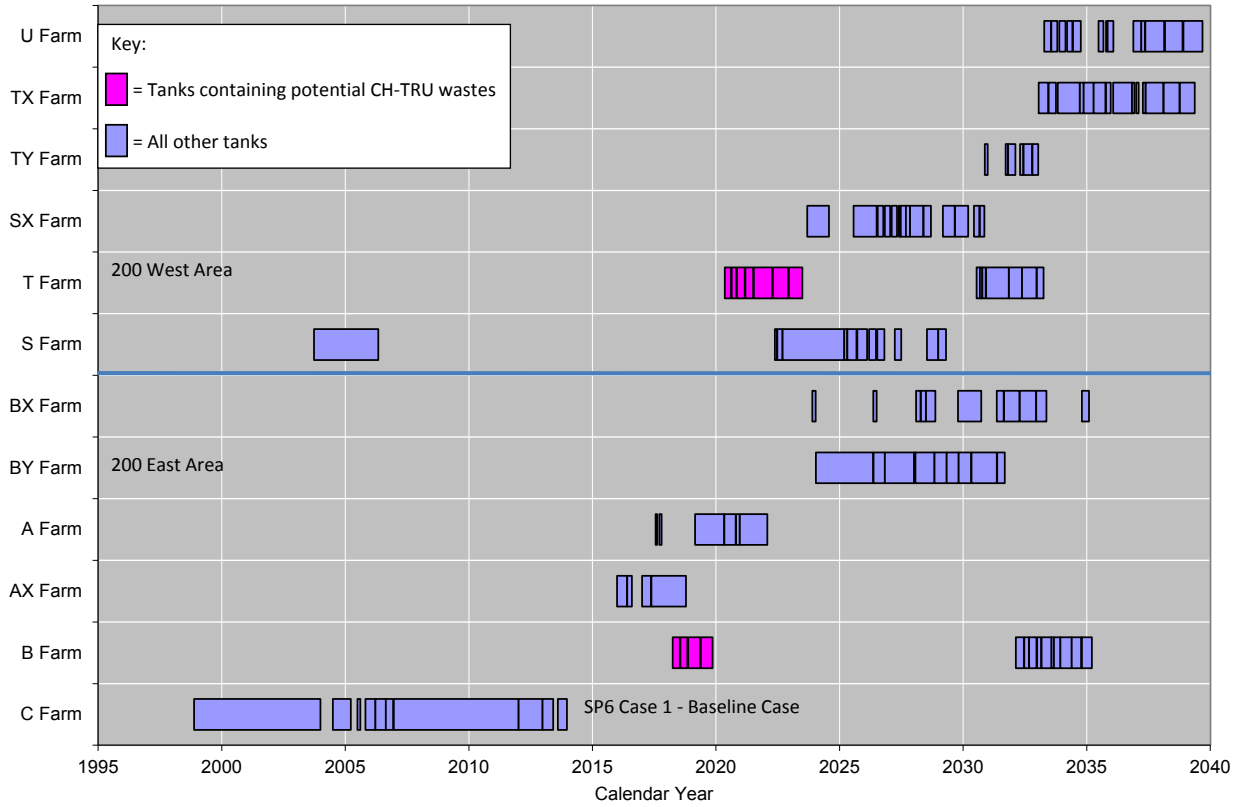

Figure 5-5. General Timing of Single-Shell Tanks Retrievals by Tank Farm

Figure 5-6 shows the sequence and timing of each SST retrieval. The DST tank space is extremely limited in the 2015 and 2025 time periods. Around 2015, the DSTs are near their total waste capacities, and the 242-A Evaporator is needed to make space for additional SST retrievals. Around 2025, the DSTs allocated for solids accumulation have been filled to their solids limits. A more detailed discussion on DST space management is provided in Section 5.5.2.1.

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

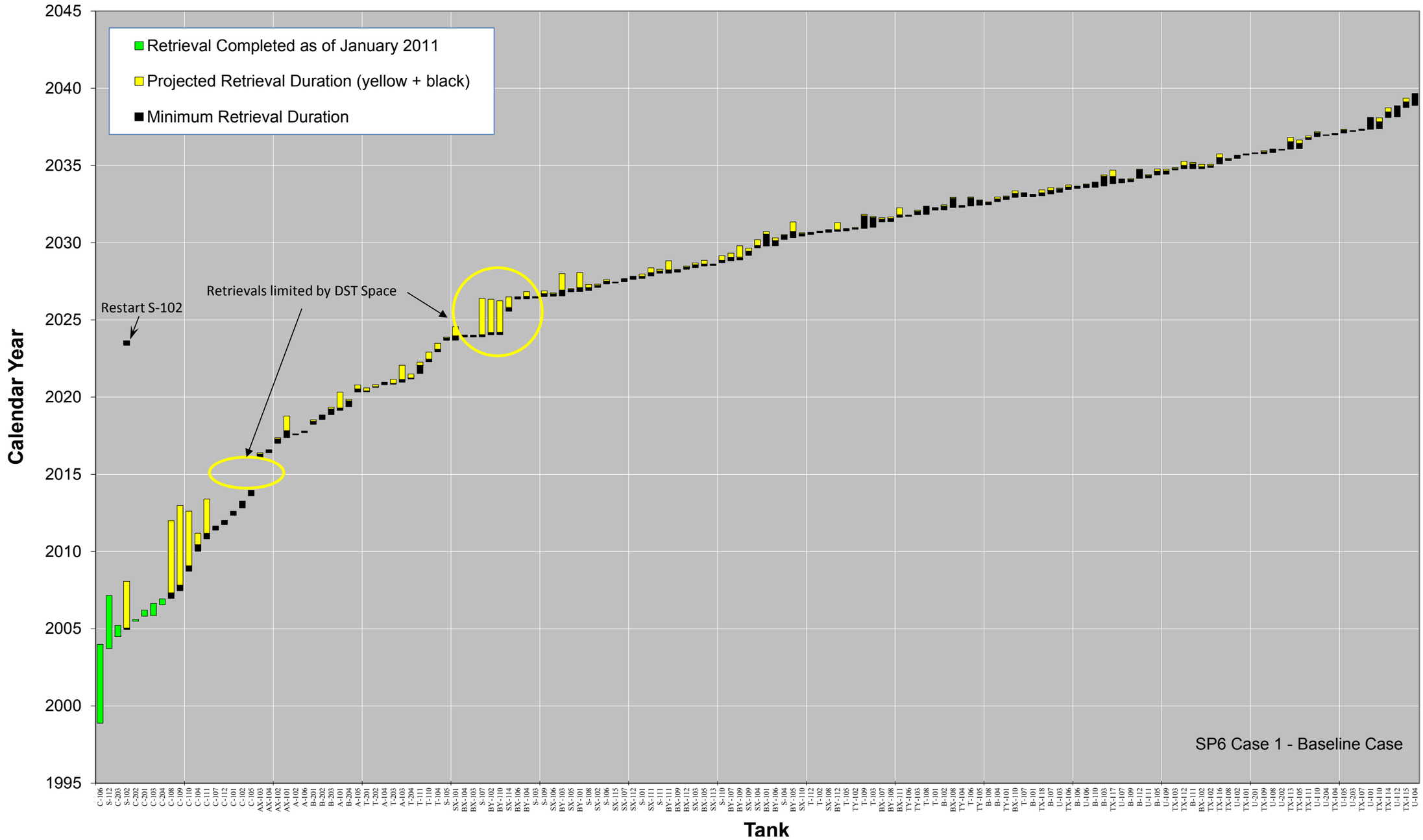

Figure 5-6. Single-Shell Tank Retrieval Sequence and Timing for the Baseline Case

5.5.2 Double-Shell Tanks

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

5.5.2.1 Double-Shell Tank Space Evaluation

Figure 5-7 shows the overall use of the DSTs for the overall waste treatment mission. It shows the total DST capacity,[49] the total volume of waste, the portion that was retrieved from the SSTs, and the various allocations of headspace for purposes other than waste storage (see Table 5-3). Space is extremely limited from 2015 to 2020, at which time the startup of the WTP frees up DST tank space as its feed tanks are filled. Tank space is made available to continue retrievals as the waste treatment system reaches full capacity in 2025.

From 2015 to 2020, the available unallocated DST space is reduced from 4.4 down to 0.9 Mgal. The 3.5 Mgal of DST space filled during this time is occupied by waste retrieved from the AX Farm SSTs and from some of the A Farm SSTs after concentration in the 242-A Evaporator. In addition, 600 kgal of tank headspace is tied up in the hot commissioning tank, which is still delivering batches of HLW feed. By 2020, the remaining space is not readily usable.

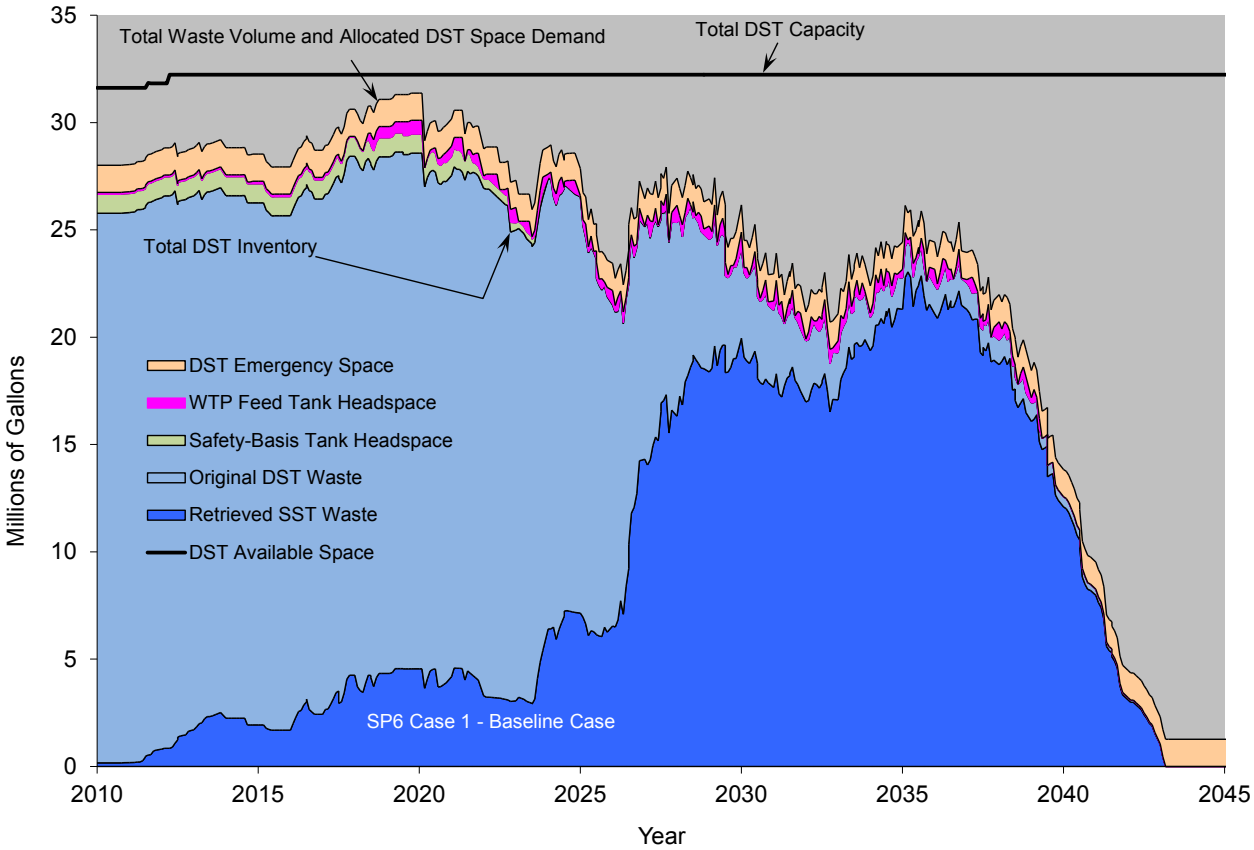

Figure 5-7. Use of the Double-Shell Tanks

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

Table 5-3. Double-Shell Tank Headspace Categories

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

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

The available space in 2020 is 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 trapped in the SY Farm, and other space is spread around the 200 East Area in tanks in the process of being staged for subsequent WTP feed. As the DST system nears capacity, it is increasingly difficult to conduct SST retrieval, evaporator, and feed staging operations.

After the retrieval of C Farm, minimal DST space is available to support additional SST retrievals, and three evaporator campaigns are needed to make space for retrieving waste from nine additional SSTs. The schedule for the retrieval of waste from the nine additional tanks for the System Plan (Rev. 6) Baseline Case has been delayed compared to the schedule for the same tanks in the System Plan (Rev. 5) Baseline Case, mitigating some of the schedule issues[50] raised in the System Plan (Rev. 5) Baseline Case.

Three SST retrievals are started in late calendar year 2023 or early 2024, only to sit idle until the WTP frees up enough tank space for them to continue and finish in mid-2026 (see Figure 5-6, inside the yellow circles—the yellow bars represent the portion of the total retrieval duration that is due to lack of tank space, and the black portion of the bar represents the minimum retrieval duration for that tank). The start of these retrievals would probably be rescheduled after sufficient DST space is made available by operation of the WTP.

The DST space needed to adequately stage, sample, and blend solids for delivery to the WTP is still under evaluation. As the WFD strategy is refined, the timing for the retrieval of the nine additional SSTs may need to be reevaluated.

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

- BDGRE controls for sludge.
- The assumption that the evaporator can, on average, be run to reach a specific gravity (SpG) of 1.43 without precipitation of problematic quantities of solids or exceeding the evaporator source term constraints.

[50] In System Plan (Rev. 5), the timing of the retrievals from A and AX Farms was driven primarily by available DST space and minimum retrieval durations. Proper allowances for the time needed to upgrade infrastructure and install the retrieval systems were not made.

- The allocation of a four-month period for sampling and analysis of waste in preparation for processing in the 242-A Evaporator, which may cause bottlenecks when retrieving dissolved saltcake. Alternative sampling and staging strategies should be considered.
- Uncertainties in the inventory and as-retrieved volumes of the SSTs retrieved before 2027, including the amount of chemicals added for waste chemistry control or for hard-to-remove heel retrieval.
- Potential delays in startup of WTP.
- Changes in mission configuration (early additional pretreatment and LAW treatment capacity).

Because DST space is so limited, small perturbations or uncertainties in assumptions, plans, or actual field operations can cause large shifts in near-term plans as the available space approaches zero. This means that the retrieval of the nine additional SSTs by the projected early retrieval date of December 2020 or by the September 2022 success criteria, without running out of tank space, continues to be at risk. If this risk is realized, those retrievals might not be completed until after 2025. Alternatives for the more effective use of DST space are being evaluated and will be incorporated into future mission scenarios. If an FCCF or an enhanced WRF is added to the baseline mission, the additional tank space provided might give transient relief for DST tank space demand.

The PMB assumes that improvements in DST space management will support the SST retrieval schedule projected for the Baseline Case. To that end, DST space management is considered one of the key issues and uncertainties and is addressed as a critical risk by the RMP (TFC-PLN-39). The key issues and uncertainties associated with DST space management and a list of the potential mitigating actions are provided in Table 7-1 (Section 7.1).

5.5.2.2 Use of Double-Shell Tanks for the Baseline Case

The series of runs used to develop the Baseline Case (see Section 5.1) resulted in a DST utilization strategy that is fully integrated with the strategy documented in RPP-40149-VOL1. The DSTs are used in various major roles throughout the RPP mission. In general, the roles of each DST change over time. The dynamic assignment of the roles over time is the key challenge in optimizing the use of the DSTs to support the RPP mission. These roles or functions include (1) safely storing the existing DST waste, (2) receiving, storing, and transferring wastes from external sources such as the 222-S Laboratory and SST retrieval, (3) staging feed and receiving concentrated waste from the 242-A Evaporator, and (4) blending, staging, and delivering LAW and HLW waste to the WTP. There are also a couple of specialized functions dealing with the mitigation of the Group A tanks and the in-tank removal of strontium and TRU from the complexed concentrate waste.

For each of these DST functions, specific equipment requirements have been established for the types, quantity, and configuration of transfer and mixer pumps to effectively perform these functions. The DSTs are used in a manner consistent with the required equipment. The plan for upgrading the equipment and infrastructure for the DSTs to successfully achieve the waste feed delivery objectives is provided in RPP-PLAN-50117. Further details on the how the DSTs will be used can be found in RPP-40149-VOL1.

5.5.2.3 Early Feed Deliveries and Feed Staging Plan

The plans for the first three LAW and first five HLW feed campaigns are discussed in RPP-40149-VOL2 (Campaign Plan).

The first three tanks of LAW feed projected to be delivered to the WTP are summarized in Table 5-4, along with a summary of the steps needed to prepare that feed. LAW feed batches, other than the hot commissioning feed, are readily interchangeable with other LAW feed. The subsequent LAW feed deliveries are also available as part of the list of all projected DST transfers, as discussed in RPP-RPT-48681.

The first five tanks of HLW feed projected to be delivered to the WTP are summarized in Table 5-5, along with a summary of the steps needed to prepare that feed. The subsequent HLW feed deliveries are available as part of the list of all projected DST transfers, as discussed in RPP-RPT-48681.

An analysis of the amount of staged feed ready for immediate delivery over the duration of the mission is documented as part of RPP-40149-VOL2. There are generally two or three DSTs containing ready-to-deliver HLW feed between 2020 and 2025; afterwards, the availability of ready-to-deliver feed is quite variable. With refinements to the WFD strategy, it may be possible to maintain a sufficient quantity of ready-to-deliver HLW feed, minimizing the potential for feed disruptions due to tank farms equipment or process issues. As for LAW feed, there is generally only one DST of LAW feed ready to deliver at any given time. This is less critical than having sufficient HLW feed on hand since much of the waste that will become LAW glass is actually delivered along with the supernate used to transfer the HLW feed to the WTP.

A discussion of the projected HLW and LAW feed batches against WTP screening criteria is provided in Section 5.6.2.3.

Table 5-4. Initial Low-Activity Waste Feed Staging Plan

Order[a]	Feed tank[b]	LAW deliveries		Preparation steps[c]				
		Start date	Volume (kgal)	Transfers		Start date	Volume (kgal)	Type
				From	To			
1	AY-102	5/11/2018	123	Water	AY-102	9/9/2017	80	Water
				Mix-Sample-Wait (ready for delivery 4/7/2018[d])				
2	AP-104	2/3/2020	996	AP-103	AP-104	11/3/2014	1,152	Supernate
				Mix-Sample-Wait (ready for delivery 6/7/2015[e])				
3	AP-104	11/22/2022	996	AP-103	AP-104	2/14/2020	729	Supernate
				AP-101	AP-104	4/30/2020	301	Supernate
				Mix-Sample-Wait (ready for delivery 11/27/2020[e])				

[a] This is the order of delivery of the staged LAW waste, consistent with the campaign number.
[b] This is the tank in which the LAW feed is staged.
[c] These are the steps to prepare a specific batch of LAW feed.
[d] The ready-for-delivery date is based on 210 days after a water addition to Tank AY-102.
[e] The ready-for-delivery date is based on 210 days after the last waste addition to Tank AP-104.

LAW = low-activity waste.

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

Order[a]	Feed tank[b]	HLW deliveries		Preparation steps[c]				
		Start date	Volume (kgal)	Transfers From	Transfers To	Start date	Volume (kgal)	Type
1	AY-102	5/31/2018	120	Mix-Sample-Wait (ready for delivery 4/7/2018[d])				
		6/5/2018	120	AY-102	WTP[e]	5/11/2018	123	Supernate
		6/10/2018	120					
		7/31/2018	120					
		2/2/2020	120					
2	AW-105	4/4/2020	120	AW-103	AW-105	1/25/2019	733	Supernate
		6/9/2020	120	AW-105	AW-103	2/2/2019	783	Slurry
		9/5/2020	120	AZ-101	AW-105	2/11/2019	506	Slurry
		11/29/2020	120	AP-103	AW-105	2/18/2019	276	Supernate
		2/3/2021	120	Mix-Sample-Wait (ready for delivery 9/18/2019[f])				
		4/1/2021	120					
		5/15/2021	120					
3	AZ-102	6/30/2021	120	Complete retrieval of AX Farm tanks (10/14/2018)				
		8/11/2021	120	AP-107	AZ-102	10/19/2018	89	Supernate
		9/14/2021	120	Mix-Sample-Wait (ready for delivery 5/17/2019[f])				
		10/13/2021	120					
		11/9/2021	120					
		12/4/2021	120					
4	AY-102	12/30/2021	120	AZ-101	AY-102	2/14/2020	379	Slurry
		1/26/2022	120	AP-105	AY-102	2/21/2020	348	Supernate
		3/2/2022	120	Mix-Sample-Wait (ready for delivery 9/19/2020[f])				
		4/8/2022	120					
		5/20/2022	120					
		6/29/2022	120					
5	AW-105	8/16/2022	120	AN-106	AW-105	5/23/2021	544	Slurry
		9/22/2022	120	AP-105	AW-105	5/31/2021	295	Supernate
		10/11/2022	120	Mix-Sample-Wait (ready for delivery 12/29/2021[f])				
		11/7/2022	120					
		11/29/2022	120					
		12/19/2022	120					
		1/13/2023	120					

[a] This is the order of delivery of the staged HLW waste, consistent with the campaign number.
[b] This is the tank in which the HLW feed is staged.
[c] These are the steps to prepare a specific batch group of HLW feed.
[d] Ready for delivery date is based on 210 days after a water addition to Tank AY-102.
[e] A key step in preparing HLW hot commissioning feed is delivery of the LAW hot commissioning feed to the WTP.
[f] The ready-for-delivery date is based on 210 days after the last waste addition to the staging tank.

HLW = high-level waste
LAW = low-activity waste.
WTP = Waste Treatment and Immobilization Plant.

5.5.3 Other Hanford Facilities and Inactive/Miscellaneous Underground Storage Tanks

The IMUSTs are projected to be retrieved into the DST system between October 2019 and October 2028, [51] with a total volume of approximately 550,000 gal of dilute supernate and sludge. The disposition of the waste in the IMUSTs has not been determined, the composition of the waste is incomplete and uncertain, and the schedule for retrieval of the IMUSTs might require adjustment to accommodate DST space limitations.

Approximately 275,000 gal of dilute waste from the 222-S Laboratory, terminal cleanout of PUREX, and deactivation of T Plant were projected to be received into the DST system between July 2011 and the end of the treatment mission.

5.5.4 Waste Transfer Systems

Numerous transfers occur between DSTs to support evaporator operations, support staging of feed for WTP, and receive transfers from retrieved SSTs. The Baseline Case predicts that approximately 1,800 transfers will occur among DSTs over the course of the RPP mission.

As shown in Figure 5-8, the transfer system needs to support an average of about 11 transfers per year (6 Mgal per year) before the WTP starts, increasing to an average of about 91 transfers[52] per year (33 Mgal per year) after the WTP and second LAW facility reach full capacity.

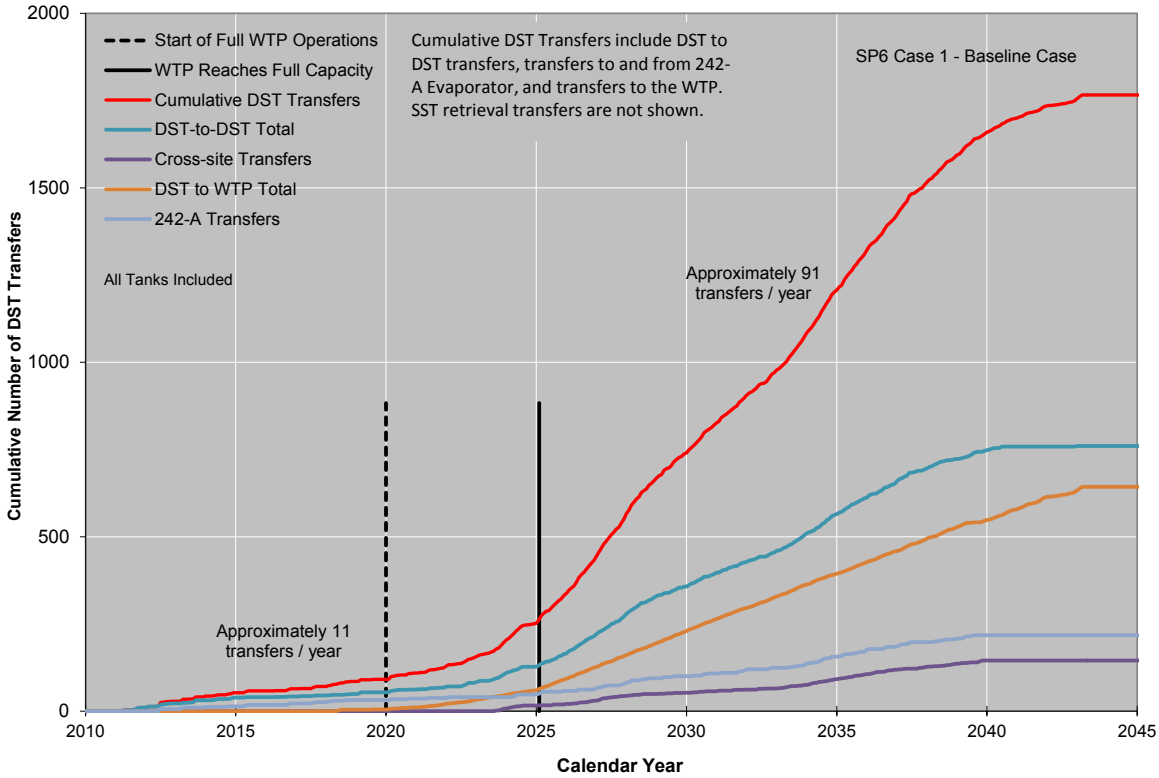

Figure 5-8. Projected Double-Shell Tank Transfer Demand

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

[52] After the WTP and second LAW facility reach full capacity, System Plan (Rev. 5) projected a sustained average of 73 transfers per year between 2030 and 2040. In contrast, a sustained average of 91 transfers per year is projected for System Plan (Rev. 6) between 2025 and 2040. This increase is due to the additional transfers needed to implement the improved management of solids in the DST system when compared to System Plan (Rev. 5).

The total number of DST transfers has increased by about 35 percent compared to the System Plan (Rev. 5) Baseline Case due to added constraints on waste transfer solids loadings and due to the implementation of the blind-blending strategy. The number of DST-to-DST transfers, cross-site transfers, and DST-to-treatment facility transfers has increased by about 26, 46, and 60 percent, respectively, due to the added constraints on waste transfer solids loadings. The DSTs in this System Plan were constrained to a maximum settled solids level to stay within the assumed limits of the in-tank mixing equipment. This constraint required additional transfers to implement when compared to the previous System Plan, which did not have this constraint. In addition, System Plan (Rev. 6) implemented a blind-blending strategy that requires additional transfers. The number of evaporator transfers has only increased slightly, by about 6 percent.

The transfer system must be sufficiently robust to support this average demand, including the year-to-year variability plus the transfers directly supporting SST retrievals. A number of transfer system upgrade projects are planned; details regarding the DST transfer system approach are available in RPP-PLAN-50117, which has been developed concurrently with and reflected in this revision of the System Plan.

5.5.5 Waste Receiver Facilities

The primary purpose of WRFs is to support the retrieval of the SSTs in the B Farm and T Farm complexes, which are far enough from the DSTs to require potentially problematic transfer line pressure drops and difficult coordination with competing DST uses. One side benefit from the use of WRFs is a transient reduction in the demand for DST storage space.

- Each WRF provides up to 900 kgal of operating volume (six tanks with an operating volume of 150 kgal each).
- WRF tanks provide a location to accumulate waste solids and control their concentrations, which should reduce the number of transfers needed to the DST system, thereby also reducing the amount of flush water generated after each transfer.
- The availability of WRF tanks allows supernate to be recycled during retrievals of the B and T Farm tanks.

In the Baseline Case, the B Complex WRF is projected to be used from 2023 to 2035 and the T Complex WRF from 2030 to 2039.

5.5.6 242-A Evaporator

Figure 5-9 shows the projected demand on the 242-A Evaporator over the waste treatment mission. The 242-A Evaporator is expected to process about 83 Mgal of waste, reducing the stored volume by about 38 Mgal for the mission duration.

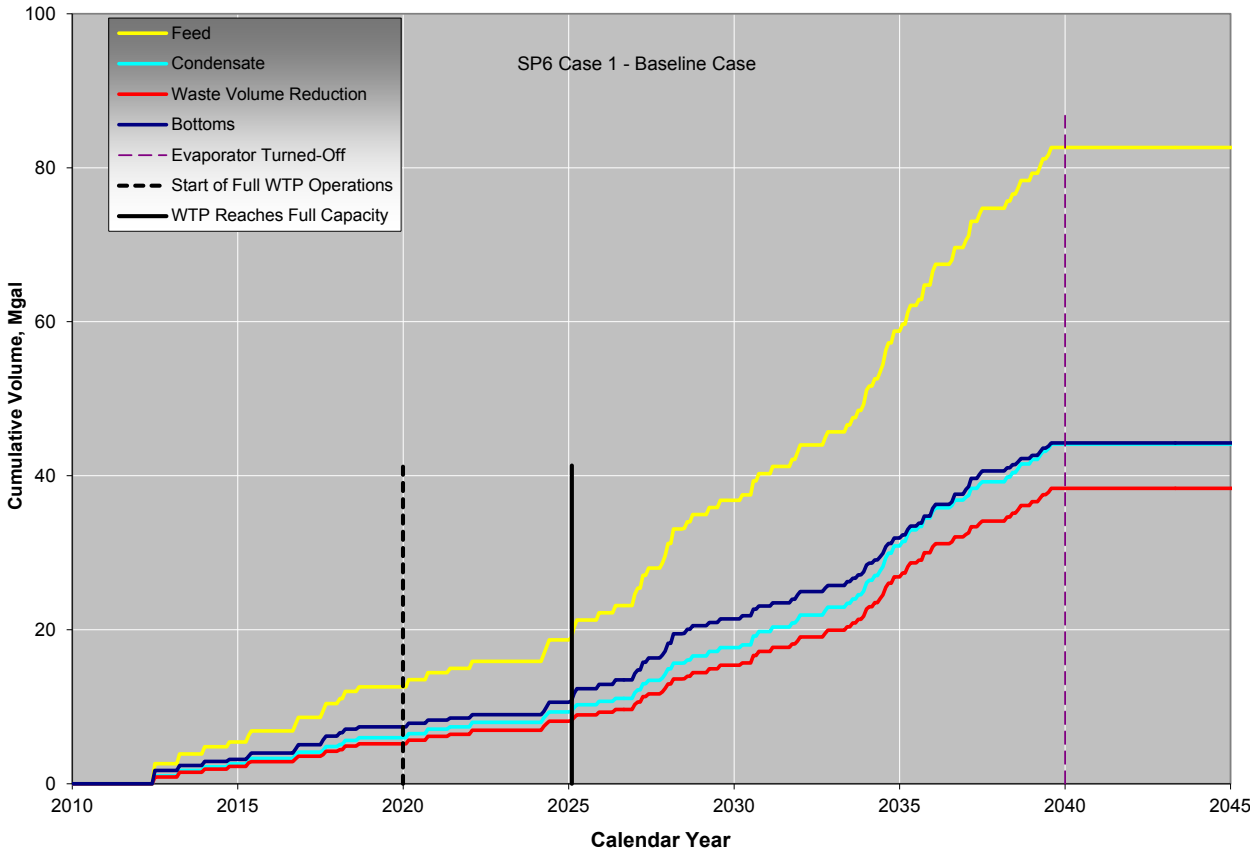

Figure 5-9. Projected Operation of the 242-A Evaporator for the Mission Duration

The projected evaporator demand is used as a starting point for establishing the baseline operational plans after consideration and integration with WFD upgrade plans, planned 242-A Evaporator facility upgrade outages, ongoing field work, current transfer system status, and the need to support the early SST retrievals. This adjusted planning basis is shown in Table 5-6 and will be the basis for the near-term evaporator campaigns in a future update to the PMB.

After 2035, Figure 5-7 suggests that the 242-A Evaporator may not be needed to manage DST space. However, future study would be needed to confirm this and to confirm that the WTP feed can be delivered within its concentration limits (see Table 7-1, Item 7.1-3, potential mitigating action iv).

Table 5-6. Plans for Double-Shell Tank Transfers and 242-A Evaporator Campaigns

Fiscal year	HTWOS Projection[a]	
	DST transfers	242-A Evaporator campaigns
2011	9	0
2012	18	3
2013	14	2
2014	8	2
2015	9	2
2016	4	1
2017	9	3
2018	13	3
2019	7	0
2020	17	2

Note: No cross-site transfers are planned during FY 2011 – 2020. The next cross-site transfer is projected to occur in August 2023.

[a] This projection includes adjusting the System Plan (Rev. 6) Baseline Case results to reflect FY 2011 activity prior to the February 1, 2011 date for demarcation between historical and projected activities.

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

5.5.7 Waste Encapsulation and Storage Facility

As discussed in Sections 1.6 and 3.1.7, the cesium and strontium capsules are assumed to be dispositioned by RL and are not addressed by the Baseline Case nor included in the PMB.

5.5.8 Vadose Zone

The Vadose Zone Program, discussed in Section 3.1.8, is not modeled by HTWOS. However, the PMB does include cost and scope for this program in the TOC baseline.

5.5.9 Closure

The LCM estimates the closure dates from the SSTs and DSTs by driving a schedule, reflecting the baseline hard-to-remove heel and closure strategies and logic, with the individual SST retrieval dates[53] and DST final use dates projected by the HTWOS model.

[53] While the minimum retrieval durations include time for performing the hard-to-remove heel retrieval on those tanks thought to contain hard-to-remove heels, they do not include the time needed to install the necessary equipment. The LCM considers this time when determining the closure dates.

5.5.9.1 Single-Shell Tanks

As discussed in System Plan (Rev. 5), all SSTs are projected to be closed by September 2043, about eight months later than the M-045-00 milestone date of January 2043. After the completion of the bulk retrieval of the last SST, the critical path includes hard-heel removal followed by tank-specific and WMA closure activities. Future work to improve the closure completion date will review the SST retrieval sequencing logic, retrieval infrastructure, potential use of sound, fit-for-use SSTs for staging, and other applicable parameters to make better use of the available DST tank space near the end of the mission.

5.5.9.2 Double-Shell Tanks

All DSTs are projected to be closed by September 2049, about three years earlier than the M-042-00A milestone date of September 2052.

5.6 TREATMENT

5.6.1 Supplemental Transuranic Treatment Facility

In the Baseline Case, processing the potential TRU tank waste is projected to begin in April 2018 and will treat a maximum of 8,040 gal of slurry per day retrieved from the 11 SSTs containing potential TRU tank waste. The Baseline Case indicates that processing this waste will produce 7,492 drums of packaged waste that will be stored at the CWC (see Section 5.7.3) pending final disposition. Processing is projected to finish in July 2023.[54] While the final disposition of CH-TRU waste packages is yet to be determined, activities associated with staging, storing, and preparing the packages for shipment to the final disposal location are scheduled to coincide with packaging operations for costing purposes. This schedule logic and the associated budget used for cost analysis are consistent with the TOC PMB.

The impact of treating the potential TRU tank waste as HLW at the WTP is discussed in Section 10.2 (Case 2).

5.6.2 Waste Treatment and Immobilization Plant

This section presents the production metrics for the WTP for the Baseline Case and discusses the mission duration drivers. The WTP is assumed to begin hot commissioning on May 11, 2018, and begin full operations on December 31, 2019. The HLW Vitrification Facility is assumed to reach full capacity by February 6, 2025, when second generation HLW melters are assumed to be operational. The LAW Vitrification Facility is assumed to reach full capacity by January 1, 2022. Waste treatment is projected to be completed in 2043 for the Baseline Case. Detailed programmatic and technical assumptions for the WTP are provided in Appendix B, Section B3.3.

[54] The CH-TRU waste was processed at a lower rate than planned due to the inadvertent use of an assumption from System Plan (Rev. 4). Using the lower rate, CH-TRU waste processing was predicted to take about 5.25 years. If the correct assumptions had been used, packaging of the potential CH-TRU waste would have been completed in 3.13 years.

5.6.2.1 Glass Production

Figure 5-10 compares the projected HLW glass production for the Baseline Case against the net capacity assumption. Figure 5-11 does likewise for the projected combined LAW glass production (WTP LAW Vitrification Facility + second LAW facility). Figure 5-12 and Figure 5-13 show the glass production of the individual LAW facilities. The net capacities of the HLW vitrification facility, the WTP LAW Vitrification Facility, and the second LAW facility are each assumed to be 70 percent of their respective design capacities. (Appendix B, Assumptions B3.3.1.3, B3.3.3.3, B3.3.4.4, and B3.4.1.2 provide additional details.)

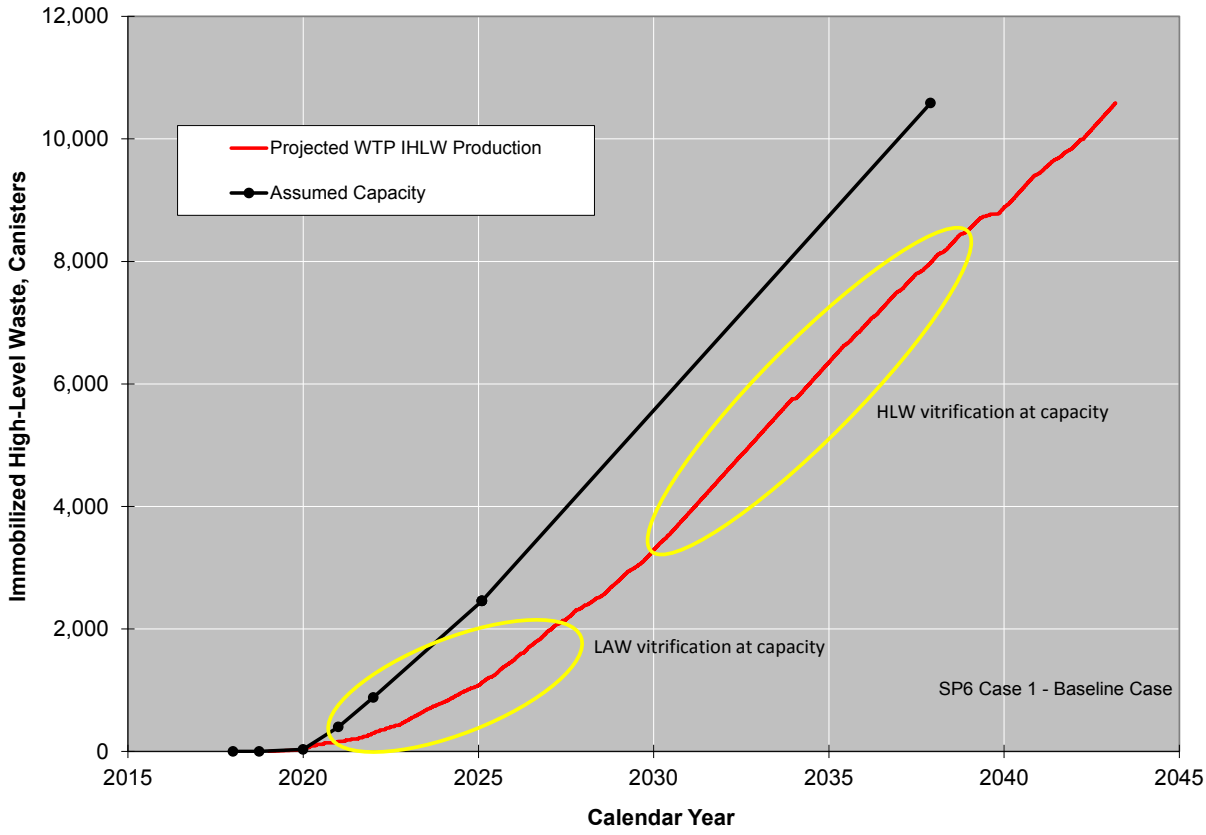

Figure 5-10. Projected Immobilized High-Level Waste Production

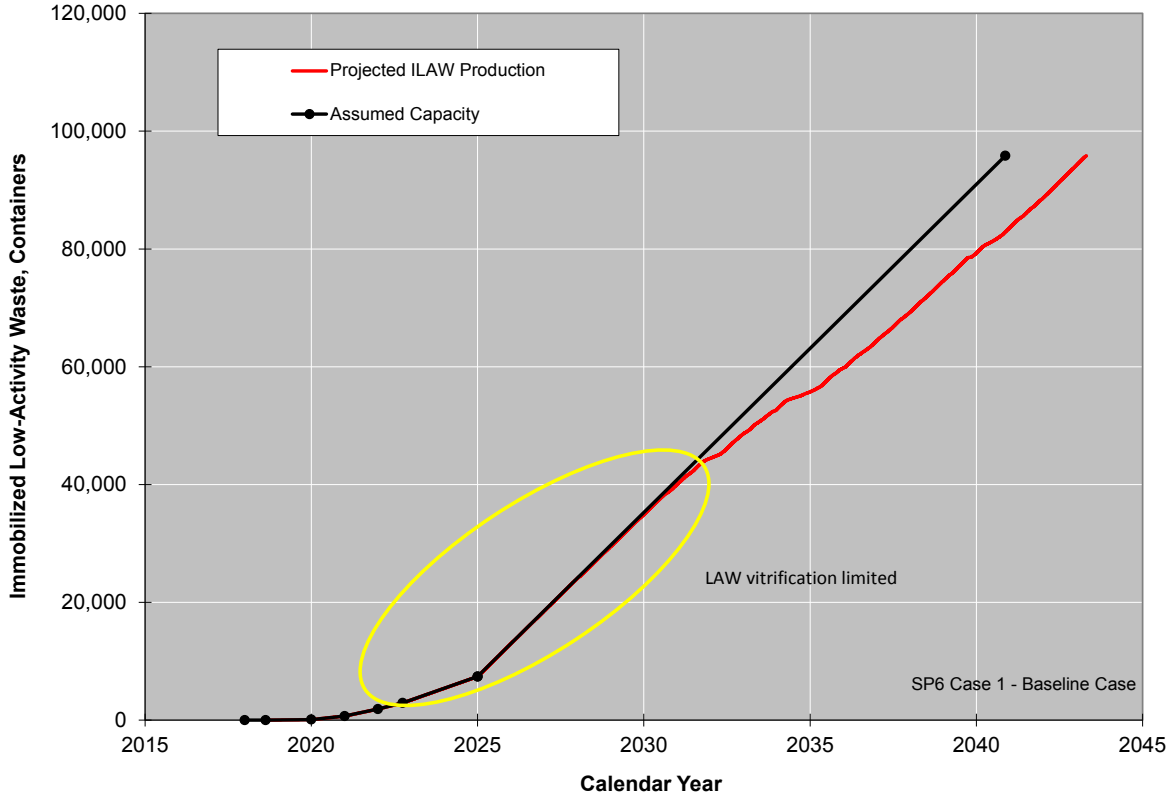

Figure 5-11. Projected Combined Immobilized Low-Activity Waste Production

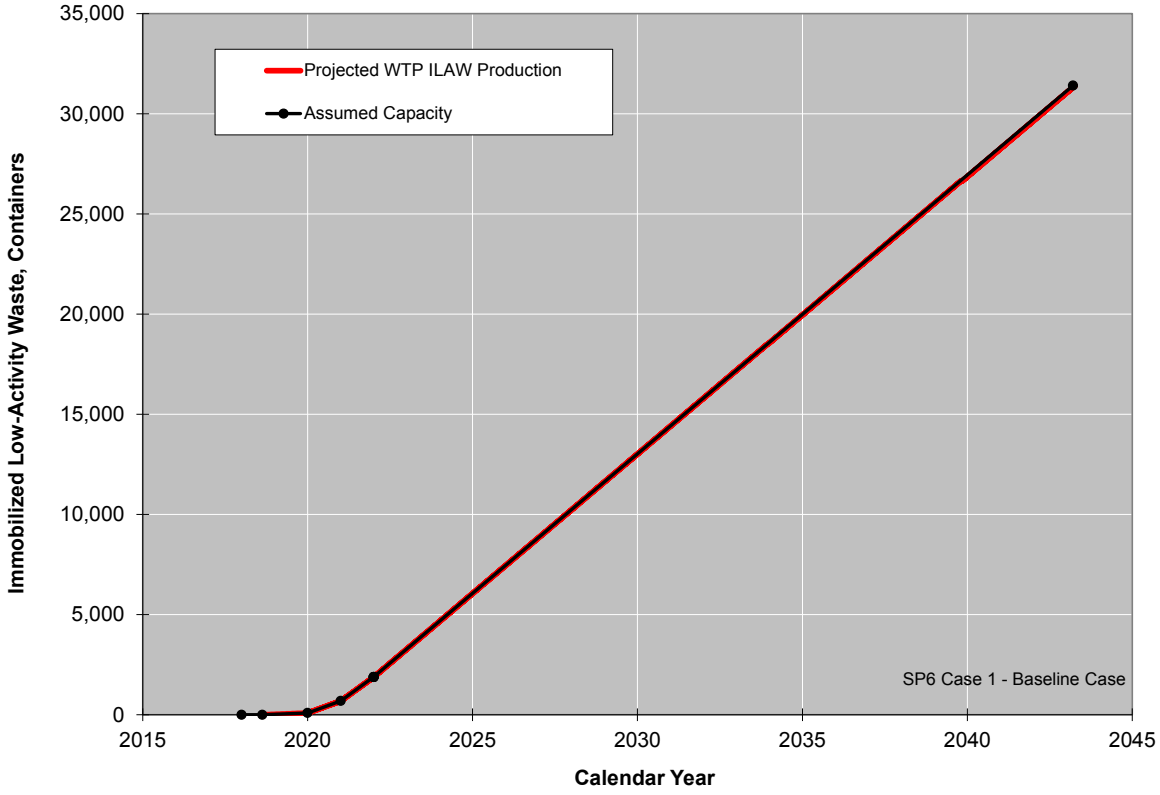

Figure 5-12. Projected Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility Glass Production

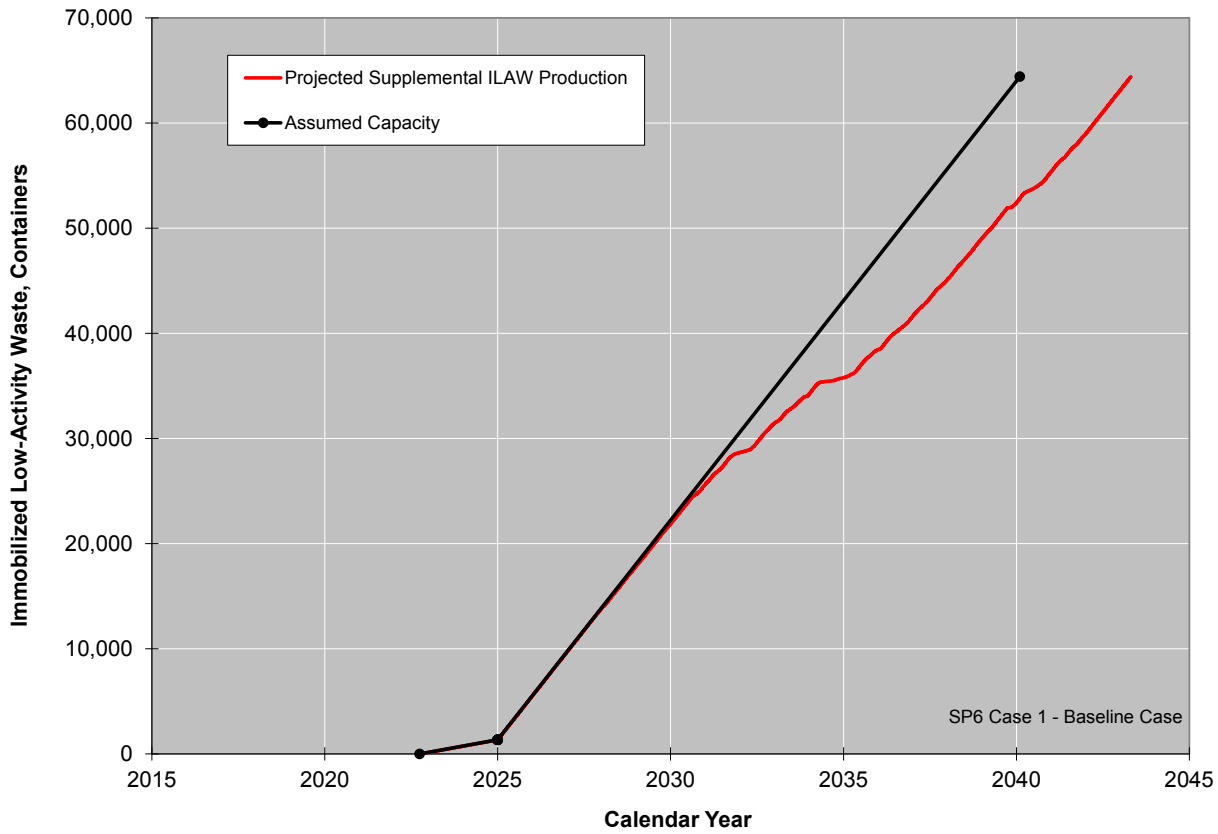

Figure 5-13. Projected Second Low-Activity Waste Facility Glass Production

The WTP LAW Vitrification Facility is projected to treat about 37 percent of the pretreated LAW from the WTP PT Facility, while a second LAW facility is projected to treat about 63 percent. A description of how the second LAW facility was sized is provided in Section 5.6.3.1. In these figures, the assumed capacity line is the theoretical cumulative production that would be achieved if the facility always had feed and was operated at the rate assumed during each step of the ramp until treatment is complete. The projected production shows the results from the HTWOS model run.

For the Baseline Case, HLW glass production was limiting during most of the waste treatment mission. However, in the early years, through 2025, the waste treatment mission is driven by the total LAW vitrification capacity from both the WTP LAW Vitrification Facility and the second LAW facility. The limited LAW vitrification capacity in those early years limits the amount of HLW that can be pretreated and prepared for vitrification. Additionally, the WTP PT Facility may be operating in the vicinity of its achievable capacity during much of the mission (Section 5.6.2.2 provides further details).

5.6.2.2 Pretreatment Throughput and Capacity

The WTP contract requires that the WTP PT Facility has a treatment[55] capacity to process 2,620 MT waste[56] sodium/year and 860 MT of as-delivered feed solids per year. The Baseline Case, as modeled, achieves a sustained average of 3,491 MT waste sodium/year and 1,274 MT as-delivered solids per year, both exceeding the contractual treatment capacity requirements for the WTP PT Facility. The treatment end date will increase if these rates are not achieved and if no mitigating actions were taken or other compensatory changes made.

The comparison of the contractual requirements to the Baseline Case demand is not straightforward and careful evaluation is required to draw conclusions.

- The conditions[57] originally used to establish the contract requirements and used for contractual assessments of the treatment capacities no longer reflect the currently envisioned use of the WTP, which confounds the assessment of the achievable capacity under mission-specific conditions. 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* (Rev. 6), which contains only 73 percent of the sodium currently planned for delivery to the WTP. The rest was assumed to be processed by supplemental pretreatment and treatment; therefore, evaluations performed with that feed vector may underestimate the achievable capacities.
- The metrics (MT waste sodium/year and MT feed solids/year) do not adequately characterize the operation of the WTP PT Facility; they do not (nor were they intended to) reflect the underlying rate limiting processes and interactions within the WTP PT Facility.
- The interaction between the tank farms, WTP PT Facility, and the three vitrification facilities further complicates the interpretation.

Recent evaluations (24590-WTP-MRR-PET-10-001, *WTP Mission Assessment of the Design and Operating Changes Expected to Resolve PJM Mixing in PT Vessels*),[58] and (24590-WTP-RPT-PET-10-020, *2010 WTP Tank Utilization Assessment*),[59] of the expected treatment and design capacities of the WTP PT Facility suggest that the facility may achieve significantly higher capacities than the contract requirements. The demand that the Baseline Case places on the

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[55] 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.

[56] 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.

[57] The purpose of the contractual pretreatment capacity requirements is to provide ORP with a means to evaluate how changes to the WTP design, flowsheet, and operating modes impact the mission and to establish minimum performance requirements so that design margin is not inadvertently lost. They do not (nor were they intended to) reflect the underlying rate limiting processes with the WTP PT Facility.

[58] The model runs performed for these assessments used a feed vector that assumed about 27 percent of the LAW sodium would be pretreated by supplemental pretreatment processes instead of the WTP PT Facility; therefore, this may underestimate the achievable capacity.

[59] The model runs performed for these assessments used a feed vector that assumed about 34 percent of the LAW sodium would be pretreated by supplemental pretreatment processes instead of the WTP PT Facility; therefore, this may underestimate the achievable capacity.

WTP PT Facility is in the vicinity of the capacities suggested by these recent evaluations, albeit evaluated at different conditions.

Although 24590-WTP-MRR-PET-10-001 concludes that the "results from these model runs indicate that the PT Facility will meet and exceed the WTP contract-required treatment capacity with all the currently proposed modifications and operating changes currently forecast," further evaluation of WTP PT Facility capacity under representative mission-specific conditions is needed to better understand the achievable pretreatment capacities. Once that is known, updated assumptions would be used for future Systems Plans to adjust the WTP PT Facility capacity or provide supplemental pretreatment so that the demand on the WTP PT Facility does not exceed its capacity.

The capabilities of the WTP are being evaluated and documented per TPA milestone M-062-49, which states, in part, that DOE will "submit a report to Ecology… which demonstrates that the WTP is designed to accomplish …pretreat(ing) 100% of retrievable tank waste…".

The required pretreatment capacity to finish treating waste in 2037 (the earliest date consistent with keeping HLW treatment as the sole mission duration driver) would be 4,026 MT waste sodium/year and 1,464 MT/year as-delivered solids. These larger capacities suggest that that the demand on the WTP PT Facility might need to be further reduced to make significant reductions in mission duration. The ability of the WTP to support these higher capacities was not evaluated.

The supplemental pretreatment capacity previously provided by the Aluminum Removal Facility significantly reduced the demand on the WTP PT Facility for System Plan (Rev. 5). For comparison, the treatment capacities for the System Plan (Rev. 5) Baseline Case were 2,335 MT waste sodium/year and 725 MT/year as-delivered solids.

The addition of supplemental pretreatment (possibly in the form of RMF and SCIX) to the mission would reduce the demand on the WTP PT Facility, which may (1) mitigate the potential capacity shortfall, and (2) allow for reducing the sodium demand on the WTP PT Facility to better accommodate pretreatment of solids and potentially keep the HLW glass production closer to the theoretical production curve.

The key issues and uncertainties associated with WTP capacity are listed in Table 7-5 (Section 7.5), along with potential mitigating actions.

5.6.2.3 Feed Vector and Feed Screening

The feed vector for the Baseline Case contains composition data for batches of LAW and HLW feed projected to be delivered to the WTP. The projected feed batch compositions were screened against the criteria in Specification 7, Specification 8, criticality safety limits (CSL), and hydrogen generation rate (HGR). The results of these screenings are documented in four spreadsheets, summarized in this section, and discussed in more detail in RPP-40149-VOL2:

- SVF-2112, "WTP_CSL_4MinTimestep(6Melters)-mmr-11-031-6.5-8.3r1-2011-03-18-at-01-31-58_M1.xlsm"
- SVF-2113, "WTP_HGR_Limits_4MinTimestep(6Melters)-mmr-11-031-6.5-8.3r1-2011-03-18-at-01-31-58_M1.xlsm"
- SVF-2115, "WTP_Spec_7_Update for SP6 Baseline Case_V8.xlsm"

- SVF-2116, "WTP_Spec_8_Update for SP6 Baseline Case_V7.xlsm."

The screening results for the Baseline Case include the following:

- The delivered sodium concentration is within the upper and lower limits for most of the batches of HLW and LAW projected to be delivered to the WTP. The sodium concentration in ten HLW batches delivered between November 2041 and August 2042 exceeds the upper limit, and the sodium concentration in the very last LAW batch is below the lower limit.[60]
- The delivered wt% solids for LAW are below the maximum 3.8 wt% limit in 41 of the 43 batches delivered. The delivered HLW is at or below the 200 g/L maximum limit in all cases, is greater than the 10 g/L minimum limit for 590 out of 600 batches and has an average solids loading of 95 g/L (7.3 wt%). This degree of solids control results from the detailed modeling assumptions for the capabilities of the DST system.
- All batches to WTP are within the volume limits.
- Several batches do not meet some criteria for the component composition limits in Specifications 7 and 8 (in Tables TS-7.1, 7.2, 8.1, 8.2, 8.3, and 8.4 of the contract DE-AC27-01RV14136). This is consistent with previous HTWOS modeling and System Plan runs. The implication of the out-of-specification batches will continue to be assessed and will provide insight for refining future plans, using the integrated project team process when appropriate.
- All of the batches meet the criticality limits except for one batch, which only slightly exceeded the CSL limit (maximum of 1 percent above the limit). This is due to the limitations of the detailed solid-liquid partitioning assumptions used in HTWOS for the tank farms.
- All HLW batches meet the HGR limit.

5.6.2.4 High-Level Waste Glass Drivers

The 2009 GFM (documented in PNNL-18501, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*) consists of a collection of glass-property-composition models developed from a DOE database of glass compositions and properties. The glass properties recorded in the database include a product consistency test response, viscosity, electrical conductivity, toxicity characteristic leach procedure response, density, 1 percent crystal temperature ($T_{1\%}$), and liquidus temperature (T_L). 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 its associated disposal costs.

[60] The out-of-specification conditions for the sodium concentration and for the solids loading are due to known limitations of the logic in the HTWOS model for the terminal cleanout phase of the mission. During terminal cleanout, the model supersedes the normal WFD logic with logic focused on treating the waste remaining in the DST system after SST retrievals have been completed. Refinement of this logic is under consideration for future versions of HTWOS.

The Baseline Case assumed that HLW glass would be formulated using the 2009 HLW GFM (PNNL-18501) per Assumption B3.3.3.8 in Appendix B. The primary glass drivers and the corresponding amount of glass limited by each are SO_3 (21.9 percent), Bi_2O_3 (13.4 percent), P_2O_5 (3.8 percent), ZrO_2 (4.2 percent), $T_{1\%}$-spinel (24.7 percent), and Al_2O_3 indirectly via the nepheline discriminator (29.8 percent). Combined, those four constraints determine about 98 percent of the glass mass.

The average waste oxide loading (WOL) for the Baseline Case is about 37 percent, although as Figure 5-14 shows, the WOL varies over time based on the composition of the incoming waste and the constraints that are driving a particular batch.

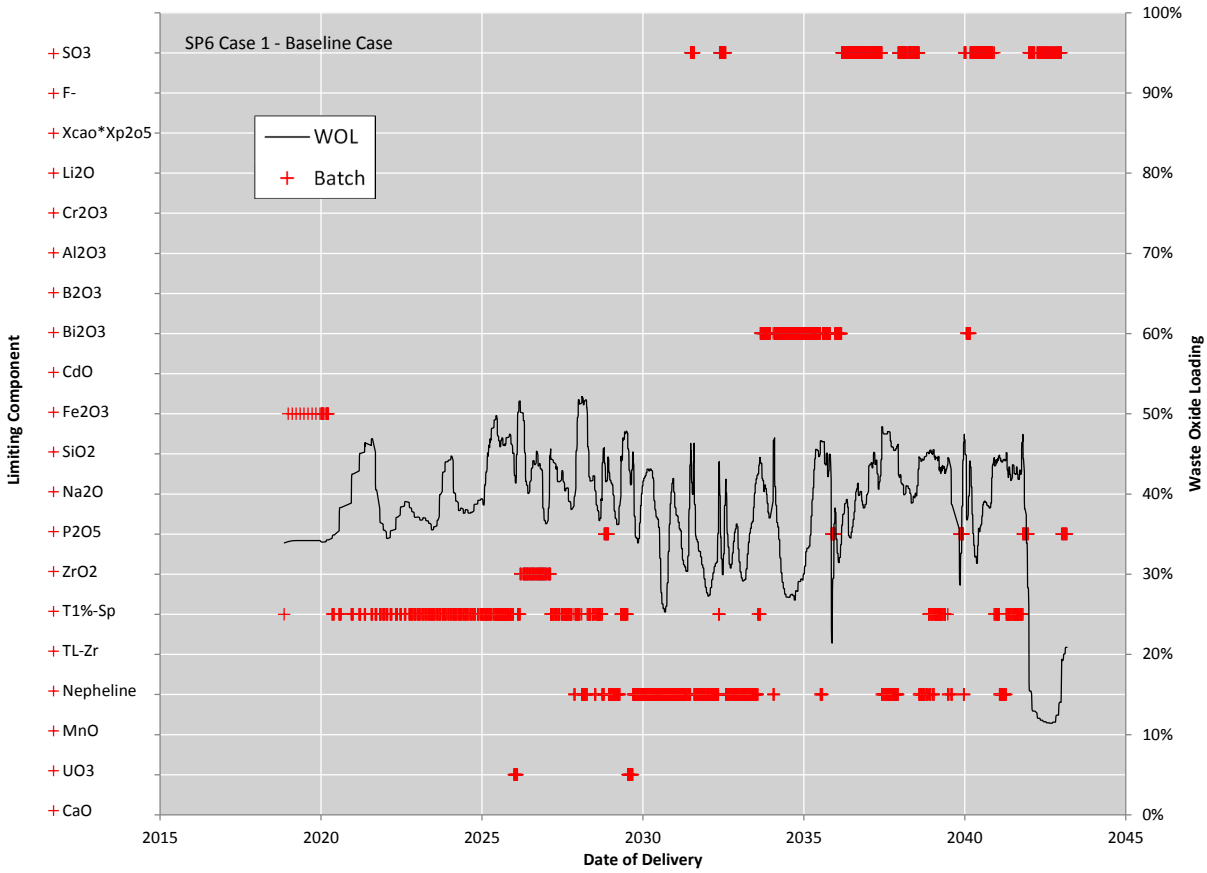

Figure 5-14. High-Level Waste Glass Drivers and Waste Oxide Loading versus Time for the Baseline Case

The blind blending that was implemented in the Baseline Case, along with changes in DST operations, reduced the variability in the WOL compared to the System Plan (Rev. 5) Baseline Case. While the WOL versus time profile is highly variable, there are only three major dips in which the WOL drops more than 10 percentage points below the average. Those time periods include the following.

- One of the major dips in WOL is from nepheline-limited batches in August and September 2030.
- In November 2035, when the WOL drops to 22 percent, the HLW glass is limited by P_2O_5.

- From the end of December 2041 through the end of the mission, the HLW glass is limited by P_2O_5 and SO_3. SO_3-limited glass often has a lower than average WOL and has been the subject of recent research and development testing.

5.6.2.5 High-Level Waste Blending

A global measure of the effectiveness of the blending of the sludge delivered to the WTP is how the projected glass mass compares to two hypothetical benchmarks—the total-blend and the no-blend. One such measure is called the percent-of-span, which is the percent of the way the projected glass mass falls between the total-blend and the no-blend glass mass. The Baseline Case achieved about an 11.6 percent percent-of-span through improvements in both incidental and intentional blending of solids and improved post-leach wash efficacy in the WTP PT Facility. For comparison, the percent-of-span achieved by the System Plan (Rev. 5) Baseline Case was about 15.6 percent.

For the Baseline Case, three intentional blending approaches were implemented in the DSTs to improve the HLW WOL and reduce feed variability. The blending of high zirconium waste from Tanks AW-103 and AW-105 and of high-fissile uranium from Tank C-104, currently stored in Tank AN-101, was implemented for the System Plan (Rev. 5) Baseline Case. Blind blending, an intentional blending strategy that blends tank waste between the HLW feed staging tanks and the HLW feed tanks,[61] was implemented in the System Plan (Rev. 6) Baseline Case.

High zirconium batches were found to limit HLW glass loading for the System Plan (Rev. 4) Baseline Case. For the System Plan (Rev. 5) Baseline Case, an intentional blending strategy was used to meter small portions of high zirconium batches from Tanks AW-103 and AW-105 into multiple HLW feed batches. This blending strategy made use of existing DST space without extending overall retrieval durations and was kept in the System Plan (Rev. 6) Baseline Case. The high zirconium waste was split into eight equal batches (on a solids basis) and transferred into a DST each time a DST was assigned to stage HLW feed to the WTP.

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

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

[61] Section 5.5.2.2 provides a discussion of the use of the DST system for the System Plan (Rev. 6) Baseline Case.

Using a blind-blending strategy, waste is blended between the HLW feed staging tanks and the HLW feed tanks. After an HLW feed tank delivers waste to WTP, it is refilled with waste from up to three different HLW feed staging tanks. The waste is delivered to the HLW feed tank based solely on waste availability; the composition of the tank waste was not taken into account. This strategy reduces mission duration and the number of HLW canisters at the cost of slightly increasing DST transfers. The blind-blending strategy and its impact on the mission are described in more detail in RPP-RPT-49398, *High-Level Waste Blending in the Hanford Tank Waste Operations Simulator*.

In System Plan (Rev. 5), the high zirconium blending strategy, the high-fissile uranium blending strategy, and improved feed staging strategies were estimated to reduce the IHLW canister count by approximately 6 percent. As shown in Figure 5-16 (Section 5.10.2), the blind-blending strategy implemented in System Plan (Rev. 6) further reduced the canister count by 6.4 percent. Despite the relative effectiveness of these three intentional blending strategies, most of the 11.6 percent-of-span achieved in System Plan (Rev. 6) is the result of significant incidental blending of waste due to heels in the DSTs and the process vessels in the WTP.

5.6.3 Second Low-Activity Waste Facility

A second LAW facility is assumed to begin production on October 1, 2022, and reach full net capacity on January 1, 2025. The glass production for a second LAW facility is discussed in Section 5.6.2.1. For the Baseline Case, the second LAW facility treated about 63 percent of the pretreated LAW from the WTP PT Facility. Based on the relative assumed treatment capacity of the WTP LAW Vitrification Facility and a second LAW facility, and their respective ramp-up schedules, a second LAW facility would need to treat about 70 percent of the pretreated LAW if waste treatment is to be completed in 2037 (the earliest date consistent with keeping HLW treatment as the sole mission duration driver).

5.6.3.1 Low-Activity Waste Vitrification Capacity

Assumptions B3.4.1.2 and B3.4.1.6 (Appendix B) for the Baseline Case require the capacity of a second LAW facility "to have the same technical assumptions as the WTP LAW Vitrification Facility," and that the capacity "be selected with the goal that the combined LAW vitrification capacity will be large enough as to not drive the mission duration, but no smaller than the WTP LAW Vitrification Facility." Therefore, the difference between the combined capacity and the WTP LAW Vitrification Facility capacity is the required supplemental capacity assumed to be provided by a second LAW facility. After calculating the required capacity for the second LAW facility, the capacity was rounded up to the next "whole" melter capacity according the assumptions for the WTP LAW Vitrification Facility.

In previous System Plans, the combined LAW glass production was selected to allow for the potential acceleration of the treatment end date that would be gained by fully using the available HLW treatment capacity. Using that approach, System Plan (Rev. 5) estimated the required combined LAW vitrification capacity (WTP LAW Vitrification Facility + second LAW facility) to be about 75 MTG/day; therefore, the required net capacity of a second LAW facility was about 54 MTG/day. Rounding up to the next "whole" melter capacity brings the required capacity to 63 MTG/day (six melters).

In System Plan (Rev. 6), this approach of balancing the LAW and HLW capacities was thought to result in oversizing the second LAW facility (eight melters) unless the projected HLW glass production drives the mission duration. Therefore, for System Plan (Rev. 6), the same capacity determined by System Plan (Rev. 5) was maintained. This also maintains consistency with the PMB, while the Supplemental Treatment and Immobilization Program determines the needed capacity. It may be prudent to allow a second LAW facility or the total pretreatment capacity (WTP pretreatment plus any assumed supplemental pretreatment capacity) to limit production during portions of the mission. In any case, the sizing of a second LAW facility will likely be iterative and involve multiple trade-offs and appropriate consideration of uncertainties in underlying assumptions and evolving configuration of the Waste Treatment Complex.

The required capacity of the second LAW facility and the relative amounts of LAW treated by that facility and the WTP LAW Vitrification Facility depend on many assumptions, including:

- WTP LAW Vitrification Facility startup date, ramp profile, and net capacity
- Second LAW facility startup dates and ramp profile
- WTP HLW Vitrification Facility startup dates, ramp profile, and net capacity
- Ability of HLW glass formulations to tolerate increases in aluminum loading
- The amount of sodium added during pretreatment of tank waste
- The ability of LAW glass formulations to tolerate increases in both sodium and sulfur loading
- The degree of blending of HLW feed to the WTP PT Facility
- The degree to which the SST retrievals and the DST system provide a balanced feed to the WTP.

5.6.4 Liquid Effluent Retention Facility/Effluent Treatment Facility

In the Baseline Case, approximately 257 Mgal of radioactive dangerous liquid effluent (secondary waste from the WTP, the second LAW facility, 242-A Evaporator, and supplemental TRU treatment system) is projected to be treated by the ETF over the duration of the treatment mission. This is significantly less than the 626 Mgal projected in System Plan (Rev 5). The large decrease occurred because the Aluminum Removal Facility was removed from the System Plan (Rev. 6) Baseline Case.

5.7 STORAGE ONSITE AND SHIPPING

5.7.1 Interim Hanford Storage

The first IHS module is planned to begin operations on November 21, 2018. Although this is after the start of WTP hot commissioning, limited internal storage in the WTP canister export area can be used until IHS becomes operational (Figure 5-15).

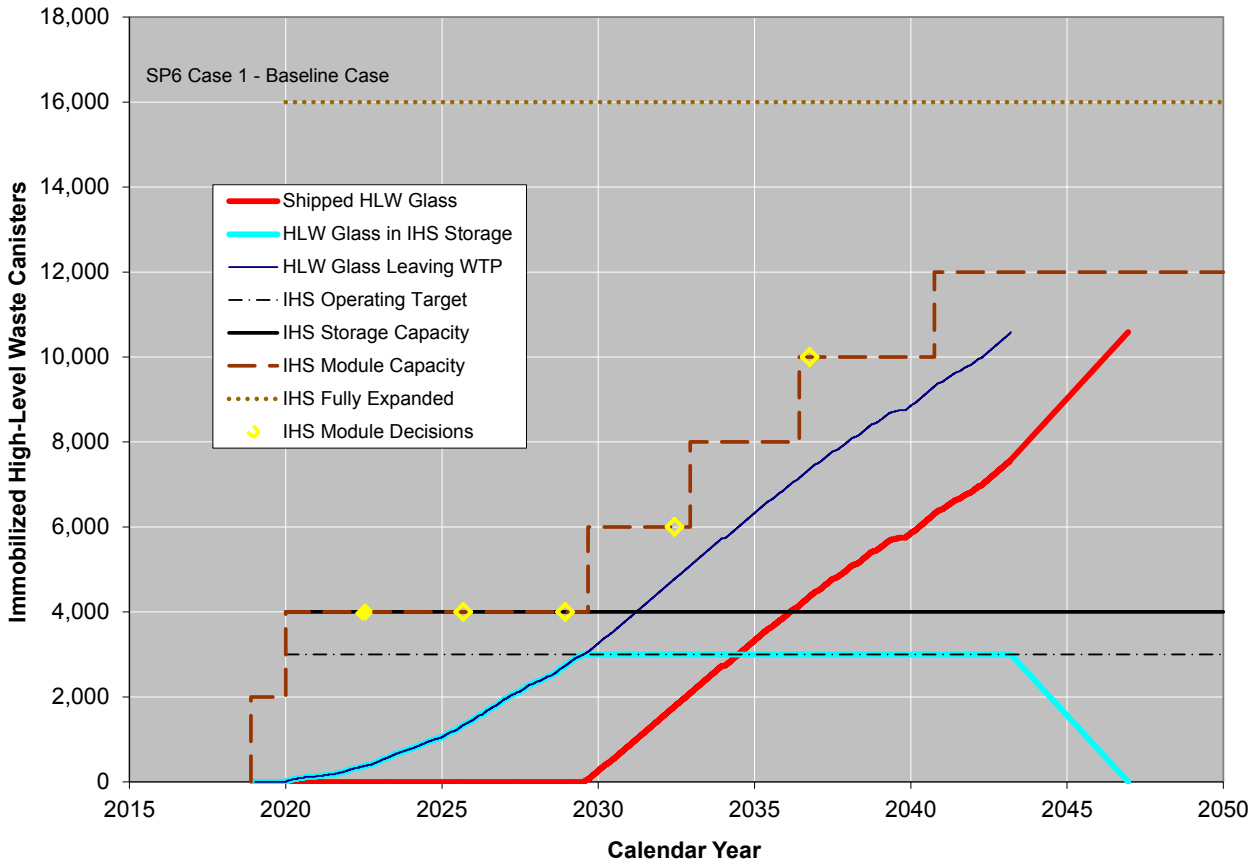

Figure 5-15. Interim High-Level Waste Storage and Shipping Projections for Baseline Case

If the decision is made to build the HSF and ship the canisters pending a final disposal alternative, the IHS is assumed to operate about 1,000 canisters below the maximum storage capacity. IHS is projected to reach the 3,000-canister operating target in June 2029. If the HSF is delayed and shipping cannot begin, the IHS will reach its maximum storage capacity of 4,000 canisters in March 2031. In that case, additional modules will be added to meet the storage requirements, as outlined in Assumption B3.5.3.2 (Appendix B) and depicted in Figure 5-15.

5.7.2 Hanford Shipping Facility

Pending a determination of the final disposal alternative, the enabling assumption is that in June 2022, a decision will be made to construct the HSF and begin shipping canisters to an off-site final disposal alternative (see Appendix B, Assumption B3.5.4.1). In that context, once IHS reaches its target operating capacity, the HSF will begin shipping IHLW canisters to the final disposal alternative. It is projected that the HSF will begin shipping operations in July 2029 and operate continually until all of the canisters have been shipped to the final disposal alternative, projected to be in December 2046 (see Figure 5-15).

5.7.3 Central Waste Complex

The CWC is assumed to store the 7,492 packaged potential TRU tank waste drums, generated between April 2018 and July 2023, until their final disposition has been determined (see Appendix B, Assumption B3.5.2.2).

5.8 DISPOSAL ONSITE

5.8.1 Integrated Disposal Facility

The IDF is projected to receive 95,825 packages of LAW glass, 35 spent LAW melters (ten from the WTP LAW Vitrification Facility and 25 from a second LAW facility), solidified secondary waste from ETF processing, and other solid waste over the duration of the mission.[62]

The schedule of when existing or new IDF cells will be filled has not been determined.

5.8.2 State-Approved Land Disposal Site

In the Baseline Case, approximately 257 Mgal of treated effluent from the ETF are projected to be disposed at the SALDS over the duration of the treatment mission.

5.9 DISPOSAL OFFSITE

5.9.1 Potential Transuranic Tank Waste

About 7,492 drums of packaged potential CH-TRU tank waste are projected to be stored at the CWC pending the determination of final disposition. If the final disposition of these packages is shipment offsite, then based on the projected retrieval and packaging schedule for this waste, the shipments could start no earlier than April 2018 and finish no earlier than July 2023.

5.9.2 Final High-Level Waste Disposal Alternative

Shipment of the projected 10,586 HLW canisters to a planned, off-site geologic repository is discussed in Sections 5.7.1 and 5.7.2 (also see Section 3.5.2).

5.10 GLASS MASS COMPARISON

5.10.1 Change in Projected Low-Activity Waste Glass Mass

The LAW glass mass for the Baseline Case was higher than the Baseline Case from System Plan (Rev. 5). The net increase of approximately 27 percent was due to an increase in sodium hydroxide additions used to maintain aluminum in solution in the WTP PT Facility. This increase of sodium was caused by removing the Aluminum Removal Facility from the RPP mission baseline and was only partially offset by the design, flowsheet, and operating mode changes implemented by the WTP equipment alternative.

The projected number of LAW packages for the Baseline Case has increased by 27 percent (from 75,419 to 95,825 packages) relative to the System Plan (Rev. 5) Baseline Case.

[62] The disposal of HLW spent melters is discussed in footnote 40.

5.10.2 Change in Projected High-Level Waste Glass Mass

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

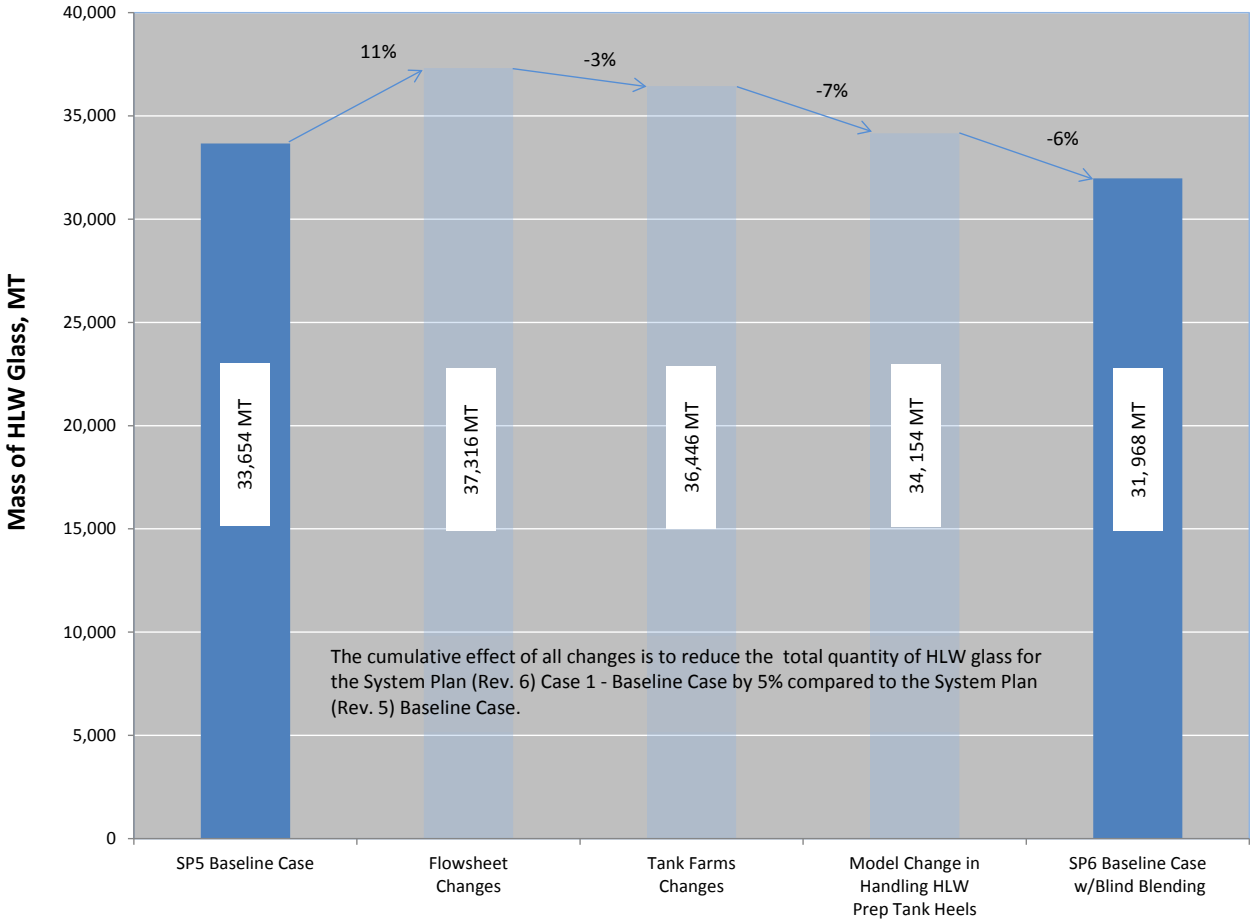

Figure 5-16. High-Level Waste Glass Change Analysis

The projected number of HLW glass canisters for the Baseline Case has decreased by about 1.2 percent (from 10,713 to 10,586 canisters) relative to the System Plan (Rev. 5) Baseline Case. This small reduction in canister count relative to the glass mass reduction is due to a change in the canister fill assumption from the thin-walled 10-gauge nominal canister holding 3.14 MTG/canister for the System Plan (Rev. 5) Baseline Case to the ⅜-in. wall canister holding 3.02 MTG/canister for System Plan (Rev. 6) Baseline Case (see Assumptions B3.3.3.4, B3.3.3.6, and B3.3.3.7 in Appendix B for more details) By itself, the change in canister fill assumptions results in a 4 percent increase in the number of canisters for the same mass of glass.

The reasons for the reduced glass mass shown in Figure 5-16 are discussed below:[63]

- **Flowsheet changes** – The flowsheet changes include removal of the Aluminum Removal Facility from the RPP mission flowsheet, implementation of the WTP equipment alternative in the WTP pretreatment system, and the addition of phosphate and oxalate solubility correlations. Flowsheet changes accounted for about an 11 percent increase in HLW glass compared to the System Plan (Rev. 5) Baseline Case.
- **Tank farms changes** – Changes to the tank farms include improvements in the logic for using the DSTs, changes in how the solids are managed in the DSTs (e.g., minimum slurry levels in the DSTs and limits on the solids loading in supernate transfers), and changes to the SST retrieval assumptions. These changes together accounted for about a 3 percent decrease in HLW glass compared to the value reported for the flowsheet changes.
- **Model change in handling HLW feed preparation tank heels** – Recent efforts to optimize the glass formulation calculations revealed that the glass formers in the melter feed preparation vessel heels were being ignored, resulting in the addition of more glass formers than were needed. Correction of the calculation led to a 7 percent decrease in the glass mass compared to the quantity reported for the tank farms changes.
- **Implementation of blind blending** – The implementation of blind blending in the DSTs led to a 6 percent decrease in the mass of HLW glass compared to the model change in handling the HLW feed preparation tank heels.

The WOL for HLW glass achieved for the Baseline Case was slightly lower than from System Plan (Rev. 5) due to the cumulative effect of the various changes in the mission.

[63] The impacts of these changes were estimated as incremental changes in the sequence shown on Figure 5-16. Each reported percentage change is the incremental change in the mass of glass expressed as a percentage of the mass of glass for the System Plan (Rev. 5) Baseline Case. While the reported values may change if the incremental changes are evaluated in a different sequence, the cumulative change will remain the same and the relative importance of each incremental change should remain about the same.

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6.0 TECHNOLOGY DEVELOPMENT FOR THE BASELINE CASE

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

The next revision of the Technology Development Roadmap (RPP-PLAN-43988) is being prepared in parallel with development of System Plan (Rev. 6). Technology development activities related to the Baseline Case are described in this section. Case-specific technology development needs for Cases 2 - 10 are addressed separately for each case within Section 10.0.

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

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

ORP and WRPS are pursuing several transformational technologies. A transformational technology is an innovative approach with the potential to significantly reduce life-cycle costs, schedule, or technical risks. Of the 16 technology initiatives described herein, seven are transformational, including:

- MARS
- Wiped-film evaporator
- Glass formulation improvements
- Second generation melters
- At-tank filtration using RMF
- SCIX systems
- FBSR.

Table 6-1. Technology Development Overview for the River Protection Project System (Baseline Case)

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

[a] Transformational technology

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

7.0 KEY ISSUES AND UNCERTAINTIES FOR THE BASELINE CASE

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

The Baseline Case defined by Appendix B and presented in this System Plan includes a number of challenges that need to be successfully addressed to reach the desired performance for the mission. These challenges are summarized in this section along with potential mitigating actions and related details. Note that key issues and uncertainties that are unique to Cases 2 - 10 are identified in their respective sections in Section 10.0.

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

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

Information sources included Appendix B, TFC-PLN-39, the RPP risk database, and the HANDI–PERF Integrated Planning and Reporting System (IPARS) Control Module, which contains the WBS. Risks identified in conjunction with Cases 2-10 were also considered when framing the risks for the Baseline Case.

7.1 DOUBLE-SHELL TANK SPACE MANAGEMENT

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.1-1	The space available in the existing 28 DSTs will be sufficient to execute the RPP mission.	a. Small perturbations in assumptions or uncertainties affecting DST space management have a disproportionate effect on the early SST retrieval schedule as available DST space approaches zero.	i. Use SST retrieval experience and technology development to increase waste retrieval volumetric efficiencies.	
			ii. Continue waste management initiatives to increase usable storage space in existing DSTs. Per RPP-RPT-45825,[a] five options are recommended for further evaluation: • Raise the allowable waste limit in nine tanks to provide up to 940 kgal of space • Concentrate the waste in 15 DSTs to 1.43 SpG to recover up to 3,500 kgal of space • Use four of six planned WRF tanks to create 600 kgal of space • Use DST space currently reserved as emergency space to make 1,265 kgal available • Implement a revised SST retrieval sequence giving priority to tanks containing sludge or less salt to reduce near-term impacts to DST space.	The level-rise modification project was recently completed in AP Farm (additional details are provided in Section 1.5). WRFs are planned and are expected to be added to the PMB.
			iii. Treat a portion of the tank waste, either by supplemental LAW treatment or by early startup of the WTP LAW Vitrification Facility.	The potential impact (good or bad) on DST space management will be considered as decisions are made on how to provide the needed supplemental treatment and pretreatment capabilities (see Table 7-8, Item 7.8-3).
			iv. Take advantage of the storage space potentially provided by any new feed conditioning, blending, new or expanded WRFs, or other facilities.	The potential impact (good or bad) on DST space management will be considered as decisions are made with respect to new or expanded facilities.
			v. The allocation of a four-month period for sampling and analysis of waste in preparation for processing through the 242-A Evaporator may cause bottlenecks when retrieving dissolved saltcake. Alternative sampling and staging strategies should be considered.	
			vi. Retrieval and staging of waste from multiple SSTs into fewer, sound SSTs determined to be fit-for-use could partially decouple SST retrievals from DST space availability limitations.[b]	RPP-RPT-47282,[c] issued in 2010, analyzes the potential reuse of SSTs and estimates the bounding resource requirements and emissions associated with reusing an SST in order to understand regulatory impacts.
		b. The fill capacity of some DSTs is currently restricted to levels less than design capacity as a safety measure to address concerns related to possible BDGRE. If safety could be verified, the current limits on DST fill capacity could be modified, thereby increasing available DST storage space, as is assumed by this System Plan.	vii. Continue to resolve technical issues associated with sludge accumulation in DSTs. viii. TD 1.2: A cone penetrometer tool will allow data to be collected to confirm that waste sludges have higher shear-strength. Empirical data confirm that high shear-strength sludge wastes have low gas content.	RPP-PLAN-30112 (2006)[d] identified the activities and decisions necessary to safely accumulate solids in DSTs in light of BDGRE concerns. Additional work followed, including publication of RPP-RPT-26836 (2010),[e] which proposed a new BDGRE model for DSTs containing only high shear strength waste. Work is ongoing.
				TRL 5: A prototype cone penetrometer measurement tool was tested in FY 2009. Design changes based on testing were completed and a new cone penetrometer was procured in FY 2011. Based on the C Farm retrieval schedule, deployment is planned in Tank AN-106 in late FY 2013.

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.1-2	The existing 28 DSTs are assumed to be available for use for the entire waste treatment mission.	a. Failures of a DST prior to 2025, such as a primary liner leak, may impact SST retrievals.	i. Build new DSTs, utilize space reserved for emergencies, take advantage of other space from the WRFs or the FCCF if built, reuse sound SSTs, or accept impacts.	New item.
		b. Failures of one or more DSTs after 2025 may impact SST retrievals or the treatment date for completion of waste treatment.	ii. Evaluate the flexibility of the DST system to operate with fewer DSTs in service, build new DSTs, take advantage of other space from the WRFs or the FCCF if built, reuse sound SSTs, take advantage of any relief provided by alternative mission configurations such as in Case 3 or 7, or accept the impacts.	New item.
7.1-3	The 242-A Evaporator will continue to operate as needed to minimize the volume of liquid waste generated during SST retrievals, and to adjust sodium levels to meet WTP feed requirements. Dilute waste will be concentrated, if at least a 15% waste volume reduction is achievable, until it reaches a bulk concentration of 1.43 g/ml or 80% of the maximum product source term. (Additional 242-A Evaporator assumptions are provided in Table 7-12, Item 7.12-3.)	a. Failure of the 242-A Evaporator system would be a single-point failure that could interrupt planned SST retrieval schedules and/or waste feed delivery schedules to WTP. b. If this assumed concentration cannot be achieved, on average, through 2025, then less DST space will be available to support SST retrievals and waste feed delivery. This is a specific example of a small perturbation in assumptions (see Table 7-1, Item 7.1-1a).	i. Perform life-extension upgrades to ensure long-term viability of 242-A Evaporator. Periodically reevaluate the upgrade needs. Perform Independent Qualified Registered Professional Engineer multidiscipline reviews as needed.	WBS 5.03.01 includes annual funding for evaporator process engineering support. A combination of operating funds and RA project funds has been allocated to implement a variety of facility upgrades.
			ii. TD 1.3: WFE technology would provide a transportable system for evaporation of SST waste, DST waste, secondary waste, and TRU mixed waste, thus reducing the volume of waste requiring storage and eliminating the current total dependence on the 242-A Evaporator.	TRL 3: Development of a WFE has been projectized to further mature the technology. RA project funding was allocated in FY 2009-2011, with additional funding in WBS 5.03.11 for FY 2012-2013. Workscope includes technology development activities to mature technology to a TRL of 6. Workscope in FY2014 – 2016 includes activities to support field deployment. Full-scale operation is planned in 2016. Work on a bench-scale thin-film evaporator is also proceeding in parallel.
			iii. TD 1.4: The waste reduction technology demonstration project will use an agitated thin-film evaporator to test the evaporation of both simulants and actual waste. Test results will provide useful data and support field implementation of the WFE.	TRL 3: The design process began in FY 2010. Testing with simulant, procurement, and assembly are occurring in FY 2011. Testing with actual waste is expected in FY 2012.
			iv. Confirm the continued need for the 242-A Evaporator to support DST space management and waste feed delivery.	Work is in progress on a parametric study of additional evaporative support to the 242-A Evaporator. In the study, the need for evaporator operations at various times during the mission is being evaluated.

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

[b] In 2002, in support of Hanford Federal Facility Agreement and Consent Order milestone M-023-24, the Tank Farms Contractor conducted an assessment of SST system integrity. The resulting report, RPP-10435, *Single-Shell Tank System Integrity Assessment Report*, concluded that "...the reinforced-concrete tank structures have an adequate collapse margin, justifying continued safe storage of the interim-stabilized waste. However, given the tank leak history and current condition of the tank liners, long-term leak integrity, for the liquids remaining in the tanks, cannot be proven for any of the SSTs..." Based on those conclusions, in a subsequent letter to Ecology (Rasmussen 2002, 02-OMD-036), ORP declared "...these tanks and ancillary systems should be considered unfit for use." The technical and regulatory hurdles that would have to be overcome to reverse this decision should not be underestimated. Ecology approval would be required to proceed. Based on a preliminary evaluation of these potential options in RPP-RPT-25589, *Evaluation of Alternatives to Support Temporary Waste Staging Needs*, and the recommendations of RPP-RPT-45921, *Single-Shell Tank Integrity Expert Panel Report*, ORP is further exploring the cost, benefits, and risks of staging waste in sound SSTs.

[c] RPP-RPT-47282, 2010, *Data to Support the Regulatory Evaluation of Single-Shell Tank Waste Staging*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

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

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

BDGRE = buoyant displacement gas release event.
DST = double-shell tank.
FCCF = Feed Characterization and Certification Facility.
FY = fiscal year.
LAW = low-activity waste.
ORP = Office of River Protection.
PMB = performance measurement baseline.
RA = Recovery Act.
RPP = River Protection Project.
SST = single-shell tank.
TD = technology development.
TRL = technology readiness level.
TRU = transuranic.
WBS = work breakdown structure.
WFE = wiped-film evaporator.
WRF = waste retrieval facility.
WTP = Waste Treatment and Immobilization Plant.

7.2 SINGLE-SHELL TANK RETRIEVAL

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.2-1	SST bulk waste retrieval methods (including modified sluicing with supernate or water, modified sluicing with water only, vacuum retrieval, a mobile retrieval system, and/or alternative processes) will meet ORP expectations for waste retrieval rates to provide feed on demand to WTP. SST heel removal technologies will be able to meet retrieval (tank residual) requirements. The System Plan (Rev. 6) Baseline Case requires that the TOE for retrievals from SSTs other than C Farm will be twice the currently estimated TOEs. The System Plan (Rev. 6) Baseline Case requires that a sustained average of nine SST retrievals be completed each year.	a. SST retrieval rates will be achieved based on assumed retrieval technologies and performance (including learning curves and demonstrated pumping rates); retrieval sequences, simultaneous retrieval constraints resulting from infrastructure or operational considerations, and available DST space; supplemental treatment (packaging) of potential TRU tank waste; providing a balanced feed to the WTP (with priority given to feeding the more limiting facility); and providing for both incidental blending and intentional blending. However, based on retrieval system experience, waste in some tanks will be difficult to retrieve. Use of multiple technologies may be required in a single tank to meet retrieval (tank residual) requirements. The retrieval technologies may not be as efficient or effective as assumed. "Special case" SSTs and SSTs assumed to have leaked may present additional retrieval challenges. In addition to the four primary bulk waste retrieval methods already identified (i.e., modified sluicing with DST supernate, modified sluicing with water, vacuum retrieval, and a mobile retrieval system), alternative methods for bulk waste retrieval may be required. b. Certain tanks may require use of chemical dissolution for the removal of heels. Use of large quantities of sodium hydroxide, oxalic acid, or other chemicals for heel removal may increase the mass of LAW glass or adversely impact the WTP flowsheet. c. If the overall required retrieval rates cannot be met with improvements in the TOEs and associated retrieval durations, then other alternatives may need to be explored (e.g., increasing the number of simultaneous retrievals). Long-term milestones for "Completion of all SST retrievals" and/or "Treat all tank waste" could be impacted. d. Fundamental changes may be required in how work is performed within the tank farms to increase the base TOEs for waste retrieval processes.	i. Develop, test, and deploy new SST retrieval technologies as needed. TD 2.1: The MARS technology consists of a telescoping arm that rotates a complete 360 degrees, enabling it to reach the furthest extremities of an SST. MARS with modified sluicing will be used for sound tanks, and MARS vacuum mode will be used for tanks that are assumed to have leaked in the past. Evaluate different methods (other than use of garnet as an abrasive in a water jet) to add risers to SSTs for installation of the MARS.	TRL 7: Sluicing version – Full-scale cold testing of MARS was performed in FY 2009. Test results prompted some design modifications, which are in progress. Deployment in Tank C-107 is scheduled in FY 2011 (additional details are provided in Sections 1.5 and 3.1.1 and in Table 3-5). TRL 4: Vacuum version – Design activities are continuing in FY 2011. Deployment in Tank C-105 is scheduled in FY 2013.
			ii. Incorporate lessons learned into retrieval system plans, designs, and operations to improve the process TOEs and reduce retrieval durations. Revise the SST Waste Retrieval Plan (RPP-PLAN-40145)[a] as appropriate.	Updated SST retrieval assumptions (assumed technology, TOEs and associated minimum retrieval durations, and as-retrieved waste volumes) used for the System Plan (Rev. 6) Baseline Case are provided by SVF-1647.[b] These will be used as a basis for establishing the initial performance requirements of future SST retrieval systems.
			iii. TD 1.1: Expand the existing SST Tank Integrity Program. Develop a suite of tools/methods and perform tests on SSTs to assess and demonstrate the integrity of the tanks for continued use, including SST use for waste staging.	An SST Integrity Program was initiated in FY 2009 with the assistance of an expert panel (additional details are provided in Section 3.1.1).
			iv. Revisit the designation of the SSTs that are assumed to have leaked, and if supported by evidence, revise those designations using the process described in TFC-ENG-CHEM-D-42.[c]	Leaks from tanks in A, AX, C and SX Farms have been reassessed using RPP-32681.[d] Adoption of results is pending the completion of formal tank leak assessments under TFC-ENG-CHEM-D-42.[c] Reports include RPP-ENV-33418,[e] RPP-ENV-37956,[f] and RPP-ENV-39658.[g]
			v. Continue communications with regulators to determine if waste retrieval from a given tank meets regulatory requirements.	Ongoing.
			vi. Demonstrate the efficacy of both caustic and oxalic acid heel removals.	A high caustic concentration heel removal demonstration is planned for Tank C-108 in FY 2011. One (or more) oxalic acid cleaning demonstration(s) is planned as part of AX Farm retrieval around FY 2016–2017.
			vii. Evaluate the costs and benefits of implementing an oxalic acid destruction process.	The Savannah River Site is currently developing enhanced chemical cleaning technology, using oxalic acid in conjunction with an oxalic acid destruction technology. Progress updates occur during regularly scheduled information sharing contacts.
			viii. Evaluate the feasibility of reducing the peak number of SST retrievals completed per year.	This may be considered as part of a future revision to RPP-PLAN-40145.[a]
			ix. Identify the specific changes in conduct of operations and engineering required to support the needed SST retrieval TOEs.	Need recognized, but not in PMB. This mitigating action may be considered for inclusion in a future PMB.

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.2-1 cont.		e. Planned retrieval infrastructure, in conjunction with allocation of current resources, may not be adequate to support the number of concurrent retrievals and the number of retrievals per year necessary to meet mission success criteria (i.e., WTP feed rates and HFFACO[h] milestones).	x. A variety of tank farm infrastructure upgrade projects are planned to support waste retrieval and waste feed delivery activities. Examples include (but are not limited to) removal of obsolete equipment and transfer lines, installation of mixer pumps, transfer pumps, instrumentation and transfer lines, and upgrades to tank ventilation and electrical systems.	Infrastructure upgrade projects are in various stages of planning and execution based on funding availability and anticipated need dates.
			xi. Consider scheduling the removal of obsolete equipment, installation of new risers, refurbishment of pits, and similar work earlier to decouple preparatory scope from the actual installation of the upgrades.	Many of these types of projects were completed with RA funding in FY 2010-2011 (additional details are provided in Section 3.1.9).
			xii. Evaluate ability to manage, coordinate, and operate multiple retrievals per year.	
		f. Waste containing high concentrations of phosphates could result in transfer line plugging that would delay waste retrieval and/or evaporator operations.	xiii. Engineering procedures and standards are in place to control the transfer of phosphate-bearing waste.	Operational controls are maintained through the Waste Compatibility Program.
			xiv. Develop methods for locating plugs and unplugging the transfer lines.	Florida International University is currently testing two possible methods for removing line plugs.
7.2-2	The System Plan assumes that no waste will leak from SSTs or SST retrieval systems during retrieval to ensure that the maximum waste inventory is modeled through the WTP.	a. The potential exists for an SST to leak during retrieval operations. The discovery of a leak may require the implementation of response actions, including the potential use of a different retrieval technology, and might delay retrievals in nearby tanks.	i. Formulate detailed tank retrieval plans to retrieve adjacent sound tank(s) prior to retrieving suspect tank(s) to reduce the impact of a leak on nearby retrievals; include monitoring strategies to identify leaks if they should occur and response actions for tank leaks in the tank waste retrieval work plans and process control plans.	RPP-PLAN-40145[a] plans to retrieve adjacent sound tank(s) prior to retrieving suspect tanks(s).

[a] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.
[b] SVF-1647, 2010, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3D.xlsx'," Rev. 3D, Washington River Protection Solutions LLC, Richland, Washington.
[c] TFC-ENG-CHEM-D-42, 2011, *Tank Leak Assessment Process*, Rev. B-3, Washington River Protection Solutions, LLC, Richland, Washington.
[d] RPP-32681, 2007, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
[e] RPP-ENV-33418, 2008, *Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 242-C-105, and Unplanned Waste Releases*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
[f] RPP-ENV-37956, 2008, *Hanford A and AX-Farm Leak Assessments Report: 241-A-103, 241-A-104, 241-A-105, 241 AX-102, 241-AX-104 and Unplanned Waste Releases*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
[g] RPP-ENV-39658, 2010, *Hanford SX-Farm Leak Assessments Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[h] Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

DST = double-shell tank.
FY = fiscal year.
HFFACO = Hanford Federal Facility Agreement and Consent Order.
LAW = low-activity waste.
MARS = mobile arm retrieval system.
PMB = performance measurement baseline.
RA = Recovery Act.
RPP = River Protection Project.
SST = single-shell tank.
TD = technology development.
TOE = total operating efficiency.
TRL = Technology Readiness Level.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

7.3 TANK/WASTE MANAGEMENT AREA CLOSURE – REGULATORY PROCESS

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.3-1	ORP and Ecology will provide timely approval to support interim closure (tank isolation and filling with grout) of each SST after retrieval of that tank is complete.	a. Interim and final closure plans have not been fully developed. b. Closure activities are not modeled in HTWOS.	i. A closure integration plan is being developed to better define the strategy and approach to be used to close the tanks. The cost and schedule for interim and final closure activities will be reflected in the life-cycle baseline.	In 2011, WRPS provided RPP-PLAN-40761[a] to ORP.
	Timely approval will be provided to support waste management area closure after all tanks in that area have been interim closed.	c. Uncertainties regarding issuance of the draft TC & WM EIS and final ROD may impact development and implementation of closure plans.	ii. Continue to support finalization of the TC & WM EIS and release of the ROD.	Upon issuance of the TC & WM EIS ROD, the impacts of the ROD upon the RPP system will be assessed, and a BCR will be submitted to bring the baseline into alignment.
		d. Selection of closure activities and technologies through the regulatory process may be more costly and require more time than is planned in the baseline. Schedule delays could impact the ability to meet HFFACO[b] closure milestones.	iii. Continue to develop information that supports closure initiatives.	Ongoing efforts in support of the Waste Management Area C performance assessment are discussed in Section 2.3.3 (see also Table 7-4, Item 7.4-1).
		e. The ability of grout to successfully encapsulate and stabilize the residual tank waste is uncertain.	iv. Continue to develop and test grout formulations.	See Table 7-4, Item 7.4-1b.

[a] RPP-PLAN-40761, 2011, *Integrated Single-Shell Tank Waste Management Area Closure Plan*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[b] Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

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

7.4 TANK/WASTE MANAGEMENT AREA CLOSURE – TECHNOLOGY

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.4-1	Sampling and analysis tools and methods to assess the quantity, composition, and radioactivity of residual tank waste will be developed. Interim tank closure technologies and waste management area closure technologies can be developed to meet as-yet-undetermined regulatory requirements.	a. Possible tools and methods for residual waste characterization are still under evaluation at this time. b. The ability of the grout to (1) sufficiently stabilize the waste heel, and (2) prevent subsidence of the tank has not yet been demonstrated.	i. Test technologies and techniques prior to field deployment. Ensure that lessons learned are gathered during testing and demonstrations and are incorporated into closure plans and the life-cycle baseline.	In 2009, WRPS released RPP-RPT-41550,[a] which documented the results of off-site cold testing of candidate grout formulations for tank closure. RPP-PLAN-43988[b] provides an overview of additional work planned.

[a] RPP-RPT-41550, 2009, *Closure Demonstration Grout Test Report*, Rev. 1A, Washington River Protection Solutions, LLC, Richland, Washington.

[b] RPP-PLAN-43988, 2011, *WRPS Technology Development Roadmap*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

WRPS = Washington River Protection Solutions, LLC.

7.5 WASTE TREATMENT AND IMMOBILIZATION PLANT

Table 7-5. Waste Treatment and Immobilization Plant (4 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.5-1	WTP hot commissioning will start May 1, 2018, and end on December 1, 2019. Full WTP production operations will start December 2, 2019, and continue until the end of the treatment mission. The net LAW treatment rate during full operations will ramp to 21.0 MTG/day by January 1, 2022. The net HLW treatment rate during full operations will ramp to 5.25 MTG/day by February 6, 2025. The WTP PT Facility will perform significantly better than its minimum contract capacity requirements and support the net HLW and combined LAW vitrification capacities assumed by the System Plan. The WTP will operate at the above rates and according to its flowsheet and operating modes as reflected in 24590-WTP-RPT-PT-02-005[a] and 24590-WTP-MDD-PR-01-002,[b] except where superseded by the "equipment alternative" modification implemented to mitigate solids precipitation in ion-exchange feed discussed in 24590-WTP-RPT-PET-09-004.[c] Flowsheet and operating mode modifications will be made as needed to implement the other assumptions in this System Plan.	a. Experience at other sites indicates startup and readiness at complex facilities is uncertain. If the start of operations is delayed, or the capacity of the WTP is lower than projected, the duration of the treatment mission may increase. b. Depending on the current mission duration driver, more waste may have to be processed through supplemental treatment. c. The WTP PT Facility, LAW Vitrification Facility, or HLW Vitrification Facility may not achieve the assumed design or net treatment capacities. d. Supplemental pretreatment capacity beyond that provided by the WTP may be needed to fully utilize the assumed HLW and combined LAW treatment (vitrification) capacity or the duration of the treatment mission may increase. e. Supplemental treatment capacity beyond that assumed by this System Plan to be provided by a second LAW facility may be needed to keep LAW treatment from causing unacceptable increases in mission duration and to more fully utilize the assumed HLW treatment capacity.	i. Continue to identify WTP construction, startup, and process throughput uncertainties and complete appropriate risk mitigation actions.	The recently formed WTP Operational Readiness organization includes personnel with knowledge and experience from both the TOC and WTP project.
			ii. Plan and execute a second (supplemental) LAW vitrification facility baseline scope of work.	WBS 5.04.01.08 is funded in FY 2011–2013.
			iii. Revisit programmatic assumptions, such as the amount and timing of supplemental treatment, if the projected mission duration exceeds the life of WTP or if the mission duration is otherwise unacceptable.	Analysis conducted as part of ongoing HTWOS modeling and system planning.
			iv. Continue to monitor WTP design capacities and predicted availabilities. Consider future improvements to WTP design, flowsheets, operating modes, and strategies.	The recently formed WTP Operational Readiness organization includes personnel with knowledge and experience from both the TOC and WTP project. Evaluate implications of the report being prepared in response to TPA milestone M-062-49, due October 31, 2011, "…which demonstrates that the WTP is designed to accomplish… pretreat[ing] 100% of retrievable tank waste…".
			v. Incorporate more accurate models of the WTP flowsheet and operating modes into future versions of the System Plan, via updates to HTWOS.	Ongoing. Additional upgrades will be implemented in the future as appropriate. WBS 5.03.01.02 is funded in FY 2010–2013.
			vi. Evaluate ways to reduce the demand on the WTP PT Facility so that HLW vitrification drives the mission duration. This includes trading-off the mass of HLW glass against the mass of LAW glass, reducing variability in the projected WTP feed, refinements to the design and operating modes of the WTP, and providing supplemental pretreatment.	The Supplemental Treatment and Immobilization Program will determine how best to provide the needed supplemental LAW treatment capability and any supplemental pretreatment capability, if needed.
7.5-2	Startup and turnover of WTP facilities to the TOC will not be adversely impacted by inadequate staffing or documentation.	a. Organizational interfaces needed to enable facility turnovers are not yet in place. b. Operating documentation does not yet exist.	i. Create and maintain organizational interfaces to promote effective communication, planning, and issue resolution. ii. Considered turning over parts of the WTP to the TOC early, to allow for a phased transition.	The WTP Operational Readiness department was created in FY 2010 to facilitate interfaces between the two organizations and includes personnel with knowledge and experience from both the TOC and WTP project.
7.5-3	The technical issues previously identified in several design oversight reviews, external reviews, and a comprehensive independent review either have been resolved or will be resolved without adverse impact to the assumed performance or schedule of WTP.	a. At this time, it is unlikely that the resolution of technical issues will have a negative impact on mission duration. If the aforementioned technical issues are not successfully resolved, the WTP may operate at less than its assumed design capacity, or its startup schedule could be delayed, either of which could increase the overall RPP mission duration.	i. Monitor resolution of the technical issues; provide support as appropriate.	Technical issues are being aggressively worked to bring timely closure and support the WTP construction schedule. Closure of critical issues is approved jointly by WTP and ORP through a technical steering group.
		b. Successful resolution of these issues could impact tank farms operations.	ii. Interface control documents, particularly ICD-19,[d] are actively managed to ensure mutual understanding of current interface requirements.	

Table 7-5. Waste Treatment and Immobilization Plant (4 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.5-4	The composition, properties, and waste oxide loading of HLW glass will be estimated using the 2009 GFM documented in PNNL-18501.[e] For modeling purposes, the glass-forming chemicals are assumed to be provided as pure oxides rather than impure minerals. Projections of IHLW produced by the WTP are based on starting tank inventory, partitioning assumptions (wash and leach factors, oxidative leach assumptions, solubility correlations), and the assumed disposition of the TRU waste. In addition, the IHLW canister count is based on filling a canister with a 3/8-in. thick wall to 95% full at an average bulk density of 2.66 kg/L. This meets the requirements set forth in DE-AC27-01RV14136, Section C, 1.2.2.1.2,[f] and is consistent with (exceeds) the fill height requirement specified in Section 3.6 of DOE/EM-0093,[g] in which the canister will be filled "to at least 80% of the volume of the empty canister." Process control strategies for the WTP HLW Facility will accept a highly variable melter feed composition without impact to waste oxide loading.	a. HLW glass formulation assumptions have not been demonstrated for all Hanford waste compositions. Incorrect assumptions could impact expected waste loading per unit of glass, number of IHLW canisters, and mission duration.	i. Continue HLW glass development at the Vitreous State Laboratory[h] with DOE funding.	Work at Vitreous State Laboratory[h] is ongoing. Higher alumina loadings have been demonstrated for some HLW glasses. DOE-WTP acknowledges the value of including a reasonably defensible basis to project-enhanced waste loading beyond the WTP contract minima. DOE recognizes the utility and flexibility of the glass formulation algorithms and will shortly undertake the formal enhancement of the qualified glass forming region. This enhancement will include the results of DOE's glass development program and throughput enhancements to the baseline design described in ORP-48578[i] and ORP-47690.[j] Additionally, results of the continued glass development efforts will be incorporated, and a more robust set of glass formulation algorithms will be delivered to the operating contractor upon completion of the commissioning activities. RPP-RPT-49196[k] describes the WRPS glass formulation vision in support of the WTP.
			ii. Develop and implement in HTWOS a new GFM that reflects recent research at PNNL.	A new GFM was developed based on PNNL-18501[e] and implemented in HTWOS for System Plan (Rev. 5). Additional information on the model update is provided in Section 4.1.1. Additional information regarding HLW glass predictions is provided in Section 5.6.2.4.
		b. Projected number of IHLW canisters generated is uncertain. HLW glass mass is sensitive to the degree of blending (both incidental and intentional) achieved during the retrieval, storage, and delivery of feed; to starting waste inventory; and to pretreatment assumptions.	iii. Continue to evaluate options for intentional blending, caustic and oxidative leaching, and improving the HLW glass formulations. Evaluate impacts that other assumption changes and operational constraints have on blending and the resulting HLW glass mass.	An intentional blending strategy (blind blending) strategy (metered blending) of waste containing high zirconium concentrations present in some tanks was evaluated in System Plan (Rev. 5) and has been adopted by System Plan (Rev. 6). An intentional blending strategy (blind blending), recommended by RPP-RPT-42968,[l] has been adopted by System Plan (Rev. 6). RPP-RPT-48372[m] evaluated the impact of recent WTP pretreatment system design, flowsheet, and operating mode changes on the RPP mission and documented a series of sensitivity runs to select the preferred operating modes for system planning purposes.
			iv. Sample, characterize, and test leaching performance of DSTs containing SST waste after early SST retrievals are complete to reduce uncertainty.	
		c. Given the current uncertainties associated with the location and waste acceptance criteria of the future federal repository, HLW product specifications are also uncertain.	v. None identified at this time.	Existing HLW product specifications for the previously assumed off-site geologic repository are being used for system planning.
		d. A single IHLW canister needs to be selected for use.	vi. System Plan (Rev. 6) assumptions have returned to use of the HLW canister with ⅜-in. thick walls.	In the event that a different canister design is selected in the future, additional work would be required to support necessary changes in design, permitting, safety analysis, project definition, and system planning.

Table 7-5. Waste Treatment and Immobilization Plant (4 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.5-4 cont.		e. Approximately 4,000 individual HLW batches are projected to be delivered to the HLW melter. While adjacent batches are often similar in composition, processing all Hanford waste will require at least 500 distinct HLW glass recipes. Process control strategies have not yet been developed to handle these diverse compositions of HLW. If the process control strategies result in the addition of trim chemicals to a HLW waste batch to bring it into a qualified composition region, the HLW glass could have lower than expected waste loading and result in a longer than predicted mission duration. The wide variety of waste delivered to the melter increases the operational complexity of the production of HLW glass.	vii. Advanced blending strategies or dedicated blending facilities might further reduce the variability of the HLW delivered to the melter. viii. Examine whether altering the SST retrieval sequence could enhance the incidental blending that occurs during the retrieval, staging, and processing of tank waste or improve performance of intentional blending strategies. ix. Establish a process control strategy for the vitrification of pretreated HLW. x. Continue HLW glass development work (see i above).	RPP-RPT-50309[n] identifies the need for a process control strategy and proposes three distinct waste clusters for qualification.
7.5-5	Projections of WTP secondary wastes are not well defined.	a. Current modeling efforts are only capturing the secondary wastes directly related to the waste treatment process. These quantities have not been validated.	i. Need to quantify and validate projections of secondary waste streams.	
7.5-6	Composition of the LAW glass will be estimated using a glass recipe model similar to that described in Table B-2 of 24590-WTP-MRQ-PO-04-0065.[o] Sodium oxide loading of LAW glass from pretreated feed will be determined using the DOE model (D-03-DESIGN-004),[p] which maximizes the sodium oxide loading subject to constraints. Projections of ILAW produced by the WTP are based on starting tank inventory, wash and leach factors, waste solubility, oxidative leach assumptions, and the assumed disposition of the TRU waste.	a. The projected number of ILAW packages from the WTP is uncertain. LAW glass mass is very sensitive to the assumed caustic addition requirements (see Table 7-8, Item 7.8-2). b. The IDF waste acceptance criteria for ILAW are not fully defined, and in their current state, may not be sufficient for ILAW disposal.	i. Continue development of improved GFMs for LAW vitrification taking into account recent glass formulation work to increase both the Na_2O and SO_3 loadings. ii. Review and refine IDF waste acceptance criteria for ILAW.	DOE-WTP acknowledges the value of including a reasonably defensible basis to project-enhanced waste loading beyond the WTP contract minima. DOE recognizes the utility and flexibility of the glass formulation algorithms and will shortly undertake the formal enhancement of the qualified glass forming region. This enhancement will include the results of DOE's glass development program and throughput enhancements to the baseline design described in ORP-48578[l] and ORP-47690.[j] Additionally, results of the continued glass development efforts will be incorporated, and a more robust set of glass formulation algorithms will be delivered to the operating contractor upon completion of the commissioning activities.

Notes to Table 7-5:

[a] 24590-WTP-RPT-PT-02-005, 2009, *Flowsheet Bases, Assumptions, and Requirements*, Rev. 5, Bechtel National, Inc., Richland, Washington.

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

[c] 24590-WTP-RPT-PET-09-004, 2010, *Recommendation of Alternative to Mitigate Solids Precipitation in Ion Exchange Feed*, Rev. 1, Bechtel National, Inc., Richland, Washington.

[d] 24590-WTP-ICD-MG-01-019, 2008, *ICD-19 - Interface Control Document for Waste Feed*, Rev. 4, Bechtel National, Inc., Richland, Washington.

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

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

[g] DOE/EM-0093, 1996, *Waste Acceptance Product Specifications for Vitrified High Level Waste Forms*, Rev. 2, U.S. Department of Energy, Office of Environmental Management, Washington, D.C.

[h] Vitreous State Laboratory of The Catholic University of America, Washington, D.C.

[i] ORP-48578, 2010, *Waste Loading Enhancements for Hanford LAW Glasses*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington.

[j] ORP-47690, 2010, *DM100 and DM1200 Melter Testing with High Waste Loading Glass Formulations for Hanford High-Aluminum HLW Streams*, U.S. Department of Energy, Office of River Protection, Richland, Washington.

[k] RPP-RPT-49196, 2011, *Optimization of Glass Formulation for WTP Vitrification Operations: Direction for High-Level Waste*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

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

[m] RPP-RPT-48372, 2011, *Pretreatment Operating Mode Sensitivity Evaluation Using the HTWOS Model*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

[n] RPP-RPT-50309, 2011, *Evaluation of Tank Waste Feed for WTP HLW Mission: Basis for Glass Composition Development*, Rev. 0 (DRAFT), Washington River Protection Solutions, LLC, Richland, Washington.

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

[p] D-03-DESIGN-004, 2003, *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*, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE = U.S. Department of Energy.
DST = double-shell tank.
FY = fiscal year.
GFM = glass formulation model.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
MTG = metric ton of glass.
ORP = Office of River Protection.
PNNL = Pacific Northwest National Laboratory.
PT = Pretreatment.
RPP = River Protection Project.
SST = single-shell tank.
TOC = Tank Operations Contract.
TPA = Tri-Party Agreement.
TRU = transuranic.
WBS = work breakdown structure.
WTP = Waste Treatment and Immobilization Plant.

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

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.6-1	Discrepancies between the current RPP baseline and the TC &WM EIS[a] scope can be resolved via the baseline change request process after the EIS ROD has been issued.	a. EISs are written more broadly than a specific project baseline, and because they look at how a program could evolve into the future, they cover more aspects than what might be in the tank farms baseline at any given time. The System Plan may evaluate some cases that are different than the EIS.	i. Once an ROD is written, the tank farms baseline may need to be modified to align with the ROD.	DOE has full responsibility for the preparation of EISs and their associated ROD. WRPS will provide support as requested.
7.6-2	Timely approval will be received to (1) interim close individual waste tanks after they are emptied, and (2) close each tank farm after all tanks in that farm are interim closed.	a. Delays in completing the TC & WM EIS[a] will impact progress in developing closure plans and initiating field closure activities. EIS alternatives and the ROD may not align with the baseline assumptions and not establish the needed standards to close tanks. Assumed closure technologies have been tested but not deployed.	See Table 7-3, Item 7.3-1.	See Table 7-3, Item 7.3-1.
7.6-3	Current HFFACO[b] milestone completion dates are being renegotiated, and therefore will not be used as a planning basis.	a. Litigation between state and federal authorities over delinquent milestones and the ability to meet remaining milestones may impact establishment of HFFACO[b] dates. New HFFACO milestone dates and commitments, if not consistent with the life-cycle baseline and associated uncertainties, would impact the baseline. Uncertainties regarding issuance of the draft TC & WM EIS[a] and final ROD have the potential to impact new HFFACO[b] milestone dates for retrieval and closure.		RESOLVED. Consent Decree No. 08-5085-FVS[b] established new milestones, which have been incorporated into the ORP planning bases.
7.6-4	The TC & WM EIS ROD will be consistent with existing HFFACO[b] milestones.	a. The TC & WM EIS ROD may not be consistent with existing HFFACO[b] milestones.	i. Once an ROD is written, the tank farms baseline may need to be modified to align with the ROD.	
7.6-5	The design, flowsheet, operating modes, and operating plans of all facilities or processes will drive the permit conditions, and the permits will be modified as the processes evolve.	a. Delays in permit changes could adversely impact the TOC or WTP schedule and cost baseline.	i. Maintain communications with agencies on permit applications to ensure that permit applications are complete and meet requirements.	
7.6-6	The Baseline Case implicitly assumes that the outcome of official WIR WDs will be consistent with the assumed disposition of the primary and secondary waste forms prior to disposal.	a. Emergent inconsistencies between planned primary/secondary waste dispositions versus WD outcomes would adversely impact waste disposal plans and schedules.	i. Schedule the WIR WDs early enough to remain off the critical path even if the outcome is different than currently assumed.	

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

[b] Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

[c] Consent Decree, 2010, *State of Washington v. DOE,* Case No. 08-5085-FVS (October 25), Eastern District of Washington.

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

7.7 222-S LABORATORY AVAILABILITY

Table 7-7. 222-S Laboratory Availability

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.7-1	Laboratory services required to support the RPP mission are available and provided in a timely manner.	a. 222-S Laboratory and associated support systems, such as core sampling trucks, are aging and prone to increased failure rates and increased maintenance attention.	i. Include any required life extension upgrades in the life-cycle baseline. Perform critical and routine maintenance on sampling systems and components to ensure readiness of these systems.	Various upgrade and facility life extension projects are in progress or are planned in the near future; some are funded through the baseline, and some are funded as RA projects. New mobile video vans were purchased recently to support SST retrievals, sampling, in-tank inspection, and leak checks. Additional details regarding upgrade projects are provided in Section 3.6.

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

7.8 INACCURATE MISSION DECISION

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-1	Execution of the RPP mission as planned will meet the success criteria.	a. This issue is essentially a roll-up of all the other key issues and uncertainties expressed throughout Section 7.0.	i. System planning activities will continue to integrate new information into baseline plans and actions.	Ongoing.
7.8-2	The amount of caustic projected for caustic leaching is adequate to leach aluminum and keep aluminum soluble through cesium ion exchange. For modeling purposes, the solubility of aluminum in supernate present in the WTP PT Facility will be approximated using the correlation shown in Equation 4 from Reynolds and Adelmund (2007).[a] This aluminum solubility correlation will be used to determine the amount of sodium hydroxide added to the waste during pretreatment, with the goal of ensuring that solids do not precipitate after filtration.	a. The WTP baseline correlation shown in Equation 9 of Reynolds and Adelmund (2007)[a] is overly conservative and results in high estimates of required sodium additions. ORP has requested that Equation 4 be used to estimate nominal caustic additions until a better correlation is available.	i. Consider operating the PT Facility waste treatment processes at a higher temperature to help keep the aluminum in solution, thereby reducing the amount of sodium hydroxide that must be added.	ORP has directed BNI to incorporate the necessary design and operating mode changes into the WTP. The operating scenarios developed in System Plan (Rev. 6) reflect those changes.
			ii. Consider tailoring the degree of caustic leaching so that no more aluminum is removed from the HLW solids than is needed to produce an acceptable quantity of HLW glass.	BNI has explored this in conjunction with Table 7-8, Item 7.8-2i. RPP-RPT-48372[b] evaluated the impact of recent WTP pretreatment system design, flowsheet, and operating mode changes on the RPP mission and documented a series of sensitivity runs to select the preferred operating modes for system planning purposes. The current logic used to tailor the degree of caustic leach had an adverse effect on mission duration and HLW glass mass, so System Plan (Rev. 6) continued fully leaching all solids. This operating mode should be revisited if and when revised logic is available, or if other changes so warrant.
			iii. Evaluate caustic recycle after pretreatment or other caustic management strategies.	
			iv. Develop refined LAW glass formulation models to increase sodium oxide loading and consider ways to increase total LAW treatment capacity.	ORP has an ongoing effort to assess sodium use in the WTP. An approved sodium management plan and a recent assessment (A-09-AMWTP-RPPWTP-002[c]) may further refine this assumption. The use of referenced Equation 4 is appropriate until further revision or improvement is supported.
			v. Provide additional LAW treatment capacity.	The objective of the Supplemental Treatment and Immobilization Program is to determine how much additional capacity is needed, and how best to provide it.

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-2 cont.			vi. Develop improved HLW glass formulation models that can accommodate higher alumina loadings. Increasing alumina waste loading in glass may reduce the number of batches or fraction of alumina that must be leached, which reduces NaOH added in processing.	Glass formulations and pilot melter studies have been performed by Vitreous State Laboratory[d] that indicate higher alumina tolerance is possible for WTP HLW glass. Additional studies have been performed that indicate the range of alumina likely to be tolerated (PNNL 2009 and 2010 glass models). Incorporation of this work into the System Plan demonstrates the possibility of decreasing waste quantity and mission duration. Completion of this effort will enable tank farms operations and WTP to accommodate these improvements.
7.8-3	Supplemental LAW treatment capacity will be provided by a second LAW vitrification facility, located adjacent to the WTP. The second LAW facility will have the same technical assumptions as the WTP LAW Vitrification Facility and will complete hot commissioning on September 30, 2022, and begin full operations on October 1, 2022.	a. A formal decision is needed to determine (1) how the required supplemental LAW treatment capacity will be provided, (2) how condensate will be managed, (3) if supplemental pretreatment capacity is required, and (4) the additional scope and cost that will need to be included in the life-cycle baseline as a result.	i. A key element of the strategy for mitigating these issues is to accelerate the justification for mission need and technology down-select: Complete a technology down-select (CD-1) by September 30, 2011. Evaluate a second LAW facility, steam reforming, bulk vitrification, and other technologies with a viable TRL 3 or higher.	The Justification for Mission Need for the Hanford Tank Waste Supplemental Treatment Program was approved by DOE in January 2011 (NA-DOE-HQ, letter, I.R. Triay to J. A. Dowell, "Approval of mission Need for Hanford Tank Waste Supplemental Treatment Program."). A BCR is being prepared to accelerate the submittal of the technology down-select to September 30, 2011.
			ii. Monitor technology development at other DOE sites for applicability to LAW pretreatment.	
			iii. Explore other options for reducing the amount of LAW that needs to be vitrified.	See Item 7.8-2 i and ii.
7.8-4	The water wash factors in TWINS circa October 2008 will be used to partition waste into solid and liquid phases during retrieval and staging; strontium partitioning will be modeled in accordance with RPP-21807.[e] The feed vector will be reported on a fully water-washed basis. The caustic leach factors in TWINS circa October 2008 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids.	a. Uncertainties and biases in the water wash and caustic leach factors can significantly influence the canister counts and treatment end dates. Water wash factors and caustic leach factors are a zero order approximation to complex solid-liquid equilibrium; this is a known limitation of this methodology.	i. Continue to optimize the waste feed provided to the WTP. Undertake engineering optimization studies to evaluate solutions such as waste blending. Ensure waste storage/blending options are incorporated into the SST retrieval sequence and schedule, waste storage plans, and the WFD sequence and schedule. Update the HTWOS model runs as required.	RPP-RPT-42968[f] was issued by WRPS.
			ii. Develop composition-based solid/liquid solubility models to supplant water wash factors.	WRPS is currently developing solid-liquid phase thermodynamic equilibria models. Solubility models for major species are expected to be completed in FY 2011. Solubility models are being developed for those solid-phases that are major components in the waste and are expected to come reasonably close to equilibrium over the timeframe of waste processing. A first step was to compile all of the known mineralogical data of the waste, which was completed this year (RPP-RPT-46618[g])

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-4 cont.			iii. Develop a composition or source-based speciation of aluminum to supplant the aluminum caustic leach factor.	An estimate of the solid-phase speciation of aluminum was completed in FY 2010 (RPP-RPT-47306).[h] This report divides aluminum into three categories. One category is aluminum that is not expected to be able to be leached appreciably (primarily aluminosilicates). The second category is aluminum that is kinetically controlled, and the amount removed depends on the leaching time and temperature (primarily boehmite). The third category is aluminum that is easy to leach (provided that sufficient NaOH is added) and is rapidly removed from the waste sludge. This category is primarily gibbsite, dawsonite, and a number of more minor species. The fractions of aluminum types concluded in this report will be incorporated in the HTWOS model in time to support preparation of System Plan (Rev. 7) in 2012.
7.8-5	A formal WD will indicate that the potential TRU tank waste can be segregated from the high-level tank waste and subsequently treated, packaged, and disposed as TRU waste.	a. WDs cannot be completed until the TC & WM EIS ROD is issued. b. TRU waste determination is uncertain. Final criteria for potential TRU tank waste may be more stringent than current standards. Some potential TRU tank waste may not meet TRU waste dose limitations. c. Final disposition of this tank waste, if determined to be TRU, has not been made.	i. Develop bases for TRU waste classification. Pursue agreement with regulators and stakeholders. ii. Assess existing waste characterization data and if needed, obtain additional waste samples to support adequate characterization. iii. In the event that the waste is determined to be treated as HLW after packaging, implement contingency plans for treatment as HLW at the WTP.	
7.8-6	Waste treatment process and packaging capability will be developed to support potential TRU tank waste retrieval and handling.	a. Potential TRU tank waste packaging system equipment was developed and tested using simulated waste. Additional testing may be required on proposed systems to demonstrate that waste can be delivered to the TRU packaging facilities within specified waste characteristics and dose limits.	i. Develop and test waste processing technologies to support TRU tank waste retrieval and packaging, including ALARA considerations. Include workscope for testing in life-cycle baseline planning.	A draft flowsheet has been prepared (RPP-21970[i]).
7.8-7	The CWC and CH-TRU waste packaging RCRA permits will be approved by Ecology to manage dried product in lieu of formal DOE designation.	a. Ecology has communicated during prior CH-TRU waste project activities that DOE designation is required prior to RCRA permit approval.	i. Perform additional and early safety analyses to document the value of CWC storage. ii. Place new scope in baseline for contingency reintroduction of waste into WTP feed. iii. Support high-level ORP and Ecology discussions on issue.	
7.8-8	CWC is managed without additional costs through the period of CH-TRU waste storage.	b. Extended/indefinite CWC storage operation is not planned in the current baseline.	i. Add planning for extended CWC operational cost pass-through from TOC.	
7.8-9	If the potential CH-TRU tank waste is retrieved, dried, drummed, and stored at the CWC, and a subsequent WD indicates that this waste is not TRU, and therefore is not suitable for off-site disposal, the drummed waste will need to be comingled with other tank waste and treated through the WTP facility.	a. Additional facilities may be required to condition the waste for processing through WTP.	i. Evaluate other options for disposition of this waste stream.	System Plan (Rev. 6) Case 2 evaluated the impact of retrieving the potential CH-TRU waste from the SSTs and sending it directly to WTP (see Section 10.2 for additional details).

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-10	The IDF will be operational on September 28, 2018, and will provide permanent disposal for the ILAW, other mixed LLW, and LLW, including LAW glass packages from the WTP; solid waste from the WTP, including spent LAW and HLW melters; and solid waste from the ETF from treating liquid effluent. The IDF can be expanded as needed to support the mission without interference from other users.	a. A final decision under the TC & WM EIS[j] as documented in the ROD is required before IDF can be used for disposal. Delays to the TC & WM EIS ROD may delay the use of IDF for this purpose.	i. Evaluate schedule impacts upon issuance of the TC & WM EIS ROD.	Delaying IDF startup until 2018 has lessened the impact of this issue.
		b. Any upgrades or expansion of these facilities that are not covered under the current TC & WM EIS[j] scope will need additional NEPA documentation to be prepared prior to implementing the upgrades.	ii. Evaluate scope impacts upon issuance of the TC & WM EIS ROD.	
		c. The performance of the IDF to safely dispose of the projected quantities, forms, and composition of primary and secondary waste from the treatment mission has not yet been demonstrated.	iii. Complete a performance assessment of the IDF to verify the ability to safely dispose of the projected primary and secondary waste forms. iv. Update the projections of primary and secondary waste to be disposed of in the IDF as underlying flowsheets and processes evolve. v. Evaluate options to reduce the projected source term of wastes to be disposed at IDF. Possibilities include: • Evaluate the disposition of the LiHT by-product. It may be possible to use this material to replace a portion of the glass-forming chemicals added to the pretreated LAW at the WTP PT Facility or a second LAW facility. • Upgrade the ETF to treat the projected liquid effluents.	
		d. The planned transportation system (fleet of 14 trailers) and emplacement strategy may not allow adequate time for cooling the ILAW packages before disposal in the IDF given the combined production rates of both the WTP LAW Vitrification Facility and a second LAW facility.	vi. Perform a timing study to see if the first layer of packages disposed in the IDF would be completed before the projected of maximum combined production rates would exceed the transport (including cooling) capability of the IDF. This would potentially allow the first layer to insulate the liner from the subsequent layers. vii. Include cooling capacity in a second LAW facility. viii. Explore the feasibility of a separate cooling area in which packages could be cooled, either on or off the trailers. ix. Explore the feasibility of starting the second layer before the first layer has been completed.	
		e. Just-in-time startup of IDF could impact WTP operations, since WTP has very limited canister storage capacity at their facility.	i. None identified at this time.	
		f. The rate at which IDF will be filled is not known. The rate at which IDF is filled is a key factor in knowing when IDF expansions will be necessary.	i. Perform a study that estimates the required timing of IDF expansion based on projected waste receipts.	

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-11	One spent LAW melter is assumed to be replaced every 5/n years on average, where n is the total number of melters in operation. Each LAW melter will contain approximately 1,875 gal of glass. Spent LAW melters from both the WTP LAW Vitrification Facility and a second LAW facility will be managed and disposed at the IDF as mixed LLW. One spent HLW melter is assumed to be replaced every 2.5 years on average, and will contain approximately 823 gal of glass. The spent HLW melters' disposal path is not yet defined.	a. Melters are expendable; their replacement frequency is uncertain. Spent melter disposal pathways and associated potential issues are not fully defined.	i. Develop a spent melter disposal strategy and the associated planning.	
7.8-12	The final disposal alternative for the IHLW glass canisters is assumed to be at an unidentified off-site national repository.	a. The planned off-site national repository may experience delays. WTP may start producing glass before the repository is ready to accept the IHLW. Depending on production capability and timing, WTP could produce more IHLW than can be stored onsite awaiting opening of the repository, requiring the construction of additional interim storage.	i. Monitor planned off-site national repository developments. Continue to integrate the WTP and TOC schedules with projected startup and operating schedules for the repository. Evaluate impacts of repository delays on planned on-site interim storage on an annual basis.	
7.8-13	The IHS will be operational on or before November 21, 2018, and provide interim storage for 2,000 IHLW canisters; storage for an additional 2,000 IHLW canisters will be operational by January 2, 2020. The average canister receipt and retrieval capability of the IHS will each be 800 canisters per year, with a peak handling rate of three canisters per day.	a. Design and construction of the HSF has not been planned in detail. b. This schedule requires that the WTP-provided storage for cooling and buffer capacity be used before transferring IHLW canisters to the IHS.	i. The life-cycle baseline will include planning for the HSF consistent with the need dates.	
7.8-14	On or before June 2022, a decision will be made to either continue to build additional IHS 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 off-site final disposal alternative. The canister shipping capability of the HSF is assumed to match the retrieval capability of the IHS. If and when the HSF begins shipping, the first priority will be given to shipping newly created IHLW canisters beyond those stored at the IHS and second priority is given to emptying the IHS after HLW vitrification is finished. Shipping needs will be estimated with the IHS operated at approximately 1,000 canisters less than capacity (i.e., operate at about 3,000 canisters) to decouple canister receipt from the WTP from shipping to a national repository.	a. Uncertainty in the timing and nature of the final disposal alternative may delay shipping.	i. Ensure that the HSF is expandable up to a maximum of at least 16,000 canisters to accommodate all projected IHLW canisters.	

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-15	The current strategy to comply with the OCRWM waste acceptance criteria is described in 24590-HLW-PL-RT-07-0001.[k] It is assumed that the strategy will be acceptable to OCRWM. It is further assumed that the WTP-prepared delisting petition for the IHLW is accepted by Ecology and the receiving state before shipping the waste to the planned off-site national repository.	a. There is a potential that the waste acceptance strategy will not be acceptable to OCRWM for the DOE/RW-0351[l] IHLW product requirements.	i. The waste compliance plan will be updated as the waste form qualification process evolves. It includes actions for ensuring that the strategy will meet waste form specifications and requirements.	
7.8-16	The timing, capacities, and capability of the ETF, LERF, SALDS, and TEDF will be driven by the needs of the waste treatment mission and are assumed to be available when needed. If the treatment mission requires that changes be made to the ETF, LERF, SALDS, or TEDF or their operating plans, ORP is assumed to successfully drive the changes.	a. The current ETF is inadequate to treat the projected liquid secondary waste stream that will be generated by the WTP. Currently assumed ETF upgrades may not be adequate to treat secondary waste streams for the waste treatment complex. Of particular importance is the ability to safely dispose of the ETF solid product in the IDF (especially the technetium and iodine) and compatibility of the waste with the ETF process (e.g., high fluoride concentrations). b. The projected disposition of technetium is uncertain due to the presence of recycle streams, and process splits based on limited test data. c. Any upgrades to these facilities that are not covered under the current TC & WM EIS[j] scope will need additional NEPA documentation to be prepared prior to implementing the upgrades.	i. Execute path forward for secondary waste treatment project.	WBS 5.03.10, Secondary Liquid Waste Treatment Project, is funded in FY 2010-2013 to provide the needed secondary liquid waste treatment capability. This capability is scheduled to be ready for operation in FY 2018. RPP-RPT-43588[m] has been issued to support the justification of mission need for the handling and disposal of liquid effluents.
			ii. Implement alternative technologies for treatment of WTP recycle streams to reduce the demand on the ETF. Implement secondary waste treatment project recommendations.	WBS 5.03.10, Secondary Liquid Waste Treatment Project, will investigate technologies capable of treating the WTP secondary liquid waste, including the flexibility to treat the WTP SBS recycle loop purge. A technology down-select process will define the project flowsheet for design and construction.
			iii. A project has been completed that identifies the expected range of technetium volatility from the LAW melters and the most promising chemical addition to increase technetium retention (VSL-11R2260-1[n]). Additional work is underway (FY 2011) to demonstrate the recycle of technetium-laden off-gas as per the WTP LAW flowsheet as a means to demonstrate technetium retention in the process.	RA funding is being used to investigate methods of improving technetium in LAW glass at the Vitreous State Laboratory. The Phase I final report (RPP-RPT-45887[o]) was issued in April 2010.
			iv. Develop improved waste forms for disposal of the solid waste generated from treating the secondary liquid waste.	RA funding is being used to investigate leachability of various waste forms that could be used by the Secondary Liquid Waste Treatment Project. The work is being done by PNNL. A screening test report was issued (PNNL-19505[p]). Final optimization reports were issued summer of 2011.[q,r]
7.8-17	RL will dispose of WESF cesium and strontium capsules at an off-site national repository, independent of processing through the RPP system.	a. If direct disposal of WESF cesium and strontium capsules at a planned off-site national repository is not viable, vitrification at WTP could be required. Facility modifications would be required to retrieve the capsules from WESF, condition them for treatment through the tank farms and/or WTP facilities, and introduce the conditioned cesium and strontium streams to the RPP system.	i. Monitor RL progress on direct disposal of WESF capsules at a planned off-site geologic repository. The WTP PT Facility can connect to a potential new facility designed to receive and condition the contents of the Hanford cesium and strontium capsules prior to incorporation into the HLW feed for immobilization in the HLW Vitrification Facility (see Section C.7(c)(2) of DE-AC27-01RV14136).[s]	

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.8-18	The results from the HTWOS model are suitable for their intended purposes.	a. In addition to the technical and programmatic assumptions used for system planning purposes, the HTWOS model reflects a number of more detailed assumptions documented in the most current version of RPP-17152[t] and may also use simplifying assumptions to facilitate modeling. Each end-user must consider the underlying assumptions when interpreting or relying on model results.	i. Periodically update and align the HTWOS model with the essential features of the most current WTP design, flowsheet, and operating modes; process flowsheet; RPP-PLAN-40145[u] and associated assumptions; and RPP-40149-VOL1.[v] ii. In advance of each system planning effort, identify and prioritize improvements to the HTWOS model to increase model fidelity and reduce the reliance on simplifying or enabling assumptions.	This is an ongoing effort. For System Plan (Rev. 6), the HTWOS model has been aligned with an expanded list of key features to the current WTP design, flowsheet, and operating modes and to an improved WFD strategy. Development and implementation of a suite of solubility models in HTWOS is being pursued to ready the HTWOS model for the next system planning effort. Other improvements are being identified and prioritized.
7.8-19	Waste from the retrieval of the IMUSTs will be transferred to the tank farms in a series of transfers between 2020 and 2030, or sooner, if practical. Waste inventory estimates for pumping of the IMUSTs, deactivation of other Hanford facilities, and operation of the 222-S Laboratory are provided in RPP-33715.[w]	a. The IMUSTs inventory is uncertain and incomplete. Specific operating plans are not in place to retrieve IMUSTs. The HTWOS only addresses the overall estimated volume of IMUST waste to be treated and feeds it into treatment from about 2020 through 2030. Final disposition of waste in the IMUSTs has not been determined.	i. Determine specific transfer dates as part of the life-cycle baseline development. ii. Continue to refine and update the IMUST inventory input to the HTWOS (RPP-33715[w]) and incorporate the results in the life-cycle baseline. Consider the feasibility and desirability of including the individual IMUST inventories in the BBI. iii. Determine disposition of waste in the IMUSTs and required closure conditions.	WRPS personnel are working to integrate IMUSTs into waste retrieval planning. Additional details are provided in Section 3.1.3.
7.8-20	Decisions regarding the required capacity of supplemental LAW treatment and projections of mission duration may be influenced by potential future improvements in the capacity of the WTP LAW and HLW facilities by means of second generation melters. This would require that second generation melters be researched, designed, installed, and operated in a way that improves HLW and/or LAW Vitrification Facility performance when compared to the first generation melters.	a. Other existing WTP facility equipment (e.g., mechanical handling systems and building HVAC systems) have been designed to support the first generation melter systems and may not be adaptable to second generation melter needs.	i. Existing facility support system limitations must be taken into consideration when exploring possible second generation melter designs.	24590-HLW-RPT-PE-07-001[x] has determined that the WTP HLW Vitrification Facility can support an increased throughput to roughly design capacity of 7.5 MTG/d with relatively minor design changes.

Notes to Table 7-8:

[a] Reynolds and Adelmund, 2007, "Contract No. DE-AC27-01RV14136-Gibbsite Solubility Models. Supersedes CNN-137192" (Memorandum CCN-160514 to S. Saunders, Bechtel National, Inc., July 30), Bechtel National, Inc., Richland, Washington.
[b] RPP-RPT-48372, 2011, *Pretreatment Operating Mode Sensitivity Evaluation Using the HTWOS Model*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[c] A-09-AMWTP-RPPWTP-002, 2009, *Design Oversight Report, Basis for Sodium Estimate*, Rev. 0, ORP WTP Engineering Division, U.S. Department of Energy, Office of River Protection, Richland, Washington.
[d] Vitreous State Laboratory of The Catholic University of America, Washington, D.C.
[e] RPP-21807, 2004, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
[f] RPP-RPT-42968, 2010, *River Protection Project Mission Analysis Waste Blending Study*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[g] RPP-RPT-46618, 2010, *Hanford Waste Mineralogy Reference Report*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[h] RPP-RPT-47306, 2010, Rev. 0, *Waste Type Analysis for Aluminum Leachability Estimates of All Non-Retrieved Hanford Tank Wastes,* Washington River Protection Solutions, LLC, Richland, Washington.
[i] RPP-21970, 2005, *CH-TRUM WPU&SE 11 Tank Material Balance*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
[j] DOE/EIS-0391, 2009, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*, U.S. Department of Energy, Office of River Protection, Richland, Washington.
[k] 24590-HLW-PL-RT-07-0001, 2008, *IHLW Waste Form Compliance Plan for Hanford Tank Waste Treatment and Immobilization Plant*, Rev. 2, Bechtel National, Inc., Richland, Washington.
[l] DOE/RW-0351, 2008, *Waste Acceptance System Requirements Document*, Rev. 5, Office of Civilian Radioactive Waste Management, Washington, D.C.
[m] RPP-RPT-43588, 2009, *Secondary Waste/ETF Preliminary Pre-conceptual Engineering Study*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[n] VSL-11R2260-1, 2011, *Improving Technetium Retention in Hanford LAW Glass – Phase 2*, Rev. A, Vitreous State Laboratory of The Catholic University of America, Washington, D.C.
[o] RPP-RPT-45887, 2010, *Improved Technetium Retention in Hanford LAW Glass – Phase 1 Final Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[p] PNNL-19505, 2010, *Secondary Waste Form Screening Test Results – Cast Stone and Alkali Alumino-Silicate Geopolymer*, Pacific Northwest National Laboratory, Richland, Washington.
[q] PNNL-20159, 2011, *Secondary Waste Form Development and Optimization – Case Stone*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.
[r] VSL-10R2140-1, 2011, *DuraLith Alkali-Aluminosilicate Geopolymer Waste Form Testing for Hanford Secondary Waste*, Rev. 1, Vitreous State Laboratory of The Catholic University of America, Washington, D.C.
[s] DE-AC27-01RV14136, *Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*, as amended through A164 (April 5, 2010), U.S. Department of Energy, Office of River Protection, Richland, Washington.
[t] RPP-17152, 2011, *Hanford Tank Waste Operations Simulation (HTWOS) Version 6.61 Model Design Document*, Rev. 5, Washington River Protection Solutions, LLC, Richland, Washington.
[u] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.
[v] RPP-40149-VOL1, 2011, *Integrated Waste Feed Delivery Plan: Volume I – Strategy*, Rev. 2 Draft, Washington River Protection Solutions, LLC, Richland, Washington.
[w] RPP-33715, 2011, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operations Simulator Model – 2011 Update*, Rev. 4, Washington River Protection Solutions, LLC, Richland, Washington.
[x] 24590-HLW-RPT-PE-07-001, 2007, *High Level Waste Vitrification Plant Capacity Enhancement Study*, Rev. 0, Bechtel National, Inc., Richland, Washington.

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

7.9 WORK STOPPAGE

Table 7-9. Work Stoppage

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

[a] TFC-PLN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

7.10 SKILL MIX AND LABOR SHORTFALLS

Table 7-10. Skill Mix and Labor Shortfalls

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

[a] TFC-PLN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

7.11 BUDGET AND FUNDING UNCERTAINTY

Table 7-11. Budget and Funding Uncertainty

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.11-1	Fiscal year funding will be available to support the Baseline Case, including that funding required for risk mitigating actions.	a. Funding availability is uncertain and funding shortfalls have the potential to impact the life-cycle baseline.	i. Complete development of the life-cycle baseline. Align the life-cycle baseline cost and schedule estimates with FY-by-FY funding guidance. ii. Use formal baseline change control to address changes to funding needs and availability. iii. Maintain adequate management reserve and contingency.	
7.11-2	The life-cycle cost of the RPP mission is accurately reflected by the PMB.	a. Evolving scope and requirements can increase costs. b. The annual operating cost of the WTP has not been fully validated c. The life-cycle cost and schedule for the RPP mission is uncertain.	i. Conduct annual updates of the System Plan, Risk Management Plan,[a] and PMB.	The System Plan is being updated on an annual basis. The PMB is being aligned with the System Plan. The Risk Management Plan (TFC-PNL-39[a]) is being updated and will be released in parallel with this revision of the System Plan.
			ii. Support independent oversight reviews.	In November 2009, an Independent Project Review team from DOE-HQ reviewed all aspects of the RPP baseline. At the completion of the review process, the team recommended that DOE-HQ approve the life-cycle PMB. The PMB was formally approved by DOE-HQ on June 18, 2010.
			iii. Develop an independent estimate of WTP operating costs, considering resources, essential materials and supplies, waste, maintenance, spare equipment, and documentation.	

[a] TFC-PLN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

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

7.12 TANK FARM SYSTEMS AND WASTE FEED DELIVERY

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.12-1	The cross-site transfer system will be modified as needed to allow for the transfer of slurry into multiple DSTs to provide operational flexibility in management of waste and staging of feed to the WTP.	a. The existing cross-site transfer system slurry line has not been approved to operate and uncertainties exist due to the unknown condition of the existing line.	i. Continue to follow operating procedures for transfer piping systems to ensure piping longevity. Inspect slurry piping system and complete safety documents for slurry transfer using the existing system. In the life-cycle baseline, plan refurbishing of the piping as necessary to meet the requirements.	An evaluation of the cross-site slurry line for purposes of identifying the work needed to activate the line is ongoing and scheduled for completion at the end of FY 2011. The cross-site slurry line activate project is to be executed by CLIN 1 (WBS 5.01.04.01.07.04) beginning August 2015 and ending March 2018. Any reconfiguration of the slurry line to add the flexibility noted below would be completed as part of this CLIN 1 project.
			ii. Modify the cross-site transfer system to allow for the transfer of slurry into multiple DSTs.	
7.12-2	The DSTs will remain fully operational for the nominal 40-year waste treatment mission duration.	a. The likelihood of a major failure of a tank or infrastructure component increases with time due to the age of the tank farms facilities. As-found tank, equipment, and facility conditions may lead to significant new scope.	i. TD 1.1: Develop a suite of tools/methods and perform tests on DSTs to assess and demonstrate the integrity of the tanks for continued use.	
			ii. Continue chemistry control programs.	
			iii. Plan and execute DST integrity, base operations field projects, and DST life extension workscope.	WBS 5.07.02.05
7.12-3	The 242-A Evaporator will continue to operate, as needed, through the life of the mission to support SST retrieval and to maintain the sodium concentration in the delivered feed within WTP feed specifications. The evaporator will not be available during scheduled maintenance outages.	a. Management of the water content of the tank waste is one of the keys to effective use of the DSTs. The likelihood of a major failure of a 242-A Evaporator component increases with time due to the age of the facility.	i. Execute 242-A Evaporator upgrades and maintain evaporator readiness to support mission needs. Evaluate evaporator replacement if necessary.	
			ii. Establish the schedule of evaporator outages and availability during development of the life-cycle baseline.	
			iii. Consider the use of a near-tank, wiped-film evaporator in the case of a failure or extended outage of the 242-A Evaporator. Significant evaluation and planning needs to be done before this mitigation option could be implemented.	WRPS is using the HTWOS model to evaluate the impact of 242-A Evaporator outages.
		b. If there are periods greater than 11 months during which the 242-A Evaporator is not used to concentrate waste, a "cold run" of 82,000 gal of water will be performed to maintain personnel qualifications. A readiness review is required if the evaporator sits idle for more than 12 months.	iv. Revisit the need for cold runs to avoid readiness reviews—these take considerable effort and have a transient DST space impact.	RESOLVED. See Appendix B, Assumption B3.2.4.2.

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.12-4	WFD (specifically, the staging of feed within the DSTs and delivery to the WTP) will support WTP treatment rates by providing sufficient HLW or LAW feed to keep the limiting facilities (WTP LAW Vitrification Facility and second LAW facility or HLW Vitrification Facility) operating at or near assumed capacities.	a. WFD system rates and reliability have not been demonstrated. PNNL-17043[a] identified that the ability to effectively mix, sample, certify, and deliver consistent batches of HLW from the DSTs to the WTP as an issue.	i. Include technology development activities in the baseline to address mixer pump performance, feed sampling capabilities, and small- and large-scale mixing demonstrations.	Tank waste mixing demonstrations and mixer pump design is funded in part by RA-4. The small-scale mixing demonstration completed with RA funding suggests the baseline mixing configuration is sufficient to meet WTP waste acceptance criteria requirements. Optimization and final risk assessment activities are planned for FY 2012 and FY 2013.
			ii. Include indexing or incremental insertion systems for the mixer pumps in deep sludge tanks.	RPP-PLAN-50117[b] identifies the DSTs that require indexing or incremental insertion systems, and forms the basis for the associated upgrade projects.
			iii. Perform an external technical review of the Tank AZ-101 mixer pump test.	Completed (see PNNL-18327[c]).
			iv. Evaluate the proposed Feed Characterization and Certification Facility.	
			v. Develop an OR model of the WFD system and evaluate its reliability, availability, and maintainability. Refine baseline plans as needed based on the results of the evaluation.	OR modeling is in progress (see Section 4.2.1). A review of the WFD maintenance system requirements was completed in FY 2010. An update to the WFD operations and maintenance concept document is in progress and will be completed by the end of FY 2011, along with an update to the DST maintenance and recovery subsystem specification. These activities, along with OR modeling results, will provide the basis for operations and maintenance system improvements needed to support the increase in operations.
		b. The allocation of specific DSTs and equipment upgrades to specific functions (e.g., HLW feed staging, LAW feed staging, evaporator bottom tank, etc.) has not been finalized.	vi. Evaluate the ability and robustness of the WFD system to supply feed on-demand. Revisit the need for a 180-day dwell time in accordance with ICD-19.[d]	
			vii. Both the near-term and long-term use of the DSTs to receive retrieved SST waste, manage stored waste, and stage and deliver feed to the WTP will be revisited as part of the integration between the Integrated WFD Plan (RPP-40149[e,f]) and SST Retrieval Plan (RPP-PLAN-40145[g]). Future revisions to the System Plan will incorporate specific WFD plans.	System Plan (Rev. 6) was aligned with Volumes 1 and 2 of the Integrated WFD Plan (RPP-40149-VOL1[e] and RPP-40149-VOL2[f]), the SST Retrieval Plan (RPP-PLAN-40145[g]), and the WFD Projects Plan (RPP-PLAN-50117[b]). These plans will be updated as the mission evolves.
7.12-5	The WFD infrastructure upgrades will be coordinated with the overall tank farms priorities, including facility operations, SST retrievals, waste transfer plan, waste site closures, etc. The resulting plan will be optimized to the overall TOC mission.	a. Uncertainties exist regarding whether the planned WFD infrastructure upgrades are optimized to the overall TOC mission due to the size, complexity, and age of the facility and the continual changes in the treatment system configuration.	i. WFD infrastructure upgrades coordination and optimization will be planned in the life-cycle baseline.	

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

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7.12-6	Physical properties and composition of feed delivered to the WTP are assumed to be compatible with WTP design calculations and safety analyses. The WTP design basis makes assumptions that place feed constraints on rheology, particle size, particle density, particle hardness and abrasivity, criticality, hydrogen generation, and potentially other parameters. Internal WTP material flows and accumulations will be consistent with the WTP authorization basis.	a. Additional conditioning or processing schemes may be required because a portion of the WTP feed is projected to fall outside of these parameters or changes to current WTP requirements might be required.	i. Continue maintenance of the feed interface control document (ICD-19)[d] using existing interface management procedures. Consider implementing the recommendations of a recent assessment of proposed changes to ICD-19 to address these parameters (24590-WTP-ES-PET-01-001[h]).	ICD-19[d] is being actively maintained. An update to Rev. 5 is in progress. RPP-40149-VOL2[f] will document the results of feed screening. The number of samples required to demonstrate that feed will meet the waste acceptance criteria has been evaluated, and the results are being incorporated in requirements. The waste feed integrated project team, sponsored by key management in ORP, WTP, and TOC, has been created as a forum to identify and resolve potential waste feed issues.
		b. A portion of the WTP feed is projected to fall outside of the feed envelopes documented in the WTP contract. Additionally, evolving WFD feed acceptance requirements are being revisited, and may impose new requirements on WFD (e.g., better control of solids content may be required in delivered feed).	ii. Continue to screen feed projected to be delivered to the WTP to proactively identify potential issues for future inquiry and resolution. Identify and correct any assumption or modeling artifacts that may be driving these projections.	
			iii. Consider implementing strategies and/or facilities (e.g., the Feed Characterization and Certification Facility) to mix, sample, settle, decant, or otherwise improve preparation of feed for WTP.	
			iv. The integrated management process for ICD-19[d] will be used to address any feed not consistent with the assumption. New controls, if any, would be incorporated into the feed control list or interface requirements might need to be revised.	
			v. Develop and maintain the WTP waste acceptance criteria data quality objectives.	

[a] PNNL-17043, 2007, *Initial Investigation of Waste Feed Delivery Tank Mixing and Sampling Issues*, Pacific Northwest National Laboratory, Richland, Washington.
[b] RPP-PLAN-50117, 2011, *Waste Feed Delivery Projects Plan*, Rev. 0 Draft, Washington River Protection Solutions, LLC, Richland, Washington.
[c] PNNL-18327, 2009, *Estimate of the Distribution of Solids Within Mixed Hanford Double-Shell Tank AZ-101: Implications for AY-102*, Pacific Northwest National Laboratory, Richland, Washington.
[d] 24590-WTP-ICD-MG-01-019, 2008, *ICD 19 – Interface Control Document for Waste Feed*, Rev. 4, Bechtel National, Inc., Richland, Washington.
[e] RPP-40149-VOL1, 2011, *Integrated Waste Feed Delivery Plan: Volume 1 – Strategy*, Rev. 2 Draft, Washington River Protection Solutions, LLC, Richland, Washington.
[f] RPP-40149-VOL2, 2011, *Integrated Waste Feed Delivery Plan: Volume 2 – Campaign Plan*, Rev. 2 Draft, Washington River Protection Solutions, LLC, Richland, Washington.
[g] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.
[h] 24590-WTP-ES-PET-01-001, 2008, *Technical and Risk Evaluation of Proposed ICD-19 Rev. 4*, Rev. 1, Bechtel National, Inc., Richland, Washington.

CLIN = contract line item number.
DST = double-shell tank.
FY = fiscal year.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
LAW = low-activity waste.
OR = operations research.
RA = Recovery Act.
SST = single-shell tank.
TD = technology development.
TOC = Tank Operations Contract.
WBS = work breakdown structure.
WFD = waste feed delivery.
WRPS = Washington River Protection Solutions, LLC.
WTP = Waste Treatment and Immobilization Plant.

7.13 PROJECT MANAGEMENT OPPORTUNITIES

Table 7-13. Project Management Opportunities

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

[a] TFC-PLN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

7.14 HANFORD ATOMIC METAL TRADES COUNCIL CRAFT REALIGNMENT PROVISION OPPORTUNITY

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

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

[a] TFC-PLN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

7.15 RECOVERY ACT

Table 7-15. Recovery Act

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

8.0 KEY DECISIONS FOR BASELINE CASE

A number of key decisions are needed to reduce risk to the RPP mission and increase confidence in planning and execution.

ORP will continue to follow a disciplined, systematic approach to guide the RPP to a successful conclusion. The *Decision Framework Key Decisions Required to Achieve the RPP Mission* (RPP-46506) connects the RPP functional hierarchy (RPP-RPT-41742) to a variety of technology development needs (RPP-PLAN-43988), which support approximately a dozen projects in the RPP PMB. The *Decision Framework* highlights the 30 tactical decisions that support the RPP mission. Each decision is described in terms of its potential programmatic impact, justification of timing, and the risk or impact of not supporting the decision date. These relationships are illustrated in a decision integration diagram, which has been published as part of the revised RPP-46506. RPP-46506 (Rev. 2) supports System Plan (Rev. 5).

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9.0 INTEGRATED SCHEDULES FOR THE BASELINE CASE

Figure 9-1, Figure 9-2, and Figure 9-3 summarize the schedule of major activities represented in this plan for the Baseline Case.[64] The success criteria (selected Consent Decree dates) are shown on the schedule, along with a projected date for completion of each criterion based on current modeling. Some key facility startup and ramp-up dates are also taken from the assumptions. The dates for waste retrieval, transfer, and treatment are based on the LCM and HTWOS model results. Significant restrictions on DST usage that have modeling and scheduling implications are also shown for each tank with such restrictions.

Summary schedules are provided for the following:

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

[64] Illustrations of the integrated schedules for Cases 2-10 are not included in System Plan (Rev. 6).

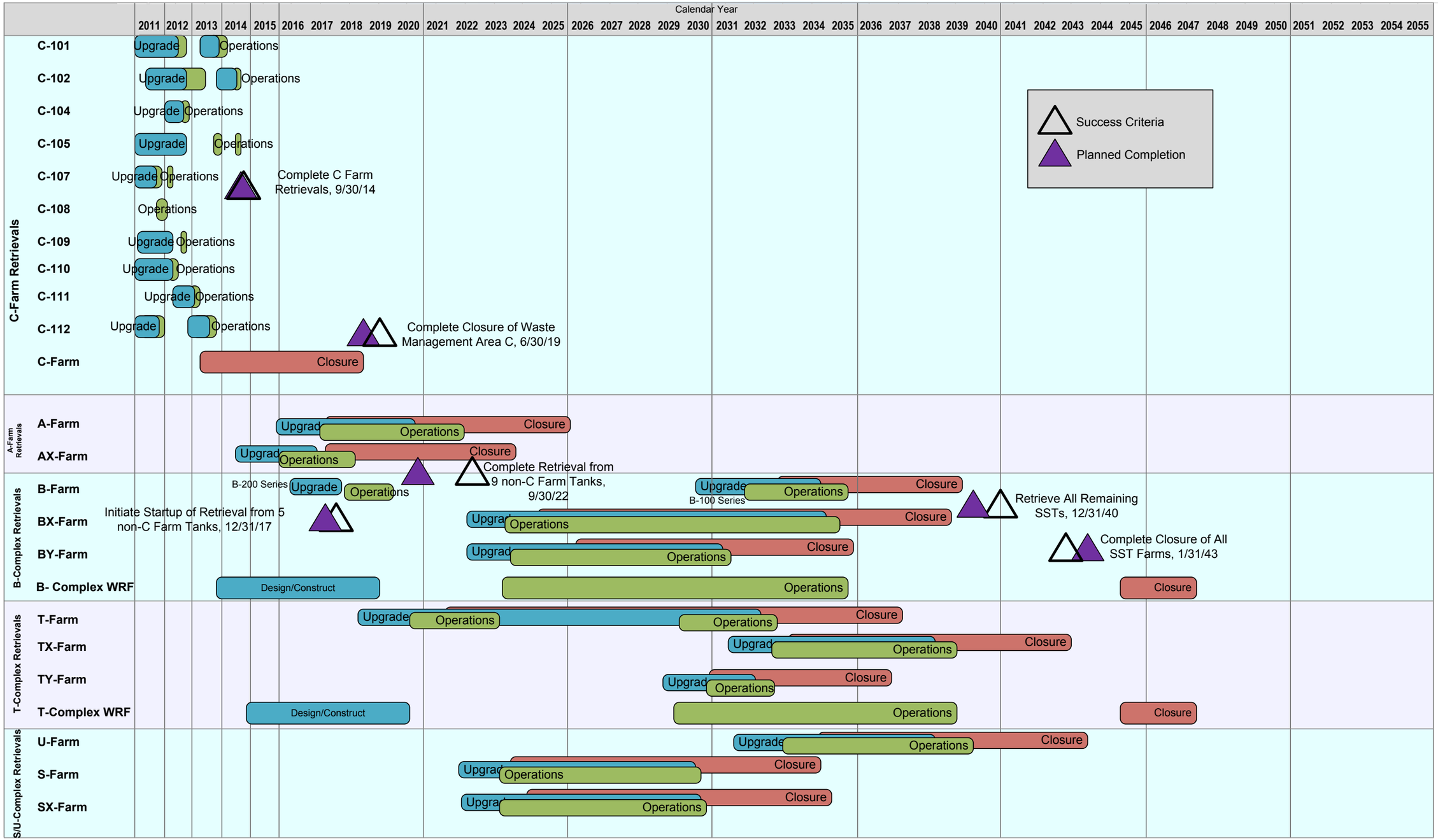

Figure 9-1. River Protection Project Mission Summary Schedule – Single-Shell Tank Retrieval and Closure

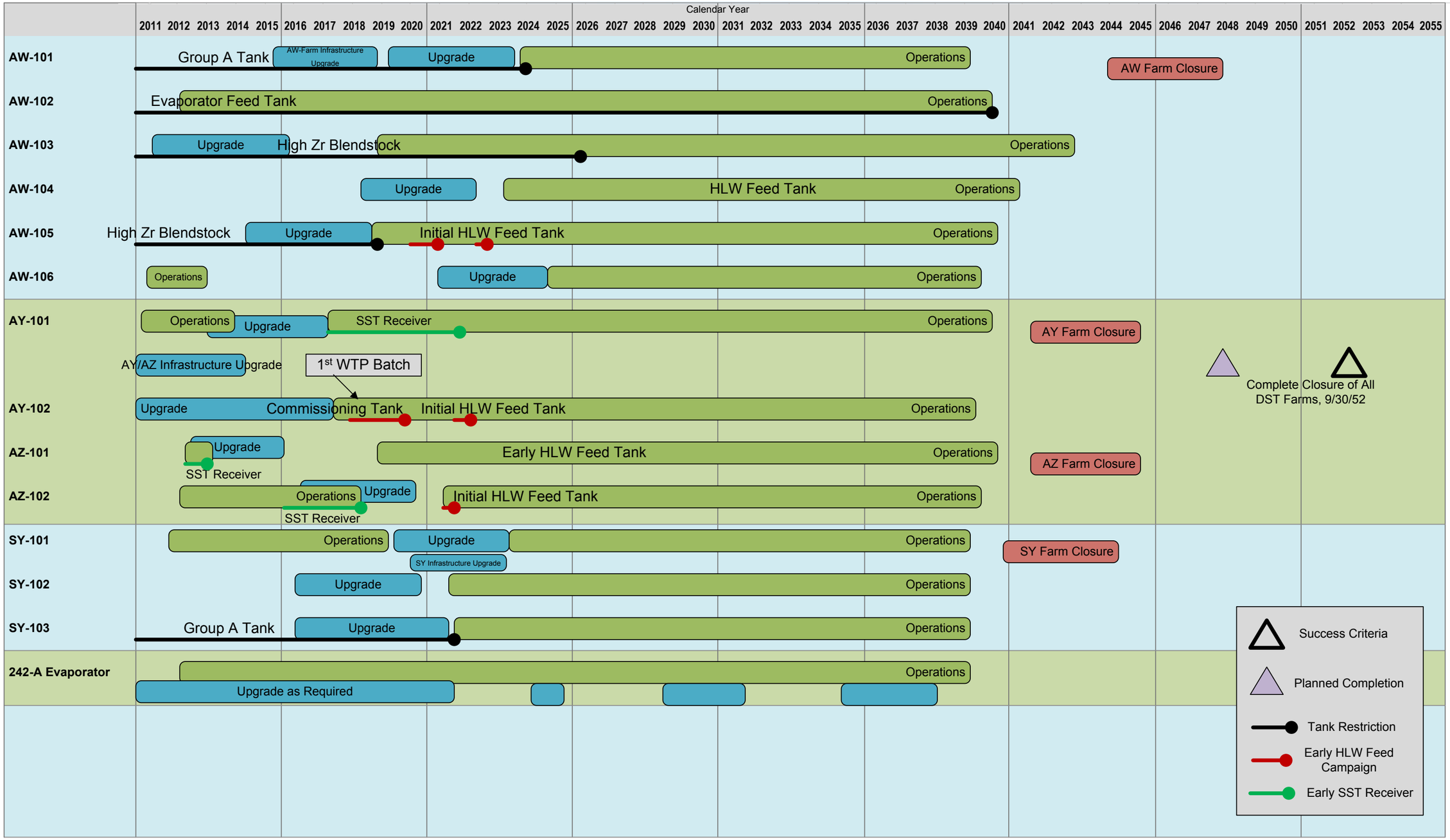

Figure 9-2. River Protection Project Mission Summary Schedule – Double-Shell Tank Retrieval, Waste Feed Delivery, and Closure (2 pages)

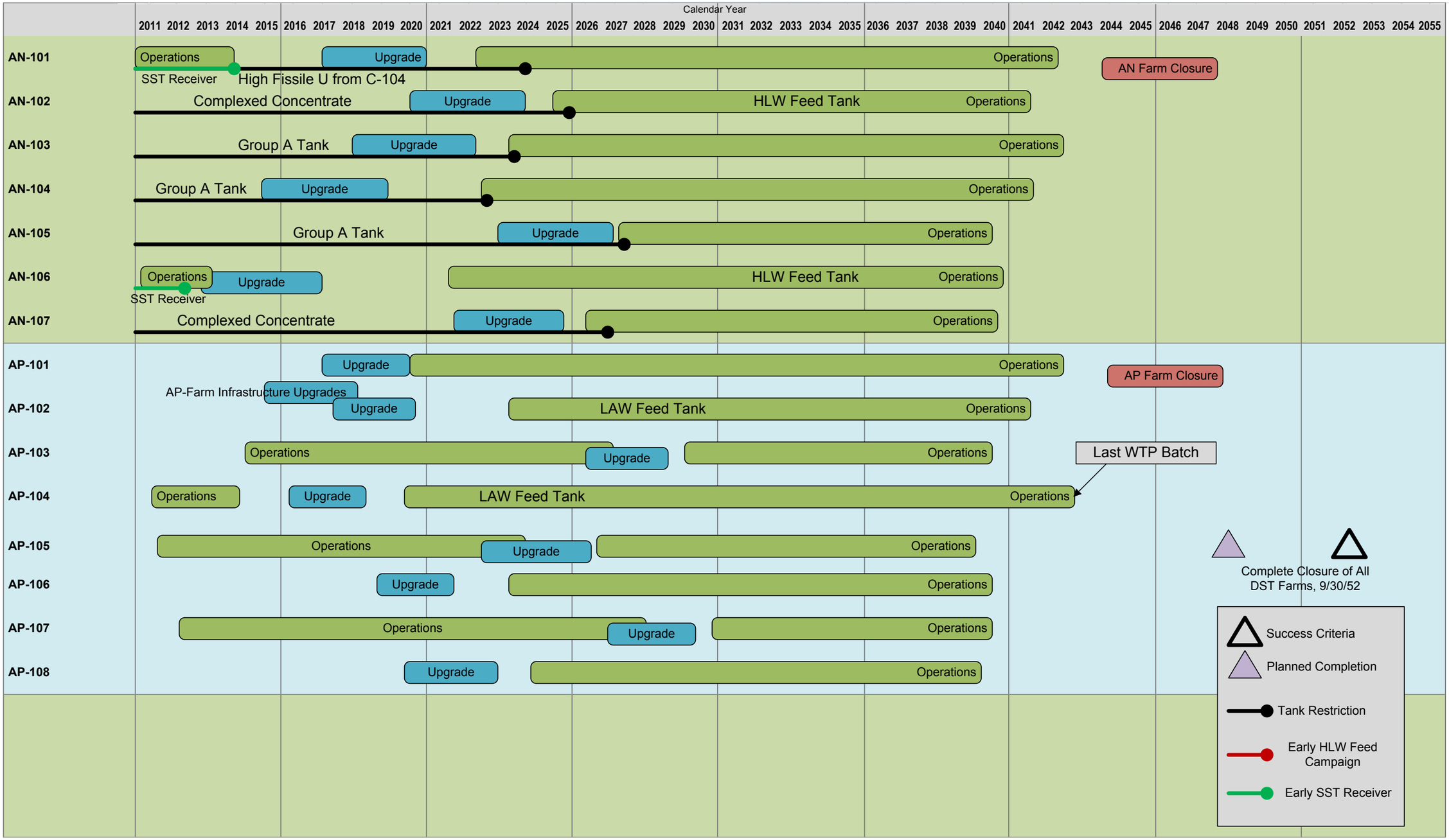

Figure 9-2. River Protection Project Mission Summary Schedule – Double-Shell Tank Retrieval, Waste Feed Delivery, and Closure (2 pages)

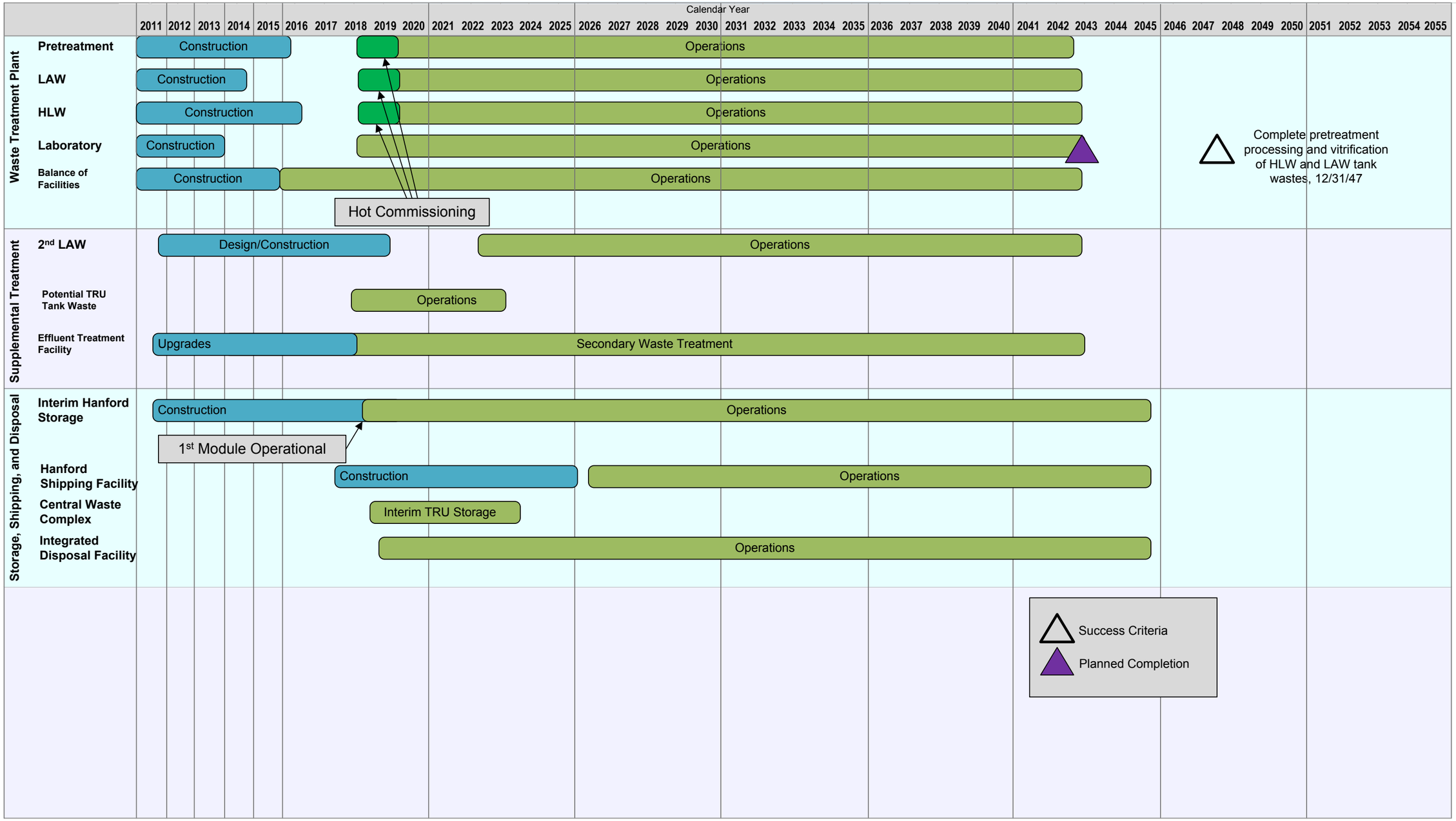

Figure 9-3. River Protection Project Mission Summary Schedule – Waste Treatment

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10.0 SELECTED SCENARIOS

In support of HFFACO Milestone M-062-40, ten possible operating scenarios were jointly defined by ORP and Ecology for evaluation via the HTWOS model and the System Plan.

The primary purpose of each System Plan is to provide a Baseline Case operating scenario for the alignment of program costs, scope, and schedules from upper-tier contracts to individual facility operating plans. A detailed analysis of the current Baseline Case has been presented in Sections 1.0 through 9.0 of this System Plan. The nine cases presented in Section 10.0 serve a different purpose. Cases 2 – 10 were jointly defined by ORP and Ecology in support of HFFACO Milestone M-062-40, which states, in part:

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

The RPP operating circumstances described in Cases 2 – 10 were modeled in HTWOS and the LCM. Those results are presented in this section.

10.1 INTRODUCTION

During the period July 28, 2010 to October 27, 2010, key personnel from ORP, Ecology, and WRPS met numerous times to discuss the scenarios to be selected for analysis in System Plan (Rev. 6). Framing the scope for System Plan (Rev. 6) began by reviewing and discussing the technical results and key assumptions and success criteria used for System Plan (Rev. 5). These discussions led to agreed-upon changes to the subsets of the System Plan (Rev. 5) key assumptions needed to define the various scenarios that would be evaluated in System Plan (Rev. 6). Each agency selected and prioritized five scenarios. Those scenarios later were assigned corresponding case numbers for ease of tracking during modeling and to be consistent with established System Plan nomenclature (Table 10-3).

Table 10-1. Final Selected Scenarios Ordered by Decreasing Priority

ORP Selections		Ecology Selections	
Case	Scenario	Case	Scenario
1	Baseline Case	2	TRU Waste to WTP
3	FBSR for Supplemental Treatment	4	WTP Delay with Increased Vitrification Capacity
5	2020 Vision One System	6	WTP Delay with New DST Farm
7	Enhanced Tank Waste Strategy	8	Accelerated Retrieval
9	Early U Farm Closure	10	Slow SST Retrievals

Key to relative difficulty of modeling and analysis: Red = Hard, Yellow = Moderate, Green= Easy.
Relative difficulty reflects the incremental effort to model the scenario.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
ORP = U.S. Department of Energy, Office of River Protection.
SST = single-shell tank.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

A more detailed description of the process for defining the scope of each scenario, and the scenarios themselves, is provided in RPP-48228. In addition, ORP and Ecology provided portions of RPP-48228 to the EPA via letter to confirm partial completion of Milestone M-062-40 (Brockman and Hedges 2010).

Additionally, milestone M-062-40 requires that:

> "The [System] Plan will present the following minimum information for each scenario evaluated: ...Sensitivities analysis of selected key assumptions…"

Sensitivity analyses reflect changes in an existing numerical model parameter or sequence of events, such as increasing or decreasing expected WTP melter capacities, or changing the tank retrieval sequence. No assumptions were selected for sensitivity analysis by ORP or Ecology during the framing of Cases 2, 3, 5, 6, or 8. Several assumptions for the Baseline Case were selected by ORP and Ecology for sensitivity analysis, including a 10 percent increase in HLW and LAW vitrification capacity with delayed startup of WTP, slowed SST retrievals, and early U Farm closure. These sensitivity analyses were subsequently elevated to the level of full standalone cases (Cases 4, 9 and 10, respectively) to provide a more complete analysis.

Milestone M-062-40 also requires that:

> "The [System] Plan will identify and consider possible contingency measures to address …risks…"

ORP performs contingency planning using the risk management process; key issues and uncertainties and potential mitigating actions are included for the Baseline Case in each System Plan. While the language of the milestone does not require that the contingency planning be based on scenarios or sensitivity analysis, a number of scenarios selected for System Plan (Rev. 6) were defined with contingency planning in mind. Contingency planning may include changes to the overall mission flowsheet, such as adding or removing a facility, development of new technologies, and use of funded management reserve and unfunded contingency.

Table 10-2 summarizes the relationship of the non-baseline scenarios to contingency planning and sensitivity analysis.

Table 10-2. Relationship to Contingency Planning and Sensitivity Analysis

Scenario		Supports mission evolution	Supports contingency planning	Supports sensitivity analysis
Case 1	Baseline Case	✓	✓	–
Case 2	TRU Waste to WTP	–	✓	–
Case 3	FBSR for Supplemental Treatment	✓	✓[a]	–
Case 4	WTP Delay with Increased Vitrification Capacity	–	✓	✓
Case 5	2020 Vision One System	✓	✓[a]	–
Case 6	WTP Delay with New DST Farm	–	✓	–
Case 7	Enhanced Tank Waste Strategy	–	✓	✓
Case 8	Accelerated SST Retrievals	–	✓	–
Case 9	Early U Farm Closure	–	✓	✓
Case 10	Slow SST Retrievals		✓	✓

[a] After evaluation of model results, Case 3 and Case 5 were also found to support contingency planning even though they were not originally selected with contingency planning in mind.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
SST = single-shell tank.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

The results from these scenarios were expected to provide information that might identify new issues and uncertainties and that might affect the risks and/or mitigating actions addressed in the RMP (see Sections 1.8, 1.9, 7.0, and 10.2 - 10.10).

Table 10-3 provides an overview of all ten cases and highlights the differences in scope.

Table 10-3. Case Comparison Matrix

Case	SST retrievals	TRU disposition	WTP pretreatment	Supplemental pretreatment	WTP HLW hot commissioning	WTP LAW hot commissioning	Supplemental treatment process	Net vitrification capacity	Glass formulation models	Additional details
Baseline Case	Aligned with SST Retrieval Plan[a]	On-site storage at CWC	WTP pretreatment with equipment alternative	None	2018	2018	Second LAW vitrification facility	HLW: 5.25 MTG/d LAW: 21 MTG/d	HLW: 2009 GFM LAW: DOE 2004 LAW glass model	Eliminated Aluminum Removal Facility
Case 2: TRU Waste to WTP	Retrieve potential CH-TRU waste tanks into the DST system	WTP	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	
Case 3: FBSR for supplemental treatment	**Baseline**	**Baseline**	**Baseline**	SCIX/RMF at-tank	**Baseline**	**Baseline**	Four fluidized bed steam reformers	**Baseline**	**Baseline**	
Case 4: WTP delay with increased vitrification capacity	**Baseline**	**Baseline**	**Baseline**	**Baseline**	2022	2022	**Baseline**	HLW and LAW capacities 110% of baseline.	**Baseline**	
Case 5: 2020 Vision One System	**Baseline**	**Baseline**	**Baseline**	RMF in Tank AP-105 and SCIX in Tank AP-107 provide interim pretreatment for early feed to WTP LAW Vitrification Facility	**Baseline**	2016	**Baseline**	Adjust ramp rates to support LAW glass in 2016	**Baseline**	Secondary liquid waste from WTP LAW Vitrification Facility will be returned to tank farms
Case 6: WTP delay with new DST farm	Integrate eight new 1-Mgal DSTs with existing DST transfer system	**Baseline**	**Baseline**	**Baseline**	2022	2022	**Baseline**	**Baseline**	**Baseline**	
Case 7: Enhanced tank waste strategy	Adjust as necessary to achieve end date 7 years earlier than baseline	**Baseline**	**Baseline**	SCIX/RMF at-tank	**Baseline**	NA	No WTP LAW Vitrification Facility, all LAW treated by eight fluidized bed steam reformers	**Baseline**[b]	HLW: 2009 GFM with OB/ND LAW: NA	
Case 8: Accelerated SST retrievals	Retrieve B Farm potential CH-TRU waste tanks into the DST system and retrieve and stage all T Farm waste in sound TX Farm tanks	WTP	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	Wiped film evaporator(s) at T Complex WRF needed to support waste staging
Case 9: Early U Farm closure	Retrieve the four AX Farm tanks and five U Farm tanks, as the nine additional retrievals after C Farm	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	
Case 10: Slow SST retrievals	Increase minimum duration of each SST retrieval by 25% for all retrievals starting between 1/1/2011 and 1/1/2021	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**	

[a] RPP-RPT-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[b] The Case 7 assumptions allow for an increase in the HLW Vitrification Facility capacity, if needed to shorten the mission duration. However, this increased capacity did not appreciably shorten the mission, so the baseline capacity was retained.

CH-TRU = contact-handled transuranic.
CWC = Central Waste Complex.
DOE = U.S. Department of Energy.
DST = double-shell tank.
FBSR = fluidized bed steam reforming.
GFM = glass formulation model.
HLW = high-level waste.
LAW = low-activity waste.
MTG = metric ton of glass.
OB/ND = optical basicity/nepheline discriminator
RMF = rotary microfiltration.
SCIX = small column ion exchange.
SST = single-shell tank.
TRU = transuranic.
WRF = waste retrieval facility.
WTP = Waste Treatment and Immobilization Plant.

The details of Cases 2 – 10 are included in Sections 10.2 - 10.10, respectively. Each section includes:

- **System description** – Describes physical differences, if any, from the Baseline Case (e.g., facilities or equipment added or removed, or connectivity changes), technology development needs, and any specific actions that would be needed to implement the case as described.
- **Planning bases** – Directs the reader to appropriate case-specific key assumptions in Appendix B.
- **Results** – Presents HTWOS model results for each case, typically presented as a collection of tables and graphics, with essential highlights indicated. Graphics included for each case were selected to best communicate data of greatest interest to that particular case, and may vary between cases. The impact of the case schedule on closure activities relative to the Baseline Case is discussed.[65]
- **Cost and schedule impacts** – Presents LCM model results, including a brief description of life-cycle cost differences in dollars relative to the life-cycle cost of the Baseline Case, overall schedule differences relative to the Baseline Case, and any relevant impacts those differences would drive. The life-cycle cost profiles[66] for each case are on a fiscal year timescale and represent escalated dollars.[67]
- **Key issues and vulnerabilities** – The impacts to Baseline Case issues or uncertainties are identified and new issues or uncertainties introduced by the specific scenario are also identified with corresponding potential mitigating actions.

[65] HTWOS and the LCM predict the date on which SST retrievals will be completed for each farm, which necessarily precedes full closure. Therefore, as the date for SST retrievals completion is accelerated or delayed based on the circumstances of each case, so too is the schedule for full closure. The Results section of each case includes a statement to indicate whether full closure for that case is earlier or later than predicted for the Baseline Case.

[66] The profiles generated by the LCM tool reflect the scheduling assumptions built into the model. Generally, this moves the end of precursor project activities to coincide with the start of operations from HTWOS results, and terminates activities consistent with the operational completion dates from HTWOS. This creates zero-float schedules that, in some cases, create large spikes in budget needs over short periods of time. Resource leveling would be performed before attempting to adopt an LCM-generated schedule for mission planning.

[67] Because of escalation, slight increases in mission duration have notable impacts on life-cycle costs.

10.2 CASE 2 – TRANSURANIC WASTE TO WASTE TREATMENT AND IMMOBILIZATION PLANT

Selected by: Ecology

Purpose: Assess the impact of treating all of the potential TRU tank waste at the WTP.

10.2.1 System Description

Case 2 explores the impact of classifying the potential CH-TRU tank waste as HLW, eliminating the supplemental TRU treatment system, and treating the CH-TRU waste at WTP. Potential CH-TRU waste is retrieved along with HLW, commingled with other HLW during storage in the DST system, and subsequently treated as HLW at the WTP. Therefore, no additional equipment or technology development is anticipated for this scenario. The simplified flowsheet for Case 2 is provided in Figure 10-1.

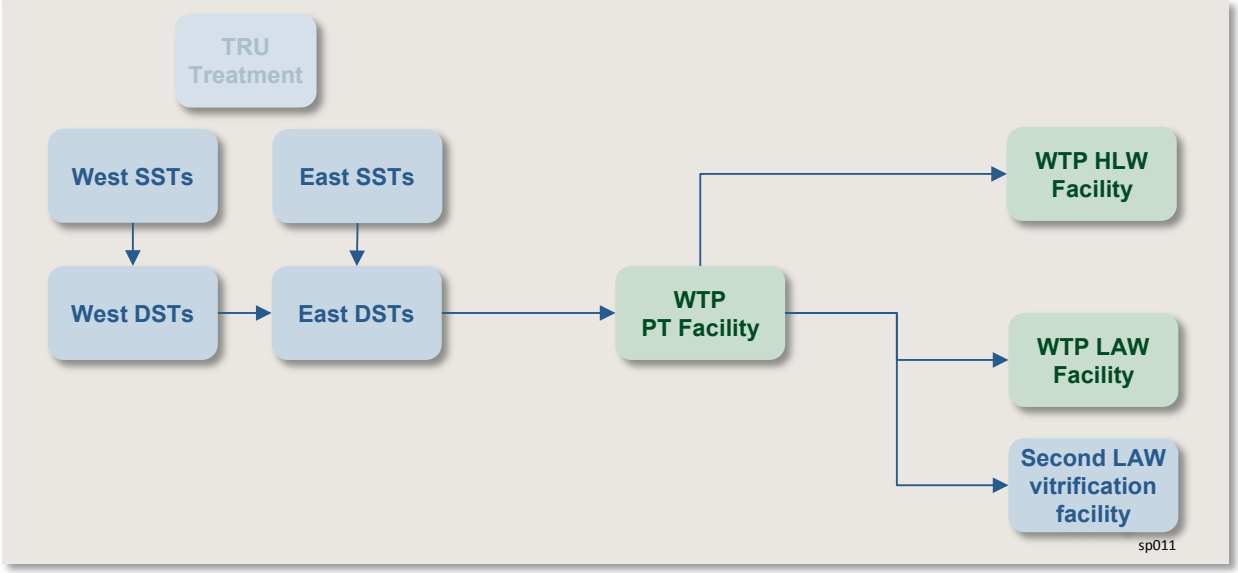

Figure 10-1. Simplified Flowsheet for Case 2

10.2.2 Planning Bases

Case 2 planning bases are described in Appendix B, Section B4.0.

10.2.3 Results

Table 1-1 (Section 1.3) and Table 10-4 show the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 2 versus the Baseline Case. Key results for Case 2 are as follows:

- Case 2 meets all mission success criteria, except:
  - Life-cycle cost of Case 2 is $61.6 billion, which exceeds the success criteria of $61.5 billion.
  - Closure of all SSTs. The milestone for the closure of all SSTs is January 31, 2043. Case 2 completes all SST closures by October 20, 2044.

Table 10-4. Mission Metrics Comparison for the Baseline Case and Case 2

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 2: TRU waste to WTP
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	**$61.6 B**
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,400 M
Meets near-term funding profile through 2015	Note a	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	7/23/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	12/16/2020
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	9/25/2040
Close all SSTs (M-045-00)	1/31/2043	**10/5/2043**	**10/20/2044**
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	5/13/2044
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	6/1/2049
Complete potential TRU tank waste packaging	–	7/13/2023	–
HLW glass mass (MTG)	–	31,968	34,884
HLW glass canisters	–	10,586	11,552
HLW glass waste oxide loading	–	36.9%	35.3%
LAW glass mass (MTG)	–	527,838	533,110
LAW glass containers	–	95,825	96,782
LAW glass sodium oxide loading	–	17.8%	17.7%
Sodium reporting to LAW glass (MT)	–	69,659	70,109
FBSR product (MT)	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	–

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

- The System Plan (Rev. 6) Baseline Case and Case 2 complete C Farm retrievals, start an additional five SST retrievals, and complete nine additional SST retrievals on identical dates.
- System Plan (Rev. 6) Case 2 takes slightly more than a year longer to complete all SST retrievals compared to the Baseline Case (September 25, 2040 compared with September 8, 2039). The extra retrieval time reflects the need to retrieve 11 additional SSTs storing potential CH-TRU tank waste to the DST system. The additional retrievals add extra strain to the DST system by adding additional waste, transfers, and scheduling complications, thus causing a delay in overall SST retrieval completion in Case 2.
- System Plan (Rev. 6) Case 2 takes approximately a year longer to treat all of the tank waste than the Baseline Case does (April 23, 2043 compared with May 13, 2044) due to the extended SST retrieval duration and the increase in the amount of HLW waste that is processed by the HLW melters.
- System Plan (Rev. 6) Case 2 results in a 9.1 percent increase in HLW glass mass compared with the Baseline Case. The additional glass mass is attributable to the additional waste being treated from the potential CH-TRU tank waste. The increase in LAW glass mass for Case 2 is 1.0 percent compared to the Baseline Case.

In System Plan (Rev. 6) Case 2, the assumed CH-TRU waste tanks in T Farm and B Farm are retrieved with the other T Farm and B Farm waste. Figure 10-2 shows the general timing of the SST retrievals.

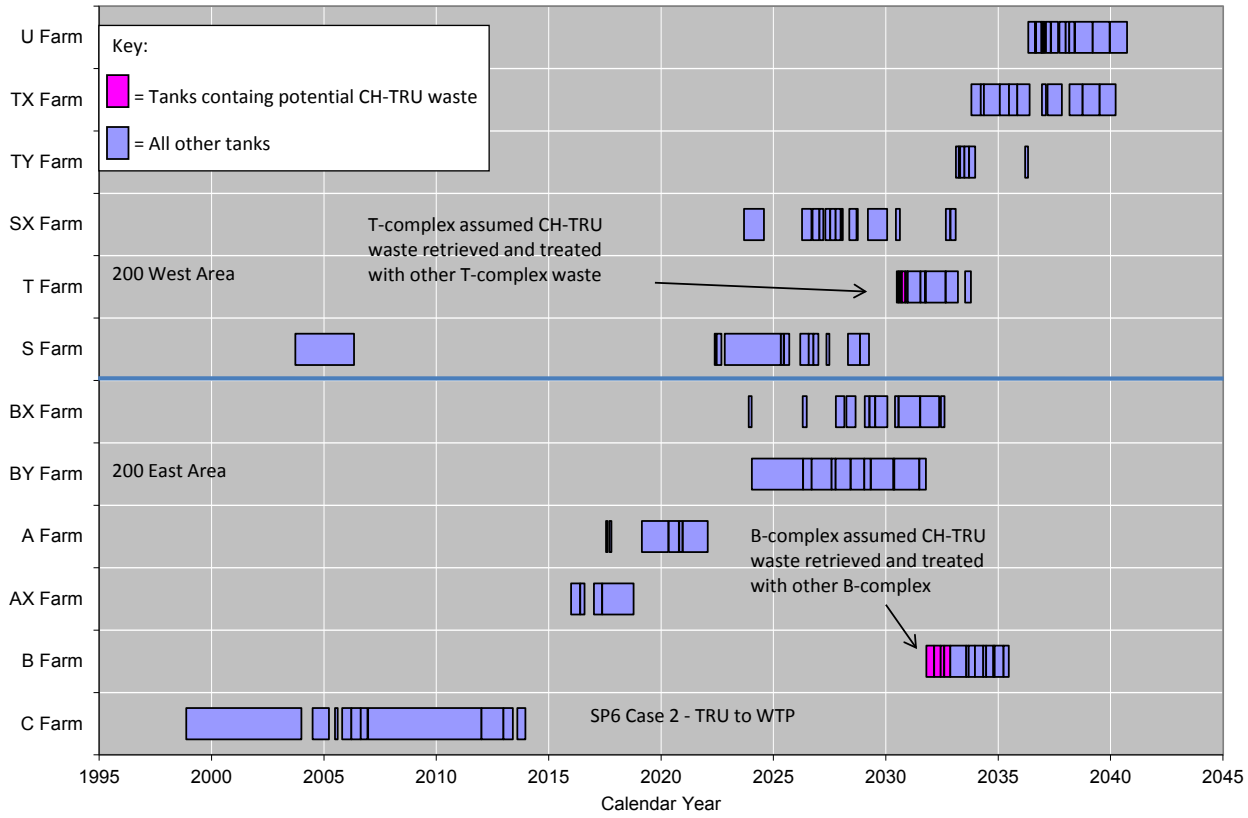

Figure 10-2. General Timing of the Single-Shell Tank Farms for Case 2

The overall SST retrieval progress for the System Plan (Rev. 6) Baseline Case and Case 2 is shown in Figure 10-3. The retrieval progress for the Baseline Case and Case 2 are identical until April 2018, when, in the Baseline Case, the potential CH-TRU waste is retrieved into the CH-TRU waste treatment and packaging system. The Baseline Case has the luxury of retrieving the potential CH-TRU waste outside of the DST system, during a period of time when SSTs retrievals are limited by available DST space. In Case 2, the potential CH-TRU waste is retrieved into the DST system starting in 2030, which pushes the subsequent retrievals back one year compared with the Baseline Case.

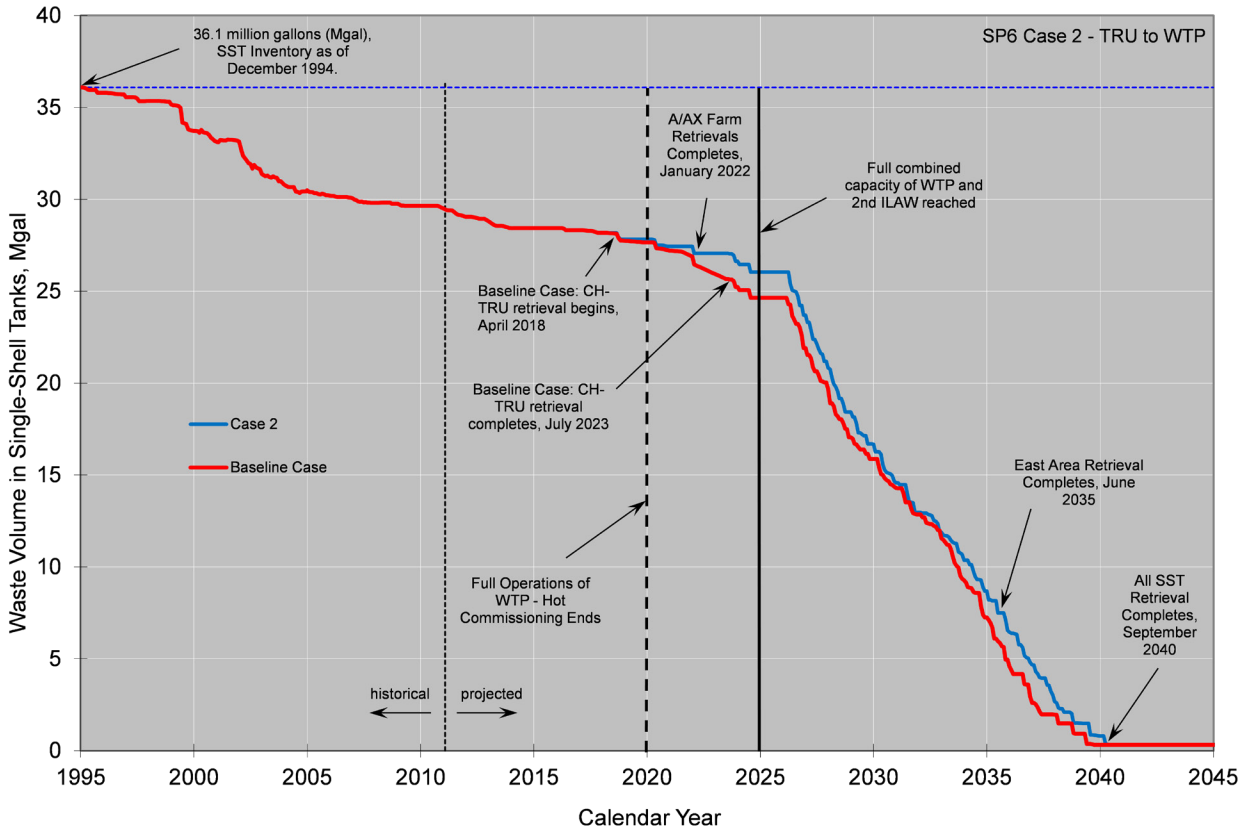

Figure 10-3. Overall Single-Shell Tank Retrieval Process for Case 2

Figure 10-4 shows the number of retrievals that were completed or projected to be completed each fiscal year for System Plan (Rev. 6) Case 2. The potential CH-TRU waste is retrieved into the DST system, so for Case 2, more SST retrievals need to be completed during the 2026 - 2040 timeframe than in the System Plan (Rev. 6) Baseline Case. Eleven or more retrievals are scheduled to be completed in calendar years 2030, 2031, and 2032. 2030 is particularly ambitious with 14 retrievals projected to be completed. It may be possible to reduce the peaks by carefully adjusting the detailed SST retrieval assumptions, but the SST retrieval logistics and timing in Case 2 are more challenging than they are in the Baseline Case.

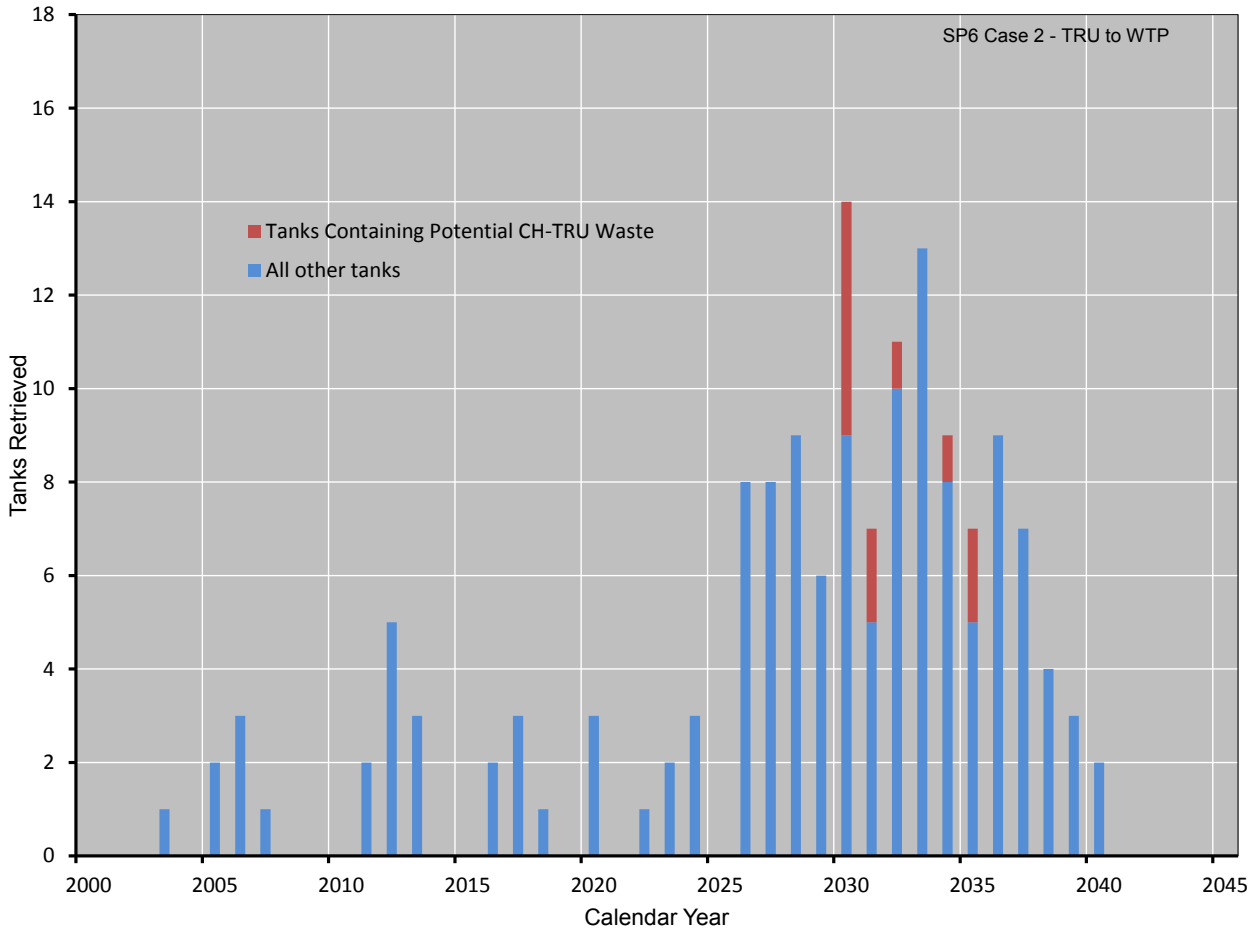

Figure 10-4. Single-Shell Tank Retrievals Completed Each Calendar Year for Case 2

Figure 10-5 shows the moving three-year average[68] for SSTs retrieved per year for Case 2 and for the Baseline Case. In Case 2, the retrieval of the potential CH-TRU SSTs into the DST system results in more SST retrievals per year during the peak retrieval period 2026 – 2037 than there are in the Baseline Case. During 2029 – 2035, there are one or two more SSTs retrieved per year in Case 2 than in the Baseline Case.

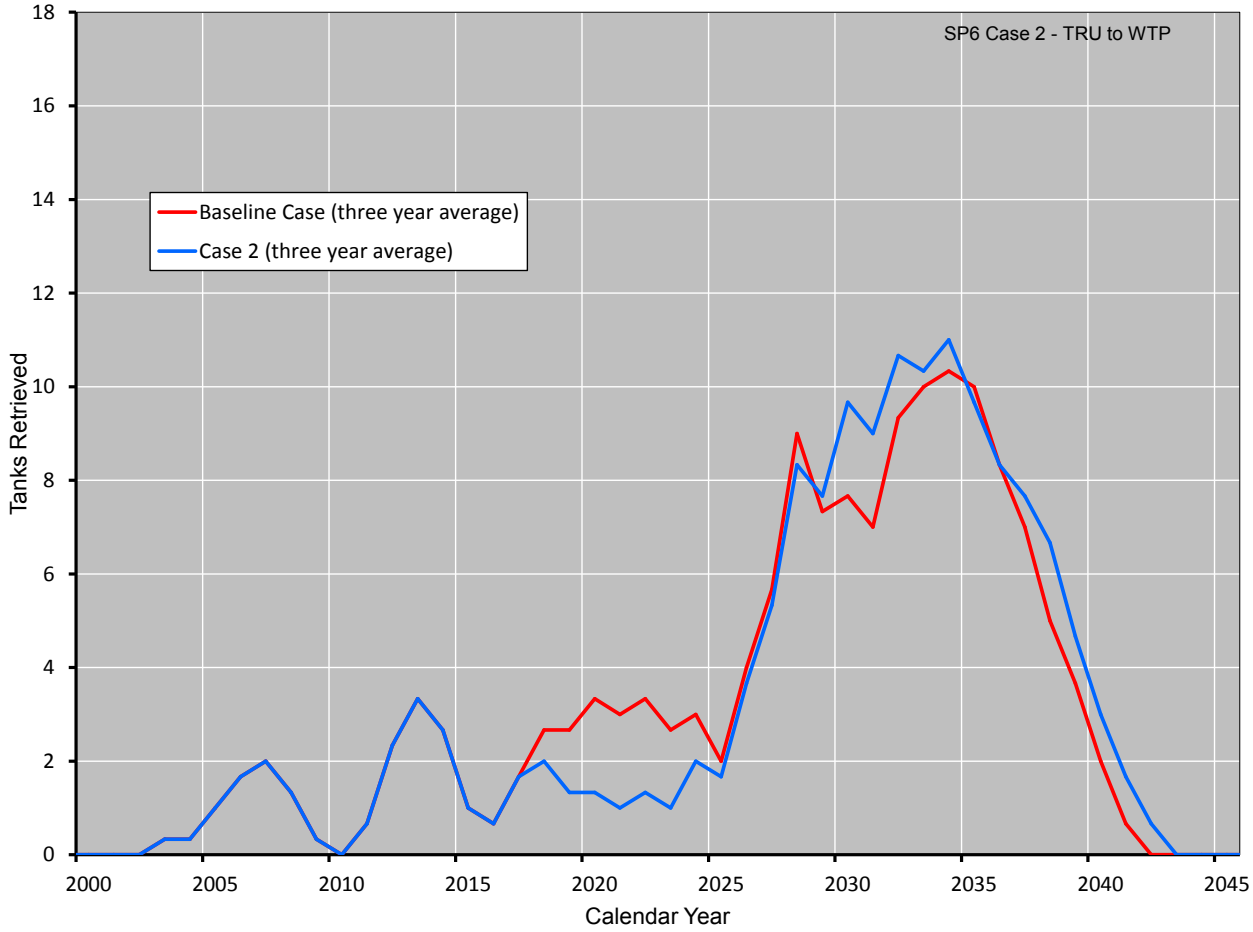

Figure 10-5. Three-Year Moving Average Single-Shell Tank Retrievals for the Baseline Case and Case 2

The sequence and timing of each SST retrieval are shown in Figure 10-6. This figure shows that when DST space is limited during the 2018 – 2025 timeframe, the retrievals of six SSTs (Tanks AX-101, A-101, A-103, S-107, BY-102 and BY-110) are projected to take significantly longer than their minimum retrieval duration. The start of many of these retrievals should probably be delayed several years to avoid having these tanks and their associated retrieval equipment sitting idle during periods of inadequate DST space.

[68] Use of a moving average facilitates comparison of scenarios by smoothing out the year-to-year variability. While somewhat subjective, a three-year moving average removed enough variability to allow the reader to focus on the real differences, but not so much as to obscure those differences.

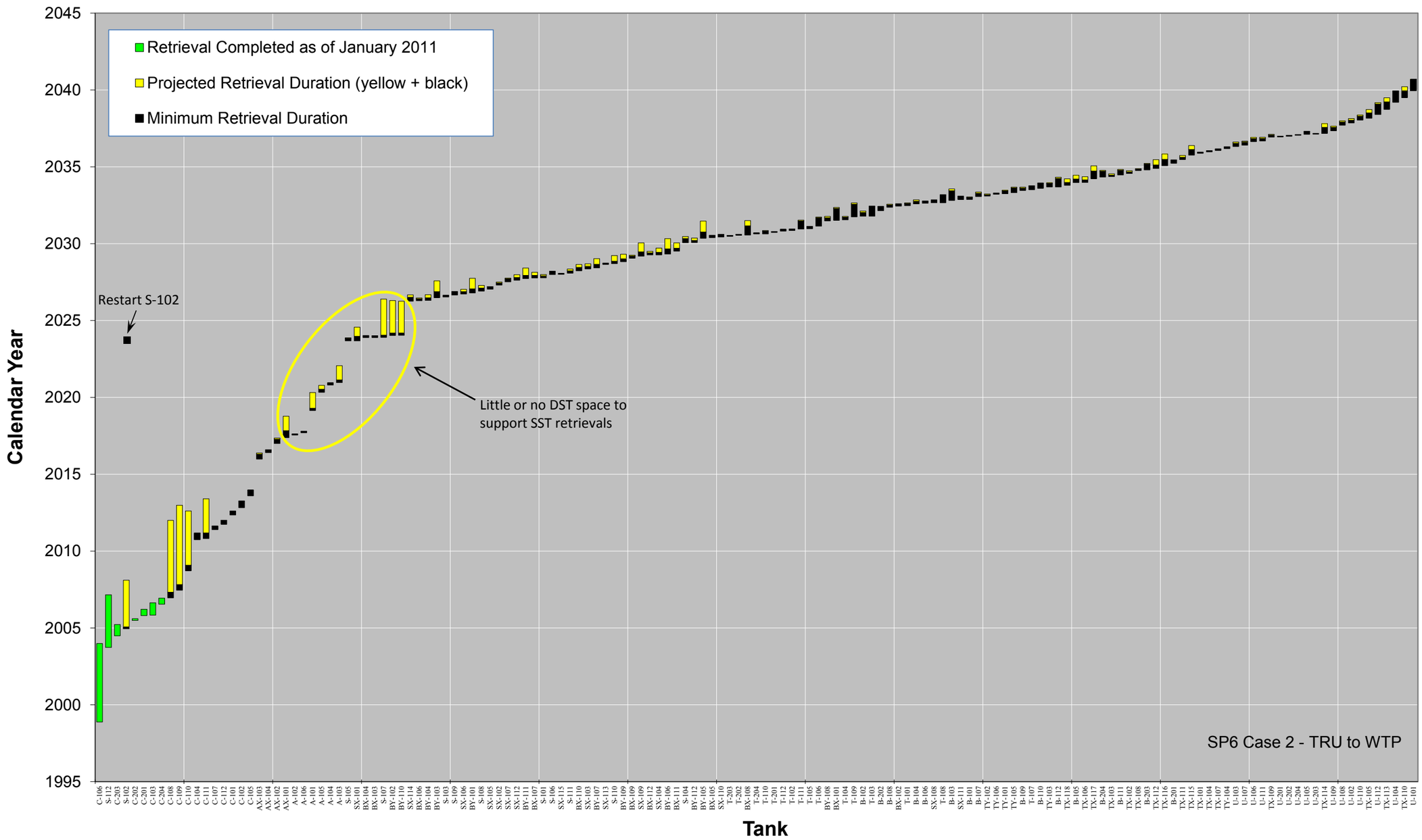

Figure 10-6. Single-Shell Tank Retrieval Sequence and Timing for Case 2

Figure 10-7 shows the allocation of DST space during the waste treatment mission. The use of the DSTs in System Plan (Rev. 6) Case 2 is very similar to the usage in the Baseline Case. DST space is very limited from 2018 - 2022. During this time, there is approximately 0.9 - 2.7 Mgal of DST space available, but it is distributed among multiple tanks and it is not readily usable. Although more DST space becomes available in 2022, the space available for SST retrievals is restricted until the WTP and second LAW facility reach full capacity in 2025. A more in-depth discussion on the DST system is provided in Section 3.1.2.

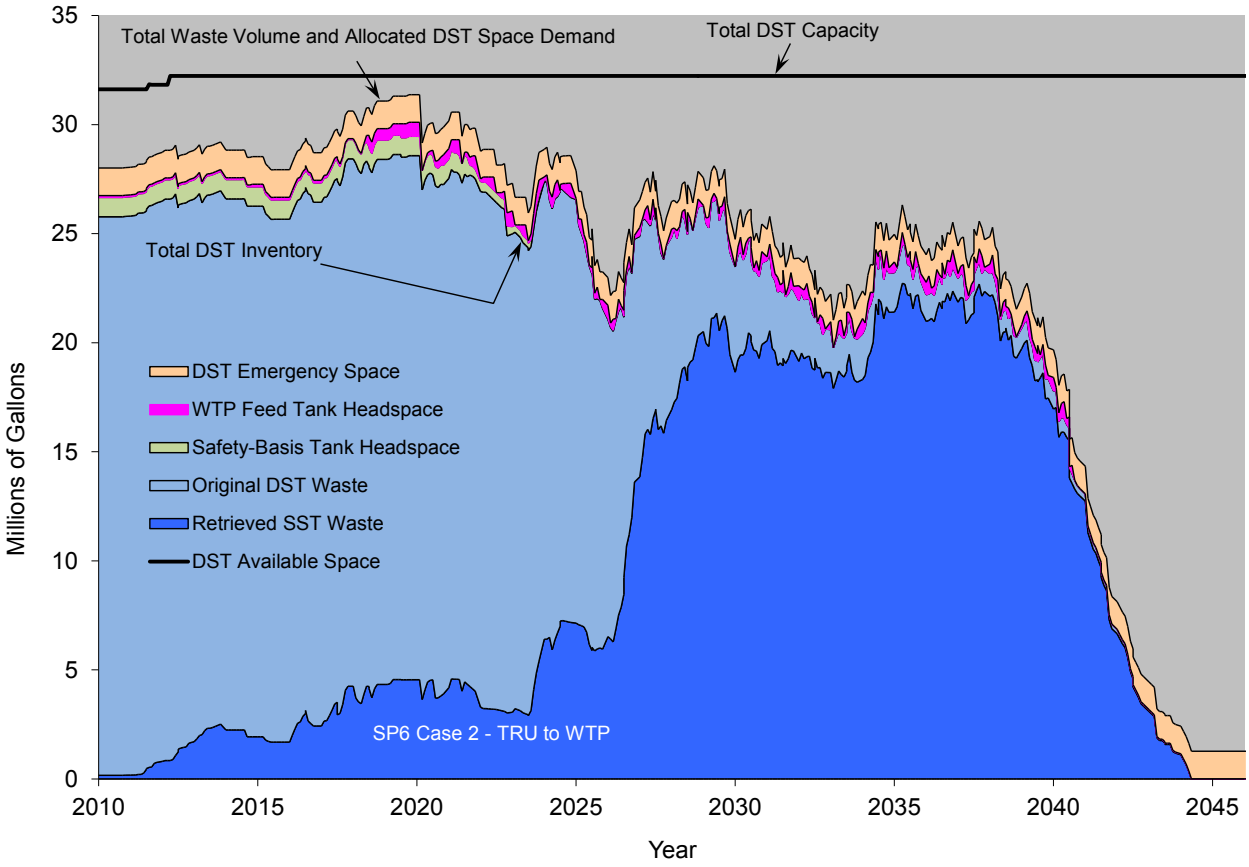

Figure 10-7. Double-Shell Tank Space for Case 2

Figure 10-8 compares IHLW glass production for the Baseline Case and Case 2 with the assumed net capacity. Figure 10-9 shows the same information for ILAW glass. The second LAW facility is ramped up to its full capacity in 2025, but the production of LAW continues to limit the waste treatment mission until 2030. LAW is generated during the pretreatment of HLW, and when the LAW melters are at capacity, the rate at which HLW is processed can be restricted. This is the case prior to 2030. After 2030, production of IHLW is the mission-limiting step.

Figure 10-8 and Figure 10-9 also show the IHLW and ILAW production for the Baseline Case. There are no significant differences between the production plots for Case 2 and the production plots for the Baseline Case.

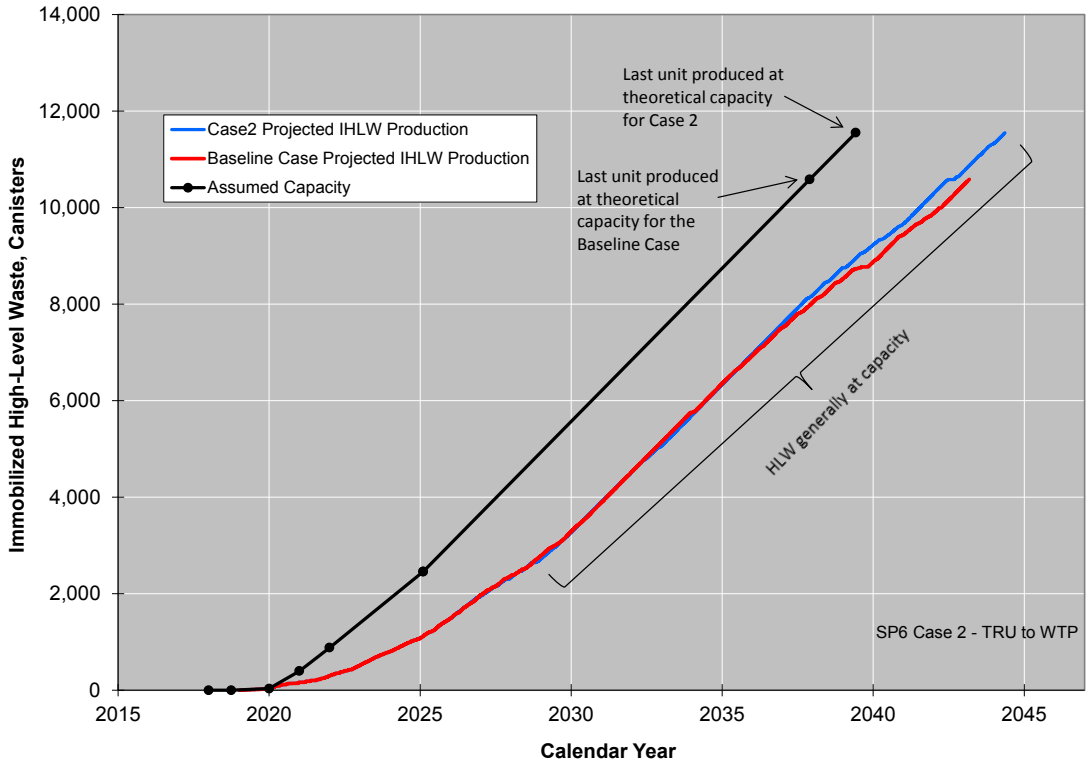

Figure 10-8. Projected Immobilized High-Level Waste Production for the Baseline Case and Case 2

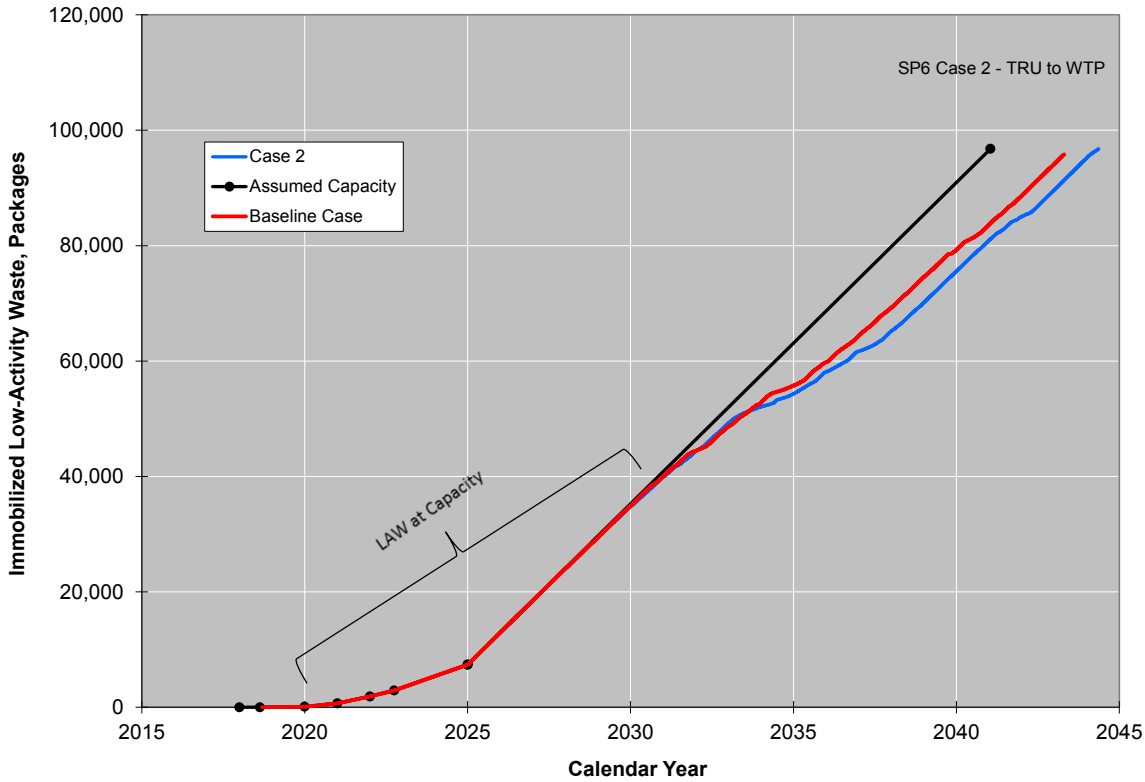

Figure 10-9. Projected Immobilized Low-Activity Waste Production for the Baseline Case and Case 2

Figure 10-10 provides a summary of the glass drivers for Case 2. The glass drivers for the Baseline Case are summarized in Figure 5-14. Case 2 produces 34,884 MT of IHLW compared to 31,968 MT produced in the Baseline Case (see Table 1-1). Two factors lead to this increase:

- When the potential CH-TRU waste is treated through the WTP, an additional 540 MT of waste oxides are sent through the HLW melters than in the Baseline Case.
- WOL in Case 2 drops to 35.6 percent, compared to 37.1 percent in the Baseline Case.

The retrieval of the potential CH-TRU waste tanks with other T Farm and B Farm tanks (see Figure 10-3) results in large quantities of high bismuth waste being staged through the DST system and processed in the WTP in the 2030s. From 2033 - 2038, bismuth oxide is the glass driver for nearly all of the HLW processed in the WTP. This ubiquity of high bismuth waste in both the DST system and the WTP, limits the opportunity for IHLW mass reduction via blending and leads to the production of low WOL HLW glass batches. In Case 2, bismuth oxide is the glass driver for 1,086 batches with an average WOL of 33.3 percent. In the Baseline Case, bismuth oxide only limits 496 batches, with an average WOL of 35.5 percent.[69]

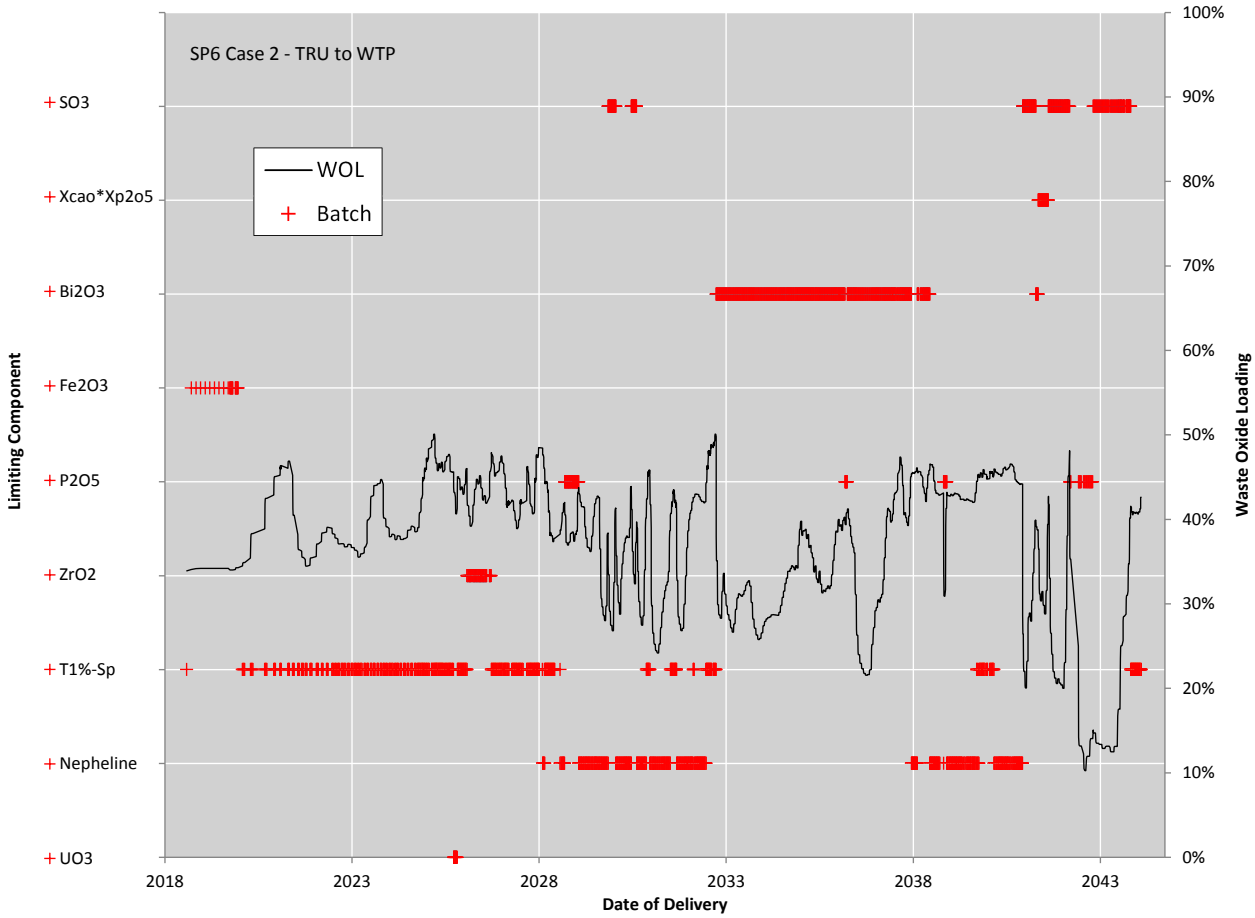

Figure 10-10. High-Level Waste Glass Drivers for Case 2

[69] A detailed breakdown for the glass drivers is provided in SVF-2130, 2011, "WTP_HLW_V6.6.1-TRU-TO-WTP-6.61-8.3r1-2011-03-23-at-22-16-40," Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

Figure 10-11 shows the interim HLW storage and shipping projections for Case 2. The IHS is expected to begin receiving HLW canisters from WTP on November 24, 2019. The delay between the start of WTP hot commissioning and the receipt of the first HLW canister is due to the use of the WTP-provided storage for cooling and buffer capacity.

If the decision is made to build the HSF and ship the canisters pending a final disposal alternative, IHS is assumed to operate about 1,000 canisters below the maximum storage capacity. IHS is projected to reach the operating target of 3,000 canisters in July 2029. If the HSF is delayed and shipping cannot begin when IHS reaches the operating target, additional modules will be added to meet the storage requirements as outlined in Appendix B, Assumption B3.5.3.3. The decision dates for the addition of each module are shown in Figure 10-11.

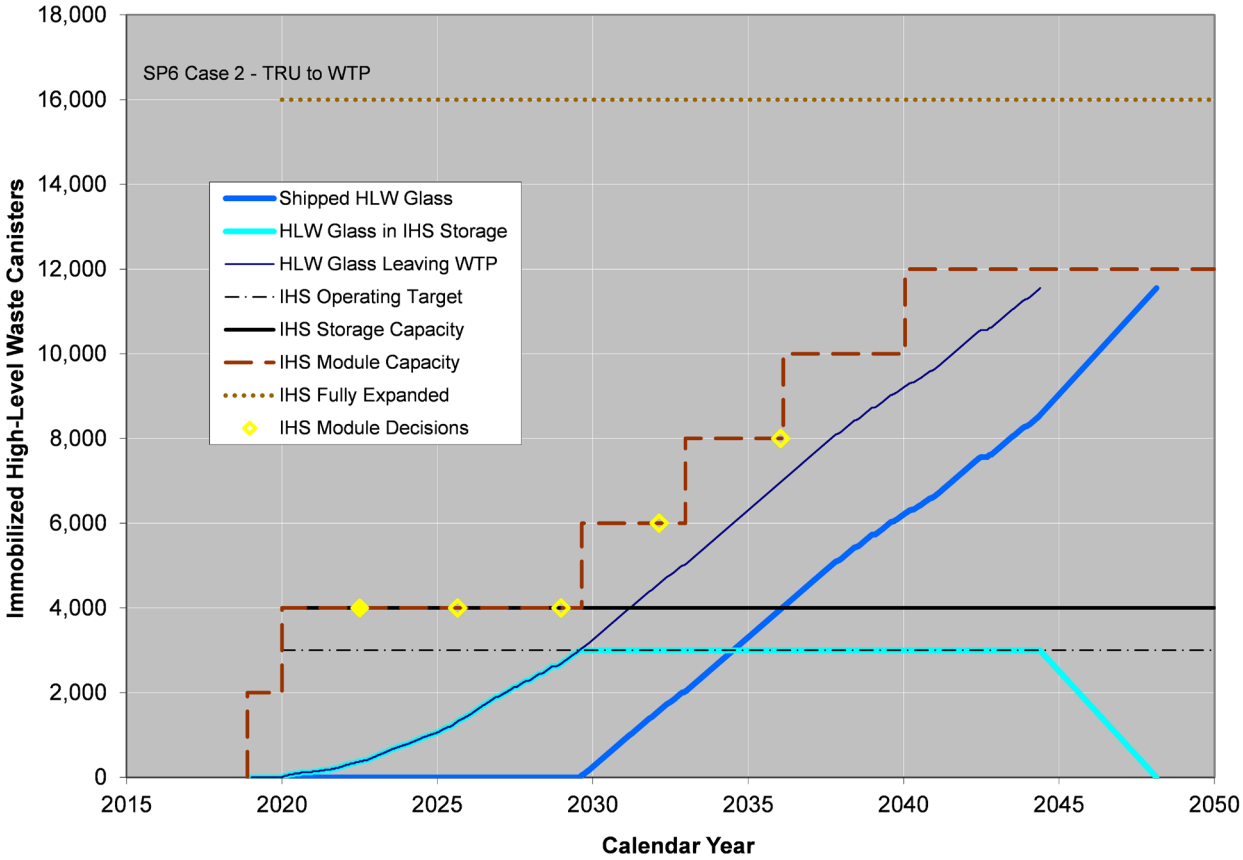

Figure 10-11. Immobilized High-Level Waste Storage and Shipping Projections for Case 2

In Case 2, the SST closure schedule is delayed by approximately one year relative to the Baseline Case because treatment of the potential TRU tank waste through WTP extends the mission.

10.2.4 Cost and Schedule Impacts

Figure 10-12 compares the cost of Case 2 versus the Baseline Case, and Table 10-5 lists the near-term funding targets and Case 2 results for 2011 - 2015. The Case 2 life-cycle cost is $61.6 billion, which is 2.8 percent greater than the Baseline Case life-cycle cost of $59.9 billion. In the near-term, Case 2 costs slightly less than the Baseline Case (the savings are due to eliminating all costs associated with CH-TRU waste packaging); however, Case 2 has significantly larger costs later in the mission. Most of this cost increase is due to the extra year that processing the potential CH-TRU waste in the WTP adds to the mission schedule. Case 2 completes treatment of all tank waste by May 13, 2044, versus the Baseline Case completion of April 23, 2043.

Table 10-5. Near-Term Funding Targets and Results for Case 2

Fiscal year	Target[a] ($M)	Case 2[a] ($M)
2011	410	394
2012	510	482
2013	510	459
2014	610	465
2015	710	600
Total	**2,750**	**2,400**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

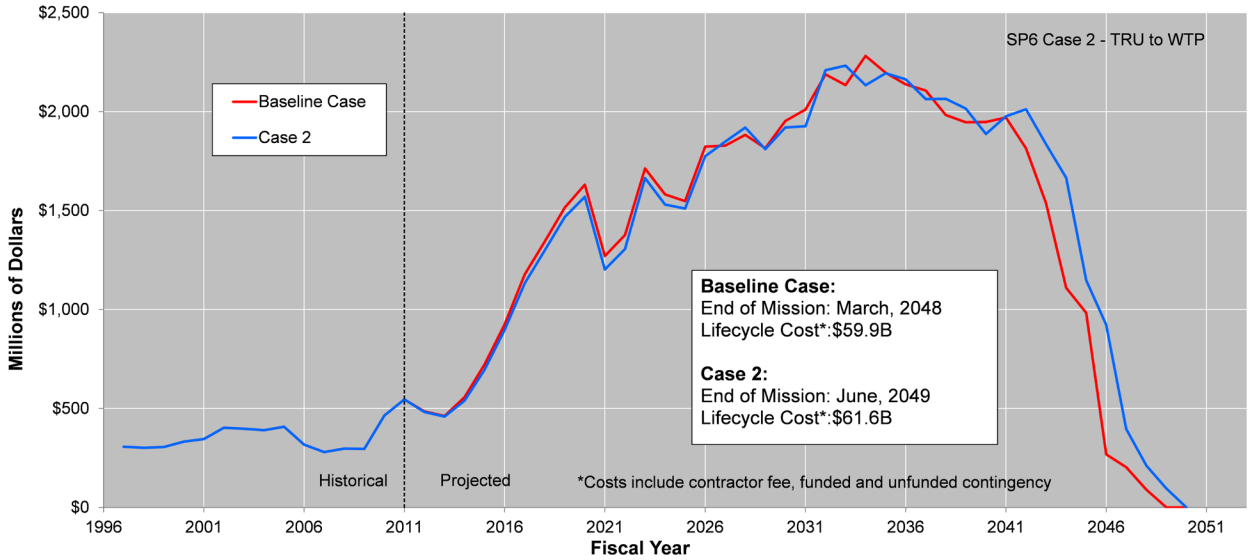

Figure 10-12. Life-Cycle Cost Comparison: Baseline Case and Case 2

In June 2030, Case 2 begins retrieving potential CH-TRU tank waste into the DST system, in preparation for subsequent CH-TRU waste treatment at WTP. Adding the CH-TRU waste to the DSTs consumes some of the storage space that would have been available to support other SST retrievals. Two schedule dates are impacted.

- Case 2 completion of SST retrievals is delayed until September 25, 2040, a little more than a year later than the Baseline Case date of September 8, 2039.
- Case 2 treatment of all tank waste is delayed until May 13, 2044, a little more than a year later than the Baseline Case date of April 23, 2043.

The Baseline Case retrieves potential CH-TRU waste tanks between 2019 and 2024; in Case 2, these tanks are retrieved later in the mission. The delay in retrievals and the savings from eliminating CH-TRU waste packaging, cross-site shipping, and costs associated with storing waste packages prior to shipment to WIPP keeps the Case 2 costs below the Baseline Case between 2021 and 2025.

Case 2 is also noticeably less expensive than the Baseline Case in 2034. This $148 million savings is primarily due to earlier completion of SST retrievals in 200 East Area tank farms, decreases in SST closure activities, and differences in contractor fee and DOE contingency.

Starting in 2038 and running through 2049, Case 2 costs are considerably greater than the Baseline Case, especially in 2043 ($298 million), 2044 ($556 million) and 2046 ($655 million). These out-year costs are due to the processing of the potential CH-TRU waste causing mission extensions to SST retrieval, DST waste feed delivery, and a 13-month extension to the WTP operating duration. All SSTs are closed by October 2044 in Case 2 compared to October 2043 in the Baseline Case, both of which miss the mission success criteria of closing all SSTs by January 31, 2043. The DSTs are closed in June 2049, 15 months later than March 2048 for the Baseline Case. The increased schedule duration causes escalated life-cycle costs to increase by about $1.7 billion, which is about the average annual out-year cost for the mission.

Although not part of the TOC PMB, the costs associated with shipping and disposing of the CH-TRU waste packages at WIPP (assuming that WIPP is determined to be their final disposition) are eliminated for Case 2.

10.2.5 Key Issues and Vulnerabilities

The following issues from the Baseline Case are impacted by Case 2.

- Item 7.2-1 (SST bulk retrieval methods) is exacerbated by Case 2 due to the need to retrieve more SSTs during the peak SST retrieval period, 2025 – 2040, than are retrieved in the Baseline Case.
- Item 7.8-5 (Formal WD segregation of potential CH-TRU waste and determination of final disposition) is eliminated by Case 2 since the potential CH-TRU waste is not segregated and separately packaged as TRU waste.
- Item 7.8-6 (Development of separate waste treatment process and packaging capacity for potential CH-TRU waste) is eliminated by Case 2 since potential CH-TRU waste is not processed and packaged separately from the HLW.
- Item 7.8-7 (Modified CWC permits) is eliminated by Case 2 since the potential CH-TRU waste is dispositioned with the HLW and not stored at the CWC.

No new issues were identified in association with Case 2.

10.3 CASE 3 – FLUIDIZED BED STEAM REFORMING FOR SUPPLEMENTAL TREATMENT

Selected by: ORP

Purpose: Demonstrate the deployment of FBSR as an alternative to a second LAW vitrification facility.

10.3.1 System Description

Case 3 consists of using fluidized bed steam reformers to provide supplemental LAW treatment instead of a second LAW facility. The FBSR technology immobilizes the LAW in a granular mineralized form by trapping waste components within the mineral structure. The granular product is then mixed with a binder to form a solid monolith product suitable for disposal at the IDF. However, the flowsheet for this case requires several connectivity changes when compared to the Baseline Case, and presupposes the successful development of several transformational technologies.

The total number of fluidized bed steam reformers required was determined by starting with the total LAW treatment capacity required, minus the expected capacity of the WTP LAW Vitrification Facility. This calculation resulted in four steam reformers. The fluidized bed steam reformers would have two sources of feed: (1) the WTP PT Facility and (2) a supplemental pretreatment system installed in the tank farms, which would include RMF and SCIX. RMF would remove solids from the LAW feed stream; SCIX would remove cesium from the LAW waste stream. The solids and cesium would be routed back to the tank farms and added to the HLW feed stream. A simple flow diagram for Case 3 is shown in Figure 10-13.

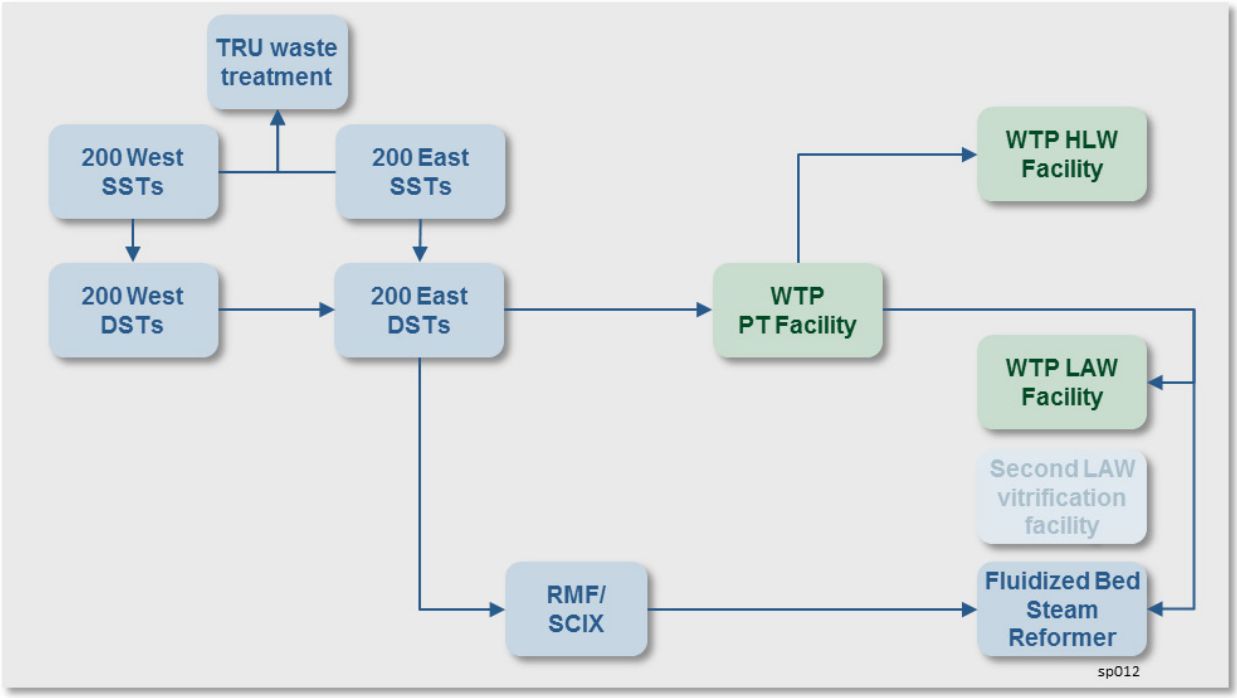

Figure 10-13. Simplified Flowsheet for Case 3

Case 3 relies on several of the transformational technologies discussed for the Baseline Case in Section 6.0. Table 10-6 highlights the anticipated technology development needed to support this case.

Table 10-6. Case 3 Technology Development Overview

Functional area	Technology	Technology description	Potential application
Supple-mental treatment	At-tank RMF[a]	RMF could be used to remove solids from the waste streams.	Rotary microfilters could be deployed inside or near waste tanks to supplement the WTP PT Facility. This allows filtered supernate to be routed directly to the cesium ion-exchange process.
	SCIX[a]	SCIX units could be used to remove cesium from the waste stream.	Implementation could reduce the demand on the WTP PT Facility and increase throughput.
	Macroencapsulation	Macroencapsulation is the process of surrounding one substance with another.	This technology could be used to further package FBSR mineral product to ensure that the FBSR product meets Hanford IDF disposal standards.
	FBSR[a]	FBSR implements steam reforming reactions in a fluidized particle bed to produce a mineral waste form.	This technology could be deployed to provide all or part of the waste treatment function currently allocated to a second LAW facility. This process produces a dry granular material, which is an insoluble mineral that must be macroencapsulated to meet Hanford IDF disposal standards.

[a] Transformational technology

FBSR = fluidized bed steam reforming.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
PT = pretreatment.
RMF = rotary microfiltration.
SCIX = small-column ion exchange.
WTP = Waste Treatment and Immobilization Plant.

10.3.2 Planning Bases

The Case 3 planning bases are described in Appendix B, Section B5.0.

10.3.3 Results

Table 1-1 (Section 1.3) and Table 10-6 show the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 3 versus the Baseline Case.

Table 10-7. Mission Metrics Comparison for the Baseline Case and Case 3.

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 3: FBSR for supplemental treatment
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	$58.1 B
Meets near-term funding targets through 2015	$2,750M	$2,440 M	**$3,226 M**
Meets near-term funding profile through 2015	Note a	✓	**X**
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	9/16/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	11/4/2019
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	11/3/2038
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	12/2/2042
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	8/13/2041
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	8/7/2046
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	31,056
HLW glass canisters	–	10,586	10,284
HLW glass waste oxide loading	–	36.9%	37.8%
LAW glass mass (MTG)	–	527,838	152,045
LAW glass containers	–	95,825	27,602
LAW glass sodium oxide loading	–	17.8%	19.92%
Sodium reporting to LAW glass (MT)	–	69,659	22,474
FBSR product (MT)	–	–	620,099
Sodium reporting to FBSR product (MT)	–	–	46,380
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.

Key results for Case 3 are as follows.

- Case 3 meets all mission success criteria, with the exception of the near-term funding targets.
- The Case 3 supplemental pretreatment and treatment systems could be installed, commissioned, and begin hot operations approximately two years earlier than the WTP PT Facility, providing the opportunity to begin processing waste at an earlier date. This earlier waste treatment would have two benefits:
  - Provide an outlet for waste in the DST system, alleviating some of the waste storage space concerns that constrain SST waste retrievals in the period immediately preceding WTP operations.
  - Provide an output for excess pretreated LAW from the WTP PT Facility, alleviating the bottleneck of excess pretreated LAW in the WTP PT Facility nearly five years earlier than the Baseline Case.
- An FBSR system produces no secondary liquid waste during processing, thereby potentially reducing the projected amount of influent to the LERF/ETF, and thus possibly reducing the extra needed capacity in that facility.

Figure 10-14 shows a simple mass balance for sodium for Case 3. It should be noted that the amount of sodium shown going to the WTP LAW Facility represents the amount transferred to the WTP LAW Vitrification Facility as opposed to the sodium number given in Table 10-7 that reports the amount of sodium in the LAW glass. The sodium management of Case 3 could be further optimized to reduce the demand on the WTP PT Facility and improve utilization of the supplemental pretreatment system.

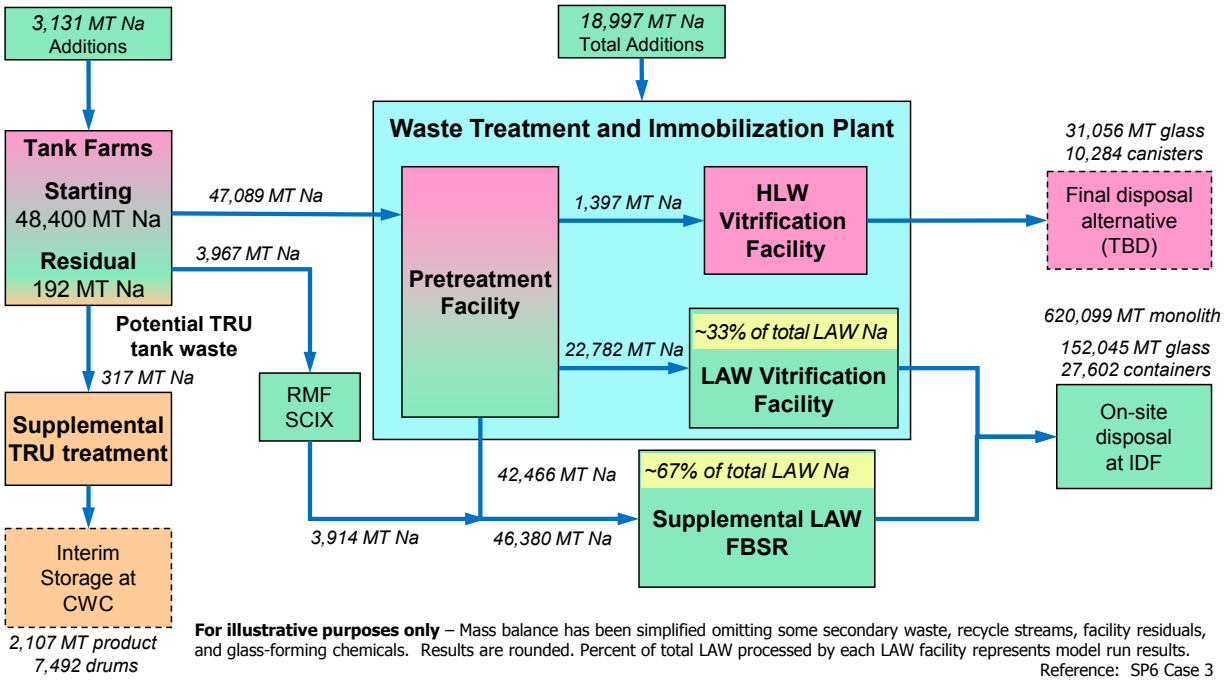

Figure 10-14. Simple Mass Balance for Case 3

Figure 10-15 is a comparative plot of the SST retrieval progress between the Baseline Case and Case 3. Early deviation from the baseline retrieval curve comes from increased available space in the DST system, allowing more SST waste volume to be retrieved sooner.

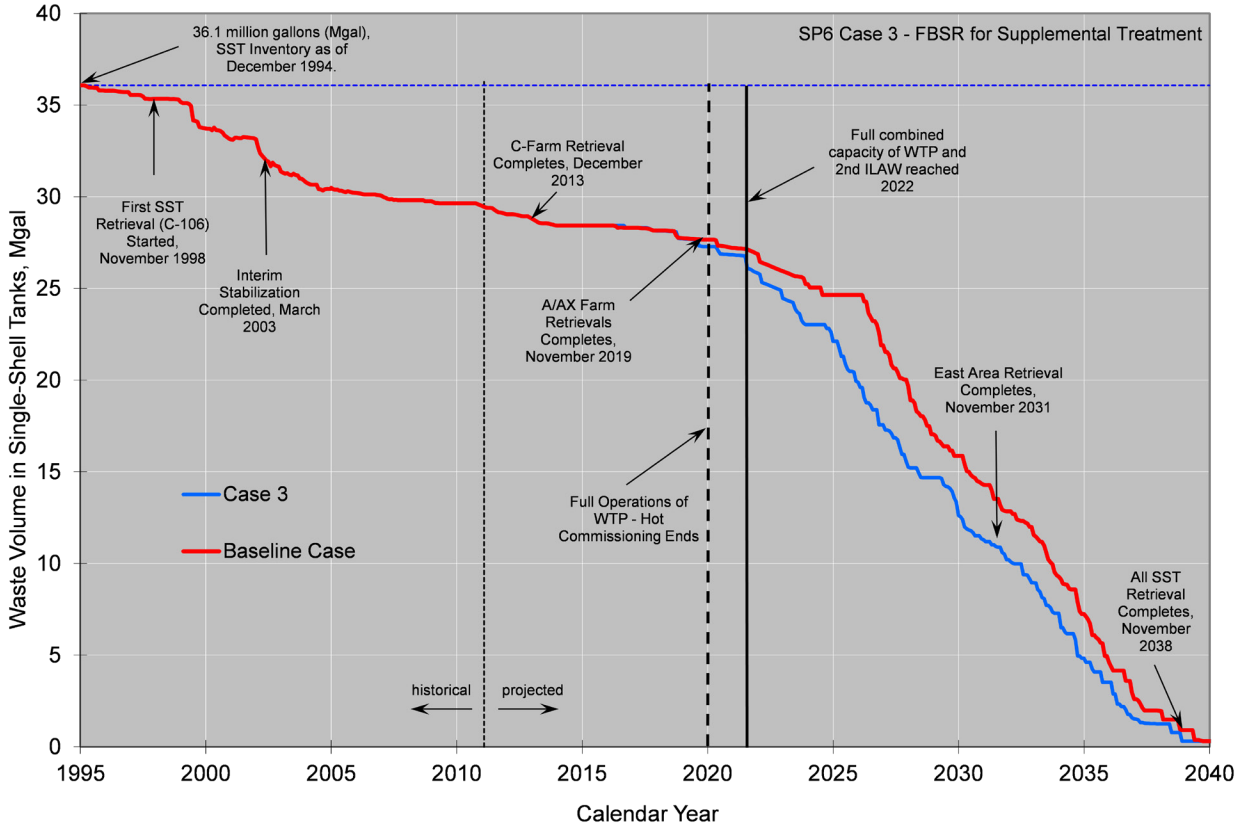

Figure 10-15. Overall Single-Shell Tank Retrieval Progress for Baseline Case and Case 3

Figure 10-16 shows the number of SST retrievals completed in each calendar year in Case 3, reaching a peak of 10 tanks per year in 2030 and 2031. The low point in 2028 is most likely caused by DST space limitations. This effect can be presupposed by comparing the available DST volume (Figure 10-20) immediately before that date, with SST retrieval progress (Figure 10-15) for the date of the low retrievals, to see that there are very few retrievals taking place during that date, and the DSTs have low available volume.

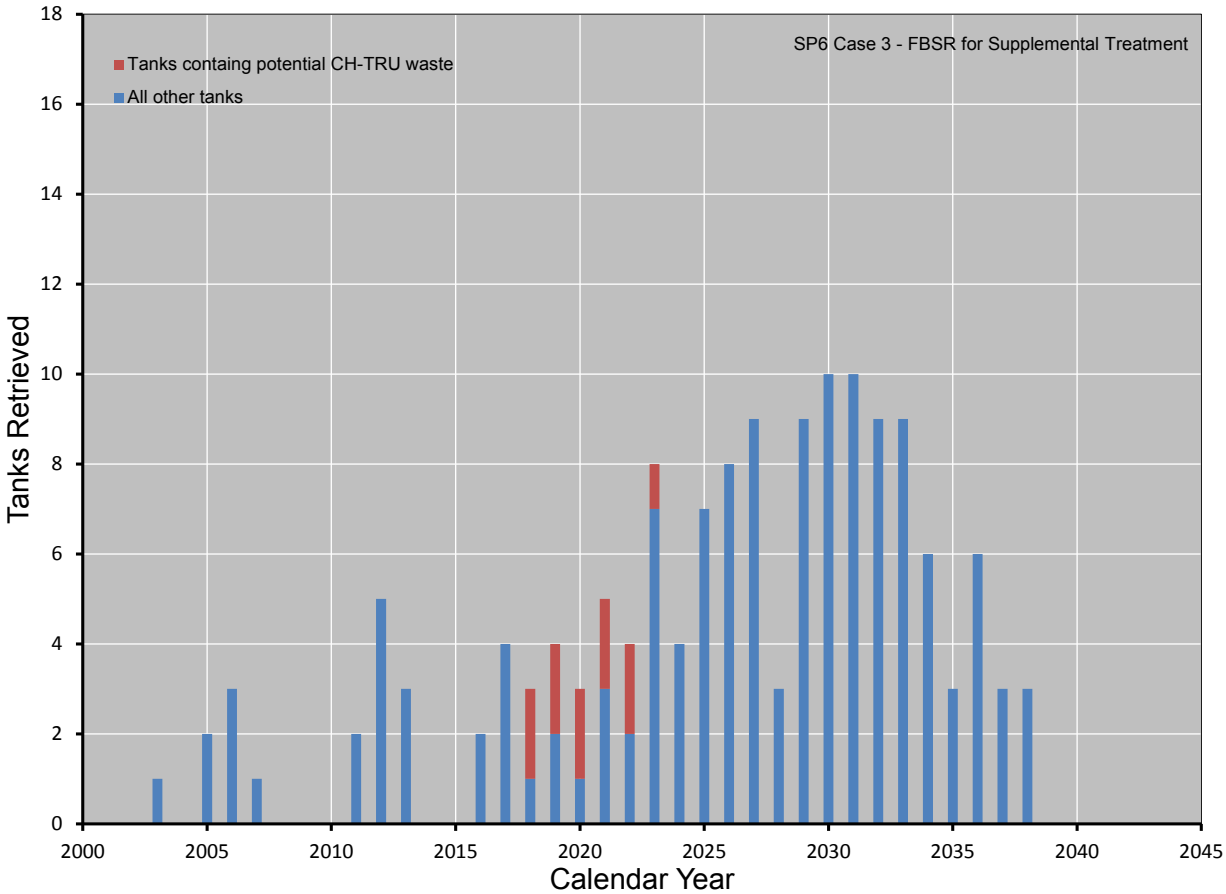

Figure 10-16. Single-Shell Tank Retrievals Completed Each Calendar Year for Case 3

Figure 10-17 compares the three-year moving average of the number of SSTs retrieved in a calendar year for the Baseline Case versus Case 3. The three-year moving average shows a sharp increase in SST retrievals during the 2020 - 2027 timeframe for Case 3 compared to the Baseline Case. This increase of SST retrievals allows the SSTs to complete nearly a year earlier than the Baseline Case.

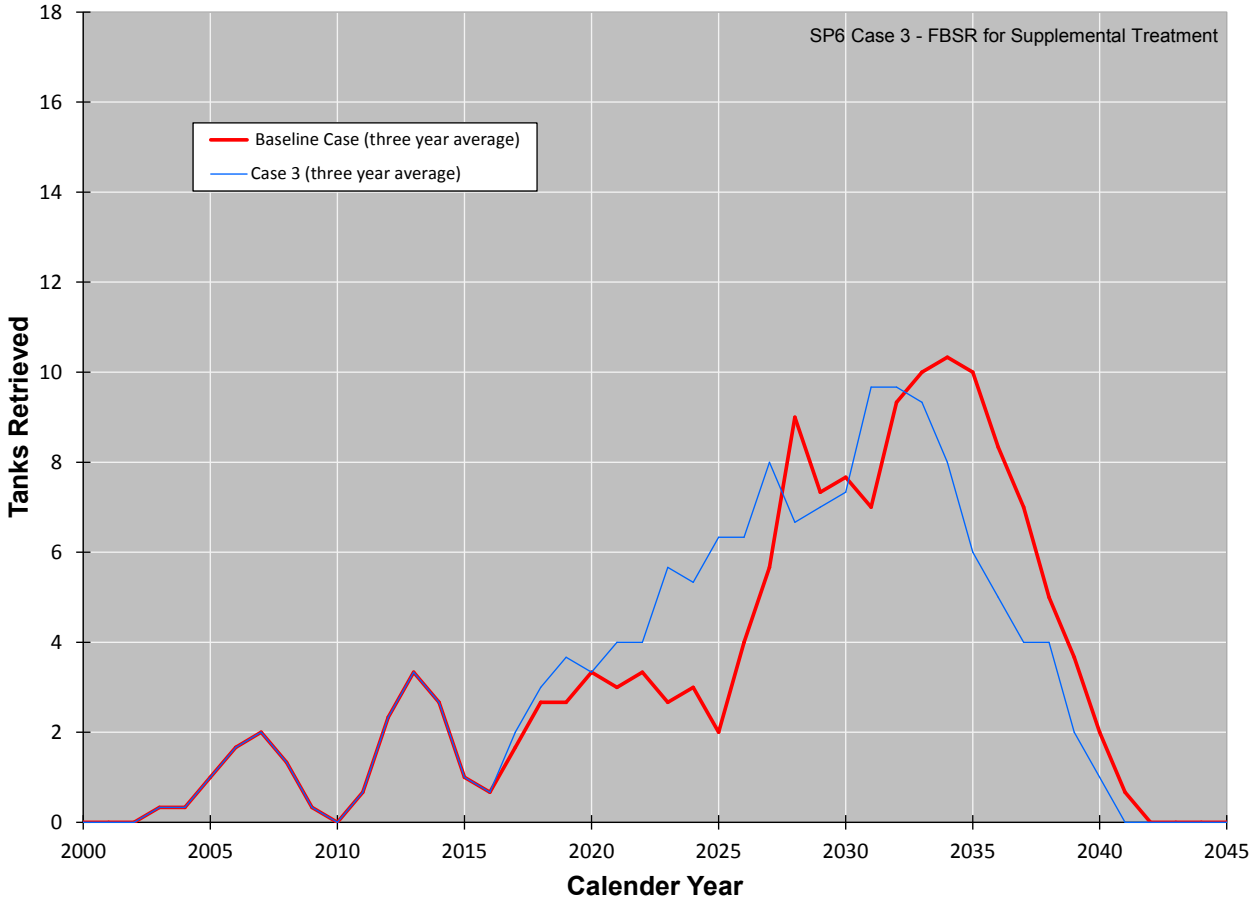

Figure 10-17. Three-Year Moving Averages of Single-Shell Tanks Retrieved Per Calendar Year for the Baseline Case and Case 3

Figure 10-18 and Figure 10-19 show the SST retrieval sequence. Figure 10-18 groups the retrievals by farm and Figure 10-19 shows the sequence on a tank-by-tank basis.

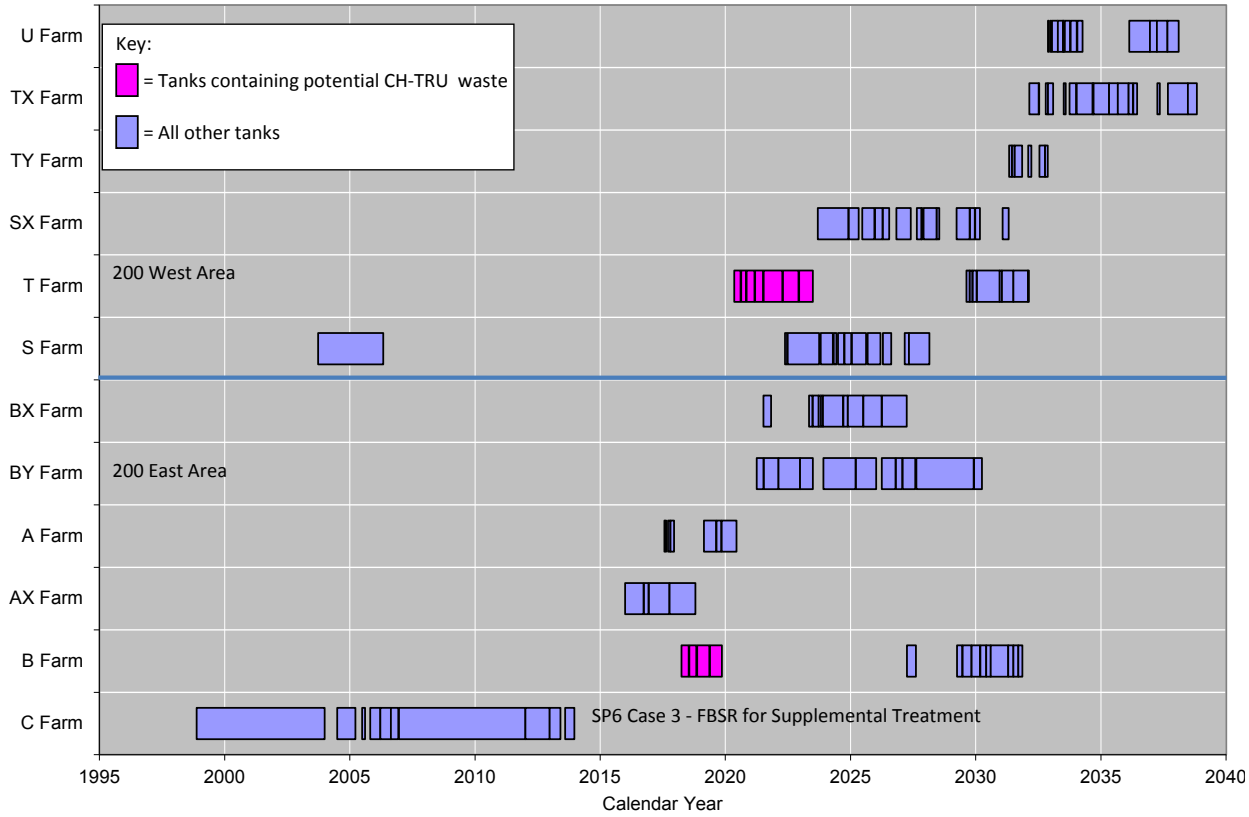

Figure 10-18. General Timing of Single-Shell Tank Retrievals by Tank Farm for Case 3

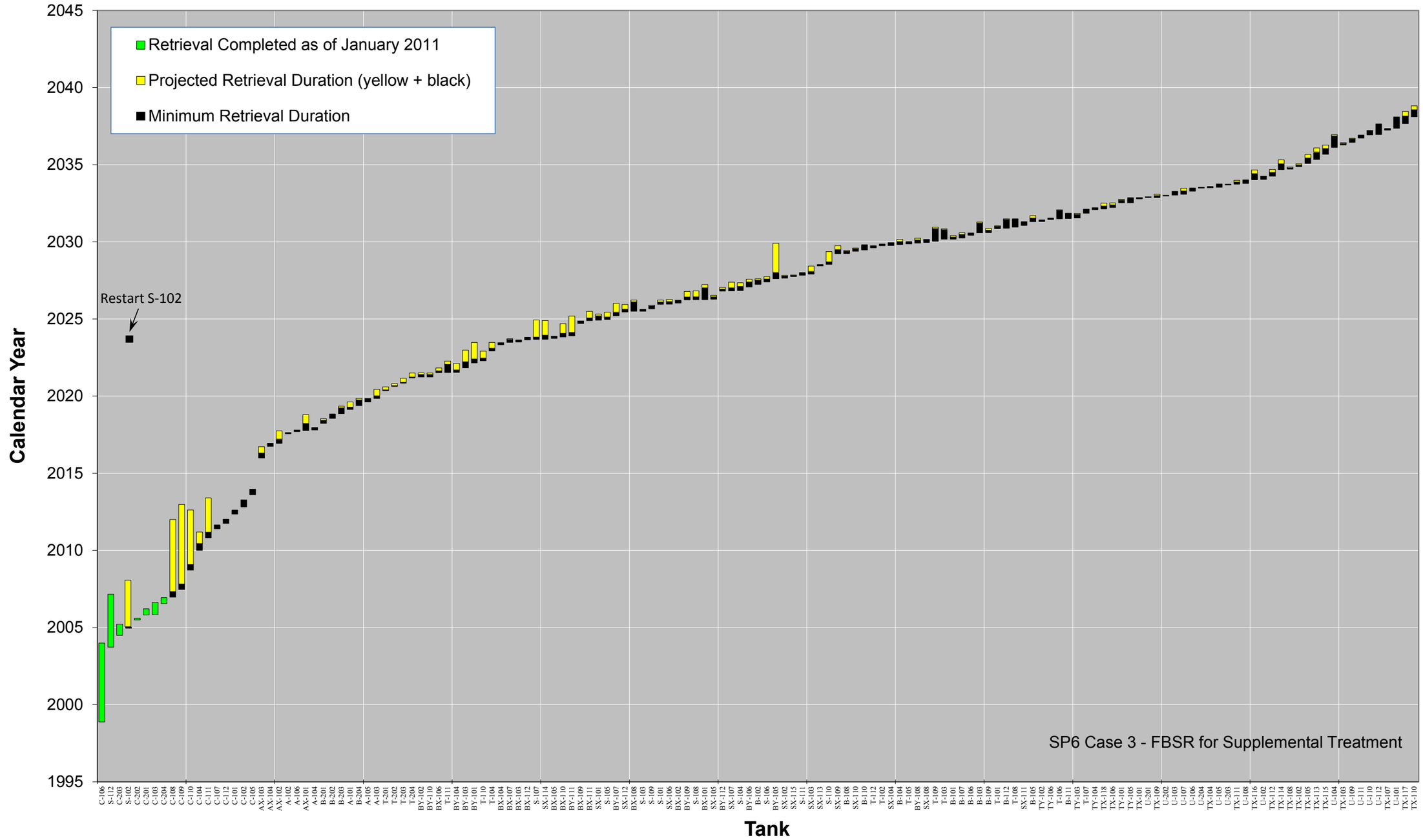

Figure 10-19. Single-Shell Tank Retrieval Sequence and Timing for Case 3

Figure 10-20 shows the use of DST storage space for Case 3. Early treatment of tank waste through the FBSR facilities allows more DST storage space to become available earlier in the mission. The space generated is used to facilitate earlier retrievals of SSTs.

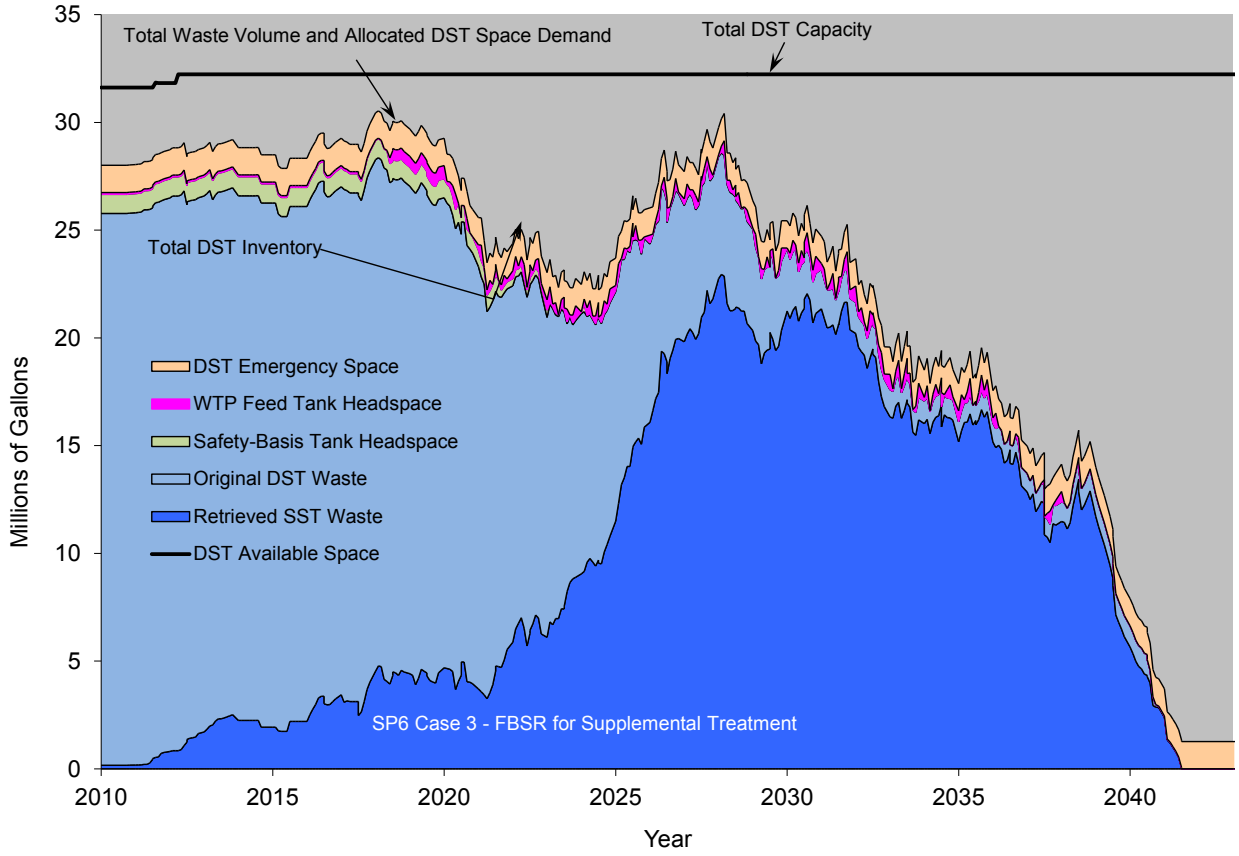

Figure 10-20. Use of the Double-Shell Tanks for Case 3

Figure 10-21 illustrates IHLW canister production for the Baseline Case and Case 3. There are two periods of significant differences between the two cases:

- During the first five years of the treatment mission, early availability of the supplemental LAW treatment in Case 3 allows the HLW Vitrification Facility to achieve and maintain its assumed capacity, whereas the Baseline Case production lags. By having supplemental treatment capacity available earlier, the WTP PT Facility is able to transfer excess pretreated LAW to the supplemental treatment facility, thereby allowing the PT Facility to process additional solids, instead of being limited by the amount of pretreated LAW feed backed up in the system.
- In the latter years of the treatment mission, 2036 - 2039, an artifact of the system modeling assumptions causes another deviation. The current assumptions state that retrieval of all the SSTs must be completed before cleanout of the DST heels can begin. In Case 3, more waste was processed more quickly, so the treatment of the waste overtook the retrieval of the waste from the SSTs, causing a shortage of feed delivered to WTP. There is an opportunity to improve the modeling assumptions to allow for the processing of DST heels before the SSTs have been completely retrieved.

Another period of interest is the time between 2024 and 2029 where production deviates from the assumed capacity. During this time, the production of HLW glass is limited by another, yet undetermined, factor. This limit appears to be in the Baseline Case but is overshadowed by the limitations imposed by the bottleneck of excess pretreated LAW in the WTP PT Facility.

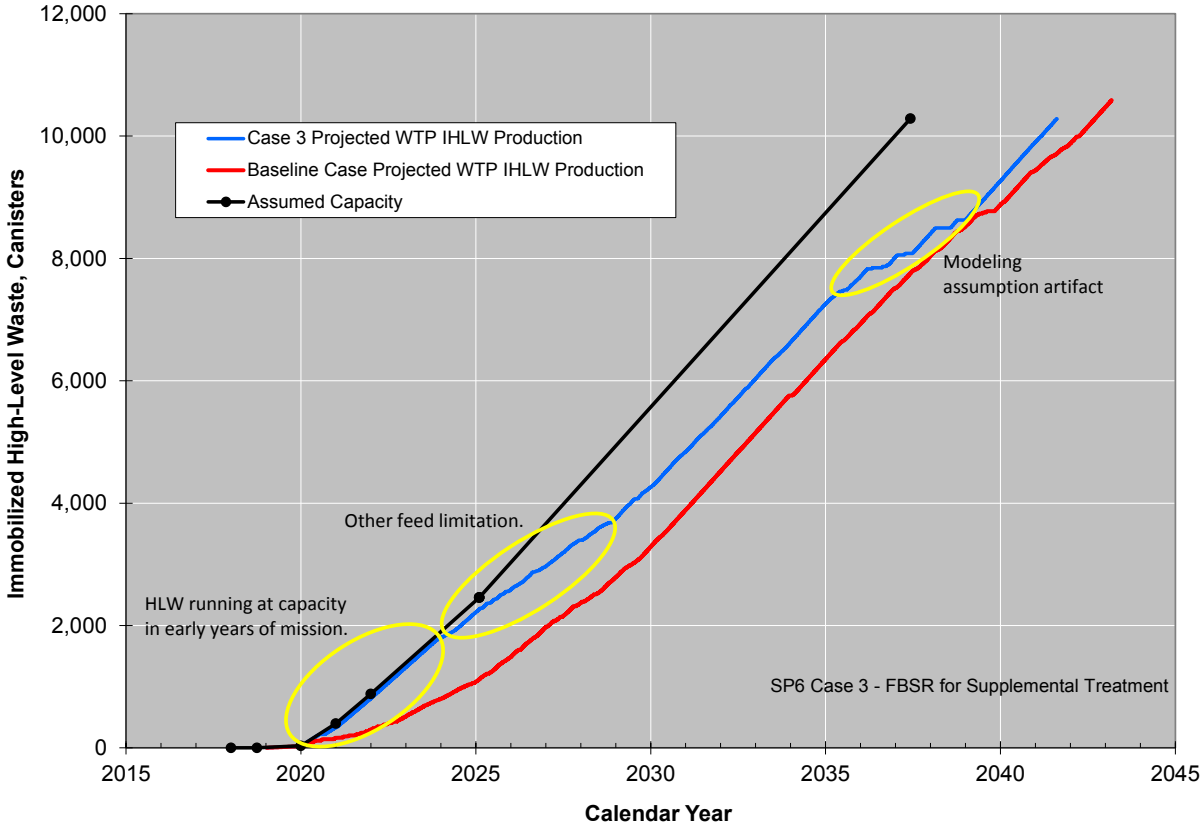

Figure 10-21. Projected Immobilized High-Level Waste Production for the Baseline Case and Case 3

Figure 10-22 shows the production of ILAW from the WTP LAW Vitrification Facility for Case 3. Its production is maintained at the assumed capacity for the majority of the mission, aside from the same assumption artifact as seen in the IHLW production. The production matches closely to the Baseline Case in capacity, but produces less glass overall.

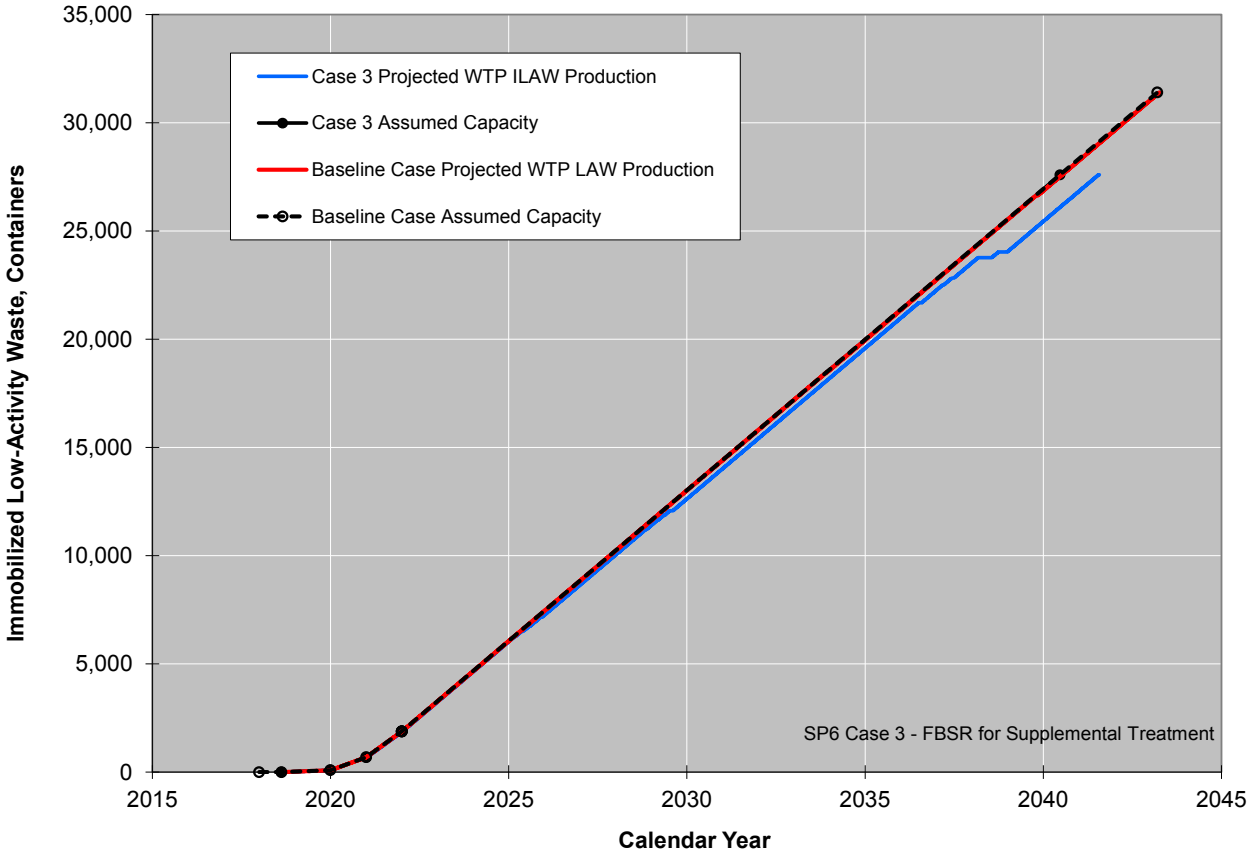

Figure 10-22. Waste Treatment and Immobilization Plant Immobilized Low-Activity Waste Production for Case 3

Figure 10-23 illustrates the projected ILAW production of glass of the Baseline Case second LAW facility compared to the ILAW production of monolith of the FBSRs in Case 3.[70] The mineralized steam reformer products were assumed to achieve a comparable sodium loading as LAW glass, approximately 14 wt% sodium. However, once the mineralized product is assumed immobilized in monolithic form, the sodium loading in the final product is reduced to approximately half of what is expected in LAW glass, approximately 7 wt% sodium. In Case 3, the FBSR processed only 5 percent more sodium than the Baseline Case, making the comparison of sodium between them reasonable. The monolithed FBSR product is also assumed to be less dense than LAW glass, resulting in a larger required volume to immobilize the same waste. When compared on a volume basis, the FBSR product is 2.4 times the volume of LAW glass for the same amount of sodium processed. For a comparison, if the FBSR product was packaged into the same volumetric spaces as an LAW container, the FBSR monolith product from Case 3 would fill 163,554 containers.

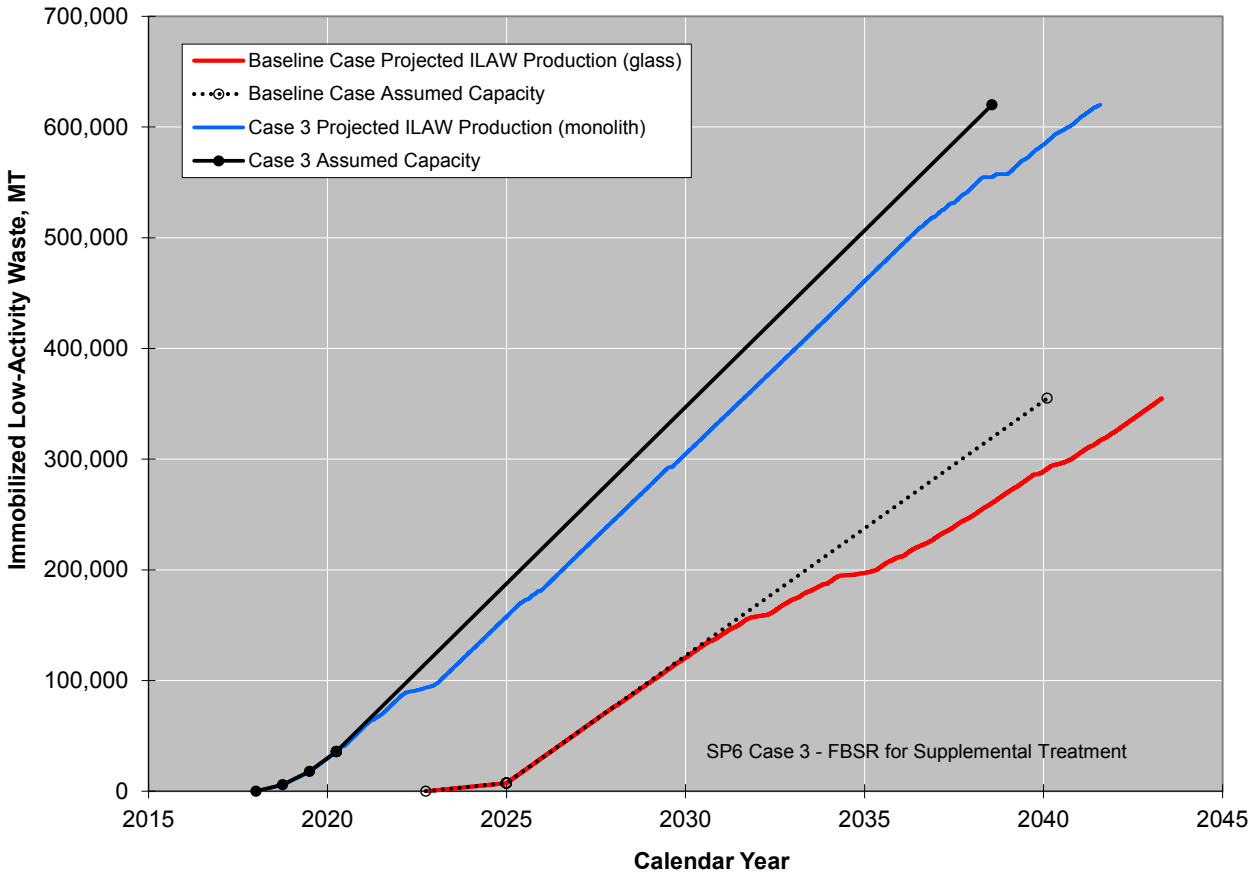

Figure 10-23. Supplemental Low Activity Waste Production Comparison for Case 3

[70] The final product of the supplemental LAW in Case 3 is reported in metric tons of immobilized mineralized steam reformer product in monolithic form, whereas in the Baseline Case, it is reported in containers of LAW glass. To make a direct comparison, the containers of LAW glass from the Baseline Case were converted to metric tons product.

In Case 3, the SST closure schedule is accelerated by approximately nine months relative to the Baseline Case because the use of fluidized bed steam reformers accelerates the completion of SST retrievals by about ten months. Closure program scope would be expanded to include four fluidized bed steam reformers and the RMF and SCIX units.

Table 10-8. Near-Term Funding Targets vs. Results for Case 3

Fiscal year	Target[a] ($M)	Case 3[a] ($M)
2011	410	414
2012	510	527
2013	510	564
2014	610	670
2015	710	1,051
Total	**2,750**	**3,226**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

10.3.4 Cost and Schedule Impacts

Table 10-8 and Figure 10-24 provide an overview of near-term funding and life-cycle costs for Case 3. This scenario provides a cost benefit of nearly $2 billion in savings and a schedule benefit of two years over the Baseline Case. The cost savings come from many of the operations ending a year to a year and a half early. Most notable among these is the early completion of treatment of all waste, saving close to $1 billion and resulting in a life-cycle cost[71] of $58.1 billion. Near-term, however, Case 3 exceeds all current funding targets through 2015 by $475 million. From 2012 to 2018, engineering, procurement, and construction of the FBSR facility and supplemental pretreatment modules require almost $1.4 billion over the baseline.

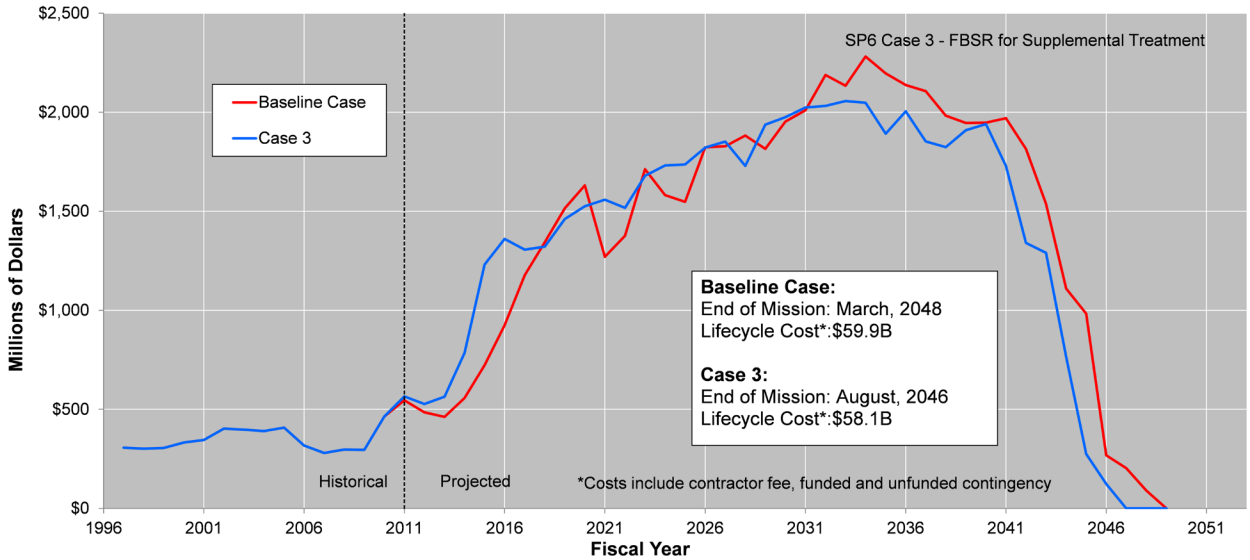

Figure 10-24. Life-Cycle Cost Comparison: Baseline Case and Case 3

[71] Includes contractor fee, funded and unfunded contingency.

10.3.5 Key Issues and Vulnerabilities

The schedule for installation of the FBSR facilities is a significant risk for Case 3, as is the technology development of the FBSR and the RMF/SCIX. All of the transformational technologies used in Case 3 are still in the technology development process; if the final processing specifications are different than what was assumed for Case 3, the outcome could be very different. However, Case 3 does provide possible mitigating action to the issue of DST space in the near-term, alleviating space issues by starting to process waste two years earlier than the Baseline Case.

All key issues identified for the Baseline Case also apply to Case 3, except as noted below.

The following issues from the Baseline Case are impacted by Case 3.

- Item 7.1-1 (DST space) is improved by the early treatment of tank waste.
- Item 7.5-1 (WTP startup and operations) is improved because of the early supplemental pretreatment and treatment provided in Case 3 that alleviates the bottleneck of excess pretreated LAW in the WTP PT Facility in the early years of operations.
- Item 7.8-3 (Supplemental LAW) is modified because of the selected amount of supplemental pretreatment and the technology used to provide the supplemental treatment.
- Item 7.8-10 (IDF operations) is negatively impacted by Case 3 because of the earlier start of the supplemental LAW facility and the increased volume of waste produced.

Case 3 introduces the following new issues and identifies potential mitigating actions or contingency measures.

- RMF, SCIX, FBSR, and other supporting technologies, such as macroencapsulation, are transformational technologies, which require additional development prior to proposed deployment and operation.
  - This issue may potentially be mitigated by accelerating work to progress the technologies to the needed technology readiness level (TRL) for deployment and operation.
- The ability for RMF and SCIX to provide a pretreated LAW stream that meets feed requirements has not been verified.
  - This issue may be mitigated by performing further tests with Hanford simulants.
- The ability for FBSR to produce a product that will meet all acceptance criteria for disposal has not been verified.
  - This issue may potentially be mitigated by completing work on the supporting technology of macroencapsulation and by performing further tests with Hanford simulants to ensure that all ILAW acceptance criteria are met.
- To achieve the early start date of January 1, 2018, for supplemental LAW, an acceleration of the CD process is required, along with a rapid waste form qualification process.
  - No potential mitigating actions are known at this time for this issue.

10.4 CASE 4 – WASTE TREATMENT AND IMMOBILIZATION PLANT DELAY WITH INCREASED VITRIFICATION CAPACITY

Selected by: Ecology

Purpose: Evaluate how well a 10 percent increase in overall vitrification capacity can offset all or part of the impacts from a uniform four-year delay in the startup of the WTP.

10.4.1 System Description

There are no physical differences between the Baseline Case and Case 4. All facilities are assumed to be the same, and all connections, equipment, and technologies are preserved. The only differences are related to schedule and vitrification capacity. In Case 4, the WTP startup and production ramp-up dates are each postponed by four years from the Baseline Case schedule (Table 10-9). This delay could be attributed to longer-than-anticipated duration of startup activities, such that events preceding and following plant startup retain their original projected durations.

Table 10-9. Case 4 Facility Start Dates.

Begin routine radiological operations at:	System Plan (Rev. 6)	
	Baseline Case date	Case 4 date
WTP PT Facility	5/15/2018	5/15/2022
WTP HLW Vitrification Facility	9/29/2018	9/29/2022
WTP LAW Vitrification Facility	8/18/2018	8/18/2022
Second LAW vitrification facility	10/1/2022	10/1/2026

HLW = high-level waste.
LAW = low-activity waste.
PT = pretreatment.
WTP = Waste Treatment and Immobilization Plant.

To compensate for the schedule delay, a 10 percent increase in vitrification capacity above the Baseline Case is uniformly projected across the WTP PT Facility, HLW Vitrification Facility, LAW Vitrification Facility, and second LAW vitrification facility. The 10 percent increased vitrification capacity for Case 4 results in the ramp rate schedule provided in Table 10-10.

Table 10-10. Case 4 Vitrification Ramp Rate Schedule.

Start date[a]	HLW Facility production rate[a] (MTG/d)	LAW Facility production rate[a] (MTG/d)	Second LAW Facility rate[a] (MTG/d)
8/18/2022	--	1.097	--
9/29/2022	0.24	1.097	--
12/31/2023	3.3	9.9	--
1/1/2025	4.4	19.8	--
1/1/2026	4.62	23.1	--
10/1/2026	4.62	23.1	9.9
1/1/2029	4.62	23.1	69.3
2/6/2029	5.775	23.1	69.3

[a] Start dates include projected 4-year WTP and second LAW facility startup delay. Rates are10% greater than the Baseline Case.

HLW = high-level waste.
LAW = low-activity waste.
MTG = metric ton of glass.

The increased capacity is assumed to be achievable with the existing melters and other WTP equipment and facilities. Therefore, Case 4 does not require any technology development activities, new equipment or facilities, or any modifications to existing systems.

10.4.2 Planning Bases

Case 4 planning bases are described in Appendix B, Section B6.0.

10.4.3 Results

Table 1-1 (Section 1.3) and Table 10-11 show the key mission metrics, including life-cycle cost, for the System Plan (Rev. 6) Baseline Case and Case 4. Key results for Case 4 are as follows.

- Case 4 meets all mission success criteria, except the following.
  - The life-cycle cost of Case 4 is $66.0 billion, which exceeds the success criteria of $61.5 billion.
  - Completion of nine additional SST retrievals was delayed by almost two years until July 17, 2024.
  - Completion of all SST retrievals was delayed by almost three years until August 14, 2043.
  - Closure of all SSTs was delayed by nearly four years until September 11, 2047.
- The 10 percent increase in vitrification capacity did not compensate for the four-year delay in WTP startup. Only one year of the mission length was recovered, resulting in Case 4 completing all tank waste treatment by March 27, 2046. This is three years later than the Baseline Case date of April 23, 2043, although it still meets the success criteria of December 31, 2047.
- Closure of all DSTs was also extended three years longer than the Baseline Case (February 17, 2051 versus March 18, 2048), but still met the success criteria of September 30, 2052.

Table 10-11. Mission Metrics Comparison for the Baseline Case and Case 4

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 4: WTP delay with increased vitrification
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	**$66.0 B**
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,314 M
Meets near-term funding profile through 2015	Note a	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	7/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	**7/17/2024**
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	**8/14/2043**
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	**9/11/2047**
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	3/27/2046
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	2/17/2051
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	31,512
HLW glass canisters	–	10,586	10,435
HLW glass waste oxide loading	–	36.9%	37.7%
LAW glass mass (MTG)	–	527,838	523,479
LAW glass containers	–	95,825	95,034
LAW glass sodium oxide loading	–	17.8%	17.9%
Sodium reporting to LAW glass (MT)	–	69,659	69,657
FBSR product (MT)	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

Figure 10-25 graphically depicts the nearly four-year delay in the Case 4 SST retrievals when compared to the Baseline Case. The four-year slip in the WTP startup causes an overall four-year shift in SST retrievals.

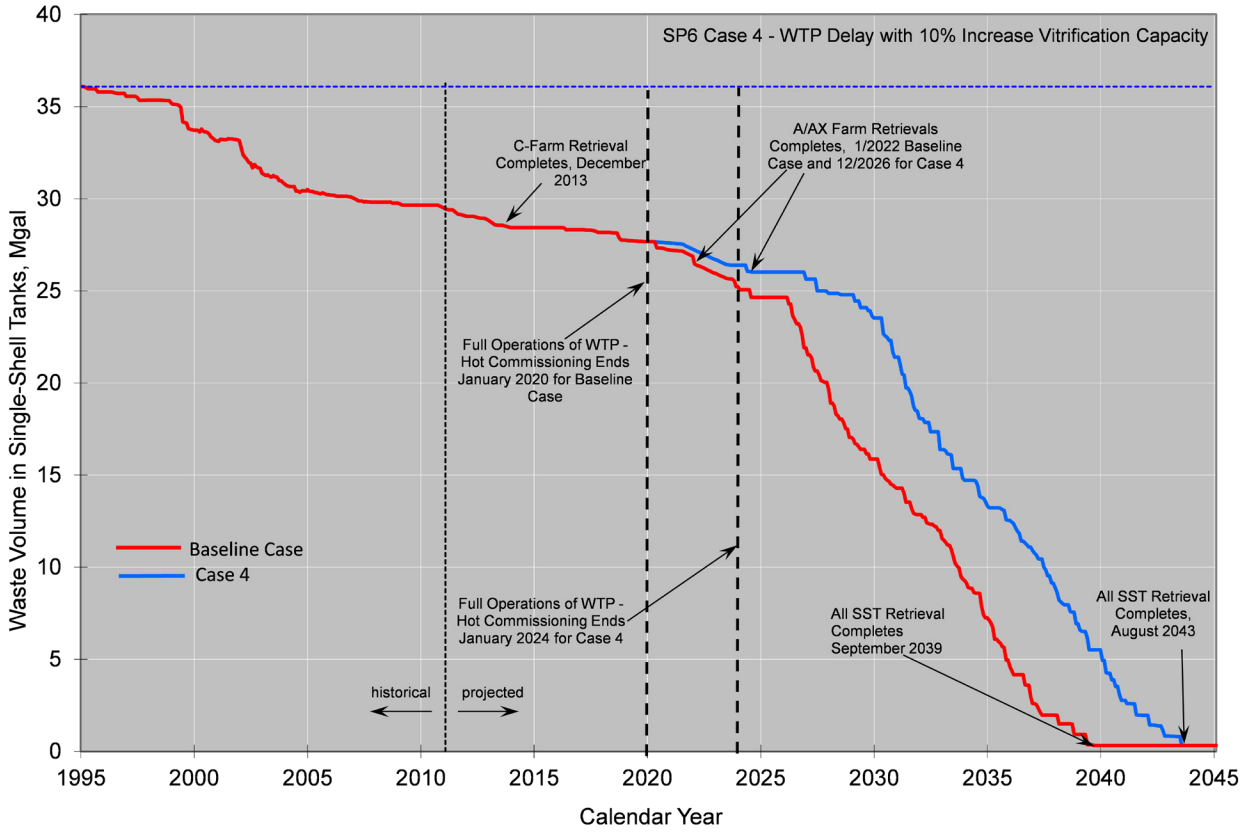

Figure 10-25. Single-Shell Tank Retrieval Progress for Baseline Case and Case 4

Figure 10-26 shows the yearly SST retrievals for Case 4. Figure 10-27, plotting a three-year moving average and comparing to the Baseline Case, shows fewer SST retrievals occurring during the 2020 - 2030 timeframe for Case 4 compared to the Baseline Case. Since waste treatment is delayed four years in Case 4, the time period in which DST space is limited is extended compared to the Baseline Case. This extension of limited DST space delays SST retrievals.

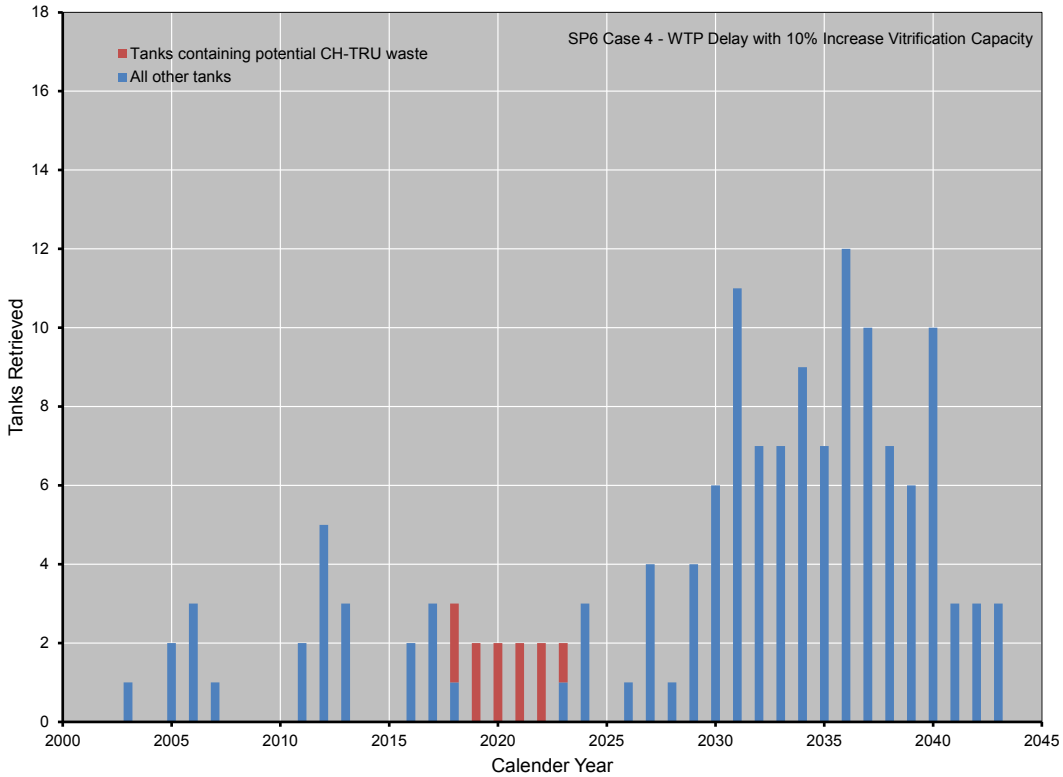

Figure 10-26. Single-Shell Tank Retrievals Completed Per Calendar Year for Case 4

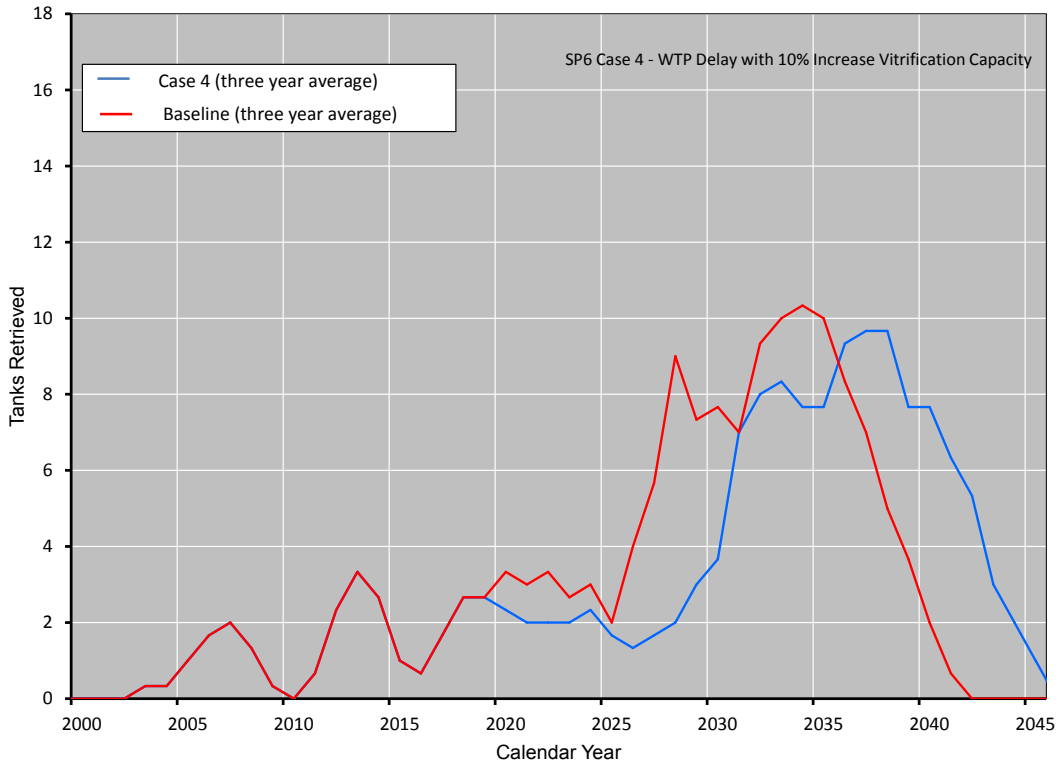

Figure 10-27. Three-Year Moving Average Single-Shell Tank Retrievals for the Baseline Case and Case 4

Figure 10-28 shows the timing of the SST retrievals by farm. Comparing Figure 10-28 for Case 4 to Figure 5-5 for the Baseline Case shows that both A Farm retrievals start in 2017. However, in Case 4, A Farm retrieval does not finish until December 2026, nearly five years later than the Baseline Case, in which A Farm retrieval is completed in January 2022. This causes a ripple effect, which delays the remaining SST retrieval end dates by an average of four years compared to the Baseline Case, as shown in Figure 10-27.

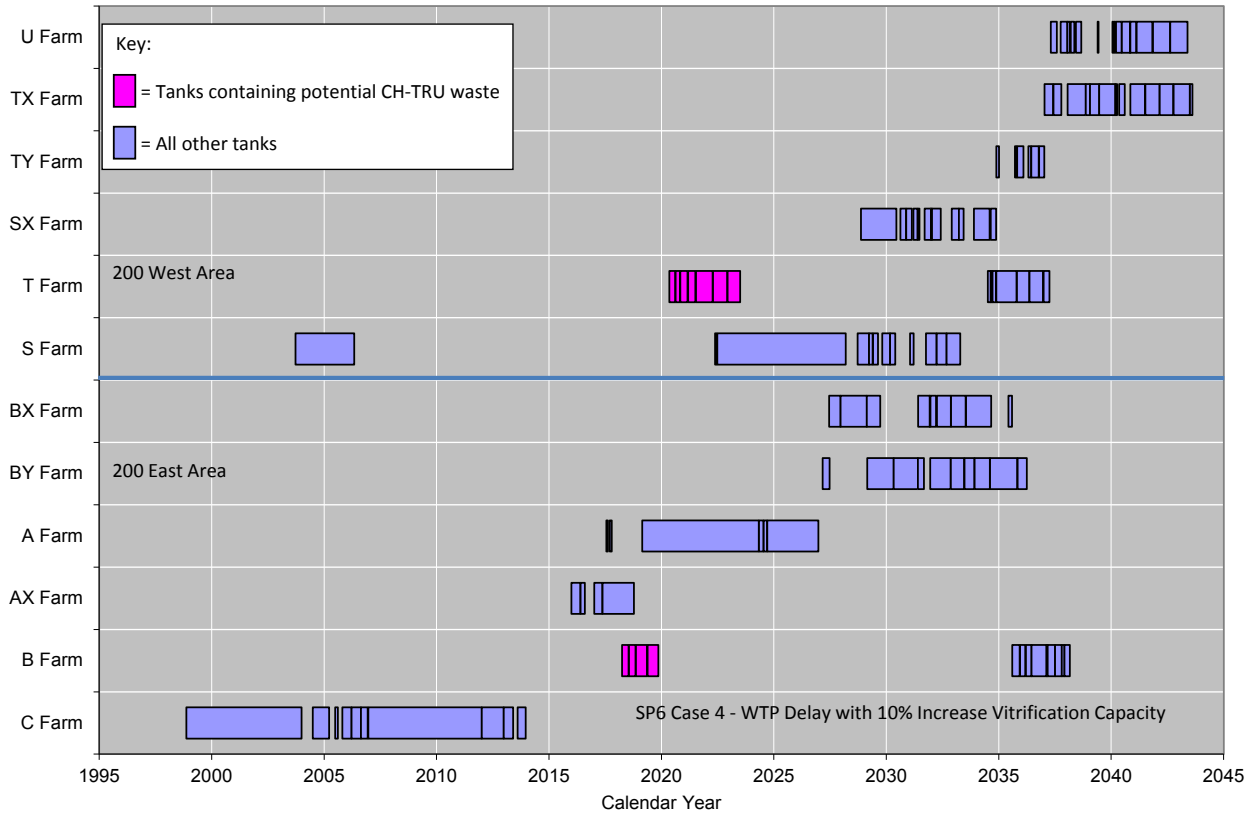

Figure 10-28. General Timing of Single-Shell Tank Retrievals by Tank Farm for Case 4

Figure 10-29 shows that in Case 4, the available DST space approaches the upper limit of total available DST space in the 2018 - 2025 time period, when compared to the Baseline Case, in which the critical period for available DST space is approximately four years shorter and does not approach as closely to the upper limit (Figure 5-7).

This is also depicted in Figure 10-30, which shows the available DST space for the Baseline Case and Case 4. This plot shows that Case 4 exasperates the duration and magnitude of the pinch time for DST availability in the 2018 – 2025 timeframe. The extended time and magnitude of restricted DST space in Case 4 causes delays in A Farm retrieval and an overall delay in SST retrievals when compared to the Baseline Case (Table 10-12).

Table 10-12. Comparison of Single-Shell Tank Farm Retrieval End Dates for the Baseline Case and Case 4

Tank farm	Farm retrieval end date		Delta (years)
	Baseline Case	Case 4	
C Farm	12/2013	12/2013	0.0
AX Farm	10/2018	10/2018	0.0
A Farm	1/2022	12/2026	4.9
BY Farm	9/2031	4/2036	4.6
BX Farm	2/2035	8/2035	0.5
B Farm	3/2035	3/2038	3.0
SX Farm	11/2030	11/2034	4.0
S Farm	7/2030	7/2034	4.0
T Farm	4/2033	4/2037	4.0
TY Farm	1/2033	1/2037	4.0
TX Farm	5/2039	8/2043	4.2
U Farm	9/2039	5/2043	3.7

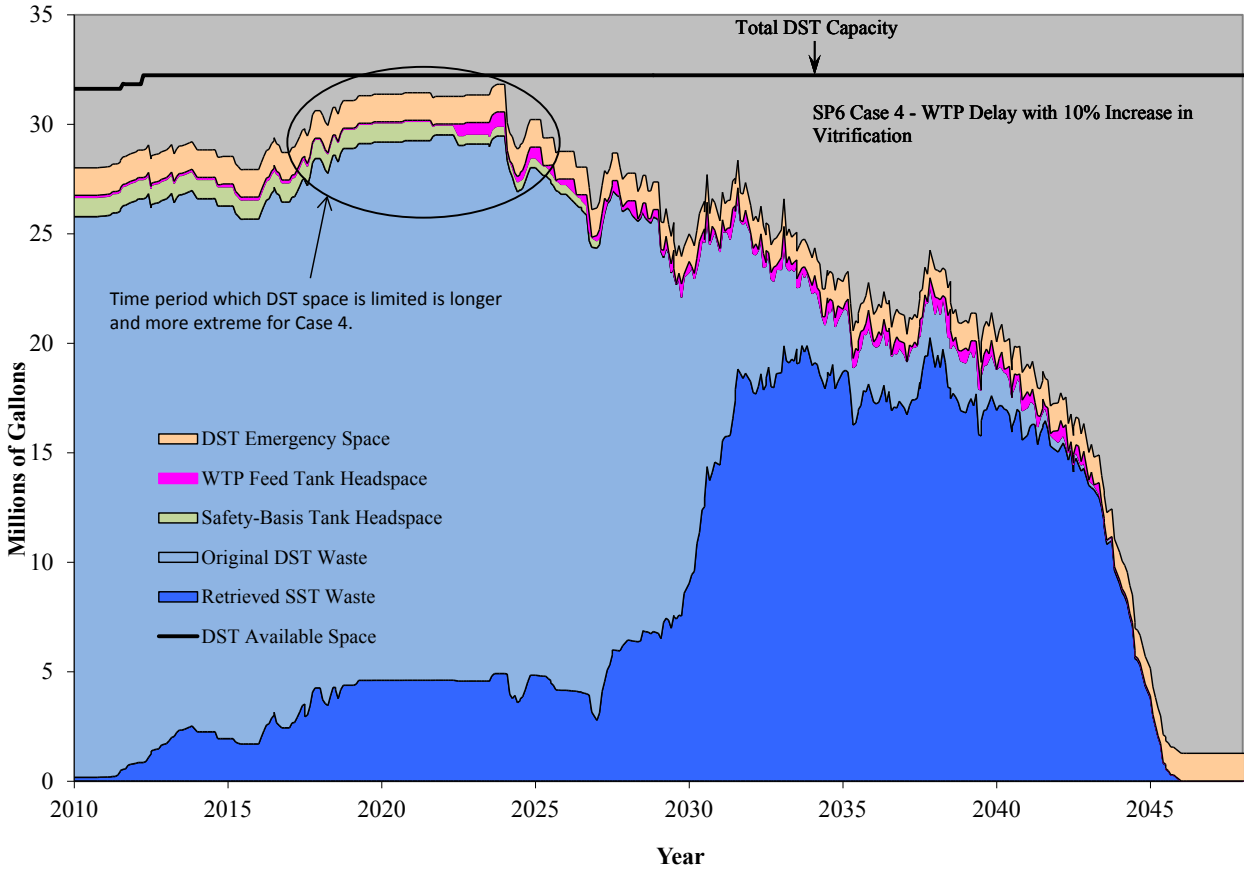

Figure 10-29. Use of Double-Shell Tanks for Case 4

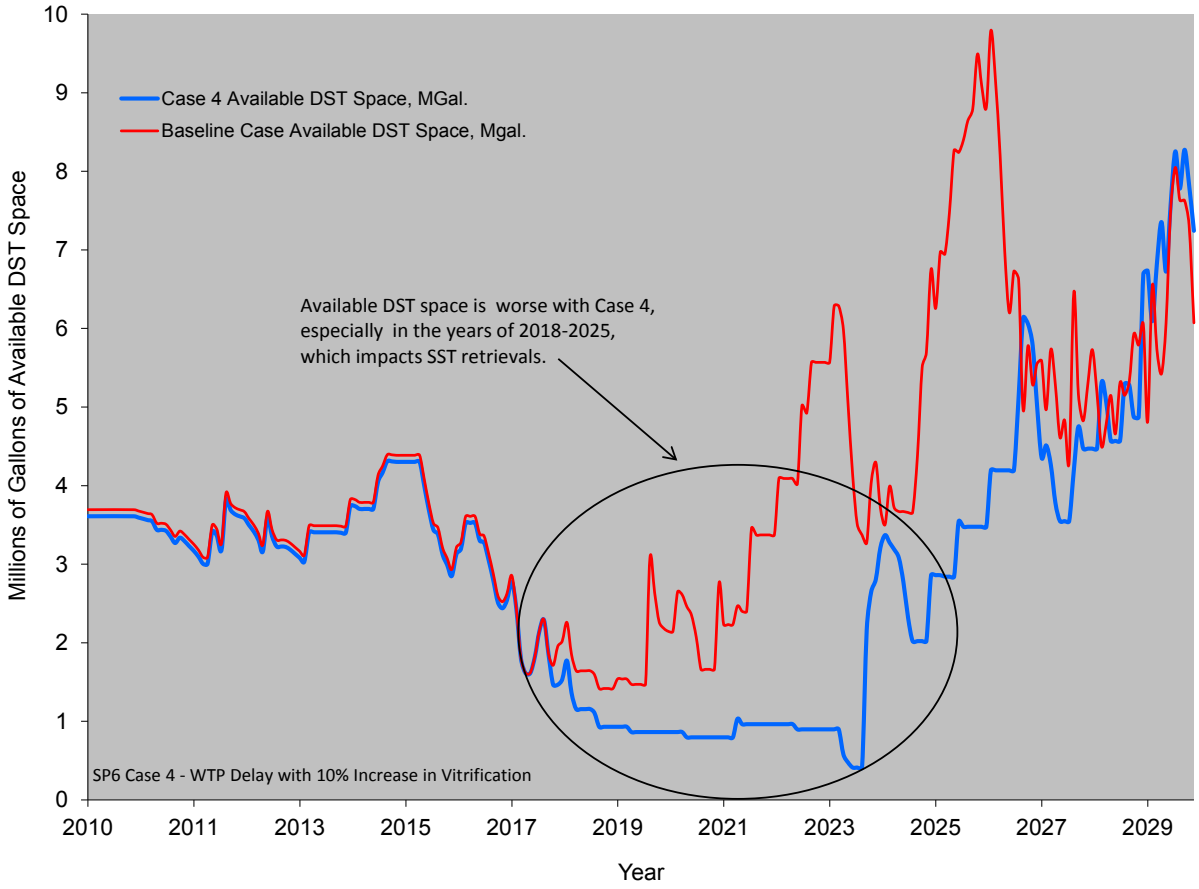

Figure 10-30. Double-Shell Tank Space Availability for the Baseline Case Versus Case 4

Figure 10-31 and Figure 10-32 show the production plots comparing Baseline Case and Case 4 IHLW and ILAW production, respectively. The assumed four-year delay causes the Case 4 plots to shift out four years, but the slopes of the production plot curves for Case 4 are nearly the same as for the Baseline Case. This indicates that the 10 percent increase in capacity doesn't substantially improve the overall production. The model results suggest that other system restrictions could be impacting production; WTP may be pretreatment limited, and/or there may be times when staged feed to WTP is not available.

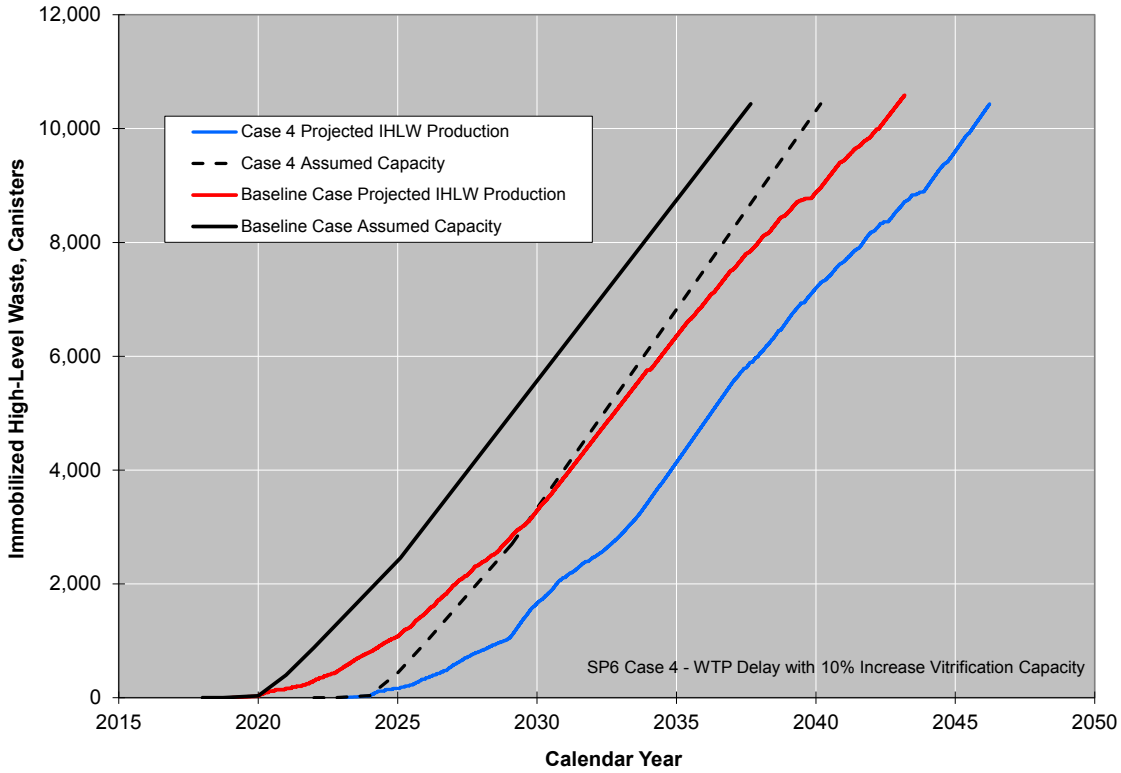

Figure 10-31. Projected Immobilized High-Level Waste Production for the Baseline Case and Case 4

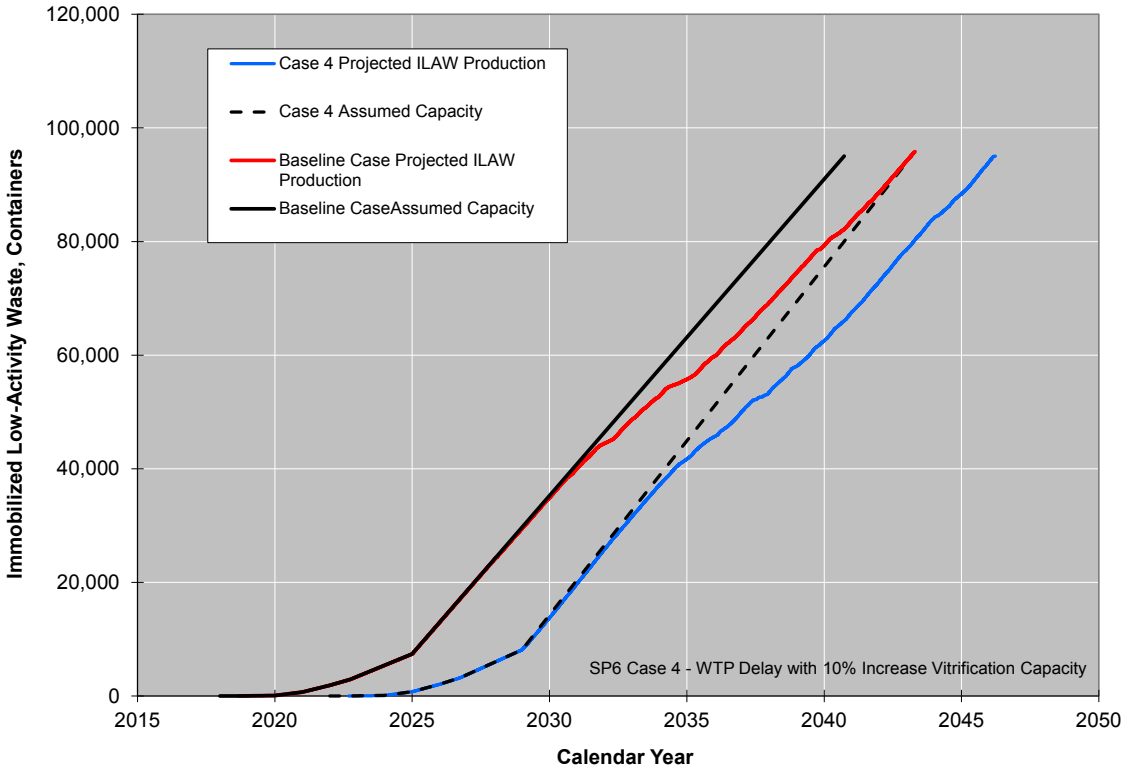

Figure 10-32. Projected Immobilized Low-Activity Waste Production for the Baseline Case and Case 4

Figure 10-33 shows the interim HLW storage and shipping projections for Case 4, which can be compared to the Baseline Case (Figure 5-15). The results for both cases are similar, except the dates are shifted out by four years.

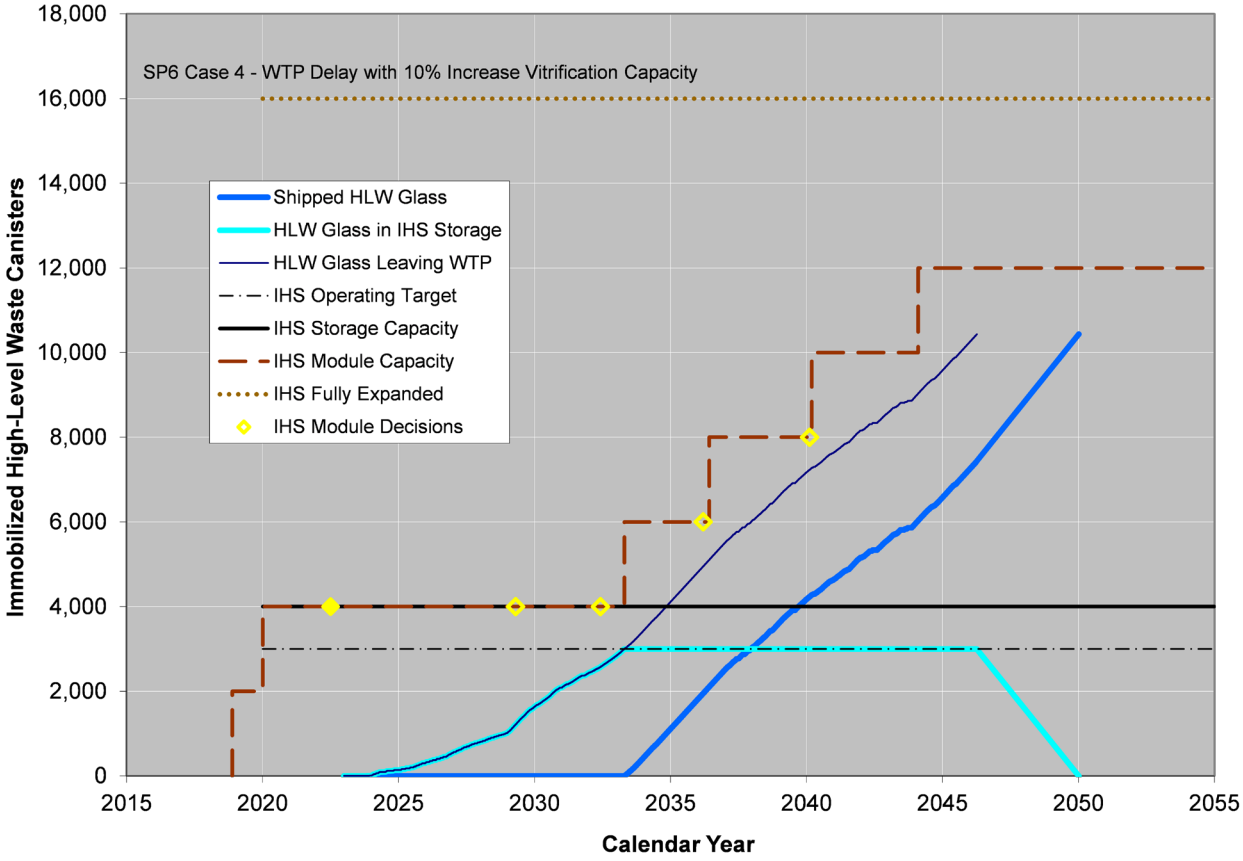

Figure 10-33. Interim High-Level Waste Storage and Shipping Projections for Case 4

In Case 4, the SST closure schedule is delayed by approximately four years relative to the Baseline Case, as the four-year delay in WTP processing causes a four-year delay in the completion of SST retrievals.

10.4.4 Cost and Schedule Impacts

Delaying the startup of the WTP by four years results in a significant increase in the life-cycle cost and extends the mission. Table 10-13 lists the near-term funding targets and Case 4 results for 2011 - 2015. The life-cycle cost profile for Case 4 is provided in Figure 10-34.

Case 4 has a four-year schedule slip in the near-term for WTP startup. This results in the SST retrievals and closures being delayed by approximately four years. DST closures are completed approximately three years later than the Baseline Case. The assumed 10 percent increase in vitrification capacity recovers one year of schedule, reducing the overall mission impact from four years to three years.

Table 10-13. Near-Term Funding Targets versus Results for Case 4

Fiscal year	Target[a] ($M)	Case 4[a] ($M)
2011	410	387
2012	510	479
2013	510	441
2014	610	451
2015	710	556
Total	**2,750**	**2,314**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

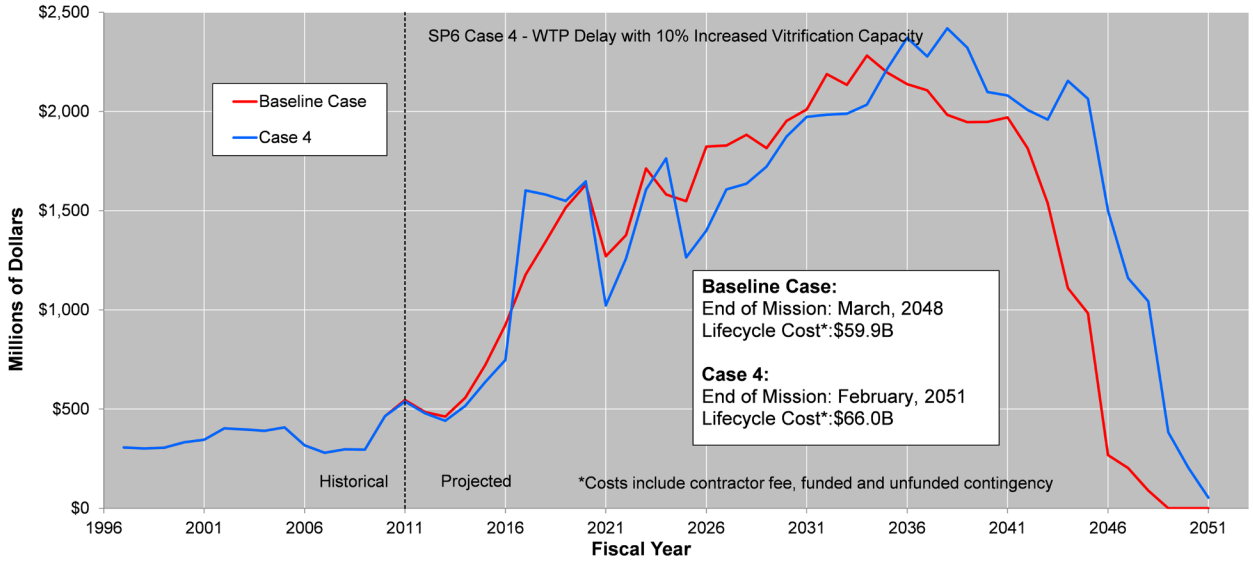

Figure 10-34. Life-Cycle Cost Profile for Case 4

The projected life-cycle cost for Case 4 is $66.0 billion, which is about 10 percent higher than the Baseline Case. The HTWOS results for Case 4 showed that the 10 percent increase in vitrification capacity could only mitigate about one year of a four-year delay in the startup of WTP, meaning the Case 4 mission end date is about three years later than the Baseline Case. Delaying the startup of the WTP impacts the SST retrieval schedule, causing closures to complete nearly four years later than the Baseline Case. Approximately half of the nearly $6 billion worth of additional escalated costs for Case 4 are from WTP waste treatment. The rest of the additional costs are distributed through base operations, WFD, and DST retrieval and closure.

The estimated $600 million added per year to cover additional costs for each of the four years delayed can be seen on the profile between the years 2017 and 2020. In the Baseline Case, costs ramp-up during those years for construction of a second LAW vitrification facility and startup activities for the WTP. Case 4 delays those costs by four years, so a spike similar to the 2017 - 2020 Baseline Case one is seen starting in 2021 for Case 4. The second, smaller cost peak in the Baseline Case profile is from SST retrievals and closures in that particular year. Because SST retrievals were impacted by the WTP delay, that peak is not seen for Case 4. The two profiles show nearly the same trends for the final years of the mission; however for Case 4, the costs are shifted out in time and incur more escalation.

10.4.5 Key Issues and Vulnerabilities

All key issues identified for the Baseline Case (Section 7.0) also apply to Case 4, except as noted below.

The following issues from the Baseline Case are impacted by Case 4.

- Item 7.1-1 (DST space) is negatively impacted by the four-year delay in WTP and second LAW facility startup.
- Item 7.5-1 (WTP startup and operations) is modified because the WTP startup is delayed by four years as part of the Case 4 assumptions. The key issues and uncertainties related to this assumption are the same as for the Baseline Case (except for the shift in startup dates).
- Item 7.8-3 (Supplemental LAW facility) is modified because the startup date is delayed four years. The key issues and uncertainties related to this assumption are the same as for the Baseline Case (except for the shift in startup dates).

Case 4 introduces the following new issues and identifies potential mitigating actions or contingency measures.

- The 10 percent additional vitrification capacity may not be achievable if the feed to the HLW melters is limited by tank farms feed delivery or by pretreatment throughput.
  - This issue may be mitigated by continuing to monitor WTP design capacities and predicted availabilities.
  - This issue may also be mitigated by improving and refining the WFD plans and SST retrieval plans.
- The 10 percent additional vitrification capacity may exceed the mechanical handling capabilities of the HLW Vitrification Facility.
  - This issue may be mitigated by exploring methods other than increasing the glass production rate to increase the waste throughput of the facility (e.g., higher WOLs).

10.5 CASE 5 – 2020 VISION ONE SYSTEM

Selected by: ORP

Purpose: Show the impacts and effects of phased turnover of the WTP facilities.

10.5.1 System Description

The Case 5 scenario is projected to accomplish three objectives:

1. Begin making LAW glass in 2016 (compared to 2018 in the Baseline Case)
2. Implement faster ramp-ups of the WTP LAW and HLW Vitrification Facilities
3. Meet Consent Decree milestone A-1, "Achieve initial plant operations for the Waste Treatment Plant,"[72] by December 31, 2022.

Meeting these objectives involves using supplemental pretreatment in the form of RMF and SCIX to prepare waste for delivery directly to the LAW Vitrification Facility before the WTP PT Facility becomes operational. The goal during early operation of the LAW Vitrification Facility is to produce one LAW glass package (5.51 MTG) per day using one melter, until the permanent WFD pathway is completed through the PT Facility. All secondary liquid waste generated during the 2016 LAW glass production will be routed back to the tank farms until the required ETF upgrades[73] are completed. Once the PT Facility becomes operational, supplemental pretreatment will end and the LAW Vitrification Facility will receive feed solely from the PT Facility.

The supplemental pretreatment system consists of installing an RMF in a riser of DST AP-105 and two SCIX columns in separate risers of DST AP-107. These technologies are currently being developed and are summarized in Table 10-14. The RMF unit removes suspended solids from the feed stream and discharges the solids into Tank AP-105. The clarified feed is then transferred to the SCIX columns in Tank AP-107 to remove cesium. The resulting LAW-compliant pretreated waste stream is transferred to one of three existing 15,000-gal staging tanks (available from the discontinued demonstration bulk vitrification project)[74] before feed delivery to the LAW Vitrification Facility. The high-cesium eluate stream (from elution of the IX resin) is conditioned/neutralized using existing high pH/OH waste in Tank AP-107. Additional chemicals may be added so that waste in Tank AP-107 remains below tank corrosion limits when the high-cesium eluate stream is added to the Tank AP-107 contents.

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[72] Initial plant operations is defined by the Consent Decree as "over a rolling period of at least three months leading to the milestone date, operating the WTP to produce high-level waste glass at an average rate of at least 4.2 metric tons of glass (MTG)/day, and low-activity waste glass at an average rate of at least 21 MTG/day."

[73] The secondary liquid waste treatment project is currently evaluating potential alternatives for accepting and handling +secondary liquid waste. For planning purposes in Case 5, it is assumed that whichever alternative is chosen will be available to accept and handle secondary liquid waste when the WTP PT Facility begins operations.

[74] This is an enabling assumption (Appendix B, Assumption B7.3.4.1). The 2020 Vision One System proposal (submitted to DOE on March 21, 2011) revised this assumption to procure new staging tanks based on the existing design and to mitigate potential waste compatibility issues by reuse of existing tanks from the bulk vitrification program.

Table 10-14. Technology Requirements for Case 5

Functional area	Technology	Technology description	Potential application
Supple-mental treatment	At-tank RMF[a]	RMF removes solids from the waste streams.	Rotary microfilters assumed to be deployed inside or near waste tanks to supplement the WTP PT Facility. This allows filtered supernate to be routed directly to the cesium ion-exchange process.
	SCIX[a]	SCIX units remove cesium from the waste stream.	Implementation assumed to reduce the demand on the WTP PT Facility and increase throughput.

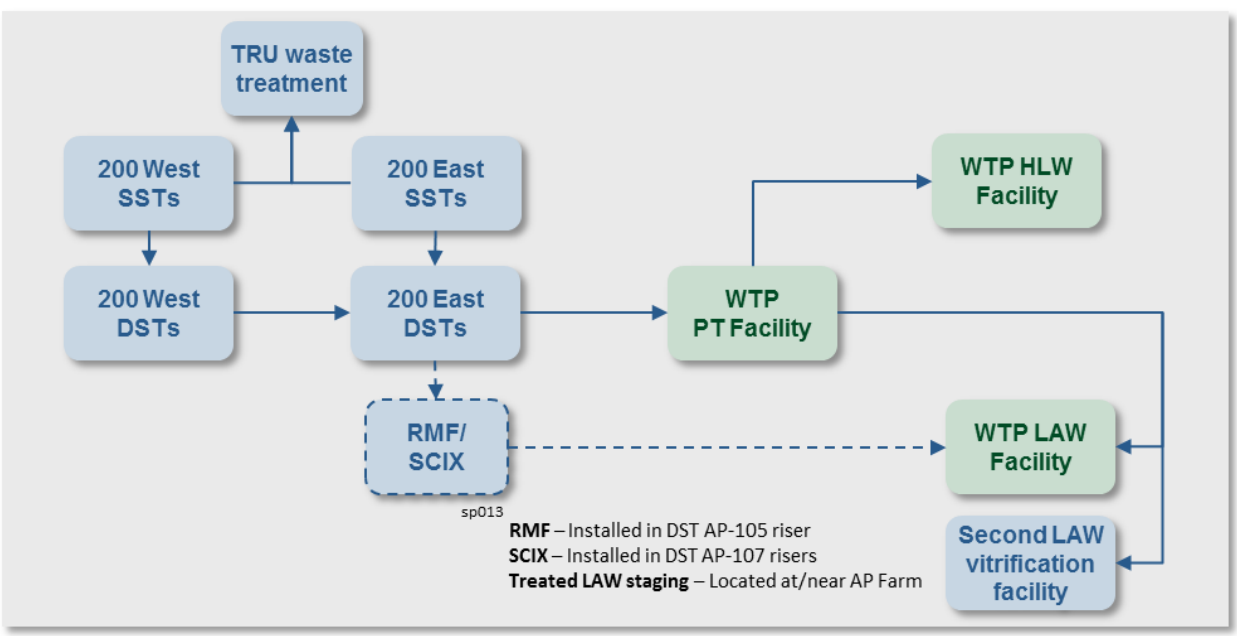
[a] Transformational technology

PT = pretreatment.
RMF = rotary microfiltration.
SCIX = small-column ion exchange.
WTP = Waste Treatment and Immobilization Plant.

Pretreated feed will be delivered directly to the LAW Vitrification Facility using a hose-in-hose transfer line. Secondary liquid waste generated from the WTP LAW off-gas system will be returned to the tank farms (compliant with existing tank farm acceptance criteria) via a hose-in-hose transfer line and concentrated using the 242-A Evaporator until the ETF has been upgraded to accept such secondary waste. The SST retrieval sequence is the same as the Baseline Case, with C Farm being followed by A and AX Farms.

Implementing faster ramp-ups of the WTP LAW and HLW Vitrification Facilities involves shortening the duration between ramp steps to achieve the final glass production rate sooner than the Baseline Case.

Meeting the third objective for Case 5 involves careful balancing of waste feed to WTP to ensure that both the LAW and HLW Vitrification Facilities consistently receive feed such that they may both operate at their full capacity. A simplified flowsheet for Case 5 is provided in Figure 10-35.



Dashed lines represent additional components/configuration for 2020 Vision One System scenario.

Figure 10-35. Simplified Flowsheet for Case 5

10.5.2 Planning Bases

The Case 5 planning bases are described in Appendix B, Section B7.0 (see also Table 1-2).

10.5.3 Results

Table 1-1 (Section 1.3) and Table 10-15 show the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 5 versus the Baseline Case.

Key results for Case 5 are as follows:

- Case 5 meets all mission success criteria, except:
  - Near-term funding targets
  - The milestone to "Start five additional SST retrievals after C Farm retrievals are complete" was delayed more than nine months until September 9, 2018. Four of the five retrievals begin as required, but the fifth tank was delayed for lack of DST space at the time. (Section 10.5.3.2 provides further explanation.)
- All other success criteria dates for Case 5 were met and were completed earlier than the Baseline Case.
- Despite a 13.5-month outage in HLW production caused by DST space constraints, all tank waste in Case 5 was treated approximately 20 months earlier than in the Baseline Case.
- Case-specific criteria to attain WTP initial plant operations[72] by December 31, 2022, were achieved. This was accomplished in part by delivering only slurry batched to the WTP through 2024 and storing pretreated supernate within tank space in the WTP PT Facility.

Table 10-15. Mission Metrics Comparison for the Baseline Case and Case 5

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 5: 2020 Vision One System
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	$58.0 B
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,705 M
Meets near-term funding profile through 2015	Note a	✓	✶
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	**9/9/2018**
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	4/21/2020
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	9/14/2038
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	10/9/2042
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	8/26/2041
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	7/30/2046
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	30,721
HLW glass canisters	–	10,586	10,173
HLW glass waste oxide loading	–	36.9%	38.4%
LAW glass mass (MTG)	–	527,838	520,966
LAW glass containers	–	95,825	94,577
LAW glass sodium oxide loading	–	17.8%	18.0%
Sodium reporting to LAW glass (MT)	–	69,659	69,689
FBSR product (MT)	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.

10.5.3.1 Single-Shell Tank Retrievals

SST retrievals are completed one year earlier in Case 5 compared to the Baseline Case, as shown in Figure 10-36. SST retrievals for both cases are identical until 2016, at which point interim pretreatment and early LAW production begin. SST retrieval progress decreases in Case 5 between 2016 and 2019 due to limited availability of DST space (Section 10.5.3.2 provides further explanation). In 2025, SST retrievals gradually increase and surpass the progress of the Baseline Case by 2026 due to increased waste processing of both HLW and LAW (Figure 10-41 and Figure 10-42, respectively, in Section 10.5.3.3).

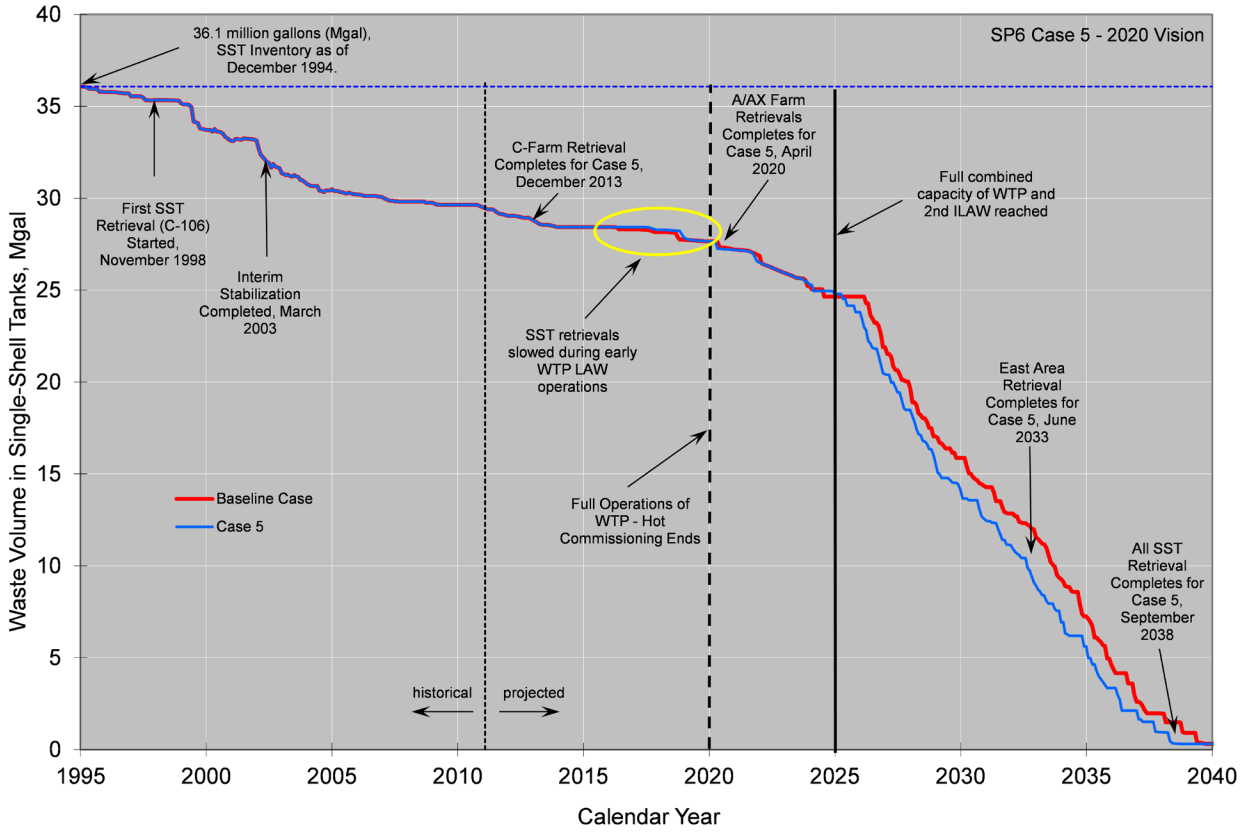


Figure 10-36. Overall Single-Shell Tank Retrieval Progress for the Baseline Case and Case 5

Figure 10-37 shows SSTs retrieved per calendar year for Case 5. These results are also apparent in Figure 10-38 and Figure 10-39 when compared with the corresponding figures from the Baseline Case results (Figure 5-5 and Figure 5-6, respectively).

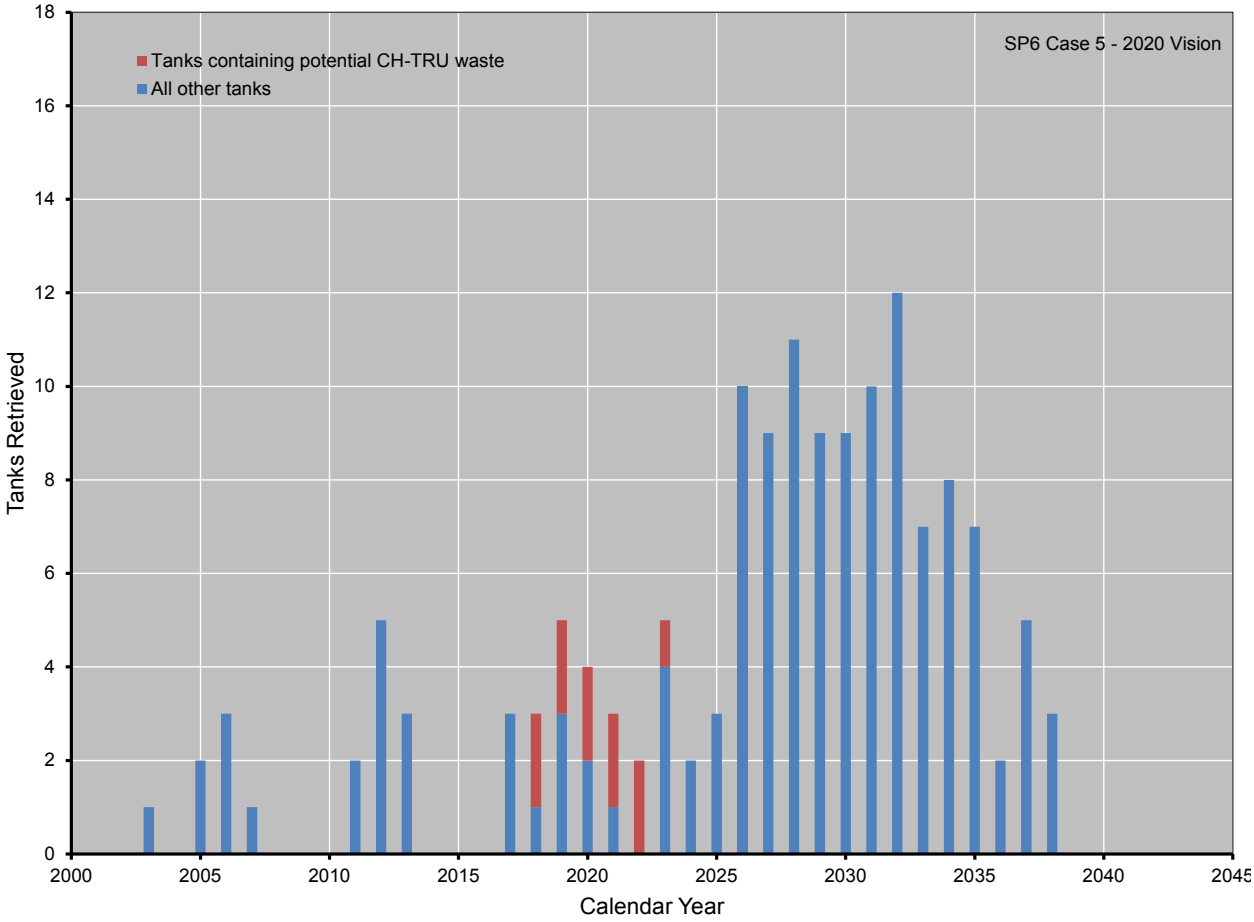


Figure 10-37. Single-Shell Tank Retrievals per Calendar Year for Case 5

Figure 10-38 shows the general timing of SST retrievals by tank farm. Comparison between Figure 10-38 and Figure 5-5 for the Baseline Case shows that there is little difference in SST retrievals by tank farm for Case 5.

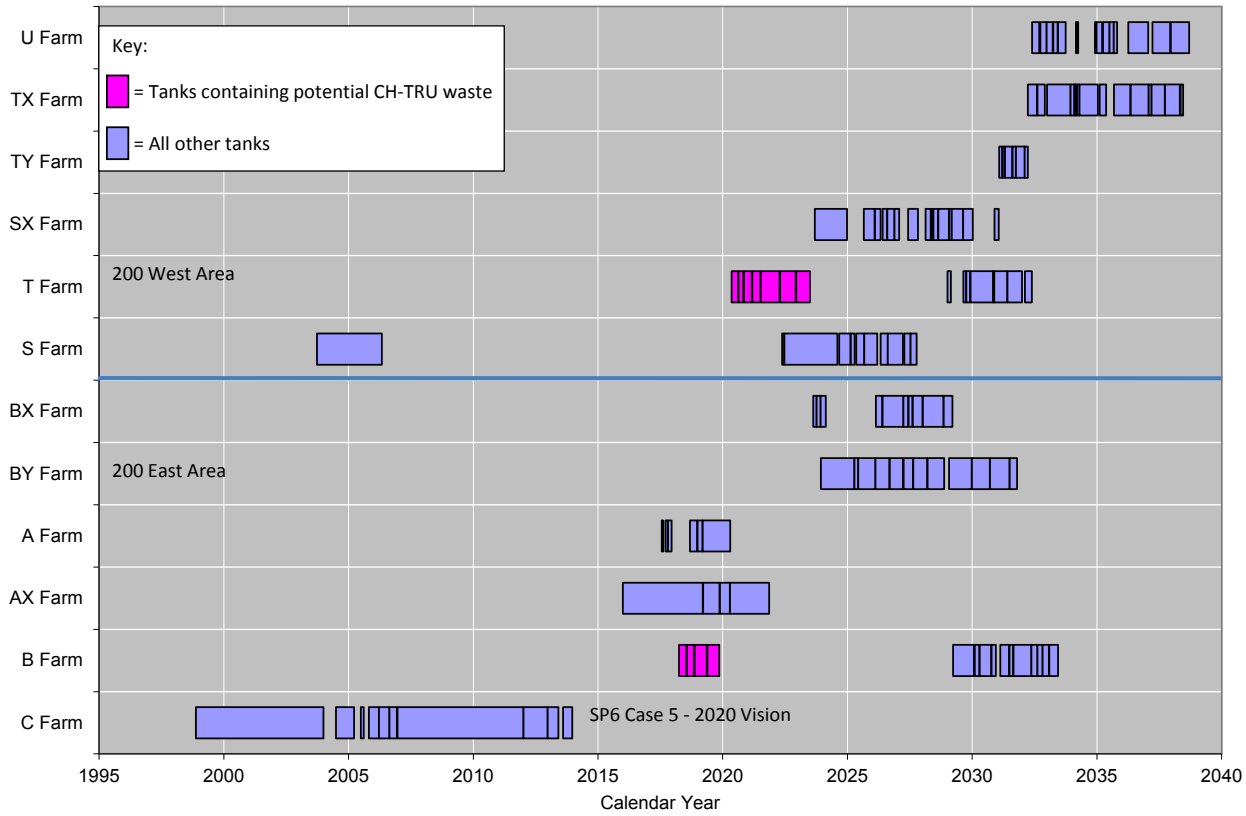


Figure 10-38. General Timing of Single-Shell Tank Retrievals by Tank Farm for Case 5

Figure 10-39 illustrates the SST retrieval sequence and timing for the entire mission. The most noticeable difference between Case 5 and the Baseline Case (Figure 5-6), pertaining to retrieval sequence and timing, occurs in the 2025 timeframe. The projected duration of retrievals during that time for the Baseline Case is noticeably greater than the projected duration of the retrievals during that time for Case 5.

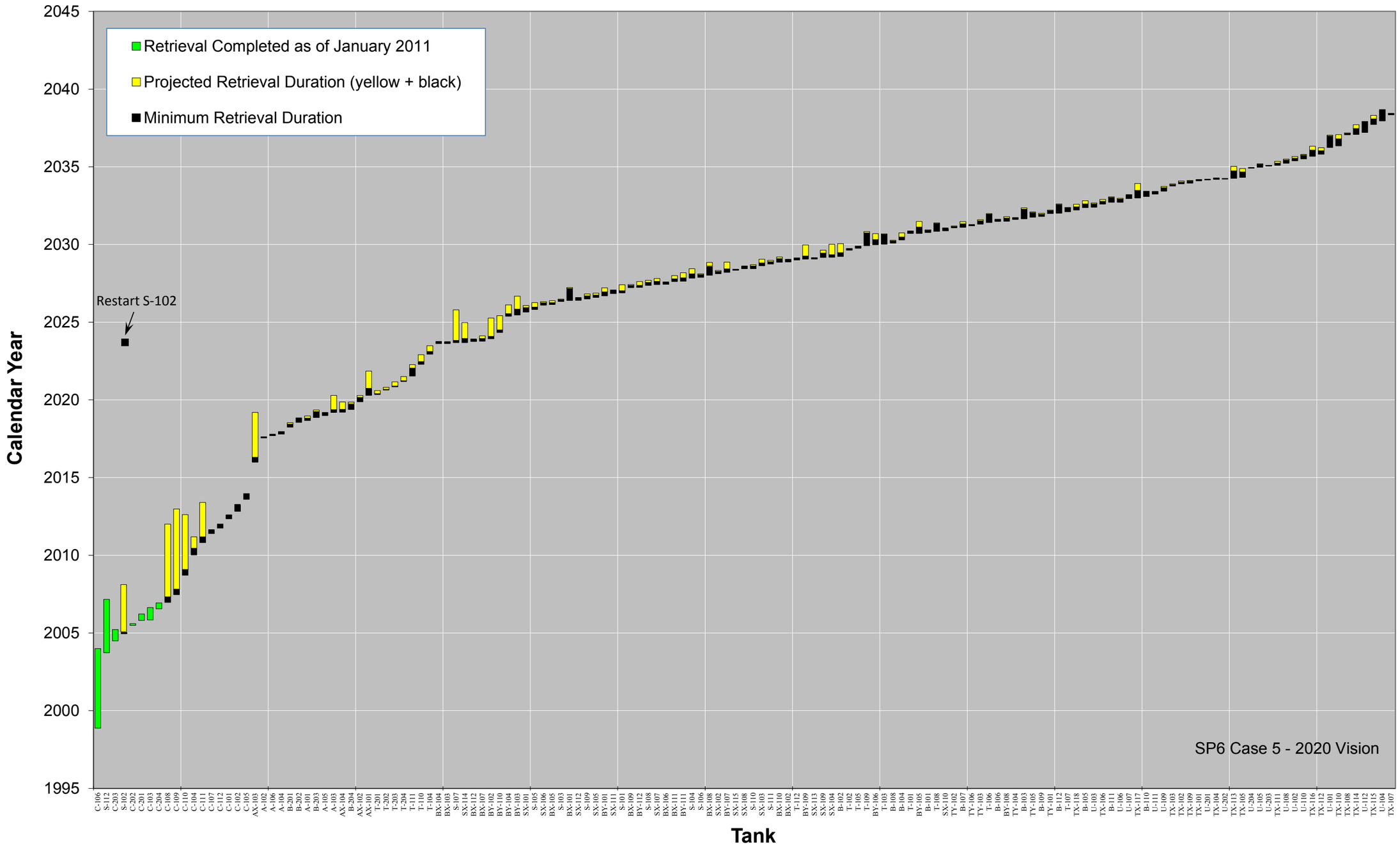


Figure 10-39. Single-Shell Tank Retrieval Sequence and Timing for Case 5

The sequence and timing of retrieving five additional SSTs after C Farm for Case 5 are listed in Table 10-16.

Table 10-16. Retrieval of Five Additional Single-Shell Tanks Following C Farm for Case 5

SST retrieved	DST receiver	Retrieval start	Retrieval complete	Projected duration (days)	Minimum duration (days)
AX-103	AZ-102	1/1/2016	3/16/2019	1,170	117
A-102	AY-101	7/23/2017	8/16/2017	25	25
A-106	AY-101	9/16/2017	10/18/2017	33	33
A-104	AY-101	10/23/2017	12/16/2017	53	53
A-101	AY-101	9/9/2018	12/25/2018	106	53

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

Table 10-16 shows that four of the five SSTs begin retrieval operations prior to the milestone date (December 31, 2017) and that three of the five SST retrievals are completed before the milestone. The extended retrieval duration of Tank AX-103 occurs as a result of two successive circumstances: lack of available DST space and a planned construction outage in Tank AZ-102, the designated DST receipt tank. Approximately 500,000 gal of Tank AX-103 is retrieved into Tank AZ-102, at which point Tank AZ-102 becomes full and begins holding in order to transfer to an available HLW feed staging tank. However, before a transfer out of Tank AZ-102 can occur, a planned construction outage[75] begins and renders the tank unavailable to transfer or receive waste for the duration of the outage. The results presented in Section 10.5.3 reflect this retrieval sequence.

The tank retrieval sequence modeled in Case 5 reflects the 2020 Vision One System proposal. However, further inspection of the Case 5 HTWOS model run reveals an opportunity to alter the retrieval sequence to meet the "Start five additional SST retrievals by 12/31/2017" success criteria, as shown in Table 10-17.

Table 10-17. Proposed Retrieval of Five Additional Single-Shell Tanks

SST retrieved	DST receiver	Retrieval start	Retrieval complete	Duration (days)
AX-104	AZ-102	1/1/2016	3/9/2016[a]	68
AX-103	AZ-102	3/10/2016[b]	Not estimated	Not estimated
A-102	AY-101	7/23/2017	8/16/2017	25
A-106	AY-101	9/16/2017	10/18/2017	33
A-104	AY-101	10/23/2017	12/16/2017	54

[a] Based on minimum retrieval duration.
[b] Can retrieve ~270 kgal from Tank AX-103 before Tank AZ-102 is full.

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

[75] The planned construction outage is scheduled to occur January 30, 2017, to October 31, 2018, to allow for equipment installation.

In the proposed change, Tank AX-104 would be retrieved before Tank AX-103. This would allow all of Tank AX-104 to be retrieved into Tank AZ-102, with enough space still remaining to retrieve approximately 270,000 gal from Tank AX-103 before Tank AZ-102 becomes full. If this change were to be implemented, it is expected[76] that starting five additional SST retrievals by December 31, 2017 could be achieved, meeting the milestone. Additionally, four of the five retrievals started would also be expected to complete prior to the milestone date (versus three of five in the original tank sequence).

10.5.3.2 Double-Shell Tank Space

Figure 10-40 shows the DST space utilization for Case 5.

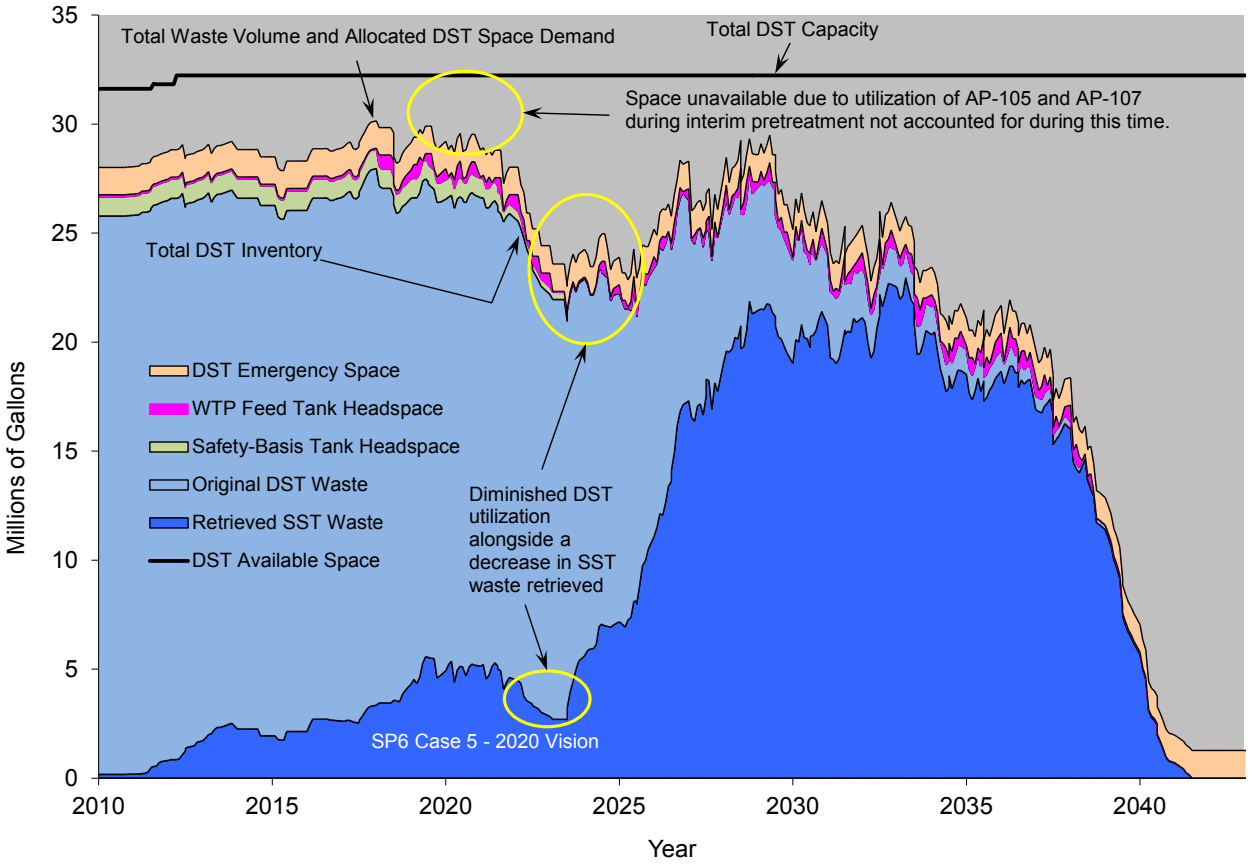


Figure 10-40. Use of the Double-Shell Tanks for Case 5

[76] Subject to future confirmation.

Two factors limit available DST space from 2016 to 2019.

- Secondary liquid waste from the WTP LAW Vitrification Facility must be returned to the tank farms for concentration in the 242-A Evaporator and subsequent storage in DSTs. (ETF upgrades are assumed to be completed by January 6, 2018 [when the PT facility begins operations], but until that time, all secondary waste generated by WTP LAW Vitrification Facility must be returned to the tank farms.)
- Two DSTs (AP-105 and AP-107) have been repurposed to support interim pretreatment activities, removing them from waste storage service.

These factors contribute to Case 5 missing the milestone "Start five additional retrievals," discussed in Section 10.5.3.

Between 2019 and 2023, there is relatively steady use of available DST space, along with fairly consistent retrieval of SST waste. This is primarily due to balancing feed to the WTP to meet Consent Decree milestone A-1. Balancing feed to the WTP involves delivering only HLW slurry batches (i.e., no LAW batches are delivered from the tank farms to the WTP during this time), which contain sufficient amounts of LAW supernate to keep both vitrification facilities operating at their assumed capacities.

There is a sharp decline in DST utilization, along with a coinciding decline in SST waste retrieved, observed from 2023 - 2024 in Figure 10-37, when compared to the corresponding figure for the Baseline Case (Figure 5-4).

This observation can be attributed to the following.

- Meeting Consent Decree milestone A-1 requires a different feed balace to the WTP, focused on delivering HLW solids with very little sodium.
- Insufficient LAW can be treated during this time (to allow HLW production to procede at assumed capacity and meet Consent Decree milestone A-1), which creates a bottleneck (lack of available space) in the DST system:
  - Bottleneck delays the blending of fissile uranium from Tank C-104 waste (C-104 blending), which could be used to supply solids to WTP
  - Bottleneck delays mitigation of Group A tanks, which could provide space for Tank C-104 blending
  - Bottleneck delays SST retrievals, which further starves the system of deliverable HLW feed.

In an attempt to optimize DST utilization during this time, three exploratory sensitivity HTWOS model runs were conducted, each case changing the date on which Tank C-104 blending may begin. The results of these sensitivity runs are shown in Table 10-18.

Table 10-18. Tank C-104 Blending Exploratory Model Run Results for Case 5

Tank C-104 blending available start date	Tank C-104 blending actual start date	Mission impacts compared to Case 5
1/1/2021	7/12/2023	• No impact on HLW production outage
1/1/2025	8/27/2033	• Duration of HLW production outage shortened by 3 months • Extended mission end date out nearly 2 years • Poor blending near end of mission • Approximately 1,400 additional HLW canisters produced
1/1/2026	11/15/2035	• Duration of HLW production outage shortened by 3 months • Extended mission end date out 1 year • Poor blending near end of mission • Approximately 800 additional HLW canisters produced

HLW = high-level waste.

The results reveal that allowing Tank C-104 blending to begin earlier has no effect on DST utilization, SST retrievals, or HLW glass production. This is an expected result because there is still no extra space available in the DST system to mitigate one of the Group A tanks earlier.

Delaying the start date of Tank C-104 blending had very little impact under the circumstances for Case 5. Although delaying the start of Tank C-104 blending did shorten the HLW production outage by months in both cases, poor blending near the end of the mission led to extending the mission end date and producing more HLW canisters. These results do project, however, that the space created to allow mitigation of Group A tanks by delaying the start of Tank C-104 blending during this time is not sufficient to eliminate the HLW production outage in its entirety.

The next logical option considered to eliminate the outage in HLW production would be to locate a different DST that could be used as the second participant for Tank C-104 blending. This would not only allow Tank C-104 blending to complete sooner, but could potentially provide enough solids to keep the WTP sufficiently fed thus drastically reducing, if not completely eliminating, the HLW glass production outage experienced from 2023 to 2024 (see Figure 10-41 in Section 10.5.3.3). There currently has not been a sensitivity model run conducted to investigate the impacts this option presents; however, this may be further explored in the future.

10.5.3.3 Glass Production

The projected IHLW production for Case 5 compared to the Baseline Case is shown in Figure 10-41. The quantity of IHLW canisters produced for Case 5 is within 4 percent of the HLW canisters produced in the Baseline Case. This can be attributed to a slightly higher WOL (1.5 percent increase) observed in Case 5, due to minor perturbations in incidental blending, when compared to the Baseline Case.

The notable observation in Figure 10-41 is the 13.5-month outage in IHLW production starting in early 2023. This outage is caused by the lack of usable space for solids handling in the DST system caused by an excess amount of supernate remaining in the DST system from the lack of supernate transfers to the WTP (see discussion in Section 10.5.3.2).

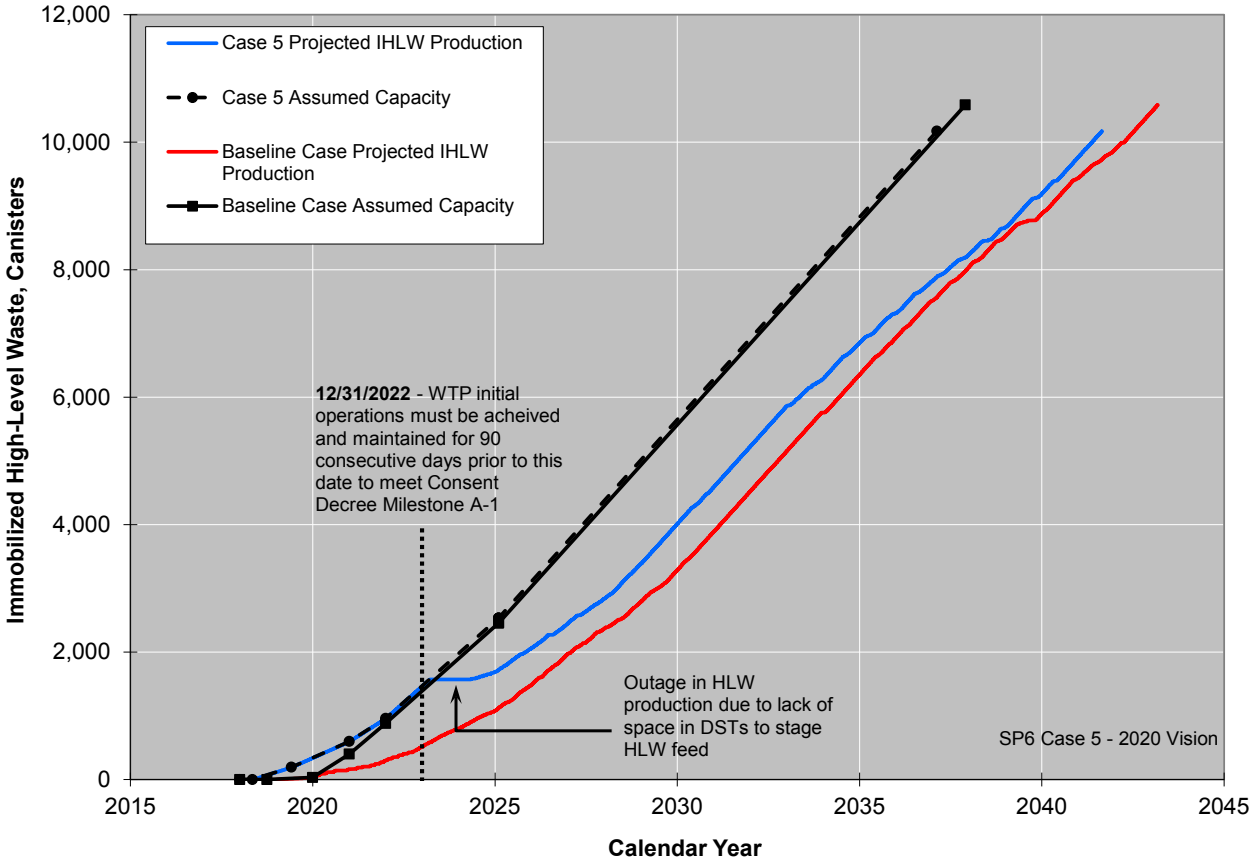


Figure 10-41. Projected Immobilized High-Level Waste Production for Case 5

The combined ILAW production for Case 5 compared to the Baseline Case is shown in Table 10-34. The quantity of ILAW packages for Case 5 is within 1.3 percent of the quantity produced in the Baseline Case. Figure 10-42 projects that initial plant operations for ILAW production are achieved by the Consent Decree milestone date of December 31, 2022, and that ILAW production continues at full capacity through 2029.

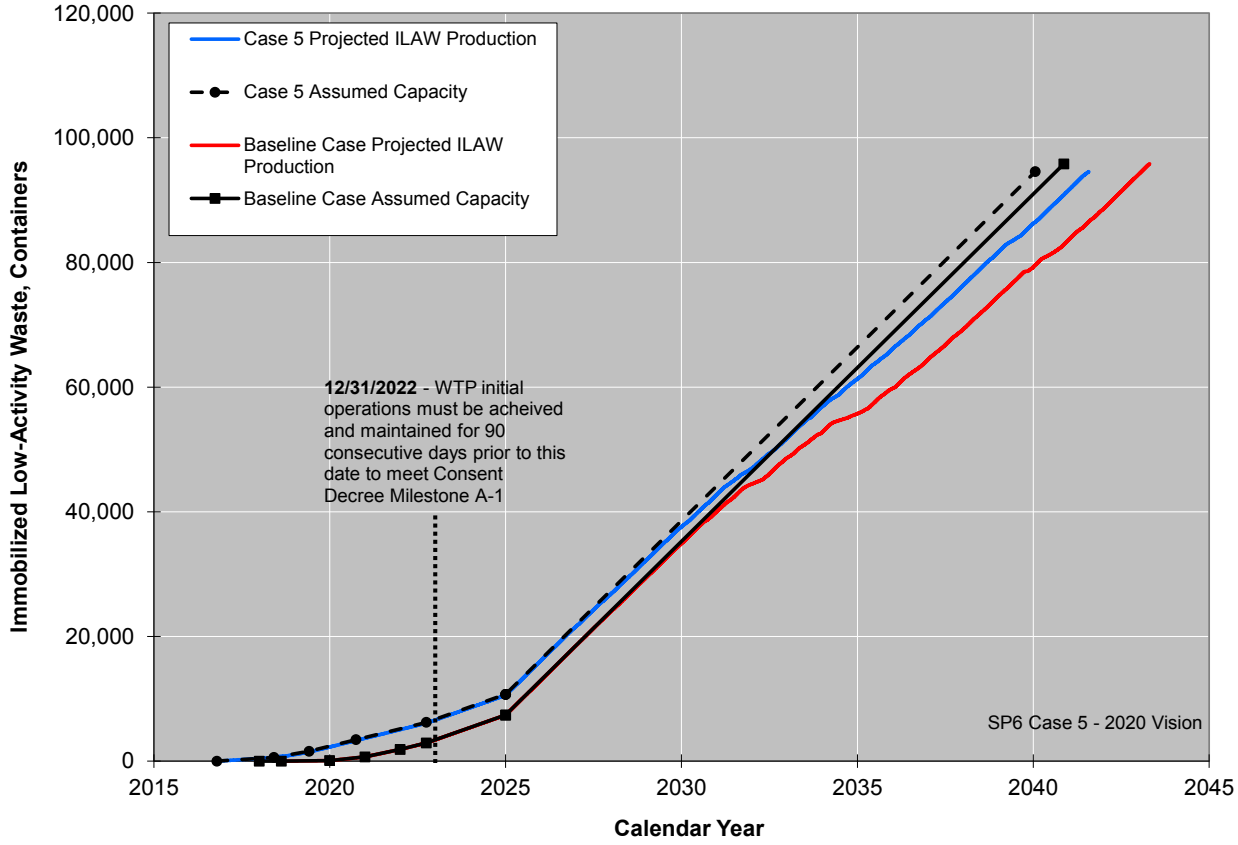


Figure 10-42. Projected Immobilized Low-Activity Waste Production for Case 5

Early treatment of some waste allows Case 5 to accelerate completion of SST retrievals by approximately one year relative to the Baseline Case. Closure program scope would be expanded to include RMF and SCIX units.

10.5.4 Cost and Schedule Impacts

In Case 5, the RPP mission completes on July 30, 2046, about 19 months earlier than the Baseline Case, resulting in a life-cycle cost savings of $1.9 billion. However, near-term schedule impacts include not meeting the success criteria to start five additional SST retrievals by December 31, 2017. Case 5 achieves this milestone on September 9, 2018, compared to the Baseline Case, which achieves that milestone on July 23, 2017. The delay is caused by conflicts in the DST farm system from installation of interim pretreatment and feed delivery systems to support the 2020 Vision One System approach.

Some activities are accelerated. Case 5 WTP operations start 18 months earlier (one LAW melter begins operating in 2016, versus 2018 in the Baseline Case), and Case 5 HLW processing begins a few months earlier in January 2018, versus May 2018 in the Baseline Case.

In the out-years, Case 5 finishes several activities earlier than the Baseline Case. Case 5 gains approximately three years in waste treatment, two years in SST retrieval and closure, and three years in DST retrieval and closure when compared to the Baseline Case.

The capital costs associated with the interim pretreatment system, interim WFD system, and interim secondary liquid waste handling are incurred between 2012 and 2016 and can be seen as an increase over the Baseline Case in the life-cycle cost profiles. The additional funding necessary for those systems also drives the costs above the near-term funding targets. Table 10-19 and Figure 10-43 provide additional detail.

Table 10-19. Near-Term Funding Targets versus Results for Case 5

Fiscal year	Target[a] ($M)	Case 5[a] ($M)
2011	410	394
2012	510	514
2013	510	510
2014	610	569
2015	710	718
Total	**2,750**	**2,705**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

The majority of the life-cycle cost savings come from waste treatment ($1.2 billion), which is due to completion of waste treatment 19 months earlier than the Baseline Case. Other life-cycle cost savings are achieved through slight schedule accelerations, which reduce costs in base operations (approximately $500 million), retrieval and closure of SSTs (approximately $150 million), and WFD/treatment planning (approximately $240 million).

The new scope in Case 5, which includes an interim pretreatment system, interim WFD system, and interim secondary liquid waste handling system, adds almost $600 million to the cost of the project. However, those costs incurred by the additional scope were more than offset by the savings achieved through a shortened treatment duration.

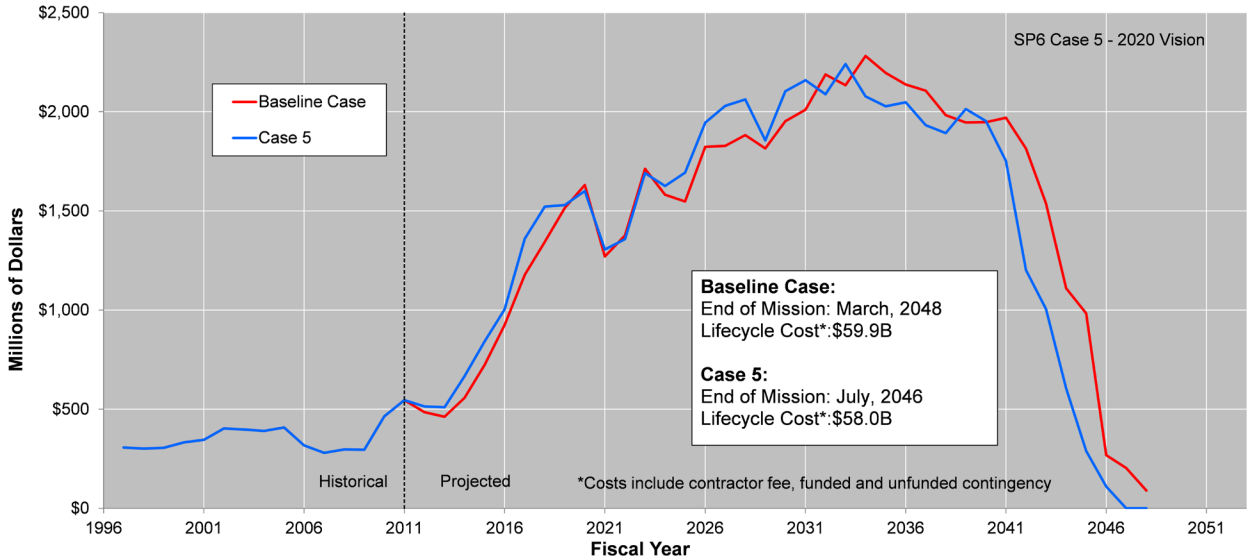


Figure 10-43. Life-Cycle Cost Comparison: Baseline Case and Case 5

10.5.5 Key Issues and Vulnerabilities

The Case 5 (2020 Vision One System) defined by Appendix B and presented in this System Plan includes a number of challenges that will need to be successfully addressed to reach the desired performance for the mission. The following issues from the Baseline Case are impacted by Case 5.

- Item 7.1-1 (DST space) is negatively impacted early in the mission, but is improved in later years. The early negative impacts are due to:
  - Secondary liquid waste returning to the tank farms during early treatment of tank waste
  - Delivery of only HLW feed to WTP early to meet Consent Decree milestone A-1.
  - Repurposing two DSTs dedicated to RMF/SCIX operations for interim pretreatment of tank waste.

  Improvements in later years are due to:
  - Early treatment of tank waste
  - Faster ramp-ups of HLW and LAW facilities treat more tank waste earlier.
- Item 7.5-1 (WTP startup and operations) is improved due to the:
  - Early supplemental pretreatment and treatment provided by Case 5
  - Faster ramp-ups of HLW and LAW facilities.
- Item 7.8-10 (IDF operations) is negatively impacted by Case 5 due to earlier start of the WTP LAW Facility.

Case 5 introduces the following new issues and identifies potential mitigating actions or contingency measures.

- RMF and SCIX are transformational technologies, which require additional development prior to proposed deployment and operation.
  - This issue may be mitigated by accelerating work to progress the technologies to the needed TRL for deployment and operation.
- Return of the non-neutralized acidic cesium eluate stream from the SCIX to the DST may require onerous engineering or administrative controls.
  - This issue may be mitigated by considering handling of the stream during preconceptual design and associated preliminary process hazard assessments.
- The ability for RMF and SCIX to provide a pretreated LAW stream that meets feed requirements has not been verified.
  - This issue may be mitigated by performing further tests with Hanford simulants.
- A readiness review may be required if the HLW facility is without feed for an extended period of time.
  - No potential mitigating action at this time.
- The three existing tanks from the discontinued bulk vitrification project may not be suitable for this reuse.
  - Review and approval of the pedigree of the three tanks would be required before they could be deployed for this purpose.

10.6 CASE 6 – WASTE TREATMENT AND IMMOBILIZATION PLANT DELAY WITH NEW DOUBLE-SHELL TANK FARM

Selected by: Ecology

Purpose: Evaluate how well a new DST farm can offset all or part of the impact from a uniform four-year delay in the startup of the WTP.

10.6.1 System Description

The new DST farm, NF Farm[77] proposed in Case 6, would consist of eight nominal 1 Mgal tanks (named NF-101 through NF-108) located in the 200 East Area and fully integrated with the rest of the DST transfer system. The tanks would be equipped with dual mixer pumps without incremental insertion capability, slurry pumps and decant pumps, and would have an operating capacity of 1.2465 Mgal each. The new farm would be operational on September 30, 2020, following an estimated eight years of design, construction, and commissioning. NF Farm is assumed to be situated near the AP, AN, and AY Farms and in close vicinity to WTP. This tank farm would be connected to the DST transfer system by three transfer lines (each constructed of 3-in. stainless steel in 6-in. carbon steel) and a new diversion box that would intercept transfer lines from the AZ valve pit. A schematic of the location and connections of the new farm is provided in Figure 10-44.

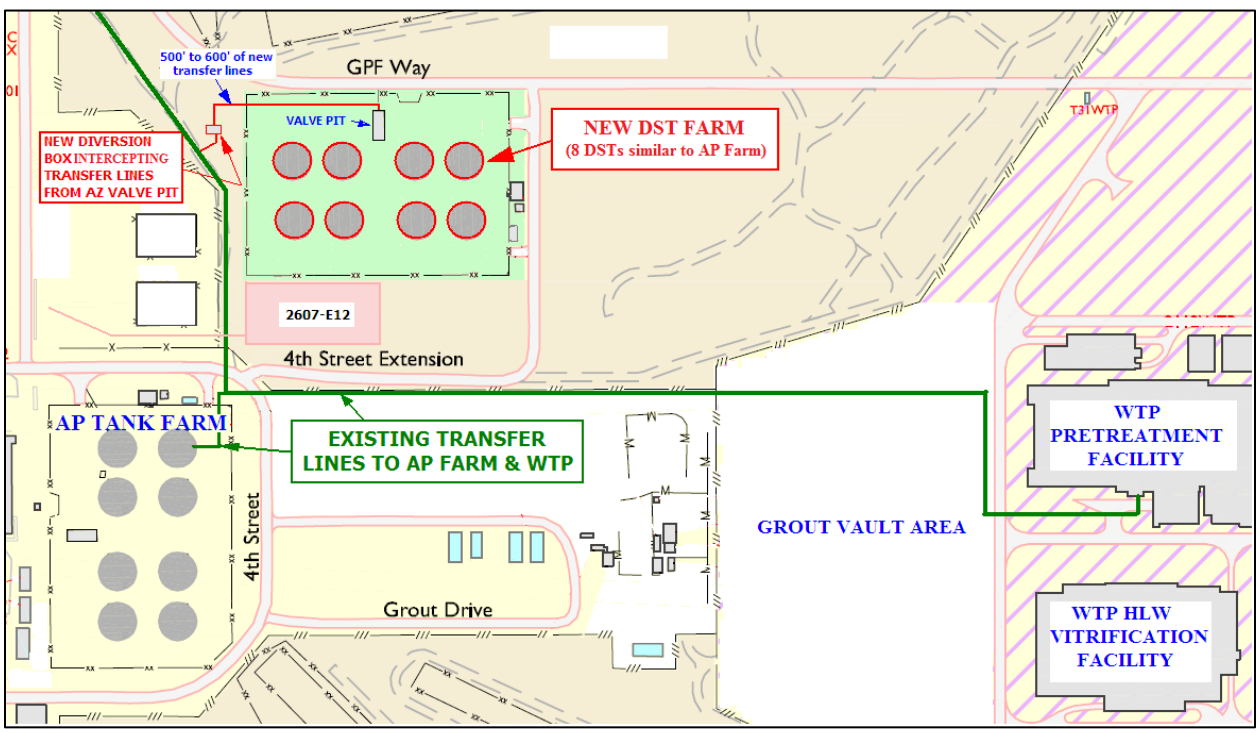


Figure 10-44. Location and Piping Configuration of NF Farm

[77] NF tanks are numbered 101-108 within the model.

In Case 6, the WTP startup dates are assumed to be postponed by four years from the Baseline Case schedule (although processing capacities established in the Baseline Case will not change). This delay, as projected in Case 6, could be attributed to longer-than-anticipated duration of startup activities. Table 10-20 lists the facility dates for Case 6, which differ from the Baseline Case dates by four years.

While this new DST farm represents a significant change to site infrastructure, its construction would not require any technology development. As the most recently constructed tank farm, AP Farm would serve as a primary template for the new farm design and cost bases.

Table 10-20. Case 6 Facility Start Dates

Begin routine radiological operations at:	System Plan (Rev. 6)	
	Baseline Case start date	Case 6 start date
WTP PT Facility	12/31/2019	12/31/2023
WTP HLW Vitrification Facility	9/29/2018	9/29/2022
WTP LAW Vitrification Facility	8/18/2018	8/18/2022
NF Farm	NA	9/30/2020
Second LAW vitrification facility	10/1/2022	10/1/2026

HLW = high-level waste.
LAW = low-activity waste.
NA = not applicable.
PT = pretreatment.
WTP = Waste Treatment and Immobilization Plant.

10.6.2 Planning Bases

The Case 6 planning bases are described in Appendix B, Section B8.0.

10.6.3 Results

Table 1-1 (Section 1.3) and Table 10-21 show the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 6 versus the Baseline Case. Key results for Case 6 are as follows:

- Case 6 meets all mission success criteria, except:
  - The Case 6 life-cycle cost increases to $68.7 billion, largely due to the delay in the mission and the construction, operation, and subsequent closure of a new DST farm.
  - Completion of SST retrievals is delayed until July 24, 2042, approximately 19 months later than the success criteria date of December 31, 2040.
  - Closure of all SSTs is delayed until August 20, 2046, more than 3.5 years later than the success criteria date of January 31, 2043.

Table 10-21. Mission Metrics Comparison for the Baseline Case and Case 6

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 6: WTP delay with new DST farm
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	**$68.7 B**
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,450 M
Meets near-term funding profile through 2015	Note a	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	7/23/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	8/25/2021
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	**7/24/2042**
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	**8/20/2046**
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	3/16/2047
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	3/21/2052
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	31,304
HLW glass canisters	–	10,586	10,366
HLW glass waste oxide loading	–	36.9%	38.3%
LAW glass mass (MTG)	–	527,838	525,433
LAW glass containers	–	95,825	95,389
LAW glass sodium oxide loading	–	17.8%	17.8%
Sodium reporting to LAW glass (MT)	–	69,659	69,487
FBSR product (MT)	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

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FY = fiscal year.
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LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

In addition to the Baseline Case, Case 6 results also were compared to an HTWOS run in which no additional tanks or other system is available to compensate for a four-year delay in WTP startup.[78] Table 10-22 lists selected milestone dates for the Baseline Case, Case 6 (WTP delay with an additional eight tanks) and the WTP delay (*without* additional tanks) alongside the success criteria dates. This comparison is useful for observing the impact of such a delay on the mission and for isolating the effectiveness of a new DST farm in mitigating this delay.

Table 10-22. Mission Metrics Comparison for the Baseline Case, Case 6, and Case 6 Without Additional Double-Shell Tanks

Metric (milestone)	Success criteria	System Plan (Rev. 6)		
		Case 1: Baseline Case	Case 6: WTP delay +8 new DSTs	WTP delay (no additional DSTs)
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	7/23/2017	7/23/2017
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	8/25/2021	**7/27/2024**
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	**7/24/2042**	**2/28/2044**
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	3/16/2047	6/2/2047

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

The additional tank farm has a greater impact on the near-term mission schedule than on the long-term, because near-term activities are largely driven by retrievals, whereas long-term successes are driven by waste treatment.

[78] This case is a sensitivity case used to show the effect of the new DST farm on the delay of the Baseline Case.

Figure 10-45 compares three mission metrics from Table 10-21, "Complete nine additional SST retrievals (B-4)," "Complete all SST retrievals (M-045-70)," and "Treat all tank waste (M-062-00)." This figure shows the delta for each case for the given mission metric. The figure shows that the new DST farm does help mitigate the effect of a four-year delay of the start of WTP operations, but does not mitigate enough of the delay to bring the metrics within the success criteria. For each of these metrics, Case 6 shows an improvement over the WTP delay, bringing each metric closer to the success criteria and the Baseline Case. However, the mitigating effect of the new DST farm has less of an impact the later in the mission the success criterion is.

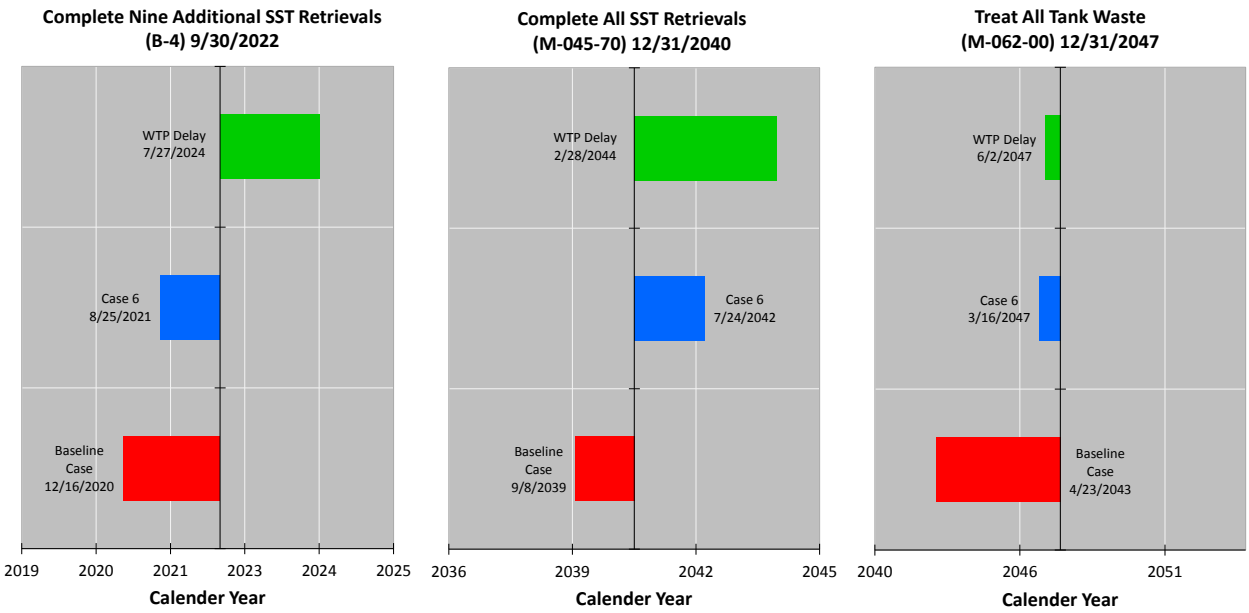

Figure 10-45. Comparison of Milestone Dates for the Baseline Case, Case 6, and a Waste Treatment and Immobilization Plant Delay Versus Success Criteria

Figure 10-46 shows the DST system space utilization along with the volume of retrieved SST waste in Case 6. Figure 10-47 overlays the total DST space demands of the Baseline Case and WTP delay cases over that of Case 6. The Case 6 total DST space demand in Figure 10-47 corresponds to the top line (representing total waste volume and allocated DST space demand) of Figure 10-46; the equivalent quantities are shown for each of the other cases. Utilization of the nearly 1 billion gal of additional space in the new DST farm is evident in Figure 10-47 by the significantly greater DST space demand than in the other cases. The space is not used immediately upon its availability due to the prescribed sequencing of SST retrievals. A Farm and AX Farm have designated receivers, so their retrievals do not and cannot benefit from the increased space provided by the NF Farm. After the completion of A Farm and AX Farm in April 2022, retrievals start in BX Farm (September 2022), at which point the additional DST space can be fully used by those and subsequent retrievals. Despite the advantages of the additional DST space, the shifts of Case 6 and WTP delay to the right from the Baseline Case in this figure highlight the lack of long-term impact to the mission.

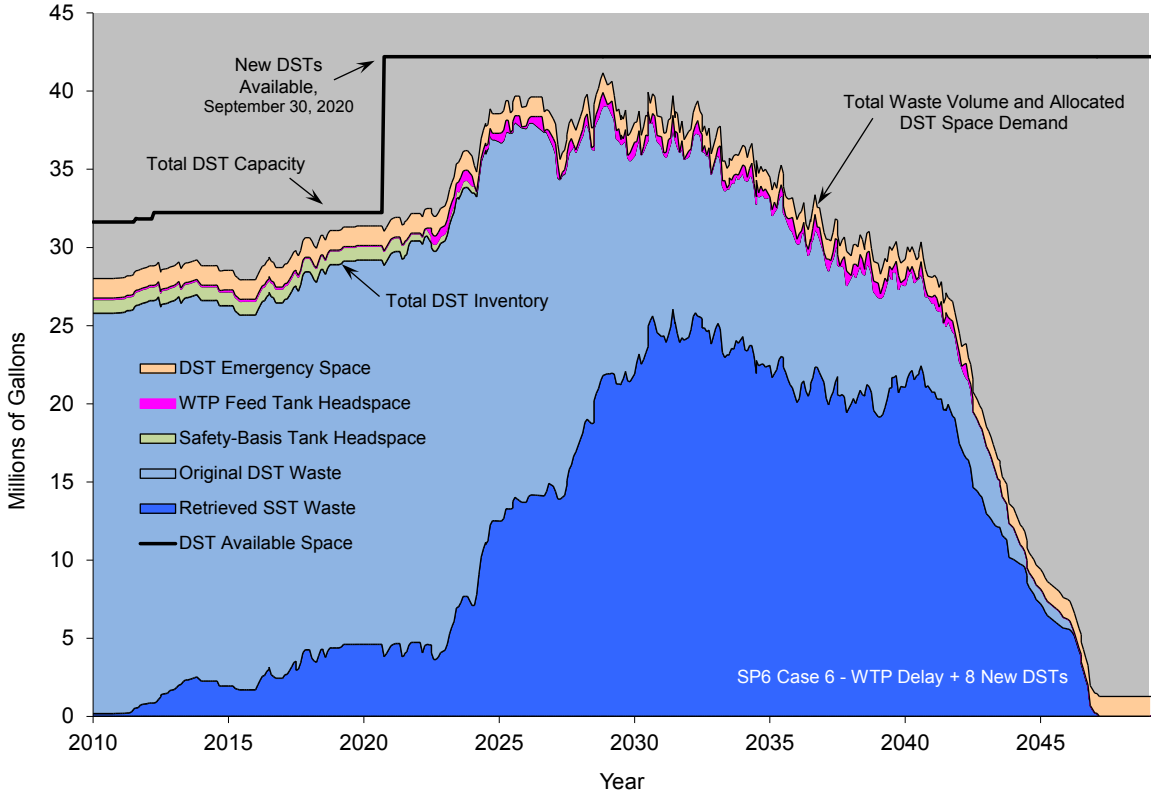

Figure 10-46. Use of the Double-Shell Tanks in Case 6

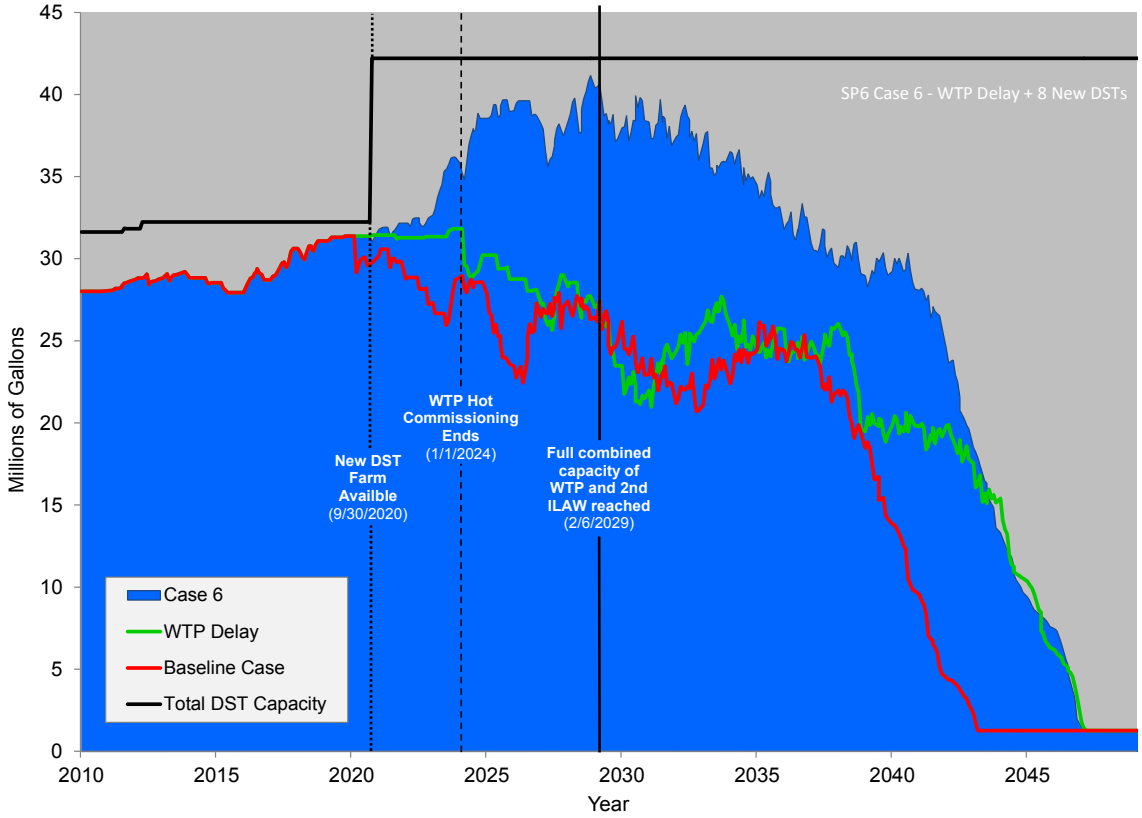

Figure 10-47. Total Double-Shell Tank Space Demand Comparison for Case 6

Figure 10-48 shows the corresponding volume of SST waste remaining at a given year. The additional DSTs provide an advantage in waste retrieval until about 2027, after which point the SST waste volume in the Baseline Case is less than that for Case 6 for the remainder of the mission. Compared to only the case of a WTP delay, however, a greater reduction is made in the volume of SST waste during that time period and retrievals are completed earlier with the additional tank farm in Case 6.

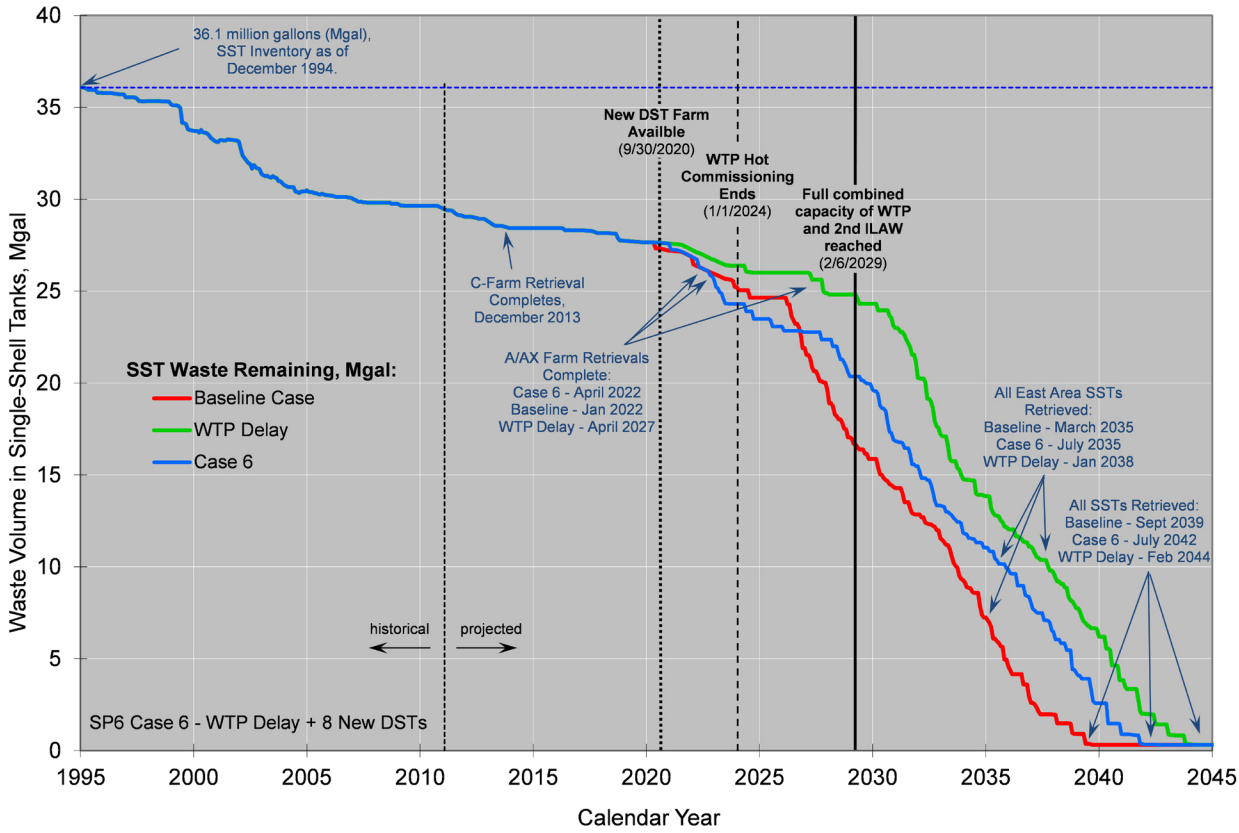

Figure 10-48. Comparison of Overall Single-Shell Tank Retrieval Progress: Baseline, WPT Delay, WTP Delay with New Double-Shell Tank Farm

Figure 10-49 and Figure 10-50 both show SST retrieval progress for Case 6. Though SST retrievals proceed in Case 6 during the time period affected by the delay in WTP startup, May 2018 (Baseline Case WTP hot commissioning start date) to February 2029 (Case 6 full capacity of WTP reached), the number of retrievals is less and the timing of individual farm retrievals is delayed relative to the Baseline Case during this timeframe. This effect is reduced, however, compared to the case of a WTP delay without an additional tank farm. Figure 10-51 shows the order and anticipated durations of SST retrievals.

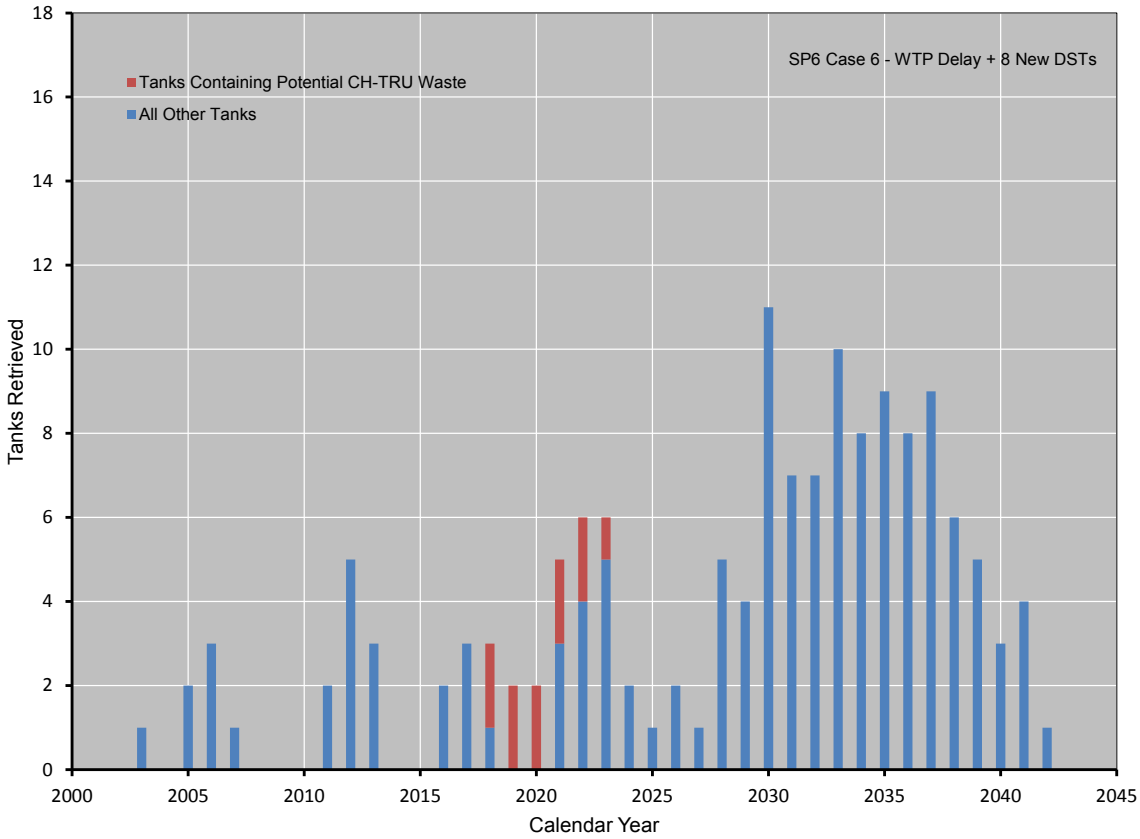

Figure 10-49. Single-Shell Tank Retrievals Completed per Calendar Year in Case 6

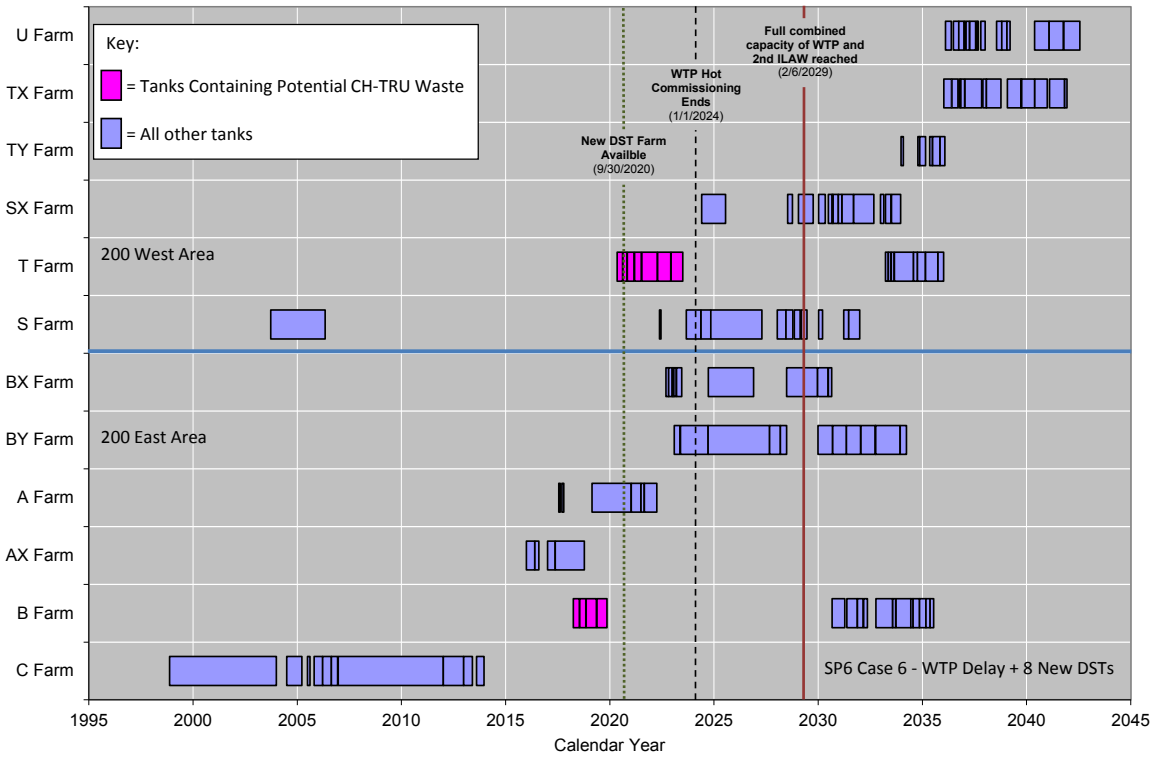

Figure 10-50. General Timing of Single-Shell Tanks Retrievals by Farm in Case 6

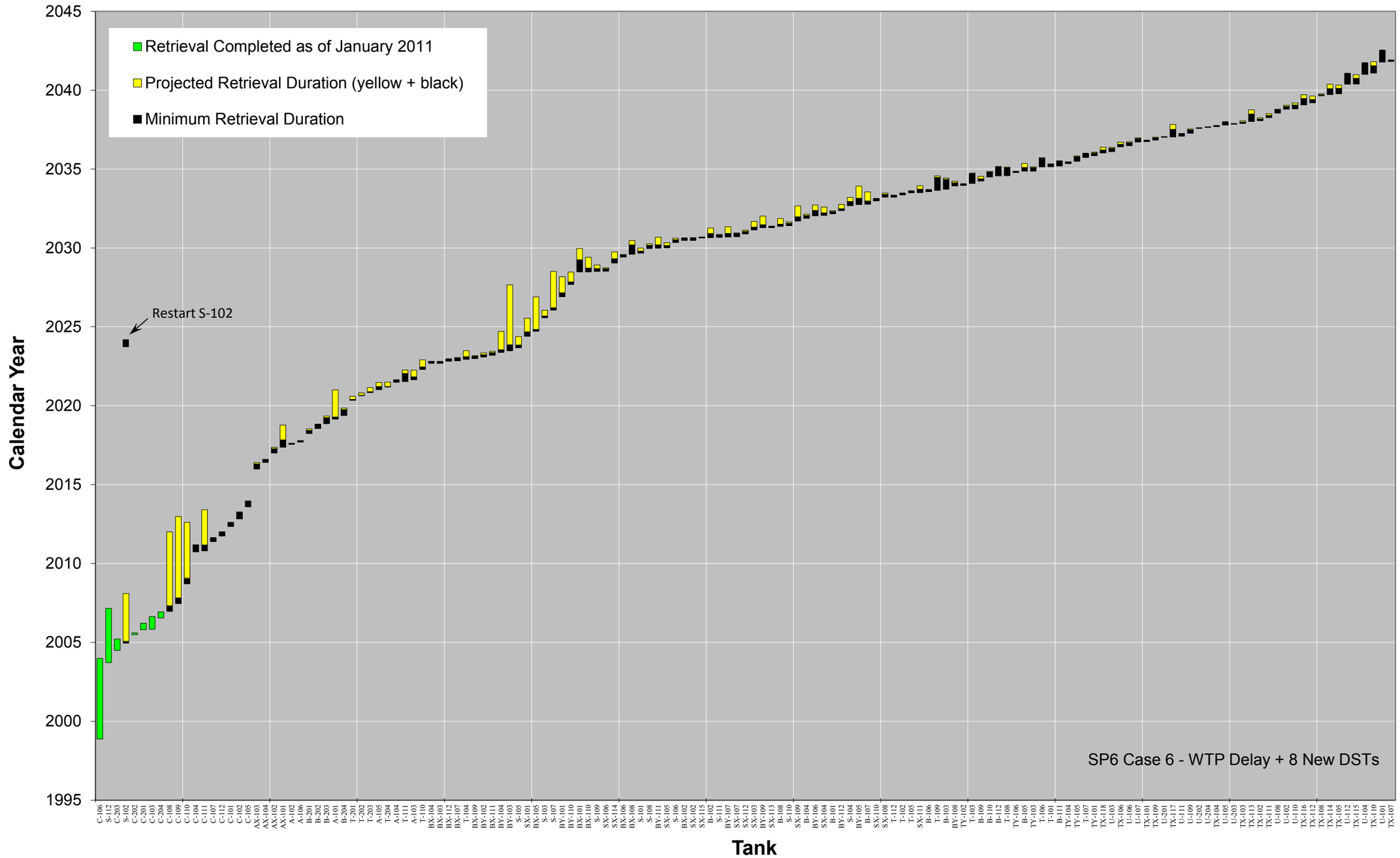

Figure 10-51. Single-Shell Tank Retrieval Sequence and Timing for Case 6

Figure 10-52 and Figure 10-53 compare the projected IHLW and ILAW production to the assumed production capacities. Production curves for Case 6 are shifted four years later than the Baseline Case for the duration of the mission and are nearly identical to those of the case of a WTP delay, showing that factors other than availability of DST space govern waste immobilization.

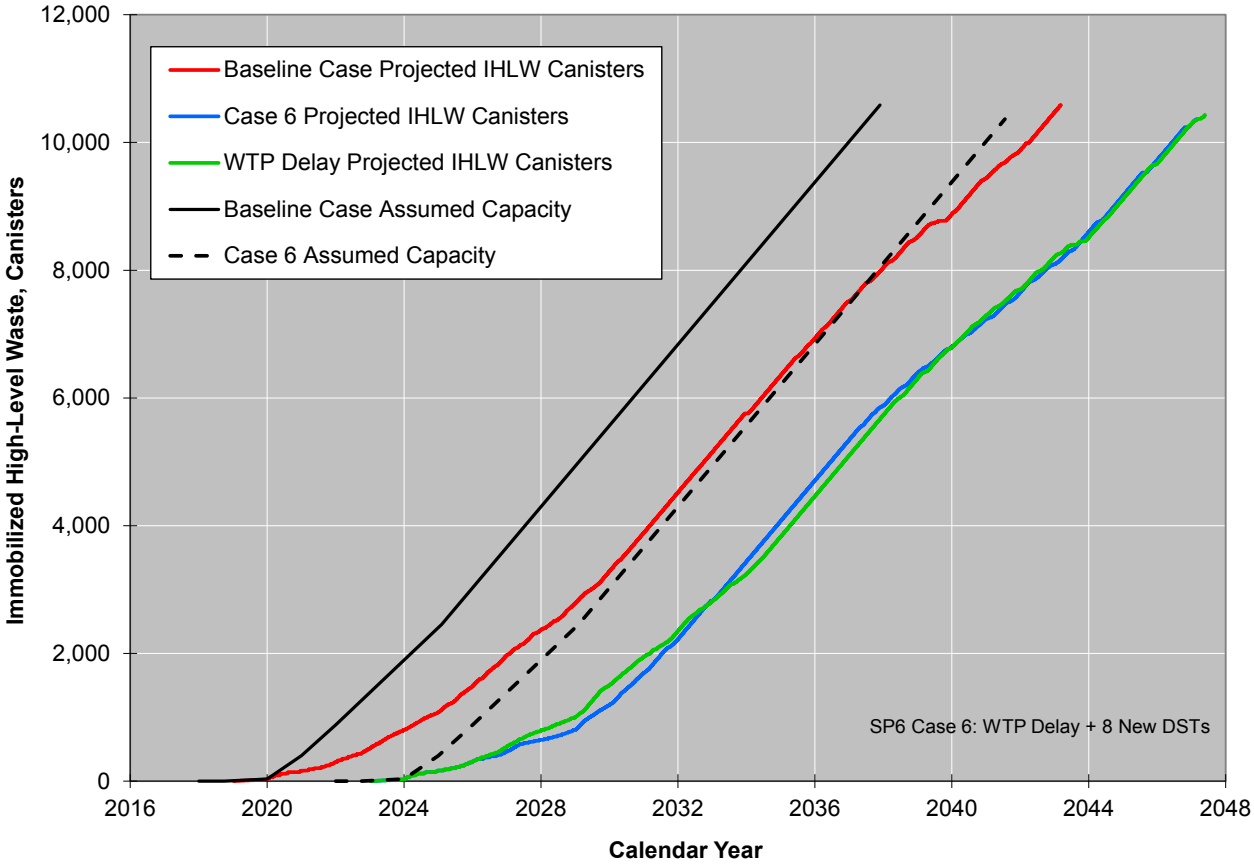

Figure 10-52. Projected Immobilized High-Level Waste Production for Case 6

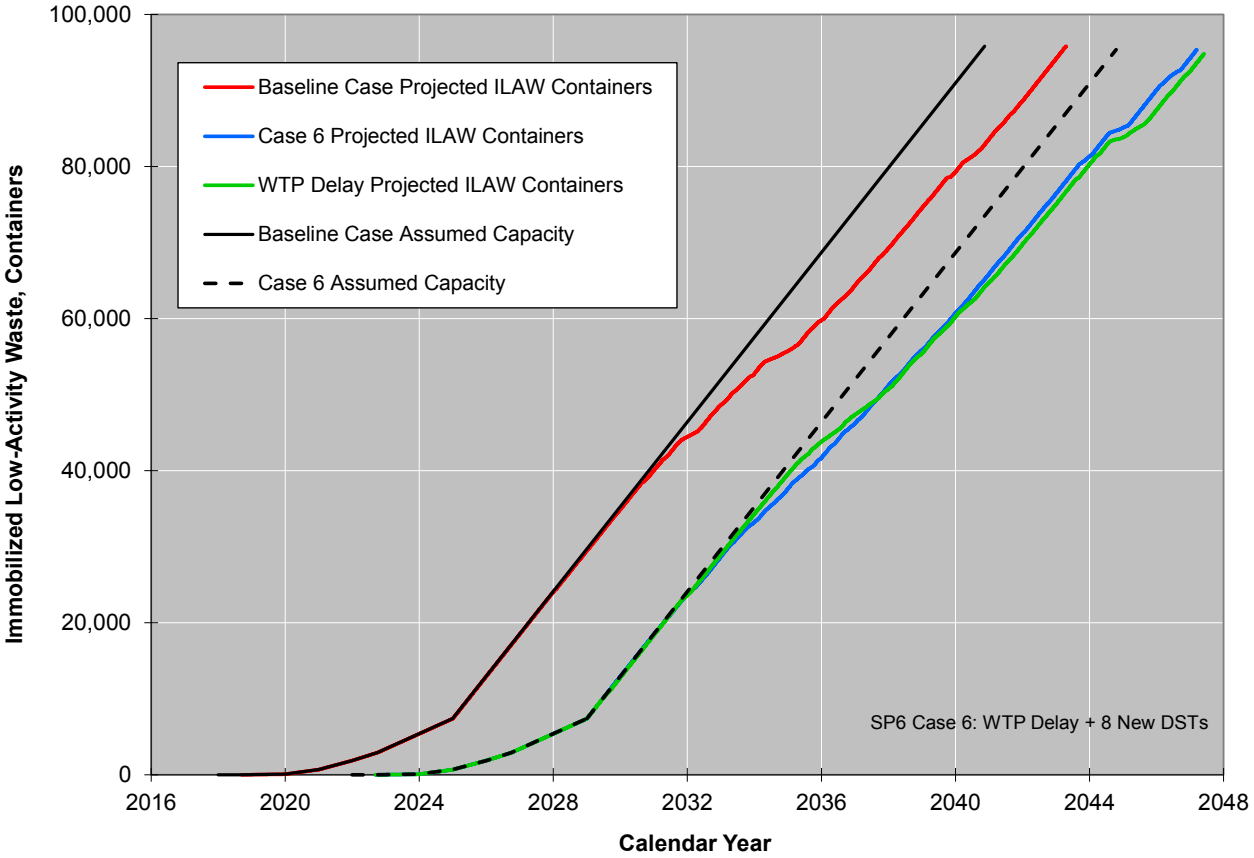

Figure 10-53. Projected Combined Immobilized Low-Activity Waste Production for Case 6

In Case 6, the SST closure schedule is delayed by approximately three years relative to the Baseline Case because the four-year delay in WTP operations leads to a three-year delay in the completion of SST retrievals. Closure program scope would be expanded to include the eight new DSTs.

10.6.4 Cost and Schedule Impacts

A four-year delay in WTP startup would shift the entire mission nearly four years later than the Baseline Case.[79] The addition of a new DST farm, available in September 2020, would help to recover from this delay, though not eliminate it completely. For Case 6, the treatment of all tank waste would be delayed until March 16, 2047, at a life-cycle cost of $68.7 billion, compared to April 23, 2043 and $59.5 billion for the Baseline Case.

The design, construction, and permitting of a new tank farm have been estimated to cost approximately $683 million and require approximately eight years to complete. It must be noted that the $683 million is a rough-order-of-magnitude estimate.

[79] The changes in funding requirements as a result of a delay in WTP startup without a new tank farm were not examined.

In the event that a decision was made to consider construction of a DST farm, a detailed estimate would be required. It is envisioned that historical engineering data would be used as a design basis because the project would not rely on any technology development. The opportunity to reduce the rough-order-of-magnitude estimate is a direct function of the ability to use existing design media.

At a minimum, two previous capital projects would be used in the development of the estimate and design:

- Project B-340, 241-AP Tank Farm
- Project W-236a, Multi-Functional Waste Facility.

Project B-340 consisted of six nominal 1 Mgal DSTs that provided terminal liquid storage and slurry distribution facilities. The design for this FY 1983 line item was based on, but not limited to, the as-built design of the 241-AW Tank Farm. The total estimated cost was $64 million in 1981. The escalated cost in 2011 is approximately $230 million using an inflation rate of 3.33 percent per year and eight tanks. This figure is presented for information only and would be affected by incorporation of farm-specific WFD requirements, site-specific effects, and current regulatory requirements.

Project W-236a consisted of six nominal 1 Mgal DSTs with weather protection enclosures. Four tanks were to be located in 200 East Area and two tanks in 200 West Area. The total project cost was estimated to be $435 million in FY 1994. The escalated cost in 2011 is approximately $860 million using an inflation rate of 3.33 percent per year and eight tanks. This figure is presented for information only and would be affected by incorporation of farm-specific WFD requirements, site-specific effects, and current regulatory requirements.

Near-term funding profiles for Case 6 are nearly identical to the Baseline Case (Table 10-23). Additional annual funding to support design of the new tank farm would begin in 2013, but in the early years (2013 – 2015), the cost is not readily distinguishable relative to the overall mission costs.

From 2016 - 2020, additional costs associated with the new farm increase significantly, as shown on Figure 10-54. From 2025 – 2035, Case 6 appears to show a cost savings relative to the Baseline Case. However, this is really just a four-year offset caused by the delay of WTP operations; the two cases follow a similar cost trend overall.

The most significant source of increased life-cycle costs, about $6.8 billion, is the extended length of the mission. Nominal operating costs are approximately $1.7 billion per year.

Table 10-23. Near-Term Funding Targets versus Results for Case 6

Fiscal year	Target[a] ($M)	Case 6[a] ($M)
2011	410	387
2012	510	479
2013	510	471
2014	610	495
2015	710	618
Total:	2,750	2,497

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

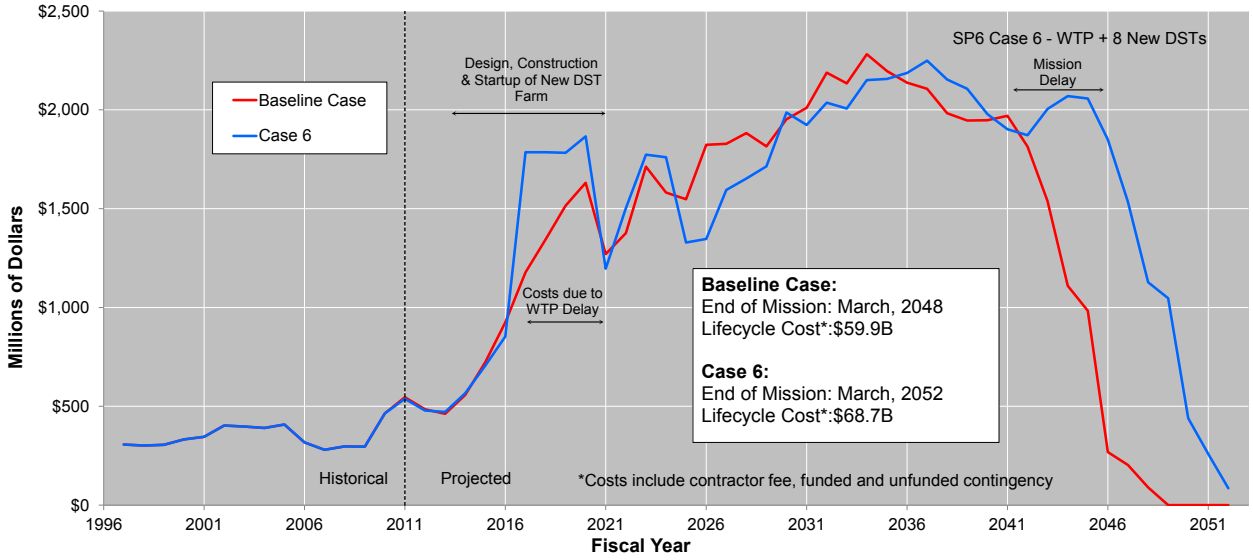

Figure 10-54. Life-Cycle Cost Comparison: Baseline Case and Case 6

10.6.5 Key Issues and Vulnerabilities

The cost and schedule associated with the new DST farm are the greatest sources of uncertainty and vulnerability in the case. While the new farm appears to have some positive impact on the retrieval of SSTs, further study is required to determine whether this impact justifies the baseline change and capital investment, and whether these activities could be completed in sufficient time to be relevant.

All key issues identified for the Baseline Case also apply to Case 6, except as noted below.

The following issues from the Baseline Case are impacted by Case 6.

- Item 7.1-1 (DST space) is improved by the increased storage capacity offered by the construction of eight additional DSTs.
- Item 7.1-3 (242-A Evaporator) is improved because the availability of additional DST space would mitigate the impact of evaporator operations interruptions.
- Item 7.5-1 (WTP hot commissioning) is modified in Case 6 to explore the impact to the mission from a four-year delay in these activities.
- Item 7.11-1 (FY funding) is negatively impacted by the increased annual operating cost prompted by the WTP delay, and the near-term design and construction of the new DSTs.
- Item 7.11-2 (Life-cycle mission cost) is negatively impacted by the increased expense imposed by the delay in WTP startup, and the design, construction, operation, and closure of the new DSTs in Case 6.

Case 6 introduces the following new issue and identifies potential mitigating actions or contingency measures.

- The decision to construct an additional tank farm must be made in 2012 to allow sufficient time for its permitting, design, and construction by the specified operating date of September 2020, which must be met to be effective in reducing the impact of a delay in WTP startup.
  - Potential mitigating actions may include conducting more detailed engineering analyses to confirm the minimum DST capacity required for a new farm, since the scope of the project necessarily drives the cost and schedule.

10.7 CASE 7 – ENHANCED TANK WASTE STRATEGY

Selected by: ORP

Purpose: The judicious use of transformational technologies may shorten the treatment mission and reduce the life-cycle cost by approximately $16 billion and schedule by seven years.

10.7.1 System Description

Case 7 consists of using only fluidized bed steam reformers to provide all LAW treatment; both the WTP LAW Vitrification Facility and a second LAW vitrification facility would be eliminated. A simplified flowsheet for Case 7 is provided in Figure 10-55.

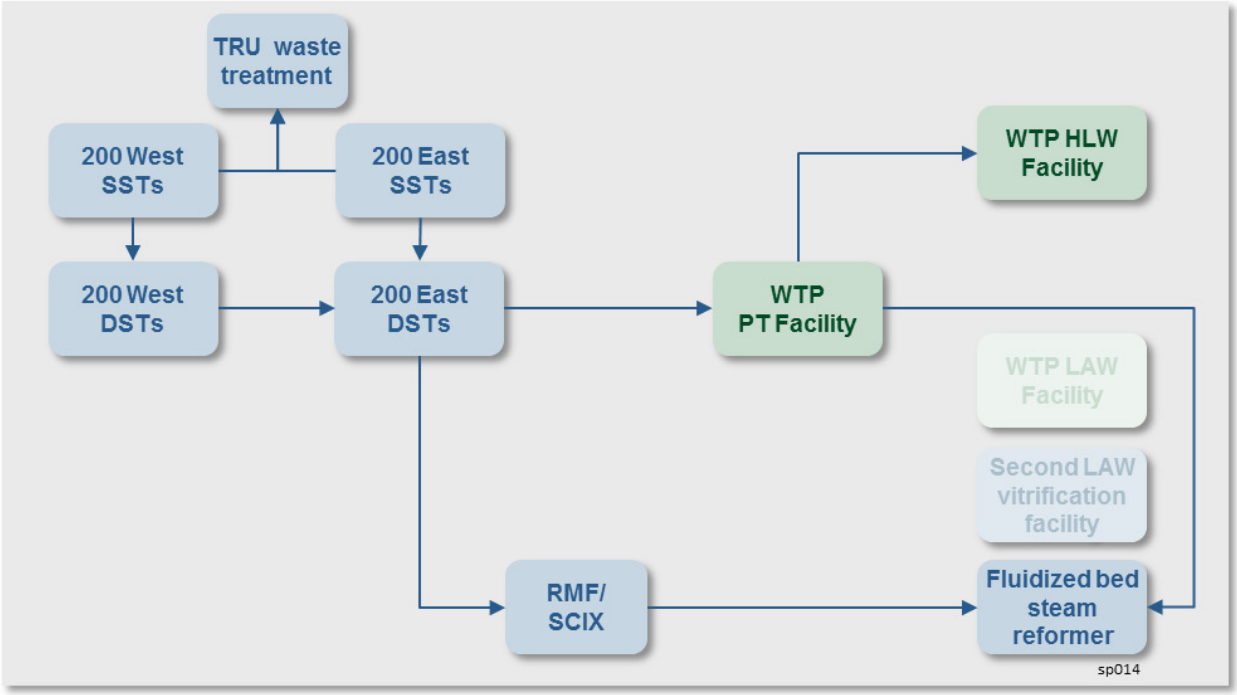

Figure 10-55. Simplified Flowsheet for Case 7

Case 7 takes advantage of potential improvements in HLW glass formulation by use of an **enhanced HLW glass model.** This model takes advantage of work documented in PNNL-19372, which recommends that several limiting constraints within the glass model (e.g., the sulfate solubility limit and the nepheline discriminator) can be relaxed. This allows more waste to be included in each melter feed batch, thereby increasing waste oxide loading in the glass.

The FBSR technology immobilizes the LAW in a granular mineralized form, which is then mixed with a binder to produce a solid monolith product suitable for disposal at the IDF. The flowsheet for this case requires several connectivity changes when compared to the Baseline Case, and presupposes the successful development of several transformational technologies. These technologies are currently being developed and are summarized in Table 10-24.

Table 10-24. Case 7 Technology Development Overview

Functional area	Technology	Technology description	Potential application
WTP	Glass formulation improvement[a]	Optimizes glass formulations for HLW facilities; may include improvements to borosilicate glasses	This technology could increase waste loading and waste throughput, which would reduce cost and schedule to complete waste treatment at WTP.
Supple-mental Treatment	At-tank RMF[a]	Uses RMF to remove solids from the waste streams	RMF could be deployed inside or near waste tanks to supplement the WTP PT Facility. This allows filtered supernate to be routed directly to the cesium ion-exchange process.
	SCIX[a]	Uses SCIX units to remove cesium from the waste stream	Implementation of SCIX could reduce the demand on the WTP PT Facility and increase throughput.
	Macroencapsulation	Macroencapsulation is the process of surrounding one substance with another	This technology could be used to further package FBSR mineral product to ensure the FBSR product meets Hanford IDF disposal standards.
	FBSR[a]	FBSR implements steam reforming reactions in a fluidized particle bed to produce a mineral waste form	FBSR could be deployed to provide all or part of the waste treatment function currently allocated to the second LAW facility. This process produces a dry granular material, which is an insoluble mineral that must be macroencapsulated to meet Hanford IDF disposal standards.

[a] Transformational technology.

FBSR = fluidized bed steam reforming.
HLW = high-level waste.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
PT = pretreatment.
RMF = rotary microfiltration.
SCIX = small-column ion exchange.
WTP = Waste Treatment and Immobilization Plant.

The total number of fluidized bed steam reformers required, in this case eight, was determined by the total LAW treatment capacity required. The fluidized bed steam reformers would have two sources of feed: (1) the WTP PT Facility, and (2) a supplemental pretreatment system installed in the tank farms, which would include RMF and SCIX. RMF would remove solids from the LAW feed stream; SCIX would remove cesium from the LAW waste stream. The solids and the cesium would be routed back to the tank farms and added to the HLW feed stream.

Case 7 presents several potential benefits compared to the Baseline Case. The supplemental pretreatment system could be installed, commissioned, and begin hot operations approximately two years earlier than the WTP PT Facility, providing the opportunity to begin processing waste at an earlier date. This would have two benefits: (1) early waste treatment would provide an outlet for waste in the DST system, alleviating some of the waste storage space concerns that constrain SST waste retrievals in the period immediately preceding WTP operations, and (2) initiating the overall waste processing mission almost two years earlier reduces the required capacity of LAW treatment, and reduces life-cycle costs. One of the benefits of using an FBSR system is that it produces no secondary liquid waste during processing, thereby potentially reducing the projected amount of influent to the LERF/ETF and possibly reducing the needed capacity in that facility.

10.7.2 Planning Bases

Case 7 planning bases are described in Appendix B, Section B9.0.

10.7.3 Results

Table 1-1 (Section 1.3) and Table 10-25 compare the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 7 versus the Baseline Case. Key points are as follows.

- Case 7 meets all of the mission success criteria, except near-term funding targets. Additional details are provided in Section 10.7.4.
- The use of the enhanced HLW glass model in Case 7 leads to an 11.8 percent reduction in the mass of HLW glass.
- The combination of (1) an earlier LAW treatment start, (2) an increased LAW immobilization capacity, and (3) a higher WOL in the HLW glass model results in Case 7 completing all SST retrievals two years earlier (by September 9, 2037) and treating all tank waste 3.5 years earlier (by October 4, 2039) than the Baseline Case.
- Case 7 almost meets the case-specific goal of reducing the mission length by seven years. The PMB currently has the mission ending on December 31, 2045; Case 7 shortens that by nearly six years and ends on October 4, 2039.
- Case 7 does not meet the case-specific goal of a $16 billion reduction from the PMB life-cycle cost. The total reduction in life-cycle cost from the PMB is $4.3 billion, $11.7 billion short of the scenario purpose.

These results are discussed in more detail below.

Table 10-25. Mission Metrics Comparison for the Baseline Case and Case 7.

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 7: Enhanced tank waste strategy
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	$57.3 B
Meets near-term funding targets through 2015	$2,750M	$2,440 M	**$3,377 M**
Meets near-term funding profile through 2015	Note a	✓	**X**
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	9/16/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	10/24/2019
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	9/9/2037
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	10/4/2041
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	10/4/2039
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	12/18/2045
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	28,205
HLW glass canisters	–	10,586	9,340
HLW glass waste oxide loading	–	36.9%	41.2%
LAW glass mass (MTG)	–	527,838	0
LAW glass containers	–	95,825	0
LAW glass sodium oxide loading	–	17.8%	0
Sodium reporting to LAW glass (MT)	–	69,659	0
FBSR product (MT)	–	–	912,751
Sodium reporting to FBSR product (MT)	–	–	68,507
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.

Assumption B9.2.4.1 for Case 7 states:

> "If needed to meet the goal of completing the waste treatment mission seven years earlier than the Baseline Case, assume that the necessary design changes to the HLW Vitrification Facility have already been made to support next generation melters, not to exceed 1.5 times the Baseline capacity, starting at the first melter change-out."

During the modeling of this scenario, it was discovered that with the Baseline HLW vitrification capacity and the higher WOL facilitated by the enhanced HLW glass model, the WTP could process waste more quickly than it could be retrieved from the SSTs. Increasing the final WTP HLW vitrification capacity did not appreciably shorten the mission duration, so the final HLW baseline vitrification capacity of 5.25 MTG/d was used (Appendix B, Assumption B9.2.4.1). SST retrieval rates and IHLW and ILAW production are discussed in more detail in the subsections that follow.

As shown in Table 1-1 (Section 1.3) and Table 10-25, the use of the enhanced HLW glass model results in a 4.3 percentage point jump in WOL over the Baseline Case. The improved WOL reduces the HLW canister count from 10,586 in the Baseline Case to 9,340 in Case 7. The enhanced HLW glass model increases WOL by relaxing the SO_3, P_2O_5, and Bi_2O_3 constraints from the 2009 GFM that were used in the Baseline Case. Also, in the enhanced HLW glass model, the nepheline discriminator constraint was supplemented with an optical basicity constraint and relaxed for certain waste compositions. Further details on the enhanced HLW model are provided in Section 4.1.1 or PNNL-19372.

The sodium mass balance for System Plan (Rev. 6) Case 7 is shown in Figure 10-56. In Case 7, approximately 68,506 MT of sodium is incorporated into the ILAW, which is comparable to the 69,250 MT of sodium in the Baseline Case. The sodium management of Case 7 could be further optimized to reduce the demand on the WTP PT Facility and improve utilization of the supplemental pretreatment system.

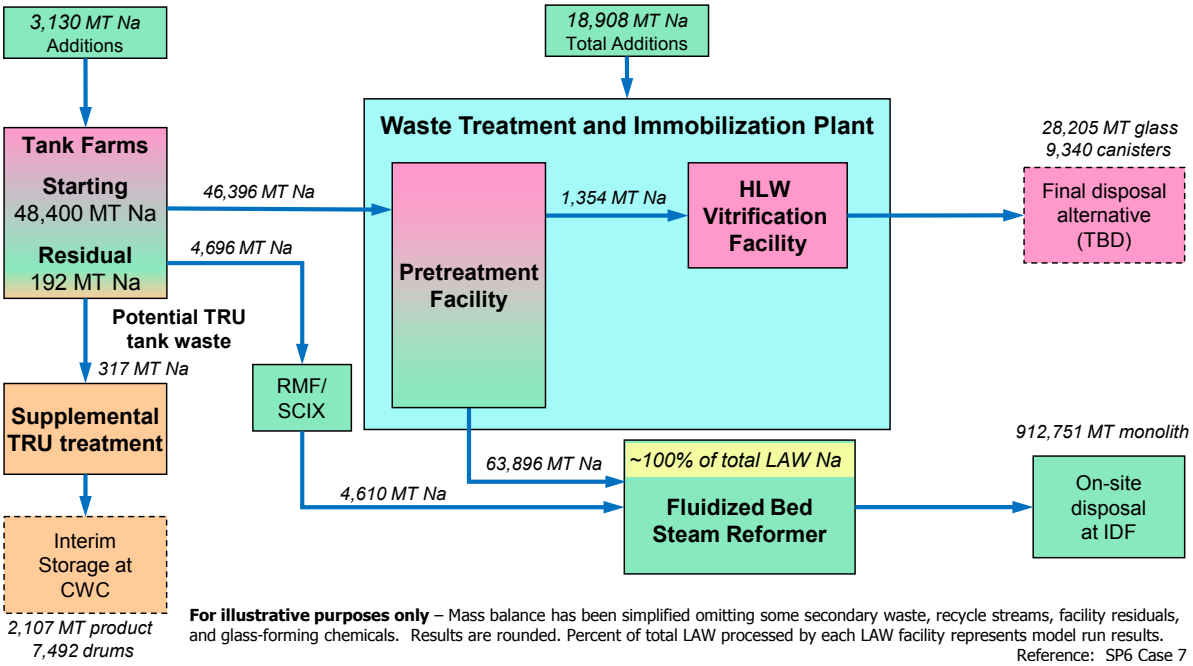

Figure 10-56. Simplified Sodium Mass Balance for Case 7

Figure 10-57 shows the overall SST retrieval progress for the System Plan (Rev. 6) Baseline Case and Case 7. The retrieval progress for both cases is identical until April 2016, at which point they begin to diverge. The earlier LAW treatment start date, the increased LAW immobilization capacity, and the enhanced HLW glass allow Case 7 to complete all SST retrievals two years earlier than the Baseline Case. The ability to process HLW sludge more quickly in Case 7 results in less demand on the DST space, so Case 7 does not have the extended SST retrieval outage that the Baseline Case does in 2025 - 2026.

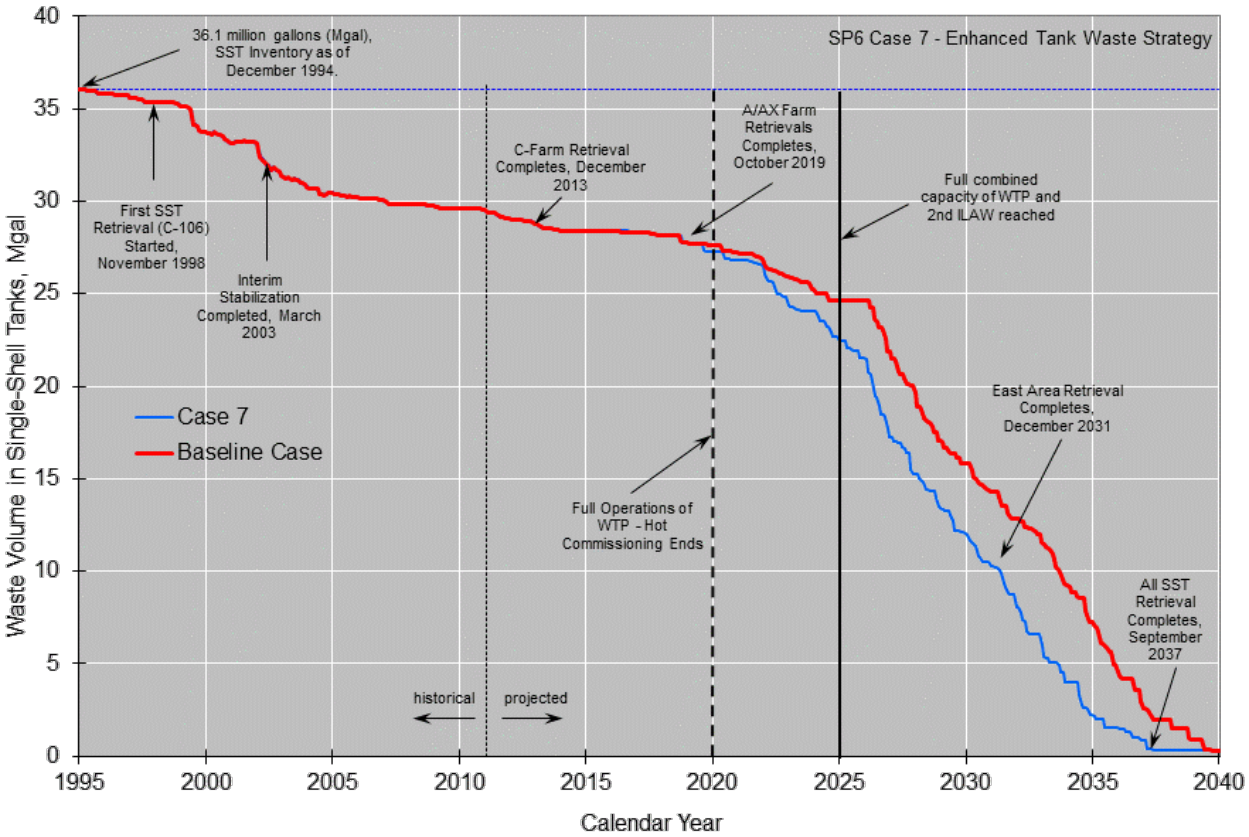

Figure 10-57. Overall Single-Shell Tank Retrieval Progress for Case 7

Figure 10-58 shows that Case 7 completes more retrievals per year and completes all SST retrievals two years earlier than the Baseline Case. In Case 7, the number of retrievals scheduled to complete per year peaks at 17, versus a peak of 11 retrievals completed per year in the Baseline Case. This increase in the required number of retrievals per year will place additional demands on the SST retrieval systems. It may be possible to reduce the retrieval peaks in Figure 10-58 by adjusting the SST retrieval sequence (e.g., in 2032 only five tanks are scheduled to complete retrieval; some of the 17 retrievals that were completed in 2031 could be adjusted to complete in 2032).

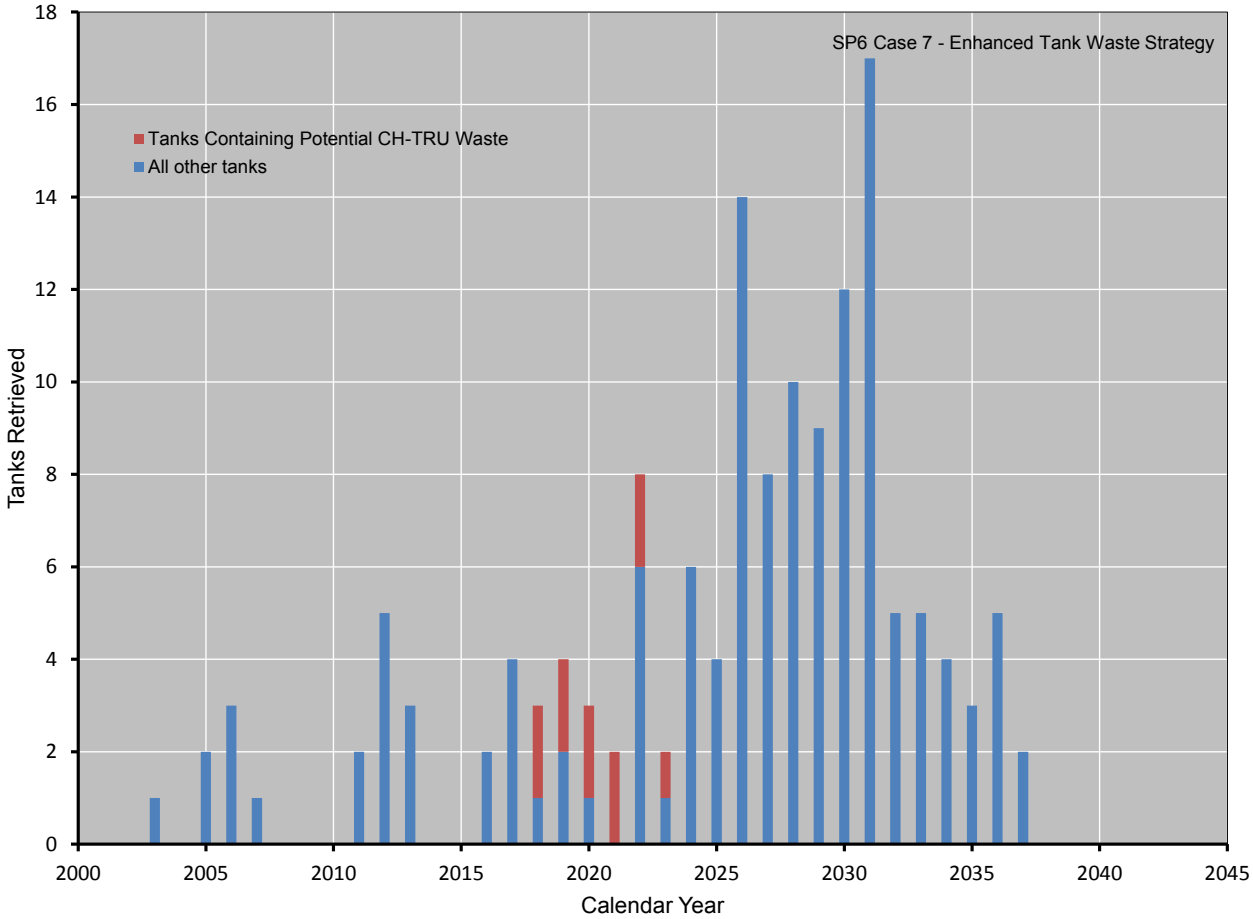

Figure 10-58. Single-Shell Tank Retrievals Completed per Calendar Year for Case 7

Figure 10-59 shows the running three-year average for SSTs retrieved per year for Case 7 and the Baseline Case. Figure 10-59 shows that Case 7 ramps up the SST retrieval rate earlier than the Baseline Case, and during the peak retrieval period, Case 7 retrieves approximately two SSTs per year more than the Baseline Case does. Both of these observations are consistent with the shorter overall SST retrieval duration for Case 7.

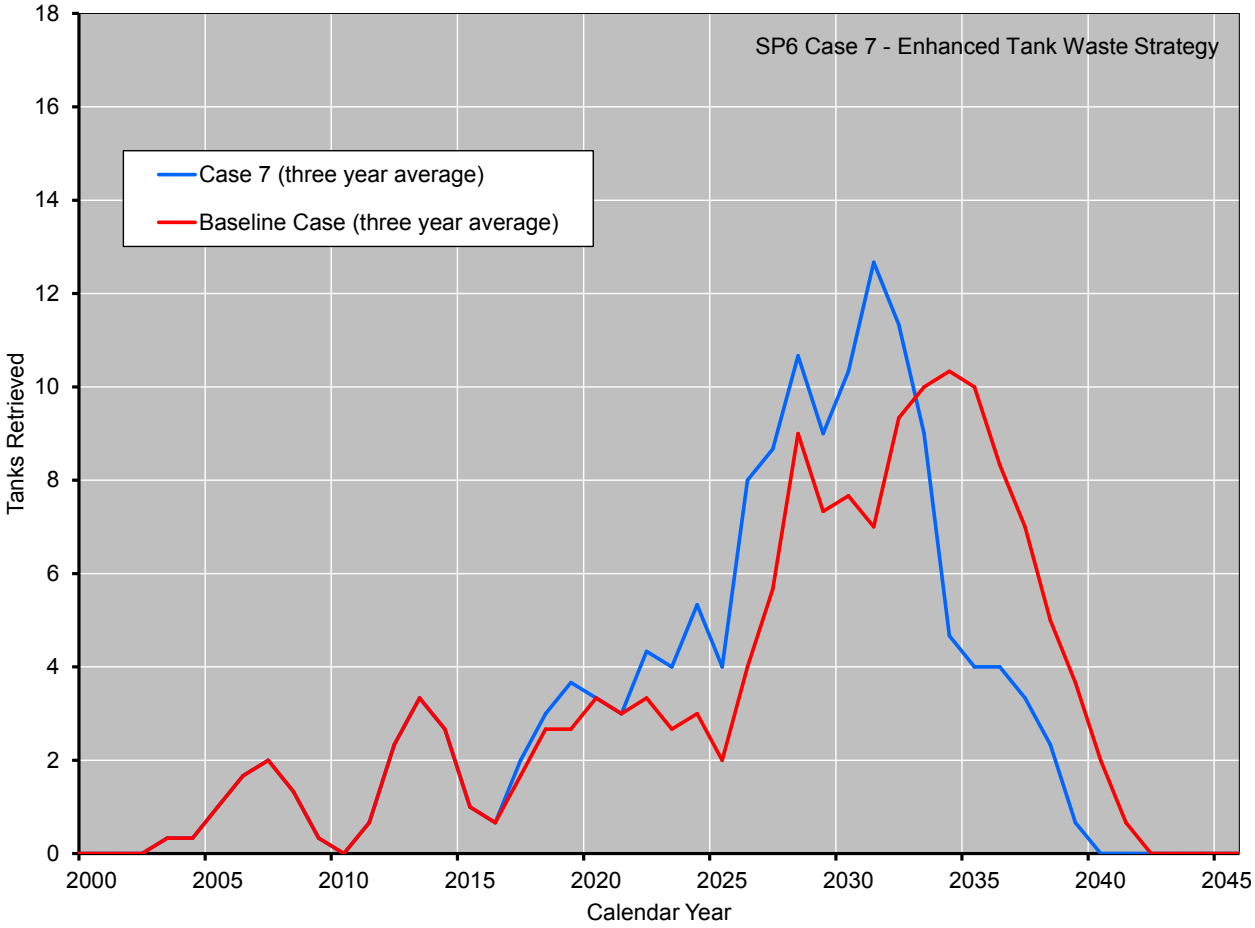

Figure 10-59. Three-Year Moving Average Single-Shell Tank Retrievals per Year for Baseline Case and Case 7

Figure 10-60 and Figure 10-61 show the general retrieval timing for the SST farms and the SST retrieval sequence timing, respectively. Both are very similar to the Baseline Case. The retrieval sequence for Case 7 is compressed by about two years compared to the Baseline Case, so in Case 7 there are fewer individual tanks with projected retrieval durations significantly longer than the minimum. Although the retrieval of two tanks (BY-101 and BY-111) takes significantly longer than the minimum retrieval duration, Case 7 does not experience the extended SST retrieval outage that the Baseline Case does during the 2025 – 2026 timeframe.

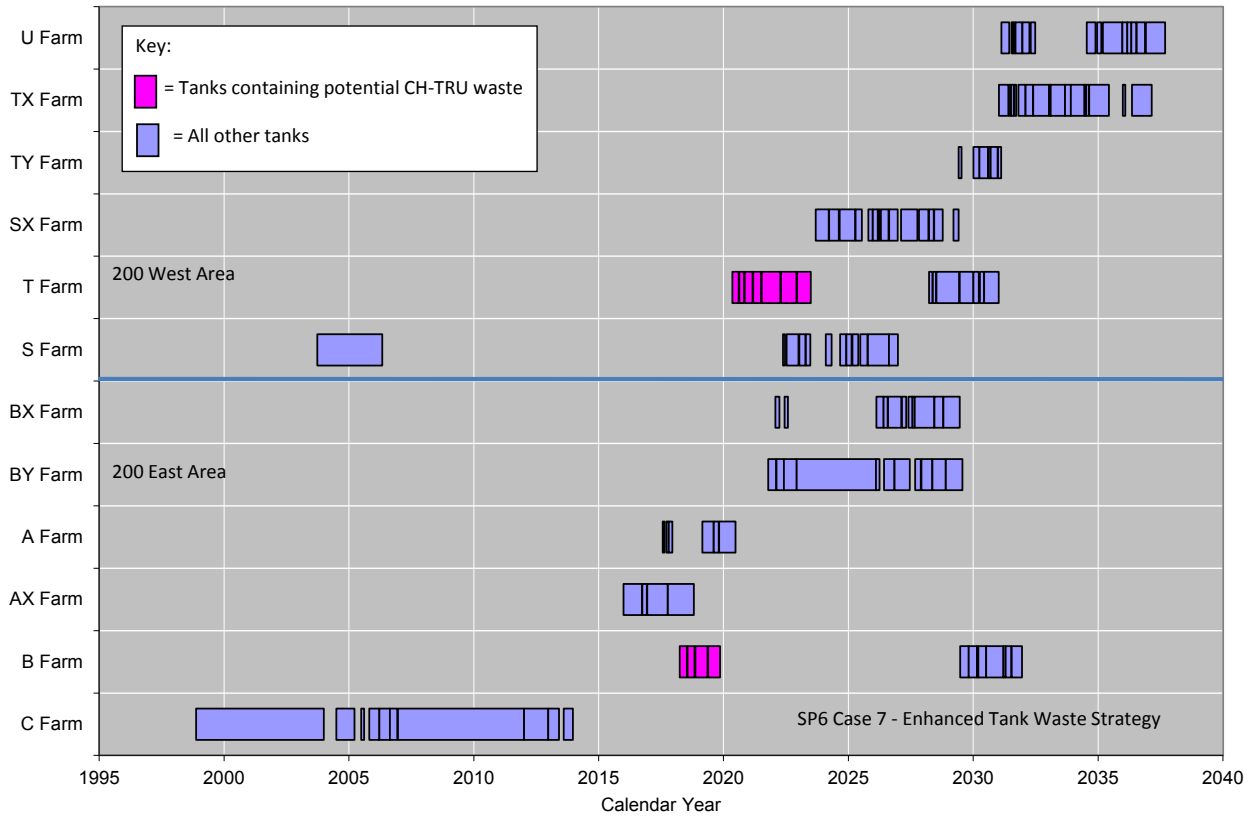

Figure 10-60. General Timing of Single-Shell Tank Farm Retrievals for Case 7

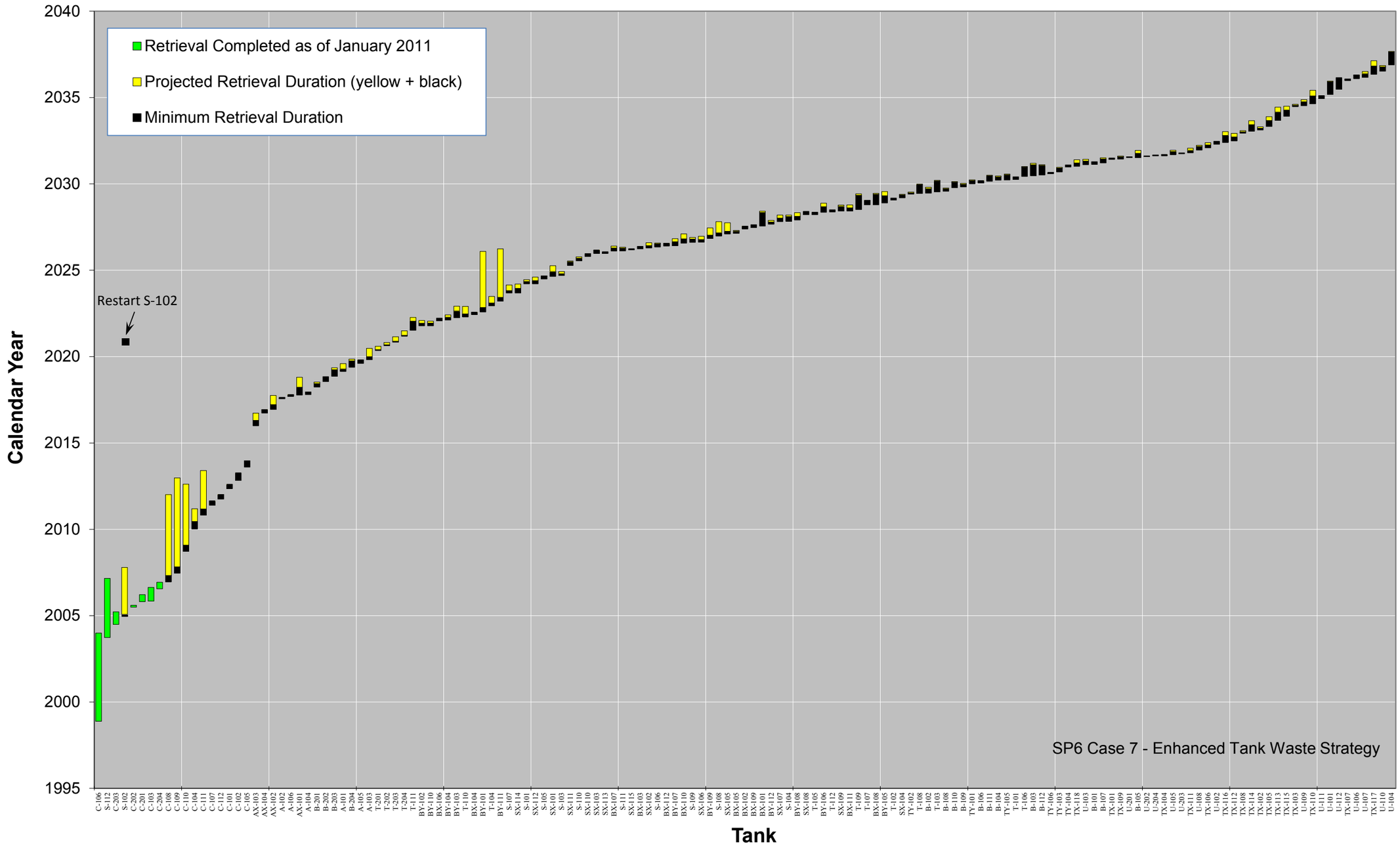

Figure 10-61. Single-Shell Tank Waste Retrieval Sequence and Timing for Case 7

Figure 10-62 shows the DST space for Case 7. The enhanced HLW glass model and the increased LAW immobilization capacity allow waste to be staged through the DST system more quickly than in the Baseline Case, so DST space is less of a mission driver in Case 7. DST space is most limited in Case 7 from October 2017 to January 2019, when the available DST space varies between 1.7–3.0 Mgal. After this time period, the amount of available DST space increases and is less constraining for Case 7 than the Baseline Case.

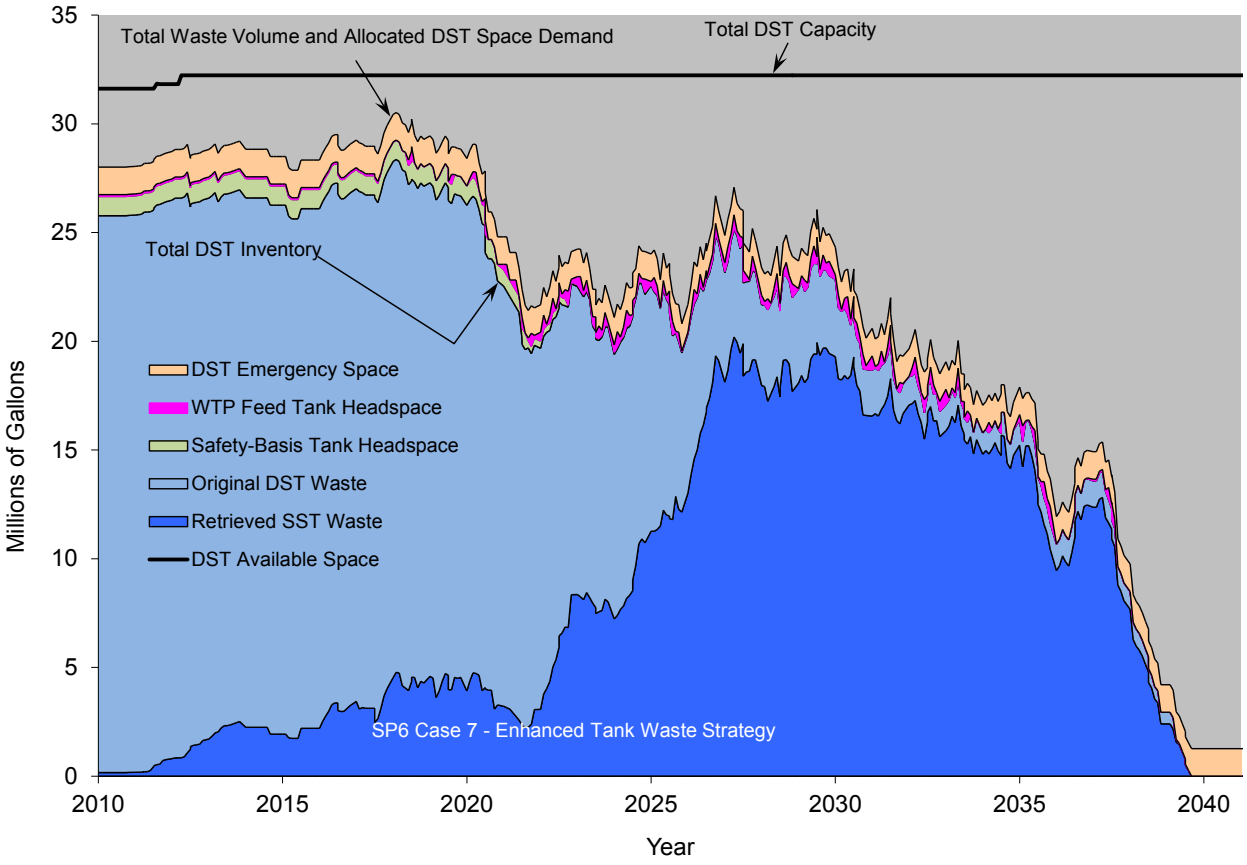

Figure 10-62. Use of the Double-Shell Tanks for Case 7

Figure 10-63 compares the IHLW production for Case 7 with the assumed net HLW vitrification capacity and the IHLW production for the Baseline Case.

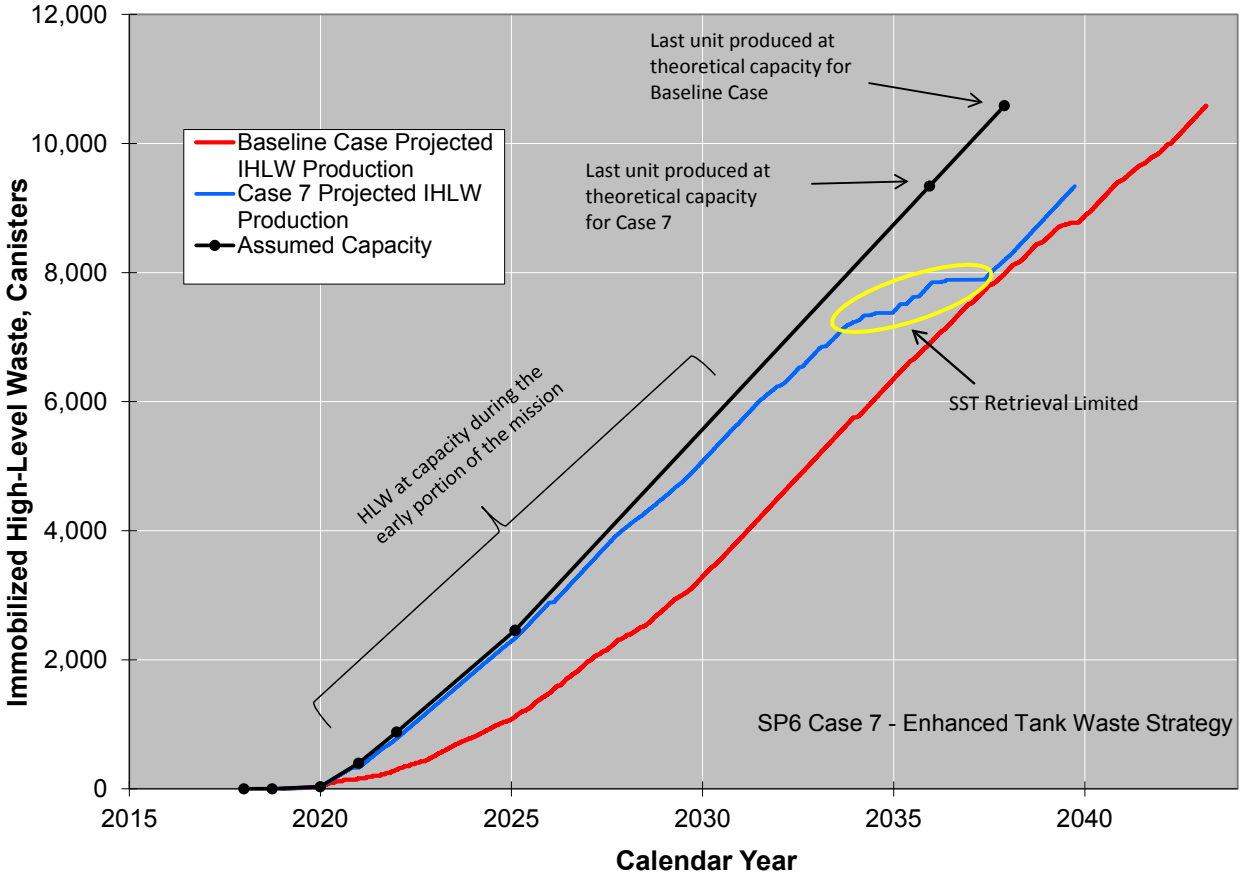

Figure 10-63. Projected Immobilized High-Level Waste Production for Case 7

Figure 10-64 illustrates the projected second LAW facility production of LAW glass in the Baseline Case compared to FBSR production of LAW monolith in Case 7.[80] The mineralized steam reformer products were assumed to achieve a comparable sodium loading as LAW glass, approximately 14 wt% sodium. However, once the mineralized product is assumed immobilized in monolithic form, the sodium loading in the final product is reduced to approximately half of what is expected in LAW glass, approximately 7 wt% sodium. In Case 7, the fluidized bed steam reformers processed only 2 percent less sodium than the Baseline Case, making the comparison of sodium between them reasonable. The monolithed FBSR product is also assumed to be less dense than LAW glass, resulting in a larger required volume to immobilize the same waste. When compared on a volume basis, the FBSR product is 2.4 times the volume of LAW glass for the same amount of sodium processed. For a comparison, if the FBSR product was packaged into the same volumetric spaces as a LAW container, the FBSR monolith product from Case 7 would fill 240,742 containers.

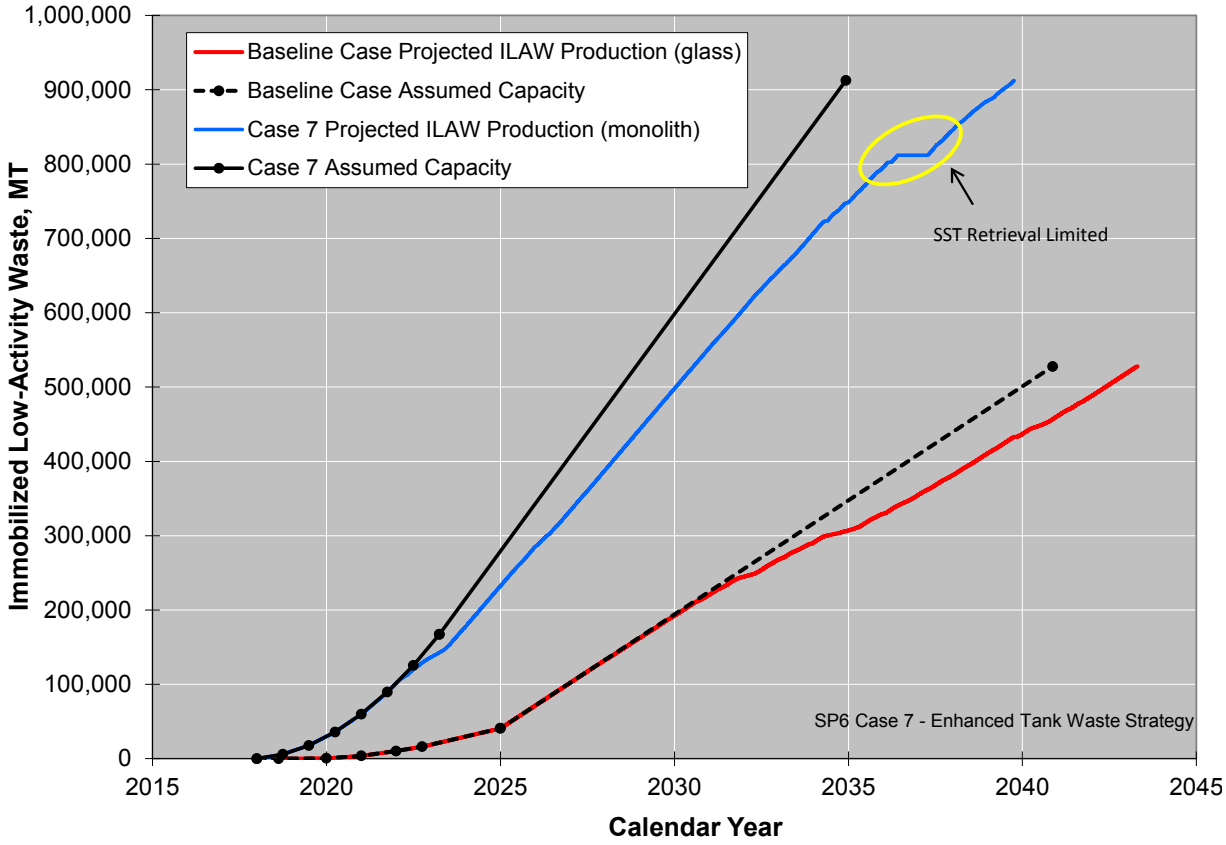

Figure 10-64. Projected Immobilized Low-Activity Waste Production for Case 7

[80] The final product of the supplemental LAW in Case 3 is reported in metric tons of immobilized mineralized steam reformer product in monolithic form, whereas in the Baseline Case, it is reported in containers of LAW glass. To make a direct comparison, the containers of LAW glass from the Baseline Case were converted to metric tons product.

Early in the Baseline Case, the projected IHLW production lags far behind the assumed HLW vitrification capacity. In Case 7, the IHLW production matches the assumed HLW vitrification capacity for much of the early portion of the mission. This change is due to a few assumptions unique to Case 7. In the Baseline Case, the final production rate ramp-up date for a second LAW facility is January 1, 2025, but in Case 7 the fluidized bed steam reformers reach their full capacity by April 1, 2023. In Case 7, an additional FBSR facility comes online every nine months, which allows the fluidized bed steam reformers to rapidly approach the maximum ILAW production rate of 175 MT product per day. During the final supplemental LAW treatment ramp-up for the Baseline Case, the ILAW production rate quadruples from 21 containers per day to 84 containers per day.

Prior to 2025, the baseline ILAW production rate is running far below the maximum, fully ramped ILAW production rate. For the Baseline Case, this results in the IHLW production rate being limited by ILAW production prior to 2025. Case 7 reaches its maximum LAW immobilization rate over 1.5 years earlier than in the baseline, and it more rapidly approaches this maximum immobilization rate than the Baseline Case does. This causes the production of IHLW to be the mission driver for much of the mission.

The projected IHLW production for Case 7 begins to significantly deviate from the assumed HLW vitrification capacity with an extended outage from circa 2036 – 2037. The ILAW production shows a similar outage from 2036 – 2037. During this period, both ILAW and IHLW production are SST retrieval limited. By these dates, nearly all of the original DST waste has been treated and the SSTs cannot be retrieved quickly enough to keep either the HLW melter or the fluidized bed steam reformers fed. During these feed outages, there is still waste in the heels of the DSTs that could be fed to the WTP, but at this point in the mission, the transfer pumps are not positioned so that they are capable of removing waste from the DST heels. If the waste retrieval strategy was altered so that DST closure and the completion of SST retrievals could occur in parallel, it would be possible to reduce the length of time that the mission is limited by the SST retrieval rate.

Figure 10-65 shows the glass drivers for Case 7. Figure 5-14 shows the same information for the Baseline Case. Key results for Case 7 are as follows:

- In Case 7, SO_3, Al_2O_3, and $T_{1\%}$-spinel are the primary glass drivers. Together these four constraints are the glass drivers for 86.4 percent of the IHLW.
  - In the Baseline Case, the four primary glass drivers are SO_3, Bi_2O_3, $T_{1\%}$-spinel, and the nepheline discriminator. Cumulatively, these four constraints limit 89.8 percent of the IHLW.
- With the relaxed Bi_2O_3 constraint in Case 7, no batch is limited by Bi_2O_3.
- Most of the HLW batches that were limited by Bi_2O_3 in the Baseline Case are limited by SO_3 in Case 7, so even though the enhanced HLW glass model relaxes the SO_3 constraint, more HLW batches are limited by SO_3 in Case 7 than they were in the Baseline Case.
- Relaxing the nepheline discriminator for certain waste composition and supplementing it with the optical basicity constraint causes the number of batches limited by nepheline to drop in Case 7.
- A majority of the batches that were limited by the nepheline discriminator in the Baseline Case are limited by the Al_2O_3 constraint in Case 7.

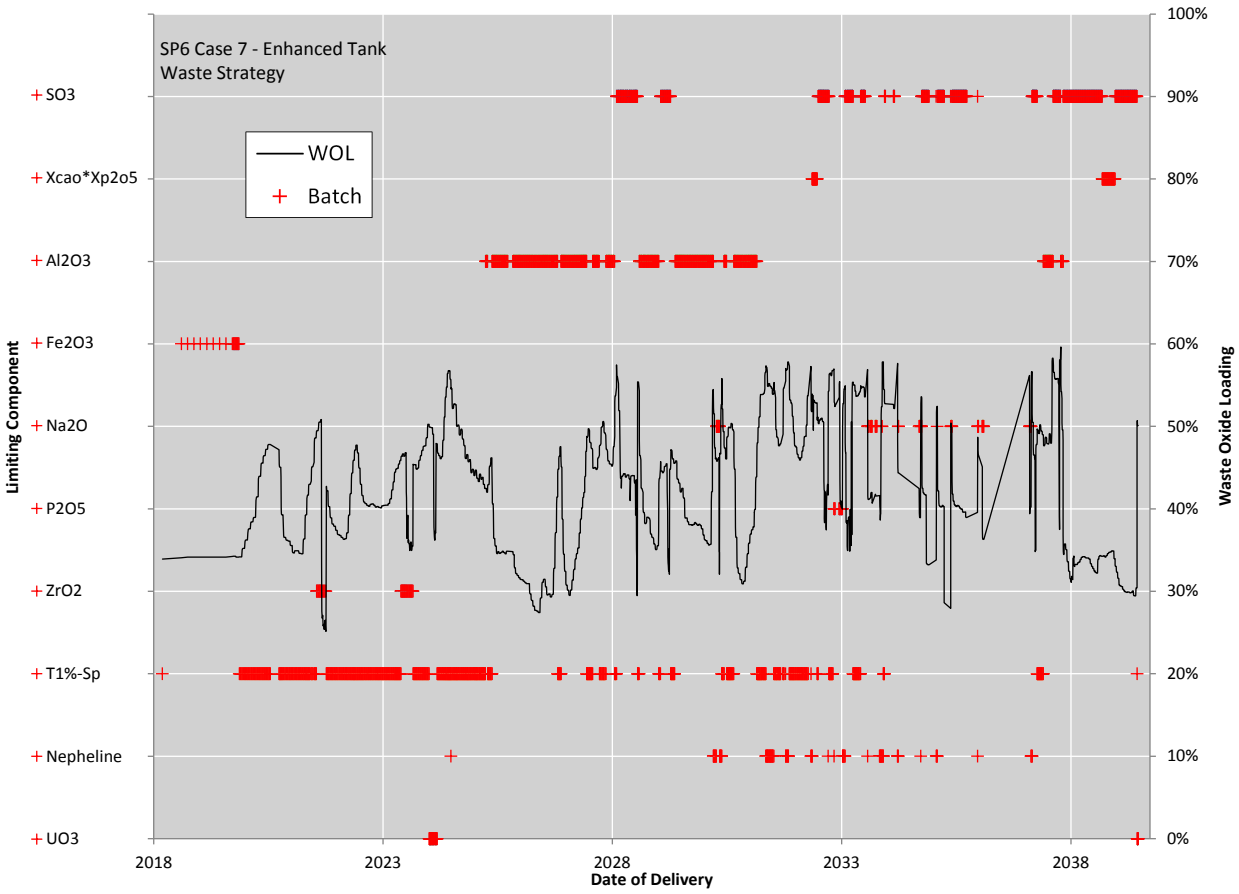

Figure 10-65. High-Level Waste Glass Drivers and Waste Oxide Loading versus Time for Case 7

In Case 7, the SST closure schedule is accelerated by approximately two years relative to the Baseline Case, because the use of RMF and SCIX units and fluidized bed steam reformers enables completion of SST retrieval approximately two years earlier. Closure program scope would be expanded to include RMF and SCIX units, and eight fluidized bed steam reformers.

10.7.4 Cost and Schedule Impacts

The life-cycle cost for Case 7 is $57.3 billion, which is 4.3 percent less than the Baseline Case life-cycle cost of $59.9 billion. In comparison to the Baseline Case, much of the cost savings for Case 7 is due to the elimination of a second LAW facility and the three-year earlier mission completion date.

The near-term criteria dates are very similar for Case 7 and the Baseline Case. However, in the out-years, Case 7 achieves earlier completions than the Baseline Case for all criteria. SST retrieval is completed two years earlier, DST retrievals end about 2.5 years earlier, and all waste is treated 3.5 years earlier. Additionally, the mission completes earlier, resulting in a reduction in life-cycle cost of about $3 billion. However, the higher near-term costs for Case 7 result in an overall savings of about $2.6 billion.

Case 7 requires about $3 billion for design, construction, and startup of the fluidized bed steam reformers. A portion of those costs, and the costs to deploy the supplemental pretreatment technologies, are incurred in the 2011 - 2015 timeframe, causing the near-term funding requirements for Case 7 to exceed the targets by a total of $627 million (see Table 10-26). This is a $937 million increase over the Baseline Case near-term funding requirements. An additional $5.5 billion is required for FBSR operations, and nearly $1 billion is required for decontamination and decommissioning (D&D). The savings due to elimination of a second LAW facility, an earlier waste treatment completion date, and a reduced operating cost for WTP[81] (not operating the WTP LAW Vitrification Facility saves $101 million annually) more than offset the increased cost due to fluidized bed steam reformers. Altogether, Case 7 costs $2.6 billion less than the Baseline Case and $4.3 billion less than the PMB; $11.7 billion short of the scenario purpose. The life-cycle cost profile for Case 7 is illustrated in Figure 10-66.

Table 10-26. Near Term Funding Targets and Results for Case 7

FY	Target[a] ($M)	Case 7[a] ($M)
2011	410	422
2012	510	538
2013	510	598
2014	610	715
2015	710	1,104
Total	**2,750**	**3,377**

[a] The values in this table include only base funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

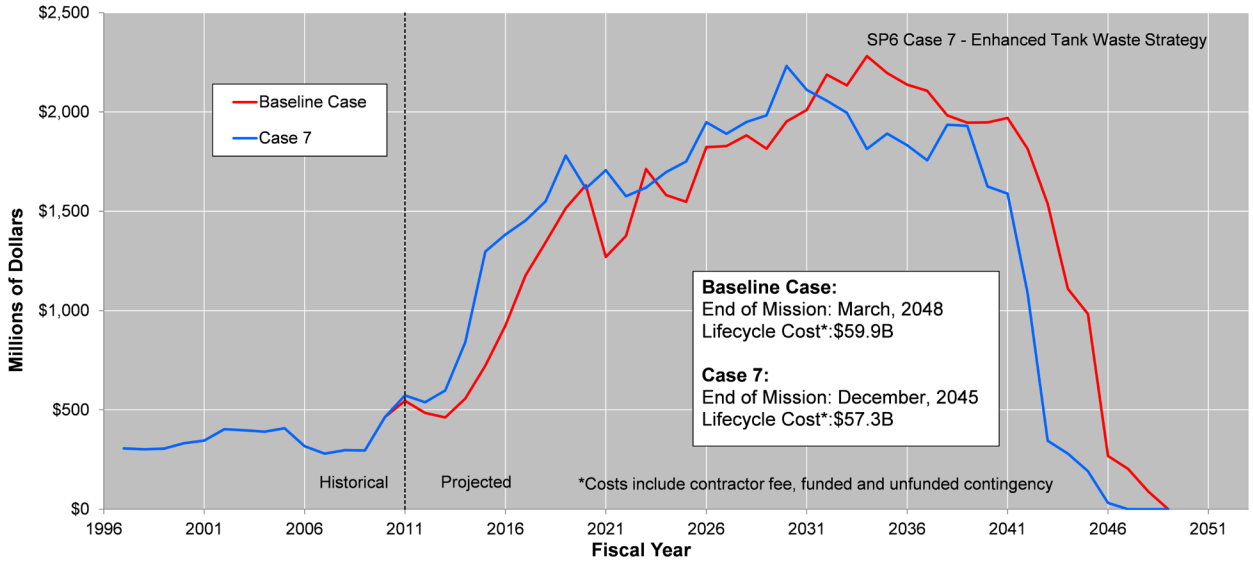

Figure 10-66. Life-Cycle Cost Profile for Case 7

[81] For this scenario, only the reduced operating cost from not running the WTP LAW Vitrification Facility was accounted for in the cost analysis. Any decision to stop construction activities on the LAW Vitrification Facility and any corresponding contract remedies would be cost adjustments to ORP-0060 and do not impact dollars represented in the System Plan (ORP-0014). Additionally, costs associated with D&D of the LAW Vitrification Facility were applied at the end of the mission at the same time as the WTP HLW and PT Facilities D&D. The rough-order-of-magnitude estimate for the D&D cost of the entire WTP from the PMB was applied.

10.7.5 Key Issues and Vulnerabilities

The following issues from the Baseline Case are impacted by Case 7.

- Item 7.2-1 (SST bulk retrieval methods) is impacted by Case 7 due to the need to retrieve the same number of SSTs in a shorter period of time than in the Baseline Case.
- Item 7.5-1 (WTP hot commissioning) is modified since in Case 7 all LAW is processed through the fluidized bed steam reformers.
- Item 7.5-4 (2009 GFM) is impacted by Case 7 due to the use of an enhanced 2009 GFM that adds uncertainties beyond that of the basic 2009 GFM.
- Item 7.5-6 (LAW glass composition estimates) is eliminated for Case 7 since all LAW is processed through the fluidized bed steam reformers.
- Item 7.8-3 (Supplemental LAW treatment capacity) is eliminated since all LAW treatment is provided by the fluidized bed steam reformers.
- Item 7.8-10 (IDF will provide permanent disposal for ILAW) is impacted by Case 7 since it produces 2.5 times by volume FBSR product than the LAW glass produced in the Baseline Case.
- Item 7.8-11 (LAW melter replacement) is eliminated since LAW melters are not used in Case 7.

Case 7 introduces the following new issues and identifies potential mitigating actions or contingency measures.

- RMF, SCIX, FBSR, and other supporting technologies (e.g., macroencapsulation) are transformational technologies, which require additional development prior to proposed deployment and operation.
  - This issue may be mitigated by accelerating work to progress the technologies to the needed TRL for deployment and operation.
- The ability of RMF and SCIX to provide a pretreated LAW stream that meets feed requirements has not been verified.
  - This issue may be mitigated by performing further tests with Hanford simulants.
- The ability of FBSR to produce a product that will meet all acceptance criteria for disposal has not been verified.
  - This issue may potentially be mitigated by completing work on the supporting technology of macroencapsulation and by performing further tests with Hanford simulant to ensure that all ILAW acceptance criteria are met.
- To achieve the early start date of January 1, 2018 for supplemental LAW treatment, an acceleration of the CD process is required, along with a rapid waste form qualification process and a large increase in near-term funding.
  - No potential mitigating actions are known at this time.

- The partially completed WTP LAW Vitrification Facility would be abandoned. This may not be a programmatically feasible option.
  - No potential mitigating actions are known at this time.
- Starting on January 1, 2018, one 72-in. inner diameter FBSR column comes online every nine months. It may be challenging to support this schedule.
  - This issue may be mitigated by evaluating FBSR facility construction and startup long-lead activities and allocating resources to maximize efficiencies.
- A readiness review may be required if the HLW facility is without feed for an extended period of time.
  - No potential mitigating action at this time.

10.8 CASE 8 – ACCELERATED SINGLE-SHELL TANK RETRIEVALS

Selected by: Ecology

Purpose: Demonstrate the effect on mission duration of using an alternative SST retrieval approach that decouples near-term SST retrievals from DST tank space limitations to:

- Mitigate SST retrieval delays for any reason
- Level-load SST retrievals throughout the mission
- Accelerate closure of T Farm WMA separate from the TX Farm and TY Farm WMA.

10.8.1 System Description

There are few physical differences between the Baseline Case and Case 8. All facilities, with the exception of the elimination of the potential CH-TRU waste packaging system and some T Complex configuration changes, are assumed to be the same as the Baseline Case. The accelerated SST retrievals case consists of retrieving the waste from T Farm SSTs, including SSTs that contain potential CH-TRU waste, into select sound TX Farm SSTs (pending approval from Ecology, see discussion below). The T Farm waste would be retrieved directly into TX Farm tanks, with T Farm sludge being layered on top of the waste already stored in the TX Farm receivers. Upon completion of retrievals, the TX Farm receivers will be returned to an interim stabilized status, with supernate being pumped out of the TX Farm tanks for concentration and storage in the T Complex WRF, pending transfer to the DSTs as space becomes available.

The accelerated retrievals scenario assumes that several TX Farm SSTs could be placed back into service for the purpose of receiving waste. Implementing this strategy would require a disciplined engineering approach to select and qualify candidate SSTs as sound and fit-for-use. The proposed selection process would screen SSTs to identify the best candidates for use based on available data, such as operation histories, design data, ex-tank monitoring data, and other information. Candidate SSTs identified by the selection process would be further evaluated during a qualification process. Potential qualification actions include upgrading in-tank equipment and performing an in-service leak check. During this test, batches of supernate would be added to the candidate receiver tanks with a hold time for leak detection monitoring between each addition. The supernate would then be decanted, and (assuming the test was successful) retrieval would continue at a standard pace. SSTs are not currently approved to receive consolidated waste. Reuse of selected SSTs would require approval from Ecology. Specific exemption from secondary containment requirements for RCRA tanks would be required. Additional details are provided in RPP-RPT-47282, *Data to Support the Regulatory Evaluation of Single-Shell Tank Waste Staging*.

The T Complex WRF will be used to manage liquid waste throughout the accelerated retrievals scenario. As necessary during the retrieval of the T Farm tanks to the TX receivers, supernate will be transferred to the WRF where a wiped film evaporator (WFE) will be used to provide evaporative capacity. A simplified flowsheet for Case 8 is provided in Figure 10-67.

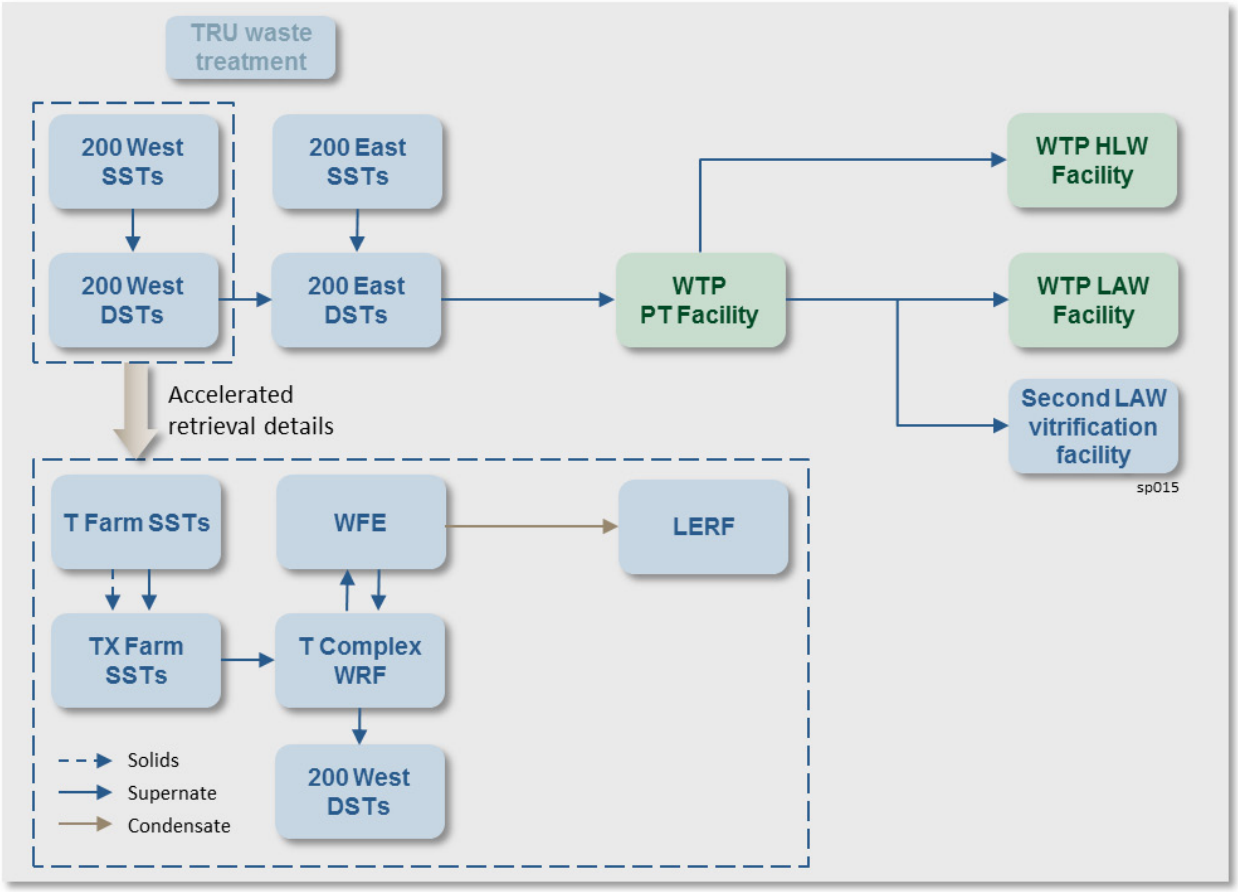

Figure 10-67. Simplified Flowsheet for Case 8

The accelerated retrievals case relies on several of the transformational technologies discussed for the Baseline Case in Section 6.0. In addition, this case will require technology development in the area of SST integrity analysis to ensure that the TX Farm receivers are fit-for-use. Table 10-27 highlights the anticipated technology development needed to support accelerated retrievals.

Table 10-27. Technology Development Overview (Case 8: Accelerated Single-Shell Tank Retrievals Case)

Functional area	Technology	Technology description	Potential application
Tank farms	MARS[a]	A device that allows different types of retrieval tools to be deployed throughout the tank	This technology would be used for retrieval of waste from SSTs. Two versions of MARS are under development: one uses a sluicing head and one uses a vacuum system.
	Enhanced chemical cleaning	Considers chemical treatments to assist with tank retrievals; may include high molarity caustic addition followed by water addition, or oxalic acid cleaning subsequently neutralized with caustic	Sluicing hard heel materials has limits, and potential in-tank obstructions can limit the range and effectiveness of retrieval equipment. Chemical treatment could improve overall retrieval efficiency.
	Wiped-film evaporator[a]	A modular, transportable at-tank system to concentrate various waste supernate streams	This technology would provide additional process capacity to evaporate SST waste, DST waste, and secondary waste, and would provide backup for the existing 242-A Evaporator facility.
	Tank integrity tools and methods	Adaptation of ultrasound probes, in-tank corrosion probes, chemical sensors, non-destructive examination methods	This technology supports the long-term use of SSTs.
	Tank qualification methods	Development of tank leak integrity qualification methods, including non-destructive examination methods, examination of in-tank equipment steel, and in-process leak check methods	This technology supports the reuse of sound SSTs.
	Tank closure methodology	Development and testing of various grout formulations for closure operations	This technology encapsulates waste tank residual heels and prevents subsidence of closed waste tank structures and other ancillary equipment, assuming future landfill closure of waste management areas.

[a] Transformational technology

DST = double-shell tank.
MARS = mobile arm retrieval system.
SST = single-shell tank.

10.8.2 Planning Bases

Case 8 planning bases are described in Appendix B, Section B10.0.

10.8.3 Results

Table 1-1 (Section 1.3) and Table 10-28 show the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 8 versus the Baseline Case and Case 2. As Case 8 shares the Case 2 assumption that all potential CH-TRU tank waste is delivered to the WTP, the comparisons in this section are primarily to the Case 2 results rather than with the Baseline results.

Table 10-28. Mission Metrics Comparison for the Baseline Case, Case 2, and Case 8

Metric (milestone)	Success criteria	System Plan (Rev. 6): Baseline Case	Case 2: TRU waste to WTP	Case 8: Accelerated retrieval
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	$61.6 B	**$62.8 B**
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,400 M	$2,413 M
Meets near-term funding profile through 2015	Note a	✓	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	7/23/2017	7/23/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	12/16/2020	12/16/2020
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	9/25/2040	3/27/2040
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	10/20/2044	**4/21/2044**
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	5/13/2044	6/7/2045
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	6/1/2049	5/31/2050
Complete potential TRU tank waste packaging	–	7/13/2023	–	–
HLW glass mass (MTG)	–	31,968	34,884	37,137
HLW glass canisters	–	10,586	11,552	12,298
HLW glass waste oxide loading	–	36.9%	35.3%	36.3%
LAW glass mass (MTG)	–	527,838	533,110	527,819
LAW glass containers	–	95,825	96,782	95,822
LAW glass sodium oxide loading	–	17.8%	17.7%	17.9%
Sodium reporting to LAW glass (MT)	–	69,659	70,109	70,018
FBSR product (MT)	–	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–	–
LiHT by-product (MT)	–	–	–	–
Potential TRU tank waste drums	–	7,492	–	–

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

Key results for Case 8 are as follows:

- Case 8 meets all mission success criteria, except:
  - Life-cycle cost
  - Close all SSTs
- In Case 8, SST retrievals were completed six months earlier than in Case 2.
- Despite the improvement in SST retrieval completion, Case 8 completed all tank waste treatment more than a year later than the Case 2.

10.8.3.1 SST Retrievals

Figure 10-68 depicts the shifts in SST retrievals compared to Case 2 and the Baseline Case. In Case 8, the SST retrievals are projected to be completed in March 2040, which is approximately six months earlier than Case 2. That six-month acceleration can be traced to the 2022 – 2025 timeframe, when T Farm tank waste is retrieved and staged into select, sound SSTs, not DSTS, as in Case 2. Once T Farm retrievals are completed in October 2025, the Case 8 retrieval rates nearly parallel the Case 2 retrieval rates. In 2028, the Case 8 retrievals begin to slow to a point where Case 2 retrievals catch up in 2034. After 2034, retrievals in both cases are on a similar pace.

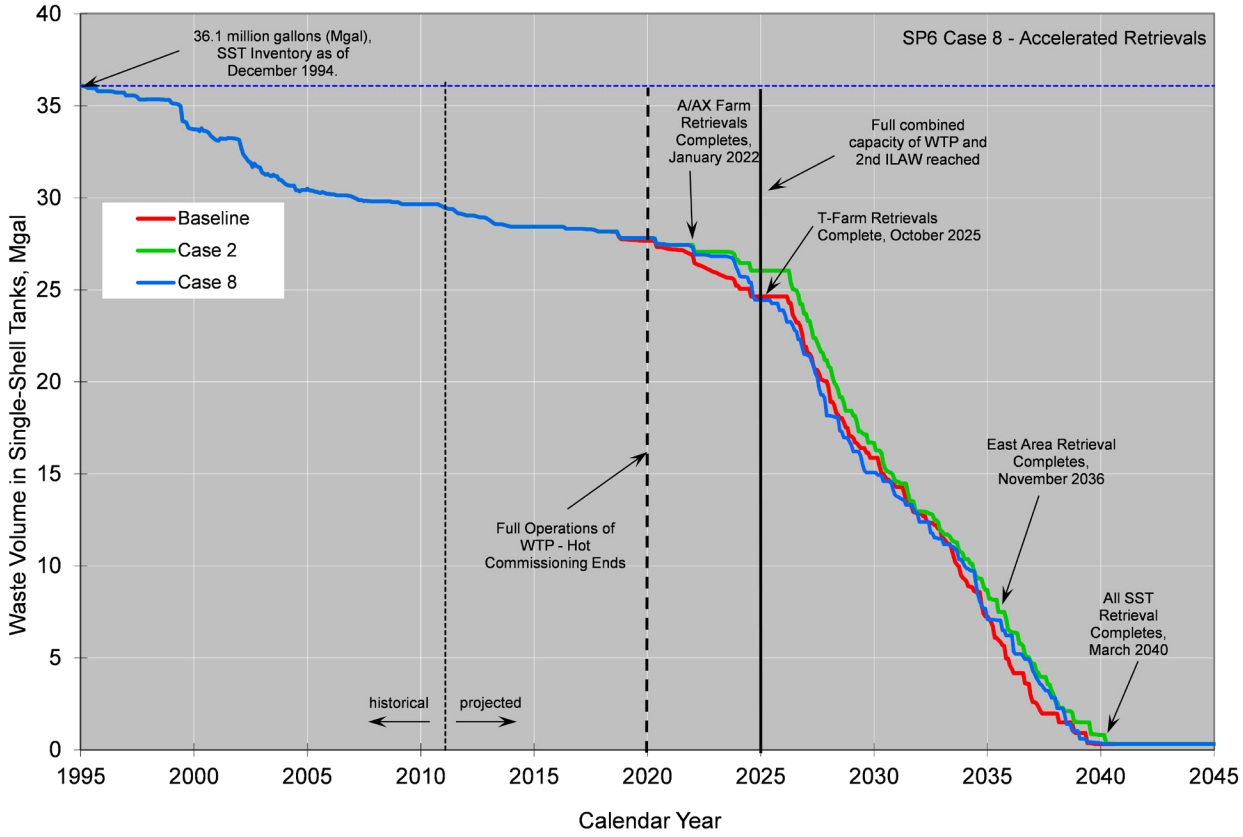

Figure 10-68. Single-Shell Tank Retrieval Progress for Case 8

Figure 10-69 shows the number of SSTs projected to be retrieved per year for Case 8. The Case 8 scenario allows for a more level yearly retrieval rate. Between 2021 and 2025, Case 8 projects 23 retrievals while Case 2 projects only six retrievals.

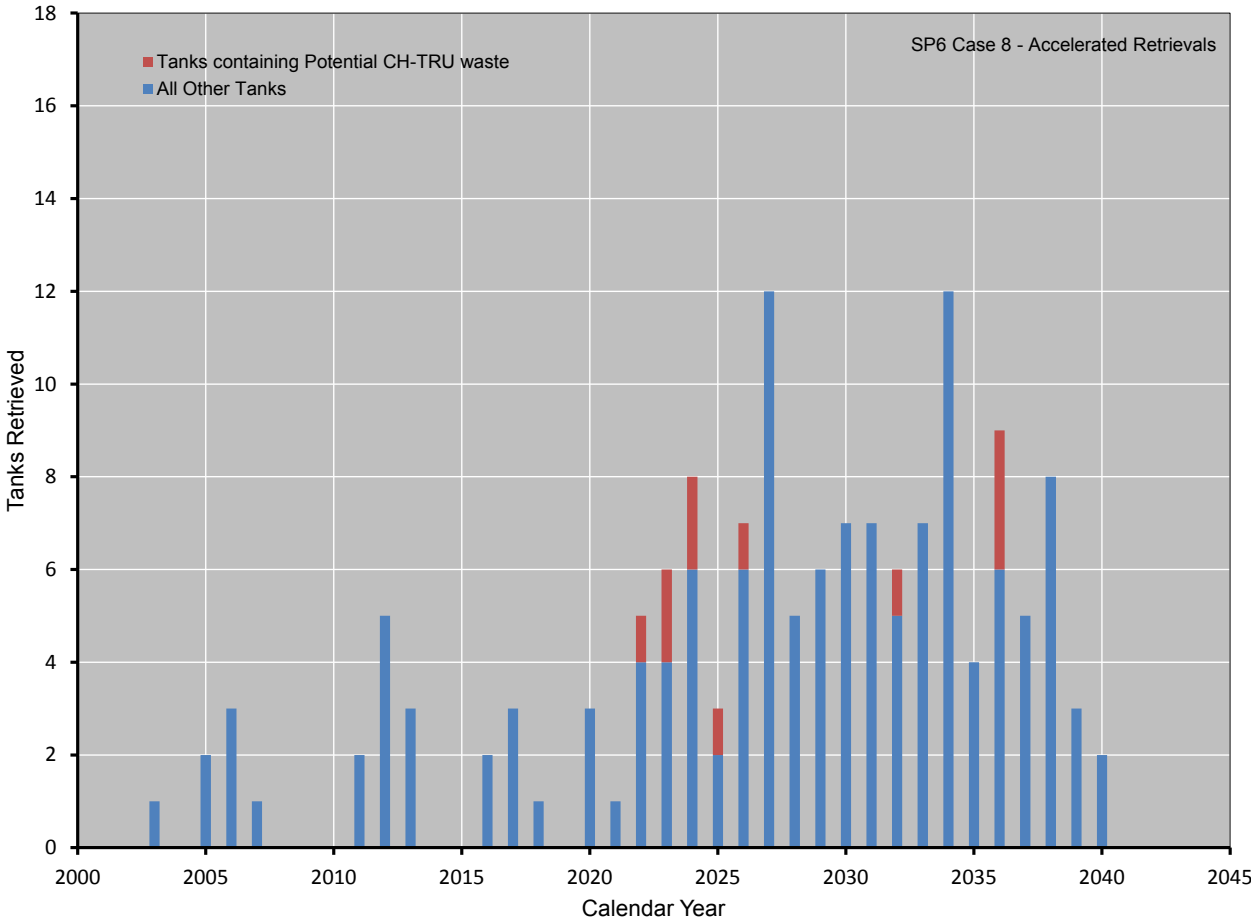

Figure 10-69. Single-Shell Tank Retrievals Completed per Calendar Year for Case 8 and Case 2

Figure 10-70 shows the three-year moving average of retrievals for the Baseline Case, Case 2, and Case 8. Case 8 levels out SST retrieval rates across the mission by starting the retrieval of T Farm earlier and reducing the maximum number of retrievals per year from 14 in Case 2 to 12 in Case 8. The maximum three-year moving average of retrievals in Case 8 is approximately eight, while Case 2 has a maximum of 11 and the baseline has a maximum of approximately 10.

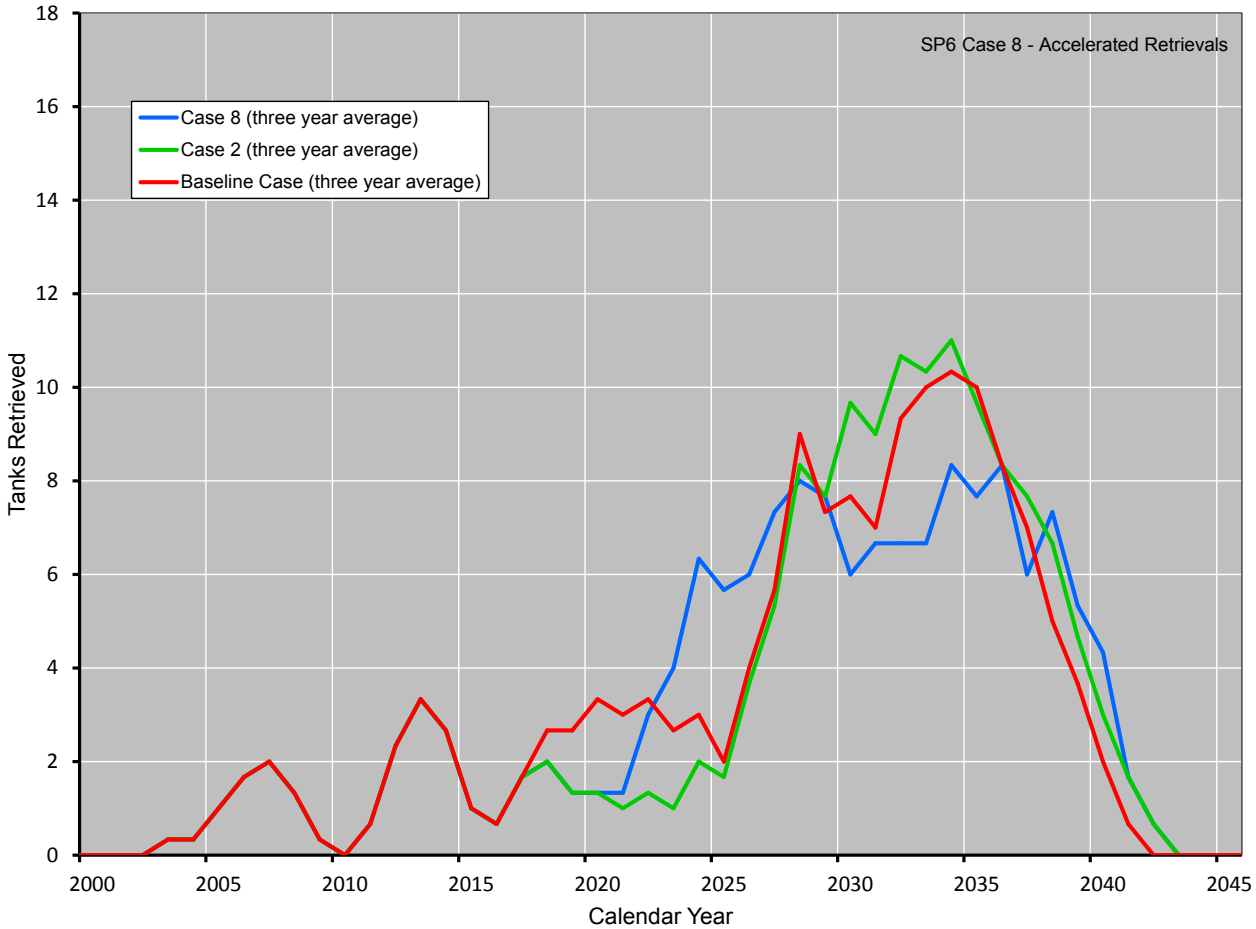

Figure 10-70. Three-Year Moving Average Single-Shell Tank Retrievals for the Baseline Case, Case 2, and Case 8

Case 8 has further potential to pull retrievals up by an additional two years, which would put at least one retrieval in 2018, a year that currently has no projected retrievals. Case 8 included the assumption that T Farm retrievals would not commence until the nine Consent Decree retrievals are completed. Retrieval of SST A-104, the final Consent Decree tank, completes in December 2020. However, as Case 8 assumed that the T Complex WRF is available for use in June 2018, the T Farm retrievals could be started in 2018 rather than 2021. Starting T Farm retrievals in 2018 would fill in the retrieval gap currently seen in 2019.

Figure 10-71 shows the general timing of SST farm retrievals for Case 8. This figure can also be compared to Figure 5-5 for the Baseline Case and Figure 10-2 for Case 2. In Case 8, the T Farm retrievals occur earlier in the mission, and the TX Farm retrievals start and end sooner than in Case 2.

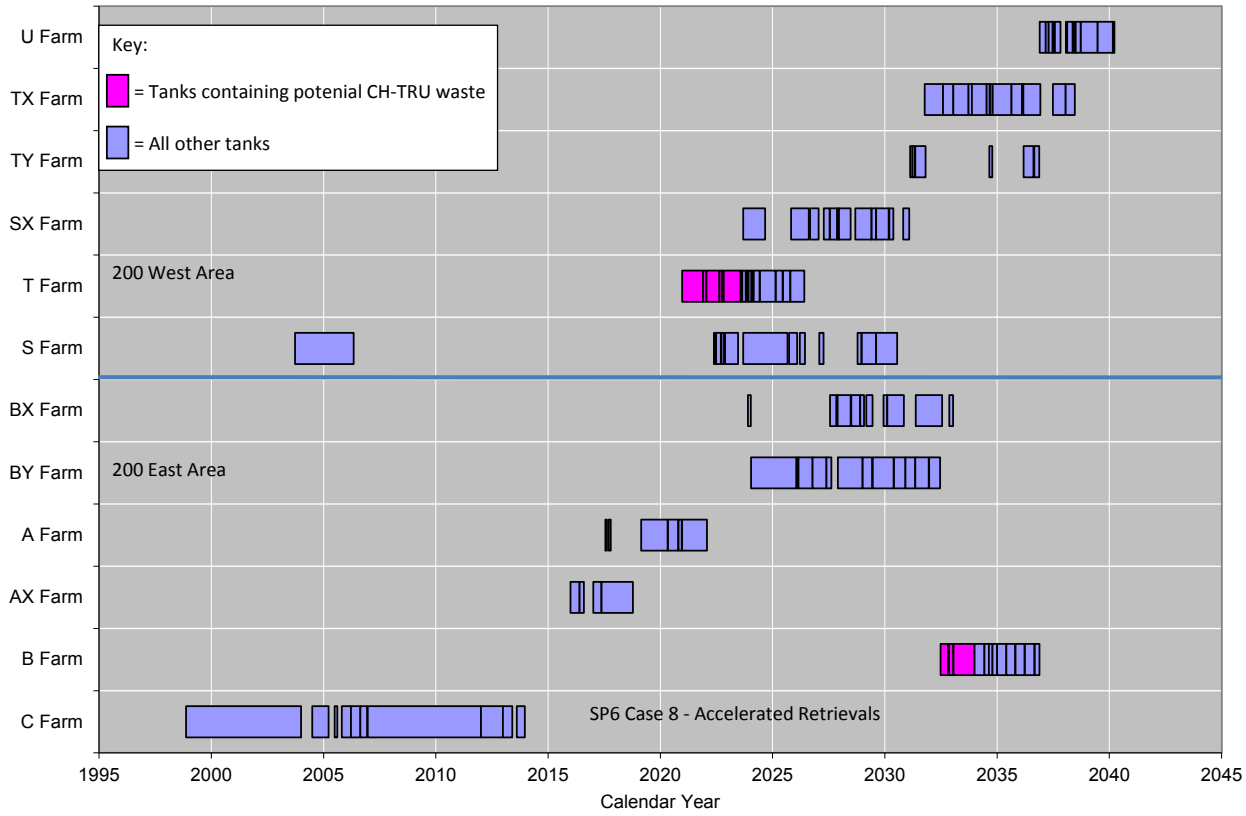

Figure 10-71. General Timing of Single-Shell Tank Retrievals by Tank Farm for Case 8

Figure 10-72 shows the sequence and timing of each SST retrieval. The minimum retrieval durations are shown in black, with the durations projected to be achieved for each tank shown in yellow. When the minimum retrieval duration is exceeded for a given tank, the DSTs are either full or not available for retrievals (i.e., locked out for equipment installation, being used for blending operations, etc.), and completion of the retrieval has to wait until more space becomes available. In Case 2, there is a distinct break in retrievals from approximately 2022 – 2024 and from approximately 2024 – 2026, three tank retrievals are delayed (see Figure 10-6).
Figure 10-72 shows that in the Case 8 scenario, both the 2022 gap and 2024 slowdown have been filled with ongoing retrievals.

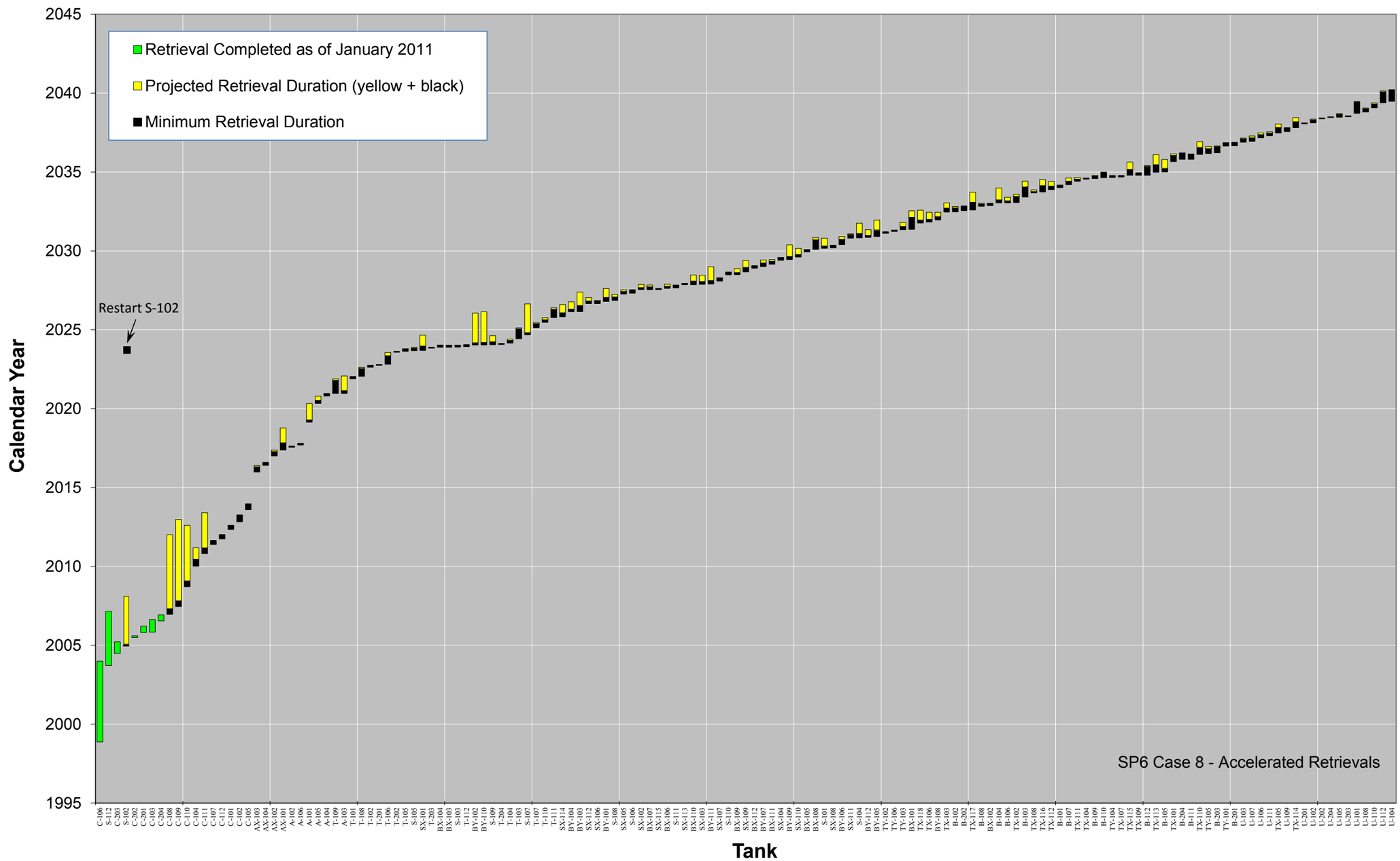

Figure 10-72. Single-Shell Tank Retrieval Sequence and Timing for Case 8

10.8.3.2 DST Space

Figure 10-73 shows the DST space utilization for Case 8. When compared to Case 2, the figure below shows that in Case 8, the DST system remains slightly fuller until later in the mission, which is expected as retrievals finish earlier and the mission runs a year longer in Case 8.

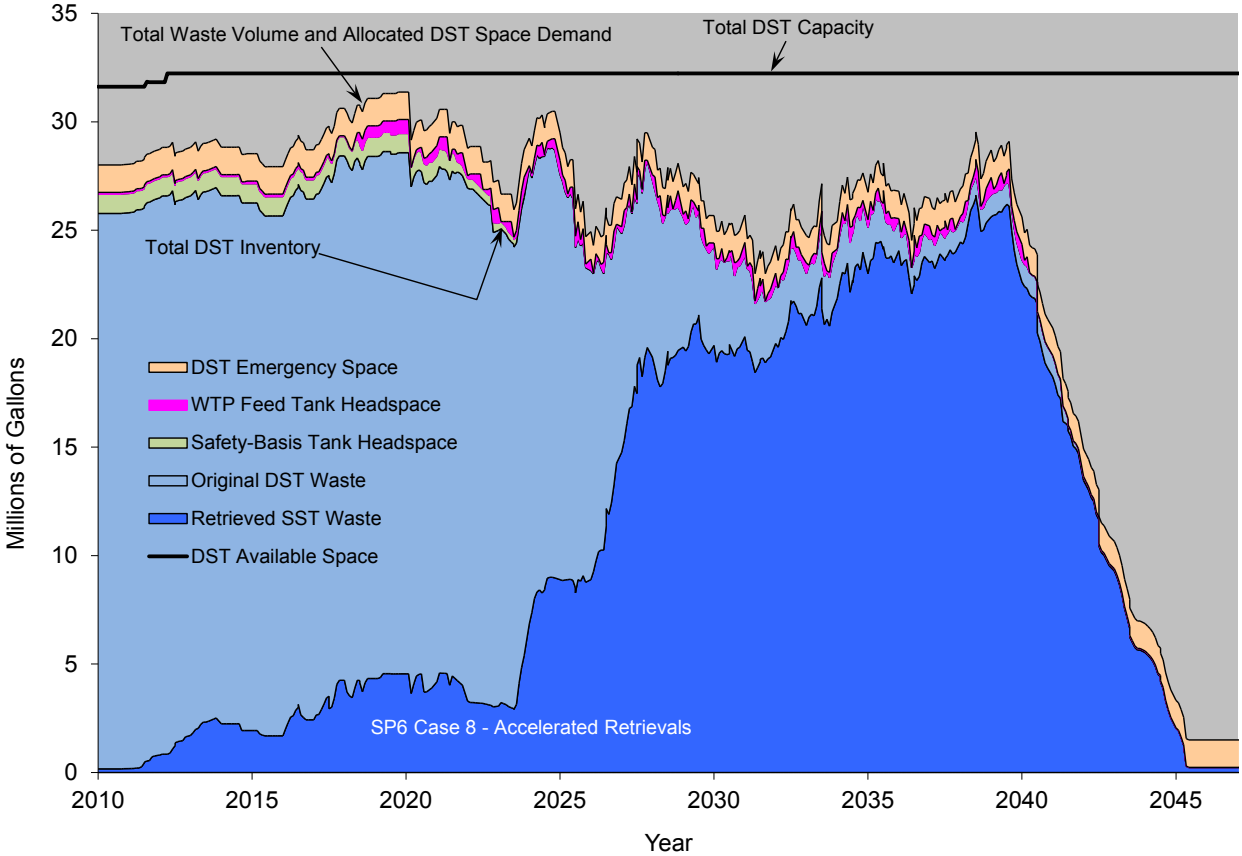

Figure 10-73. Use of the Double-Shell Tanks for Case 8

10.8.3.3 Glass Production

Figure 10-74 and Figure 10-75 show the projected IHLW and ILAW production projections, respectively, for Case 8. Case 8 did not involve changes in WTP or supplemental treatment, so the production curves for Case 8 are similar to those in Case 2. The one notable difference between the Case 8 and Case 2 production curves is the quantity of HLW produced in Case 8. Case 8 produces 746 more glass canisters than Case 2. The additional canister production is attributed to reduced opportunity for HLW glass blending. In Case 8, the T Farm potential CH-TRU tank waste is consolidated into TX Farm before being retrieved to the DST system, effectively delaying the introduction of T Farm potential CH-TRU tank waste to the DST system. In Case 2, the potential CH-TRU tank waste enters the DST system in 2030, while in Case 8 the potential CH-TRU tank waste is not retrieved until the 2033 – 2036 timeframe. Since the Case 8 potential CH-TRU tank retrievals are delayed, there are fewer opportunities for the potential CH-TRU tank waste to blend with other tank wastes, thus causing a decrease in bismuth loading in the IHLW and in turn increasing the quantity of IHLW produced. Targeting a non-TRU waste tank farm for consolidation or moving up the TX Farm retrievals could potentially mitigate the increased HLW glass production seen in Case 8.

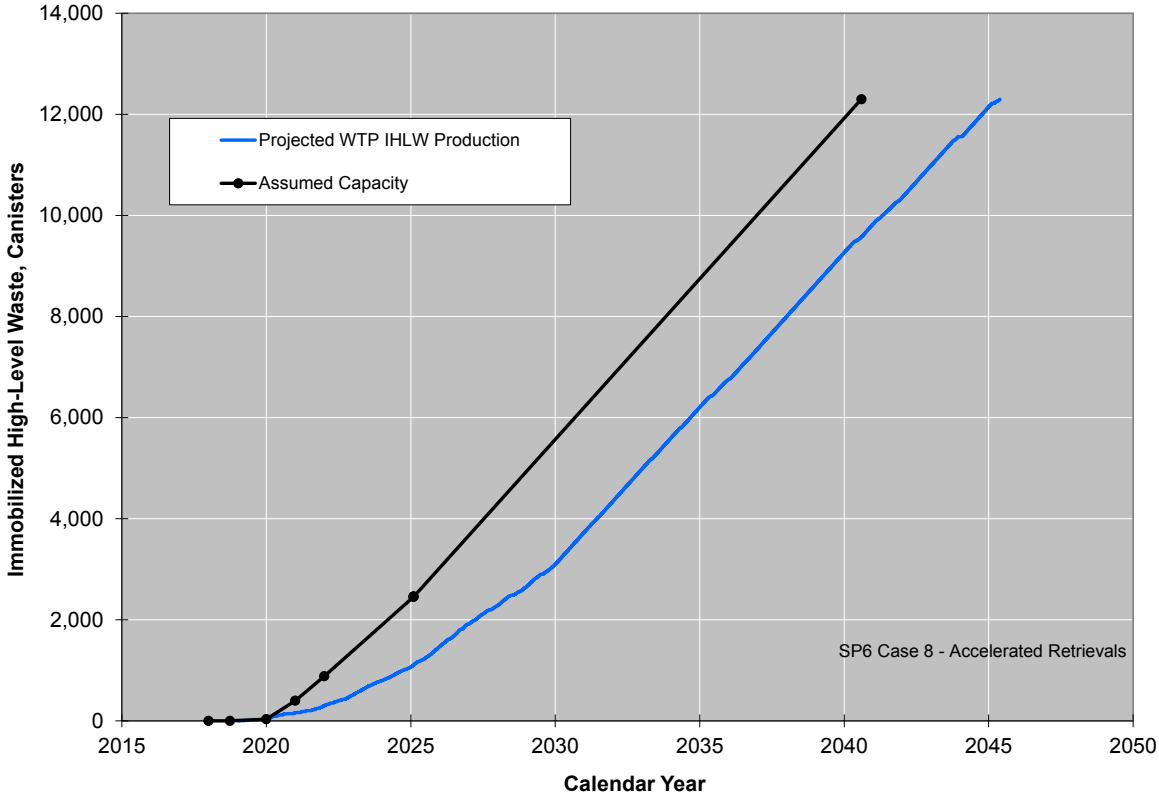

Figure 10-74. Projected Immobilized High-Level Waste Production for Case 8

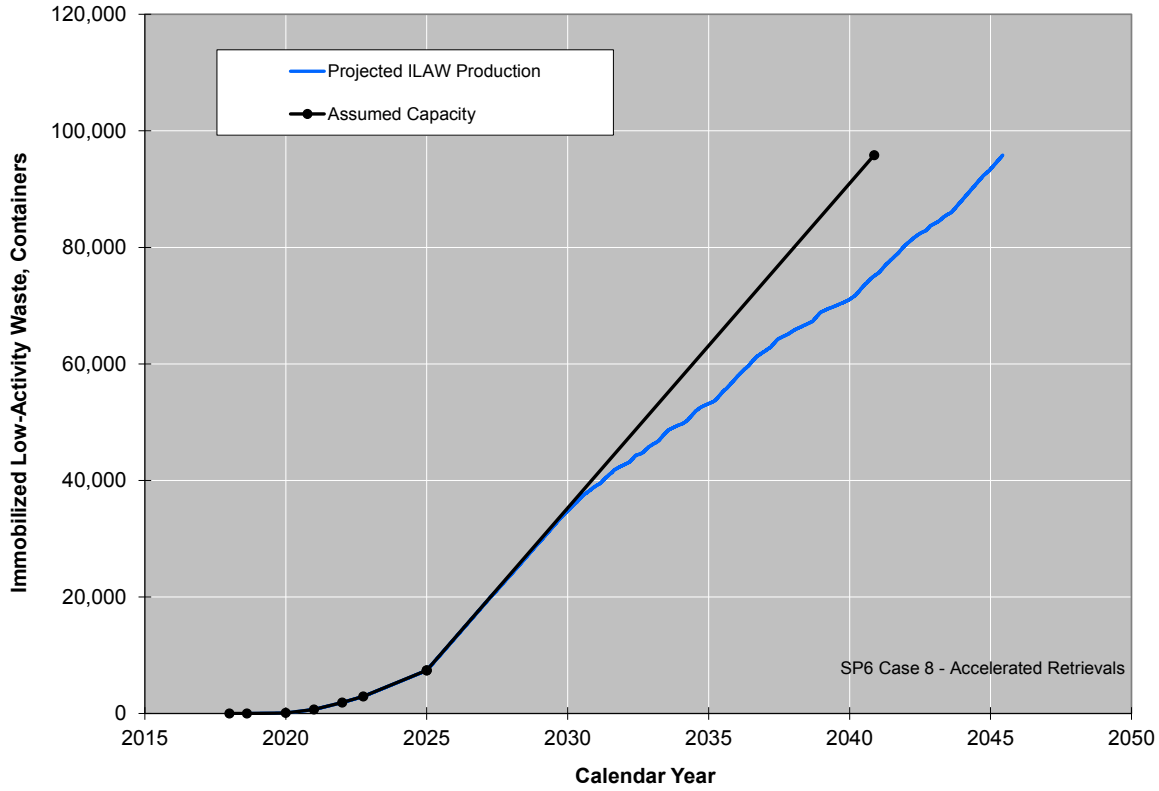

Figure 10-75. Projected Immobilized Low-Activity Waste Production for Case 8

In Case 2, the SST closure schedule is delayed by approximately one year relative to the Baseline Case because 11 additional SSTs storing potential CH-TRU waste are retrieved to the DST system. Case 8 also sees a delay in SST closures over the Baseline Case, but due to the decoupling of SST retrievals from DST space by use of waste staging, six months of the Baseline Case SST closure delay associated with potential CH-TRU retrievals are recovered. This effectively accelerates the completion of SST retrievals over Case 2 and mitigates the Baseline Case delay associated with potential CH-TRU waste to approximately six months.

Table 10-29. Near-Term Funding Targets versus Results for Case 8

Fiscal year	Target[a] ($M)	Case 2[a] ($M)	Case 8[a] ($M)
2011	410	394	394
2012	510	482	485
2013	510	459	461
2014	610	465	469
2015	710	600	604
Total	**2,750**	**2,400**	**2,413**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

10.8.4 Cost and Schedule Impacts

Table 10-29 lists the near-term funding targets and Case 8 results for 2011 – 2015. The life-cycle cost profile for Case 8 is provided in Figure 10-76. As seen in Figure 10-76, Case 8 results in a two-year delay in mission completion compared to the Baseline Case, and a one-year delay in mission completion compared to Case 2.

Case 8 costs are similar to both the Baseline Case and Case 2. Case 8 sees minor cost increases over the other two cases starting in 2018, as preparations for tank waste consolidation start in T and TX Farms.

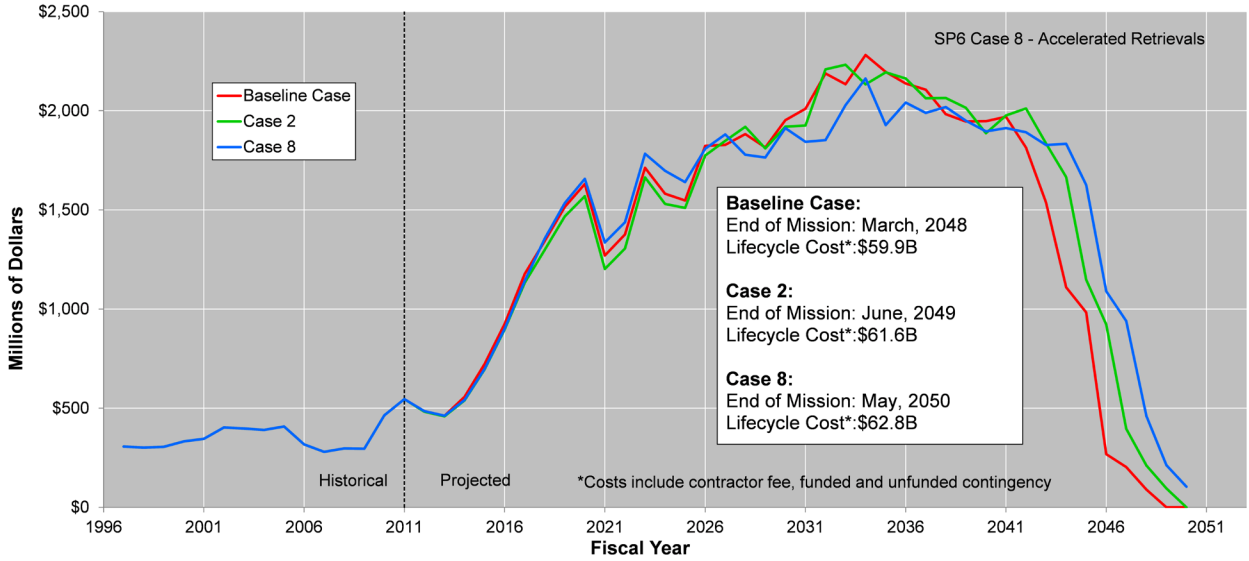

Figure 10-76. Life-Cycle Cost Comparison: Baseline Case, Case 2, and Case 8

Spending in Case 8 continues to be higher than the other two cases through 2025, which is when retrievals of T Farm waste are completed. Between 2025 and 2041, Case 8 costs are below those of the Baseline and Case 2, but in 2042 and 2043, respectively, the Case 8 cost profile exceeds the yearly costs of the other two cases. Case 8 results in an overall life-cycle cost of $62.8 billion, which is $1.2 billion higher than Case 2 and $2.9 billion higher than the Baseline Case.

The additional life-cycle costs seen in Case 8 are partially due to the requirement in Case 8 that potential CH-TRU waste be processed through the WTP rather than being packaged and shipped offsite for disposal as in the Baseline Case. The additional plant throughput of potential CH-TRU waste results in additional glass production and increased plant operating time over the Baseline Case. However the processing of potential CH-TRU waste in WTP does not explain the difference seen between Case 2 and Case 8, as Case 2 has the same potential CH-TRU waste handling requirements. Rather, the delta in life-cycle costs between Case 2 and Case 8 can be attributed to increased glass production in Case 8. This increase in glass production can be attributed to a decrease in incidental blending of the potential CH-TRU waste, which leads to an increase in glass production. There is potential for a decrease in Case 8 life-cycle costs by rearranging the SST retrieval sequence to introduce the potential CH-TRU waste into the DST system earlier, thereby increasing blending and decreasing glass production.

10.8.5 Key Issues and Vulnerabilities

The following issues from the Baseline Case are impacted by Case 8.

- Item 7.1-1 (DST space) is improved by the consolidation of sludge in TX Farm, by using a WFE to concentrate supernate in the T Complex and by using the T Complex WRF as short-term storage for concentrated supernate.
- Item 7.2-1 (SST retrieval) is improved by decoupling T Farm retrievals from other site retrievals.
- Item 7.8-5 (Inaccurate mission decision, waste determination for potential CH-TRU waste in tanks) is eliminated, since no WD would be required.
- Item 7.8-6 (Inaccurate mission decision, technology development) is eliminated since no CH-TRU waste handling facility would need to be developed.
- Item 7.8-7 (Inaccurate mission decision, CWC permit modifications) is eliminated because all of the potential TRU waste would be processed through the WTP facility; no treated potential CH-TRU waste packages would be stored at CWC, so no permit modification would be required.
- Item 7.8-9 (Inaccurate mission decision, WD for potential CH-TRU waste drums) is eliminated because in Case 8, the potential CH-TRU tank waste goes directly to WTP and is never dried or drummed.

Case 8 introduces the following new issues and identifies potential mitigating actions or contingency measures.

- A method for screening and qualifying an SST for accelerated retrievals has not been developed.
  - Potential mitigating actions include expanding the existing SST Integrity Program and developing a suite of tools/methods to assess and demonstrate the integrity of an SST tank for use in accelerated retrievals.
- The receiver tank selection process may identify a tank as a candidate for accelerated retrievals that does not pass the qualification step.
  - Potential mitigating actions include selecting and screening multiple candidate tanks to provide a back-up SST candidate for qualification.
- SST receiver loss of integrity could delay accelerated retrievals.
  - Potential mitigating actions include providing instrumentation to allow monitoring of liquid level during retrieval operations, including response actions for tank leaks in the tank waste retrieval work plans and process control plans, and qualifying two tanks to allow for backup capability.
- The addition of water and chloride to SSTs is not recommended per the SST integrity work (RPP-RPT-43116).
  - Potential mitigating actions include implementing operating procedures to prevent the inadvertent addition of water and chlorides to the SSTs post-consolidation and implementing a corrosion control program similar to that for DSTs during consolidation activities.
- The WFE technology may not be available.

10.9 CASE 9 – EARLY U FARM CLOSURE

Selected by: ORP

Purpose: Show the impacts of beginning U Farm retrievals instead of the A Farm retrievals for the nine retrievals after C Farm.

10.9.1 System Description

The sequence of waste tank retrievals is changed in Case 9 for the purpose of accelerating U Farm closure. There are no physical differences between the Baseline Case and Case 9; however, the timing of infrastructure upgrades is altered. All facilities are assumed to be the same as the Baseline Case and all connections, equipment, and technologies are preserved. The Baseline Case assumption is that a portion of a transfer line from the T Complex WRF will be used to support U Farm retrievals. For Case 9, the T Complex WRF will not be operational in time to support the earlier retrievals. Therefore, Case 9 assumes that installation of the portion of the T Complex WRF transfer line that connects U Farm to SY Farm is accelerated to support early U Farm retrievals. Schedules for other infrastructure upgrades are also adjusted to support early U Farm retrieval and closure.

Both the Baseline Case and the Case 9 SST retrieval sequences begin with C Farm, followed by AX Farm. Up to that point, both cases also operate on the same retrieval schedule. However, where the Baseline Case then moves to A Farm, Case 9 instead moves to U Farm. In both cases, retrieval operations must meet the schedule-based success criteria listed in Appendix B, Assumption B2.1.2 (summarized in Figure 10-77).

Success criteria	Baseline Case	Case 9
Start five additional retrievals by December 31, 2017	AX-103 AX-104 AX-102 AX-101 A-102	AX-103 AX-104 AX-102 AX-101 U-101
Complete nine additional retrievals by September 30, 2022	A-106 A-101 A-105 A-104	U-104 U-110 U-112 U-106

sp019

Figure 10-77. Comparison of Single-Shell Tank Retrieval Sequences

The first five tanks retrieved in U Farm were selected for initial operations because they contain the smallest quantity of waste, so retrieval of these tanks will have the least impact on DST storage space. Additionally, these tanks were selected to accelerate the development and deployment of retrieval and leak assessment technologies necessary for problematic tanks—the first four U farm tanks proposed in Case 9 are assumed leakers and the fifth has a bulged bottom.

Parallel activities to upgrade the DST transfer system to permit cross-site transfer of waste from the 200 West Area to the 200 East Area provide the opportunity to continue with U Farm retrievals. The retrieval sequence is further adjusted to accelerate the remaining U Farm retrievals, and the closure sequence is adjusted to begin U Farm closure activities once U Farm retrievals are completed. U Farm tanks are retrieved into Tank SY-102, as it is the only DST in 200 West that is capable of accepting solid waste in this time period.[82]

[82] Tank SY-101 is classified as a waste Group B tank and cannot accept solids from any retrievals; it can only accept liquid transfers. Tank SY-103 is considered a waste Group A tank and cannot accept transfers of any kind until mitigated.

Tank SY-102 decants excess supernatant into Tank SY-101, the cross-site supernatant transfer tank, which allows the supernatant to be transferred to DSTs in 200 East Area. Solid waste is accumulated into Tank SY-102, reclassifying Tank SY-102 as a deep-sludge tank. This process is outlined in Figure 10-78.

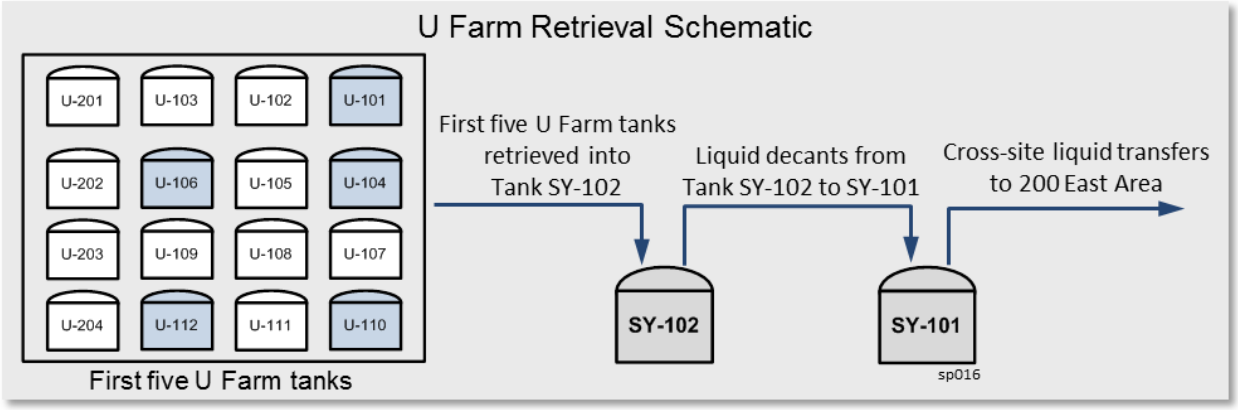

Figure 10-78. Retrieval Schematic for the First Five U Farm Tanks

After the first five retrievals, U Farm tanks continue to be retrieved into Tanks SY-102 and SY-103 (after mitigation). Cross-site supernatant and slurry transfers further support U Farm retrievals by sending excess solids and supernatant to DSTs in 200 East Area. Both Tanks SY-102 and SY-103 are classified as deep-sludge tanks during U Farm retrieval.

No new technology development activities are associated with Case 9, except those associated with SST retrieval technologies as stated in the Baseline Case.

10.9.2 Planning Bases

Case 9 planning bases are described in Appendix B, Section B10.0.

10.9.3 Results

Table 1-1 (Section 1.3) and Table 10-30 show the key mission metrics, including life-cycle cost, for Case 9 versus the Baseline Case. Key results for Case 9 are as follows.

- Case 9 meets all mission success criteria.
- The time to complete near-term retrieval milestones of starting five additional SST retrievals and completing nine additional SST retrievals are comparable but are slightly shorter (two and four months, respectively) than the Baseline Case.
- Case 9 completes all SST retrievals one year earlier than the Baseline Case.
- Case 9 completes treatment of all tank waste three months earlier than the Baseline Case.
- HLW and LAW glass masses and canister/container counts are marginally lower in Case 9 than in the Baseline Case.

In the 2020 – 2025 time period, Case 9 performs more retrievals than the Baseline Case because Case 9 is retrieving 200 West SSTs (U Farm), which do not significantly impact the 200 East DST system.

Table 10-30. Mission Metrics Comparison for the Baseline Case and Case 9

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 9: Early U Farm closure
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	$59.6 B
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,442 M
Meets near-term funding profile through 2015	Note a	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	12/21/2013
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	5/21/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	8/15/2020
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	9/7/2038
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	10/2/2042
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	1/17/2043
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	1/17/2048
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	31,875
HLW glass canisters	–	10,586	10,555
HLW glass waste oxide loading	–	36.9%	36.6%
LAW glass mass (MTG)	–	527,838	526,269
LAW glass containers	–	95,825	95,540
LAW glass sodium oxide loading	–	17.8%	18.0%
Sodium reporting to LAW glass (MT)	–	69,659	70,136
FBSR product (MT)	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,491

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.

A comparison of the overall SST retrieval progress of Case 9 versus the Baseline Case is shown in Figure 10-79. Deviation between Case 9 and the Baseline Case first occurs in 2017 when U Farm retrieval begins in Case 9. Retrieval progress is similar between the two cases throughout the mission, with Case 9 retrievals being completed approximately one year earlier than the Baseline Case.

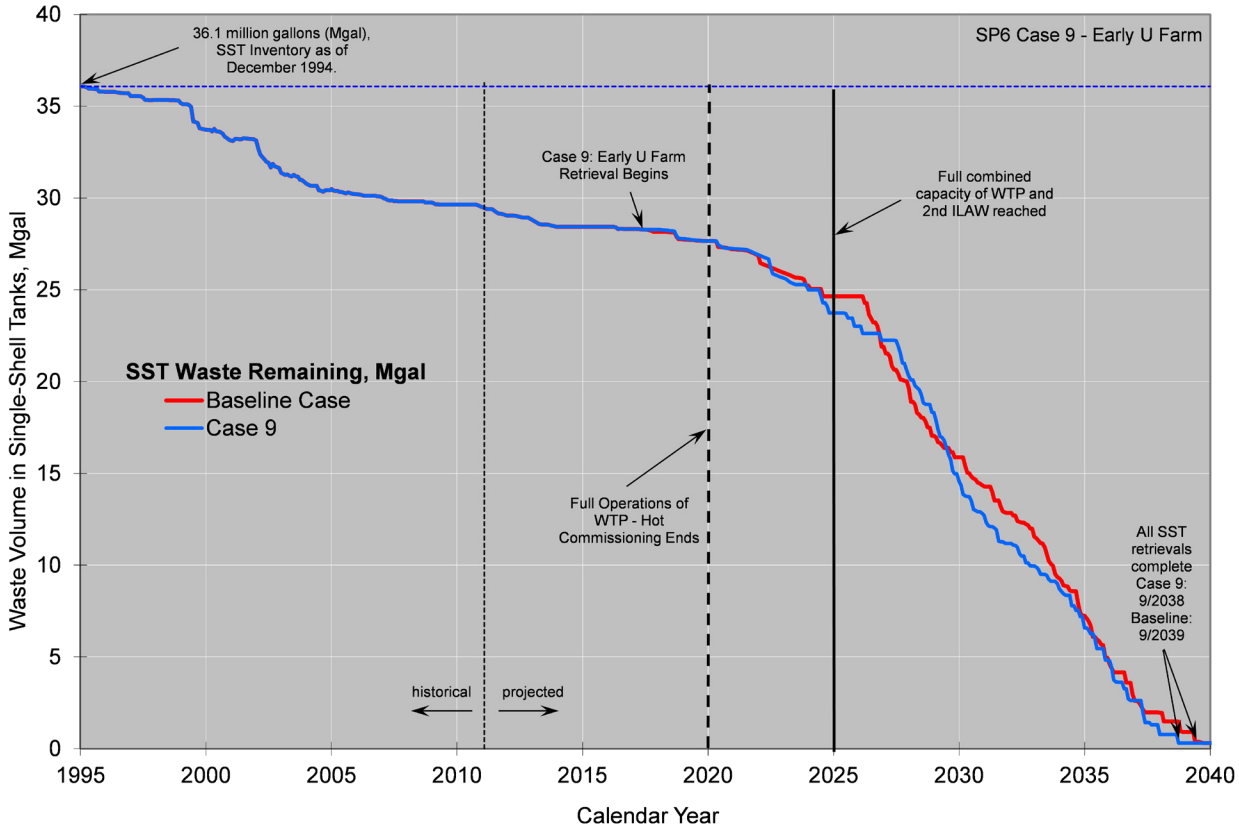

Figure 10-79. Overall Single-Shell Tank Retrieval Progress Comparison for the Baseline Case and Case 9

A comparison of Figure 10-80 to Figure 5-5 illustrates the acceleration of U Farm retrievals and the delay of A Farm retrievals for Case 9 relative to the Baseline Case.

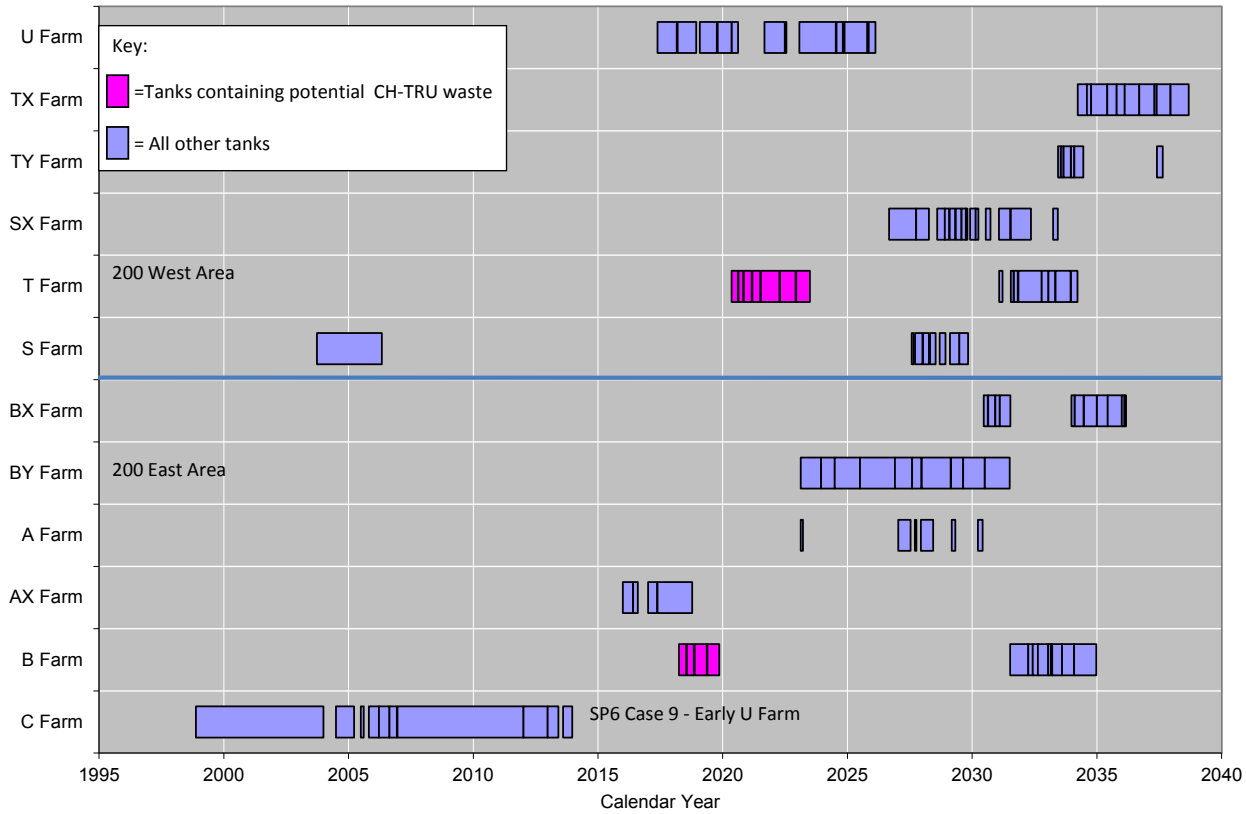

Figure 10-80. General Timing of Single-Shell Tank Retrievals by Tank Farm for Case 9

The changes to the U Farm and A Farm schedules triggered some significant differences in other farm schedules, as shown in Table 10-31. Three farms (A, TY, and U Farms) take longer to complete their retrievals, while two farms (BX and TX Farms) see decreases in retrieval durations. The change is a result of the DST system status at the time of retrievals and the tank selection logic.

During the 2020 – 2025 timeframe, the DST system has limited space available to support retrievals, thus SST farms that are retrieved during this time (A, BY, and U Farms) have increased retrieval durations. Similarly, SST farms with retrievals moved to a different time period have a retrieval duration decrease (BX and SX Farms). Although retrieval durations change from the baseline, the total volume of waste retrieved from SSTs in Case 9 exceeds that retrieved in the Baseline Case during the 2020 – 2025 time period.

Table 10-31. Retrieval Completion Date and Duration by Farm for the Baseline Case and Case 9

Farm	Retrieval completion date		Retrieval duration (years)		Percent change
	Baseline Case	Case 9	Baseline Case	Case 9	
A Farm	1/29/2022	6/4/2030	4.5	7.3	62%
AX Farm	10/14/2018	10/14/2018	2.8	2.8	0
B Farm	3/20/2035	12/24/2034	17.0	16.7	(2%)
BX Farm	2/4/2035	3/5/2036	11.2	5.7	(51%)
BY Farm	9/8/2031	7/6/2031	7.6	8.4	11%
C Farm	12/21/2013	12/21/2013	15.1	15.1	0
S Farm	7/16/2030	1/25/2031	26.8	27.4	2%
SX Farm	11/11/2030	6/9/2033	7.2	6.8	(6%)
T Farm	4/5/2033	3/23/2034	12.9	13.9	8%
TX Farm	5/19/2039	9/7/2038	6.3	4.5	(29%)
TY Farm	1/15/2033	8/22/2037	2.2	4.2	91%
U Farm	9/8/2039	2/16/2026	6.4	8.7	36%

Figure 10-81 illustrates the number of SST retrievals completed each calendar year for Case 9. In the 2020 - 2025 time period, Case 9 performs more retrievals than the Baseline Case (Figure 5-4) because Case 9 is retrieving 200 West SSTs (U Farm), which do not significantly impact the 200 East DST system. The Baseline Case performs more SST retrievals in the last three years of retrieval, while Case 9 performs more retrievals during the busiest time of the mission. There are large deviations in number of retrievals completed per year for Case 9. Seven retrievals are completed in 2032, and 13 are completed the following year in 2033. It may be possible to reduce these peaks by adjusting the detailed SST retrieval assumptions.

Figure 10-82 shows a comparison of SSTs retrieved as a three-year moving average, which allows the reader to compare the relative rates of retrievals for Case 9 versus the Baseline Case.

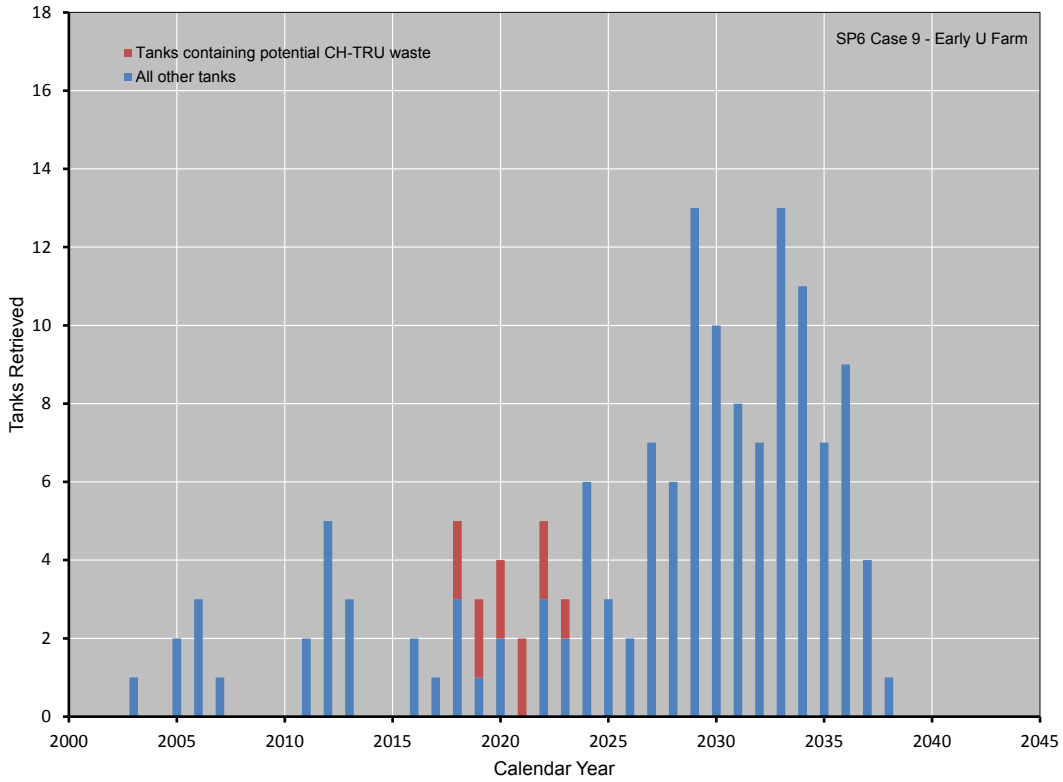

Figure 10-81. Single-Shell Tank Retrievals Completed per Calendar Year for Case 9

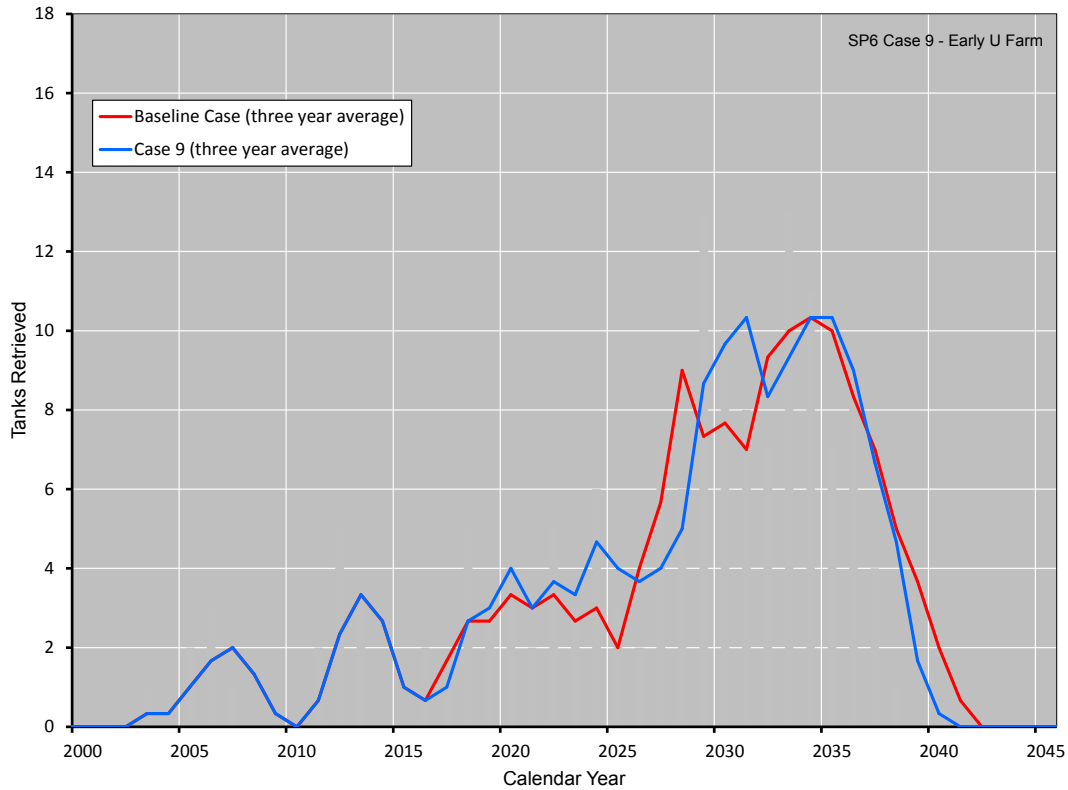

Figure 10-82. Three-Year Moving Average Single-Shell Tanks Retrieved for the Baseline Case and Case 9

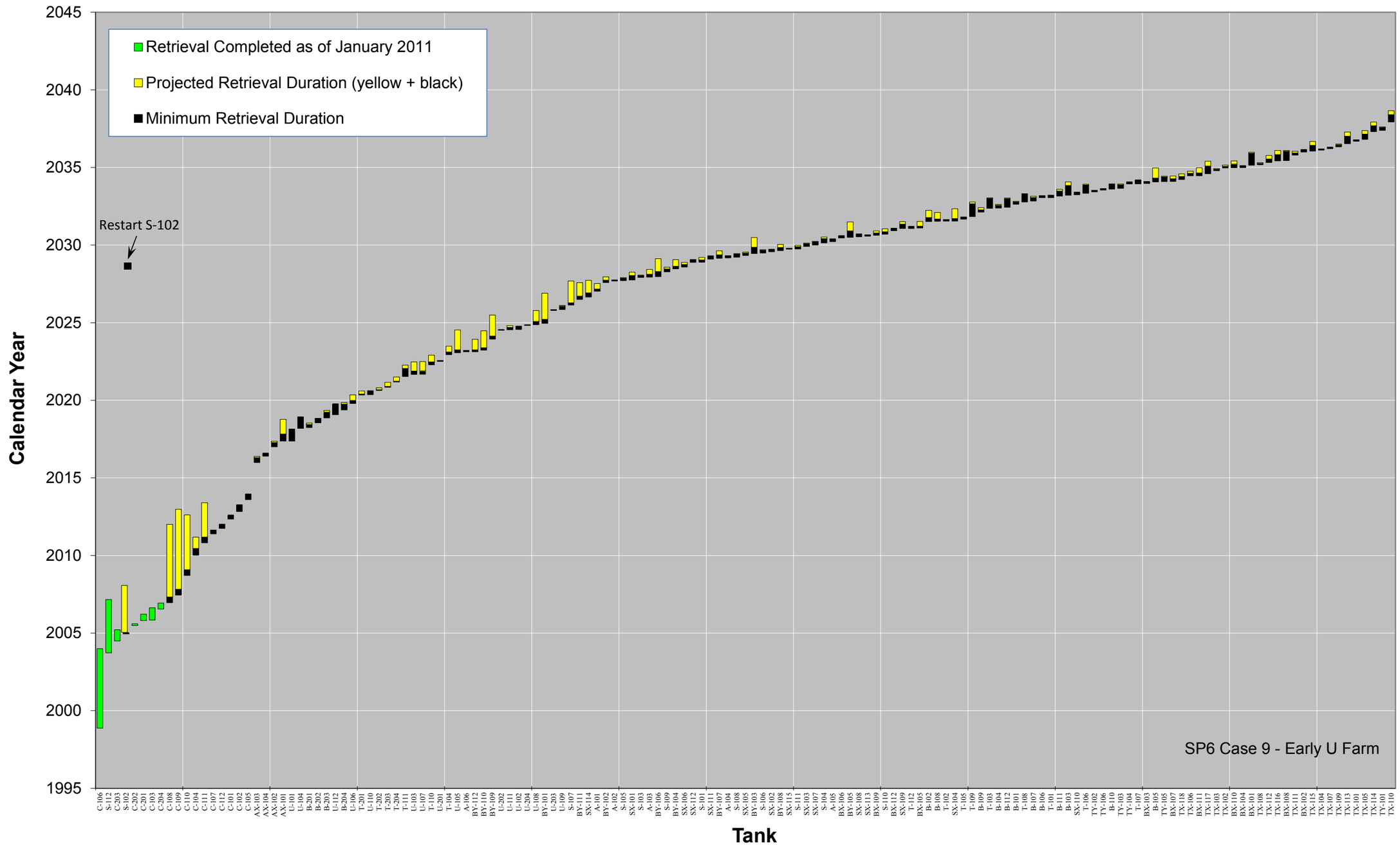

Figure 10-83. Single-Shell Tank Retrieval Sequence and Timing for Case 9

A comparison of Figure 10-84 (Case 9) and Figure 5-7 (Baseline Case) highlights the differences in DST space usage for the overall mission. Overall, DST space use is similar between the two cases. The largest difference is in the 2020 – 2025 time period, when the DST system reaches full capacity.[83] Case 9 is able to use more DST space during this time period because scenario-specific assumptions allow the creation of deep-sludge DST receivers (Tanks SY-102 and SY-103) to support U Farm retrievals. This enables more waste to be stored in the DST system, which allows SST retrievals to proceed more quickly than in the Baseline Case.

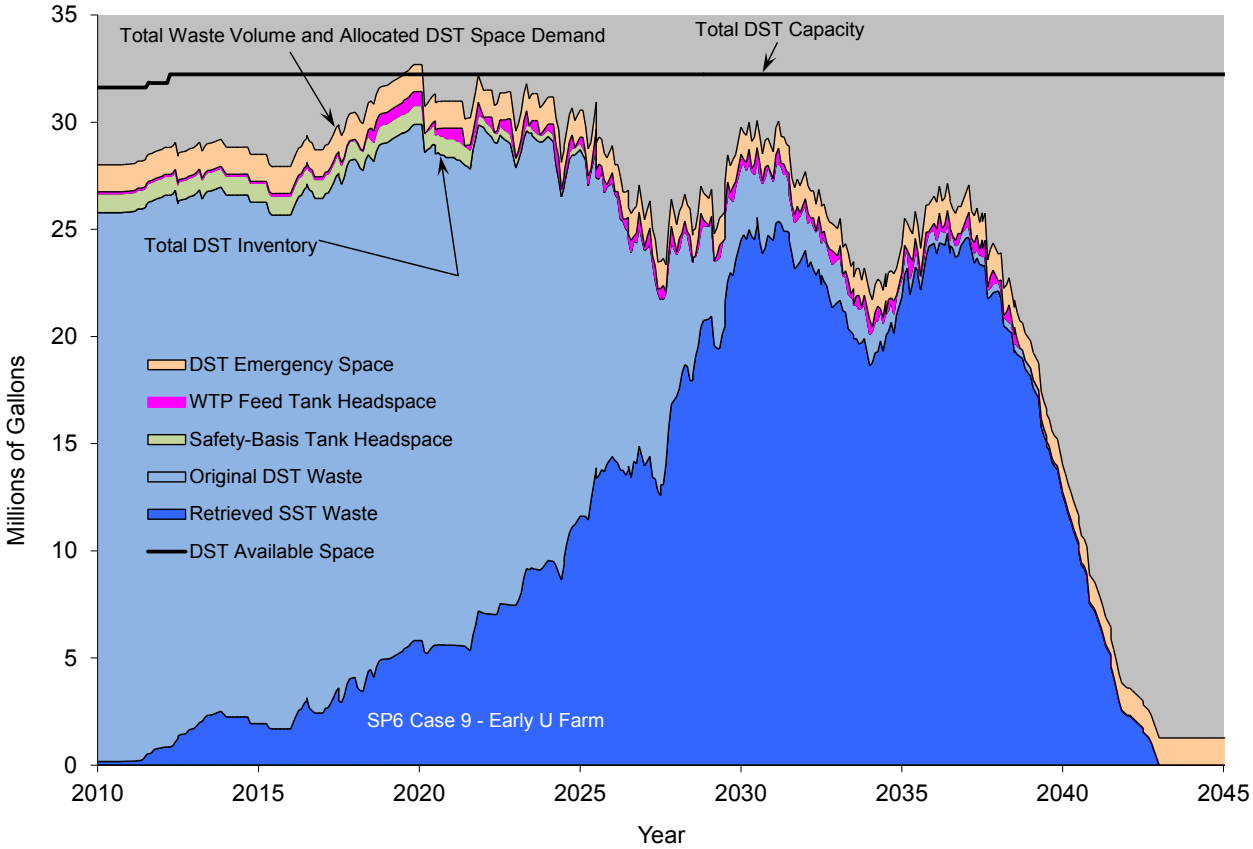

Figure 10-84. Use of Double-Shell Tanks for Case 9

[83] In Case 9, due to a modeling oversight, the SST retrievals were not paused in time to prevent the total waste volume plus allocated DST space from exceeding the total DST capacity by about 450 kgal for a six-month period beginning in August 2019. The timing of the two retrievals in progress during that period (Tanks U-112 and U-106) would therefore need to be delayed by about six months.

Figure 10-85 displays the amount of activity[84] removed from the SST system during the overall mission for both the Baseline Case and Case 9, reported at the time of retrieval.[85] The biggest difference between the two cases is the timing of the A Farm retrievals. A Farm tanks contain a significant amount of activity, and by retrieving those tanks sooner, the Baseline Case is able to remove more activity from the SST system sooner. While Figure 10-85 is a useful metric for understanding and comparing retrieval progress (much like Figure 10-79 does for waste volume), total activity may not be a predominant driver in the sequencing of retrievals. Assumption B3.2.3.2 states that the goal for sequencing the retrieval of SST waste is to minimize the waste treatment mission duration and asserts that minimizing treatment mission duration significantly reduces the risk to human health and the environment.

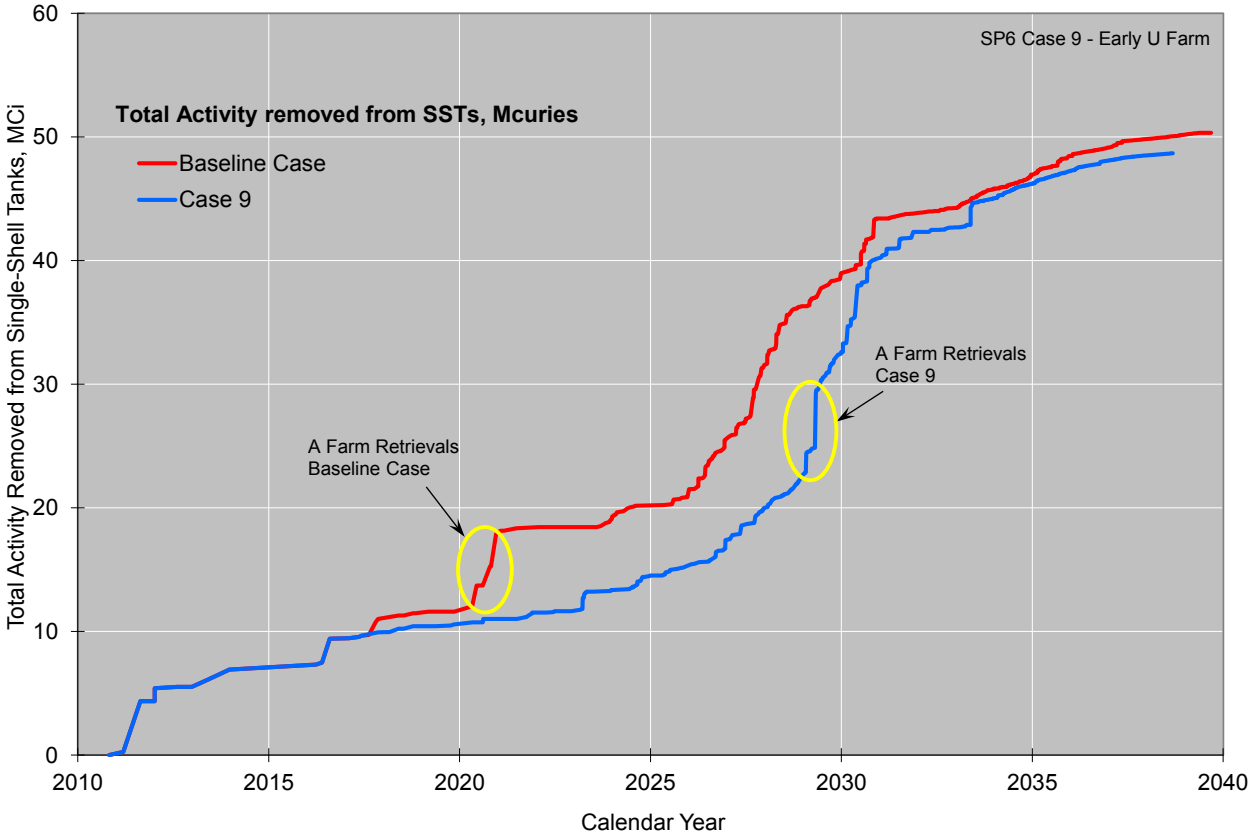

Figure 10-85. Total Activity Removed from Single-Shell Tanks for the Baseline Case and Case 9

[84] In this context, "activity" is an indication of the total amount of radionuclides in the waste, measured in MCi.

[85] The *reported* activities on this figure have not been back-decayed to the uniform decay date of January 2008 used for the rest of the document (Appendix B, Assumption B3.6.1). Differences in the timing of the retrievals will change the reported activity—the reported activity removed from a tank will be reduced by the amount of decay that occurs from January 2008 and the time of delivery, even though the same amount of waste has been retrieved from that tank. Therefore, the total activities reported on this basis will not be the same for different scenarios.

Figure 10-86 and Figure 10-87 display the projected IHLW and ILAW production, respectively. The projected IHLW production curves between the Baseline Case and Case 9 are comparable. The projected ILAW production curves for the two cases are also very similar, with the biggest difference being in 2035 when Case 9 produces ILAW at a slightly higher rate.

In Case 9, the SST closure schedule is accelerated by approximately one year relative to the Baseline Case because the Case 9 SST retrievals are completed one year earlier relative to the Baseline Case.

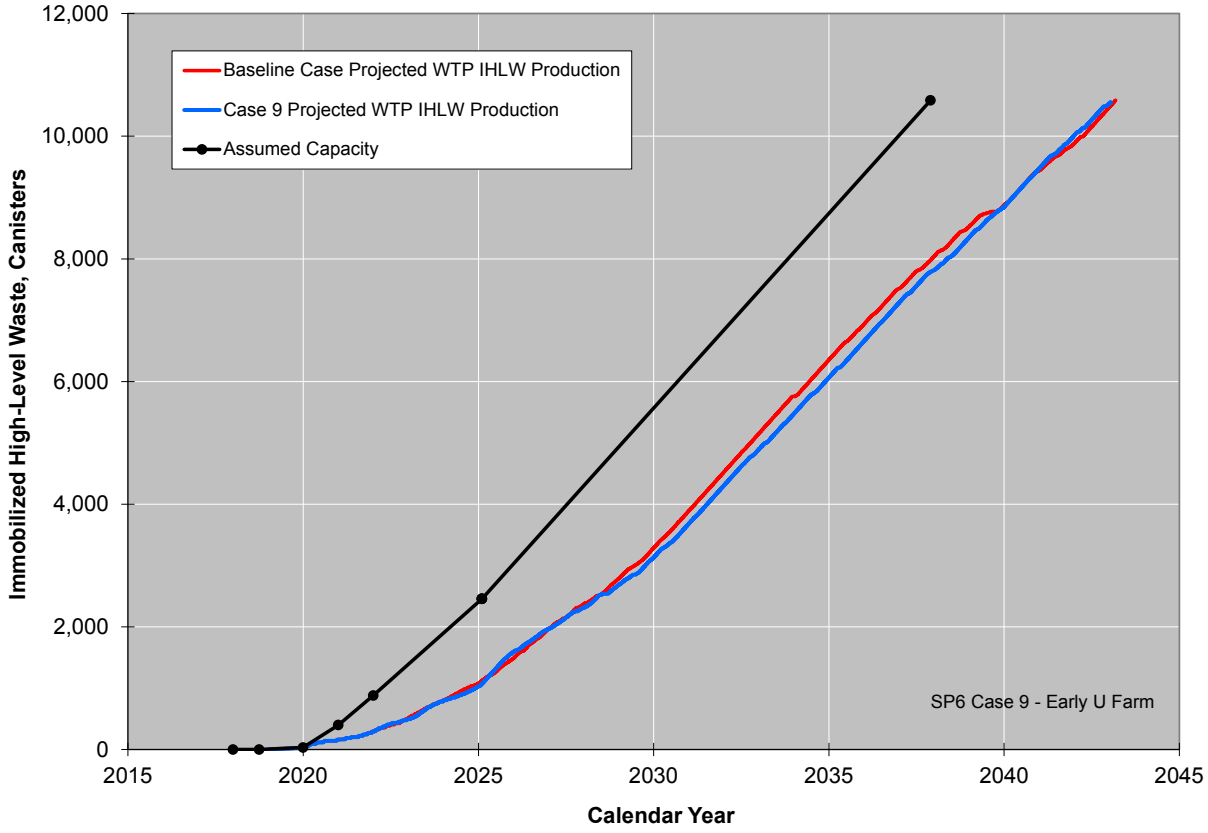

Figure 10-86. Projected Immobilized High-Level Waste Production for the Baseline Case and Case 9

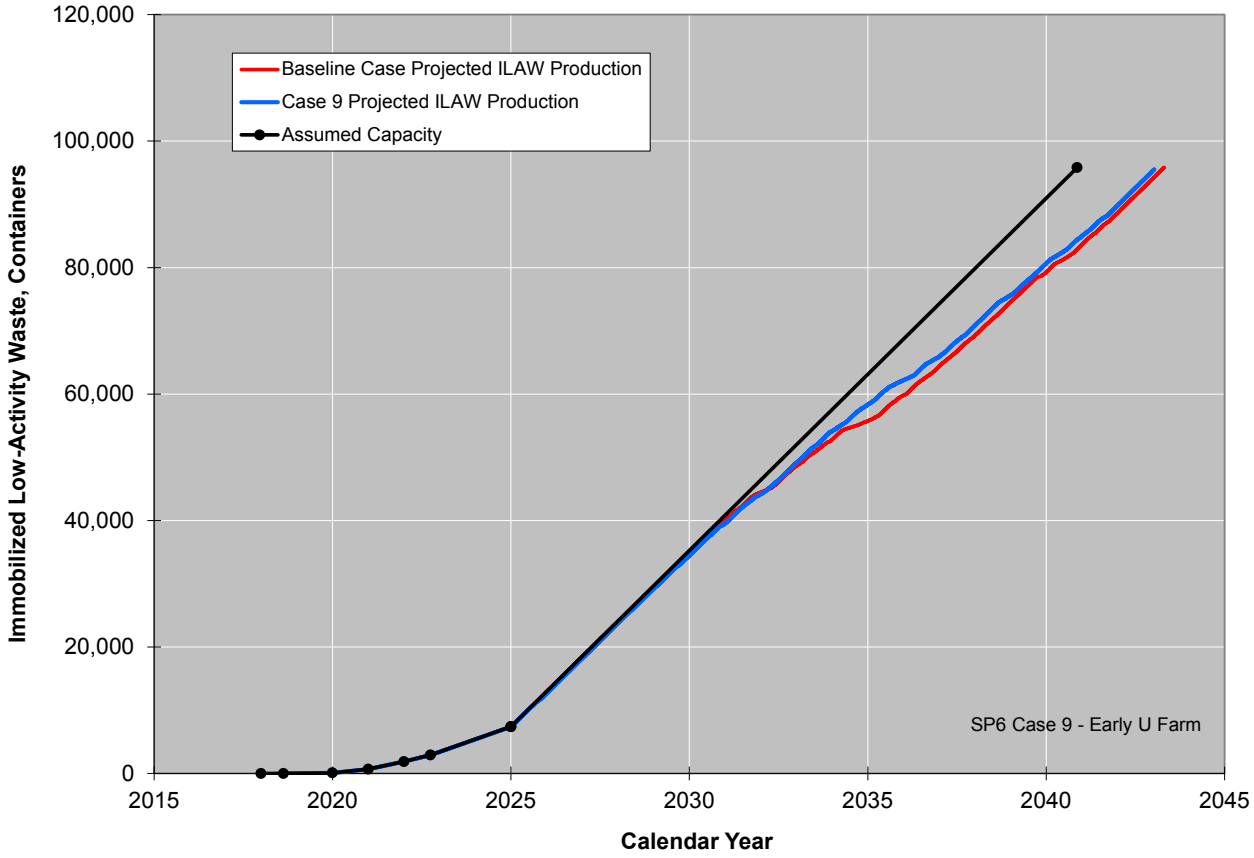

Figure 10-87. Projected Immobilized Low-Activity Waste Production for the Baseline Case and Case 9

10.9.4 Cost and Schedule Impacts

Figure 10-88 displays the life-cycle cost profile for both the Baseline Case and Case 9. Modifying the tank retrieval sequence has only minor impacts on schedule and costs, primarily in the year-to-year costs for SST retrieval. Both cases have similar life-cycle cost profiles for the duration of the mission. Adjustment of the SST retrieval sequencing drives the biggest difference between the two profiles, primarily in the 2021 – 2031 time period. In Case 9, many SST retrievals are delayed two to three years, when compared to the Baseline Case, as a result of shifting U Farm retrievals to the beginning of the mission. By adjusting this sequence, the cost profile for Case 9 is altered. The overall life-cycle cost, however, is very similar between the cases. The overall difference of $300 million accounts for only 0.5 percent of the total life-cycle cost. This small difference can be attributed to the end of mission being two months earlier for Case 9.

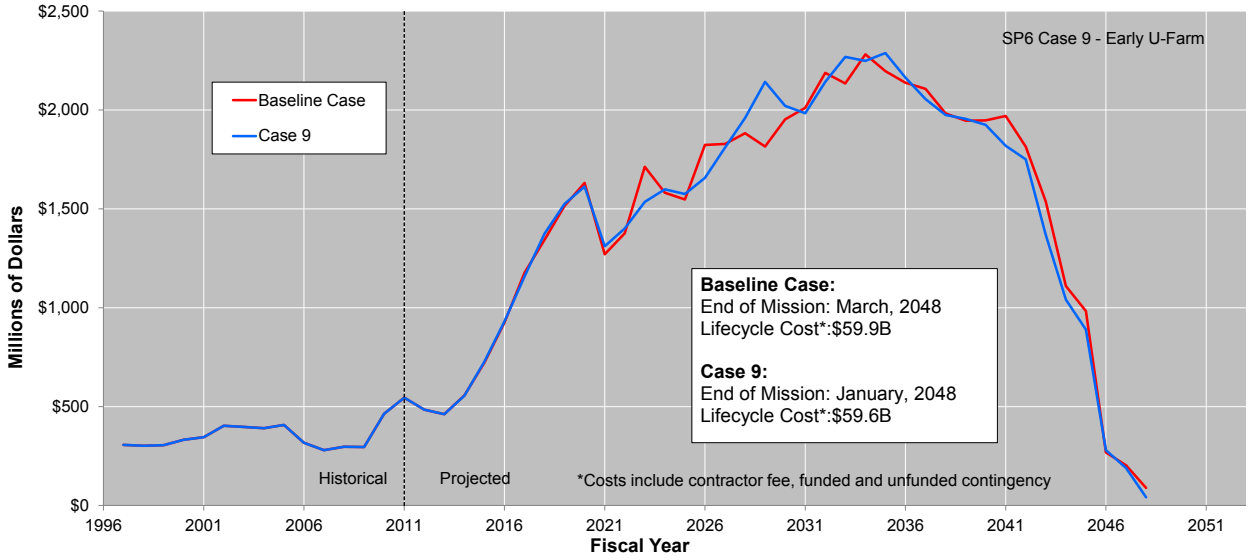

Figure 10-88. Life-Cycle Cost Comparison: Baseline Case and Case 9

Table 10-32 displays the short-term funding targets and the projected funding needs for Case 9. For each of the next five years, Case 9 has lower projected funding requirements than the funding targets. Case 9 has nearly identical near-term funding projections as the Baseline Case.

Table 10-32. Near-Term Funding Targets versus Results for Case 9

Fiscal year	Target[a] ($M)	Case 9[a] ($M)
2011	410	394
2012	510	485
2013	510	462
2014	610	477
2015	710	624
Total	**2,750**	**2,442**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

The infrastructure upgrade timing differences between the Baseline Case and Case 9 are accounted for in the cost profile. The Baseline Case assumption is that a portion of a transfer line from the T Complex WRF will be used to support U Farm retrievals. For Case 9, the T Complex WRF will not be operational in time to support the earlier retrievals. Therefore, Case 9 assumes that installation of the portion of the T Complex WRF transfer line that connects U Farm to SY Farm is accelerated to support early U Farm retrievals. Building that portion of the line early will create a cost savings later in the mission when the T Complex WRF is designed and constructed. The cost for building that portion of the transfer line was estimated to be $4.02 million. The same cost (escalated to the proper years) was subtracted from the years of T Complex WRF construction. These costs are small relative to the total projected annual costs and therefore do not have a noticeable impact on the cost profile (Figure 10-88).

10.9.5 Key Issues and Vulnerabilities

All key issues identified for the Baseline Case also apply to Case 9, except as noted below.

The following issues from the Baseline Case are impacted by Case 9.

- Item 7.1-1 (DST space) is negatively impacted and extremely limited during the 2020 - 2025 time period due to increased SST retrievals in the 200 West Area prior to WTP startup. Although DST space is more fully utilized, this reduces the flexibility in the operation of the DST system to support retrieval and WFD activities. Operational plans become sensitive to small perturbations of assumptions affecting DST space utilization as available space approaches zero.
- Item 7.2-1 (SST retrieval) is positively impacted by accelerating the development and deployment of retrieval and leak assessment technologies necessary for problematic tanks.

Case 9 introduces the following new issues and identifies potential mitigating actions or contingency measures.

- The first four U Farm tanks proposed in Case 9 are assumed leakers and the fifth has a bulged bottom. Retrieval of these tanks runs contrary to the current waste retrieval strategy to retrieve sound tanks first.
  - A potential mitigating action includes adjusting the retrieval sequence to retrieve sound SSTs before assumed leakers.
- Case 9 produces two additional deep-sludge DST receivers (Tanks SY-102 and SY-103) to support early U Farm retrieval. This leads to an increased risk of BDGRE issues and increased risk in logistical DST management requirements. Additionally, the waste currently in Tank SY-102 may require special consideration from a criticality perspective due to the presence of plutonium oxide solids.
  - Potential mitigating actions include (1) delaying continued U Farm retrievals beyond the milestone for the next nine non-C Farm SST retrievals to minimize the amount of sludge accumulated in the DST receivers, and (2) activating the cross-site slurry transfer line earlier in the mission to reduce solids accumulation in 200 West Area DSTs.
- Equipment upgrades for U Farm retrievals are accelerated. This results in increased cost and schedule risk, most notably for installation of the waste transfer system between U Farm and SY Farm.
  - Potential mitigating actions include performing U Farm retrievals later in the mission, and accelerating the design and planning activities required to support U Farm retrievals.

10.10 CASE 10 – SLOW SINGLE-SHELL TANK RETRIEVALS

Selected by: Ecology

Purpose: Show the impacts on the baseline of increasing the minimum retrieval durations for the SSTs retrieved over a near-term 10-year period.

10.10.1 System Description

There are no physical differences between the Baseline Case and Case 10. All facilities are assumed to be the same as for the Baseline Case, and all connections, equipment, and technologies are preserved. The retrieval technologies assigned to each SST for the Baseline Case (from SVF-1647) are assumed to be the same in Case 10; however, the minimum retrieval durations for all SSTs retrieved between January 1, 2011, and January 1, 2021, are increased by 25 percent. It is assumed that the increase in durations is due to unspecified near-term retrieval difficulties, which are overcome by January 1, 2021, when the minimum retrieval durations are restored.

Because the retrieval difficulties for this case were not specified and the retrieval technologies are assumed to remain the same, there are no changes in technology development needs between the Baseline Case and Case 10.

The flowsheet for the Baseline Case applies to Case 10, with no exceptions.

10.10.2 Planning Bases

Scenario-specific assumptions for Case 10 are discussed in Appendix B, Section B12.0.

10.10.3 Results

Table 1-1 (Section 1.3) and Table 10-33 show the key mission metrics, including life-cycle cost, for System Plan (Rev. 6) Case 10 versus the Baseline Case. Key results for Case 10 are as follows:

- Case 10 meets all mission success criteria, except to close all SSTs by January 31, 2043.
- All other metrics are comparable to the Baseline Case results.

Table 10-33. Mission Metrics Comparison for the Baseline Case and Case 10

Metric (milestone)	Success criteria	System Plan (Rev. 6)	
		Case 1: Baseline Case	Case 10: Slow SST retrievals
Life-cycle cost, FY 1997 to end of mission	$61.5 B	$59.9 B	$60.8 B
Meets near-term funding targets through 2015	$2,750M	$2,440 M	$2,439 M
Meets near-term funding profile through 2015	Note 1	✓	✓
Complete C Farm retrievals (B-1)	9/30/2014	12/21/2013	1/23/2014
Start five additional SST retrievals (B-3)	12/31/2017	7/23/2017	7/27/2017
Close WMA C (M-045-83)	6/30/2019	11/9/2018	11/9/2018
Complete nine additional SST retrievals (B-4)	9/30/2022	12/16/2020	1/17/2021
Complete all SST retrievals (M-045-70)	12/31/2040	9/8/2039	10/4/2040
Close all SSTs (M-045-00)	1/31/2043	10/5/2043	**10/31/2044**
Treat all tank waste (M-062-00)	12/31/2047	4/23/2043	10/16/2043
Close all DSTs (M-042-00A)	9/30/2052	3/18/2048	10/22/2048
Complete potential TRU tank waste packaging	–	7/13/2023	7/13/2023
HLW glass mass (MTG)	–	31,968	31,995
HLW glass canisters	–	10,586	10,595
HLW glass waste oxide loading	–	36.9%	37.0%
LAW glass mass (MTG)	–	527,838	523,693
LAW glass containers	–	95,825	95,073
LAW glass sodium oxide loading	–	17.8%	17.9%
Sodium reporting to LAW glass (MT)	–	69,659	69,499
FBSR product (MT)	–	–	–
Sodium reporting to FBSR product (MT)	–	–	–
LiHT by-product (MT)	–	–	–
Potential TRU tank waste drums	–	7,492	7,492

Notes: **BOLD RED** text indicates a figure or date that does not meet the success criteria.

[a] Near-term funding targets are: FY 2011: $410 M; FY 2012: $510 M; FY 2013: $510 M; FY 2014: $610 M; FY 2015: $710 M. Total FY 2011 – FY 2015 is $2,750 M.

✓ – The case meets or is generally consistent with the near-term funding targets. **X** – The case deviates from the near-term funding targets. ✶ – The case meets the near-term funding targets in some years, but not others.

[b] All projected results are contingent on favorable resolution of the key issues and uncertainties associated with each scenario.

[c] Life-cycle costs for Cases 1-10 were developed using the TOC cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

DST = double-shell tank.
FBSR = fluidized bed steam reforming.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MT = metric tons.
MTG = metric tons glass.
SST = single shell tank.
TOC = Tank Operations Contract.
TRU = transuranic.
WMA = waste management area.

10.10.3.1 Single-Shell Tank Retrievals

The SSTs are projected to be retrieved by October 2040, which is about one year after the Baseline Case. Figure 10-89 shows the SST retrieval progress over time for Case 10, overlaid with Baseline Case results. The first ten years of projections (starting in 2011) show the trends matching very closely for the two cases. Note that the period between 2011 and 2021 is when the minimum durations for SST retrievals were increased by 25 percent over the Baseline Case. Even with the slow retrievals, the near-term milestones (complete C Farm retrievals, start five additional SST retrievals, and complete nine additional SST retrievals) are all met, indicating that there is some tolerance for a 25 percent delay in the near-term retrieval schedules. This is because the near-term retrievals have scheduled start dates that were established with consideration to cost and logistics, so that minor increases in one retrieval duration does not have a significant impact on other retrievals.

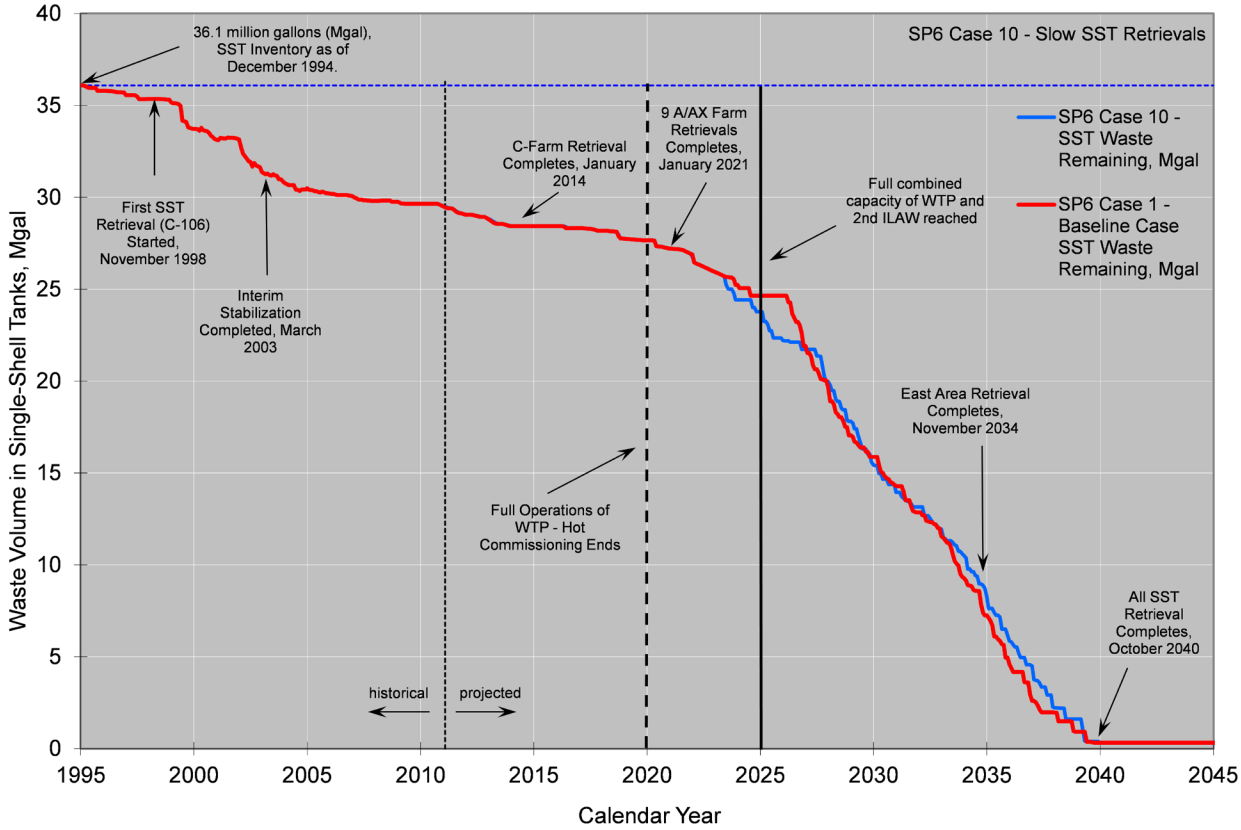

Figure 10-89. Overall Single-Shell Tank Retrieval Progress for Case 10

Ten years of slower retrievals (relative to the Baseline Case) have a minor effect on the overall retrieval sequence and schedule, as can be seen in the years after about 2023 when the curves slightly diverge. Because each near-term retrieval for this scenario takes about 25 percent longer, decants and evaporator campaigns during that time period occur later than for the Baseline Case. By the time the original minimum retrieval durations are restored in 2021, the schedule has been perturbed enough to show slightly different trends.

The largest difference between the two curves occurs between about 2024 and 2026. This gap can be attributed to an unintentional difference in the modeling of Tank C-104 blending operations (see Appendix B, Assumption B3.2.2.7). For Case 10, blending occurs with slightly different batch volumes from the Baseline Case, but the goals of the blending operations are still met. This difference allows the flat spot seen on the Baseline Case curve (where SST retrievals are halted) to be avoided for Case 10. However, the Case 10 curve begins to flatten out shortly after its gain, and retrievals end up completing slightly behind the Baseline Case. These differences reflect the ability of the HTWOS logic to adjust to new operating points and not inherent differences between the cases.

Figure 10-90 shows the number of SSTs projected to be retrieved per year. Slowing down the first ten years of retrievals does not appear to impact the number of retrievals projected to be completed between 2011 and 2021. Because the WTP will not reach full operations and begin freeing up DST space until 2020, the number of SSTs that can be retrieved before 2020 is limited to what can fit in the existing DST space (with the space gained by use of the evaporator as well). Whether the retrievals are completed according to their Baseline Case schedules or 25 percent slower (for Case 10), the same number of retrievals can be completed before more space is made available.

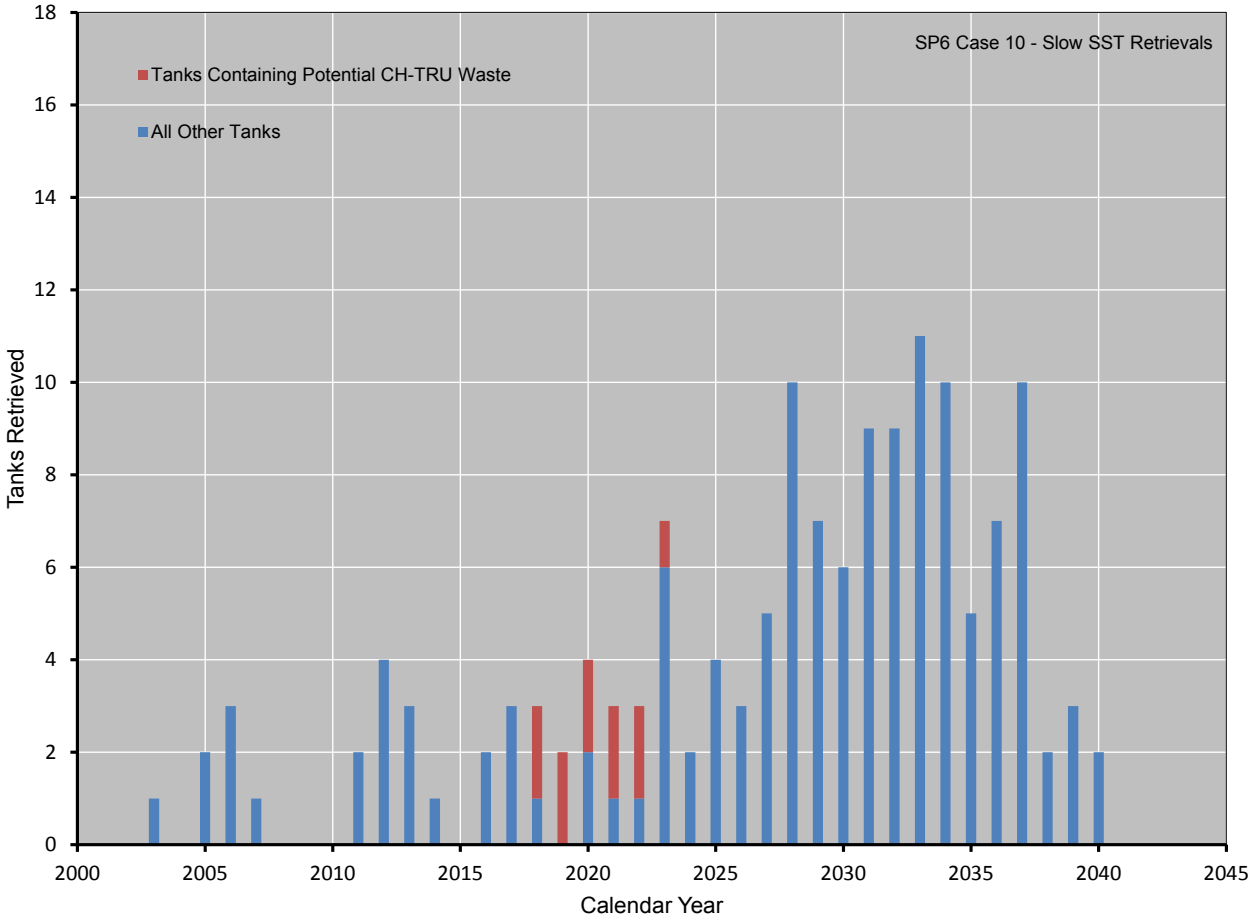

Figure 10-90. Single-Shell Tank Retrievals Completed per Calendar Year for Case 10

The general timing of SST farm retrievals is shown in Figure 10-91. Only very minor changes from the Baseline Case plot (Figure 5-5) can be observed.

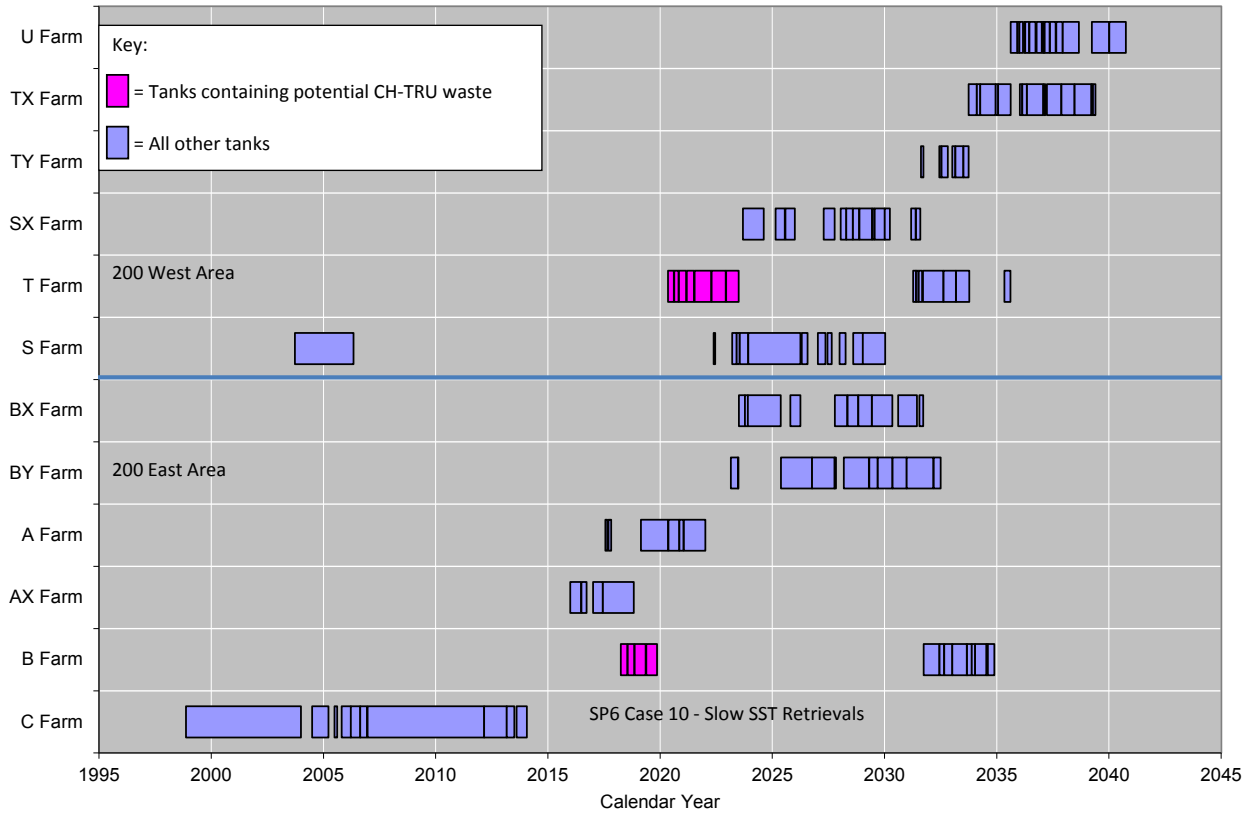

Figure 10-91. General Timing of Single-Shell Tanks Retrieved by Tank Farm for Case 10

Figure 10-92 shows the sequence and timing of each SST retrieval. The minimum retrieval durations are shown in black, with the durations projected to be achieved for each tank shown in yellow. When a minimum retrieval duration is exceeded for a given tank, the DSTs are either full or not available for retrievals (e.g., locked out for equipment installation, being used for blending operations, etc.), and completion of the retrieval has to wait until more space becomes available. For Case 10, the minimum retrieval durations have been increased by 25 percent over the Baseline Case between 2011 and 2021.

The minimum retrieval durations are, for the most part, projected to be achieved for the near-term C Farm and A and AX Farm retrievals. That is because the project schedules for near-term retrievals have been made with consideration as to how much DST space is available to support SST retrievals until WTP begins full operations. The fact that near-term milestones for those early retrievals can still be met, even with 25 percent slower retrievals, indicates that the schedules were built with some margin for delays. If the minimum retrieval durations were increased by more than 25 percent, or if the slow retrievals occurred later in the mission when more is happening in the DST system, larger schedule impacts would probably be observed.

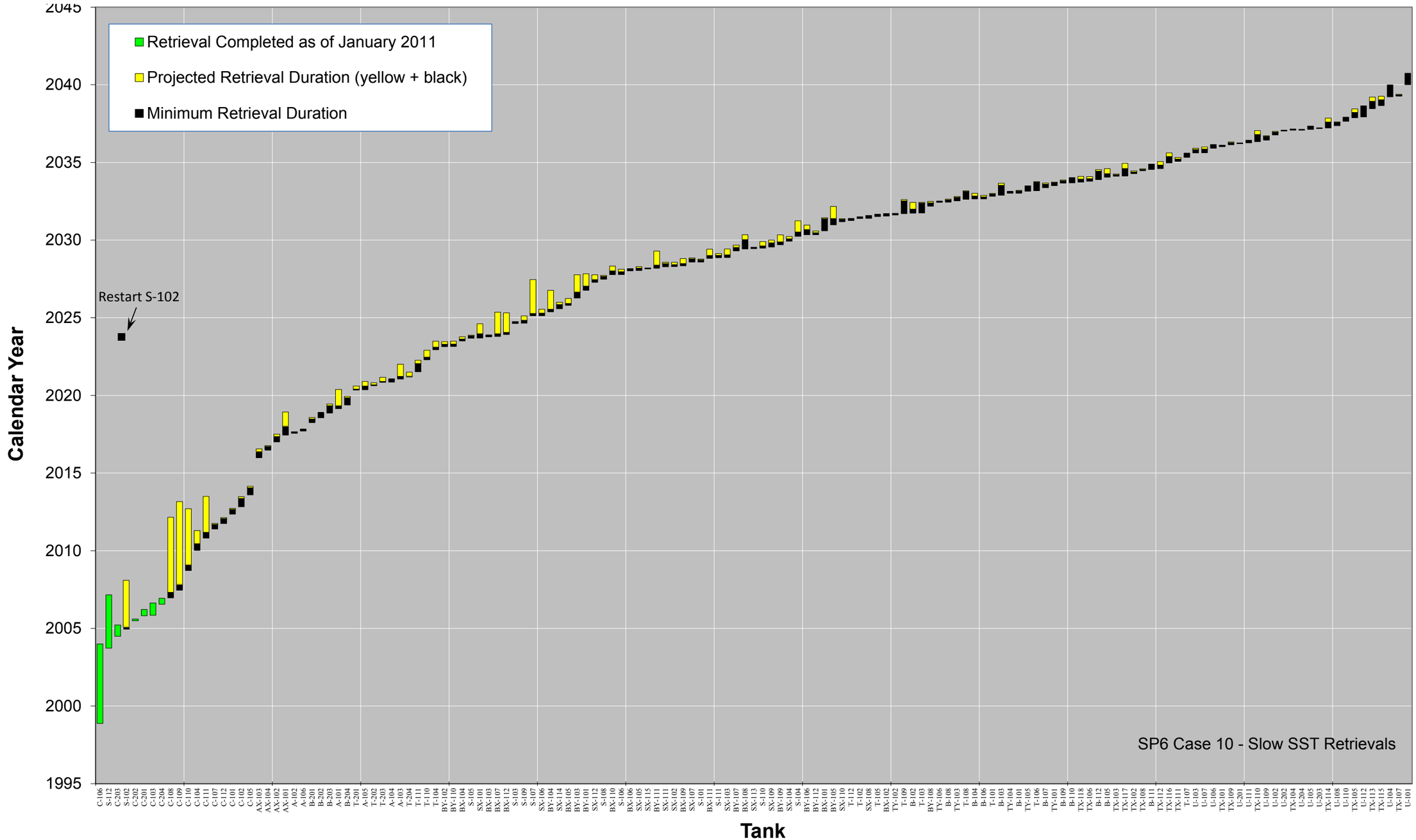

Figure 10-92. Single-Shell Tank Retrieval Sequence and Timing for Case 10

10.10.3.2 Double-Shell Tank Space

Figure 10-93 shows the DST space utilization for Case 10. The slow SST retrievals occur predominantly before WTP begins full operations, when the DSTs are filling and space is only gained by evaporation. Slowing the retrievals by 25 percent during that time does not have a noticeable impact on the overall mission space demand.

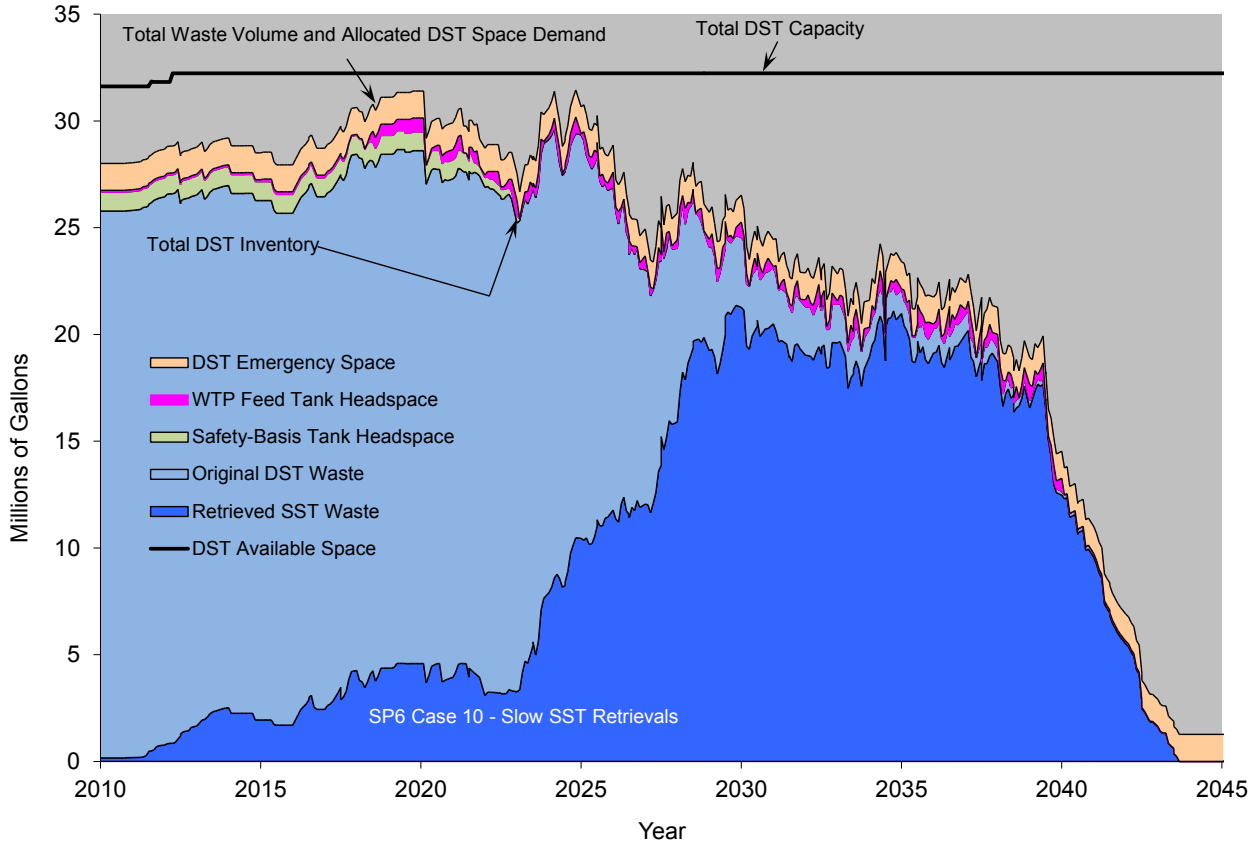

Figure 10-93. Use of the Double-Shell Tanks for Case 10

10.10.3.3 Glass Production

Figure 10-94 and Figure 10-95 show the projected production of IHLW and ILAW, respectively, for Case 10. Since this case did not involve any changes in WTP configuration or supplemental treatment from the Baseline Case, the curves are very similar to what is observed for the Baseline Case. The ten years of slow SST retrievals do not appear to impact the projected WFD in a way that impacts glass production.

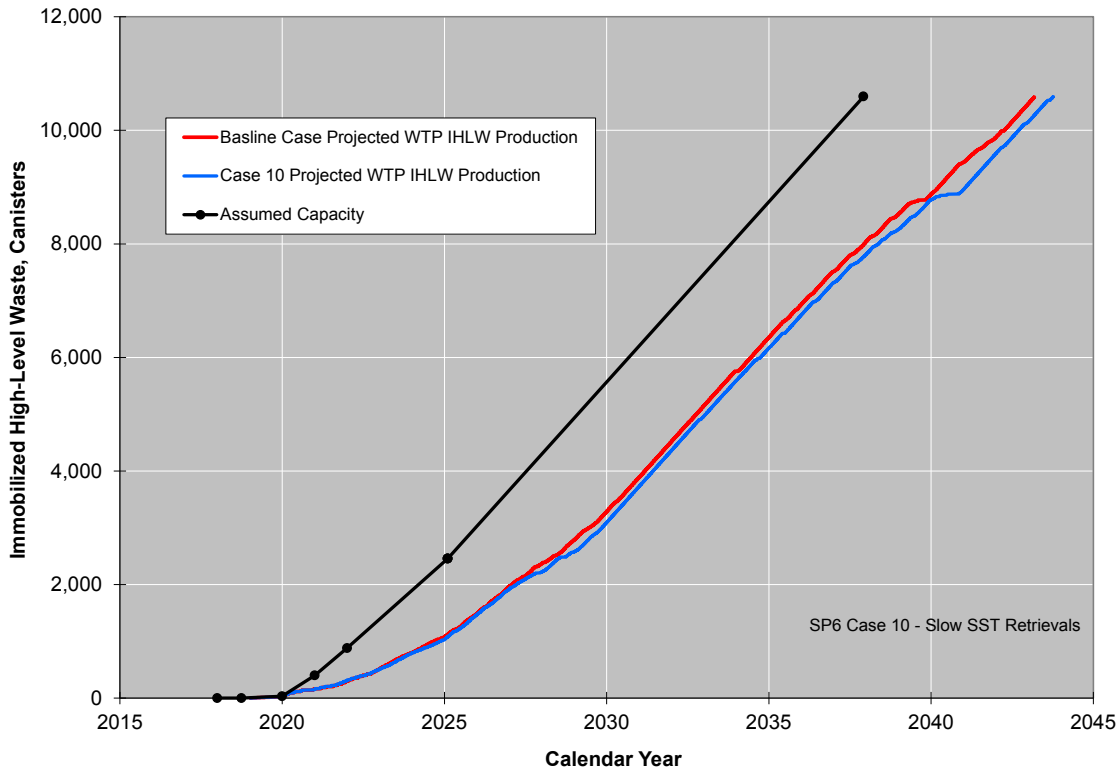

Figure 10-94. Projected Immobilized High-Level Waste Production for Case 10

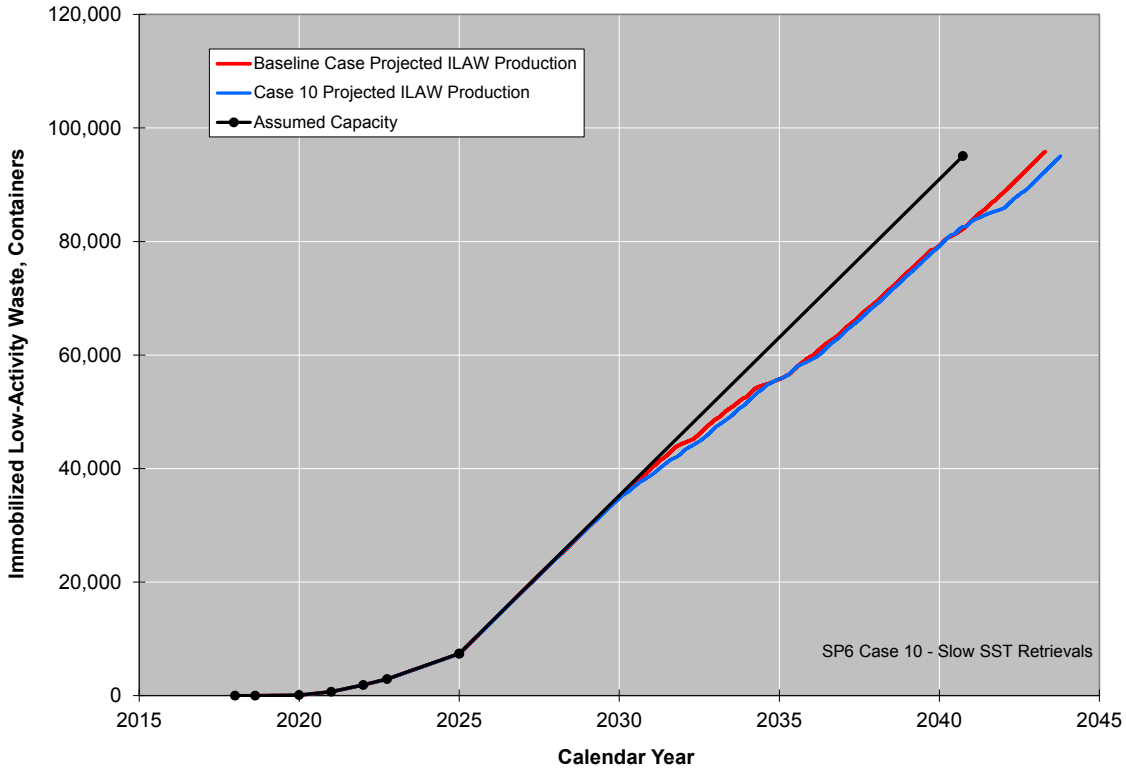

Figure 10-95. Projected Combined Immobilized Low-Activity Waste Production for Case 10

In Case 10, the SST closure schedule is delayed by approximately one year relative to the Baseline Case, because extending the minimum SST retrieval durations during the 2011 - 2021 timeframe had a long-term, one-year impact on the completion of SST retrievals.

10.10.4 Cost and Schedule Impacts

The projected schedule and life-cycle cost profile for Case 10 is not significantly different from the Baseline Case, especially during the decade of slow SST retrievals (Figure 10-96). Although the near-term SST retrieval durations were increased between 2011 and 2021, there is very little impact on near-term milestones. This indicates that there is enough contingency built into the near-term retrieval schedules to allow for minor delays. It was noted in the technical analysis for Case 10, though, that the period of slower retrievals changed the timing of decants and other routine DST operations enough to create a slightly different SST retrieval sequence from the Baseline Case. As a result, the final SST retrieval is projected to occur approximately one year behind the Baseline Case. This delay has a corresponding impact on WTP treatment duration and closure of DSTs, which extends about seven months beyond the Baseline Case.

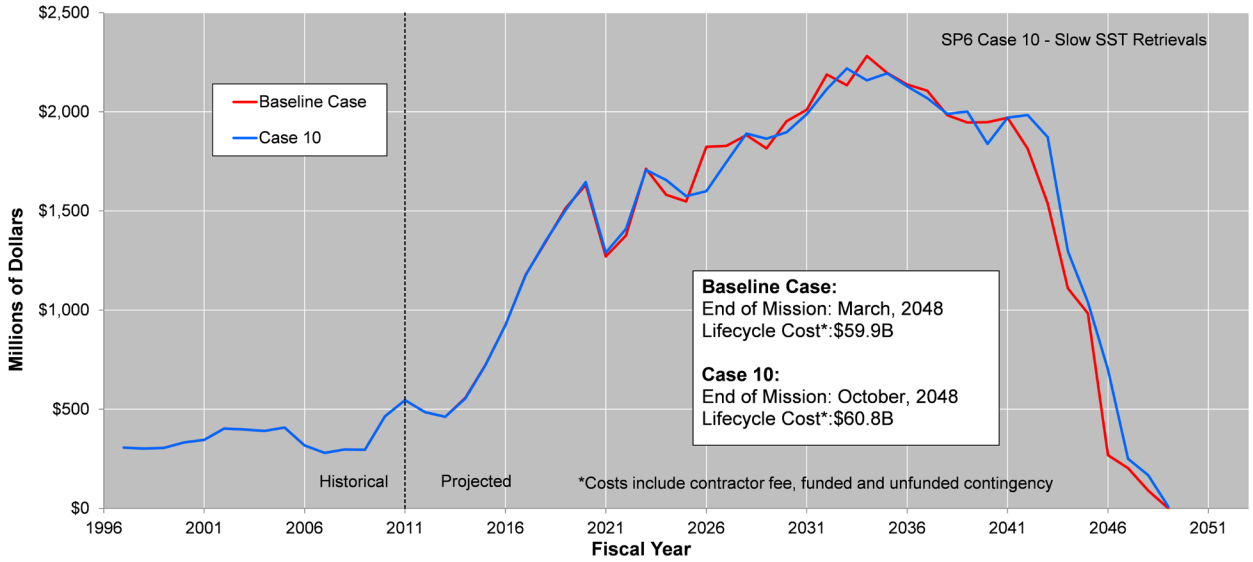

Figure 10-96. Life-Cycle Cost Comparison: Baseline Case and Case 10

The life-cycle cost for Case 10 is nearly $1 billion (about 1.5 percent) more than the Baseline Case ($60.8 billion versus $59.9 billion). The majority of the increase occurs between 2042 and 2048 as a result of increased costs for extended treatment (WTP and second LAW facility operations), extended DST and SST retrieval operations and closure, and associated management and operations activities.

As shown in Table 10-34, Case 10 near-term funding needs are all below the funding targets and are similar to those for the Baseline Case.

Table 10-34. Near-Term Funding Targets Versus Results for Case 10

Fiscal year	Target[a] ($M)	Case 10[a] ($M)
2011	410	394
2012	510	485
2013	510	462
2014	610	477
2015	710	621
Total	**2,750**	**2,439**

[a] The values in this table include only base-funded workscope (Recovery Act costs and unfunded contingency are not included).

[b] Life-cycle costs were developed using the Tank Operations Contract cost model. Life-cycle cost figures are for use in the System Plan for comparative purposes only, and do not reflect the currently approved performance measurement baseline.

10.10.5 Key Issues and Vulnerabilities

All of the key issues and uncertainties identified for the Baseline Case apply to Case 10. Though the modeling results of this scenario show only minor schedule impacts resulting from the slower SST retrievals, it should not be concluded that retrievals can be delayed in general without impacting the mission. This scenario only evaluated a 25 percent increase in minimum durations for a ten-year period. If the increase was greater, or if it was applied at a later date in the mission, significant schedule impacts would likely result. The near-term retrievals are modeled based on their project schedules, rather than being driven by model logic and constraints. This scenario showed that there is tolerance in the near-term schedules for 25 percent slower SST retrievals. Milestones and success criteria are still met in the model results for Case 10, but it should not be overlooked that any schedule delay caused by slow retrievals increases the long-term risks of not meeting SST retrieval and closure, WFD, and completion of the treatment mission milestones.

The following issues from the Baseline Case are impacted by Case 10.

- Item 7.2-1 (SST retrievals) is impacted by slower retrieval rates, possibly affecting the ability to meet HFFACO milestones for SST retrieval, closure, and waste treatment.
- Item 7.12-4 (WFD) is impacted because the TOC ability to provide compliant, sufficient, and timely feed to WTP is at risk.

Case 10 does not introduce any new issues.

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11.0 CONTINGENCY PLANNING

Milestone M-062-40 requires that:

> "The [System] Plan will identify and consider possible contingency measures to address …risks…"

This section is a contingency discussion focused on six specific risks stated in milestone M-062-40, listed in Table 11-1. While the language of the milestone does not require that the contingency measures be based on scenarios or sensitivity analysis, a number of scenarios selected for System Plan (Rev. 6) were defined with contingency planning in mind. Contingency measures may include changes to the overall mission flowsheet, such as adding or removing a facility, increasing capacity, or improving glass formulations.

Table 11-1. Risks from Milestone M-062-40 Addressed by the System Plan

Risk	Supporting Cases
SST integrity	Case 6, Case 8
Retrievals take longer	Case 3, Case 5, Case 6, Case 7, Case 8, Case 10
DST space	Case 3, Case 5, Case 6, Case 7, Case 8
Delayed WTP cold commissioning	Case 3, Case 4, Case 5, Case 6, Case 7
Delayed WTP hot start	Case 3, Case 4, Case 5, Case 6, Case 7
WTP treatment rates	Case 3, Case 4, Case 5, Case 7

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

ORP performs contingency planning using the risk management process. Key issues and uncertainties and potential mitigating actions that align with the risk management plan are included for the Baseline Case in each System Plan (see Section 7.0). The next revisions of TFC-PLN-39 will first bring it into alignment with System Plan (Rev. 5) and then incorporate the results of System Plan (Rev. 6).

Section 11.0 is not intended to provide as much detail as the WTP or WRPS RMPs, and is not an all-inclusive mission contingency plan, but rather is a compilation of some of the contingency measures that were identified and considered in System Plan (Rev. 6) with a focus on milestone M-062-40 requirements.

11.1 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."

11.1.1 Identification of Possible Contingency Measures

If results from SST integrity evaluations indicate a change in tank integrity status, possible contingency measures might include:

- Adjusting waste retrieval plans by treating the SST as an assumed leaker
- Reusing sound SSTs (Case 8)
- Permitting, designing, constructing, and operating a new DST Farm (Case 6).

11.1.2 Consideration of Possible Contingency Measures

In the event that an SST integrity evaluation indicates the integrity of a particular SST may be compromised, the immediate mitigating action may be to treat the SST as an assumed leaker. This includes retrieval of adjacent sound tank(s) prior to retrieving suspect tank(s) to reduce the impact of a leak on nearby retrievals. In addition, monitoring strategies to identify leaks and response actions for potential leaks should be included in the tank waste retrieval work plans and process control plans.

SST reuse as a contingency measure is considered in Case 8 (discussed in Section 10.8). The Case 8 scenario could provide sound tank space for sludge in the case of immediate retrieval needs that cannot be supported by the DST system. The accelerated retrievals scenario assumes that several TX Farm SSTs could be placed back into service for the purpose of receiving waste. Implementing this strategy would require a disciplined engineering approach to select and qualify candidate SSTs as sound and fit-for-use. A proposed selection process (RPP-RPT-47282) would screen SSTs to identify the best candidates for use based on available data, such as operation histories, design data, ex-tank monitoring data, and other information. Candidate SSTs identified by the selection process would be further evaluated during a qualification process. Implementation of this strategy would require approval from Ecology. Case 8 showed a lower average number of retrievals late in the mission. Redistribution of the retrieval schedule results in early completion of SST retrievals. Similarly, it can be expected that reuse of sound SSTs would help mitigate schedule delays due to poor SST integrity.

Case 6 evaluated the effectiveness of a new DST farm to compensate for an assumed four-year delay in the startup of the WTP (discussed in Section 10.6). A new DST farm could also be a contingency measure for SST integrity evaluations that indicate compromised tank integrity. As assumed in Case 6, the new DST farm would consist of eight nominal 1 Mgal tanks (named NF-101 through NF-108) located in the 200 East Area and fully integrated with the rest of the DST transfer system. Although not explicitly modeled, it can be inferred from Case 6 results that a new DST farm could help recover some of the near-term schedule impacts of a delay in SST retrievals resulting from loss of tank integrity by providing additional tank space. The major tradeoff of this option is the cost impact, which is estimated to be $900 million for the design, construction, and permitting of a new DST farm.

11.1.3 Status of Contingency Measures

Possible loss of SST integrity is a known risk and is addressed in Section 7.2, Table 7-2 Item 7.2-2). Section 3.1.1 provides additional information on the SST Integrity Program.

The Baseline Case and the PMB do not rely on reuse of SSTs or a new DST farm; however, the PMB does include the SST Integrity Program. More information on cost and schedule impacts of SST reuse is presented in Section 10.8.4.

Section 10.6 presents additional information on cost and schedule impacts of a new DST farm. The pursuit of the new DST farm as a contingency measure would require additional detailed engineering analysis. The decision to construct an additional tank farm must be made eight years prior to the desired operational date to allow sufficient time for permitting, design, and construction.

11.2 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."

11.2.1 Identification of Possible Contingency Measures

If retrievals take longer than originally anticipated and impact the schedule, possible contingency measures might include:

- Accepting impacts (Case 10)
- Accelerating treatment start (Case 3, Case 5, and Case 7)
- Reusing SSTs (Case 8)
- Permitting, designing, constructing, and operating a new DST Farm (Case 6).

11.2.2 Consideration of Possible Contingency Measures

Slow SST retrievals were analyzed in Case 10 (discussed in Section 10.10). This scenario showed that there is tolerance in the near-term schedules for 25 percent slower SST retrievals. If the minimum retrieval durations were increased by more than 25 percent, or if the slow retrievals occurred later in the mission when the DST system is supporting significantly more transfers, larger schedule impacts would probably occur.

Cases 3, 5, and 7 consider the potential contingency measures of accelerated treatment start by installing, commissioning, and beginning hot operations of a supplemental pretreatment system approximately two years earlier than the WTP PT Facility, providing the opportunity to begin processing waste at an earlier date. Earlier waste treatment provides an outlet for waste in the DST system, alleviating some of the waste storage space concerns that constrain SST waste retrievals in the period immediately preceding WTP operations. This may allow for individual retrievals to start earlier, partially offsetting the increase in durations.

Case 8 assumed reuse of SSTs and showed a lowered average number of retrievals late in the mission. Redistribution of the retrieval schedule results in early completion of SST retrievals. Similarly, it can be expected that SST reuse would help mitigate schedule impacts of long retrieval durations by decoupling retrievals from DST space availability.

This decoupling could allow for retrievals to occur earlier, thereby creating additional schedule float to make up for longer retrieval times.

Case 6 evaluated the effectiveness of a new DST farm to compensate for an assumed four-year delay in startup of the WTP. Although not explicitly modeled in the case, it can be inferred from Case 6 results that a new DST farm could help recover some of the near-term schedule impacts of a delay in SST retrievals by providing additional waste capacity and flexibility.

11.2.3 Status of Contingency Measures

The Baseline Case and PMB do not rely on reuse of SSTs, early treatment start, or a new DST farm; however, the PMB does include the SST Integrity Program. More information on cost and schedule impacts of SST reuse is presented in Section 10.8. The Supplemental Treatment and Immobilization Program will determine the needed capacity and technology for supplemental LAW treatment (see Section 3.2.3). Section 10.6.4 presents additional information on cost and schedule impacts of a new DST farm; however, pursuit of the new DST farm as a contingency plan would require additional detailed engineering analysis. The decision to construct an additional tank farm must be made eight years prior to the desired operational date to allow sufficient time for its permitting, design, construction, and startup.

11.3 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."

11.3.1 Identification of Possible Contingency Measures

If DST space is not sufficient and impacts the schedule, possible contingency measures might include:

- Accelerating treatment start (Cases 3, 5, and 7)
- Permitting, designing, constructing, and operating a new DST farm (Case 6)
- Reusing SSTs (Case 8)
- Adjusting the SST retrieval sequence (Case 9).

11.3.2 Consideration of Possible Contingency Measures

In Cases 3, 5, and 7, additional DST space is made available during the early years of the mission by an accelerated start of waste treatment. Earlier waste treatment would provide an outlet for waste in the DST system, alleviating some of the waste storage space concerns.

In Case 8, reuse of selected, sound SSTs shows that the need for DST space is lessened by the consolidation of sludge in TX Farm. In this case, a WFE is used to concentrate supernate in the T Complex, while the T Complex WRF serves as short-term storage for the concentrated supernate.

Case 6 showed that an additional DST farm would help compensate for a delay in the startup of WTP to a greater degree earlier in the mission than later. Since near-term activities are largely driven by retrievals and long-term activities by waste treatment, it can be inferred from Case 6 results that a new DST farm would provide support to keep continued retrievals on schedule.

Case 9 adjusts the near-term SST retrieval sequence to target 200 West Area SSTs, thereby shifting waste storage (tank space) demands from the 200 East to the 200 West DSTs. This lessens tank space demands on the 200 East DSTs, where the majority of near-term SST retrieval and WFD activities occur. However, this scenario only provides contingency in the near-term, since storage space in 200 West is limited and can only support a few SST retrievals.

11.3.3 Status of Contingency Measures

DST space is identified as a key issue and uncertainty in Table 7-1, Item 7.1-1b. The Baseline Case and the PMB do not rely on reuse of SSTs, early treatment start via supplemental pretreatment, or a new DST farm; however, the PMB does include the SST Integrity Program and technology development for the transformational technologies in Table 10-27. More information on cost and schedule impacts of SST reuse is presented in Section 10.8.4. The Supplemental Treatment and Immobilization Program will determine the needed capacity and technology for supplemental LAW treatment (see Section 3.2.3). Section 10.6.4 presents additional information on cost and schedule impacts of a new DST farm; however, pursuit of the new DST farm as a contingency plan would require additional detailed engineering analysis. The decision to construct an additional tank farm must be made eight years prior to the desired operational date to allow sufficient time for its permitting, design, and construction.

11.4 DELAYED WTP 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."

11.4.1 Identification of Possible Contingency Measures

Contingency measures for a delay in cold commissioning are identified with regard to their impact on hot commissioning, if the delay cascades to affect the WTP hot start (see Section 11.5.1).

11.4.2 Consideration of Possible Contingency Measures

See Section 11.5.2.

11.4.3 Status of Contingency Measures

See Section 11.5.3.

11.5 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."

11.5.1 Identification of Possible Contingency Measures

If any portion of the WTP does not complete hot start on schedule, possible contingency measures might include:

- Increasing vitrification capacity (Case 4)
- Improving the HLW glass formulation (Case 7)
- Accelerating treatment start (Cases 3, 5, and 7)
- Permitting, designing, constructing, and operating a new DST farm (Case 6).

11.5.2 Consideration of Possible Contingency Measures

Increased vitrification capacity may recover some schedule if the WTP hot start is delayed. As shown in Case 4, a 10 percent increase in vitrification capacity compensated for one year of the assumed four-year delay in WTP startup. This allowed ORP to complete all tank waste treatment by March 27, 2046, which is three years later than the Baseline Case date of April 23, 2043, although it still meets the success criteria of December 31, 2047.

Case 7 alleviates schedule impacts by taking advantage of potential improvements in HLW glass formulation by use of an enhanced HLW glass model. This model takes advantage of work documented in PNNL-19372, which recommends that several limiting constraints within the glass model (e.g., the sulfate solubility limit and the nepheline discriminator) can be relaxed. This allows more waste to be included in each melter feed batch, thereby increasing the WOL in the glass.

Cases 3, 5, and 7 consider the potential contingency measure of an accelerated start of waste processing by use of a supplemental pretreatment system to begin hot operations approximately two years earlier than the WTP PT Facility. This could help recover some schedule in the event that WTP does not start on time.

Case 6 shows that the new DST farm does help mitigate the effect of a four-year delay in the start of WTP operations, but it does not mitigate enough of the delay to bring all mission metrics within the success criteria. For each of these metrics, Case 6 shows an improvement over the WTP delay, bringing each metric closer to the success criteria and to the Baseline Case. The additional tank farm has a greater impact on the near-term mission schedule than on the long-term, because near-term activities are largely driven by retrievals, whereas long-term successes are driven by waste treatment.

11.5.3 Status of Contingency Measures

Increased vitrification capacity, an enhanced HLW glass model, and a new DST farm are beyond the scope assumed in the Baseline Case. More information on cost and schedule impacts of increasing vitrification capacity is presented in Section 10.4.4. Information on the cost and schedule impacts of increasing glass throughput is presented in Section 10.7.4. Section 10.6.4 presents additional information on cost and schedule impacts of a new DST farm; however, pursuit of the new DST farm as a contingency plan would require additional detailed engineering analysis. The decision to construct an additional tank farm must be made eight years prior to the desired operational date to allow sufficient time for its permitting, design, construction, and startup.

11.6 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."

11.6.1 Identification of Possible Contingency Measures

If operation of the WTP does not meet treatment rates that are adequate to complete retrievals on schedule, possible contingency measures might include:

- Providing supplemental pretreatment capacity (Cases 3, 5, and 7)
- Evaluating ways to reduce the demand on the WTP PT Facility so that HLW vitrification drives the mission duration, including trading-off the mass of HLW glass against the mass of LAW glass, reducing variability in the projected WTP feed, refining the design and operating modes of the WTP, and providing supplemental pretreatment
- Providing earlier supplemental treatment startup capacity (Cases 3, 5, and 7)
- Improving the HLW glass formulation or capacity (Cases 4 and 7).

11.6.2 Consideration of Possible Contingency Measures

Cases 3, 5, and 7 assume that a supplemental pretreatment system that includes RMF and SCIX is installed in the tank farms. The supplemental pretreatment system could be installed, commissioned, and begin hot operations approximately two years earlier than the WTP PT Facility. Supplemental pretreatment capacity and early startup capacity reduce the schedule impact of decreased WTP operational treatment rates.

Additionally, Case 7 takes advantage of potential improvements in HLW glass formulation by use of an enhanced HLW glass model. This model takes advantage of work documented in PNNL-19372, which recommends that several limiting constraints within the glass model (e.g., the sulfate solubility limit and the nepheline discriminator) can be relaxed. This allows more waste to be included in each melter feed batch, thereby increasing the WOL in the glass. Increasing glass throughput by improving the HLW formulation could potentially alleviate schedule impacts of reduced WTP processing rates.

Case 4 increases assumed vitrification capacity as a contingency measure for a delay in WTP startup; however, the schedule recovery seen in the case could similarly reduce the schedule impact of decreased WTP operational rates. More information on the cost and schedule impacts of increasing the vitrification capacity by 10 percent is presented in Section 10.4.4.

11.6.3 Status of Contingency Measures

The WTP Operational Readiness organization was created in FY 2010 to facilitate interfaces between the TOC and WTP project and support timely resolution of any emergent issues impacting both projects. WBS 5.04.01.08, funded in FY 2011 – 2013, addresses the supplemental LAW vitrification facility. Additional analysis is being conducted as part of ongoing HTWOS modeling and system planning to improve programmatic assumptions. Creation of more accurate models of the WTP is ongoing. Additional upgrades will be implemented in the future as appropriate. The Supplemental Treatment and Immobilization Program will determine how best to provide the needed supplemental LAW treatment capability and any supplemental pretreatment capability, if needed.

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APPENDIX A – GLOSSARY

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Term or Abbreviation	Definition or Expansion
Assumed Leaker	The integrity classification of a waste storage tank for which surveillance data indicates a loss of liquid attributed to a breach of integrity in the past. No tanks are known to be leaking today.
Baseline Case	In System Plan (Rev. 6), the Baseline Case is a mission scenario that forms the technical basis for both the near-term baseline and the out-year planning estimate range.
Blind Blending	Blind blending is a type of intentional blending that does not rely on knowledge of the composition of the wastes being blended (additional details are provided in RPP-RPT-49398[a]).
Bulk Retrieval	The retrieval of waste down to any hard-to-remove heel encountered in the tank.
Buoyant-Displacement Gas Release Events (BDGRE)	Tank waste generates flammable gases through the radiolysis of water and organic compounds, thermolytic decomposition of organic compounds, and corrosion of the carbon steel tank walls. Under certain conditions, this gas may accumulate in a settled solids layer until the waste becomes hydrodynamically unstable (less dense waste near the bottom of the tank). A BDGRE is the rapid release of this gas, partially restoring hydrodynamic equilibrium. The release may result in the temporary creation of a flammable mixture in the headspace of the tank, depending on the size of the release relative to the size of the tank headspace and capacity of the ventilation system.
Caustic Leach Factor	The fraction of an analyte in previously washed solids that will go into solution by caustic leaching. The term, caustic leach factor, as used in this System Plan, is technically a *differential* caustic leach factor.
Closure	"Closure" is defined as the deactivation and stabilization of a radioactive waste facility intended for long-term confinement of waste (per DOE M 435.1-1[b]). "Final closure" of the operable units (tank farms) shall be defined as regulatory approval of completion of closure actions and commencement of post-closure actions. For the purpose of this document, all units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610.[c]
Cold Commissioning	This refers to the Waste Treatment and Immobilization Plant (WTP) making production runs using agreed-upon simulant waste.
Cross-Site Transfer	The Hanford waste tanks are located in two physically separated areas called "East Area" and "West Area," about seven miles apart. The cross-site transfer system is a pair of transfer pipelines and ancillary equipment that is used to transfer supernate and slurry from the West Area to the East Area.
Disposal	Emplacement of waste in such a manner that ensures protection of the public, workers, and the environment with no intention of retrieval and that requires deliberate action to regain access to the waste (per DOE M 435.1-1[b]).
Enhanced Waste Retrieval Facility (WRF)	A proposed concept in which a WRF-like facility with augmented mixing, blending, sampling, and filtration systems would be used to prepare feed for delivery to the WTP. This concept could be implemented as an extension of the B Complex (East Area) WRF or a separate Feed Characterization and Certification Facility. In any case, the enhanced WRF would most likely need to be located near in proximity to both the East Area double-shell tanks (DST) and the WTP.

Term or Abbreviation	Definition or Expansion
Feed Characterization and Certification Project	This facility is proposed to mitigate the risk of not being able to properly mix and sample high-level waste (HLW) feed before delivery to the WTP. It might consist of about six 500 kgal tanks specially designed and equipped for slurry handling. The Feed Characterization Project is not included in the performance measurement baseline.
Feed Vector	The "feed vector" is a list of the individual feed batches projected to be delivered to a facility (e.g., WTP) and includes the associated waste composition and caustic leach factors.
Fluidized Bed Steam Reforming or Reformer (FBSR)	A process or equipment in which waste feed is converted into a mineral product using steam-reforming reactions in a fluidized particle bed. Organics are destroyed, nitrates and nitrites are converted to nitrogen gas, and no secondary waste is generated. Radionuclides, non-volatile heavy metals, and alkali metals are immobilized in the crystalline mineral structure where the leaching resistance of the mineral product exceeds the performance of most low-activity waste (LAW) and HLW borosilicate glasses (RPP-RPT-48092[d]).
Group A Tanks	Tanks, that due to their waste composition and quantities, have the potential for a spontaneous BDGRE and are 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.
Group B Tanks	Tanks, that due to their waste composition and quantities, are 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, but do not have the potential for a spontaneous BDGRE.
Hard-to-Remove Heel	A large solid mass or group of large solids not easily removed from the bottom of some large tanks.
High-Level Waste (HLW)	As used in this System Plan, the term HLW refers to the fraction of the tank waste containing most of the radioactivity that will be immobilized into glass and disposed at an off-site repository. This includes the solids remaining after pretreatment plus certain separated radionuclides.
High-Level Waste (HLW) Feed	This refers to the slurry stream (sludge plus supernate) that is delivered to the WTP Pretreatment Facility. Any solids remaining after pretreatment will go to the WTP HLW Vitrification Facility, along with separated radionuclides.
Hot Commissioning	The phase in which WTP does production runs using actual tank waste.
In-Tank Vehicle (ITV)	A tracked vehicle used in conjunction with the mobile retrieval system (MRS) to push or spray tank waste toward the vacuum head inlet for retrieval of single-shell tank (SST) waste.
Incidental Blending	This refers to the blending that occurs during the retrieval, staging, storage, and delivery of feed without any special effort other than SST sequencing. It is sometimes called unavoidable blending.
Initial Planning Case	In System Plan (Rev. 4), the Initial Planning Case was a mission scenario consistent with older funding guidance for fiscal year (FY) 2009 to 2018 (Anderson 2007a[e]) and 2019 (Anderson 2007b[f]) and assumed that after a near-term ramp-up, future budget allocations would be essentially level.

Term or Abbreviation	Definition or Expansion
Intentional Blending	Any blending that is specifically orchestrated and, therefore, requires additional effort. Examples of intentional blending include pairwise blending (blending two tanks at a time), metered blending (where small amounts of a problematic waste are blended into a number of successive feed batches), and the blending of different wastes first segregated according to limiting constituents.
Interim Stabilized	A tank that contains less than 50 kgal of drainable interstitial liquid and less than 5 kgal of supernatant. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow or saltwell screen inflow must also have been at or below 0.05 gpm before interim stabilization criteria are met.
Limit of Technology	The recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment mission. (Consent Decree No. 08-5058-FVS,[g] Appendix C, page 37, lines 16-22.)
Low-Activity Waste (LAW)	Waste that remains following the process of separating as much of the radioactivity as is practicable from HLW. When solidified, LAW may be disposed of as low-level waste in a near-surface facility.
Low-Activity Waste (LAW) Feed	This refers to the liquid stream (supernate plus a small amount of entrained solids) that is delivered to the WTP Pretreatment Facility. After removal of key radionuclides, this supernate and the supernate from the HLW feed will then go to the WTP LAW Vitrification Facility.
Low-Level Waste (LLW)	Radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material, as defined in section 11e.(2) of the *Atomic Energy Act of 1954*.[h]
Mixed Waste	Mixed waste contains both radioactive and chemically hazardous components.
Mobile Arm Retrieval System (MARS)	A robotic arm used to retrieve tank waste, and designed to be able to access all areas of a tank (unless obstructed by an air lift circulator). (Additional details are provided in RPP-PLAN-40145.[i])
Mobile Retrieval System (MRS)	A vacuum retrieval system used in conjunction with an in-tank vehicle (ITV) to push or spray waste toward the vacuum head inlet for retrieval of SST waste. (Additional details are provided in RPP-PLAN-40145.[i])
Modified Sluicing for Saltcake Dissolution	Modified sluicing refers to the addition of water or supernate to a tank for the purposes of dissolving and retrieving salt or retrieving sludge: • Modified sluicing for sludge removal with DST supernate consists of directing a stream of DST supernate onto the SST sludge 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 SST for re-use. • 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 sluicer 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 that the solution may have a longer residence time in the tank in order to promote effective saltcake dissolution. (Additional details are provided in RPP-PLAN-40145.[i])

Term or Abbreviation	Definition or Expansion
No-Blend	The hypothetical case in which the waste from each individual tank is retrieved, pretreated, and the HLW fraction vitrified as a separate batch. No blending of waste between tanks is permitted.
Percent-of-Span	This is the percent of the way the projected glass mass falls between the total-blend and the no-blend glass mass. For example, 0 percent of span corresponds to the total blend, while 50 percent of span corresponds to halfway between the total-blend and no-blend.
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,[j] 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."
Rotary Microfiltration (RMF)	Membrane-mounted disks rotating at high speeds induce vortex flow near the membrane surfaces, which cause insoluble solids to separate from the waste stream (RPP-RPT-48092,[d] page v)
Saltcake	Saltcake is a mixture of crystalline sodium salts that originally precipitated when alkaline liquid waste from the various processing facilities was evaporated to reduce waste volume. Saltcakes are comprised primarily of the sodium salts of nitrate, nitrite, carbonate, phosphate, and sulfate. Concentrations of transition metals such as iron, manganese, and lanthanum and heavy metals (e.g., uranium and lead) are generally small. Saltcake typically contains a small amount of interstitial liquid. The bulk of the saltcake will dissolve if contacted with sufficient water.
Sludge	Sludge is a mixture of metal hydroxides and oxyhydroxides that originally precipitated when acid liquid waste from the various reprocessing facilities was made alkaline with sodium hydroxide. Sludge is comprised primary of the hydroxides and oxyhydroxides of aluminum, iron, chromium, silicon, zirconium, and uranium, plus the majority of the insoluble radionuclides such as ^{90}Sr and the plutonium isotopes. Sludge typically contains a significant amount of interstitial liquid (up to nominal 40 wt% water). Sludge is mostly insoluble in water; however, a significant amount of aluminum and chromium will dissolve if leached with sufficient quantities of sodium hydroxide.
Slurry	The term slurry is used in two different contexts: • Slurry is a mixture of solids, such as sludge or undissolved saltcake, suspended in a liquid. For example, a slurry results when the sludge and supernate in a tank is mixed together. Slurries can be used to transfer solids by pumping 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.

Term or Abbreviation	Definition or Expansion
Small-Column Ion Exchange (SCIX)	Ion-exchange technology achieves cesium removal through a selective ion-exchange process, resulting in a LAW stream that could be used to feed a supplemental immobilization facility (RPP-RPT-48092,[d] page vii).
Sound	The integrity classification of a waste storage tank for which surveillance data indicates no loss of liquid attributed to a breach of integrity.
Success Criteria	Metrics that are used to determine how well a scenario meets overall mission goals or requirements, including schedule- and cost-based metrics.
Supernate	Supernate is technically the liquid floating above a settled solids layer. At Hanford, it is typically used to refer to any non-interstitial liquid in the tanks, even if no solids are present. Supernate is similar to saltcake in composition and contains many of the soluble radionuclides such as ^{137}Cs and ^{99}Tc.
Tank Bump	A tank bump is a postulated event in which gases, primarily water vapor, are suddenly emitted from the waste causing the tank headspace to pressurize due to vaporization of locally superheated liquid.
Total-Blend	The total-blend represents the hypothetical case in which all of the waste is blended together, pretreated, and the HLW fraction vitrified as a single batch of uniform composition.
Total Operating Efficiency (TOE)	A measure of the net throughput of a process, facility, or system relative to its design capacity. This can either be estimated from an operations research model, from operating data, or established as a goal. TOEs may be reported on a variety of bases, depending on the specific process, facility, or system.
Transformational Technology	A transformational technology is an innovative approach potentially able to significantly reduce life-cycle costs, schedule, or technical risks.
Vacuum Retrieval	The VR-200 process previously used in some C Farm tanks used a mast arm capable of in-and-out, back-and-forth, and rotational motion, which was inserted through a riser near the tank perimeter. A vacuum head covered by a protective screen was used to retrieve waste from the SSTs to a DST. (Additional details are provided in RPP-PLAN-40145.[i])
Waste Oxide Loading (WOL)	A measure of the quantity of pretreated waste that can be incorporated into a unit mass of glass. The quantity of pretreated waste is on a non-volatile oxide basis, with all components in their most prevalent oxide form, plus any halogens.
Waste Retrieval Facility (WRF)	A future facility used to support the retrieval of waste involving slurry transfers from SSTs that are located too far away to be readily retrieved directly into a DST. The WRF, located near the SSTs, would accumulate and condition retrieved waste before transfer to a DST.
Waste Treatment Complex	This complex comprises all of the existing and future facilities, pipelines, and infrastructure needed for the storage, retrieval, and treatment of the Hanford tank waste.
Water Wash Factor	The fraction of an analyte in a solid waste phase that dissolves on contact with water either during retrieval or subsequent processing.

Notes to Glossary:

[a] RPP-RPT-49398, 2011, *High-Level Waste Blending in the Hanford Tank Waste Operations Simulator*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[b] DOE M 435.1-1*,* 2011, *Radioactive Waste Management Manual*, Change 2, Office of Environmental Management, U.S. Department of Energy, Washington, D.C.

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

[d] RPP-RPT-48092, 2011, *Supplemental Treatment Program Technology Readiness Assessment*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

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

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

[g] Consent Decree, 2010, *State of Washington v. DOE,* Case No. 08-5085-FVS (October 25), Eastern District of Washington.

[h] *Atomic Energy Act of 1954*, 42 USC 2011, et seq.

[i] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington

[j] OSD-T-151-00007, 2011, *Operating Specifications for the Double-Shell Storage Tanks,* Rev. 7*,* Washington River Protection Solutions, LCC, Richland, Washington.

APPENDIX B – KEY ASSUMPTIONS AND SUCCESS CRITERIA

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TERMS

BBI	Best-Basis Inventory
BCR	baseline change request
BDGRE	buoyant displacement gas release events
BNI	Bechtel National, Inc.
BOF	balance of facilities
CD	Critical Decision
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH-TRU	contact-handled transuranic
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
ETF	Effluent Treatment Facility
FBSR	fluidized bed steam reforming
FCCF	Feed Characterization and Certification 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
HRR	high resolution resistivity
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
IMUST	inactive miscellaneous underground storage tank
IPTS	interim pretreatment system
LAW	low-activity waste

TERMS

LDM	leak detection and monitoring
LERF	Liquid Effluent Retention Facility
LLW	low-level waste
NEPA	National Environmental Policy Act
NTB	near-term baseline
OPER	out-year planning estimate range
ORP	U.S. Department of Energy, Office of River Protection
PMB	performance measurement baseline
PT	pretreatment
PUREX	Plutonium-Uranium Extraction (Plant)
RH-TRU	remote-handled transuranic
RL	U.S. Department of Energy, Richland Operations Office
RLD	radioactive liquid waste disposal
RMF	rotary microfiltration
ROD	Record of Decision
RPP	River Protection Project
SALDS	State-Approved Land Disposal Site
SBS	submerged bed scrubber
SCIX	small-column ion exchange
SST	single-shell tank
TC & WM	Tank Closure and Waste Management
TEDF	Treated Effluent Disposal Facility
TOE	total operating efficiency
TRU	transuranic
TWINS	Tank Waste Information Network System
WBS	work breakdown structure
WESP	wet electrostatic precipitator
WFE	wiped-film evaporator
WIPP	Waste Isolation Pilot Plant
WRF	waste retrieval facility
WRPS	Washington River Protection Solutions LLC
WTP	Waste Treatment and Immobilization Plant

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B1.0 GENERAL INFORMATION

The key assumptions and success criteria in this appendix document the approved input for Hanford Tank Waste Operations Simulator (HTWOS) modeling and mission planning purposes as of May 16, 2011 (Fletcher 2011b).

The U.S. Department of Energy (DOE), Office of River Protection (ORP) originally approved these key assumptions and success criteria on February 1, 2011 (Fletcher 2011a) and approved revised assumptions on May 16, 2011 (Fletcher 2011b). The major changes between the revised and original assumptions are:

- The Feed Characterization and Certification Facility (FCCF) was removed from the Baseline Case to maintain consistency with the performance measurement baseline (PMB) and to avoid unacceptable near-term cost impacts. The FCCF still remains a potential mitigating action for mixing and sampling risks.
- The assumptions for Case 5 (2020 Vision One System) were aligned with the key technical features of the 2020 Vision One System proposal submitted to DOE on March 21, 2011 (Spencer and Russo 2011).
- An error in the nominal capacity of a single fluidized bed steam reformer in Case 3 (Fluidized bed steam reforming [FBSR] for supplemental treatment) and Case 7 (Enhanced tank waste strategy) was corrected.

The schedule-based success criteria listed in Section B2.0 are a subset of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO, Ecology et al. 1989) and Consent Decree (08-05085-FVS) milestones against which model results for all scenarios will be compared. The key assumptions documented in Sections B3.0 through B12.0 were developed, reviewed, and approved as described below.

This revision of the River Protection Project (RPP) System Plan (Rev. 6) is being prepared to meet milestone M-062-40, recently added to the HFFACO (as known as the Tri-Party Agreement). Scenario framing discussions between ORP, Washington State Department of Ecology (Ecology), and Washington River Protection Solutions, LLC (WRPS), occurring between July 28 and October 27, 2010, defined the distinguishing features of each case to establish the underlying and scenario-specific assumptions (RPP-48288, *Selected Scenarios for RPP System Plan, Revision 6*). The cases to be evaluated in this System Plan revision were selected by ORP and Ecology, with both agencies agreeing on the underlying and scenario-specific assumptions (Brockman and Hedges 2010).

Between November 1 and December 7, 2010, WRPS translated the selected scenarios and distinguishing features documented in RPP-48288 into the key assumptions and success criteria presented here. These more detailed assumptions needed to actually model and evaluate the selected scenarios were prepared by reviewing existing assumptions from the previous version of the System Plan, the Waste Treatment and Immobilization Plant (WTP) contract (DE-AC27-01RV14136, *Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*), and the other source documents cited.

The ten cases selected by ORP and Ecology that are evaluated in this revision of the System Plan are:

- Case 1: Baseline Case
- Case 2: Transuranic (TRU) Waste to WTP
- Case 3: FBSR for Supplemental Treatment
- Case 4: WTP Delay with Increased Vitrification Capacity
- Case 5: 2020 Vision One System
- Case 6: WTP Delay with New Double-Shell Tank (DST) Farm
- Case 7: Enhanced Tank Waste Strategy
- Case 8: Accelerated Single-Shell Tank (SST) Retrievals
- Case 9: Early U Farm Closure
- Case 10: Slow SST Retrievals.

This appendix presents the success criteria first. All ten cases will be compared to a single set of success criteria to determine whether the model results meet both the near-term and long-term planning expectations. The key assumptions for each scenario are described next, with Case 1 (Baseline Case) first. Cases 2 – 10 have only their unique assumptions that differ from the Baseline Case listed. Unless explicitly stated otherwise with a scenario-specific assumption, the Baseline Case assumptions apply to all cases.

Caveats

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

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

B2.0 SUCCESS CRITERIA

Success criteria are metrics that will be used to evaluate how well each case meets its intended purpose and may include dates or other objectives; however, there is no guarantee that they will be met. Changes to the timing of certain activities, assumed facility capacities, or other process variables might be needed to meet the success criteria.

All cases presented in this System Plan will be compared to the same set of success criteria. For the Baseline Case, if preliminary results indicate that the success criteria cannot be met using the approved assumptions, the reasons will be identified and discussed with ORP and agreement reached on how to proceed, including potential modification of Baseline Case assumptions. For the other cases, if results indicate that the success criteria cannot be met using the approved assumptions, the reasons will be identified.

B2.1 BASELINE CASE

B2.1.1 The Baseline Case will be considered successful if it is consistent with the HFFACO and Consent Decree (08-05085-FVS) milestones for key mission activities identified in Assumption B2.1.2 and the ORP-provided funding guidance in Assumption B2.1.3. In the event that the guidance cannot reasonably be met within the degrees of freedom discussed in Assumption B2.1.6, the reasons will be identified.

B2.1.2 The following schedule-based success criteria are a subset of the HFFACO and Consent Decree milestones. The Baseline Case will meet the dates listed in Table B-1.

Table B-1. Schedule-Based Success Criteria

Metric	Success criteria	Milestone number
Complete C Farm retrievals	9/30/2014	B-1
Start five additional SST retrievals[a]	12/31/2017	B-3
Close Waste Management Area C	6/30/2019	M-045-83
Complete nine additional SST retrievals	9/30/2022	B-4
Complete all SST retrievals	12/31/2040	M-045-70
Close all SSTs	1/31/2043	M-045-00
Treat all tank waste	12/31/2047	M-062-00
Close all DSTs	9/30/2052	M-042-00A

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

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

B2.1.3 The Baseline Case will meet the ORP-provided funding targets (Basche 2010) for fiscal year (FY) 2010 through FY 2015 (Table B-2). These targets are consistent with the most recent budget planning guidance and briefing materials. After FY 2015, a reasonable ramp-up may be assumed.

Table B-2. Near-Term Funding Targets

Fiscal year	Target ($M)
2010	418
2011	410
2012	510
2013	510
2014	610
2015	710

B2.1.4 The total life-cycle cost[87] of the Baseline Case, including funded and unfunded contingency, will not exceed $61.5 billion, measured from the start of FY 1997 through the end of the RPP mission.

B2.1.5 The funded management reserve for the near-term baseline (NTB) and unfunded contingency for the out-year planning estimate range (OPER) is assumed to be equal to the most current estimates of $26.3 million and $7.55 billion, respectively.

B2.1.6 The timing of activities in the Baseline Case may be shifted as needed to satisfy the guidance dates, even if this requires deviation from other programmatic assumptions, including deviating from the funding guidance.

B2.2 CASES 2 – 10

B2.2.1 Results from Cases 2 – 10 will be compared to the schedule-based success criteria identified in Assumption B2.1.2 and ORP-provided funding guidance in Assumptions 0, B2.1.4, and B2.1.5 for comparative purposes. The funded and unfunded contingency for Cases 2 – 10 will be held constant (equal to that of the Baseline Case per Assumption B2.1.5) for purposes of estimating the total life-cycle costs for this revision of the System Plan.

B2.2.2 The assumptions for Cases 2 – 10 will not be adjusted to meet the success criteria.

[87] In this context, the total life-cycle cost refers specifically to project baseline summary ORP-0014, "Radioactive Liquid Tank Waste Stabilization and Disposition Project," and HQ-HLW-0014X, "Radioactive Liquid Tank Waste Stabilization and Disposition – Storage Operations Awaiting Geologic Repository."

B3.0 CASE 1: BASELINE CASE KEY ASSUMPTIONS

The Baseline Case defines the RPP technical baseline and provides the basis for updating the existing PMB. The Baseline Case aligns with the following:

- The current WTP flowsheet (24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements*)
- The WTP "equipment alternative" for mitigating post-filtration precipitation in the cesium ion-exchange process (24590-WTP-MRR-PET-10-001, *WTP Mission Assessment of Design and Operating Changes Expected to Resolve PJM Mixing in Vessels*)
- RPP-40149, *Integrated Waste Feed Delivery Plan* (Volumes 1 and 2)
- RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*
- SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, File Name 'SVF-1647 Rev 3D.xls'"
- The high-level waste (HLW) glass formulation model (GFM) (PNNL-18501, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*)
- Removal of the Aluminum Removal Facility
- Addition of a new dedicated feed line for low-activity waste (LAW) transfers to the WTP.

A baseline change request (BCR) will be required to realign the PMB with the Baseline Case, with allowances for additional funding guidance and emerging plans and field conditions.

The implementation of this set of assumptions into the HTWOS model is described in detail in the RPP-17152, *Hanford Tank Waste Operations Simulator (HTWOS) Version 6.6.1 Model Design Document*, and associated data package (RPP-RPT-48681, *Hanford Tank Waste Operations Simulator Model Data Package for the River Protection Project System Plan Rev. 6 Cases*).

The following set of key assumptions defines the Baseline Case (Case 1), and unless explicitly stated otherwise in Sections B4.0 – B12.0, these assumptions apply to all other cases.

B3.1 WASTE TREATMENT COMPLEX

The overall configuration and process flow assumed for the Waste Treatment Complex is shown in Figure B-1 for the Baseline Case.

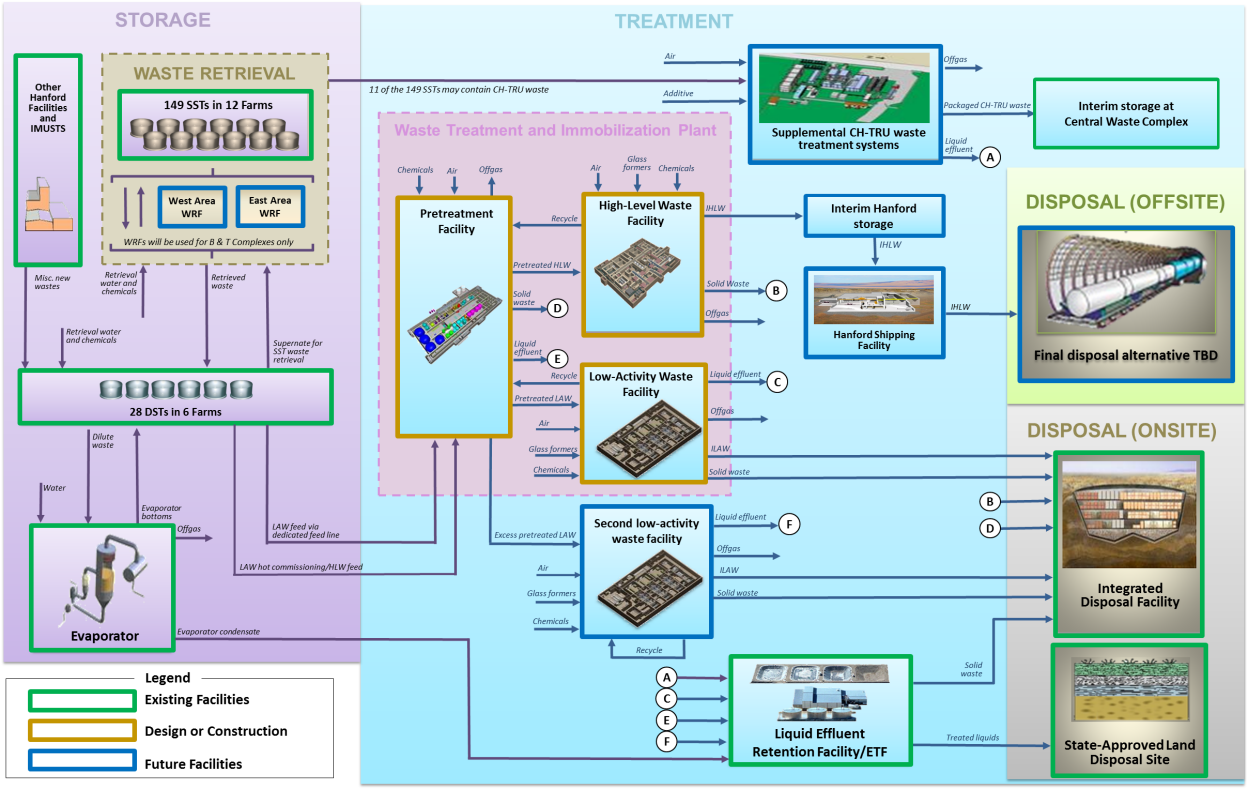

Figure B-1. River Protection Project Simplified Flow Diagram for the Baseline Case

B3.2 TANK FARMS

B3.2.1 Single-Shell Tanks

B3.2.1.1 The integrity of the 149 SSTs is described in HNF-EP-0182, *Waste Tank Summary Report for Month Ending September 30, 2010* (Rev. 270), with pending changes as agreed to with Ecology, ORP, and the Tank Operations Contractor.

B3.2.1.2 It is assumed that timely approval will be received to support interim closure (tank isolation and filling with grout) of each SST sometime after retrieval of that tank is complete.[88]

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

B3.2.2 Double-Shell Tanks

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

B3.2.2.2 The maximum modeled operating liquid levels for the DSTs are the "normal operating limits" provided in OSD-T-151-00007, *Operating Specifications for the Double Shell Storage Tanks*, with the exception that the maximum modeled operating level for all AP Farm tanks is increased to 454 in. (1.2465 Mgal).[89] The "normal operating limits" for Tanks AP-103 and AP-108 have already been increased to 454 in. It is assumed that the other AP Farm tanks will successfully pass the in-service leak testing required to use this increased operating level.

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

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

B3.2.2.5 Insoluble solids retrieved from SSTs are assumed to settle to approximately 40 wt% solids in the DSTs within 30 days, except for C Farm. Insoluble solids retrieved from

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[88] A closure integration plan (RPP-PLAN-40761, *Integrated Single-Shell Tank Waste Management Area Closure Plan*) has been prepared to better define the strategy and approach to be used to close the tanks. The cost and schedule for interim and final closure activities will be reflected in the PMB. Closure activities are not modeled in HTWOS.

[89] Note: At liquid levels above 426 in., the nominal 2,750 gal/in. of tank level begins to decrease, dropping to about 2,600 gal/in. at 454 in. The official spreadsheet tool for converting between liquid level and volume for both DSTs and SSTs is released under SVF-1770, "Tank Waste Volume Calculator.xlsx."

C Farm are assumed to settle within two days to a solids-loading comparable to that in the source SST (see Section 4.3.5 of RPP-17152).[90]

B3.2.2.6 The solids management strategy for the DSTs is to operate the DSTs so that they do not become Group A tanks (i.e., stay within acceptable buoyant displacement gas release event [BDGRE] criteria). For mission planning purposes, the following simplified proxy limits will be used:

- Existing BDGRE controls are assumed to apply to DSTs containing an accumulation of settled salts, including:
  - Restrictions on the use of currently existing Group A tanks will continue to be followed for those tanks until the waste has been retrieved.
  - Assumption B3.2.4.6 is intended to prevent future accumulations of salts that might result in classifying a DST as Group A under existing BDGRE controls.
- The depth of settled sludge accumulated in each DST will be maintained less than 250 in.[91,92]

B3.2.2.7 The waste blending and segregation controls in the feed control list (HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*, Table A-1) will be followed.

B3.2.2.8 Enhanced blending of sludge will be used to help reduce the projected mass of HLW glass to meet the success criteria for the completion date of waste treatment and SST retrievals. Blending strategies include:

- Significant heels in the DSTs and in the HLW melter increase incidental blending.
- The delivery of partial batches from the SST receivers to the HLW feed staging tanks and the delivery of partial batches from the HLW feed staging tanks to the HLW feed tanks may optionally be used to provide intentional blending.[93]

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[90] The solids settling endpoints in HTWOS may be refined; if so, this assumption may be reworded to be consistent with the final approach documented in a future revision to RPP-17152.

[91] RPP-PLAN-30112, *Plan to Resolve Technical Issues Associated with Sludge Accumulation in Double-Shell Tanks,* states that the current limits on preventing BDGREs are based on the behavior of settled salts and therefore are not applicable to accumulations of sludge. A review of open literature suggests that high-shear strength sludge may not retain gas in a way that would lead to BDGREs. A technical basis for relaxing BDGRE-related controls on sludge is being developed, with plans to implement a revision to the BDGRE-related controls in the safety basis by September 2012. It is assumed that this work is successful in relaxing BDGRE-related controls on the accumulation of sludge and supernate in DSTs. Unpublished scoping calculations suggest that the allowable sludge depth is expected to range between 160 and 400 in., depending on the actual physical properties of the settled sludge.

[92] DSTs containing more than about 70 in. of settled solids will require incremental insertion or lowering of mixer-pumps per Assumption B3.2.3.14. An allowance for mixing up to a nominal 76 in. without incremental insertion will be assumed for the blending of Tank C-104 sludge per Assumption B3.2.2.7.

[93] In this context, HLW feed staging tanks and HLW feed tanks refer to DSTs performing functions defined in Table 4-1 and shown in Figures 4-1 and 4-2 of RPP-17152.

- The remote-handled transuranic (RH-TRU) waste solids from Tanks AW-103 and AW-105 may be blended with other HLW solids to reduce the zirconium concentration if possible and beneficial.

B3.2.2.9 The strontium and 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-24809, *Strontium and TRU Separation Process in the DST System*, as adopted by RPP-17152, Section 12.0, "In-Tank Strontium/Transuranic Precipitation."

B3.2.2.10 It is assumed that the blending strategy described in Section 7.2.4 of RPP-RPT-43828, *Enhanced Use of AN Farm for C Farm Single-Shell Tank Retrieval*, will successfully mitigate the uranium enrichment issues with Tank C-104 solids.[94]

B3.2.3 Waste Retrieval and Transfers

B3.2.3.1 The next group of SSTs to be retrieved in the near-term will be the C Farm tanks.

B3.2.3.2 The goal for sequencing the retrieval of SST waste is to minimize the waste treatment mission duration[95] by attempting to provide sufficient HLW or LAW feed to keep the limiting facilities operating at or near assumed capacity and by maintaining as high an average waste oxide loading of the limiting facility product as reasonably achievable. In addition, the sequencing should be operationally tractable.

B3.2.3.3 The retrieval of the SSTs will be sequenced using a staggered, overlapping, farm-by-farm approach, described in RPP-PLAN-40145, 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
- Special handling for the contact-handled transuranic (CH-TRU) waste

[94] Since Tank AN-101 will contain nearly 250 in. of settled solids after retrieval of Tanks C-104, C-111, C-112, C-101, and C-105, the waste will need to be retrieved layer-by-layer using incremental insertion of mixer pumps per RPP-40149. The intent is to fill two DSTs functioning as HLW staging tanks, each with half of Tank C-104 waste plus enough of the low-fissile blend stock to mitigate the uranium enrichment issue; the settled depth of the blended sludge in each of these two tanks is expected to be about 76 in. Note that the bulk of the sludge from the last two tanks to be retrieved into Tank AN-101 (currently assumed to be Tanks C-101 and C-105) would need to first be retrieved and transferred to other DSTs. The details are described in Section 7.2.4 of RPP-RPT-43828.

[95] It is asserted that minimizing treatment mission duration significantly reduces the risk to human health and the environment. This input is consistent with discussions held with Ecology.

- Providing a balanced[96] feed to the WTP, with priority given to feeding the more limiting facility
- Retrieving A/AX Farm tanks after completion of C Farm
- Using dedicated receiver tanks for A/AX Farm retrievals.

B3.2.3.4 Updated SST retrieval assumptions (assumed technology, minimum retrieval duration, and as-retrieved waste volumes) are provided by SVF-1647.

B3.2.3.5 Waste retrieved from B Complex (B, BX and BY Farms), not including waste handled as CH-TRU waste (see Assumption B3.4.2.2), will be transferred to a tank in the B Complex waste retrieval facility (WRF), with supernate routed back and forth from the WRF tank to the SST as required. Retrieved waste will be transferred from the WRF tank to DST storage via new double-encased hose-in-hose transfer lines (HIHTL) or stainless-steel lines (RPP-PLAN-40145).

B3.2.3.6 Waste retrieved from T Complex (T, TX and TY Farms), not including waste handled as CH-TRU waste (see Assumption B3.4.2.2), 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).

B3.2.3.7 Each WRF will consist of six tanks, each tank with a 150,000-gal operating volume, along with all needed ancillary equipment per RPP-17152.

B3.2.3.8 The B Complex WRF will be available for operations on July 2, 2019; the T Complex WRF will be available for operations on June 30, 2020.[97]

B3.2.3.9 All other SSTs (except those specifically retrieved into WRFs per Assumptions B3.2.3.5 and B3.2.3.6 or those handled as CH-TRU waste per Assumption B3.4.2.2) will be retrieved directly into the DST system.

B3.2.3.10 During retrieval of waste from SSTs to the DST system, sodium hydroxide and sodium nitrite will be added as needed so that the as-retrieved liquid phase composition satisfies the DST waste chemistry limits given in Table 3-9 of HNF-SD-WM-OCD-015. Caustic additions for intra-DST transfers and for depletion of caustic over time are not modeled.

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[96] In this context, a "balanced feed" means that the composition and relative quantities of the LAW and HLW feed are such that the treatment facilities can be operated as close to the assumed production curves as is practical, minimizing the overall duration of waste treatment.

[97] These dates are taken from the PMB and may be adjusted to meet success criteria.

B3.2.3.11 Allow a minimum of 210 days[98] to sample the feed staged in a DST and verify compliance with permits and the safety authorization basis before delivery to the WTP, starting from when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.[99]

B3.2.3.12 The feed for LAW hot commissioning will be delivered by decanting[100] a portion of the supernate from Tank AY-102 and transferring it to the WTP; the feed for HLW hot commissioning will be delivered by remobilizing the solids in Tank AY-102 with the remaining supernate and then transferring them to the WTP. Water may be added to the contents of Tank AY-102 before sampling to adjust the solids concentration, if needed.

B3.2.3.13 Subsequent deliveries of feed to the WTP will be timed and sequenced to balance the production of HLW glass and LAW glass.

B3.2.3.14 The use of the DSTs to receive retrieved SST waste, manage stored waste, and stage and deliver feed to WTP will be revisited as part of the integration with RPP-40149 and RPP-PLAN-40145. Key areas of alignment include (subject to change during the integration effort):

- Planned configuration of each DST
- Timing of upgrades to each DST
- Entrained solids concentrations or quantities for supernate transfers[100]
- The maximum settled solids level that can be effectively mobilized and well-mixed using two mixer-pumps without incremental insertion capability is 70 in. An allowance for mixing up to a nominal 76 in. will be assumed for the blending of Tank C-104 sludge per Assumption B3.2.2.7.
- Mixer pumps with incremental insertion capability can accommodate settled solid layers up to 200 in.[101]
- Deep sludge tanks with more than 200 in. of settled solids will require another technology, such as sluicing, to retrieve solids down to the 200-in. limit.[102]
- After retrieval of the next nine SSTs after C Farm, the goal is to minimize the creation of additional deep sludge (>70 in. of settled solids) DSTs.

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[98] The 210-day dwell time comprises the 180 days required by ICD-19 (24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed*) with an additional 30 days allocated for the Tank Operations Contractor to mix and sample the staged waste.

[99] A filled staging tank may not be mixed and sampled right away due to programmatic or operational considerations, even if the mixing and sampling capability is available, but for planning purposes, it is assumed to start as soon as possible.

[100] Assumptions concerning entrained solids concentrations are being developed as part of the integration effort with the next revision of the Integrated Waste Feed Delivery Plan (RPP-40149).

[101] The 200-in. limit is based on the 12-ft vertical stroke of the mixer pump.

[102] The use of the second technology will not be explicitly modeled at this time.

- During normal operations, mixer-pumps will not be operated with less than 72 in. of waste in the tank for deliveries of HLW feed to the WTP to ensure well-mixed feed.
- During normal operations, mixer-pumps will not be operated with less than 36 in. of waste in the tank for DST-to-DST transfers to prevent damage to the pumps.
- When used to stage HLW solids, the DSTs in AZ and AY Farms will each be limited to a maximum of nine complete fill-mix-empty cycles to avoid fatigue damage to in-tank components, not including final DST cleanout (Leonard 2010).[103, 104]
- Key transfers are needed to prepare the initial batches of feed for delivery to the WTP and to position the DST system to continue waste feed delivery operations (bootstrap transfers).
- With the exception of the LAW hot commissioning feed, all LAW transfers from tank farms to the WTP originate in a subset of AP Farm tanks and are transferred through a dedicated LAW feed line.[105]
- When a slurry transfer from a deep sludge (>70 in. of settled solids) DST occurs, a 30-day delay will be imposed prior to a subsequent slurry transfer from the same source tank.[106]

B3.2.3.15 All HLW batches delivered to the WTP should be between 40,000[107] and 120,000[108] gal before line flushes whenever possible and contain between 10 and 200 gm of unwashed solids per liter of slurry.[109] In addition, HLW batches are maintained at a maximum of 10 wt% of undissolved solids to meet mixing constraints in the HLW feed receipt tank.[110]

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[103] This is an enabling assumption pending the outcome of the mixing demonstration program. These tanks contain air-lift circulators and other in-tank equipment that may be damaged by excessive mixer-pump operation.

[104] The HTWOS model does not explicitly implement this assumption. Model results will be compared to the assumption.

[105] This minimizes HLW solids in the LAW transfers to the WTP (Charboneau 2010).

[106] The 30 days are based on the expectation of the need for a high-risk work package involving multiple cranes, tank containment, and elevated loads to adjust the insertion of the mixer pumps and the transfer pump to new levels in the DST. This is an enabling assumption pending additional detail on resource requirements needed to change mixer and transfer pump heights in a DST (Haigh 2010).

[107] This operational consideration reduces the number of transfers needed to deliver staged HLW from a DST to the WTP. The minimum delivered batch volume is assumed to be one-third of the maximum, the same ratio used in ICD-19 (24590-WTP-ICD-MG-01-019) (see footnote 108).

[108] The WTP equipment alternative (Assumption B3.3.2.4) reduces the maximum delivered batch volume to 120,000 gal, based on the minimum heel and set volumes for the WTP HLW feed receipt tank (HLP22). ICD-19 (24590-WTP-ICD-MG-01-019) still allows for transfers between 52,834 and 158,503 gal before line flushes.

[109] The WTP contract (DE-AC27-01RV14136), Section C, Specification 8, Paragraph 8.2.2.1, establishes the range of acceptable solids concentration in the delivered HLW feed. The System Plan will attempt to target a nominal 10 wt% solid concentration to facilitate more efficient WTP operations.

[110] This is an operational constraint to meet mixing requirements of the pulse-jet mixers in HLP-VSL-00022 (24590-WTP-MRR-PET-10-001).

B3.2.3.16 The residual waste remaining in the SSTs and DSTs after retrieval is complete will be estimated as follows:

- The residual inventory in a 200-series SST will be Best-Basis Inventory (BBI) data for that SST where waste retrieval actions have already been completed, when that information is available, or will be estimated as 25 ft^3 of residual containing 83 wt% water-washed solids with liquids at 5E-4 times the concentration (moles/liter) of the bulk as-retrieved supernate.[111, 112, 113]
- 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.[111, 112, 113]
- DSTs: 100 gal with composition of the last waste contained in the tank.[114]

B3.2.3.17 No waste is assumed to leak from the SSTs during retrieval.[115]

B3.2.4 Tank Farm Waste Evaporator (242-A)

B3.2.4.1 The 242-A Evaporator will be available, as needed, to support SST retrieval and to attempt to maintain the sodium concentration in the delivered feed within WTP feed specifications. The evaporator will not be available during scheduled maintenance outages.[116]

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[111] The residual volumes are conservatively assumed to be the maximum allowed by the Tri-Party Agreement (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 Tri-Party Agreement.

[112] The weight percent solids and liquid remaining in the residual is based on an informal review of post-retrieval waste volume estimates for Tanks C-103, C-106, S-112, C-201, C-202, C-203, and C-204 (Sasaki 2008).

[113] 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.

[114] The 100-gal DST residual volume is a placeholder assumption that has been used in the HTWOS model since 1997, and is not based on any evaluation of DST waste retrieval capability or end-of-mission flushing strategy. Use of this value is not meant to imply that the end-of-mission DST retrievals are efficient enough to leave this small of a residual. The resulting source term is equivalent to 100-gal of the last waste in the tank.

[115] While performance assessments assume nominal leakage during retrieval operations, the System Plan assumes no leakage occurs to ensure that the maximum waste inventory is modeled through the Waste Treatment Complex.

[116] The schedule of evaporator outages and availability will be established by WRPS as part of the integration effort.

B3.2.4.2 "Cold runs" are no longer assumed to be required if there are periods greater than 11 months during which the 242-A Evaporator is not used to concentrate waste.[117]

B3.2.4.3 A four-month period is allocated for the sampling and analysis of dilute feed staged in one or more DSTs, and for preparation of the process control plan before that feed can be run through the evaporator (RPP-17152, Section 5.3.3, "242-A Evaporator Feed Staging Dwell Time").[118] This assumes that the sampling and analysis effort is given high priority.

B3.2.4.4 When processing waste, the evaporator is assumed to run at the lesser of 40 gpm boil-off or 140 gpm feed (RPP-17152, Section 5.3.6, "242-A Maximum Evaporation Rate").[118]

B3.2.4.5 When processing waste, the minimum slurry rate is assumed to be 30 gpm.[119]

B3.2.4.6 Dilute waste will be concentrated until it reaches a bulk concentration of 1.43 g/mL; feed will not be evaporated if it would achieve less than a 15 percent waste volume reduction at 1.43 g/mL or at 80 percent of the maximum product source term (RPP-17152, Section 5.3.2, "242-A Evaporator Feed Staging Requirement").[120]

B3.2.4.7 The composition of process condensate from the 242-A Evaporator and the releases from the condenser to the atmosphere will be estimated using the formulas, partition coefficients, and split factors given in RPP-17152, Section 5.2, "Model Description." The volume of process condensate will be 1.15 times the waste volume reduction to account for the vacuum system steam jets (RPP-17152, Section 5.3.7, "242-A Process Condensate Volume").

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[117] The 242-A Evaporator is continuously manned, preventive and corrective maintenance performed, and operator training and qualifications are maintained. Therefore, performing a cold run or waste reduction campaign is not considered a restart after an extended shutdown within the context of DOE O 425.1C, *Start Up and Restart of Nuclear Facilities*, even if such a campaign has not occurred for 12 months or longer (Sax 2010a).

[118] These are estimates of recent 242-A Evaporator performance (Conner 2008).

[119] Additional estimate of recent 242-A Evaporator performance (Conner 2010).

[120] This density is expected to be the average density selected for future evaporator campaigns—it is not an inherent limitation of the evaporator. The feed for each evaporator campaign will be evaluated and a target density specific for that feed will be determined considering the ability of the transfer system to maintain solids in suspension and the DSTs ability to stay within BDGRE controls. In the future, a lower value may be used for waste containing high concentrations of phosphates. Precipitation of solids is not modeled.

B3.3 WASTE TREATMENT 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.

B3.3.1 General

B3.3.1.1 The WTP will be operable for 40 years, from the start of hot commissioning through 2058.

B3.3.1.2 The balance of facilities (BOF), laboratory, and other support facilities are assumed to be capable of supporting the WTP. The WTP sampling and analysis times are assumed to support production.

B3.3.1.3 The integrated total operating efficiency (TOE) of the WTP is assumed to be 70 percent.[121]

B3.3.1.4 Hot commissioning[122] will begin on May 11, 2018,[123] and end on December 30, 2019.[124]

B3.3.1.5 Delivery of the first batch of LAW feed will begin on May 11, 2018.[123]

B3.3.1.6 Delivery of the first batch of HLW feed will begin on May 31, 2018.[123]

B3.3.1.7 Routine WTP operations will begin on December 31, 2019,[125] and continue until the end of the treatment mission.

B3.3.1.8 The WTP is assumed to not return any waste streams or wastewater back to the tank farms.

B3.3.1.9 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.

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[121] DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that "The minimum integrated facility availability and the individual facility availability shall be equal to or greater than 70 percent." This assumption is implemented by Assumptions B3.3.3.3 and B3.3.4.4.

[122] The production goals for hot commissioning are addressed in Assumptions B3.3.3.2 and B3.3.4.3; detailed hot commissioning plans are not explicitly modeled.

[123] This is based on the WTP summary startup and commissioning schedule, dated December 2010, which reflects sequential operational readiness reviews and technical issue changes.

[124] This date assumes that all schedule contingency for WTP commissioning is used.

[125] Per Consent Decree (08-05085-FVS) milestone A-17.

B3.3.1.10 It is assumed that the delivered feed and internal WTP material flows and accumulations will be consistent with the WTP authorization basis.[126]

B3.3.1.11 The temperature of LAW feed delivered to the WTP is assumed to be less than 120°F; the temperature of HLW feed delivered to the WTP is assumed to be less than 150°F as an enabling assumption.[127] Minimum temperature limits have not been established.

B3.3.1.12 Feed projected to be delivered to the WTP will be screened[128] against several sets of requirements to proactively identify potential issues for future resolution. These screenings are not directly suitable for safety basis or design decisions—they serve to identify areas of further inquiry. The criteria sets to be used are the following:

- Specification 7: LAW envelope definition from DE-AC27-01RV14136, Section C.
- Specification 8: HLW envelope definition from DE-AC27-01RV14136, Section C.
- WTP hydrogen generation rate (HGR) limits.[129]
- The criticality safety limits in Section 8.1 of 24590-WTP-CSER-ENS-08-0001, *Preliminary Criticality Safety Evaluation Report for the WTP*. This screening will be based on point estimates of the as-delivered feed; confidence limits and uncertainty will not be addressed.

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[126] This assumption is not necessarily true for all feed to the WTP. It is assumed that the integrated management process for ICD-19 (24590-WTP-ICD-MG-01-019), as described in 24590-WTP-PL-MG-01-001, *Interface Management Plan*, will be used to successfully address any feed not consistent with this assumption. New tank-specific controls, if any, would be incorporated into the feed control list. For example, the feed control list (HNF-SD-WM-OCD-015, Table A-1) already requires blending of the solids in Tank AZ-101 to reduce the HGR and blending of the solids in Tank C-104 to reduce the concentration of ^{233}U.

[127] Revision 4 of ICD-19 (24590-WTP-ICD-MG-01-019) currently states a limit of 120°F for LAW feed and 190°F for HLW feed. The integrated project team for ICD-19 has agreed to reduce the limit for HLW feed to 150°F (Pell 2009). When that change is formally approved and promulgated, the impacts on waste feed delivery systems and operations will need to be assessed.

[128] Based on previous feed screening, some delivered feed is expected to fall outside of the screening criteria and may require multiple iterations with ORP, Bechtel National, Inc. (BNI), and WRPS over several years to fully define an acceptable set of feed requirements.

[129] The projected WTP feed will be screened against HGR criteria to flag batches of feed that are potentially problematic and may require special consideration. This simplified screening will only be applied to the feed as projected to be delivered to the WTP feed receipt tanks. The HGR calculation will be performed using screening criteria, provided by BNI and approved by ORP, documented in RPP-39811, *Waste Treatment and Immobilization Plant Hydrogen Generation Rate Screening Criteria for System Modeling*. BNI has recommended the continued use of the existing screening criteria in RPP-39811, including the continued use of 120°F and 190°F as the LAW and HLW maximum operating temperature, until new HGR criteria are established (Eager 2010).

B3.3.1.13 Key features of the WTP that will be modeled for purposes of mission planning and estimation of secondary waste streams include the following:

- Pretreatment (PT) Facility
  - LAW feed receipt tanks (combined)
  - HLW feed receipt tank
  - Front-end evaporators:
    - Recycle evaporator
    - Feed evaporator (modeled, but turned off per Assumption B3.3.1.14)
  - Two ultrafilter process trains (full-cycle):
    - Caustic leach
    - Concentration
    - Post-leach wash
    - Oxidative leach
    - Post-oxidative leach wash
    - Final solids concentration
    - Solids discharge
    - Filter rinse or acid cleaning
  - Pretreated HLW lag storage tanks
  - The three permeate receipt tanks (UFP-VSL-00062A/B/C) and the eluate contingency storage vessel CNP-VSL-00003[130] are modeled as a single tank with equivalent volume
  - Cesium ion-exchange:
    - Four-column carousel
    - Resin replacement, regeneration, and acid recovery simplified
  - Back-end treated LAW evaporator[131] and pretreated LAW storage
  - Plant waste disposal system, which processes recycle from the cesium ion-exchange process, ultrafiltration process, HLW canister decontamination process, and the HLW off-gas system back to the front-end evaporator
  - The radioactive liquid waste disposal (RLD) system collects process condensate from the front-end and back-end evaporator condensers and routes the process condensate to the ultrafiltration process; excess process condensate is sent to the Effluent Treatment Facility (ETF)/Liquid Effluent Retention Facility (LERF). Liquid streams from the LAW off-gas caustic scrubbers and the cesium ion-exchange resin addition process are routed through the RLD system and sent directly to ETF/LERF.
  - Aluminum solubility modeled (uses ORP-specified correlation)
  - Oxalate and phosphate solubility are modeled.

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[130] Based on 24590-WTP-RPT-PET-09-004, *Recommendation of Alternative to Mitigate Solids Precipitation in Ion Exchange Feed*.

[131] Back-end evaporator refers to the treated LAW evaporation process system.

- HLW Vitrification Facility
  - Both melter trains are combined
  - Both off-gas treatment systems are combined
  - HLW melter feed preparation (simplified; uses 2009 HLW GFM)
  - HLW melter
  - HLW canister
  - HLW melter off-gas system
  - Recycle of HLW condensate (from submerged bed scrubber [SBS], wet electrostatic precipitator [WESP], and high-efficiency mist eliminator) and canister wash-water and decontamination chemicals to the front-end recycle evaporator via the plant wash disposal system.
- LAW Vitrification Facility
  - Both melter trains are combined
  - Both off-gas treatment systems are combined
  - LAW melter feed preparation (simplified)
  - LAW melter
  - LAW container
  - LAW melter off-gas system
  - Recycle of both LAW SBS and WESP condensate to the back-end evaporator
  - Discharge of LAW caustic scrubber effluent and evaporator condensate to the LERF/ETF via the RLD system.
- General
  - Internal equipment and line flushed not modeled
  - Facility and process vessel vents not modeled
  - Sample hold times not modeled
  - Aqueous and solid phase densities (use tank farms assumptions rather than WTP)
  - TOE includes downtime for major facility equipment change-out (e.g., LAW and HLW melters).

B3.3.1.14 The basis for WTP flowsheet (equipment configuration, capacities, chemical reactions and extents, operating modes and logic, process splits and decontamination factors) used for mission modeling will be 24590-WTP-RPT-PT-02-005, except where superseded by the "equipment alternative" modification implemented to mitigate solids precipitation in ion-exchange feed discussed in 24590-WTP-RPT-PET-09-004, *Recommendation of Alternative to Mitigate Solids Precipitation in Ion Exchange Feed*.[132] Flowsheet and operating mode modifications will be made 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* (Rev. 10).

[132] Additional details for modeling the WTP "equipment" modification taken from 24590-WTP-MCR-PET-10-0016, *Optimized Oxalate Solids Control by Dilution (Back-End Caustic Leaching – In Advance of Engineering Design Updates).*

B3.3.2 Pretreatment

B3.3.2.1 When the WTP requests delivery of HLW feed, the HLW feed receipt tanks at the WTP will have sufficient space to receive 120,000 gal (454 m^3) of HLW feed plus associated transfer line flushes from the DST system without interruption.[133]

B3.3.2.2 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 Mgal of feed from the DST system plus associated transfer line flushes without interruption.[133, 134]

B3.3.2.3 The WTP PT Facility will be configured so that a portion of concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to a second LAW vitrification facility as feed. This is downstream of the point to which LAW SBS/WESP condensate is recycled, so the feed to a second LAW vitrification facility will include a proportional fraction of recycled condensate from both LAW facilities. The treated LAW concentrate tank feeds the WTP LAW Vitrification Facility as its first priority, with excess going to a second LAW facility.

B3.3.2.4 The pretreatment configuration will reflect the WTP "equipment alternative," which operates the ultrafiltration process and cesium ion-exchange system at 45°C. Under this configuration, the three permeate receipt vessels (UFP-VSL-00062A/B/C) and the eluate contingency storage vessel (CNP-VSL-00003) operate in a recirculation loop, which is modeled as one tank with equivalent volume.[130, 132]

B3.3.2.5 For modeling purposes, the solubility of aluminum in supernates present in the WTP PT Facility will be approximated using the correlation shown in Equation 4 from CCN: 160514 (Reynolds and Adelmund 2007).[135]

B3.3.2.6 For modeling purposes, the solubility of phosphate in the supernates present in the WTP PT Facility will be approximated using the correlation from CCN: 211818, "Revised Phosphate Algorithm for G2 Model (supersedes CCN 204880)" (Herting 2010).

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[133] These are operational considerations.

[134] The WTP contract (DE-AC27-01RV14136) requires 1.5 Mgal of space be provided to receive and store LAW feed from the DST system. 1.125 Mgal of space is allocated for receiving feed, while the remaining 0.375 Mgal is reserved for storage. For planning purposes, deliveries of feed to WTP will not be scheduled until a nominal 1 Mgal of space is available to avoid deliveries of small batches and tying up a DST for extended periods.

[135] The WTP baseline correlation in Equation 9 of the same reference is believed to provide overly conservative (biased high) estimates of required sodium additions. This is discussed in more detail in Reddick (2008). ORP has requested that Equation 4 be used instead of the WTP baseline as "a temporary estimate of nominal caustic additions until a better correlation is available." ORP has an ongoing effort to assess sodium use in the WTP. An approved sodium management plan and recent assessment (A-09-AMWTP-RPPWTP-002, *Design Oversight Report, Basis for Sodium Estimate*) may further refine this assumption. The use of the reference Equation 4 is appropriate until further revision/improvement is supported.

B3.3.2.7 For modeling purposes, the solubility of oxalate in the supernates present in the WTP PT Facility will be approximated using the correlation from CCN: 160518, "Sodium Oxalate Solubility Model for the Dynamic Flowsheet, Rev. 1, Supersedes CCN 153220" (Reynolds 2007).[132, 136]

B3.3.2.8 The solubility for aluminum, oxalate, and phosphate is applied throughout pretreatment at the conditions listed in 24590-WTP-MCR-PET-10-0016, *Optimized Oxalate Solids Control by Dilution (Back-End Caustic Leaching – In Advance of Engineering Design Update*.

B3.3.2.9 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).

B3.3.2.10 For planning purposes, all of the solids in each ultrafilter feed batch will be fully caustic leached.

B3.3.2.11 The extent of sludge dissolved by caustic leaching will be defined by the caustic leach factors associated with each delivered feed batch.

B3.3.2.12 An oxidative leach process that removes chromium from the HLW sludge will be implemented in the ultrafilter process system. Reaction stoichiometry and endpoint are described in 24590-WTP-RPT-PT-02-005. Batches with solid chromium concentrations greater than 5,000 μg Cr/g dried solids will be oxidative leached (RPP-15552, *Hanford Tank Waste Oxidative Leach Behavior Analysis*).

B3.3.2.13 The number of times the cesium ion-exchange resin is replaced will be tracked.

B3.3.2.14 The constituents that remain on the spent cesium ion-exchange resin are assumed to be negligible for system planning purposes and will not be modeled at this time.

B3.3.3 High-Level Waste Vitrification

B3.3.3.1 HLW vitrification at the WTP will begin on September 29, 2018.[137]

B3.3.3.2 During hot commissioning, the WTP will produce 84 MTG[138] of HLW glass.

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[136] Although, the cited correlation (CCN: 160518) is preliminary, it provides similar results to a newer, checked, correlation documented in 24590-WTP-M4C-V37T-00006, *Sodium Oxalate Solubility Equation for Water-Sodium Oxalate-Sodium Nitrate Systems*, which concludes "Both equations provide equally suitable results along the range of experimental data from which they were developed."

[137] This includes the hot commissioning period and reflects the modeled date on which the WTP HLW Vitrification Facility is changed from zero to the average hot commissioning rate; the actual date may vary (see Assumption B3.3.1.4 and associated footnote 122).

[138] DE-AC27-01RV14136, Standard 5, (g)(4) and (g)(5), requires that 4.2 MTG/day of HLW glass be produced for 20 days. For modeling purposes, the average glass production rate during hot commissioning is set so that the contract goal (rounded up to the next whole canister) is just met by the end date for hot commissioning.

B3.3.3.3 After hot commissioning, the net WTP HLW vitrification capacity will be ramped as follows:

Starting On	Rate MTG/d
12/31/2019	3.0
1/1/2021	4.0
1/1/22	4.2[139]
2/6/2025	5.25[139]

B3.3.3.4 The average bulk[140] density of immobilized high-level waste (IHLW) glass will be 2.66 Kg/L at 20°C; the average density of the molten glass will be 2.40 Kg/liter (24590-WTP-RPT-PT-02-005, Sections 4.2.3.6 and 4.2.3.2, respectively).

B3.3.3.5 An average bulk density of 2.66 Kg/L will be used to estimate the mass of glass contained in a filled IHLW canister (24590-WTP-RPT-PT-02-005, Section 4.2.3.6, "HLW Canister").

B3.3.3.6 On the average, each canister of IHLW will be filled to 40.088 ft^3 (1.1352 m^3).[141]

B3.3.3.7 Each canister of IHLW will contain 3.02 MT of HLW glass on the average.[142]

B3.3.3.8 The composition, properties, and waste oxide loading of HLW glass will be estimated[143] using the 2009 GFM documented in PNNL-18501. For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals. For planning purposes, the allowable glass-forming chemicals are: Al_2O_3, B_2O_3, Fe_2O_3, Li_2O, Na_2O, and SiO_2.[144]

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[139] DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that the HLW Vitrification Facility will support a combined design capacity of 6 MTG/d with the original two melters and 7.5 MTG/d with two replacement melters, with a minimum integrated TOE of 70%. The capability of the 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*.

[140] This is based on crucible density data and estimated volume percent void content per Section 4.2.3.6 of 24590-WTP-RPT-PT-02-005, and is consistent with Section 4.6 of 24590-WTP-MDD-PR-01-002.

[141] DE-AC27-01RV14136, Section C, Specification 1, Section 1.2.2.1.2, requires that on average, the canisters will be filled to 95% of the volume of an empty canister; the corresponding glass volume for nominal canister dimensions is estimated by Appendix C of 24590-HLW-M0C-30-00003, *HLW Glass Canister Weight and Volume Calculations*. This is also consistent with the estimate provided in 24590-HLW-M0-30-00001001, *HLW Test Canister Assembly*.

[142] This is based on filling a canister with 3/8-in. thick walls to 95% fill (40.088 ft^3 or 1.135 m^3) of glass with a bulk density of 2.66 kg/L per Assumptions B3.3.3.4 and B3.3.3.6.

[143] This model defines a constrained, non-linear programming problem, which is then solved in HTWOS by iterating over a linearized version of the model.

[144] The HTWOS implementation of the 2009 GFM allows the user to specify which glass-forming chemicals may be used. In addition to the six stated above, the user can specify CaO, MgO, TiO_2, ZnO, and ZrO_2. However, for this revision of the System Plan, the allowable glass-forming chemicals are being aligned to those used by BNI per Gimpel (2009).

B3.3.3.9 One HLW melter is assumed to be replaced every 2.5 years on the average and contains approximately 823 gal of glass.[145] For purposes of this System Plan, spent HLW melters are assumed to be disposed of at the Integrated Disposal Facility (IDF) per Assumption B3.5.6.2 and footnote 164, pending determination of their final disposition.

B3.3.4 Low-Activity Waste Vitrification

B3.3.4.1 LAW vitrification at the WTP will begin on August 18, 2018.[146]

B3.3.4.2 The WTP LAW Vitrification Facility will receive all of its feed from the WTP PT Facility.

B3.3.4.3 During hot commissioning, the WTP will produce 480 MTG[147] of LAW glass.

B3.3.4.4 After hot commissioning, the net WTP LAW vitrification capacity will be ramped as follows for all cases:

Starting On	Rate MTG/d
12/31/2019	9.0
1/1/2021	18.0
1/1/2022	21.0[148]

B3.3.4.5 The average bulk[149] density of immobilized low-activity waste (ILAW) glass will be 2.58 Kg/liter at 20°C; the average density of the molten glass will be 2.45 Kg/liter (24590-WTP-RPT-PT-02-005, Sections 3.2.3.2 and 3.2.3.7).

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[145] Replacement of spent melters is already accounted for in the net production capacity assumptions (assumes two melters, each with a 5-year minimum design life per 24590-HLW-3PS-AE00-T0001, *Engineering Specification for High Level Waste Melters*). The volume of glass in the melter is assumed to reflect the 25-in. heel remaining after the maximum pour and includes an allowance for increased volume due to corrosion of the refractory (CCN: 102476 [Hall 2004]); other contributions to source term are neglected. No credit is taken for purging the melter with "cold" glass prior to removal from service.

[146] This includes the hot commissioning period and reflects the modeled date on which the LAW Vitrification Facility is changed from zero to the average hot commissioning rate; the actual date may vary (see also Assumption B3.3.1.4 and associated footnote 122).

[147] DE-AC27-01RV14136, Standard 5, (g)(4) and (g)(5), requires that 24 MTG/day of HLW glass be produced for 20 days. For modeling purposes, the average WTP glass production rate during hot commissioning is set so that the contract goal (rounded up to the next whole package) is just met by the end date for hot commissioning.

[148] Assumes two LAW melters, each 15 MTG/d design at a 0.7 TOE. DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that the LAW Vitrification Facility will support a combined design capacity of 30 MTG/d, with a minimum integrated TOE of 70%.

[149] This is based on crucible density data and estimated volume percent void content per Section 3.2.3.7 of 24590-WTP-RPT-PT-02-005, and is consistent with Section 4.6 of 24590-WTP-MDD-RP-01-002.

B3.3.4.6 An average bulk density of 2.58 Kg/L will be used to estimate the mass of glass contained in a filled ILAW container (24590-WTP-RPT-PT-02-005, Section 3.2.3.7, "LAW Container").

B3.3.4.7 On the average, each package of ILAW will be filled to 564 gal (2.135 m^3).[150]

B3.3.4.8 Each package of ILAW will contain 5.51 MT of LAW glass on the average.[151]

B3.3.4.9 The total sodium loading of LAW glass from pretreated feed will be determined using the "DOE 2004" model (D-03-DESIGN-004, *An Assessment of the Factors Affecting the Ability to Increase the Na_2O Loading in the Waste Treatment and Immobilization Plant (WTP) Low Activity Waste (LAW) Glass*), which maximizes the sodium oxide loading in the LAW glass subject to the following constraints:[152]

$$[Na_2O] \leq 20wt\%$$
$$[SO_3] \leq 0.8wt\%$$

B3.3.4.10 The composition of the LAW glass will be estimated using a glass recipe model similar to that described in Table B-2 of 24590-WTP-MRQ-PO-04-0065, *Model Run Request, Supplemental LAW Data Collection*.

B3.3.4.11 One LAW melter is assumed to be replaced every 2.5 years on the average and contains approximately 1,875 gal of glass.[153] For purposes of this System Plan, spent melters will be managed and disposed of at the IDF as mixed low-level waste (LLW).

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[150] DE-AC27-01RV14136, Section C, Specification 2, Section 2.2.2.5, requires that the packages will be filled to at least 90% of the volume of an empty package; the corresponding volume is obtained from 24590-WTP-RPT-PT-02-005, Section 3.2.3.7.

[151] This is based on filling a package to 90% (2.135 m^3) of glass with a bulk density of 2.58 kg/L per Assumptions B3.3.4.5 and B3.3.4.7.

[152] LAW glass formulation work reviewed in D-03-DESIGN-004 suggests that the sodium loading projected by the DOE model can be achieved. Ongoing glass formulation work in the DOE complex suggests that glass formulations with even higher sodium oxide loadings may be achievable.

[153] Replacement of spent melters is already accounted for in the net production capacity assumptions (assumes two melters, each with a 5-year minimum design life per 24590-LAW-3PS-AE00-T0001, *Engineering Specification for Low Activity Waste Melters*). The volume of glass in the melter does not include an allowance for increased volume due to corrosion of refractory and reflects the heel remaining after the maximum pour; other contributions to source term are neglected. No credit taken for purging melter with "cold" glass prior to removal from service.

B3.4 SUPPLEMENTAL TREATMENT

B3.4.1 Second LAW Vitrification Facility

B3.4.1.1 For purposes of this System Plan, supplemental LAW treatment capacity is assumed to be provided by a second LAW vitrification facility, located in 200 East Area adjacent to the WTP.[154]

B3.4.1.2 The second LAW vitrification facility is assumed to have the same technical assumptions as the WTP LAW Vitrification Facility.

B3.4.1.3 The second LAW vitrification facility will receive "excess" pretreated LAW from the WTP PT Facility per Assumption B3.3.2.3.

B3.4.1.4 An evaporator at the back-end of the second LAW vitrification off-gas system will be used to concentrate condensate from the SBS and WESP. The resulting concentrated stream will be recycled to a second LAW vitrification facility feed tank. Evaporator condensate will be discharged directly to the LERF/ETF. The evaporator supporting the second LAW facility will be modeled using the same assumptions as the pretreatment back-end evaporator.

B3.4.1.5 Caustic scrubber effluent will be discharged directly to the LERF/ETF.

B3.4.1.6 The net capacity of a second LAW vitrification facility will be selected with the goal that the combined LAW vitrification capacity will be large enough so as to not drive the mission duration. The second LAW vitrification facility will complete hot commissioning on September 30, 2022 (hot commissioning will not be modeled) and begin routine operations on October 1, 2022. The facility will be ramped as follows:

Starting On	Rate MTG/d
10/1/2022	9.0
1/1/2025	Per Assumption B3.4.1.6

B3.4.1.7 One LAW melter is assumed to be replaced every P[155] years on the average and contains approximately 1,875 gal of glass.[156] Spent melters will be managed and disposed of at the IDF as mixed LLW.

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[154] This is a placeholder assumption pending a final decision circa 2015 as to how the needed LAW treatment capacity will be provided—by using a second LAW vitrification facility or by using bulk vitrification or another process in one or more supplemental treatment plants.

[155] Each melter is assumed to have a 5-year design life and therefore the average replacement period, P, will be 5 years divided by the number of melters.

[156] Replacement of spent melters is already accounted for in the net production capacity assumptions (assumes two melters, each with a 5-year minimum design life per 24590-LAW-3PS-AE00-T0001). The volume of glass in the melter does not include an allowance for increased volume due to corrosion of the refractory and reflects the heel remaining after the maximum pour; other contributions to source term are neglected. No credit has been taken for purging melter with "cold" glass prior to removal from service.

B3.4.2 Supplemental Transuranic Sludge Treatment

B3.4.2.1 The supplemental CH-TRU waste treatment and packaging process will be available on April 2, 2018[157] and will treat a maximum of 8,040 gal of CH-TRU slurry from retrieved CH-TRU tank waste per day.[158]

B3.4.2.2 The SSTs assumed to provide CH-TRU sludge are [B-201, B-202, B-203, B-204], [T-201, T-202, T-203, T-204], T-111, T-110, and T-104, in the stated order except that the tank order within the [brackets] can be changed (RPP-21970, *CH-TRUM WPU&SE 11-Tank Material Balance*, Sections 3.0 and 5.0, Assumption 2).[159]

B3.4.2.3 The supplemental CH-TRU waste treatment and packaging system for CH-TRU waste will first be located near B Farm and then moved to T Farm. There will be a minimum 10-day outage between tanks and a minimum 180-day outage to move equipment between farms.

B3.4.2.4 Waste previously assumed to be RH-TRU[160] waste will be retrieved and treated at the WTP together with the HLW (Harp 2008).

B3.4.2.5 The process flowsheet for the CH-TRU sludge treatment is described in the material balance for the CH-TRU waste tanks and is assumed to use the "dry batch mode" (RPP-21970). For modeling purposes, the two dryers may be combined into one continuous dryer of equivalent treatment capacity. Additional modeling details and simplifications are provided in Chapter 13 of RPP-17152.

B3.4.2.6 The dried waste product from the CH-TRU waste process is assumed to be packaged in 55-gal drums containing 620 lb_m product per drum (RPP-21970).

B3.4.2.7 Although not explicitly modeled, the CH-TRU waste drums are assumed to be stored onsite at the Central Waste Complex until their final disposition has been determined.

B3.4.2.8 Liquid effluent will either be transferred to the LERF via tank truck or recycled to the retrieval project. For planning purposes, it will be assumed that the liquid effluent is transferred only to LERF (no recycle) and will be modeled as a continuous pipeline transfer.

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[157] This is the date assumed by the life-cycle PMB.

[158] The assumed rate is based on 1:1 dilution of solids with water during retrieval and a 0.67 TOE per RPP-21970, Section 3.0.

[159] These are operational considerations. Order and timing may be adjusted to match the PMB.

[160] The SSTs previously assumed to contain RH-TRU sludge are Tanks T-105, T-107, T-112, B-107, B-110, and B-111; the DSTs previously assumed to contain RH-TRU sludge are Tanks SY-102, AW-103, and AW-105.

B3.5 INTERFACING FACILITIES

B3.5.1 Liquid Effluents

B3.5.1.1 The capacities and capability of the ETF, LERF, State-Approved Land Disposal Site (SALDS), and 200 Area Treated Effluent Disposal Facility (TEDF) will be driven by the needs of the waste treatment mission and are assumed to be available when needed. If the treatment mission requires a new secondary waste treatment facility or that changes be made to the ETF, LERF, SALDS, or TEDF or their operating plans, ORP is assumed to successfully drive the changes.

B3.5.1.2 The Secondary Liquid Waste Treatment Project will determine how best to provide the needed treatment capability for the secondary liquid waste—options may include, but are not limited to, upgrades to ETF or the use of other technologies. Meanwhile, for modeling purposes, this System Plan assumes that the project will select ETF upgrades to provide the needed capability.

B3.5.1.3 The LERF consists of three basins, each with an operating volume of 7.8 Mgal (HNF-SD-WM-SAD-040, *Liquid Effluent Retention Facility Final Hazard Category Determination*), which are used to provide lag storage of liquid effluent. For planning purposes, only two of the basins will be allocated to supporting the waste treatment mission; the third basin will be reserved for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) effluents.

B3.5.1.4 The ETF will be modeled as a black box. Overall partitioning of feed into solid waste and treated effluent will be approximated per HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*, Appendix A. Chemicals (e.g., those for bulking or stabilization of the solid waste form) will not be tracked.

B3.5.1.5 The SALDS will not be modeled; however, the demand on the SALDS from ETF will be estimated.

B3.5.1.6 The 200 Area TEDF[161] will not be modeled.

B3.5.2 Central Waste Complex

B3.5.2.1 The Central Waste Complex is assumed to support the needs of the waste treatment mission and is assumed to be available when needed. The demand on the Central Waste Complex will not be modeled.

B3.5.2.2 The packaged CH-TRU waste is assumed to be stored at the Central Waste Complex until the final disposition of CH-TRU waste has been determined.

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[161] The 200 Area TEDF treats and disposes of nonradioactive, non-dangerous liquid effluents such as 242-A Evaporator and WTP evaporator condenser cooling water and WTP cooling tower blow-down.

B3.5.2.3 The life-cycle cost for implementing the final disposition of CH-TRU waste (yet to be determined) from the Central Waste Complex is assumed to be similar to the costs that were allocated for disposal at Waste Isolation Pilot Plant (WIPP) directly from the CH-TRU waste packaging facility.

B3.5.3 Interim Hanford Storage

B3.5.3.1 Interim Hanford storage (IHS) will receive and temporarily store canisters of IHLW, with the canisters eventually retrieved and transported to the Hanford Shipping Facility (HSF) in preparation for shipment to a potential national repository (WRPS-1003700 [Sax 2010b]; RPP-23674, *Immobilized High-level Waste Interim Storage Facility System Specification*).

B3.5.3.2 IHS will be located in 200 East Area in the proximity of the WTP HLW Vitrification Facility and will provide interim storage for a minimum of 4,000 IHLW canisters. IHS 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 off-site geologic storage (RPP-23674).

B3.5.3.3 The need date for IHS will be the date on which the first radioactive HLW canister leaves the WTP (see Assumption B3.5.3.4). As of November 2010, the summary life-cycle baseline schedule (work breakdown structure [WBS] 5.03.06.06, "Hanford IHLW Storage Project") reflects:

- December 30, 2010: Critical Decision (CD)-0
- November 21, 2018: First 2,000 canister module operational
- January 2, 2020: Second 2,000 canister module operational
- Each additional module operational 1.5 years in advance of projected need date
- Decision to construct each additional module made four years in advance of the projected operational need date.

B3.5.3.4 The following factors will be considered when determining the time between when a HLW canister is poured and when it must be shipped out of the WTP to IHS.

- The HLW canister pour handling (HPH) system canister cooling rack provides 24 positions for placement of canisters (Section 6.2.1.4 of 24590-HLW-3YD-HPH-00001, *System Description for HLW System HPH Canister Pour Handling*).
- The HLW Export Cave Room 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 export operations, and 21 slots are designated for storage of non-conforming canisters (see Assumption B3.5.3.5). The remaining 24 slots are assumed to be allocated for interim canister storage in the HLW export area.

B3.5.3.5 The disposition of nonconforming canisters has not yet been determined.

B3.5.3.6 The average canister receipt and retrieval capability of IHS will *each* be 800 canisters per year,[162] with a peak handling rate of three canisters per day (RPP-23674).

B3.5.4 Hanford Shipping Facility

B3.5.4.1 It is assumed that on or before June 2022, a decision will be made to either continue to build additional 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 off-site final disposal alternative (see Assumption B3.5.5).

B3.5.4.2 The HSF will be located in the 200 East Area either as a standalone facility or a module attached to IHS. It will provide for shipping HLW canisters to a potential national repository.

B3.5.4.3 The canister shipping capability of the HSF is assumed to match the retrieval capability of IHS in Assumption B3.5.3.6. If and when the HSF begins shipping, the first priority will be given to shipping newly created IHLW canisters beyond those stored at IHS, and second priority will be given to emptying IHS after HLW vitrification is finished. Shipping needs will be estimated with IHS being operated at approximately 1,000 canisters less than capacity in order to decouple receipt of WTP canisters from shipping to a national repository.

B3.5.5 Final Disposal Alternative

B3.5.5.1 The final disposal alternative for HLW glass canisters is assumed to be at an unidentified off-site national repository.

B3.5.5.2 As an enabling assumption, the final disposal alternative will have the same waste acceptance criteria as the Yucca Mountain national repository waste acceptance criteria.

B3.5.6 Integrated Disposal Facility

B3.5.6.1 The IDF will be operational on September 28, 2018,[163] and will provide permanent disposal for the ILAW, other mixed LLW, and LLW.

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[162] This is about 25% above the average net production capacity required to support the assumed HLW glass production rate in Assumption B3.3.3.3.

[163] The stated date is taken from the PMB.

B3.5.6.2 The IDF will receive LAW glass packages from the WTP; solid waste from the WTP, including spent LAW and HLW[164] melters; and solid waste from the ETF from treating liquid effluent. Only that portion of the primary and secondary waste streams directly related to treatment of the tank waste will be modeled.[165]

B3.5.6.3 For planning purposes, the IDF can be expanded as needed to support the mission without interference from other users.

B3.5.7 222-S Laboratory

B3.5.7.1 It is assumed that the laboratory services required to support waste characterization for Tank Operations Contract projects and operations are available and provided in a timely manner.

B3.5.7.2 Any required facility life-extension upgrades will be aligned with the PMB.

B3.5.7.3 The 222-S Laboratory is assumed to transfer 5 kgal/year of waste (see Assumption B3.6.3) to the tank farms before the startup of the WTP, and 10 kgal/year thereafter.

B3.5.8 Waste Encapsulation and Storage Facility

B3.5.8.1 Cesium and strontium capsules are assumed to be dispositioned outside of the WTP and tank farm facilities by the DOE Richland Operations Office (RL).[166]

B3.5.9 Waste Isolation Pilot Plant

B3.5.9.1 Permitting and operational requirements to accept Hanford CH-TRU tank waste at WIPP will not impact the schedule critical path, if it is determined that the final disposition of the packaged CH-TRU tank waste is disposal at WIPP.

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[164] The final disposition of the spent HLW melters has not yet been determined. The many alternatives in DOE/EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC & WM EIS), assume that these spent HLW melters will be packaged in an overpack and stored at the HLW Melter Interim Storage Facility until they can be removed for disposition and final disposal. For planning purposes, the final disposition of the spent HLW melters is assumed to be at the IDF to maintain consistency with the current PMB. Plans will be updated as needed after a Record of Decision (ROD) is published.

[165] For example, the inventory that is retained on a disposable filter will be modeled, but the mass, composition, and overall volume of the filter itself will not be tracked.

[166] Pretreatment can connect to a potential new facility designed to receive and treat the Hanford cesium and strontium capsules prior to incorporation into the HLW feed for immobilization in the HLW Vitrification Facility, Section C.7(c)(2) of DE-AC27-01RV14136. All options in the draft EIS, except the "do nothing" alternative, assume that the contents of the cesium and strontium capsules are treated at the WTP. Therefore, this assumption may be revised when the disposition of the cesium and strontium capsules and their contents are formally established by the ROD and subsequent changes to the PMB.

B3.5.10 Other Hanford Site Facilities

B3.5.10.1 Sludge generated from the cleanup of the K Basins is assumed to be dispositioned outside of the WTP and tank farms facilities by RL.

B3.5.10.2 The Plutonium Uranium Extraction (PUREX) Plant is assumed to transfer a one-time 15 kgal of waste circa 2025 (see Assumption B3.6.3) to the tank farms as part of its deactivation.

B3.5.10.3 The T Plant Facility is assumed to transfer a one-time 15 kgal of waste circa 2025 (see Assumption B3.6.3) to the tank farms as part of its deactivation. The transfer will include a flush equal to 22 vol% of the waste transferred.

B3.5.10.4 Waste from the retrieval of the inactive miscellaneous underground storage tanks (IMUST) (see Assumption B3.6.3) will be transferred to the tank farms in a series of transfers between 2020 and 2030,[167] or sooner if practical.

[167]The dates and timing of the transfers will be integrated with the PMB.

B3.6 CROSS-CUTTING ASSUMPTIONS

B3.6.1 The decay date used for reporting all radionuclides is January 1, 2008, unless explicitly stated otherwise (RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operations Simulator Model - 2011 Update*).

B3.6.2 The starting tank inventory, as documented in RPP-33715, reflects the contents of the SSTs and DSTs as of October 1, 2010 (with the exception of Tanks AW-102 and AW-106, which have inventories effective as of October 13, 2010). This is called the "FY 2011 First Quarter" inventory and is based on the BBI downloaded from the Tank Waste Information Network System (TWINS) in February 2011, with adjustments to reflect improvements in the estimation and reporting of bound hydroxide and bound oxygen. Adjustments will be made in the HTWOS model for historical transfers as needed and to account for chemicals added during cleanout of hard-to-remove heels from SST retrievals.

B3.6.3 Estimates of the inventory for the IMUSTs, the waste resulting from deactivation of other Hanford facilities, and operation of the 222-S Laboratory are provided in RPP-33715.

B3.6.4 The water-wash factors[168] in TWINS circa January 2011 will be used to partition waste into solid and liquid phases during retrieval and staging; strontium partitioning will be modeled per RPP-21807, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*. The feed vector will be reported on a fully water-washed basis.

B3.6.5 The caustic leach factors in the TWINS circa January 2011 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids.

B3.6.6 For modeling purposes, the approximations to waste chemistry in the tank farms are described in RPP-17152, Section 2.8.7, "Waste Chemistry and Mass Balances."

B3.6.7 Liquid density and specific gravity will be estimated using the correlations described in RPP-17152, Section 2.5.1, "Liquid Density."

B3.6.8 For modeling purposes, solid particulate density is assumed to be a constant 3 g/mL[169] per RPP-17152, Section 2.8.9 "Solids Density."

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[168] Uncertainties and biases in the water-wash and caustic-leach factors can significantly influence the canister counts and treatment end dates. Water-wash factors and caustic-leach factors are a zero order approximation to complex solid-liquid equilibrium; this is a known limitation of this methodology.

[169] The value of this constant is being reevaluated and may be changed if warranted.

B3.6.9 The portion of total organic carbon due to oxalate will be tracked as oxalate rather than total organic carbon to avoid double-counting and will not be further speciated.[170] However, for modeling purposes, the remaining total organic carbon will be treated as carbon once it enters the WTP to allow for reaction stoichiometry (RPP-17152, Section 2.8.7).

B3.6.10 The modeled composition of waste retrievals from SSTs will be homogeneous. The modeled composition of waste transferred from a DST will reflect the overall composition of the specific layers (e.g., supernate, dissolved salts, mobilized solids) being transferred.[171]

B3.6.11 The design, flowsheet, operating modes, and operating plans of all facilities or processes will drive the permit conditions, and the permits will be modified as the processes evolve. Permits are assumed be issued by regulatory agencies in a timely fashion. Permit preparation activities of external agencies are not modeled.

B3.6.12 The Baseline Case is assumed to be consistent with and bounded by the outcome of the *National Environmental Policy Act of 1969* (NEPA) process.

B3.6.13 The Baseline Case is assumed to be consistent with and bounded by the appropriate facility authorization basis.

[170] Assumptions for speciating total organic carbon into its constituent organic compounds other than oxalate are not available. Therefore, the organic content of the various secondary waste streams will not be estimated.

[171] This is a simplifying assumption required for a tractable model.

B4.0 CASE 2: TRANSURANIC WASTE TO THE WASTE TREATMENT AND IMMOBILIZATION PLANT KEY ASSUMPTIONS

The purpose of Case 2 is to assess the impact of treating all of the potential CH-TRU tank waste at the WTP. Assumptions for Case 2 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B4.1 TRANSURANIC WASTE DISPOSITION

B4.1.1 All potential CH-TRU tank waste will be retrieved, mixed with other tank waste solids, and treated at the WTP as HLW.

B4.1.2 All potential CH-TRU tank waste may be commingled with other tank waste solids. This assumption replaces the CH-TRU controls found in the feed control list referenced in Baseline Case Assumption B3.2.2.7.

B4.1.3 No special handling is required for potential CH-TRU tank waste. This assumption replaces the following Baseline Case Assumptions: B3.2.3.3 (bullet 4 only); B3.2.3.5, B3.2.3.6, and B3.2.3.9 (for special handling of CH-TRU waste only); and B3.4.2.1 through B3.4.2.7.

B5.0 CASE 3: FLUIDIZED BED STEAM REFORMING FOR SUPPLEMENTAL TREATMENT KEY ASSUMPTIONS

The purpose of this case is to demonstrate the deployment of FBSR facilities as an alternative to a second LAW vitrification facility. The number of FBSR facilities required for this case will be calculated from the total required LAW treatment capacity. Supplemental pretreatment, comprising of rotary microfiltration (RMF) and small-column ion exchange (SCIX), will be used to supplement the feed from the WTP PT Facility to the FBSR facilities. Assumptions for Case 3 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B5.1 TANK FARMS

B5.1.1 Allow a minimum of 210 days[172] to sample the feed staged in a DST and verify compliance with permits and the safety authorization basis before delivery to the supplemental pretreatment system, starting from when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.[173]

B5.2 WASTE TREATMENT AND IMMOBILIZATION PLANT

B5.2.1 Pretreatment

B5.2.1.1 The WTP PT Facility will be configured so that a portion of concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to the FBSR facilities as feed. This is downstream of the point to which LAW SBS/WESP condensate is recycled, so the feed to the FBSR facilities will include a proportional fraction of recycled condensate from the WTP LAW Vitrification Facility. The treated LAW concentrate tank feeds the WTP LAW Vitrification Facility as its first priority, with excess going to the FBSR facilities. This assumption replaces Baseline Case Assumption B3.3.2.3.

B5.3 SUPPLEMENTAL TREATMENT

B5.3.1 Supplemental Pretreatment, General

B5.3.1.1 A portion of the waste feeding the supplemental immobilization (FBSR) facilities will come directly from the tank farms after it has been pretreated using a combination of RMF and SCIX. The pretreated LAW waste feed stream will meet currently established LAW feed requirements consistent with feed from the PT Facility and 24590-WTP-PL-PR-04-0001, *Integrated Sampling and Analysis Requirements Document*.

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[172] The 210-day dwell is a conservative sample and characterization time based on a similar assumption (B3.2.3.11) for WTP feed.

[173] A filled staging tank may not be mixed and sampled right away due to programmatic or operational considerations, even if the mixing and sampling capability is available, but for planning purposes, it is assumed to start as soon as possible.

B5.3.1.2 The supplemental pretreatment system will have sufficient capacity so that when combined with excess LAW from the WTP PT Facility, it will provide feed for the supplemental treatment (FBSR) facilities without limiting production of immobilized product.

B5.3.1.3 A skid-mounted exhaust system will be used to ventilate the staging tanks and those with RMF and SCIX units installed.

B5.3.2 Rotary Microfiltration

B5.3.2.1 The RMF unit is deployed as an in-tank filtration process and will be installed in a riser of a DST. Once the RMF unit is installed, the DST on which it is installed will be excluded from all other DST activities until the RMF unit is no longer needed and removed.

B5.3.2.2 Feed for the supplemental pretreatment system is staged and transferred from a LAW feed DST, to the DST in which the RMF unit is installed. Suspended solids are removed from the feed stream and discharged back into the DST where the RMF is installed.

B5.3.2.3 Clarified feed from the RMF is diluted to approximately 5 M sodium[174] (when warranted) and sodium hydroxide is added to ensure the feed is not supersaturated with aluminum at 25°C (see Assumption B3.3.2.5). The clarified feed is then transferred to the SCIX system.

B5.3.3 Small-Column Ion Exchange

B5.3.3.1 The SCIX system consists of two columns installed in two separate risers of a DST. Once the SCIX unit is installed, the DST on which it is installed will be excluded from all other DST activities until the SCIX unit is no longer needed and removed.

B5.3.3.2 For planning purposes, it is assumed that the resin media used for SCIX operations is the same media (spherical resorcinol formaldehyde) used in the WTP PT Facility.

B5.3.3.3 For planning purposes, it is assumed that the SCIX system has the same cesium removal efficiency, 99.97 percent per 24590-WTP-MDD-PR-01-002, as the WTP PT Facility.

B5.3.3.4 Key features[175] of the SCIX system that will be modeled for the purposes of mission planning include the following:

- Two-column carousel
- Column loading volume
- Resin regeneration (including cesium elution)
- Resin replacement.

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[174] This molarity is based on feed to the ion-exchange system in the WTP per 24590-WTP-MDD-PR-01-002.

[175] The basis of the CSIX flowsheet (equipment configuration, operating modes and logic) is from Thorson (2010).

B5.3.3.5 The pretreated feed from the SCIX system is transferred directly to the lag-storage vessels[176] where confirmatory samples will be taken prior to delivery to the supplemental treatment system.

B5.3.3.6 Spent resin from the SCIX system is assumed to be disposed of at the IDF in a yet-to-be-determined waste form. The spent resin source term will be neglected for modeling purposes.

B5.3.3.7 Eluate generated during resin regeneration is neutralized and discharged into the DST upon which the SCIX is installed.

B5.3.4 Supplemental Treatment

B5.3.4.1 Supplemental LAW treatment capacity is assumed to be provided by a collection of FBSR facilities, located in the 200 East Area and adjacent to the WTP.[177] This assumption and Assumptions B5.3.4.2 through B5.3.4.7 replace Baseline Case Assumptions B3.4.1.1 through B3.4.1.7.

B5.3.4.2 The FBSR facilities will be standalone facilities that use a process based on the THOR Treatment Technologies[178] FBSR flowsheet for producing a mineralized product.[179] Standalone means that each facility contains all of the necessary unit operations and will not rely on the DST system, the 242-A Evaporator, or the WTP PT Facility for support, and that it includes any needed lag storage.

B5.3.4.3 The LAW/clay slurry feed rate is based on 72-in. inner diameter columns that will each provide a nominal treatment capacity of 606 MT sodium/year.[180]

B5.3.4.4 The combined FBSR facilities will be modeled as a black box, with the following attributes (see references from footnote 179).

- Incoming LAW feed will be adjusted to 5 M sodium.
- Clay additions will be calculated based on feed composition.

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[176] The location of the lag storage will be determined by the Supplemental Treatment and Immobilization Program.

[177] A final decision has not been made as to how the needed LAW treatment capacity will be provided—by using a second LAW vitrification facility or by using bulk vitrification or another process in one or more supplemental treatment plants. This exploratory case uses FBSR, as requested in RPP-48228.

[178] THOR Treatment Technologies is a joint venture between URS and Studsvik.

[179] Attributes for the FBSR are collected from the following documents:

- RPP-RPT-46137, *Preliminary Evaluation of Fluidized Bed Steam Reformer Technology for Hanford Low-Activity Waste Processing*. Used for FBSR feed sodium molarity, column size, and feed rate.
- PSDD-30284-21-001, *Process System Description Document: THOR® Fluidized Bed Steam Reforming Treatment of Hanford LAW*. Used for clay addition calculation and mineralized product loading in a monolith. THOR (which stands for thermal organic reduction) is a registered trademark of Studsvik, Inc. Erwin, Tennessee.
- RT-21-002, *Report for Treating Hanford LAW and WTP SW Simulants: Pilot Plant Mineralizing Flowsheet*. Used for splits for radionuclides, NO_x destruction extent, and carbon addition and split.

[180] This capacity is based on a nominal 5 M sodium feed at a constant feed slurry rate of 3.23 gpm, operating with a 70% TOE and 10% excess clay (PSDD-30284-21-001); projected treatment rate will vary with feed composition.

- The coal addition rate will be maintained at 0.29 times the product stream rate.
- LAW/clay slurry will be fed continually at a rate of 3.23 gpm for each operating fluidized bed steam reformer.
- Splits for select radionuclides ^{99}Tc, ^{137}Cs, ^{90}I, ^{3}H and ^{14}C will be used to partition the product stream from the off-gas stream.
- Destruction reactions for NO_x, total organic carbon, and coal will be used to account for phase and speciation change of the input constituents.
- The mass of the monolithic product will be estimated using an average waste loading from PSDD-30284-21-001.

B5.3.4.5 The FBSR facilities will receive pretreated LAW from the supplemental pretreatment facility. The facilities will also receive "excess" pretreated LAW from the WTP PT Facility per Assumption B5.2.1.1. Priority will be given to the "excess" pretreated LAW from WTP to prevent bottlenecking WTP operations.

B5.3.4.6 The net capacity of the FBSR facilities will be selected with the goal that the combined LAW immobilization capacity will be large enough so as to not drive the mission duration.

B5.3.4.7 The first FBSR facility will begin routine operations on January 1, 2018. Succeeding facilities will come online with a nine-month delay between each startup (RPP-48228).

B6.0 CASE 4: WASTE TREATMENT AND IMMOBILIZATION PLANT DELAY WITH INCREASED VITRIFICATION CAPACITY KEY ASSUMPTIONS

The purpose of this case is to evaluate how well a 10 percent increase in overall vitrification capacity can offset all or part of the impacts from a uniform four-year delay in the startup of WTP. Assumptions for Case 4 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B6.1 WASTE TREATMENT AND IMMOBILIZATION PLANT

B6.1.1 General

B6.1.1.1 WTP hot commissioning will begin on May 11, 2022,[181] and end on December 30, 2023. This assumption replaces Baseline Case Assumption B3.3.1.4.

B6.1.1.2 Delivery of the first batch of LAW feed to WTP will begin on May 11, 2022. This assumption replaces Baseline Case Assumption B3.3.1.5.

B6.1.1.3 Delivery of the first batch of HLW feed to WTP will begin on May 31, 2022. This assumption replaces Baseline Case Assumption B3.3.1.6.

B6.1.1.4 Routine WTP operations will begin on December 31, 2023, and continue until the end of the treatment mission. This assumption replaces Baseline Case Assumption B3.3.1.7.

B6.1.2 High-Level Waste Vitrification

B6.1.2.1 HLW vitrification at the WTP will begin on September 29, 2022. This assumption replaces Baseline Case Assumption B3.3.3.1.

B6.1.2.2 After hot commissioning, the net WTP HLW vitrification capacity will be ramped as follows:

Starting On	Rate MTG/d
12/31/2023	3.3[182]
1/1/2025	4.4
1/1/2026	4.62
2/6/2029	5.775

B6.1.2.3 This assumption replaces Baseline Case Assumption B3.3.3.3.

[181] In accordance with RPP-48228, defining Case 4, a nominal four years have been added to all start dates specified in the Baseline Case for the HLW, LAW, and second LAW facilities (including those for hot commissioning, feed delivery, routine WTP operations, and vitrification rate increases).

[182] In accordance with RPP-48228, defining Case 4, HLW, LAW, and second LAW facility vitrification rates have each been increased by 10% for an overall 10% increase in WTP capacity.

B6.1.3 Low-Activity Waste Vitrification

B6.1.3.1 LAW vitrification at the WTP will begin on August 18, 2022. This assumption replaces Baseline Case Assumption B3.3.4.1.

B6.1.3.2 After hot commissioning, the net WTP LAW vitrification capacity will be ramped as follows:

Starting On	Rate MTG/d
12/31/2023	9.9
1/1/2025	19.8
1/1/2026	23.1

B6.1.3.3 This assumption replaces Baseline Case Assumption B3.3.4.4.

B6.2 SUPPLEMENTAL TREATMENT

B6.2.1 Second LAW Vitrification Facility

B6.2.1.1 The second LAW vitrification capacity for this case will be 10 percent more than the numerical value determined for the Baseline Case second LAW capacity. The Baseline Case capacity will be determined as described in Assumption B3.4.1.6.

Starting On	Rate MTG/d
10/1/2026	9.9
1/1/2029	B3.4.1.6 + 10%

B6.2.1.2 This assumption replaces Baseline Case Assumption B3.4.1.6.

B7.0 CASE 5: 2020 VISION KEY ASSUMPTIONS

The purpose of this case is to show the impacts and effects of phased turnover of the WTP facilities. Case 5 is based on and generally consistent with the key technical features of the 2020 Vision One System proposal submitted to DOE on March 21, 2011 (Spencer and Russo 2011), and evaluates the ability to meet Consent Decree milestone A-1, "Achieve Initial Plant Operations for the Waste Treatment Plant" by December 31, 2022. Assumptions for Case 5 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B7.1 GENERAL

B7.1.1 Hot commissioning of the WTP will begin on October 17, 2016, and end on December 31, 2022. The WTP PT Facility will start hot commissioning on January 6, 2018. This assumption replaces Assumption B3.3.1.4. A phased approach will be used in which the WTP LAW Vitrification Facility begins commissioning on one melter followed by the remaining melter, WTP PT Facility, and the WTP HLW Vitrification Facility.

B7.1.2 Delivery of the first batch of pretreated LAW feed to the WTP LAW Facility will begin on October 17, 2016. This assumption replaces Assumption B3.3.1.5.

B7.1.3 Delivery of the first batch of HLW feed to the WTP PT Facility will begin on January 6, 2018. This assumption replaces Assumption B3.3.1.6.

B7.1.4 Routine WTP operations will begin on January 1, 2023, and continue until the end of the treatment mission. This assumption replaces Assumption B3.3.1.7.

B7.1.5 Supplemental pretreatment in the form of RMF and SCIX will be used to feed the WTP LAW Vitrification Facility until the WTP PT Facility becomes available. This assumption replaces Baseline Case Assumption B3.3.4.2.

B7.1.6 Prior to availability of supplemental LAW treatment on October 1, 2022, the following PT Facility operating mode changes are assumed.

- Only HLW feed will be delivered to the WTP PT Facility.[183]
- Pretreated LAW may be managed so that any excess pretreated LAW will not impact the production of the LAW or HLW Vitrification Facilities, including the option to temporarily store pretreated LAW in existing WTP PT Facility vessels.[184]

[183] The LAW generated from pretreating HLW feed and its carrier supernate provides ample pretreated LAW to operate the WTP LAW Vitrification Facility during this time period.

[184] Other options for managing excess treated LAW include returning the treated LAW back to tank farms or accelerating the beginning of supplemental LAW treatment.

- The solids and sodium in delivered HLW feed may be adjusted within existing feed specifications to balance the operation of the LAW and HLW Vitrification Facilities.

B7.1.7 In addition to the success criteria in Section B2.2, the ability of Case 2 to meet Consent Decree milestone A-1 by December 31, 2022, will be evaluated. The 2020 Vision One System proposal plans to meet this milestone by ramping up production to demonstrate a steady-state throughput of 4.2 MTG/day IHLW and 21 MTG/day ILAW for 90 consecutive days by December 31, 2022. This assumption replaces Baseline Case Assumptions B3.3.3.2 and B3.3.4.3.

B7.2 TANK FARMS

B7.2.1 Allow a minimum of 210 days[185] to sample the feed staged in a DST and verify compliance with permits and the safety authorization basis before delivery to the interim pretreatment system (IPTS), starting from when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.[186]

B7.3 SUPPLEMENTAL PRETREATMENT

B7.3.1 Interim Pretreatment System

B7.3.1.1 The waste will be pretreated using a combination of RMF and SCIX to achieve a pretreated LAW waste feed stream that meets currently established LAW feed requirements consistent with feed from the PT Facility and 24590-WTP-PL-PR-04-0001.

B7.3.1.2 The IPTS will be capable of supporting a minimum average of 5.51 MT per day of ILAW glass.

B7.3.1.3 A skid-mounted exhaust system will be used to ventilate the staging tanks (see Assumption B7.3.4) and Tanks AP-105 and AP-107.

B7.3.2 Rotary Microfiltration

B7.3.2.1 Waste feed selected for pretreatment in the IPTS is diluted to approximately 5.5 M sodium [187](when warranted), and sodium hydroxide is added to ensure that the feed is not supersaturated with aluminum at 25°C (see Assumption B3.3.2.5).

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[185] The 210-day dwell is a conservative sample and characterization time based on Assumption B3.2.3.11.

[186] A filled staging tank may not be mixed and sampled right away due to programmatic or operational considerations, even if the mixing and sampling capability is available, but for planning purposes, it is assumed to start as soon as possible.

[187] This molarity is based on feed to the ion-exchange system in the WTP per 24590-WTP-MDD-PR-01-002.

B7.3.2.2 The feed is staged and characterized per Assumption B7.2.1 before being transferred to the RMF unit installed in a riser on DST AP-105. Suspended solids are removed from the feed stream and discharged back into DST AP-105. Once the RMF unit is installed, DST AP-105 will be excluded from all other DST activities until the RMF unit is no longer needed and removed.

B7.3.2.3 Clarified feed exiting the RMF system is then transferred to the SCIX system.

B7.3.3 Small-Column Ion Exchange

B7.3.3.1 The SCIX system consists of two columns installed in two separate risers of DST AP-107. Once the SCIX unit is installed, DST AP-107 will be excluded from all other DST activities until the SCIX unit is no longer needed and removed.

B7.3.3.2 For planning purposes, it is assumed that the resin media used for SCIX operations is the same media (spherical resorcinol formaldehyde) used in the WTP PT Facility.[188]

B7.3.3.3 For planning purposes, it is assumed that the SCIX system has the same cesium removal efficiency (99.97 percent) as the WTP PT Facility.

B7.3.3.4 Key features[189] of the SCIX system that will be modeled for the purposes of mission planning include the following:

- Two-column carousel
- Column loading volume
- Resin regeneration
- Resin replacement.

B7.3.3.5 The pretreated feed from the SCIX system is transferred to three feed-staging tanks where confirmatory samples will be taken prior to delivery to the LAW Vitrification Facility (see Assumption B7.3.4.1).

B7.3.3.6 Spent resin from the SCIX system is assumed to be disposed of at the IDF in a yet-to-be-determined waste form. The spent resin source term will be neglected for modeling purposes.

B7.3.3.7 Eluate generated during resin regeneration is neutralized and discharged into DST AP-107.

[188] This is an enabling assumption. Media testing and selection for the SCIX resin is currently ongoing.
[189] Basis for the CSIX flowsheet (equipment configuration, operating modes, and logic) is from Thorson (2010).

B7.3.4 Feed Staging Tanks

B7.3.4.1 The pretreated LAW stream from the IPTS will be staged in three existing[190] 15,000-gal staging tanks prior to delivery to the LAW Vitrification Facility.

- For planning purposes, the working volume of the three staging tanks will be between 10 percent and 80 percent of the actual tank volume.
- After a staging tank has been filled, solubility correlations for aluminum, phosphate, and oxalate will be applied to prevent solids precipitation (see Assumptions B3.3.2.5, B3.3.2.6, and B3.3.2.7) before delivery to the LAW Vitrification Facility.
- Once a staging tank has been filled to its maximum fill volume, allow 3 days[191] to sample the staged feed and verify compliance with permits and the safety authorization basis (see Assumption B3.3.1.12) before delivery to the LAW Vitrification Facility.
- The three staging tanks will operate in a first-in/first-out queue.

B7.4 WASTE TREATMENT AND IMMOBILIZATION PLANT

B7.4.1 High-Level Waste Vitrification

B7.4.1.1 The net WTP HLW vitrification capacity will be ramped[192] as follows (this assumption replaces Assumption B3.3.3.3):

Starting On	Rate MTG/d
5/7/2018	1.5
6/1/2019	2.1
6/1/2020	3.0
1/1/2022	4.2
2/6/2025	5.25

B7.4.2 Low-Activity Waste Vitrification

B7.4.2.1 A single LAW melter will be placed in service on January 1, 2016[193] for WTP cold commissioning and will be operated in a manner that produces one package (5.51 MT) of ILAW per day on average. Cold commissioning will not be modeled.

[190] The three staging tanks are available from the discontinued bulk vitrification demonstration project and are currently located in the 200 East Area.

[191] Basis for confirmation sampling time is from Seidel (2011).

[192] The shape of the ramp prior to January 1, 2022, may be adjusted if needed to balance the operation of the WTP LAW and HLW Vitrification Facilities, not to exceed 4.2 MTG/day.

[193] This is an enabling assumption based on rough order of magnitude estimates of cost and schedule found in the 2020 Vision One System proposal submitted to DOE on March 21, 2011 (Spencer and Russo 2011).

B7.4.2.2 Hot commissioning of the single LAW melter will begin on October 17, 2016, based on time allotted for initial treated LAW feed preparation and delivery by tank farms.

B7.4.2.3 The second LAW melter will begin hot commissioning on January 6, 2018, in conjunction with the start of PT Facility hot commissioning. After start of the PT Facility hot commissioning, both melters will receive all of their feed from the PT Facility. The net WTP LAW vitrification capacity, including the hot commissioning period, will be ramped as follows (this assumption replaces Assumption B3.3.4.4):

Starting On	Rate MTG/d
1/6/2018	5.5
6/1/2018	15.0
6/1/2019	21.0
6/1/2020	21.0[194]
10/1/2022	21.0

B7.4.2.4 A single HIHTL with appropriate valving is routed from a waste feed pump to a connection point at the LAW Vitrification Facility.

- Pretreated waste from the three feed staging tanks will be delivered to the LAW Vitrification Facility, into tank LCP-VSL-00001, via this HIHTL.
- The connection point is assumed to be the existing connection for supply of simulant for cold commissioning that is located inside the LAW Vitrification Facility secondary containment area.
- Any pretreated waste that enters the LAW Vitrification Facility that does not meet the LAW feed specifications will be routed directly to the secondary waste collection tanks for conditioning and return to the tank farms.

B7.4.2.5 Secondary liquid waste from the LAW Vitrification Facility will be routed back to the tank farms using a HIHTL (this assumption supersedes Baseline Case Assumption B3.3.1.8).

- A single HIHTL will be installed from the LAW Vitrification Facility back to a modified valve pit in AP Farm.
- To meet the tank farm waste acceptance criteria, caustic and sodium nitrite will be added to the secondary liquid waste in the LAW Vitrification Facility prior to pumping it back to the tank farms.
- Secondary liquid waste will be routed back to the tank farms to be concentrated by the 242-A Evaporator.

[194] The net capacity for this step in the ramp-up may be adjusted up to 24.0 MTG/day, if needed to balance the operation of the WTP LAW and HLW Vitrification Facilities. This short-term increase assumes that the change-out of the first melter may be delayed until October 1, 2022.

B7.4.3 Integrated Disposal Facility

- The IDF will be operational on October 17, 2016 and will provide permanent disposal for the ILAW, other mixed LLW, and LLW (this assumption replaces Baseline Case Assumption B3.5.6.1).

B8.0 CASE 6: WASTE TREATMENT AND IMMOBILIZATION PLANT DELAY WITH NEW DOUBLE-SHELL TANK FARM KEY ASSUMPTIONS

The purpose of this case is to evaluate how well a new DST farm can offset all or part of the impacts from a uniform four-year delay in the startup of the WTP. Assumptions for Case 6 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B8.1 TANK FARMS

B8.1.1 Double-Shell Tanks

B8.1.1.1 A new DST farm will be installed in 200 East Area and be fully integrated into the DST transfer system. The number of tanks will be chosen to compensate for a four-year delay in the startup of the WTP, but will be no more than eight.[195]

B8.1.1.2 Each tank of the new farm will have a nominal capacity of 1 Mgal (actual operating volume of 1.2465 Mgal, see Assumption B3.2.2.2).

B8.1.1.3 Each tank of the new farm will be equipped to handle solids using the following installed equipment: dual mixer pumps without incremental insertion capability, slurry pumps, and decant pumps. Supporting infrastructure upgrades will be conducted as needed.

B8.1.1.4 The new farm will be fully operational as of September 30, 2020.

B8.1.1.5 As stated in Assumption B3.2.2.1, the integrity of 28 DSTs is described in HNF-EP-0182, and it is assumed that the DSTs will remain fully operational for the duration of the waste treatment mission. Each of the tanks of the new DST farm is assumed to meet similar criteria and to also remain fully operational for the duration of the waste treatment mission.

B8.2 WASTE TREATMENT AND IMMOBILIZATION PLANT

B8.2.1 General

B8.2.1.1 Hot commissioning will begin on May 11, 2022,[196] and end on December 30, 2023. This assumption replaces Baseline Case Assumption B3.3.1.4.

B8.2.1.2 Delivery of the first batch of LAW feed will begin on May 11, 2022. This assumption replaces Baseline Case Assumption B3.3.1.5.

B8.2.1.3 Delivery of the first batch of HLW feed will begin on May 31, 2022. This assumption replaces Baseline Case assumption B3.3.1.6.

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[195] Assumptions B8.1.1.1 through B8.1.1.4 are based on criteria for Case 6 specified in RPP-48228.

[196] In accordance with RPP-48228, defining Case 6, a nominal four years have been added to all start dates specified in the Baseline Case for the HLW, LAW, and second LAW facilities (including those for hot commissioning, feed delivery, routine WTP operations, and vitrification rate increases).

B8.2.1.4 Routine WTP operations will begin on December 31, 2023, and continue until the end of the treatment mission. This assumption replaces Baseline Case Assumption B3.3.1.7.

B8.2.2 High-Level Waste Vitrification

B8.2.2.1 HLW vitrification at the WTP will begin on September 29, 2022. This assumption replaces Baseline Case Assumption B3.3.3.1.

B8.2.2.2 After hot commissioning, the net WTP HLW vitrification capacity will be ramped up as follows:

Starting On	Rate MTG/d
12/31/2023	3.0
1/1/2025	4.0
1/1/2026	4.2
2/6/2029	5.25

B8.2.2.3 This assumption replaces Baseline Case Assumption B3.3.3.3.

B8.2.3 Low-Activity Waste Vitrification

B8.2.3.1 LAW vitrification will begin on August 18, 2022. This assumption replaces Baseline Case Assumption B3.3.4.1.

B8.2.3.2 After hot commissioning, the net WTP LAW vitrification capacity will be ramped as follows for all cases:

Starting On	Rate MTG/d
12/31/2023	9.0
1/1/2025	18.0
1/1/2026	21.0

B8.2.3.3 This assumption replaces Baseline Case Assumption B3.3.4.4.

B8.3 SUPPLEMENTAL TREATMENT

B8.3.1 Second LAW Vitrification Facility

B8.3.1.1 The net capacity of a second LAW facility will be determined for the Baseline Case. For this case, the startup and ramp-up will be delayed by four years, but the capacity will be held to the Baseline Case value.

Starting On	Rate MTG/d
10/1/2026	9.0
1/1/2029	As determined in B3.4.1.6

B8.3.1.2 This assumption replaces Baseline Case Assumption B3.4.1.6.

B9.0 CASE 7: ENHANCED TANK WASTE STRATEGY KEY ASSUMPTIONS

The purpose of this case is to evaluate the judicious use of transformational technologies that may have the potential to shorten the treatment mission and reduce the life-cycle cost. Assumptions for Case 7 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B9.1 TANK FARMS

B9.1.1 Allow a minimum of 210 days[197] to sample the feed staged in a DST and verify compliance with permits and the safety authorization basis before delivery to the supplemental pretreatment system, starting from when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.[198]

B9.2 WASTE TREATMENT AND IMMOBILIZATION PLANT

B9.2.1 General

B9.2.1.1 This case uses FBSR facilities for all LAW treatment instead of the WTP LAW Vitrification Facility and a second LAW vitrification facility. This assumption and those that follow in this section, supersede all details in Baseline Case Assumption B3.3.1.13 pertaining to the LAW Vitrification Facility.

B9.2.2 Pretreatment

B9.2.2.1 The WTP PT Facility will be configured so that the concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to the FBSR facilities as feed. This assumption replaces Baseline Case Assumption B3.3.2.3.

B9.2.3 Low-Activity Waste Vitrification

B9.2.3.1 The WTP LAW Vitrification Facility will not be used in this case. This assumption replaces Baseline Case Assumptions B3.3.4.1 through B3.3.4.11.

B9.2.4 High-Level Waste Vitrification

B9.2.4.1 If needed to meet the goal of completing the waste treatment mission seven years earlier than the Baseline Case, assume that the necessary design changes to the HLW Vitrification Facility have already been made to support next generation melters, not to exceed 1.5 times the baseline capacity, starting at first melter change-out.

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[197] The 210-day dwell is a conservative sample and characterization time based on Assumption B3.2.3.11.

[198] A filled staging tank may not be mixed and sampled right away due to programmatic or operational considerations, even if the mixing and sampling capability is available, but for planning purposes, it is assumed to start as soon as possible.

B9.2.4.2 After hot commissioning, the net WTP HLW vitrification capacity will be ramped as follows (this assumption replaces Baseline Case Assumption B3.3.3.3):

Starting On	Rate MTG/d
12/31/2019	3.0
1/1/2021	4.0
1/1/22	4.2[199]
2/6/2025	Per B9.2.4.1

B9.2.4.3 The composition, properties, and waste oxide loading of HLW glass will be estimated[200] using the 2009 GFM documented in PNNL-18501 and PNNL-19372, *Glass Composition Constraint Recommendations for Use in Life-Cycle Mission Modeling*.[201] For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals.[202] For planning purposes, the allowable glass-forming chemicals are: Al_2O_3, B_2O_3, Fe_2O_3, Li_2O, Na_2O, and SiO_2.[203] This assumption replaces Baseline Case Assumption B3.3.3.8.

B9.3 LOW-ACTIVITY WASTE PROCESSING

B9.3.1 Supplemental Pretreatment, General

B9.3.1.1 A portion of the waste feeding the LAW immobilization (FBSR) facilities will come directly from the tank farms after it has been pretreated using a combination of RMF and SCIX. The remainder of the feed will come from the WTP PT Facility. The LAW waste feed stream from the supplemental pretreatment systems will meet currently established LAW feed requirements consistent with feed from the PT Facility and 24590-WTP-PL-PR-04-0001.

B9.3.1.2 The supplemental pretreatment system will have sufficient capacity so that when combined with excess LAW from the PT Facility, it will provide feed for the LAW treatment (FBSR) facilities without limiting production of immobilized product.

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[199] DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that the HLW Vitrification Facility will support a combined design capacity of 6 MTG/d with the original two melters and 7.5 MTG/d with two replacement melters, with a minimum integrated TOE of 70%.

[200] This model defines a constrained, non-linear programming problem, which is then solved in HTWOS by iterating over a linearized version of the model.

[201] PNNL-19372 recommends relaxed values for the phosphate, bismuth oxide, and sulfate solubility limits, and augments the nepheline discriminator with a new constraint, optical basicity. These constraints are the subject of ongoing research and have the high potential of being revised in the next update of the HLW GFM.

[202] A comparison of the 2009 GFM with the model used prior to System Plan (Rev. 5) is provided in RPP-RPT-42649, *High-Level Waste Glass Formulation Model Sensitivity Study, 2009 Glass Formulation Model versus 1996 Glass Formulation Model*.

[203] The HTWOS implementation of the 2009 GFM allows the user to specify which glass-forming chemicals may be used. In addition to the six stated above, the user can specify CaO, MgO, TiO_2, ZnO, and ZrO_2. However, for this revision of the System Plan, the allowable glass-forming chemicals are being aligned to those used by BNI per Gimpel (2009).

B9.3.1.3 A skid-mounted exhaust system will be used to ventilate the staging tanks and those with RMF and SCIX units installed.

B9.3.2 Rotary Microfiltration

B9.3.2.1 The RMF unit is deployed as an in-tank filtration process and will be installed in a riser of a DST. Once the RMF unit is installed, the DST on which it is installed will be excluded from all other DST activities until the RMF unit is no longer needed and removed.

B9.3.2.2 Feed for the supplemental pretreatment system is staged and transferred from a LAW feed DST to the DST in which the RMF unit is installed. Suspended solids are removed from the feed stream and discharged back into the DST where the RMF is installed.

B9.3.2.3 Clarified feed from the RMF is diluted to approximately 5 M sodium[204] (when warranted), and sodium hydroxide is added to ensure the feed is not supersaturated with aluminum at 25°C (see Assumption B3.3.2.5). The clarified feed is then transferred to the SCIX system.

B9.3.3 Small Column Ion Exchange

B9.3.3.1 The SCIX system consists of two columns installed in two separate risers of a DST. Once the SCIX unit is installed, the DST on which it is installed will be excluded from all other DST activities until the SCIX unit is no longer needed and removed.

B9.3.3.2 For planning purposes, it is assumed that the resin media used for SCIX operations is the same media, spherical resorcinol formaldehyde, used in the WTP PT Facility.

B9.3.3.3 For planning purposes, it is assumed that the SCIX system has the same cesium removal efficiency, 99.97 percent per 24590-WTP-MDD-PR-01-002, as the WTP PT Facility.

B9.3.3.4 Key features[205] of the SCIX system that will be modeled for the purposes of mission planning include the following:

- Two-column carousel
- Column loading volume
- Resin regeneration (including cesium elution)
- Resin replacement.

[204] This molarity is based on feed to the ion-exchange system in the WTP per 24590-WTP-MDD-PR-01-002.
[205] Basis for the CSIX flowsheet (equipment configuration, operating modes, and logic) is from Thorson (2010).

B9.3.3.5 The pretreated feed from the SCIX system is transferred directly to the lag-storage vessels[206] were confirmatory samples will be taken prior to delivery to the supplemental treatment system. Spent resin from the SCIX system is assumed to be disposed of at the IDF in a yet-to-be-determined waste form. The spent resin source term will be neglected for modeling purposes.

B9.3.3.6 Eluate generated during resin regeneration is neutralized and discharged into the DST upon which the SCIX is installed.

B9.3.4 Treatment

B9.3.4.1 FBSR facilities located in 200 East Area, adjacent to the WTP, will be used to treat all LAW. This assumption replaces all Baseline Case assumptions pertaining to the WTP LAW Vitrification Facility and second LAW vitrification facility (Assumptions B3.3.4.1 through B3.3.4.11, and B3.4.1.1 through B3.4.1.7).

B9.3.5 Fluidized Bed Steam Reforming

B9.3.5.1 The FBSR facilities will be standalone facilities that use a process based on the THOR Treatment Technologies FBSR flowsheet for producing a mineralized product (see footnote 179). Standalone means that each facility contains all of the necessary unit operations and will not rely on the DST system, the 242-A Evaporator, or the WTP PT Facility for support, and that it includes any needed lag storage.

B9.3.5.2 The LAW/clay slurry feed rate is based on 72-in. inner diameter columns that will each provide a nominal treatment capacity of 606 MT sodium/year.[207]

B9.3.5.3 The combined FBSR facilities will be modeled as a black box, with the following attributes (see footnote 179).

- Incoming LAW feed will be adjusted to 5 M sodium.
- Clay additions will be calculated based on feed composition.
- The coal addition rate will be maintained at 0.29 times the product stream rate.
- LAW/clay slurry will be fed continually at a rate of 3.23 gpm for each operating fluidized bed steam reformer.
- Splits for select radionuclides ^{99}Tc, ^{137}Cs, ^{90}I, ^{3}H, and ^{14}C will be used to partition the product stream from the off-gas stream.
- Destruction reactions for NO_x, total organic carbon, and coal will be used to account for phase and speciation change of the input constituents.

[206]The location of the lag storage will be determined by the Supplemental Treatment and Immobilization Program.

[207] This capacity is based on a 5 M sodium feed at a constant feed slurry rate of 3.23 gpm, operating with a 70% TOE and 10% excess clay (PSDD-30284-21-001); projected feed rate will vary with feed composition.

- The mass of the monolithic product will be estimated using an average waste loading from PSDD-30284-21-001.

B9.3.5.4 The FBSR facilities will receive pretreated LAW from the supplemental pretreatment facility. The facilities will also receive pretreated LAW from the WTP PT Facility per Assumption B9.2.2.1. Priority will be given to the pretreated LAW from WTP to prevent bottlenecking WTP operations, delaying HLW treatment.

B9.3.5.5 The net capacity of the FBSR facilities will be selected with the goal that the combined LAW immobilization capacity will be large enough so as to not drive the mission duration.

B9.3.5.6 The first FBSR facility will begin routine operations on January 1, 2018. Succeeding facilities will come online with a nine-month delay between each startup (RPP-48228).

B10.0 CASE 8: ACCELERATED RETRIEVALS KEY ASSUMPTIONS

The purpose of this case is to demonstrate the effect on mission duration of using an alternative SST retrieval approach that decouples near-term SST retrievals from DST tank space limitations to mitigate SST retrieval delays for any reason, level-load SST retrievals throughout the mission, and accelerate closure of T Farm separate from TX Farm and TY Farm.

The accelerated retrievals case consists of retrieving the waste from T Farm SSTs into selected, sound TX Farm SSTs. The T Farm waste will be retrieved directly into TX Farm tanks, with T Farm sludge being layered on top of the waste already existing in the TX Farm receivers. The T Complex WRF will be used to manage liquid waste. One or more wiped film evaporators (WFE) will be installed on tanks in the WRF to provide evaporative capacity. Upon completion of retrievals, the TX Farm receivers will be returned to an interim stabilized status, with supernate being stored in the WRF pending retrieval and delivery to the DSTs through the WRF.

Assumptions for Case 8 are consistent with the Baseline Case assumptions, with the exception of those outlined below:

B10.1 TANK FARMS

B10.1.1 Waste Retrieval and Transfers

B10.1.1.1 The consolidation of T Farm into TX Farm will commence upon completion of the nine A/AX Farm retrievals.

B10.1.1.2 The waste from T Farm will be retrieved into the following TX Farm tanks in the order listed: TX-101, TX-102, TX-103, TX-104, TX-118, TX-108, TX-106, and if needed TX-111 (RPP-48228).

B10.1.1.3 Consistent with RPP-RPT-47282, *Data to Support the Regulatory Evaluation of Single-Shell Tank Waste Staging*, an external high resolution resistivity (HRR) leak detection and monitoring (LDM) system is assumed to provide additional LDM capability for each TX Farm tank receiving T Farm waste.

B10.1.1.4 Each TX Farm tank will be assumed to complete an in-service (during retrieval) leak check. As described in Section 3.2 of RPP-RPT-47282, the leak check will be assumed to consist of pausing retrievals into a TX Farm tank each time the waste and liquid level in the tank achieves a previously unproven 2-ft increment. Between each 2-ft increment, retrieval will pause for a 48-hour period to allow for leak monitoring to occur. Once the level in the TX Farm tank reaches a maximum operating level, retrievals will continue at a standard pace.

B10.1.1.5 Consistent with Baseline Case Assumption B3.2.2.6 for the DSTs, the depth of settled solids accumulated in the TX Farm tanks will be maintained at less than 250 in. In addition, to permit the installation of a mobile arm retrieval system for retrieval of the consolidated TX Farm tanks, the maximum final waste volume in the tanks will be limited to 685,000 gal.[208]

B10.1.1.6 Insoluble solids retrieved from T Farm are assumed to settle in the TX Farm receiver tank within two days to a solids-loading comparable to that in the source SST. This assumption modifies Baseline Case Assumption B3.2.2.5.

B10.1.1.7 The waste from TX Farm will not be retrieved prior to the completion of T Farm retrievals.

B10.1.1.8 All potential TRU tank waste will be retrieved and treated at the WTP together with the HLW. This assumption replaces Baseline Case Assumptions B3.2.3.3 and B3.4.2.1 through B3.4.2.7, which address supplemental TRU sludge treatment.

B10.1.1.9 Within T Farm, the waste management strategy will consist of retrieving the saltcake tanks first and then using the dissolved saltcake to sluice the sludge tanks. This assumption modifies Baseline Case Assumption B3.2.3.3 for retrievals within the T Farm only.

B10.1.1.10 This assumption modifies Baseline Case Assumption B3.2.3.4.

- The T Farm retrieval methods will be assumed to be the same as those in Assumption B3.2.3.4, with the exception that an SST rather than a DST will be used as the receiving and supernate recycle tank.
- The minimum retrieval durations and as-retrieved waste volumes calculated in SVF-1647 will still apply to the TX Farm receiver tanks; however, the additional times and durations associated with the retrieval of the consolidated sludge will be calculated and added to the values from SVF-1647 in the HTWOS model. The T Farm sludge added to the TX Farm tanks will be assumed to be added in a layer on top of the waste already existing in the TX Farm tank. As the consolidated sludge will be on top of the existing TX Farm waste, the consolidated sludge will be assumed not to contribute to TX Farm tank hard heels. Upon retrieval from the TX Farm, the consolidated sludge retrieval volumes and time will be calculated as bulk retrieval and will be consistent with the assumptions in RPP-40545, *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*.

[208] RPP-40545 specifies that the minimum clearance between the bottom of the riser in which the mobile arm retrieval system is installed and the top of the waste is 15 ft.

B10.1.1.11 Waste retrieved from T Farm, including CH-TRU waste, will be transferred into TX Farm tanks. Supernate will be routed back and forth from the TX Farm tanks to T Farm, with decants from the TX Farm to the T Complex WRF, as required (supernate recycles will not be explicitly modeled). This assumption modifies Baseline Case Assumption B3.2.3.6.

Waste retrieved from TX and TY Farms will be transferred to a tank in the T Complex WRF, with supernate routed back and forth from the WRF tank to DST storage via new double-encased HIHTLs or steel lines (per RPP-PLAN-40145).

B10.1.1.12 The T Complex WRF will be available for operations on June 30, 2018, two years earlier than the baseline. The availability of the transfer line to SY Farm will remain the same as the Baseline Case. This assumption modifies Baseline Case Assumption B3.2.3.8.

B10.1.1.13 This assumption modifies Baseline Case Assumption B3.2.3.9. All T Farm SSTs will be retrieved directly to TX Farm. All other SSTs (except those retrieved to the WRFs) will be retrieved directly into the DST system.

B10.1.1.14 Assume that the DST waste chemistry limits given in Table 3-9 of HNF-SD-WM-OCD-015 will apply to TX Farm consolidation SSTs. During the retrieval of waste from the T Farm SSTs to the TX Farm SSTs, sodium hydroxide and sodium nitrite will be added as needed so that the as-retrieved liquid phase composition satisfies the DST waste chemistry limits.

B10.1.1.15 Upon completion of retrievals to a TX Farm receiver, the tank will be returned to a state that meets the interim stabilization criteria of less than 50,000 gal of drainable interstitial liquid and less than 5,000 gal of supernatant liquid (CT-99-5076-EFS, *Interim Stabilization Consent Decree No. CT-99-5076-EFS*). An enabling assumption will be made that decanting the consolidated TX Farm SSTs to leave only 5,000 gal of supernate on top of the consolidated waste material will meet this requirement without the use of saltwell pumping.

B10.1.2 Wiped Film Evaporator

B10.1.2.1 WFEs will be available, as needed, to support SST retrieval. The number of WFEs will be matched to retrieval rates.

B10.1.2.2 The WFE(s) will be installed on T Complex WRF tank(s).

B10.1.2.3 Dilute waste will be concentrated until it reaches a bulk concentration of 1.43 g/mL.

B10.1.2.4 The WFE will be modeled with a nominal evaporation rate of 2.52 gpm.[209]

B10.1.2.5 Overall partitioning of feed will be calculated using the condensate decontamination factors calculated during pilot-scale testing for SST dissolved saltcake simulant. The

[209] Condensate production range: 2-3 gpm; nominal 2.52 gpm (Tedeschi 2010)

decontamination factors are reported in Table 9-5 of RPP-RPT-47442, *Pilot-Scale Wiped Film Evaporator Test Report*. For constituents that are not included in Table 9-5, but that are tracked in HTWOS, the values associated with the 242-A Evaporator (see Assumption B3.2.4.7) will be used.

B10.1.2.6 Liquid effluent will be transferred to the ETF via tank truck; however, for modeling purposes, the liquid effluent will be modeled as a continuous pipeline transfer.

B11.0 CASE 9: EARLY U FARM CLOSURE

The purpose of this case is to show the impacts of beginning U Farm retrievals instead of the A Farm retrievals as part of the nine retrievals after C Farm. Assumptions for Case 9 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B11.1 TANK FARMS

B11.1.1 Waste Retrieval and Transfers

B11.1.1.1 The next nine SSTs to be retrieved after C Farm will be the four AX Farm tanks and five U Farm tanks (U-101, U-104, U-110, U-112, and U-106).[210]

B11.1.1.2 Infrastructure upgrades will be completed in time to support the U Farm retrievals.

B11.1.1.3 U Farm closure will be started once U Farm retrievals are completed.

B11.1.1.4 Baseline Case Assumption B3.2.3.3 is superseded in part to account for the revised SST retrieval sequence and schedule.

B11.1.1.5 Baseline Case Assumption B3.2.3.14 is partially superseded with respect to timing of DST upgrades to ensure that necessary DST receivers are available to support early U Farm retrievals.

B11.1.1.6 Baseline Case Assumption B3.2.3.14 is partially superseded with respect to creation of deep sludge DSTs as necessary to complete early U Farm closure.

[210] The specific U Farm tanks used in this study were based on RPP-48228.

B12.0 CASE 10: SLOW SINGLE-SHELL TANK RETRIEVALS KEY ASSUMPTIONS

The purpose of this case is to show the impacts on the baseline of increasing the minimum retrieval durations for the SSTs. Assumptions for Case 10 are consistent with the Baseline Case assumptions, with the exception of those outlined below.

B12.1 TANK FARMS

B12.1.1 Waste Retrieval and Transfers

B12.1.1.1 For all SST retrievals that start between January 1, 2011 and January 1, 2021, the minimum retrieval duration of each SST will be increased by 25 percent due to unspecified near-term retrieval difficulties (RPP-48228). This assumption partially replaces Baseline Case Assumption B3.2.3.4 (only for minimum retrieval durations, selected retrieval technologies will not change from the Baseline Case) for the ten-year period specified.

B12.1.1.2 The unspecified retrieval difficulties have been overcome for all retrievals that start after January 1, 2021.

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APPENDIX C – SINGLE-SHELL TANK RETRIEVAL SEQUENCE

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SINGLE-SHELL TANK RETRIEVAL SEQUENCE

Table C-1 provides the overall sequence and schedule for retrieving waste from all of the single-shell tanks (SST) during the River Protection Project mission for the Baseline Case. The table includes a mix of historical and projected data—historical for those tanks for which retrievals have already been completed and for the start of tanks currently being retrieved; projected for all future retrievals and for the end of tanks currently being retrieved. The range of operating efficiencies for SST retrievals, after C Farm is retrieved, is assumed to be improved by a factor of two[211] in the Baseline Case over the expected performance based on past experience, process records, laboratory test results, technology development testing, inspections of tanks, and best engineering judgment. The reference date for the transition from historical to projected retrievals in this table is February 2011 (see Section 1.7.1 of the System Plan). Adjustments may be made to the projected dates based on funding guidance or in response to emerging plans and field conditions as part of aligning the performance measurement baseline with the Baseline Case results.

The "Current Waste Volume" is the volume in each SST as of the reference date. The "Total Retrieved Waste Volume" is an estimate of the volume generated during the retrieval of the waste and represents the transient demand on double-shell tank (DST) space. The "DST Volume Impact Post-Evap" volume is an estimate of the volume after settling of retrieved solids and concentration of the supernatant layer to a liquid specific gravity of 1.43 in the 242-A Evaporator, and represents an estimate of the final demand on DST space for each retrieval; this estimate does not consider evaporator source term and operational constraints. Both the "Total Retrieved Waste Volume" and the "DST Volume Impact Post-Evap" reflect the portion of the retrievals projected to occur after the reference date. "Minimum Retrieval Duration" is set to zero for tanks which have already completed retrievals.

Table C-1. Single-Shell Tank Retrieval Sequence (5 pages)

Tank	Retrieval start date[a, b]	Minimum retrieval duration (days)	Modeled or actual retrieval duration[a] (days)	Modeled or actual retrieval end date[a, b]	Current waste volume[a] (kgal)	Total retrieved waste volume[a] (kgal)	DST volume impact post-evap[a] (kgal)
C-106	11/18/1998	0	1,869	12/31/2003	3	0	0
S-112	9/26/2003	0	1,253	3/2/2007	2	0	0
C-203	6/30/2004	0	267	3/24/2005	0	0	0
S-102	12/16/2004	29	6,841	9/8/2023	187	339	286
C-202	6/30/2005	0	42	8/11/2005	0	0	0
C-201	10/25/2005	0	149	3/23/2006	0	0	0
C-103	11/6/2005	0	290	8/23/2006	3	0	0
C-204	7/23/2006	0	141	12/11/2006	0	0	0
C-108	12/20/2006	134	1,843	1/5/2012	7	94	24

[211] For perspective, the expected total operating efficiencies (before the 2x multiplier) range from 21 to 34 percent, with the multiplier they would need to range from 42 to 68 percent.

Table C-1. Single-Shell Tank Retrieval Sequence (5 pages)

Tank	Retrieval start date[a, b]	Minimum retrieval duration (days)	Modeled or actual retrieval duration[a] (days)	Modeled or actual retrieval end date[a, b]	Current waste volume[a] (kgal)	Total retrieved waste volume[a] (kgal)	DST volume impact post-evap[a] (kgal)
C-109	6/19/2007	134	2,018	12/27/2012	8	111	29
C-110	9/22/2008	134	1,422	8/14/2012	17	235	69
C-104	1/8/2010	160	428	3/11/2011	64	224	126
C-111	10/28/2010	134	946	5/31/2013	57	480	180
C-107	5/28/2011	87	87	8/23/2011	247	399	300
C-112	10/2/2011	96	96	1/6/2012	104	248	155
C-101	5/10/2012	91	91	8/9/2012	88	209	150
C-102	11/2/2012	157	157	4/7/2013	316	950	604
C-105	8/9/2013	134	134	12/21/2013	132	224	148
AX-103	1/1/2016	117	146	5/26/2016	106	1,177	265
AX-104	5/31/2016	68	68	8/6/2016	7	294	17
AX-102	1/5/2017	102	132	5/16/2017	30	855	68
AX-101	5/21/2017	167	511	10/14/2018	357	2,491	1,036
A-102	7/23/2017	25	25	8/16/2017	40	309	92
A-106	9/16/2017	33	33	10/18/2017	79	328	169
B-201	4/2/2018	72	106	7/16/2018	29	225	35
B-202	7/26/2018	99	102	11/5/2018	29	218	35
B-203	11/15/2018	139	178	5/12/2019	50	379	58
A-101	2/26/2019	53	430	5/1/2020	320	1,035	757
B-204	5/22/2019	138	174	11/12/2019	49	371	58
A-105	5/6/2020	71	166	10/19/2020	37	228	99
T-201	5/10/2020	18	93	8/11/2020	30	197	35
T-202	8/21/2020	16	67	10/27/2020	20	143	24
A-104	10/24/2020	53	53	12/16/2020	28	184	60
T-203	11/6/2020	18	116	3/1/2021	36	247	43
A-103	12/21/2020	66	404	1/29/2022	379	1,429	783
T-204	3/11/2021	18	116	7/5/2021	36	247	43
T-111	7/15/2021	192	269	4/10/2022	447	574	475
T-110	4/20/2022	67	227	12/3/2022	370	484	397
T-104	12/13/2022	62	201	7/3/2023	317	429	346
S-105	9/10/2023	59	76	11/24/2023	406	1,354	1,074
SX-101	9/13/2023	106	321	7/30/2024	418	2,355	1,384
BX-104	11/26/2023	46	50	1/15/2024	100	202	144
BX-103	11/26/2023	43	47	1/12/2024	75	177	118
S-107	11/30/2023	54	910	5/28/2026	358	605	541
BY-102	1/17/2024	56	846	5/11/2026	278	1,165	766
BY-110	1/21/2024	57	800	3/31/2026	366	1,060	855

Table C-1. Single-Shell Tank Retrieval Sequence (5 pages)

Tank	Retrieval start date[a, b]	Minimum retrieval duration (days)	Modeled or actual retrieval duration[a] (days)	Modeled or actual retrieval end date[a, b]	Current waste volume[a] (kgal)	Total retrieved waste volume[a] (kgal)	DST volume impact post-evap[a] (kgal)
SX-114	7/26/2025	98	343	7/4/2026	155	382	265
BX-106	5/14/2026	48	52	7/4/2026	38	282	81
BY-104	5/17/2026	62	170	11/3/2026	405	1,174	1,021
S-103	6/2/2026	41	41	7/13/2026	237	699	543
S-109	7/12/2026	71	136	11/25/2026	533	1,580	1,361
SX-106	7/19/2026	59	82	10/9/2026	397	1,272	894
BY-103	7/26/2026	141	532	1/9/2028	413	2,276	1,150
SX-105	11/1/2026	57	77	1/17/2027	376	1,033	900
BY-101	11/8/2026	94	447	1/29/2028	370	2,067	1,141
S-108	11/30/2026	72	145	4/24/2027	550	1,576	1,315
SX-102	2/12/2027	51	78	5/1/2027	341	908	771
S-106	5/6/2027	68	102	8/15/2027	455	1,517	1,130
SX-115	5/27/2027	25	25	6/21/2027	4	83	8
SX-107	6/27/2027	75	74	9/9/2027	94	216	157
SX-112	8/22/2027	66	76	11/5/2027	75	196	135
S-101	9/14/2027	50	102	12/25/2027	352	629	572
SX-111	11/10/2027	81	194	5/21/2028	115	301	217
S-111	1/15/2028	55	94	4/18/2028	401	1,003	834
BY-111	1/16/2028	80	293	11/3/2028	402	1,822	1,102
BX-109	2/7/2028	53	65	4/12/2028	193	323	290
BX-112	4/17/2028	50	72	6/28/2028	164	266	195
SX-103	5/26/2028	67	111	9/14/2028	509	1,326	1,131
BX-105	7/3/2028	46	137	11/16/2028	72	285	168
SX-113	7/14/2028	35	34	8/17/2028	19	130	25
S-110	9/19/2028	57	167	3/5/2029	389	1,018	851
BY-107	11/5/2028	85	179	5/3/2029	272	1,134	728
BY-109	11/21/2028	71	339	10/26/2029	287	1,486	706
SX-109	3/10/2029	102	173	8/30/2029	241	1,043	580
SX-104	9/4/2029	60	193	3/16/2030	446	1,056	919
BX-101	10/16/2029	284	346	9/27/2030	48	623	88
BY-106	10/28/2029	121	185	4/30/2030	429	1,706	1,087
S-104	3/21/2030	102	117	7/16/2030	288	800	496
BY-105	5/5/2030	151	373	5/13/2031	481	2,226	1,465
SX-110	6/9/2030	60	79	8/27/2030	56	220	111
T-112	7/21/2030	43	47	9/6/2030	67	171	82
T-102	9/1/2030	39	39	10/9/2030	32	135	41
SX-108	9/8/2030	65	64	11/11/2030	74	195	190

Table C-1. Single-Shell Tank Retrieval Sequence (5 pages)

Tank	Retrieval start date[a, b]	Minimum retrieval duration (days)	Modeled or actual retrieval duration[a] (days)	Modeled or actual retrieval end date[a, b]	Current waste volume[a] (kgal)	Total retrieved waste volume[a] (kgal)	DST volume impact post-evap[a] (kgal)
BY-112	10/2/2030	48	206	4/26/2031	286	943	801
T-105	10/13/2030	46	50	12/2/2030	98	204	137
TY-102	11/18/2030	28	43	1/1/2031	69	421	186
T-109	12/9/2030	302	333	11/6/2031	62	803	167
T-103	1/6/2031	230	256	9/19/2031	27	444	41
BX-107	5/15/2031	64	101	8/23/2031	347	484	418
BY-108	5/20/2031	77	111	9/8/2031	222	855	590
BX-111	8/31/2031	67	224	4/11/2032	188	701	437
TY-106	9/24/2031	31	30	10/24/2031	16	116	27
TY-103	10/29/2031	81	107	2/12/2032	155	562	262
T-108	11/9/2031	186	195	5/22/2032	16	395	44
T-101	2/17/2032	50	60	4/16/2032	99	365	185
B-102	2/18/2032	94	119	6/17/2032	32	806	72
BX-108	4/18/2032	220	240	12/13/2032	31	508	76
TY-104	4/21/2032	41	46	6/5/2032	44	144	69
T-106	5/23/2032	198	213	12/21/2032	22	431	45
TY-105	6/13/2032	111	126	10/17/2032	231	367	313
B-108	6/23/2032	53	68	8/30/2032	92	543	234
B-104	9/5/2032	69	107	12/21/2032	374	694	581
TY-101	10/24/2032	68	83	1/15/2033	118	490	202
BX-110	12/19/2032	88	150	5/18/2033	215	941	537
T-107	12/27/2032	90	100	4/5/2033	173	284	234
B-101	12/29/2032	49	59	2/26/2033	109	396	225
TX-118	1/23/2033	72	139	6/11/2033	247	1,623	610
B-107	3/6/2033	83	147	7/31/2033	161	709	335
U-103	4/13/2033	79	99	7/21/2033	417	1,271	897
TX-106	6/19/2033	62	108	10/4/2033	348	1,313	867
B-106	7/15/2033	48	52	9/6/2033	123	243	182
U-106	7/28/2033	74	90	10/25/2033	170	851	369
B-110	8/7/2033	116	126	12/10/2033	245	376	317
B-103	9/11/2033	232	257	5/26/2034	56	733	126
TX-117	10/30/2033	179	326	9/20/2034	480	3,103	1,340
U-107	11/22/2033	82	94	2/23/2034	294	1,357	781
B-109	12/18/2033	55	75	3/3/2034	125	552	314
B-112	3/8/2034	203	222	10/15/2034	35	446	72
U-111	3/18/2034	58	77	6/3/2034	222	708	519
B-105	5/28/2034	87	142	10/17/2034	290	1,583	682

Table C-1. Single-Shell Tank Retrieval Sequence (5 pages)

Tank	Retrieval start date[a, b]	Minimum retrieval duration (days)	Modeled or actual retrieval duration[a] (days)	Modeled or actual retrieval end date[a, b]	Current waste volume[a] (kgal)	Total retrieved waste volume[a] (kgal)	DST volume impact post-evap[a] (kgal)
U-109	6/15/2034	82	116	10/8/2034	401	1,456	909
TX-103	9/25/2034	34	53	11/17/2034	145	588	361
TX-112	10/19/2034	83	178	4/16/2035	634	2,142	1,596
B-111	10/22/2034	115	149	3/20/2035	241	344	284
BX-102	10/22/2034	55	105	2/4/2035	79	176	97
TX-102	11/22/2034	41	74	2/4/2035	217	796	529
TX-116	2/15/2035	149	236	10/9/2035	598	2,366	1,677
TX-108	5/6/2035	30	45	6/20/2035	126	445	310
U-102	6/27/2035	66	71	9/6/2035	327	922	763
TX-101	9/10/2035	26	31	10/11/2035	91	190	265
U-201	10/14/2035	15	15	10/28/2035	4	27	7
TX-109	10/14/2035	50	70	12/23/2035	363	478	458
U-108	11/8/2035	76	86	2/2/2036	434	1,265	1,013
U-202	1/6/2036	15	15	1/21/2036	4	26	6
TX-113	1/27/2036	178	281	11/2/2036	638	2,734	1,867
TX-105	2/10/2036	127	203	8/31/2036	576	2,229	1,481
TX-111	9/10/2036	53	89	12/8/2036	365	1,095	859
U-110	11/22/2036	91	116	3/18/2037	176	280	221
U-204	12/14/2036	14	14	12/27/2036	3	20	4
TX-104	1/4/2037	25	35	2/7/2037	69	194	192
U-105	2/15/2037	69	86	5/11/2037	353	1,031	779
U-203	3/23/2037	15	15	4/6/2037	3	24	6
TX-107	4/12/2037	27	38	5/19/2037	30	287	90
U-101	5/17/2037	272	279	2/20/2038	23	583	109
TX-110	5/24/2037	167	259	2/7/2038	467	2,591	1,254
TX-114	2/14/2038	140	232	10/3/2038	532	2,557	1,366
U-112	3/5/2038	251	260	11/20/2038	45	609	141
TX-115	10/10/2038	134	222	5/19/2039	553	2,363	1,449
U-104	12/1/2038	270	282	9/8/2039	54	676	56

[a] The reference date for the transition from completed historical to projected retrievals (and hence the basis for the actual retrieval duration, current waste volume, total retrieved waste volume, and DST volume impact post-evaporator) in this table is February 2011. The reference date for all other SSTs, including Tank C-104, is October 2010—the effective date of the tank inventory used for this System Plan.

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

DST = double-shell tank.
MARS = mobile arm retrieval system.
SST = single-shell tank.

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APPENDIX D – CROSSWALK: TRI-PARTY AGREEMENT MILESTONE M-062-40 LANGUAGE VERSUS SYSTEM PLAN (REV. 6)

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CROSSWALK OF HFFACO MILESTONE M-062-40 AND RIVER PROTECTION PROJECT SYSTEM PLAN (REV. 6) IMPLEMENTATION

The Hanford Federal Facility Agreement and Consent Order (HFFACO), also known as the Tri-Party Agreement (TPA), was signed by U.S. Department of Energy (DOE), U.S. Environmental Protection Agency, and the Washington State Department of Ecology (Ecology) in 1989. This comprehensive agreement includes legally enforceable milestones for regulatory compliance and environmental remediation. Some TPA milestones were revised, and some new ones were created, when a Consent Decree was issued in 2010. One such new milestone, M-062-40, requires the DOE Office of River Protection (ORP) to prepare an expanded System Plan every three years with its own specific set of requirements. Table D-1 provides a "crosswalk" that demonstrates how the RPP System Plan (Rev. 6), meets each aspect of the M-062-40 milestone requirements.

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference	
1	**Due Date:** Starting October 31, 2010 and every three years thereafter, Ecology and DOE will each have the right to select a minimum of three scenarios that will be analyzed in the System Plan.	On October 28, 2010, Ecology and DOE each selected five scenarios to be analyzed in the System Plan.	See Item 5	
2	Beginning October 31, 2011 and every three years thereafter, issue the System Plan.	The issue date of the System Plan is documented on page i of the System Plan, which meets the October 31, 2011 deadline.	Page i	
3	**Milestone:** Submit a System Plan to Ecology describing the disposition of all tank waste managed by ORP, including the retrieval of all tanks not addressed by the Consent Decree 08-5085-FVS[a] and the completion of the treatment mission.	The System Plan addresses the disposition of the tank waste managed by the ORP, specifically the waste contained in the 149 SSTs, the 28 DSTs, and the 60 IMUSTs. The disposition of each fraction is derived from: **Fraction** — **Disposition** LAW — ILAW disposed at IDF HLW — IHLW disposed at off-site geologic repository CH-TRU tank waste — Stored at CWC, until final disposal path is determined Secondary liquid waste — Disposed at IDF as solid after treatment Spent LAW melters — Disposed at IDF Spent HLW melters — Assume disposal at IDF; plans may be updated after TC & WM EIS ROD is issued Other solid waste — Disposed at IDF Tank residuals — Disposed in place pending TC & WM EIS ROD.	**LAW:** Section 3.2.3 Section 3.2.2.3 Section 3.4.1 Section 5.8.1 Table 7-8, Item 7.8-10 Appendix B, Section B3.5.6.1 Appendix B, Section B3.5.6.2 **HLW:** Section 3.2.2.2 Section 3.3.2 Section 5.9.2 Table 7-8, Item 7.8-12 Table 7-8, Item 7.8-14 Executive Summary Footnote 6 Executive Summary Footnote 8 **CH-TRU tank waste:** Baseline Case: Section 3.5.1 Section 5.9.1 Case 2: Section 10.2	**Secondary liquid waste:** Section 3.2.2 Section 3.2.4 Section 3.4.1 Table 7-8, Item 7.8-10 Appendix B, Section B3.5.6.2 **Spent HLW melters:** Section 3.4.1 Section 5.8.1 Table 7-8, Item 7.8-10 Table 7-8 Item 7.8-11 Appendix B, Section B3.3.3.9 Appendix B, Section B3.5.6.2 Footnote 152 **Spent LAW melters:** Section 3.4.1 Section 5.8.1 Table 7-8, Item 7.8-10 Table 7-8, Item 7.8-11 Appendix B, Section B3.3.4.11 Appendix B, Section B3.4.1.7 Appendix B, Section B3.5.6.2 **Other solid waste:** Section 5.8.1 Table 7-8, Item 7.8-10 Appendix B, Section B3.5.6.2 **Tank residuals:** Section 2.3.2

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference	
4	The [System] Plan will be updated and submitted to Ecology every three years to document any further optimization of retrieval and waste treatment capabilities to, in the case of SST retrievals, complete such retrievals as quickly as is technically feasible (but not later than the date established in milestone M-045-70), and, in the case of tank waste treatment, complete such treatment as quickly as is technically feasible (but not later than the date established in milestone M-062-00), both with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission.	The Baseline Case in System Plan (Rev. 6) documents the further optimization of the retrieval and waste treatment capabilities that has occurred since System Plan (Rev. 5). SST retrievals and waste treatment capabilities are completed as quickly as technically feasible, not later than the dates established in M-045-70 and M-062-00. For SST retrievals, this is done in HTWOS by developing assumed minimum durations for future activities based on past experience, process records, laboratory test results, technology development testing, inspections of tanks, and best engineering judgment. Similarly for waste treatment, HTWOS simulates the treatment as quickly as feasible, subject to system constraints such as design, flowsheets, rates, capacities, and logistics. The set of scenarios analyzed in the System Plan were developed and selected *"both with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission"* as further addressed in Item 5.	**Further optimization:** Executive Summary Table ES-1 Table ES-2 Section 1.5 **Milestone dates:** Table 1-1 **Past experience:** Section 1.6 Section 3.1	**Process records:** Section 1.8 Figure 1-9 **Laboratory test results:** Section 1.8 Figure 1-9 **Technology development testing:** Section 6.0 **Inspections of tanks:** Section 3.1.1 **Scenario considerations:** See Item 5
5	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, with DOE and Ecology each having the right to select a minimum of three scenarios each.	Planning meetings among ORP, Ecology, and WRPS personnel began as early as June 2010, and continued through October 2010, to establish the scope of System Plan (Rev. 6). WRPS personnel provided guidance and feedback to ORP and Ecology on how best to define scenarios, given the capabilities of the HTWOS model and the one-year time constraint to produce results. ORP and Ecology each selected five scenarios for a total of 10, to be analyzed in System Plan (Rev. 6). The selection process is described in RPP-48228.[b] The final set of selected scenarios is documented in 10-TPD-148.[c]	History Sheet Revision 6 Section 10.0 Section 1.2 Section 1.9 Figure 1-11 Table 1-2 Table 10-1	
6	The [System] Plan will include the following elements: **OVERALL MINIMUM REQUIREMENTS** The Plan will present the following minimum information for each scenario evaluated: • A system description for each system utilized in the planning	Baseline Case: The system description for the Baseline Case includes Figure 1-7, "Simplified Process Flow Diagram," and Section 3.0, "State of the River Protection Project System." More details on specific assumptions can be found in Appendix B. Cases 2 – 10: The system descriptions for Cases 2 - 10 describe the physical differences, if any, from the Baseline Case (e.g., facilities or equipment added or removed, or connectivity changes), technology development needs, and any specific actions that would be needed to implement the case as described. The system description for each of these cases is defined by a combination of text and tables in Section 10.n.1, "System Description." In addition, Cases 3, 5, 6, 7, and 8 describe operating scenarios based on flowsheets that differ from the Baseline Case, so the system descriptions for those cases also include line diagram flowsheets.	**Baseline Case:** Figure 1-7 and Section 3.0, and Appendix B **Case 2-10 General:** Section 10.1 **Case 2:** Section 10.2.1 **Case 3:** Section 10.3.1 **Case 4:** Section 10.4.1 **Case 5:** Section 10.5.1 **Case 6:** Section 10.6.1 **Case 7:** Section 10.7.1 **Case 8:** Section 10.8.1 **Case 9:** Section 10.9.1 **Case 10:** Section 10.10.1	
7	• Planning bases for each case	For all cases, planning bases include the scope of each scenario as defined by ORP and Ecology, with further refinements necessary to create meaningful model input. This includes detailed analysis of the underlying assumptions for each case, and identification of areas where existing assumptions must be modified. The assumptions for all ten cases were approved by ORP,[d] and subsequently incorporated into the HTWOS model and the System Plan (Rev. 6) document. Planning bases for all ten cases are captured in Appendix B.	**Baseline Case:** Table ES-2 and Appendix B, Sections B1.0, B2.0 and B3.0 **Case 2:** Section 10.2.2 and Appendix B, Section B4.0 **Case 3:** Section 10.3.2 and Appendix B, Section B5.0 **Case 4:** Section 10.4.2 and Appendix B, Section B6.0 **Case 5:** Section 10.5.2 and Appendix B, Section B7.0 **Case 6:** Section 10.6.2 and Appendix B, Section B8.0 **Case 7:** Section 10.7.2 and Appendix B, Section B9.0 **Case 8:** Section 10.8.2 and Appendix B, Section B10.0 **Case 9:** Section 10.9.2 and Appendix B, Section B11.0 **Case 10:** Section 10.10.2 and Appendix B, Section B12.0	

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
8	• 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.	For the Baseline Case, the key issues and vulnerabilities (System Plan [Rev. 6] refers to these as "uncertainties") are described in detail in Section 7.0, "Key Issues and Uncertainties for the Baseline Case." These key issues and vulnerabilities can be traced back to assumptions when appropriate. For Cases 2 - 10, any additions or reductions to the baseline case key issues and uncertainties are captured in Section 10.n.5, "Key Issues and Vulnerabilities."	**Baseline Case:** Section 7.0 **Case 2:** Section 10.2.5 and Table 10-4 **Case 3:** Section 10.3.5 and Table 10-6 **Case 4:** Section 10.4.5 and Table 10-8 **Case 5:** Section 10.5.5 and Table 10-9 **Case 6:** Section 10.6.5 and Table 10-11 **Case 7:** Section 10.7.5 and Table 10-13 **Case 8:** Section 10.8.5 and Table 10-14 **Case 9:** Section 10.9.5 and Table 10-15 **Case 10:** Section 10.10.5 and Table 10-16
9	• Sensitivities analyses of selected key assumptions.	No sensitivity analyses were selected during scoping for key assumptions in Cases 2, 3, 5, 6, or 8. Several were selected by ORP and Ecology for the Baseline Case, including +10% HLW and LAW vitrification capacity with delayed startup of WTP, slowed SST retrievals, and early U Farm closure. These sensitivity analyses[b] were subsequently elevated to the level of full, standalone cases (Cases 4, 9 and 10, respectively) to provide a more complete analysis. Case 7 also had a selected sensitivity analysis of -10% HLW and LAW treatment capacity, which was elevated to a scenario, but due to time and resource constraints, it was mutually agreed that this scenario not be included in the final set of scenarios selected by ORP and Ecology for System Plan (Rev. 6).	Section 10.1 Table 10-2
10	• 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.	Table 1-1, "System Plan (Rev. 6) Highlights," shows a comparison of key metrics for each case relative to the success criteria, including both cost and schedule comparisons. Case-specific results are published in Sections 10.n.3, "Results," including a life-cycle cost comparison figure, which shows the case-specific life-cycle cost profile overlaid on the Baseline Case life-cycle cost profile; and Section 10.n.4, "Cost and Schedule Impacts." System Plan (Rev. 6) goes well beyond this requirement in that all cases include cost comparisons, rather than just a limited subset.	**Overview:** Table 1-1 **Case 2:** Section 10.2.3, Figure 10-2, and Section 10.2.4 **Case 3:** Section 10.3.3, Figure 10-5, and Section 10.3.4 **Case 4:** Section 10.4.3, Figure 10-7, and Section 10.4.4 **Case 5:** Section 10.5.3, Figure 10-10, and Section 10.5.4 **Case 6:** Section 10.6.3, Figure 10-13, and Section 10.6.4 **Case 7:** Section 10.7.3, Figure 10-16, and Section 10.7.4 **Case 8**: Section 10.8.3, Figure 10-19, and Section 10.8.4 **Case 9:** Section 10.9.3, Figure 10-22, and Section 10.9.4 **Case 10:** Section 10.10.3, Figure 10-24, and Section 10.10.4
11	• 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).	For the Baseline Case, technology development needs are identified in Section 6.0, "Technology Development for the Baseline Case." Actions needed are captured in Section 8.0, "Key Decisions for Baseline Case." Additional information is provided in RPP-PLAN-43988,[e] TFC-PLN-39,[f] and RPP-46506.[g] Equipment and upgrade needs for the Baseline Case are addressed in Section 3.0. For Cases 2 - 10, case-specific technology development, equipment, and actions needed are identified in Section 10.n.1, "System Description."	**Baseline Case:** Section 3.0, Section 6.0, and Section 8.0 **Case 2-10 General:** Section 10.1 **Case 2:** Section 10.2.1 **Case 3:** Section 10.3.1 **Case 4:** Section 10.4.1 **Case 5:** Section 10.5.1 **Case 6:** Section 10.6.1 **Case 7:** Section 10.7.1 **Case 8:** Section 10.8.1 **Case 9:** Section 10.9.1 **Case 10:** Section 10.10.1

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
12	• Identification of issues, techniques, or technologies that need to be further evaluated or addressed in order to accelerate tank retrievals and tank waste treatment.	For the Baseline Case, Section 7.0, "Key Issues and Uncertainties for the Baseline Case." captures current issues and opportunities, including techniques and technologies, related to Baseline Case scope, schedule, or cost. For Cases 2 - 10, Section 10.n.5, "Key Issues and Vulnerabilities," reflect changes to issues and opportunities, including techniques and technologies, specific to each case relative to the Baseline Case.	**Baseline Case:** Section 7.0 **Case 2:** Section 10.2.5 and Table 10-4 **Case 3:** Section 10.3.5 and Table 10-6 **Case 4:** Section 10.4.5 and Table 10-9 **Case 5:** Section 10.5.5 and Table 10-11 **Case 6:** Section 10.6.5 and Table 10-13 **Case 7:** Section 10.7.5 and Table 10-15 **Case 8:** Section 10.8.5 and Table 10-17 **Case 9:** Section 10.9.5 and Table 10-18 **Case 10:** Section 10.10.5 and Table 10-19
13	• Impacts on closure activities for each scenario.	For the Baseline Case, impacts on closure activities are addressed as part of Section 5.5.9, "Closure." For Cases 2 - 10, impacts on closure activities are addressed as part of Section 10.n.3, "Results."	**Baseline Case:** Section 5.5.9 **Case 2:** Section 10.2.3 **Case 3:** Section 10.3.3 **Case 4:** Section 10.4.3 **Case 5:** Section 10.5.3 **Case 6:** Section 10.6.3 **Case 7:** Section 10.7.3 **Case 8:** Section 10.8.3 **Case 9:** Section 10.9.3 **Case 10:** Section 10.10.3
14	**TANK WASTE TREATMENT** The [System] Plan will evaluate scenarios and identify potential near- and long-term actions to optimize tank waste treatment so that the treatment mission is completed as quickly as is technically feasible but not later than the date established in Milestone M-062-00, with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission.	The scenarios evaluated in the System Plan address this requirement and are described and analyzed in Section 10.0. Tank waste treatment is completed as quickly as technically feasible, not later than the date established in M-062-00. HTWOS simulates the treatment as quickly as feasible, subject to system constraints such as design, flowsheets, rates, capacities, and logistics. The set of scenarios analyzed in the System Plan were developed and selected *"both with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission,"* as further addressed in Item 5.	**Scenario evaluation of near- and long term actions to optimize tank waste treatment:** Section 10.0 Table ES-1 Table ES-2 **Milestone date:** Table 1-1 **Scenario considerations:** See Item 5
15	The [System] Plan will, at a minimum, describe how the tank waste treatment mission can: • Pretreat 100% of the retrievable tank waste (at a rate sufficient to operate the HLW Facility, LAW Facility, and supplemental treatment system simultaneously at their estimated average production rates).	The WTP PT Facility, which will receive both HLW and LAW feed from the tank farms, is described in Section 3.2.2.1, "Pretreatment Facility." Specific rate assumptions are further detailed in Appendix B, Section B3.3.2. An analysis of pretreating 100% of the tank waste is addressed in Case 2, which assesses the impact of treating potential TRU tank waste at the WTP. Section 10.2.3 discusses the average production rates for simultaneous operation of HLW and LAW Facilities. Estimated average production rates vary over time and reflect the complex interactions between the assumed facility capacity and delivered feed composition, retrieval, blending, pretreatment, and vitrification facilities.	**Pretreatment:** Section 1.6 Section 3.2.2.1 Appendix B, Section B3.3.2 **Case 2:** Section 10.2 **Product plots:** Section 10.2.3
16	• Vitrify 100% of the separated HLW stream at estimated average production rates.	The WTP HLW Vitrification Facility is described in Section 3.2.2.2. Specific rate assumptions are further detailed in Appendix B, Section B3.3.3. Figure 5-10 shows the average HLW glass production rates over the course of the mission. Estimated average production rates vary over time and reflect the complex interactions between assumed facility capacity and delivered feed composition, retrieval, blending, pretreatment, and vitrification facilities.	**HLW vitrification:** Section 3.2.2.2 Table 7-5 Appendix B, Section B3.3.3 **Average production rates:** Section 5.6.2.1 Figure 5-10

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
17	• Vitrify 100% of separated low-activity waste stream at estimated average production rates.	The WTP Low-Activity Waste Vitrification is described in Section 3.2.2.3 and Section 3.2.3. Specific rate assumptions are further detailed in Appendix B, Section B3.3.4 for the LAW Vitrification Facility and in Appendix B, Section B3.4.1 for a second LAW vitrification facility. Figure 5-11 through Figure 5-13 show the average LAW glass production rates over the course of the mission. Estimated average production rates vary over time and reflect the complex interactions between assumed facility capacity and delivered feed composition, retrieval, blending, pretreatment, and vitrification facilities.	**LAW Vitrification:** Section 3.2.3 Section 3.2.2.3 Table 7-5 Appendix B, Section B3.3.4 Appendix B, Section B3.4.1 **Average production rates:** Section 5.6.2.1 Figure 5-11 Figure 5-12 Figure 5-13
18	• Appropriately manage secondary waste streams.	The management of secondary waste streams is described in Section 3.2.4. Specific assumptions are further detailed in Appendix B, Section B3.5.1. Other solid waste, such as spent melters, is disposed of at IDF.	**Liquid Secondary waste:** Section 3.2.4 Appendix B, Section B3.5.1 **Solid Secondary waste:** Section 5.8.1 Table 7-8 Item 7.8-10 Appendix B, Section B3.5.6.2
19	The [System] Plan will take into account the results from testing of the pretreatment engineering platform and other studies.	Test results from the pretreatment engineering platform are incorporated into the WTP "equipment alternative," which employs a combination of design, flowsheet, and operating mode changes in the WTP PT Facility. Additional details are provided in 24590-WTP-RPT-PET-09-004.[h] These changes are incorporated into the HTWOS model, and results of the model are reported in the System Plan.	Section 3.2.2.1 Section 4.1.1 Appendix B, Section B3.3.1.14 Appendix B, Section B3.3.2.4
20	**SUPPLEMENTAL TREATMENT** The [System] Plan will also describe: • How much total sodium will need to be treated.	For the Baseline Case, total sodium is discussed in Section 5.6.2.2. For Cases 2 - 10, sodium management impact is discussed in Section 10.n.3, "Results."	**Baseline Case:** Section 5.6.2.2 **Case 2:** Section 10.2.3 **Case 3:** Section 10.3.3 **Case 4:** Section 10.4.3 **Case 5:** Section 10.5.3 **Case 6:** Section 10.6.3 **Case 7:** Section 10.7.3 **Case 8:** Section 10.8.3 **Case 9:** Section 10.9.3 **Case 10:** Section 10.10.3
21	• 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, with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities and (ii) and impact on the overall cleanup mission.	Supplemental treatment capacity is addressed in Section 3.2.3. Tank waste treatment capabilities are completed as quickly as technically feasible, not later than the date established in milestone M-062-00. HTWOS simulates the treatment as quickly as feasible, subject to system constraints such as design, flowsheets, rates, capacities, and logistics. The set of scenarios analyzed in the System Plan were developed and selected *"both with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission"* as further addressed in Item 5.	**Supplemental Treatment:** Section 3.2.3 **Milestone date:** Table 1-1 **Scenario considerations:** See Item 5
22	The System Plan will outline specific options to treat all the LAW. Such options include: • Build and operate a second LAW vitrification facility • Build and operate a Bulk Vitrification Facility.	All LAW treatment options considered in System Plan (Rev. 6) are intended to treat all of the LAW waste. These and other options are addressed in detail by the Supplemental Treatment and Immobilization Program, as discussed in Section 3.2.3. Also, Cases 3 and 7 incorporate fluidized bed steam reforming as a possible method of LAW treatment.	Section 3.2.3 **Case 3:** Section 10.3 **Case 7:** Section 10.7

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
23	Not later than the System Plan report due date of 10/31/2014, DOE will submit a one-time Hanford Tank Waste Supplemental Treatment Technologies Report, which will be required if a tank waste supplemental treatment technology is proposed, other than a second LAW vitrification facility. This report will: • Describe additional treatment facilities, technologies, and cost, which in combination with the WTP are needed to vitrify all of Hanford's tank waste by a date that is as quickly as is technically feasible but not later than the date established in milestone M-062-00, with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission. • Apply the same selection criteria to all options and include a second LAW vitrification facility as an option. • Include all the results from all waste form performance data (compared against the performance of borosilicate glass) for all the treatment technologies being considered. • Describe the technologies being considered, including size, throughput, sodium loading, quantity of waste to be processed, quantity of final waste forms, secondary waste quantity and nature, technical viability, and life-cycle cost and schedule estimates. Include data from both cold and hot testing if bulk vitrification is to be retained as an option.	This is a separate report that will be prepared in the future, if required. System Plan (Rev. 6) plays no role in implementing these requirements.	NA
24	**TANK WASTE RETRIEVAL** The [System] Plan will evaluate scenarios and identify potential near- and long-term actions to optimize tank waste retrieval so that the SST retrievals are completed as quickly as is technically feasible but not later than the date established in milestone M-045-70, with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities and (ii) and impact on the overall cleanup mission.	The Baseline Case in System Plan (Rev. 6) documents the further optimization of the retrieval and waste treatment capabilities that has occurred since System Plan (Rev. 5). SST waste retrieval plans modeled in HTWOS are aligned with the assumptions, guidelines, and recommendations for SST retrieval planning described in RPP-PLAN-40145[i] and spreadsheet SVF-1647.[j] These include the retrieval technologies, tank sequencing strategy, waste retrieval methods, as-retrieved waste volumes, minimum retrieval durations, and chemical additions for near-term SST retrievals. The minimum durations for future activities are based on past experience, process records, laboratory test results, technology development testing, inspections of tanks, and best engineering judgment. SST retrievals and waste treatment is completed as quickly as technically feasible, not later than the date established in milestone M-045-70. This is modeled in HTWOS by retrieving the SSTs as fast as possible (but no faster than the minimum retrieval durations and subject to availability of suitable DST space), consistent with the above assumptions, guidelines, and recommendations. The set of scenarios analyzed in the System Plan were developed and selected "both with and without consideration of (i) whether such further optimization would be excessively difficult or expensive within the context of such activities, and (ii) any impact on the overall cleanup mission" as further addressed in Item 5.	**SST Retrievals in HTWOS:** Section 4.1.1 **Milestone date:** Table 1-1 **Past Experience:** Section 1.6 Section 3.1 Table 3-2 Table 3-3 Table 3-4 **Process Records:** Section 1.8 Figure 1-9 **Lab Test Results:** Section 1.8 Figure 1-9 **Technology Development Testing:** Section 6.0 **Inspections of Tanks:** Section 3.1.1 **Scenario considerations:** See Item 5
25	The Plan will consider: • SST integrity information, including the SST integrity assurance review provided under milestone M-045-91 and any further integrity assessments.	The SST integrity program and related assessments are addressed in Section 3.1.1. Also, current tank integrity status is reflected in the SST Retrieval Plan[i] and spreadsheet SVF-1647,[j] which provide input to the HTWOS model and the System Plan assumptions.	Section 3.1.1 Section 1.6

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
26	• Waste retrieval rate sufficient to operate all waste treatment facilities at their full capacities, considering optimized waste feed rates.	For the Baseline Case, waste retrieval and processing rates are shown in Section 5.0. As seen in the figures in Section 5.6.2.1, different facilities operate at full capacity at different points in time. Estimated production rates vary over time and reflect the complex interactions between assumed facility capacities and delivered feed composition, retrieval, blending, pretreatment, and vitrification facilities. For Cases 2 - 10, waste retrieval and processing rates are shown in Section 10.n.3, "Results."	**Baseline Case:** Section 5.0, Section 5.6.2.1 **Case 2:** Section 10.2.3 **Case 3:** Section 10.3.3 **Case 4:** Section 10.4.3 **Case 5:** Section 10.5.3 **Case 6:** Section 10.6.3 **Case 7:** Section 10.7.3 **Case 8:** Section 10.8.3 **Case 9:** Section 10.9.3 **Case 10:** Section 10.10.3
27	• The effect on waste retrieval rates of the waste retrieval technologies selected through the TWRWP process.	Retrieval processes selected in the TWRWP process for specific tanks are reflected in RPP-PLAN-40145[i] and RPP-40545,[k] which gives the parameters and rates that feed into updating the HTWOS model and the System Plan. The retrieval processes were selected for modeling purposes. The actual TWRWP approval process for each tank will identify the retrieval process to be deployed in each tank.	Section 1.6 Section 1.8 Section 3.1.1 Section 4.1.1 Table 7-2, Item 7.2-1, potential mitigating action ii and Item 7.2-2 Appendix B, Section B3.2.3.14
28	• Sequences for remaining SSTs and DSTs to be retrieved based on a risk prioritization strategy, waste treatment feed optimization as affected by blending, and WMA closure considerations.	Past System Plan experience has revealed that overall risk reduction, waste treatment feed optimization (including blending), and WMA closure considerations are best achieved by implementing an overlapping, farm-by-farm retrieval strategy. Specific guidelines (developed and described in RPP-PLAN-40145[i] and spreadsheet SVF-1647[j]) implemented in the HTWOS model allow the model to determine a viable tank retrieval sequence consistent within this overall strategy. For the Baseline Case, the SST tank retrieval sequence is published in Appendix C and shown in Figure 5-6. DSTs are not included in this appendix, because DSTs will be emptied and refilled repeatedly over the course of the mission. Final retrieval of the DSTs is planned by the HTWOS model; details are captured in a spreadsheet that can be found in the DST transfer table cited in RPP-RPT-48681.[l] For Cases 2 - 10, the same guidelines will apply. The general timing (by farm) of the retrieval sequences for these cases and the specific sequence for all cases, except for Case 4, are shown in the cross-referenced figures. The specific tank retrieval sequence for each of these cases is captured in a case-specific spreadsheet; the final retrieval dates and sequence for the DSTs can be found in the DST transfer table. The citation for these spreadsheets can be found in the data package (RPP-RPT-48681[l]).	**Baseline Case** **SST and DST sequence:** Section 1.8, Section 3.1.1, Section 4.1.1 Figure 5-3, Figure 5-4, Figure 5-5 Section 5.5.1, Figure 5-6 Appendix B, Section B3.2.3.3, and Section B3.2.3.14 Appendix C **Blending:** Section 5.6.2.5 **Closure:** Section 3.1.2 **Cases 2-10** Case 2: Figure 10-2, Figure 10-6 Case 3: Figure 10-18, Figure 10-19 Case 4: Figure 10-28 Case 5: Figure 10-38, Figure 10-39 Case 6: Figure 10-50, Figure 10-51 Case 7: Figure 10-60, Figure 10-61 Case 8: Figure 10-71, Figure 10-72 Case 9: Figure 10-80, Figure 10-83 Case 10: Figure 10-91, Figure 10-92

Table D-1. System Plan (Rev. 6) Crosswalk with Tri-Party Agreement Milestone M-062-40 (10 pages)

Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
29	The [System] Plan will also take into account the results from previous waste retrievals and other waste treatment studies. This shall include: • The retrieval methodologies that could be employed and estimated waste volumes to be generated for transfer to the DST or other safe storage.	RPP-PLAN-40145[i] takes into account results from previous waste retrievals. Retrieval processes selected for specific tanks are reflected in RPP-PLAN-40145[i] and RPP-40545,[k] which gives estimated waste volumes that feed into updating the HTWOS model and the System Plan.	Section 1.6 Section 1.8 Section 3.1.1 Section 3.1.1.3 Section 4.1.1 Section 5.5.1 Figure 5-4 Figure 5-5 Figure 5-6 Table 7-2, Item 7.2-1, potential mitigating action ii and Item 7.2-2 Appendix B, Section B3.2.3.14
30	• DST space evaluations for the waste retrieval sequence.	For the Baseline Case, DST space impacts are shown in Figure 5-7, and evaluated in the accompanying text in Section 5.5.2.1. For Cases 2 - 10, a similar graphic is produced and included in Section 10.n.3, "Results."	**Baseline Case:** Figure 5-7, Section 5.5.2.1, Table 5-1, Table 7-1 **Case 2:** Section 10.2.3 **Case 3:** Section 10.3.3 **Case 4:** Section 10.4.3 **Case 5:** Section 10.5.3 **Case 6:** Section 10.6.3 **Case 7:** Section 10.7.3 **Case 8:** Section 10.8.3 **Case 9:** Section 10.9.3 **Case 10:** Section 10.10.3
31	Proposed improvements to reduce waste retrieval durations.	Potential improvements to reduce waste retrieval durations originate in RPP-PLAN-40145,[i] and are then incorporated into HTWOS and subsequent System Plan results as appropriate. Additionally, Case 8 investigates SST reuse as a proposed improvement to reduce waste retrieval durations for the Baseline Case.	Executive Summary Assumptions Section 3.1.1.1 Section 3.1.1.2 Section 10.8
32	**CONTINGENCY PLANNING** The Plan will identify and consider possible contingency measures to address the following risks:	Several of the scenarios defined for System Plan (Rev. 6) will explicitly address elements listed in the milestone. However, additional contingency planning is in place for all scenarios as reflected by the key issues and uncertainties identified for each case.	Section 10.1
33	• Results from SST integrity evaluations.	As the SST Integrity Program proceeds, tank integrity status is updated as appropriate and reflected in the development of the SST Waste Retrieval Plan,[i] which is used for input to the HTWOS model (also see Case 8).	Section 3.1.1 Table 10-17 Section 10.1 Section 10.6
34	• If retrievals take longer than originally anticipated and there is a potential impact to the schedule for retrieving specified tanks under this agreement.	Case 10 shows the impact of retrievals taking longer than originally anticipated. Case 8 evaluates a possible contingency plan for this risk.	Section 10.1 Section 10.8 Section 10.10

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Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference
35	• If DST space is not sufficient or is not available to support continued retrievals on schedule.	The flowsheet changes reflected in each scenario will be assessed against a number of variables, including the impact on DST storage space. Scenarios that may address this concern are Cases 3, 6, 7, and 8.	Table 10-4 Section 5.5.2.1 Figure 5-6 Figure 5-7 Table 5-1 Table 7-1 **Case 3:** Section 10.3 **Case 6:** Section 10.6 **Case 7:** Section 10.7 **Case 8:** Section 10.8
36	• If any portion of the WTP does not initiate cold commissioning on schedule.	Cases 4 and 6 evaluate using increased vitrification capacity or a new DST farm as contingency for a delayed WTP startup.	Section 10.1 Section 10.4 Section 10.6
37	• If any portion of the WTP does not complete hot start on schedule.	Cases 4 and 6 evaluate using increased vitrification capacity or a new DST farm as contingency for a delayed WTP startup.	Section 10.1 Section 10.4 Section 10.6
38	• 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.	Cases 3, 4, 6, 7, and 8 all evaluate different possible contingency plans for accelerating treatment rates.	Section 10.1 Section 10.3 Section 10.4 Section 10.6 Section 10.7 Section 10.8
39	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.	Case 6 evaluates providing a new DST farm as a contingency for WTP delay.	Section 10.1 Section 10.6

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Item	HFFACO Milestone M-062-40 Requirements	Implementation in River Protection Project System Plan (Rev. 6)	Cross Reference

Notes to Table D-1

[a] Consent Decree, 2010, *State of Washington v. DOE,* Case No. 08-5085-FVS (October 25), Eastern District of Washington.

[b] RPP-48228, 2010, *Selected Scenarios for RPP System Plan, Revision 6,* Rev. 0, Washington River Protection Solutions LLC, Richland, Washington.

[c] Brockman, D. A., and J. A. Hedges, 2010, "Partial Completion of Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Interim Milestone M-062-40, to Submit a System Plan to Washington State Department of Ecology (Ecology) Describing the Disposition of All Tank Waste Managed by the U.S. Department of Energy (DOE), Office of River Protection (ORP), Including 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," (Letter 10-TPD-148 to D. A. Faulk, Program Manager, Office of Environmental Cleanup, Hanford Project Office, U.S. Environmental Protection Agency, October 28), U. S. Department of Energy, Office of River Protection, and Washington State Department of Ecology Nuclear Waste Program, Richland, Washington.

[d] Fletcher, T. W., 2011, "*Contract No. DEAC27-08RV14800 – Approval of the Appendix B – Key Assumptions and Success Criteria for River Protection Project (RPP) System Plan, Revision 6, in Support of Contract Deliverable C.2.3.1-1, River Protection Project System Plan,*" (Letter 11-TPD-005 to A. B. Dunning, Contracts Manager, Washington River Protection Solutions LLC, February 1), U.S. Department of Energy, Office of River Protection, Richland, Washington and Fletcher, T.W. 2011, "*Contract No. DE-AC27-08RV14800- Approval of the Appendix B-Key Assumptions and success for the river protection project (RPP) system Plan, Revision 6, in support criteria of contract deliverable C.2.3.1-1, River Protection Project System Plan*" (Letter 11-TF-057 to A.B. Dunning, Contracts Manager, Washington River Protection Solutions LLC, May 16), U.S. Department of Energy, Office of River Protection, Richland, Washington.

[e] RPP-PLAN-43988, 2011, *WRPS Technology Development Roadmap*, Rev. 1 Draft, Washington River Protection Solutions, LLC, Richland, Washington.

[f] TFC-PLN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

[g] RPP-46506, 2011, *Decision Framework – Key Decisions Required to Achieve the RPP Mission*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[h] 24590-WTP-RPT-PET-09-004, 2010, *Recommendation of Alternative to Mitigate Solids Precipitation in Ion Exchange Feed*, Rev. 1, Bechtel National, Inc., Richland, Washington.

[i] RPP-PLAN-40145, 2011, *Single-Shell Tank Waste Retrieval Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[j] SVF-1647, 2011, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3D.xlsx'," Rev. 3D, Washington River Protection Solutions, LLC, Richland, Washington.

[k] RPP-40545, 2011, *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*, Rev. 2 Draft, Washington River Protection Solutions, LLC, Richland, Washington.

[l] RPP-RPT-48681, 2011, *Hanford Tank Waste Operations Simulator Model Data Package for the River Protection Project System Plan Rev. 6 Cases*, Rev. 0 Draft, Washington River Protection Solutions, LLC, Richland, Washington.

CH-TRU = contact-handled transuranic.
CWC = Central Waste Complex.
DOE = U.S. Department of Energy.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
EIS = environmental impact statement.
HFFACO = Hanford Federal Facility Agreement and Consent Order.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
IMUST = inactive miscellaneous underground storage tank.
LAW = low-activity waste.
n = corresponds to the Case Number (e.g., for Case 2, n=2).
NA = not applicable.
ORP = U.S. Department of Energy, Office of River Protection.
PT = Pretreatment Facility.
SST = single-shell tank
TC & WM = Tank Closure and Waste Management.
TRU = transuranic.
TWRWP = Tank Waste Retrieval Work Plan.
WMA = waste management area.
WRPS = Washington River Protection Solutions, LLC.