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Integrated Waste Feed Delivery Plan

Volume 1 – Process Strategy

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Abstract: The Integrated Waste Feed Delivery Plan (IWFDP) describes how waste feed will be delivered to the Waste Treatment and Immobilization Plant (WTP) to safely and efficiently accomplish the River Protection Project (RPP) mission. The IWFDP is integrated with the Baseline Case operating scenario documented in ORP-11242 (Rev. 6), *River Protection Project System Plan*. **Volume 1 – Process Strategy** (RPP-40149-VOL1) provides an overview of waste feed delivery (WFD) and describes how the WFD system will be used to prepare and deliver feed to the WTP based on the equipment configuration and functional capabilities of the WFD system. **Volume 2 – Campaign Plan** (RPP-40149-VOL2) describes the plans for the first eight campaigns for delivery to the WTP, evaluates projected feed for systematic issues, projects 242-A Evaporator campaigns, and evaluates double-shell tank (DST) space and availability of contingency feed. **Volume 3 – Project Plan** (RPP-40149-VOL3) identifies the scope and timing of the DST and infrastructure upgrade projects necessary to feed the WTP, and coordinates over 30 projectized projects and operational activities that comprise the needed WFD upgrades. Issues or project-specific risks, potential mitigating actions, and future refinements are also identified in each volume of the IWFDP.

APPROVED
By Kelly L Wheeler at 7:28 am, Mar 26, 2012

DATE:
Mar 26, 2012
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Release Approval | Date | Release Stamp

RPP-40149-VOL1, Rev. 2

Integrated Waste Feed Delivery Plan

Volume 1 – Process Strategy

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Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

washington river protection solutions

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Tank Operations Contractor **RECORD OF REVISION**		(1) Document Number: RPP-40149-VOL1, Rev. 2	
(2) Title Integrated Waste Feed Delivery Plan, Volume 1 – Process Strategy			
Change Control Record			
(3) Revision	**(4) Description of Change – Replace, Add, and Delete Pages**	**Authorized for Release**	
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0	Initial release.	R. A. Sexton July 2009	R. D. Greenwell July 2009
1	Revisions were made to fully align with the System Plan (ORP-11242 Rev. 5). Incorporation of expanded baseline scope and schedule refinement. Updated risk register. Appendices C, K, L, M, and 0 have been cancelled for Revision 1 but are reserved for future revisions. The Sludge Staging Plan and Summary of Cost Estimates are brief and have been included in the main body of the document in Sections 5.4.3 and 8.3 respectively. To maintain continuity and to allow for future updates, Appendices F and H have been maintained in the lettered list of Appendices.	P. G. Haigh November 2010	D. C. Larsen November 2010
1A	Editorial changes, Figure 2-1 was reinserted, pagination correction for Appendix N, and page number alignment.	P. G. Haigh December 2010	D. C. Larsen December 2010
2 RS	Complete rewrite. Split RPP-40149 into three volumes, addressing waste feed delivery process strategy (Volume 1), campaign plan (Volume 2), and project plan (Volume 3). Content was aligned with the System Plan (ORP-11242, Rev. 6) Baseline Case operating scenario.	E. B. West Elizabeth B. West 3/19/2012	T. W. Crawford for [signature] 3/19/2012

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 Mgal[1] of radioactive waste contained in the Hanford Site waste tanks and closure of all the tanks and associated facilities. The *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*[2] requires DOE to complete the treatment of the Hanford tank waste by September 30, 2047.

Washington River Protection Solutions (WRPS), under the Tank Operations Contract (TOC),[3] is the prime contractor responsible for the construction, operation, and maintenance activities necessary to safely store, retrieve, prepare, and transfer waste to the Waste Treatment and Immobilization Plant (WTP). The Tank Operations Contractor provides other supporting functions related to Hanford tank wastes, including supplemental treatment, supplemental pretreatment (if needed), and the management of interim Hanford storage and the Hanford Shipping Facility. Bechtel National, Inc. (BNI), the WTP Construction and Commissioning Contractor, is responsible for the design, construction, and commissioning of the WTP Pretreatment Facility, High-Level Waste (HLW) Vitrification Facility, Low-Activity Waste (LAW) Vitrification Facility, dedicated analytical and radiochemical laboratory, and support facilities to immobilize the radioactive tank wastes into glass for long-term storage or final disposal. WRPS and BNI are jointly responsible for managing the transition to WTP operations. The Tank Operations Contractor will then provide for the treatment, storage, and/or disposal of glass product and secondary waste streams supporting WTP operations throughout the RPP mission duration, and the ultimate decommissioning of associated facilities once treatment is complete.

To achieve the RPP mission, wastes must be stored until they are retrieved from 149 aging single-shell tanks (SST) and consolidated into 28 double-shell tanks (DST). Waste feed from the DSTs must be delivered to the WTP in a manner that assures continuous WTP operations over the life-cycle of the treatment mission. The DSTs are used for various roles throughout the RPP mission, and the role each DST performs may change over time. A key challenge in supporting the RPP mission is to efficiently manage the use of the DSTs and the rest of the waste feed delivery (WFD) system. This includes:

- Safely storing the existing tank waste
- Receiving, storing, and transferring wastes from sources outside of the WFD system, such as the 222-S Laboratory and the SSTs

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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] 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.

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

- Staging feed for, and receiving concentrated waste from, the 242-A Evaporator
- Incidental and intentional blending or segregation, staging, and delivering solids and supernate tank waste to the WTP
- Accepting emergency returns from the WTP, if necessary.

The planned configuration of the WFD system has been established to effectively perform these functions within the DST system, and associated issues have been identified.

Purpose

The Integrated Waste Feed Delivery Plan (IWFDP) is prepared[4] and will be implemented to "provide optimum and reliable pretreatment (if needed), blending/mixing, retrieval and delivery of feed to DOE-ORP treatment facilities. This plan shall include the needs of commissioning, near-term, and long-term operations; necessary studies, testing, and infrastructure installation; and projected waste transfer/pretreatment operations" (TOC Section C.2.3.1, "Sub-CLIN 3.1: Treatment Planning, Waste Feed Delivery, and WTP Transition").

The IWFDP defines the systems and infrastructure necessary for conducting WFD operations, identifies the specific upgrades and other workscope to be performed, and describes the approach to prepare and deliver tank waste feed to the WTP.

The IWFDP is divided into three volumes: Volume 1 – Process Strategy, Volume 2 – Campaign Plan,[5] and Volume 3 – Project Plan.[6] The purpose and scope of each volume, and the primary inputs to and outputs from the IWFDP as a whole, are shown in Figure ES-1.

The IWFDP draws from ORP direction, technical and programmatic assumptions, and requirements provided from various documents as they relate to WFD and the interface between the Hanford tank farms and WTP. The IWFDP, in turn, provides the process strategy for WFD, describes the initial campaign plans based on the process strategy and associated operating scenario, identifies the scope and timing of the DST upgrades projects necessary to achieve the RPP mission under the established process strategy, and identifies the project execution plans that are needed for each projectized operational activity. Issues, potential mitigating actions, and future refinements regarding WFD are also identified within each volume of the IWFDP. Each revision of the IWFDP then evolves and matures through an ongoing iterative process of successive refinements whereby issues are evaluated and potential mitigating actions are established when risks exceed predefined thresholds or are otherwise warranted. Mitigating actions are then performed to the extent permitted by funding and schedule. Refinements to the architecture, tank usage, operating scenario, and delivered feed are identified, as issues are mitigated, resolved, and closed. Each revision of the IWFDP then incorporates the resulting feedback and refinements recommended through the aforementioned process.

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[4] This revision of the IWFDP was initiated by the WRPS WTP Support organization; future revisions will be prepared by the newly implemented One System Integrated Project Team.

[5] RPP-40149-VOL2, 2012, *Integrated Waste Feed Delivery Plan, Volume 2 – Campaign Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[6] RPP-40149-VOL3, 2012, *Integrated Waste Feed Delivery Plan, Volume 3 – Project Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

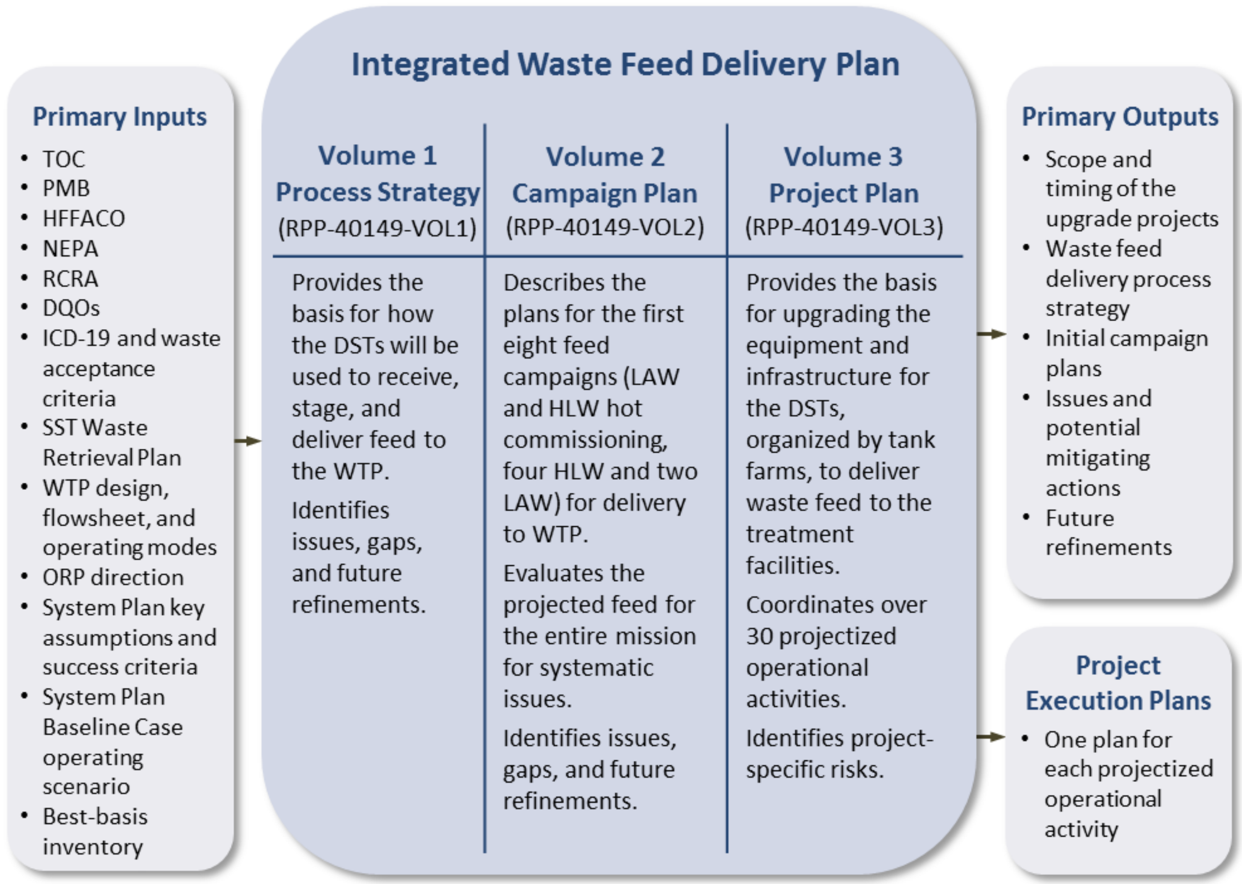

Figure ES-1. Scope and Purpose of the Integrated Waste Feed Delivery Plan

Results

The IWFDP process strategy provides the basis for how the DSTs will be used to stage and deliver waste feed to the WTP. This volume also provides an overview of WFD topics, describes the WFD system utilization based on the capabilities of the DST system configuration, and presents the WFD process strategy. This revision of the IWFDP is integrated with the assumptions, requirements, and baseline operating scenario in ORP-11242, *River Protection Project System Plan* (Rev. 6).[7]

The general process for delivering waste feed to the WTP is shown in Figure ES-2. The steps involved for WFD include:

- Complete the necessary DST infrastructure upgrades, including mixer/transfer pumps installation, to perform WFD activities
- Prepare waste for delivery to WTP, including sampling for waste compatibility assessments and process control requirements

[7] ORP-11242, 2011, *River Protection Project System Plan*, Rev. 6, U.S. Department of Energy, Office of River Protection, Richland, Washington.

- Perform mixing, sampling, and waste characterization to confirm the tank waste meets prescribed waste acceptance criteria[8]
- Deliver waste feed[9] to WTP:
  - Perform pre-transfer flush to preheat the transfer line and reduce the possibility of solids precipitation during waste transfer
  - LAW feed campaigns: A waste feed campaign is settled and then transferred to the WTP LAW feed receipt tanks, targeting a nominal 1 Mgal per campaign received
  - HLW feed campaigns: A waste feed campaign is mixed and then transferred to the WTP HLW feed receipt tank, in multiple batches with mixing occurring prior to each batch delivery, targeting 120 kgal per batch received
  - Perform post-transfer flush following each batch delivery to clear the transfer line of any remaining waste.

The general process described above is followed for each LAW and HLW feed delivery to WTP throughout the RPP mission.

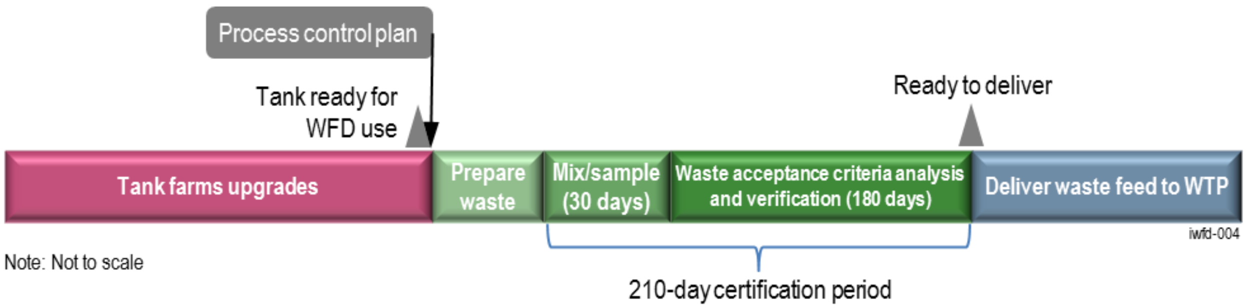

Figure ES-2. General Strategy for Waste Feed Delivery to Waste Treatment and Immobilization Plant

Issues and Uncertainties

Some of the assumptions used for the IWFDP process strategy present issues and uncertainties that need to be successfully addressed to increase confidence in achieving the desired performance for the RPP mission. The challenges and potential mitigating actions identified in this volume of the IWFDP, and a mapping to the risk items defined in TFC-PLN-39, *Risk and Opportunity Management Plan*,[10] that are associated with each identified issue, are presented in Section 5.0. Selected WFD assumptions and associated issues and uncertainties are summarized in Table ES-1.

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[8] Mixing and sampling of prepared waste feed occurs over a prescribed hold time of 30 days. Samples are then supplied to the WTP for waste characterization and feed acceptance certification no less than 180 days prior to the scheduled waste transfer date, per 24590-WTP-ICD-MG-01-019, *ICD-19 – Interface Control Document for Waste Feed*. These events together comprise the minimum 210-day certification period required prior to WFD to the WTP.

[9] Hanford tank waste, including "LAW feed" and "HLW feed" are managed as HLW per the *Nuclear Waste Policy Act of 1982*, as amended.

[10] TFC-PLN-39, 2010, *Risk and Opportunity Management Plan*, Rev. G, Washington River Protection Solutions, LLC, Richland, Washington.

Table ES-1. Selected Waste Feed Delivery Assumptions and Related Uncertainties

Assumption, assertion, or requirement	Issues and uncertainties
The RPP mission can be successfully executed using the existing DST space.	DST space is limited early in the mission until WTP reaches full capacity operation. Using existing BDGRE controls may be overly conservative for high shear-strength sludge waste, potentially decreasing the total available space available to fill a DST. An unplanned outage of the 242-A Evaporator, especially in the near-term when DST space is limited (before 2025), may negatively impact WFD and SST retrievals.
Mixing, sampling, and transfer systems are capable of supporting the execution of the RPP mission.	The ability of the DST mixer pump system to adequately suspend and homogenously distribute the HLW solid particles within a full-scale DST is uncertain, as is the ability to obtain representative samples of the mixed waste. Uncertainty exists regarding the maximum sludge depth that can be mobilized, and the ability of the mixer pumps to restart when submerged in solids. Maintaining waste temperatures below the established limits may restrict mixer pump operations and impact WFD.
Waste feed delivered to the WTP must meet all established waste acceptance criteria.	A portion of the WTP feed is projected to fall outside of the feed envelopes documented in the WTP Contract.[a] Also, evolving WTP waste acceptance criteria may impose new requirements on WFD.
WFD equipment availability will support WTP operations without limiting melter throughput.	Current projections from the OR model, documented in RPP-RPT-50742,[b] indicate multi-year delays due to equipment failures.
DST assignments for WFD functional operations are appropriate to accomplish the RPP mission.	Waste feed deliveries from AW Farm are expected to exceed operating limits on pressure drop when contingency for conservatism is applied. AY and AZ Farm tanks may not support deep sludge using incremental lowering of the mixer pumps due to exacerbated stresses on the in-tank equipment. Evolving mission architecture/configuration changes may require changes in DST assignments.
Solid-liquid partitioning impacts planning for transfers and evaporator operations.	Current waste phase equilibriums are approximated for most constituents by limited experimental data and simple split factors.

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

[b] RPP-RPT-50742, 2011, *Phase 3 Waste Feed Delivery Operations Research Model Initial Assessment Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

BDGRE = buoyant-displacement gas release event.
DST = double-shell tank.
OR = operations research.
RPP = River Protection Project.
SST = single-shell tank.
WFD = waste feed delivery.
WTP = Waste Treatment and Immobilization Plant.

Future Refinements

Future revisions of the IWFDP will include updates to WFD planning assumptions, incorporate resolutions to existing issues and uncertainties, and identify emerging issues that arise during ongoing WFD planning activities. A list of specific refinements identified for inclusion in future IWFDP revisions is discussed in Section 6.0. Some of these selected items include:

- Updating WFD requirements to reflect changes identified in 24590-WTP-ICD-MG-01-019, *Interface Control Document for Waste Feed* (Rev. 5),[11] which was released in August 2011
- Maintaining alignment with WFD requirements in response to modifications of the WTP design, flowsheet, and operating modes
- Replacing the water wash factors used to estimate waste solubility behavior throughout the tank farms and WTP with enhanced solubility correlations
- Adjusting the WFD process strategy to minimize or eliminate HLW feed deliveries from the AW Farm to WTP
- Aligning the timing, quantities, and types of waste feed delivered during hot commissioning with WTP planning assumptions
- Incorporating screening of total organic carbon for waste batches delivered to WTP.

Path Forward

The IWFDP process strategy will evolve as WFD issues and uncertainties are addressed by the One System Integrated Project Team, and in response to changes in the overall RPP mission. A list of studies, projects, and actions necessary to improve the WFD strategy is discussed in Section 6.0. Some of these selected items include:

- Finalizing WFD requirements for WTP waste acceptance
- Completing the rationale and basis for specific DST equipment configurations and capabilities
- Incorporating results from the operations research model into WFD planning
- Determining the limits of performance for the tank farms and WTP equipment with respect to the ability to mix, sample, and transfer waste solids
- Exploring alternative SST retrieval sequencing rules for potential improvements in meeting overall mission metrics and waste acceptance criteria
- Developing a strategy to add outstanding WFD activities, such as mixer pump operations, to the tank farms documented safety analysis (RPP-13033[12])
- Completing tank waste mixing and sampling studies to demonstrate DST mixing, sampling, and transfer performance

[11] 24590-WTP-ICD-MG-01-019, 2011, *Interface Control Document for Waste Feed*, Rev. 5, Bechtel National, Inc., Richland, Washington.

[12] RPP-13033, 2011, *Tank Farms Documented Safety Analysis*, Rev. 4J, Washington River Protection Solutions, LLC, Richland, Washington.

- Updating the tank farms and WTP criticality safety evaluation reports to address the presence of large plutonium particles; determining necessary corrective actions regarding WRPS waste retrieval and WTP mixing efforts; and, evaluating the impacts of those corrective actions on WFD, WTP operation, and the overall waste treatment mission
- Conducting studies and testing to refine the waste blending strategy for systematic issues and problematic wastes.

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CONTENTS

APPENDICES

FIGURES

TABLES

TERMS

Abbreviations and Acronyms

ARRA	American Recovery and Reinvestment Act
BBI	best-basis inventory
BDGRE	buoyant displacement gas release event
BNI	Bechtel National, Inc.
CC	complexed concentrate
CH	contact-handled
CSER	criticality safety evaluation report
CSL	criticality safety limit
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DQO	data quality objective
DSA	documented safety analysis
DST	double-shell tank
Ecology	Washington State Department of Ecology
FEP	feed evaporator process
FY	fiscal year
GG	governance group
GRE	gas release event
HFFACO	Hanford Federal Facility Agreement and Consent Order
HGR	hydrogen generation rate
HLAN	Hanford local area network
HLW	high-level waste
HTWOS	Hanford Tank Waste Operations Simulator
ICD	interface control document
ICDRT	interface control document review team
IHLW	immobilized high-level waste
ILAW	immobilized low-activity waste
IMUST	inactive miscellaneous underground storage tank
IOG	interface owner group
IPT	integrated project team
IWFDP	Integrated Waste Feed Delivery Plan
LAW	low-activity waste
LFL	lower flammability limit
MAR	mission analysis report
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
O&M	operations and maintenance
OR	operations research
ORP	U.S. Department of Energy, Office of River Protection
OSD	operating specification document
PCB	polychlorinated biphenyl
PCP	process control plan
PMB	performance measurement baseline

PT	Pretreatment Facility
RAM	reliability, availability, and maintainability
RCRA	Resource Conservation and Recovery Act
RPP	River Protection Project
SSMD	small-scale mixing demonstration
SST	single-shell tank
TMP	technology maturation plan
TOC	Tank Operations Contract
TRU	transuranic
TSR	technical safety requirement
TWINS	Tank Waste Information Network System
UFP	ultrafiltration process
WCA	waste compatibility assessment
WFD	waste feed delivery
WFE	wiped-film evaporator
WOL	waste oxide loading
WRF	waste retrieval facility
WRPS	Washington River Protection Solutions, LLC
WTP	Waste Treatment and Immobilization Plant
WVR	waste volume reduction

Units

°F	degrees Fahrenheit
cP	centipoise
ft	feet
g	gram
gal	gallon
gpm	gallons per minute
hp	horsepower
in.	inch
kg	kilogram
kgal	thousand gallons
L	liters
M	molar
Mgal	million gallons
mL	milliliter
min	minute
Pa	pascals
ppm	parts per million
sec	second
SpG	specific gravity
Sv	sievert
wt%	weight percent

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) manages the River Protection Project (RPP) at the Hanford Site. 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,[13] treatment, and disposal of approximately 55 Mgal[14] of radioactive waste contained in the Hanford waste tanks and closure of all the tanks and associated facilities. The tank farms must be able to reliably prepare and transfer waste feed to the Waste Treatment and Immobilization Plant (WTP) and other potential new treatment facilities to execute the RPP mission.

1.1 PURPOSE

The purpose of the Integrated Waste Feed Delivery Plan (IWFDP) is to plan for those activities needed to "provide optimum and reliable pretreatment (if needed), blending/mixing, retrieval and delivery of feed to DOE-ORP treatment facilities. This Plan shall include the needs of commissioning, near-term, and long-term operations; necessary studies, testing, and infrastructure installation; and projected waste transfer/pretreatment operations. The Contractor shall ensure that the *Integrated Waste Feed Delivery Plan* is integrated with the *RPP System Plan*" (DE-AC27-08RV14800, *Tank Operations Contract* [TOC], Section C.2.3.1, "Sub-CLIN 3.1: Treatment Planning, Waste Feed Delivery, and WTP Transition").

The IWFDP is divided into three volumes: Volume 1 – Process Strategy, Volume 2 – Campaign Plan (RPP-40149-VOL2), and Volume 3 – Project Plan (RPP-40149-VOL3). The purpose and scope of each volume, and the primary inputs to and outputs from the IWFDP as a whole, are shown in Figure 1-1.

The IWFDP draws from ORP direction, technical and programmatic assumptions, and requirements provided from various documents as they relate to waste feed delivery (WFD) and the interface between the Hanford tank farms and WTP. The IWFDP, in turn, provides the process strategy for WFD, describes the initial campaign plans based on the process strategy and associated operating scenario, identifies the scope and timing of the double-shell tank (DST) upgrades projects necessary to achieve the RPP mission under the established process strategy, and identifies the project execution plans that are needed for each projectized operational activity. Issues, potential mitigating actions, and future refinements regarding WFD are also identified within each volume of the IWFDP. The IWFDP is integrated with ORP-11242, *River Protection Project System Plan* (referred to hereafter as System Plan), since the RPP System Plan Baseline Case uses the assumptions from Volume 3 (Project Plan) and Volume 1 (Process Strategy) of the IWFDP. Volume 2 (Campaign Plan) then documents and evaluates the resulting operating scenario from the System Plan.

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[13] 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.

[14] 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.

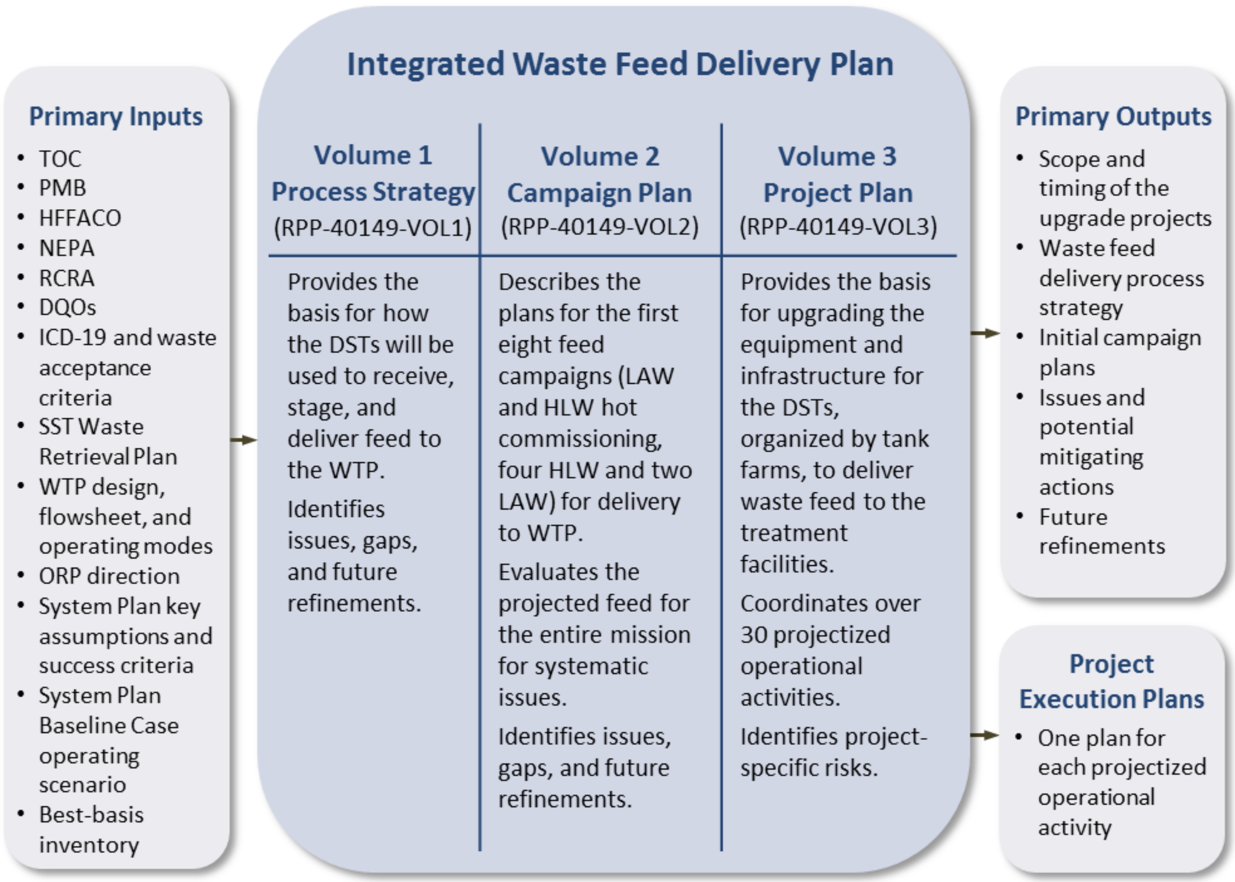

Figure 1-1. Scope and Purpose of the Integrated Waste Feed Delivery Plan

1.2 OBJECTIVES

Consistent with the contractual scope and purpose of the IWFDP, the primary objective of the IWFDP is to develop the scheme for delivering timely and compliant waste feed to the WTP to safely and efficiently accomplish the RPP mission. Timely, within the context of the IWFDP, refers to the ability of the tank farms to supply adequate waste feed to the WTP, upon request, to maintain efficient operations of the WTP and the second low-activity waste (LAW) facility throughout the treatment mission. Modifications to and installations of new systems will be coordinated to meet WTP startup, commissioning, and processing needs. The architecture, process strategy, and plans required to achieve this primary objective will be refined in response to a number of potential changes based on funding, decisions affecting the overall system configuration, evolving waste acceptance criteria and criticality specifications, a better understanding of tank farms mixing and sampling capabilities, and evolving documented safety analysis (DSA) requirements. Supporting objectives that may aid in accomplishing the primary WFD objective include:

- Providing an integrated systems approach to waste retrieval, treatment, and delivery, which includes establishing the hardware baseline wherein existing DST farm conditions are evaluated to document the status of site infrastructure and storage/retrieval systems

- Managing the dynamic between supporting near-term single-shell tank (SST) retrievals and WFD activities
- Integrating DST system upgrades with other tank farms workscope
- Relying on mature/proven technologies
- Placing a high priority on operability and maintainability of systems
- Assessing technical and programmatic risks and opportunities on a continuous basis
- Providing flexibility to adapt to evolving requirements and process improvement opportunities
- Assessing and responding to project performance risks
- Optimizing cost efficiency
- Ensuring that work is performed safely and is bounded by appropriate safety analysis.

1.3 EVOLUTION OF THE INTEGRATED WASTE FEED DELIVERY PLAN

The IWFDP evolves and matures through an ongoing iterative process of successive refinements, portrayed in Figure 1-2. An iterative approach is more tractable than attempting to determine the required configuration of the WFD system and how that system will be used to prepare and delivery feed *directly* based on the success criteria,[15] waste acceptance criteria, and other requirements. This iterative approach takes advantage of the existing WFD configuration, upgrade plans and projects, and WFD process strategy.

Volume 3 of the IWFDP establishes the basis for the WFD system architecture (DST equipment, waste transfer systems, and supporting infrastructure and utilities). Volume 1 builds the WFD process strategy (i.e., how the DSTs are used to prepare and deliver feed) based on the planned WFD system configuration. The WFD process strategy assumptions are used with other system planning assumptions to form the baseline operating scenario, outlined in the RPP System Plan (ORP-11242). Volume 2 of the IWFDP then builds the campaign plan from the baseline operating scenario and evaluates the delivered feed.

Issues identified during this process are gathered and managed using the TOC risk management process (TFC-PLN-39, *Risk and Opportunity Management Plan*), the processes defined in 24590-WTP-PL-MG-01-001, *Interface Management Plan*, and the Flowsheet Integrated Project Team (IPT). Issues are evaluated and potential mitigating actions are established when risks exceed predefined thresholds or are otherwise warranted. Mitigating actions are performed to the extent permitted by funding and schedule. Refinements to the architecture, tank usage, operating scenario, and delivered feed are identified, as issues are mitigated, resolved, and closed; this may include system-level trade-offs on system performance or establishment of new or updated requirements. The next iteration of the IWFDP then incorporates the feedback and refinements recommended and the process begins again.

[15] Success criteria refer to those metrics that are used to determine how well a scenario meets overall mission goals or requirements. For System Plan (Rev. 6), these success criteria comprise cost-based metrics (both near-term funding targets and life-cycle cost) and selected *Hanford Federal Facility Agreement and Consent Order – Tri Party Agreement* (Ecology et al. 1989) and Consent Decree (2010) milestones.

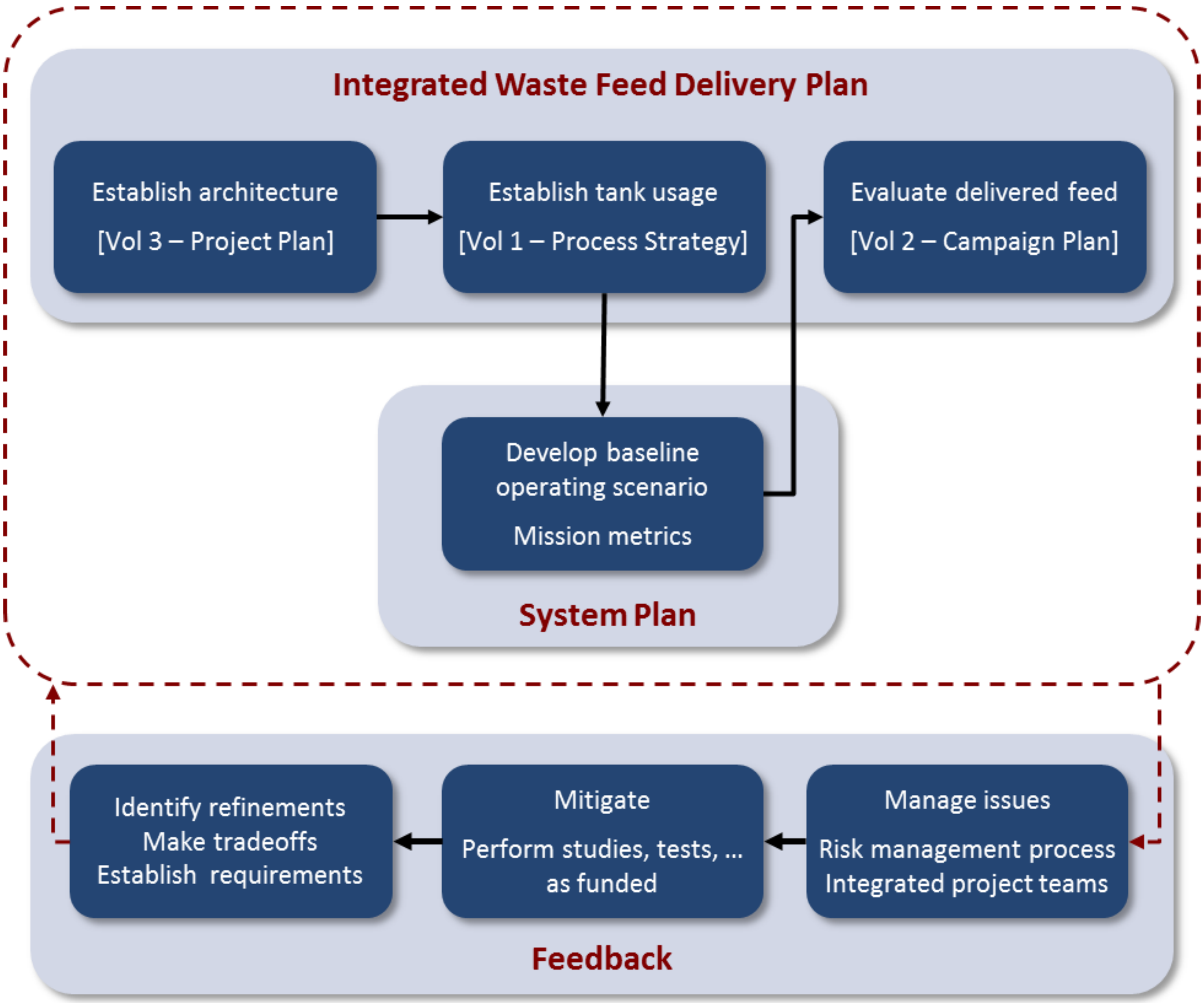

Figure 1-2. Iterative Refinement of the Integrated Waste Feed Delivery Plan

1.4 WASTE FEED DELIVERY PLANNING PROCESS

The WFD planning process, shown in Figure 1-3, expands on the iterative process depicted in Figure 1-2 to show the general information flow and relationship between key documents important to WFD. This section will first discuss general features of the planning process and then discuss specific documents and information flow. In the discussions that follow, names of items on Figure 1-3 are shown in bold text.

The WFD planning process overlaps with and complements the system planning process described in Section 1.8 of the RPP System Plan (ORP-11242, Rev. 6).

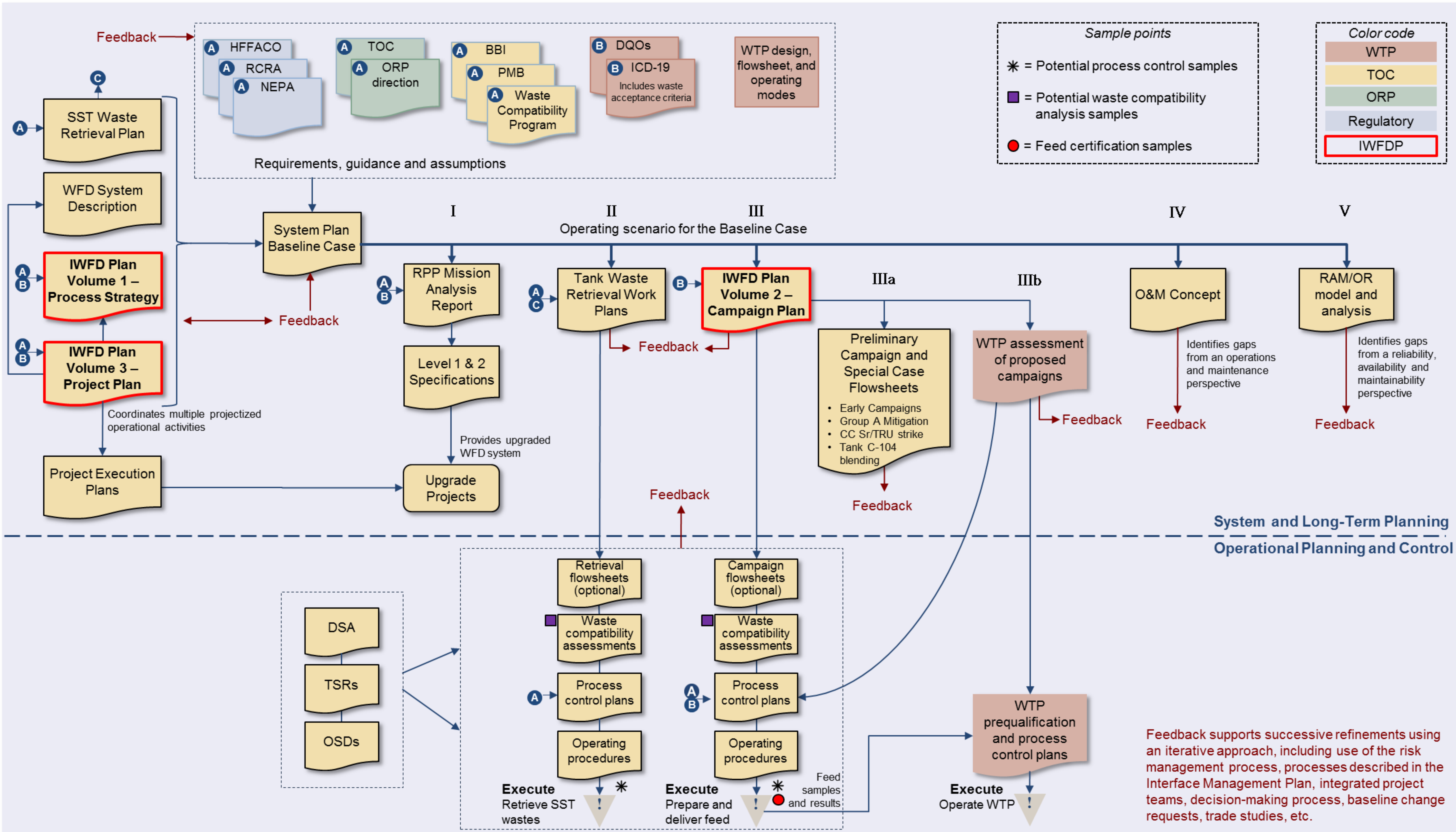

Figure 1-3. Integrated Waste Feed Delivery Planning Process

General Features

The planning process and figure is split into two sections; the top section comprises the **system and long-term planning** aspects of WFD and the bottom section comprises **operational planning and control**. The page-shaped boxes (with the curved bottom edge) refer to either individual documents, classes of documents, or collections of documents. Each box is color-coded to indicate the source or owner of the document. The boxes comprising the three **IWFD Plan** volumes are highlighted with a red border.

As shown on both Figure 1-2 and Figure 1-3, an essential feature of the planning process is the provision for adjustments based on **feedback**. Figure 1-3 shows the primary **feedback** paths; many other possible paths are not shown to simplify the figure. **Feedback** supports the evolution and maturation of the IWFDP and associated physical systems through an ongoing iterative process of successive refinements (see Section 1.3). **Feedback** includes issues or gaps identified during the planning process. Critical or high-stakes issues are generally managed and resolved using the risk management process, the processes described in the WTP Interface Management Plan (24590-WTP-PL-MG-01-001), or under the guidance of the IPT. Issues may be resolved using the decision-making process, baseline change requests, trade studies, or engineering studies, either in conjunction with or independently from the risk management and interface management processes. Some issues may also be resolved as part of routine updates to the various documents associated with the WFD planning process. Other issues may require changes or additions to the WFD system (equipment and infrastructure).

While the TOC requires that the **SST Waste Retrieval Plan** (RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*) and **IWFD Plan** be integrated with the **System Plan** (ORP-11242), there may be instances where some of the other documents lag or lead the **System Plan Baseline Case** or even skip a revision depending on the extent of technical changes, programmatic needs, and available funds and resources. These documents will be updated on a case-by-case basis when (1) there are sufficient technical or programmatic changes to warrant an update, and (2) the updated document is needed for decision making or input into other documents. Meanwhile, documents that lag the System Plan Baseline Case may still provide useful information to the risk management process or be used for relevant assumptions or other information.

Information Flow

The **System Plan Baseline Case** is an appropriate starting point for describing the WFD planning process as it provides "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."

One group of inputs to the System Plan Baseline Case is shown on Figure 1-3 as **requirements, guidance, and assumptions**. These comprise regulatory requirements such as the *Hanford Federal Facility Agreement and Consent Order – Tri Party Agreement* (**HFFACO**, Ecology et al. 1989), the *Resource Conservation and Recovery Act of 1976* (**RCRA**), and the *National Environmental Policy Act of 1969* (**NEPA**); ORP requirements and assumptions such as the **TOC** and **ORP direction**; the TOC baseline (performance measurement baseline [**PMB]**) and **Waste Compatibility Program**; WTP documents defining the feed interface and requirements such as 24590-WTP-ICD-MG-01-019, *Interface Control Document for Waste Feed* (**ICD-19**), which includes the waste acceptance criteria generated by the data quality objective (DQO) process, and applicable **DQOs** (both waste acceptance criteria and regulatory), and finally the collection of WTP documents that establish the **WTP design, flowsheet, and operating modes**.

The other inputs to the **System Plan** are those resulting from integration with the **IWFD Plan** and the **SST Waste Retrieval Plan**. The **IWFD Plan Volume 3 – Project Plan** establishes the basis for upgrading the equipment and infrastructure for the DSTs to deliver waste feed to the treatment facilities. The WFD system description, together with the IWFD Plan Volume 3, establishes the WFD architecture (equipment and infrastructure) and the associated dates for beneficial use. The IWFD Plan Volume 3 also coordinates over 30 projectized operational activities (the **upgrade projects**), with each **upgrade project** having its own **project execution plan**. Once the architecture is defined, the **IWFD Plan Volume 1 – Process Strategy**, provides the basis for how the DSTs will be used to receive, stage, and deliver feed to the WTP. Finally, the **SST Waste Retrieval Plan** defines the strategy, technologies, and requirements for the retrieval of waste from the SSTs, including guidelines for the sequencing and timing of those retrievals.

The inputs to the System Plan described above are incorporated into the Hanford Tank Waste Operations Simulator (HTWOS) and life-cycle cost model; these models are used to develop an **operating scenario for the Baseline Case**, which is generally documented as part of the **System Plan Baseline Case**. The actual integration of most aspects of the **System Plan Baseline Case**, the **SST Waste Retrieval Plan**, and the three volumes of the **IWFD Plan** takes place during the modeling and analysis for the Baseline Case operating scenario. Once the **operating scenario for the Baseline Case** is established, the actual production of the **System Plan**, **SST Waste Retrieval Plan**, and **IWFD Plan** are managed as three separate efforts according to their own schedules.

The **operating scenario for the Baseline Case** serves as a convenient point for continuing the discussion of the WFD planning process. The Baseline Case operating scenario provides input to a number of interrelated documents and their associated engineering efforts. Each branch of the figure is discussed further in the remainder of this section.

In the first branch (I), the top-level functions and requirements for the RPP mission are established by RPP-RPT-41742, *River Protection Project Mission Analysis Report*, shown on the figure as **RPP Mission Analysis Report**.[16] The specifications for the systems and subsystems needed to provide the identified functions are then established by the **Level 1 and 2 specifications**. These specifications are then allocated, as appropriate, to the various **upgrade projects**.

In the second branch (II), **Tank Waste Retrieval Work Plans** are prepared for each SST retrieval. Optional **retrieval flowsheets** may be prepared depending on the complexity of the retrieval. **Waste compatibility assessments** evaluate the proposed retrieval activities against the **Waste Compatibility Program** and identify any needed controls; **potential waste compatibility analysis samples** may be required to support these assessments. A **Process Control Plan** identifies the full set of controls and key steps that will be used for that retrieval, and those controls are implemented in **operating procedures**. The operating procedures are then used to **retrieve SST wastes** (**execute**) taking process control samples (**potential process control samples**) as required by the **Process Control Plan**.

[16] In the future, the mission analysis and top-level functions and requirements may be issued as two separate documents.

In the third branch (III), the **IWFD Plan Volume 2 – Campaign Plan** describes the plans for the first eight campaigns for delivery to the WTP; evaluates the projected feed for the entire mission for systemic issues; and identifies issues, gaps, and future refinements. Optional **campaign flowsheets** may be prepared depending on the complexity of the steps needed to prepare that campaign. **Waste compatibility assessments** evaluate the proposed activities against the **Waste Compatibility Program** and identify any needed controls; **potential waste compatibility analysis samples** may be required to support these assessments. A **Process Control Plan** identifies the full set of controls and key steps that will be used for preparing that campaign, and those controls are implemented in **operating procedures**. The operating procedures are then used to **prepare and deliver feed** (**execute**) taking process control samples (**potential process control samples**) as required by the **Process Control Plan**. The **feed samples and results** from sampling the prepared campaign (**feed certification samples**) are used to determine the acceptability of the waste feed per the **waste acceptance criteria** and to prepare the **WTP prequalification and process control plans**. Those plans establish how the waste delivered by the campaign will be treated at the WTP (**operate WTP [execute]**).

In a side branch (IIIa), **preliminary campaign and special case flowsheets** are developed and maintained (1) to address mitigation of Waste Group A tanks, the precipitation of strontium and transuranic (TRU) elements from complexed concentrate (CC) waste, and the blending of the fissile uranium from Tank C-104, and (2) for early identification of issues with the proposed campaigns. In another side branch (IIIb), a **WTP assessment of proposed campaigns**, facilitated by the One System IPT, is anticipated to provide feedback that will be used to adjust the timing, quantities, and composition of the next few campaigns on a rolling basis. This assessment is also anticipated to provide input to the **process control plans** for the next campaign, also on a rolling basis.

In the fourth branch (IV), an operations and maintenance concept (**O&M concept**) is prepared to describe how the physical WFD systems will be operated and maintained under normal and off-normal conditions. The **O&M concept** may identify **feedback** in the form of issues or gaps from an O&M perspective.

In the fifth branch (V), a series of reliability, availability, and maintainability/operations research models (**RAM/OR model and analysis**) are used to evaluate the ability of the WFD systems to deliver feed to the WTP on time. The **RAM/OR model and analysis** is expected to identify **feedback** in the form of issues or gaps from a RAM perspective.

All of the **operational planning and control** documents and activities must be performed in accordance with the tank farms **DSA** (RPP-13033, *Tank Farms Documented Safety Analysis*), technical safety requirements (**TSR**), and operating specification documents (**OSD**).

1.5 PROCESS STRATEGY OUTLINE

This volume of the IWFDP is organized into seven sections.

- Section 1.0 provides a brief site background and summarizes the scope and objectives of the IWFDP, evolution of the WFD strategy, and the WFD planning process.
- Section 2.0 presents the WFD overview, including hot commissioning feed, LAW feed delivery, high-level waste (HLW) feed delivery, waste volume management, waste compatibility, SST retrieval support, and other special topics associated with WFD.

- Section 3.0 describes the WFD system utilization, including DST system configurations and capability and the process flow diagram.
- Section 4.0 presents the overall RPP WFD process strategy, including WTP waste acceptance criteria, WTP feed receipt, supernate and slurry handling, and dedicated DST emergency space.
- Section 5.0 provides a table of WFD issues and uncertainties arising from this volume of the IWFDP, along with associated assumptions and potential mitigating actions.
- Section 6.0 presents path forward recommendations, including necessary technologies, future projects, key decisions, additional studies, and optimization opportunities. This section also outlines future refinements identified to be incorporated into future revisions of the IWFDP and associated System Plan.
- Section 7.0 lists the references used in the main body of this volume of the IWFDP.

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2.0 WASTE FEED DELIVERY OVERVIEW

The following subsections provide an overview of WFD topics, including hot commissioning feed, LAW feed and HLW feed delivery, HLW feed blending, waste volume management, waste compatibility, and SST retrieval support.

The terms "LAW feed" and "HLW feed" are established by the WTP Contract (DE-AC27-01RV14136, *Design, Construction, and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*). These terms refer to the supernate with entrained solids (LAW feed) and the slurry (HLW feed) that will be delivered to the WTP Pretreatment Facility (PT) Facility. "Hanford tank waste" refers to waste as it is currently stored in tanks, prior to retrieval. In this context and throughout the IWFDP, both LAW feed and HLW feed, and the Hanford tank waste, are managed as HLW per the *Nuclear Waste Policy Act of 1982*, as amended. Following pretreatment, the LAW feed can be managed as low-level waste. Additional details are provided in the System Plan (Rev. 6), Sections 2.3.1, "Definition of High-Level Waste," and 2.3.2, "Waste Incidental to Reprocessing."

2.1 HOT COMMISSIONING FEED

Originally, Tank C-106 was selected by the Tank Waste Remediation System Privatization Contractor for the HLW commissioning feed (WHC-SD-WM-ES-370, *Phase I High-Level Waste Pretreatment and Feed Staging Plan*). When Tank C-106 was retrieved into Tank AY-102, AY-102 then took over as the designated HLW commissioning tank. Iterations to determine the initial LAW hot commissioning feed source eventually settled on the supernate contained in Tank AP-101.[17] To create more DST space for SST retrievals, a baseline change request[18] was prepared in October 2003 to consolidate DST waste. At the approval and direction of ORP in 2005 (Schepens 2005), Tank AP-101 was consolidated with the waste in Tank AY-102. This permitted Tank AY-102 to become the sole source for HLW and LAW hot commissioning feed, which is detailed in HNF-SD-WM-SP-012, *Tank Farm Contractor Operation and Utilization Plan* (Rev. 5), and has since been incorporated into subsequent System Plan[19] operating scenarios. A recent study reviewed the suitability of Tank AY-102 as the source for hot commissioning feed (RPP-RPT-46355, *A Comparative Evaluation of Tank AY-102 Wastes for WTP Hot Commissioning*). That comparative evaluation endorsed the aforementioned selection of Tank AY-102 wastes as the hot commissioning source for the WTP.

The WFD strategy entails transferring the waste currently in Tank AY-102, consisting primarily of solids from Tank C-106 and supernate from Tank AP-101, to the WTP to support hot commissioning activities. Due to evaporation that has occurred and is assumed to occur before hot commissioning is slated to begin, dilution water will be added to the contents of Tank AY-102 to bring sodium and solids concentrations to proper levels prior to hot commissioning.

[17] HNF-SD-WM-SP-012, *Tank Waste Remediation System Operation and Utilization Plan* (Rev. 1), and HNF-SD-WM-SP-012, *Tank Farm Contractor Operation and Utilization Plan* (Rev. 2), document the evolution of determining the selected HLW and LAW hot commissioning feed sources.

[18] Documented under BCR-04-001, "Software Change Summary Form for Case BCR-04-001."

[19] The consolidated hot commissioning feed source was first incorporated into the ORP-11242 (Rev. 3) Reference Case operating scenario, and has remained in the Baseline Cases of Revisions 4, 5, and 6.

The waste staged in Tank AY-102 will then be mixed and sampled[20,21] for certification based on the WTP waste acceptance criteria for HLW and LAW feed, respectively. A process control sample will be taken to confirm sodium and solids concentrations after completing the required time for sampling and characterization and immediately before delivery. A portion of the supernate from Tank AY-102 will then be delivered to the WTP LAW feed receipt tanks. The remaining waste in Tank AY-102 will be mixed, a process control sample taken to confirm sodium and solids concentrations, and multiple HLW batches transferred to the WTP HLW feed receipt tank.

2.2 LOW-ACTIVITY WASTE FEED DELIVERY

The WFD logic for a typical LAW campaign is illustrated in Figure 2-1.

A prerequisite to the preparation and delivery of waste feed is that the tank-specific upgrades and any associated transfer system and tank farm infrastructure upgrades have been completed (see IWFDP Volume 3 for details).

The general strategy for delivering LAW feed to the WTP is expected to proceed as follows: a tank operating as a LAW feed tank (see Section 4.4.1) is identified to receive staged waste, from one or more tanks operating as LAW feed staging tanks, for delivery to the LAW feed receipt tanks in WTP. Waste compatibility and process control samples are taken prior to filling the LAW feed tank to generate a waste compatibility assessment and to assist in the development of the process control plan for the identified LAW feed tank. Additional process control samples may be taken during and after the process control plan is developed to identify if the plan has adequately addressed the process controls necessary for delivering the designated LAW feed.

After the LAW campaign is fully prepared, the LAW feed tank undergoes a prescribed hold time of 30 days to allow for solids settling and sampling, and an additional 180 days for waste characterization to confirm the feed meets the waste acceptance criteria. A pre-transfer flush[22] of inhibited water[23] precedes the designated waste transfer—this preheats the transfer line and helps prevent solids precipitation during the waste transfer. The LAW feed campaign is then transferred to the LAW feed receipt tanks,[24] targeting a nominal 1 Mgal per campaign received.[25] The delivery of a LAW feed campaign will have to be managed to fill multiple tanks in turn, which may involve multiple transfers, since each of the four LAW feed receipt tanks has a maximum operating volume of 375 kgal.

[20] RPP-40149-VOL2, Section 3.1.5, provides detailed mixing and sampling activities associated with the operating scenario for hot commissioning.

[21] The current strategy assumes that a single sampling activity will be able to provide the waste feed needed to confirm the waste acceptance criteria is met for both the HLW and LAW portions of the waste.

[22] Flush requirements and purpose are consistent with ICD-19 and TFC-ENG-STD-26, *Waste Transfer, Dilution, and Flushing Requirements*.

[23] ICD-19 (Rev. 5), released during the final preparation of this IWFDP, and therefore, not evaluated in this revision of the document, eliminates the requirement for the water flush to explicitly be inhibited water. Future revisions of the IWFDP will evaluate and incorporate the requirements from the most recent revision of ICD-19 that is approved for use in the System Plan.

[24] The LAW feed receipt capability is comprised of four WTP tanks (FRP-VSL-00002A, FRP-VSL-00002B, FRP-VSL-00002C, and FRP-VSL-00002D), each with a maximum operating volume of 375,000 gal.

[25] The WTP may request waste transfers less than the target volume based on the waste composition prior to transfer.

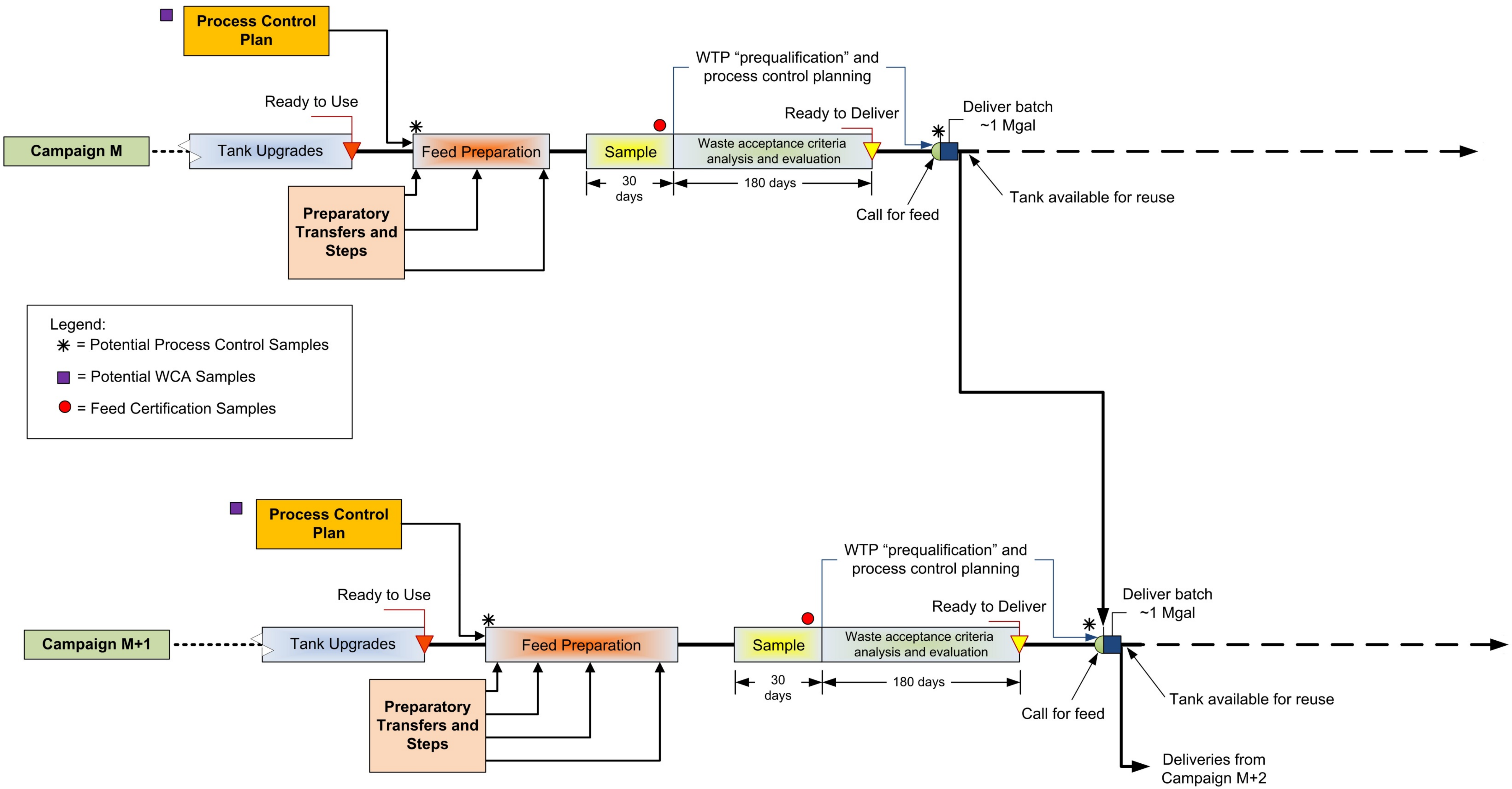

Figure 2-1. Feed Delivery Logic for Typical Low-Activity Waste Campaign

Once a LAW campaign to the WTP is complete, the transfer line will be flushed with additional inhibited water to clear it of any remaining waste. The received LAW may then be transferred by WTP to either the feed evaporator process (FEP)[26] or ultrafiltration process (UFP)[27] system, depending on the SpG and wt% solids in the waste[28] until the LAW feed receipt tanks transfer out enough waste to receive another nominal 1 Mgal, based on the combined volume of the four receipt tanks. This process is then repeated for each LAW campaign, with a goal of ensuring that the steps required for the next LAW campaign to be transferred are completed prior to WTP requesting the feed.

2.3 HIGH-LEVEL WASTE FEED DELIVERY

The WFD logic for a typical HLW campaign is illustrated in Figure 2-2.

A prerequisite to the preparation and delivery of waste feed is that the tank-specific upgrades and any associated transfer system and tank farm infrastructure upgrades have been completed (see IWFDP Volume 3 for details).

The general strategy for delivering HLW feed to the WTP is expected to proceed as follows: a tank operating as a HLW feed tank (see Section 4.5.1) is identified to receive staged waste, from one or more tanks operating as HLW feed staging tanks, for delivery to the HLW receipt tank in WTP. Waste compatibility and process control samples are taken prior to filling the HLW feed tank to generate a waste compatibility assessment and to assist in the development of the process control plan for the identified HLW feed tank. Additional process control samples may be taken during and after the process control plan is developed to identify if the plan has adequately addressed the process controls necessary for delivering the designated HLW feed.

After the feed is fully prepared, the HLW feed tank undergoes a prescribed hold time of 30 days for mixing and sampling, and an additional 180 days for waste characterization to confirm the feed meets the waste acceptance criteria. A pre-transfer flush[22] of inhibited water[23] precedes the designated waste transfer—this preheats the transfer line and helps prevent solids precipitation during the waste transfer. The HLW feed campaign is then transferred to WTP HLW feed receipt tank, HLP-VSL-00022, in multiple batches, targeting up to 120 kgal per batch received.[25]

The HLW feed tank is mixed prior to each HLW batch delivery to the WTP, and the transfer line will be flushed with inhibited water to clear it of any remaining waste following each HLW batch transfer. The received HLW feed may then be transferred by WTP to either the FEP[26] or UFP[27] system, depending on the SpG and wt% solids in the waste[28] until the HLW feed receipt tank transfers out enough waste to receive another 120 kgal. This process is then repeated for each HLW campaign, with a goal of ensuring that the steps required for the next campaign of HLW batches to be transferred are completed prior to WTP requesting the feed.

[26] The FEP system within the WTP consists of two evaporator trains (located at the front-end of pretreatment), one dedicated to concentrate recycle streams and the other dedicated for evaporation needs of delivered feed.

[27] The UFP system within the WTP consists of two ultrafilter trains, with a primary function to filter solids for delivery to HLW vitrification and route the solids-free stream to further pretreatment operations for eventual delivery to LAW vitrification.

[28] The operating scenario for System Plan (Rev. 6) bypasses the FEP, routing waste directly to the UFP, since the waste is being delivered at sodium and solids concentrations that do not require additional evaporation.

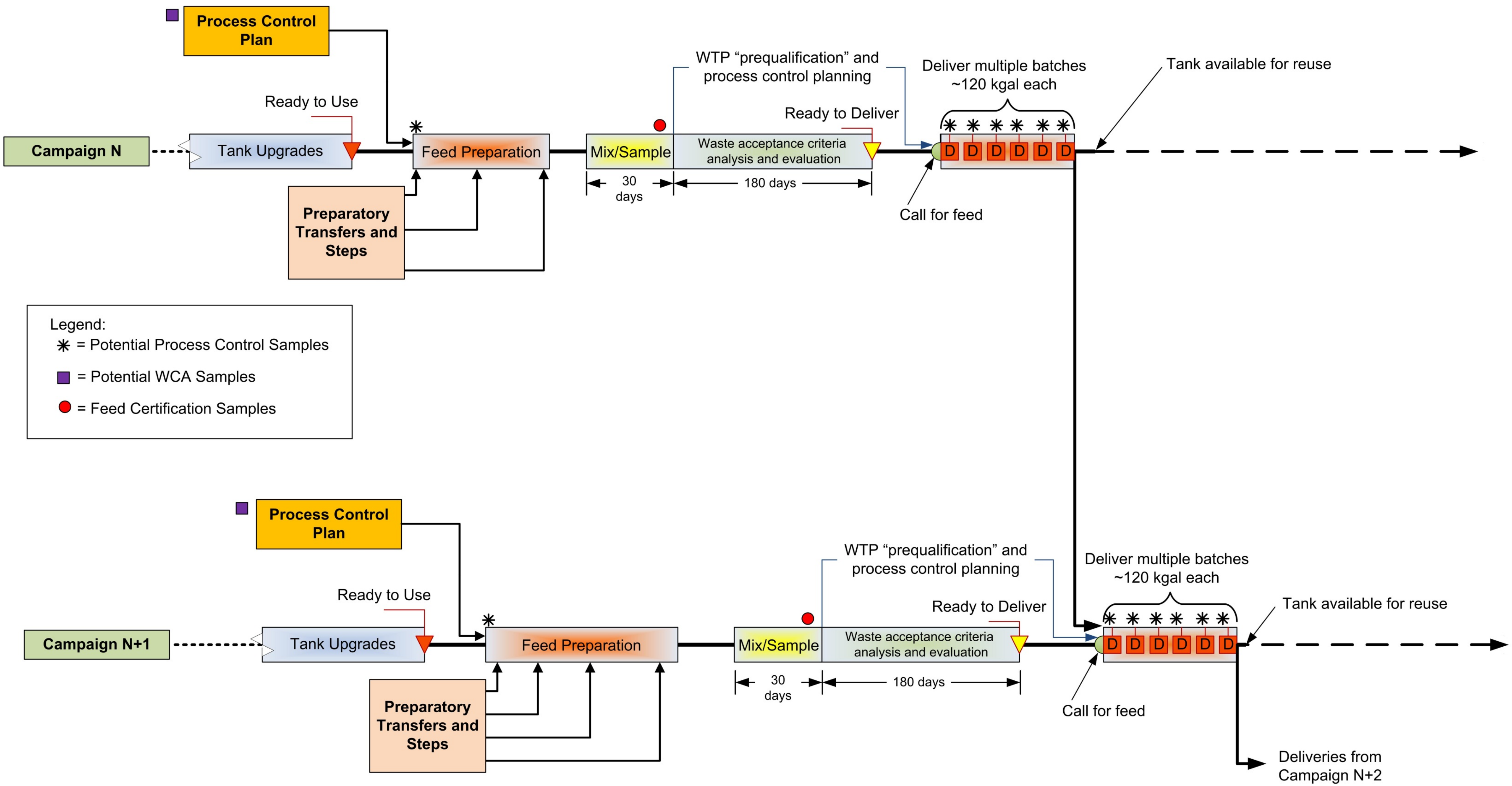

Figure 2-2. Feed Delivery Logic for Typical High-Level Waste Campaign

2.4 HIGH-LEVEL WASTE FEED BLENDING

The extent to which tank waste is blended may have a significant impact on the amount of immobilized high-level waste (IHLW) produced by the WTP. Waste blending is effective in reducing HLW glass mass when wastes with different glass drivers are combined.[29] The most effective blending occurs when tanks with different glass drivers are blended, and the resulting blend has a glass driver that was not limiting in any of the source tanks. The amount of resulting waste is reduced because the glass formers used not only meet the glass former requirements imposed by the new glass driver, but also meet the requirements of the constraint that was previously the glass driver of the source tanks. There are two hypothetical limits on the amount of IHLW that can be produced: the total-blend case and the no-blend case. The total-blend case represents the amount of IHLW that would be produced if all the tank waste is blended together to produce a uniform feed to the WTP. The no-blend case represents the amount of IHLW that would be produced if all the tank waste was segregated and treated separately. Therefore, the total-blend case represents the lower limit of IHLW that can be produced and the no-blend case represents the upper limit.[30] These two cases, however, are only theoretical blending scenarios that cannot be achieved under reasonable SST retrieval sequences.

The primary objectives for blending HLW feed are to (1) reduce the total amount of IHLW produced, by increasing the overall waste oxide loading (WOL), (2) reduce variability in both the feed delivered to the WTP and the glass ultimately produced, and (3) address problematic feed that exists in the tank farms. The desired outcome is to achieve as close to the total-blend case as may be reasonably accomplished.

Numerous studies have been conducted to determine the extent to which waste may be reasonably blended to decrease the amount of IHLW produced, the most recent of which is presented in RPP-RPT-49398, *High-Level Waste Blending in the Hanford Tank Waste Operations Simulator*.[31] The purpose of this study, completed in 2010, was to model several blending strategies in the HTWOS and evaluate their effectiveness in reducing the amount of IHLW produced at the WTP, and the ability of the blending strategies to decrease the mission operating schedule and reduce the variability of the HLW feed sent to the WTP. HLW blending strategies addressed in the study include incidental blending and three types of intentional blending: blind blending, metered blending, and smart blending.

Waste blending strategies for WFD consist of intentional blending for problematic waste, intentional blind blending, and incidental blending. Intentional blending for problematic waste includes the blending of high-zirconium waste in Tanks AW-103 and AW-105 (see Section 4.5.4) and blending of the high concentration of fissile ^{233}U in Tank C-104 (see Section 4.5.5). The basis and requirements for the blending of problematic waste is documented in HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*.

[29] Glass drivers are defined as the solubility, property, or validity constraints that require adding the most glass-forming chemicals; the active constraint that limits the waste oxide loading in the glass.

[30] For the System Plan (Rev. 6) Baseline Case, there are projected to be approximately 9,340 IHLW canisters using the total-blend calculation, compared to a projected 24,020 IHLW canisters produced using the no-blend calculation. These projections were calculated within the verified HTWOS model run (unique run identifier 4MinTimestep(6Melters)-mmr-11-031-6.5-8.3r1-2011-03-18-at-01-31-58) approved for use as the System Plan approved for use as the System Plan (Rev. 6) Baseline Case.

[31] RPP-RPT-49398 contains the sources of several previous studies investigating HLW blending.

Intentional blind blending occurs based on available space within the DSTs. Incidental blending is assumed to occur throughout the RPP mission as waste is blended with the heels of other tanks during retrieval, staging, and delivery of waste.

2.5 WASTE VOLUME MANAGEMENT

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 32.2 Mgal. The majority of that space is used for waste storage or as operability space for preparing WFD campaigns for transfer to WTP. 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 buoyant displacement gas release event (BDGRE) involving flammable gas (RPP-13033). The Authorization Agreement (29633-ESQ-AA-0001, *River Protection Project Authorization Agreement between the U.S. Department of Energy, Office of River Protection and Washington River Protection Solutions, LLC*) prohibits waste additions to existing Waste Group A tanks and prohibits the creation of new Waste Group A tanks, without prior approval from ORP.
- **DST emergency space**, in accordance with DOE M 435.1-1, *Radioactive Waste Management Manual*, represents 1.265 Mgal of available space that could be used to receive waste from another DST in the event that a DST would leak.[32]
- **WTP feed headspace** represents the unfilled space in a DST containing waste specifically identified for delivery to the WTP as waste feed.[33] Once the contents of these feed tanks have been sampled for WTP feed, they must be isolated from any transfers into the tank.

The primary strategy for managing DST storage space involves using the 242-A Evaporator. The primary mission of the 242-A Evaporator is to support tank farms waste storage by reducing dilute waste volume (see Section 4.4.6). Evaporator availability is essential to continue SST waste retrievals and to adjust the sodium levels to meet WTP feed requirements. Other strategies for DST space management include refining SST retrieval technology (e.g., modified sluicing, which uses DST supernate rather than water for mobilizing SST waste), intentionally creating deep sludge tanks by using modified BDGRE controls (see Section 4.5.3), and increasing the maximum liquid level limit of certain DSTs to hold more waste.[34]

Another technology under investigation for potential use in DST space management is the wiped-film evaporator (WFE). The WFE system is currently envisioned to be a modular, transportable unit that can be deployed to a location where evaporative capacity is required and is capable of redeployment when that mission has been completed. The WFE is in the development phase and is following RPP-PLAN-43339, *Wiped Film Evaporator Technology Maturation Plan* (TMP).

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[32] 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*).

[33] This information is drawn from ORP-11242 (Rev. 6).

[34] The basis for increasing the maximum limit of specific DSTs is documented in OSD-T-151-00007, Appendix A.

Washington River Protection Solutions, LLC (WRPS) conducted a WFE pilot-scale test program during fiscal year (FY) 2010, and demonstrated the technology at full-scale during FY 2011, under funding acquired through the *American Recovery and Reinvestment Act of 2009* (ARRA).[35]

Two primary functions the WFE may potentially serve are:

- Mitigating the risk of an extended, unplanned 242-A Evaporator outage by providing the needed volume reduction capacity
- Accelerating DST space recovery by providing additional evaporative capacity to supplement that which is available using the 242-A Evaporator.

The baseline operating scenario does not currently entail the use of the WFE; however, it is under consideration as a viable option to enhance DST space management and to mitigate a potential failure of the 242-A Evaporator.

In 2009, RPP-7702, *Tank Space Options Report*, was updated to reevaluate options from the previous revision and to include evaluations of new options for alleviating projected restrictions in mission execution due to DST storage space limitations. In 2010, the Tank Operations Contractor commissioned the Tank Space Decision Support Board to evaluate options that could mitigate the potential shortfall of DST tank space projected by System Plan (Rev. 4), including options previously recommended by RPP-7702. Their recommendations, documented in the RPP-RPT-45825, *Tank Space Alternatives Analysis Report*, include a number of short- and long-term options. Additional options, such as the use of sound[36] SSTs for staging waste or to provide emergency tank space, are also provided in the event that the primary options are less than adequate.

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[35] Results of the WFE pilot-scale testing program are documented in RPP-RPT-47442, *Pilot-Scale Wiped Film Evaporator Test Report*.

[36] 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.

2.6 WASTE COMPATIBILITY

Key controls that govern the use of the DSTs relating to waste transfers within the tank farms are described in HNF-SD-WM-OCD-015. These key controls are divided into six categories: (1) tank farms administrative controls,[37] (2) 242-A Evaporator administrative controls, (3) safety controls, (4) regulatory controls, (5) programmatic controls, and (6) operational controls.[38] Table 2-1 identifies the topics that fall within these categories and the control strategy used to address each topic.

The DSTs are also governed by controls for normal operations. Controls are in place to ensure that the waste stored or transferred between DSTs is within specified limits (e.g., tank corrosion limits, temperature limits, and liquid level limits). The controls, limits, and recovery actions for normal operations of the DSTs are presented in OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*. Corrosion controls of the DSTs are explicitly addressed within the operating scenario such that chemicals may be added to prevent DST tank corrosion during bulk SST retrieval operations.

HNF-SD-WM-OCD-015 also includes operational controls and evaluations to prevent line plugging, aluminum and phosphate precipitation, and gel formation during transfers.

Controls not addressed in the operating scenario may be addressed later in future operating scenarios through flowsheets and will be explicitly addressed in future waste compatibility assessments and future process control plans (as shown in Table 2-1). Other controls may need to be developed to account for potential WFD-specific waste feed issues, such as preventing the formation of non-leachable solids containing aluminum (e.g., cancrinite).

[37] The administrative controls specific to the tank farms are described in HNF-IP-1266, *Tank Farms Operations Administrative Controls*.

[38] The key controls governing the DSTs are identified in HNF-SD-WM-OCD-015.

Table 2-1. Planned Control Strategies for Waste Compatibility

Control Type	Parameter[a]	Control Strategy
Administrative (tank farms)	DST-induced gas release evaluation	Operating scenario, future flowsheets, PCP, WCA
	DST and SST time to LFL	
	Waste characteristics	
	Nuclear criticality safety	
Administrative (242-A Evaporator)	Source strength	Operating scenario, future flowsheets, PCP, WCA
	Nuclear criticality safety	
	Evaporator feed verification	
	Evaporator C-A-1 vessel time to LFL	
	Other evaporator feed requirements	
Regulatory	Waste analysis plan requirements	Future flowsheets, PCP, WCA
	PCB management	
	Tank waste retrieval work plan limits	
Programmatic (feed control list)[b]	Blend off high ^{233}U solids	Operating scenario, future WCA
	Protect hot commissioning feed	
	Segregate Envelope C	
	Segregate TRU sludge from complexed waste	
	Reduce WTP hydrogen generation rate by blending	
	Emergency pumping space	
	Segregate waste destined for TRU packaging	
Operational	Corrosion mitigation	Operating scenario, future flowsheets, PCP, WCA
	Tank bump	Future flowsheets, PCP, WCA
	Hydrostatic load	

[a] HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*, provides detailed descriptions of the parameters identified under each control type.
[b] HNF-SD-WM-OCD-015, Table A-1, identifies which tanks are affected by each issue and the controls that govern them.

DST = double-shell tank.
LFL = lower flammability limit.
PCB = polychlorinated biphenyl.
PCP = process control plan.
SST = single-shell tank.
TRU = transuranic.
WCA = waste compatibility assessment.
WTP = Waste Treatment and Immobilization Plant.

2.7 SINGLE-SHELL TANK RETRIEVAL SUPPORT

A pivotal role the DSTs play is receiving waste from the aging SSTs in preparation for WFD to the WTP for treatment and ultimate disposal. The DSTs also provide supernate recycle to sluice sludge from the SSTs during retrieval operations.

The technical guidance for SST retrieval planning is documented in the SST Waste Retrieval Plan (RPP-PLAN-40145). This plan provides the basis for SST waste retrieval planning, including the retrieval methods to be used for each tank and the criteria for determining the tank retrieval sequence. The information in this plan is used as input for two related documents used for SST retrieval planning: SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3D.xlsx'," and RPP-40545, *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*. Spreadsheet SVF-1647 is used to calculate waste retrieval volumes and durations using RPP-PLAN-40145 and RPP-40545 for input to the calculations. RPP-40545 provides the technical assumptions, including the basis for those assumptions, used for estimating waste retrieval volumes and durations.

The assumptions for the operating scenario reflect the SST retrieval plan, planning assumptions for the SSTs, and near-term SST operation planning. The operating scenario, in turn, provides the long-term SST retrieval sequence and operations based on the HTWOS model output.

2.8 SPECIAL TOPICS

The purpose of this section is to consolidate and discuss special or cross-cutting topics that relate to the WFD process.

2.8.1 Solid-Liquid Partitioning

Current waste phase equilibriums and reaction extents are approximated for most constituents by limited experimental data and simple split factors from the best-basis inventory (BBI). These water wash and caustic leach factors are zero-order approximations representing complex solid-liquid equilibria, and do not incorporate waste conditions. Furthermore, they are unidirectional, accounting for the dissolution of waste components, but not their precipitation. Prevention of precipitation of large quantities of solids is approximated by limiting the maximum specific gravity of the 242-A Evaporator product. Simple correlations, depending on limited variables (e.g., temperature and ionic strength), have been added to the WTP pretreatment portion of the HTWOS model for select aluminum, phosphate, oxalate, and strontium components. Near-term improvements are planned to incorporate more simple solubility correlations and thermodynamic models for the components that have a high impact on the mission.

Work is currently underway to replace the water wash and caustic leach factors with more sophisticated solubility correlations and to improve on the existing correlations. Simple solubility models will be incorporated into the HTWOS to replace wash and leach factors for several components. The thermodynamic-based Pitzer[39] ion-interaction model is under development for those waste constituents that have intermediate solubility and high impact to the mission.

[39] The original Pitzer model (first documented in Pitzer 1973) has undergone countless revisions, additions, interpretations, and applications since its inception. The current basis for the ongoing solubility work is found in SAND2009-3115, *Implementation of Equilibrium Aqueous Speciation and Solubility (EQ3 type) Calculations into Cantera for Electrolyte Solutions*.

This solubility model offers a more accurate representation of the system than simple water wash and leach factors due to its basis on published thermodynamic data and accounting for many aspects of waste conditions (e.g., temperature and the interactions between specific ions).

2.8.2 Flammable Gas Controls

Waste generates hydrogen by radiolysis of water and organic compounds, decomposition of organic compounds by thermolysis, and corrosion of the carbon-steel tank walls. Other flammable and nonflammable gases are also formed. Some gas is released to the tank headspace over time; however, certain tanks have shown large episodic gas releases in the past. Active ventilation systems can effectively manage gradual flammable gas release to the tank headspace. A sudden increase in the flammable gas concentration in the tank headspace and associated equipment, piping, and ductwork spaces may be more difficult to manage, and may result in the tank headspace temporarily exceeding the lower flammability limit (LFL).

Tanks that have historically displayed episodic gas releases contain saltcake solids wastes. These tanks are designated as Waste Group A tanks (see Section 2.8.3) (RPP-10006, *Methodology and Calculations for the Assignment of Waste Groups for the Large Underground Waste Storage Tanks at the Hanford Site*). Studies conducted in the 1990s revealed that gas would accumulate in the settled salt layer until the bulk density of the settled solids became lower than the supernate liquid, causing a localized portion of waste, or gob, to become buoyant. When the waste gob rises through the supernate, the retained gas expands as the hydrostatic head pressure decreases. Significant expansion breaks apart the waste gob, resulting in a gas release event. The resultant gas release caused by this instability is a BDGRE (RPP-7771, *Flammable Gas Safety Issue Resolution*). Criteria have been established to prevent new tanks from potentially being at risk to BDGREs (RPP-PLAN-30112, *Plan to Resolve Technical Issues Associated with Sludge Accumulation in Double-Shell Tanks*, and RPP-10006). Specific BDGRE controls are currently based on low shear-strength salt slurries because BDGREs in high shear-strength sludge wastes have not been observed.

Current flammable gas control strategies for Waste Group A tanks include a TSR control requiring that ignition controls be applied at all times in the tank headspace and in connected enclosed spaces directly above the Waste Group A tanks (HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*). In addition, the Authorization Agreement prohibits any waste additions to Waste Group A tanks or the creation of new Waste Group A tanks without prior approval from ORP (29633-ESQ-AA-0001). The 242-A Evaporator operates to a maximum specific gravity of 1.43, which serves as a proxy limit to avoid precipitation of large quantities of solids. These controls reduce the potential for a flammable gas deflagration from a spontaneous BDGRE.

The current BDGRE controls may be overly conservative for sludge wastes, further restricting potential DST storage space. Updated criteria for predicting BDGRE behavior in tanks containing high shear-strength sludge waste have been identified in RPP-RPT-26836, *Gas Retention and Release from Hanford Site High Shear Strength Waste*, and have been implemented in the baseline operating scenario. The new criteria presented are based on an updated model of gas release in sludge sediment wastes, which suggests that gas is slowly released over time through cracks and channels in the sludge. The cracks and channels allow gas bubbles to travel to the surface of the waste, resulting in a slow release over time as opposed to large BDGREs.

A technical basis for updated BDGRE controls (RPP-PLAN-44573, *Project Plan for Implementing New Buoyant Displacement Gas Release Event Criteria*) may be used to establish new DST fill limits to use more available DST space and potentially accelerate SST retrievals.

New BDGRE controls require process testing to confirm that DST sludge wastes behave similarly to the updated sludge sediment gas release model. The new BDGRE model will need to become part of the tank farms safety basis. However, model implementation requires showing that Hanford Site sludge waste maintains low gas fractions as the settled solids depth is increased. In-situ waste measurements, for shear strength with a modified cone penetrometer, density, and water content, and process tests will be needed to validate the sludge sediment gas release model. A key uncertainty exists because the in-situ waste measurements will require creation of deep sludge tanks (see Section 4.5.3). Additionally, the results of any waste measurements and process testing will be tank-specific, and variances will likely exist between deep sludge tank properties from tank to tank, and between the assumptions used in this plan.

Future sludge-specific controls may be based on updated BDGRE criteria. The System Plan (Rev. 6) uses an enabling assumption that the depth of settled sludge accumulated in any DST will be maintained at less than 250 in. This assumes implementation of the updated BDGRE controls such that the new sludge-specific controls may be relaxed from the current controls approved for use in the DSA. Unpublished calculations suggest that the allowable sludge depth, under the new controls, is expected to range between 160 in. and 400 in., dependent on the physical properties of the settled sludge. These increased sludge depths would potentially allow for a greater utilization of DST space, while a decrease would further restrict DST space and impact SST retrieval and WFD operations.

Phosphate may also impact flammable gas controls. A tank containing phosphate gel may retain flammable gases, potentially resulting in a gas release event occurring under a different mechanism than a BDGRE (RPP-23584, *Safety Evaluation of Waste Gel in the Tank Farms*). The tank farms DSA indicates that there is uncertainty concerning flammable gas retention and release behavior in a waste gel layer and therefore a control is required to prevent waste gel formation in the tank farms (RPP-13033). The current control relies on the Waste Compatibility Program and process flowsheets to prevent phosphate gel formations due to waste transfers or chemical additions (HNF-SD-WM-OCD-015). The proposed transfers in the current operating scenario have not screened for potential phosphate gel formation; however, screening waste for this condition may be added in future operating scenarios to evaluate the likelihood of forming phosphate gels in the waste. In any case, HNF-SD-WM-OCD-015 also includes operational controls and evaluations to prevent line plugging, aluminum and phosphate precipitation, and gel formation during transfers.

2.8.3 Waste Group A Tank Mitigation

RPP-10006 outlines the methodology for categorizing waste storage tanks into waste groups. The waste group assignments reflect the propensity of a tank to retain a significant volume of flammable gases and the potential for the waste to release retained gas by a BDGRE.

Waste Group A tanks are tanks with a potential spontaneous BDGRE flammable gas hazard in addition to a potential induced gas release event (GRE) flammable gas hazard. These tanks are conservatively estimated to achieve a flammable gas concentration of 100 percent of the LFL in the tank headspace, if all of the retained gas is released from a spontaneous BDGRE.

There are five tanks that have been identified as Waste Group A tanks: AN-103, AN-104, AN-105, AW-101, and SY-103. These tanks are restricted from having waste transferred into or out of them until they are mitigated and reclassified as Waste Group B or C tanks.

The strategy for the mitigation of Waste Group A tanks is based on assumptions and analysis presented in HNF-4347, *Alternatives Generation and Analysis for Low Activity Waste Retrieval Strategy – DRAFT*. RPP-8218, *Generalized Feed Delivery Descriptions and Tank Specific Flowsheets*, further refines the general strategy and establishes preliminary flowsheets for mitigation of these tanks. The goal of mitigation is to remove supernate above the saltcake and then dissolve the saltcake. The first step involves installing transfer pumps in the tank in order to remove as much supernate as possible. Removal of the supernate will likely induce a GRE as the hydrostatic head above the solids is reduced. Once the supernate is removed, mixer pumps are installed and the tank topped off with water to dissolve the soluble solids. The dissolved solids are then pumped out, and the tank can be reclassified as a Waste Group B or C tank.

The development of this strategy has not progressed beyond conceptual design. Before the mitigation activities can take place, more advanced design and planning must be completed. The DSA will also need to be updated to reflect the planned mitigation activities.

The enabling assumptions for the mitigation process are those described in HNF-4347, with the exception that equipment installation takes place upfront, and not between mitigation steps. This is a limitation since the design is solely conceptual. The assumptions will be refined as more detailed design and planning is completed.

2.8.4 Tank C-104 Blending

Tank C-104 sludge contains a relatively high concentration of fissile ^{233}U, which must be "diluted" prior to transfer to the WTP. The WTP requirement is that the ratio of fissile uranium to total uranium be less than 8.4 g/kg. The strategy to meet the WTP requirement is to blend the sludge retrieved from Tank C-104 to AN-101, with portions of sludge to be retrieved from Tanks C-111, C-112, C-101, and C-105. RPP-RPT-43828, *Enhanced Use of AN Farm for C Farm Single-Shell Tank Retrieval*, describes the current strategy to blend off the high concentration of fissile ^{233}U waste in Tank C-104.

Since Tank AN-101 will contain nearly 230 in. of settled solids after retrieval of Tanks C-104, C-112, C-101, C-111, and C-105, adequate blending is not expected to occur within the tank. Because of the assumption that mixer pumps can mobilize and mix up to a nominal 70 in. of settled solids layer (see Appendix B, Section B2.1), a new blending strategy was developed in which two DSTs function as HLW tanks used for mixing and blending Tank C-104 waste.

To achieve adequate blending after the above-mentioned C Farm tanks are retrieved to Tank AN-101, the top 100 in. of retrieved waste will need to be transferred to another DST for staged feed to the WTP. This will allow the remaining 130 in. of HLW to be mixed to mitigate the fissile uranium issue with Tank C-104 waste.

With roughly 100 in. of waste transferred out of Tank AN-101, there will be approximately 130 in. of waste left; 50 in. of C Farm low-fissile stock and 90 in. of Tank C-104 stock. Two designated DSTs, DST-A and DST-B, will need to be used to adequately blend the Tank C-104 material. Current plans designate that the first 100 in. of Tank AN-101 waste are transferred into DST-A.

The 50 in. of low-fissile C Farm waste will need to be transferred to DST-A, and half of the Tank C-104 waste will need to be transferred to DST-B. This will leave Tank AN-101 and DST-B each containing approximately 46 in. of Tank C-104 waste. The 50 in. of low-fissile waste in DST-A will then be transferred back to Tank AN-101 and DST-B, split equally between the two tanks. Therefore, both DSTs containing Tank C-104 waste will have sufficient, low-fissile blending stock to mitigate the fissile uranium issue. This blending scenario is outlined in Section 8.0 of RPP-CALC-45086, *Preliminary Uranium and Plutonium Criticality Assessment for the Enhanced Use of AN Farm for C Farm Retrieval*.

A uranium blending analysis was conducted on this blending strategy (SVF-1802, "SVF-1802Rev2.xlsm.xlsm"). The analysis shows that as long as Tank C-104 waste is divided in half and blended with any of the four tanks (C-112, C-111, C-101, and C-105) up to 70 in., as described in the blending strategy, it will result in a ratio of fissile uranium to total uranium of 8.15 g/kg or less. This gives operational flexibility to change the retrieval order of Tanks C-101, C-105, C-111, and C-112 into Tank AN-101.

There are limitations on the ability to accurately transfer waste layers as described in this strategy, and improvements will be made as more solid waste handling experience is achieved.

2.8.5 Tanks AZ-101 and C-102 Blending

The waste stored in Tank AZ-101 currently contains high levels, relative to other Hanford tank waste, of both insoluble ^{90}Sr and soluble ^{137}Cs, which could result in exceeding the hydrogen generation rate (HGR) limit in the WTP process vessels. The current strategy to mitigate this risk involves waste blending to reduce the radionuclide concentration, thereby reducing the HGR.

RPP-25856, *Blending of Tank 241-AZ-101 Solids*, describes the current strategy to blend the high-heat[40] Tank AZ-101 waste with Tank C-102. Tank C-102 has a large volume of solid waste with low levels of the components that lead to high HGR, which makes it a good candidate for blending. Analysis in RPP-25856 indicates that the blended Tank AZ-101 and C-102 waste results in a projected HGR that is well within the limits.

This constraint on waste handling is specified in the feed control list in Table A-1 of HNF-SD-WM-OCD-015. The feed control list indicates ORP has given direction to proceed with the Tank C-102/AZ-101 blending strategy.

2.8.6 Complexed Concentrate Strontium/Transuranic Precipitation

The complexed concentrate wastes stored in Tanks AN-102 and AN-107 contain soluble ^{90}Sr and TRU elements that will require removal from the liquid phase prior to vitrification to comply with the WTP immobilized low-activity waste (ILAW) feed specification and with the 1997 agreement with the U.S. Nuclear Regulatory Commission (NRC) on incidental waste (Paperiello 1997). The strategy for removal of the ^{90}Sr and TRU elements from the supernate is completed by transferring the supernates into another DST, adjusting the sodium concentration, and precipitating the ^{90}Sr and TRU elements using strontium nitrate and sodium permanganate, respectively. Controls must be developed and established for the handling of the treated supernate and precipitated solids to ensure that the ^{90}Sr and TRU elements do not become significantly resolvated prior to delivery to the WTP.

[40] High-heat refers to the radioactive decay heat in the described waste.

2.8.7 Waste Temperature Control

Numerous operating limits related to tank temperature are identified in OSD-T-151-00007. The operating specifications identify both maximum bulk temperature limits and bulk temperature change over time for waste, concrete, and steel. The temperature limits are in place to prevent excessive stress to the tank structure and extreme temperature gradients that may cause concrete deterioration and cracking.

WTP waste acceptance criteria requirements include both LAW and HLW feed delivery temperature limits that must be met in the feed tank prior to delivery to WTP. HLW feed deliveries are required to be at a temperature less than 150°F. LAW feed deliveries are required to be at a temperature less than 120°F (Section 4.1, Table 4-1). 24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria*, also establishes a waste feed temperature change range of plus or minus 20°C, which requires observing any temperature changes from mixing 10 mL of staged feed with 10 mL of residual waste from WTP feed receipt tanks to verify that no waste compatibility issues will arise from transferring the waste batch into the residual waste heel of the receiver tank.

A waste temperature control strategy will need to be developed, depending on the temperature response of the waste due to a series of WFD operations. There are three potential scenarios for waste temperature control.

1. If WFD operations have a marginal effect on the overall waste temperature, the strategy may be to monitor the temperature for feed delivery to ensure that the WTP waste acceptance criteria temperature limits are met.
2. If WFD operations result in tank temperatures that are near the WTP waste acceptance criteria temperature limits, the strategy may be to increase ventilation system air-flow rates, start with or add supernate with a lower temperature than the waste, or limit mixer pump operation.
3. If WFD operations result in tank temperatures that exceed the WTP waste acceptance criteria temperature limits, the strategy may be to identify and implement new engineering controls to ensure that the waste temperature is maintained below the WTP waste acceptance criteria for feed delivery.

Historic and current tank waste temperatures range between 50°F and 120°F annually, with a few tank wastes (AY and AZ Farms) reaching approximately 180°F.[41] In general, there are multiple heat inputs and outputs in the tank farms.

Tank heat inputs include:

- Radioactive decay heat
- Shaft work and motor losses due to mixer pump operations
- Ventilation air when ambient air exceeds tank waste temperature.

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[41] The PC surveillance analysis computer system (PC SACS), queried July 15, 2011, for SY, AN, AP, AW, AY, and AZ Farms primary reported values, approximate maximum and minimum temperatures for each tank from January 1, 2001 to January 1, 2011, HLAN Server APSACSPROD.

Tank heat outputs include:

- Evaporative and convective cooling at the waste surface
- Conduction through primary tank walls
- Convection between the tank wall and annular space air
- Conduction through refractory concrete
- Cooling channels in refractory concrete
- Natural convection of supernate
- Conduction through solids to supernate, the tank walls, and the tank bottom.

A key issue exists because the temperature response of the waste due to a series of WFD operations is unknown. The required run time and power of the mixer pump during WFD operations is also unknown. It is, therefore, uncertain if periods of cooling, during which no mixing operations occur, will sufficiently offset periods of heating, due to mixer pump operations, to maintain waste temperatures below both tank operating specifications and WTP feed delivery limits. The required run time and associated power of the mixer pump will likely have a significant impact on the tank waste temperature.

A mixer pump test was completed in Tank AZ-101 in 2001 (RPP-6548, *Test Report, 241-AZ-101 Mixer Pump Test*). The test was based on two 300-hp mixer pumps installed in Tank AZ-101. The tank waste temperature was observed to increase approximately 3.4°F to 4.5°F per day. However, the results indicate that during mixer pump operations, tank and concrete temperatures remained within the operating specifications outlined in OSD-T-151-00007. No additional full-scale, in-tank mixer pump tests have been conducted since the Tank AZ-101 test.

Thermal-hydraulic ventilation system evaluations have been completed for the following:

- AP Farm – RPP-45912, *Thermal-Hydraulic Evaluation for 241-AP Tank Farm Primary Ventilation System*
- SY Farm – RPP-43971, *Thermal Hydraulic Evaluation for 241-SY Tank Farm Primary Ventilation System*
- AW Farm – RPP-11731, *Thermal Hydraulic Evaluation for 241-AW Tank Farm Primary Ventilation System*
- AN Farm – RPP-7171, *Thermal Hydraulic Evaluation for 241-AN Tank Farm Primary Ventilation System.*

These evaluations used the GOTH-SNF[42] computer model software to assess ventilation system performance for future normal and waste retrieval operations. Each tank farm assessment concluded that the ventilation systems are adequate to maintain tank waste temperature below 195°F. AY/AZ Farm ventilation upgrades are currently in the design phase. It is important to note the differences in the mixer pump assumptions used in the AP, SY, AW, and AN Farm tank thermal hydraulic evaluations. The AP Farm evaluation assumed two 300-hp mixer pumps were installed in one AP Farm DST, and one 300-hp mixer pump was installed in a second AP Farm DST. The SY Farm evaluation assumed two 300-hp mixer pumps were installed in two SY Farm DSTs, for a total of four 300-hp mixer pumps operating at one time.

[42] GOTH-SNF is a registered trademark of John Marvin, Inc., West Richland, Washington.

The AW and AN Farms were evaluated based on two 300-hp mixer pumps installed into the tanks. Waste heat input due to mixer pump motor losses was included as part of the 300-hp total power. The current strategy, however, is to use two 400-hp mixer pumps. The increased horsepower may result in an increase in tank temperatures during operations beyond that modeled under the 300-hp pump scenarios.

The AP, SY, AW, and AN Farm thermal-hydraulic evaluations completed are based on normal retrieval operations with a DST full of waste. The rate of waste temperature increase in the HLW feed tank due to mixer pump operation will likely increase as waste is transferred out of the tank. Additional thermal-hydraulic analyses should be performed to evaluate the temperature increase when the tank is at the reduced levels expected during HLW feed batch transfers.

Tank AY-102 waste temperatures during mixer pump operations have also been predicted using the GOTH-SNF model (RPP-RPT-49492, *702 AZ Thermal Hydraulic Evaluation Benchmark and Flammable Gas Analysis*). The model is based on Tank AY-102 waste only, and assumes two 300-hp mixer pumps are operated in the tank, with radiolytic decay heat omitted. Tank waste temperatures are predicted to rise above 150°F shortly after the initial 10-day mix and sample period. The waste temperature is then predicted to slowly decrease during the 180-day sample characterization time period. At the time of the first waste transfer to WTP, the HLW feed temperature is predicted to be below the 150°F waste acceptance criteria limit. However, these results are based on computer simulation only, and no actual tests have been completed to determine the extent of temperature response of the waste due to mixer pump operations. Tests have also not been conducted to determine temperature response during batch transfers.

A thermal-hydraulic ventilation system evaluation was also recently completed for AY and AZ Farms (RPP-49579, *Thermal Hydraulic Evaluation for 241-AY and 241-AZ Tank Farm Primary Ventilation System*). The evaluation concluded that some tanks may have to be pre-cooled prior to operating the mixer pumps to lower their initial temperature so that the mixed supernate temperature will not exceed the waste feed temperature criterion for HLW feed of 150°F. The length of time required for pre-cooling will depend on the mixed supernate temperature of the tank prior to the mixer pump operation, decay heat load, and vapor suppression. Pre-cooling tank waste should be further evaluated as a potential mitigation strategy for wastes that may exceed the WTP feed temperature criterion.

2.8.8 Mixing and Sampling Demonstration Program

The historical TOC approach to feed certification includes mixing waste in a DST using slurry mixer pumps, turning off the mixer pumps, and then performing grab-and-core sampling for sludge and supernate feed waste acceptance analysis. This approach is not sufficient to achieve the required waste acceptance confidence for HLW slurry, as defined in 24590-WTP-RPT-MGT-11-014. A 2009 value engineering workshop identified an alternate sampling approach that collects the HLW slurry sample directly from the transfer pump discharge while the mixer pumps are operating. Additional work is required to determine the capability of the tank farms to sample and characterize the feed to meet the WTP confidence requirements for feed qualification.

Currently, a remote sampler concept is being demonstrated that eliminates the need for multiple core sampling events by collecting a slurry sample from a recirculation loop driven directly from the tank transfer pump. If proven effective, this sampling concept being demonstrated in the remote sampler demonstration (RPP-PLAN-49858, *WRPS Remote Sampler Demonstration Project Phase 1 Test Plan*) will replace the historic baseline concept of taking multiple core samples.

The purpose of the small-scale mixing and sampling demonstration program (RPP-PLAN-41807, *Waste Feed Delivery Small Scale Mixing and Sampling Demonstration Plan*) is to define the mixing, sampling, and batch transfer capabilities of the DST systems. As these testing and demonstration activities are completed over the next several years, gap analyses will be performed against the evolving requirements, and actions will be identified to close the gaps. The risk is that the requirements are not determined in time to assess the impact and recover from the scenario where enhanced mixing and sampling capability is required.

The challenges of the mixing and sampling program include:

- The ability to obtain representative samples to satisfy the DQOs for meeting the WTP waste acceptance criteria action limits within the confidence requirements for safety and mission success (e.g., criticality safety limits, H_2 generation rate, bulk density, viscosity, etc.)
- The ability to achieve sufficient mixing in a DST to limit variability between feed batches and permit representative sampling.

Specifically, the uncertainty in tank waste mixing is the ability of the DST mixer pump system to adequately suspend and distribute the HLW solid particles within a million-gallon tank. Solids should be distributed such that they can be representatively sampled. The WTP design basis assumes a staged HLW feed tank is homogenously mixed and delivered in consistent feed delivery batches of 120 kgal.[43] Consistent, as used here, is intended to mean that the first 120 kgal batch has the same solids composition as the last 120 kgal batch. An evaluation of full-scale mixer pump testing, completed in 2009, concluded that the DSTs are not homogenously mixed, and therefore each 120 kgal batch transferred to the WTP will likely contain differing amounts and types of HLW solids (PNNL-18327, *Estimate of the Distribution of Solids Within Mixed Hanford Double-Shell Tank AZ-101: Implications for AY-102*). Small-scale mixing demonstrations completed in 2010 (RPP-47557, *SSMD Test Platform, Small Scale Mixing Demonstration Initial Results Report*) confirmed this non-homogeneous mixing behavior, but also identified observable and predictable trends in solids distribution.

The Defense Nuclear Facilities Safety Board (DNFSB) issued Recommendation 2010-2, "Pulse Jet Mixing at the Waste Treatment and Immobilization Plant," (Winokur 2010) to develop greater knowledge in several areas related to mixing that address safety issues in WTP feed receipt vessels. In November 2011, DOE provided an implementation plan in response to the DNFSB recommendation (Chu 2011). The impacts of this plan on WFD and the mixing and sampling demonstration program need to be evaluated.

Additionally, there is uncertainty because some of the WTP feed acceptance requirements are based on physical and transport properties (e.g., particle hardness, densities, and critical velocity) that are not easily measured in an analytical laboratory. The Remote Sampler Demonstration Program will also be demonstrating a pulse-echo ultrasound device that has the ability to directly measure critical velocity in the recirculation loop previously described.

[43] 120 kgal, before line flushes, is based on the WTP equipment alternative (24590-WTP-MRR-PET-10-001, *WTP Mission Assessment of the Design and Operating Changes Expected to Resolve PJM Mixing in PT Vessels*), which reduced the maximum delivered batch volume based on the minimum heel and set volume for the WTP HLW feed receipt tank.

The mixing and sampling objectives to resolve the above identified uncertainties are as follows:

- Demonstrate tank mixing, sampling, and batch transfer using scaled prototypical vessels
- Define scaled test approaches to apply test results at full scale
- Provide sampling and performance data to optimize WTP and TOC requirements; this will support updating the WTP waste acceptance criteria and DQOs
- Provide necessary information to define and test the sampling system for the certification loop
- Develop criteria for recirculation loop instrumentation and configuration requirements
- Define instrumentation required for Tank AY-102 full-scale demonstration application, which will provide confidence in the instrumentation selected for use at full scale to confirm mixing performance is equivalent to small-scale application.

Mixing and sampling tests have been accelerated using ARRA funding to determine if representative samples can be obtained from a DST to meet the required confidence levels anticipated to be in the WTP waste acceptance criteria. Initial test results are needed so that a recommendation can be made to ORP on whether a need exists for enhanced mixing and sampling capabilities. Initial small-scale mixing demonstration sampling and batch transfer results, conducted using simulant representative of the contents in Tank AY-102, indicate that representatively bounding samples can be obtained with the baseline DST mixing systems and the proposed remote sampler system connected to a recirculation loop driven by the DST transfer pump (RPP-49740, *Small Scale Mixing Demonstration Sampling and Batch Transfer Initial Results Report*). "Representatively bounding" is defined as sampling the most difficult (e.g., fastest settling) particles in a manner that bounds the highest concentrations of those particles transferred in the multiple feed batches from Tank AY-102. These results have led to the conclusion that there is no driver for developing a dedicated mixing and sampling facility (RPP-50557, *Tank Waste Mixing and Sampling Update*).

Small-scale mixing demonstration testing is scheduled to continue through FY 2013 and will focus on closing remaining uncertainties and optimizing feed sampling performance. Future work for this program includes expanding the types of waste tested and analyzed to obtain a better confidence level of mixing and sampling that is representative of various Hanford tank waste compositions.

2.8.9 Waste Feed Interface Control Document, Data Quality Objectives, and Waste Acceptance Criteria

The Tank Operations Contractor has the responsibility to deliver feed to the WTP in accordance with the WTP waste acceptance criteria, which establish requirements that must be met for feed to be delivered to the WTP PT Facility for treatment. These requirements are defined in ICD-19 and further refined by the waste acceptance criteria DQO document (24590-WTP-RPT-MGT-11-014). The waste acceptance criteria DQO groups the waste acceptance criteria into two sets called "action limits" and "additional data." The action limits are those waste acceptance criteria that must be met for safe and compliant transfer of feed to the WTP. The additional data are those waste acceptance criteria required for processability purposes and do not affect the acceptance of the feed.

The DQO process is iterative—it is anticipated that waste acceptance criteria may be deleted, revised, or added as additional data and knowledge are obtained. A final set of waste acceptance criteria (especially, the action limits) must be developed, documented, and promulgated. The basis of each waste acceptance criterion should be reevaluated to ensure that it is necessary and sufficient to establish waste acceptance.

In addition to the requirements defined in ICD-19 and refined in the waste acceptance criteria DQO, the WTP Contract (DE-AC27-01RV14136) requires that the feed to be transferred to WTP meets the requirements in Specification 7 and Specification 8. However, the waste acceptance criteria DQO identifies some, but not all, of the requirements from Specifications 7 and 8, as action limits. The relationship and content of ICD-19, the waste acceptance DQO, and Specifications 7 and 8 in the WTP Contract should be reviewed for consistency and intent.

At present, significant efforts remain to finalize the WTP acceptance requirements and confirm the ability of the tank farms to mix and sample tank waste to meet these feed delivery requirements. For example, emerging concerns (DNFSB 2010-2 [Winokur 2010]) related to the potential accumulation of large, dense, particles in WTP vessels pose criticality, flammable gas, or pulsed jet mixer issues that could result in additional waste acceptance criteria.

The primary WTP waste acceptance criteria vulnerability is that the Tank Operations Contractor may not be able to demonstrate with necessary confidence that the feed in the tank farms meets the WTP waste feed waste acceptance criteria with the necessary degree of confidence as dictated by the waste acceptance criteria DQO (24590-WTP-RPT-MGT-11-014). ICD-19 is intended to document agreement on WTP waste feed requirements; however, agreement has not yet been reached between the TOC and WTP contractors. It is assumed that when the waste acceptance criteria is finalized through the processes established in the WTP Interface Management Plan[44] (24590-WTP-PL-MG-01-001), qualitative and quantitative constraints will be established for WTP waste feed acceptance that have been agreed on by ORP, the WTP contractor (BNI), and Tank Operations Contractor (WRPS). Until the waste acceptance criteria is in its final form and accepted by ORP, BNI, and WRPS, there will be uncertainties regarding what steps must be taken by WRPS to ensure that the feed is acceptable for receipt and processing by the WTP. Significant efforts remain to establish the WTP feed acceptance requirements, including progressing the WTP design to a point where unverified assumptions can be closed, completing the WTP large-scale integrated testing program and understanding the impact on waste acceptance limitations, completing the WTP integrated safety management hazards assessments and resulting DSA controls, and ultimately determining the WTP feed qualification sampling and analysis performance requirements.

[44] The Interface Management Plan "governs the definition, development, management, issue resolution, approval, and documentation of external interfaces between the WTP and the WTP Interface Partners." The plan establishes three distinct levels of WTP interface control document (ICD) management: ICD review teams (ICDRT), interface owner groups (IOG), and a governance group (GG). Each ICD has its own ICDRT that is responsible for the technical and administrative accuracy of the interface. The IOG for ICD-19 is the Waste Feed Interface Owners Group, which is responsible for evaluating issues and initiating "any necessary contract baseline changes needed to drive the issue to resolution." The GG receives "input from the IOGs and makes site-wide project management decisions…" and GG members are responsible "to negotiate funding matters when ICD issues require a change to their organization baseline."

The System Plan (Rev. 6) Baseline Case operating scenario and the IWFDP are based on ICD-19 (Rev. 4), which was issued on April 15, 2008. Revision 5 was issued on August 10, 2011.[45] Revision 6 is intended to address the remaining gaps. The DQO process has identified a number of issues with some of the feed requirements in ICD-19 (Rev. 4) and 24590-WTP-RTP-MGT-11-014. An abbreviated summary of open items includes:

- Defining the technical basis for the critical velocity requirement as it relates to WTP mixing performance
- Establishing a basis for the sampling confidence requirements to meet WTP waste acceptance criteria
- Reviewing the 95 percent confidence level for criticality and 90 percent confidence level for other parameters, which could result in very large numbers of samples being required
- Developing TOC sampling design and mixing protocols for both HLW feed and LAW feed that will meet waste acceptance criteria requirements without excessive TOC sampling and analysis requirements
- Establishing measurement sensitivity requirements for the HGR
- Determining the measurement definition, liquid or vapor, for ammonia/ammonium ion concentration in LAW feed
- Establishing protocols to ensure that LAW suspended solids requirements are met
- Establishing an acceptable deminimis level for a separable organic layer in staged feed
- Quantifying acceptable measurement uncertainty for in-line critical velocity measurement instrumentation
- Reevaluating and agreeing on the sampling size requirements and action limit for the $U_{fissile}$-to-U_{total} ratio
- Reviewing potentially unnecessary specifications on constituents in feed, such as sulfate and aluminum concentrations in waste envelope specifications.[46]

The strategy necessary to provide waste feed that meets the WTP waste acceptance criteria will be finalized once the criteria are finalized. The potential impacts include:

- A very large number of samples being required to demonstrate that waste acceptance criteria requirements are met at currently specified confidence levels
- Insufficient laboratory capacity for the timely completion of sample analysis to support the waste treatment schedule

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[45] ICD-19 (Rev. 5) was released during the final preparation of this IWFDP and after the development of the Baseline Case operating scenario for the System Plan (Rev. 6), and therefore, is not evaluated in this revision of the document. Future revisions of the IWFDP will evaluate and incorporate the requirements from the most recent available revision of ICD-19 that is approved for use in the System Plan.

[46] In addition to drivers specific to the WTP PT Facility, recent LAW and HLW glass formulation work should be considered during this review.

- New mixing/blending and characterization capabilities may be needed to demonstrate that waste acceptance criteria requirements are met without excessive sampling and analysis
- Waste batches identified that require excessive conditioning to meet waste acceptance criteria requirements or that require additional unanticipated steps to meet requirements
- Not being able to provide feed at required rates due to issues associated with the preceding three bullets.

In addition to the ICD review team, interface owner group, and governance group for ICD-19 established by the WTP Interface Management Plan, a Flowsheet IPT has been chartered to provide timely technical resolution of process issues and challenges that impact the integrated flowsheet for WTP operations and TOC WFD, more specifically "identifying, prioritizing, assembling, and providing guidance to technical task teams in support of technical issue resolution." The team is sponsored by senior ORP, WRPS, and BNI management; membership comprises technical, operational, and commissioning staff assigned as needed to address the specific technical issues requiring resolution. The initial activity of the IPT was to develop an integrated schedule that clearly identifies the program logic and path to resolve these gaps and issues. Remaining actions include addressing the open issues identified above, with a focus on developing the requirements basis, and documenting them in the WTP waste acceptance criteria DQO.

2.8.10 Out-of-Specification Feed

Tank waste must meet waste feed criteria established by WTP contractual and interface requirements prior to delivery to WTP feed receipt vessels. ICD-19 stipulates:

> "If the waste (prior to transfer to WTP) does not meet the acceptance criteria, confirmatory action will be taken (re-analysis or re-sampling, or both). If the waste remains out of compliance, one of two steps will be taken:
>
> 1. If the waste does not meet the waste acceptance criteria… it will be refused.
> 2. If the waste does not meet the (waste acceptance criteria)… the WTP contractor or the TFC [Tank Operations Contractor], or both, will determine and take actions necessary for the WTP contractor to be able to receive the feed, such as waste conditioning or adjustment, or negotiation with DOE."

The WFD strategy involves a proactive approach to ensure that waste will meet contractual and interface requirements prior to waste acceptance criteria samples being taken. This includes taking process control samples throughout the preparation steps to ready a batch for delivery, identifying any waste that may be out-of-specification, and taking action to adjust the waste to conform to requirements for waste acceptance.

A systematic review comparing waste feed with various feed screening criteria for the RPP mission operating scenario is presented in Section 4.0 of IWFDP Volume 2. This section identifies potential out-of-specification feed throughout the mission, helping to distinguish problematic waste feed campaigns that may warrant further inspection to address potential mitigating actions. Not all non-compliant feed may be easily mitigated through dilution, transfer, and blending. As waste acceptance criteria are finalized, it may be possible to develop generalized contingency plans for addressing hard-to-mitigate, non-compliant waste feed batches.

2.8.11 Contingency Feed

Contingency feed is defined as supplemental feed ready for delivery to the WTP if a planned feed campaign is unable to be delivered for any reason. Availability of both HLW and LAW contingency feed is a key concern throughout the mission. If a particular planned campaign is unable to be delivered to the WTP, for example, by not meeting waste acceptance criteria or due to WFD system equipment failure, the availability of another waste feed campaign is crucial to keep the WTP operating at capacity. The current strategy to ensure adequate availability of contingency feed is to begin preparation of the next campaign as soon as tank space and appropriate waste is available. However, the demands on the DST system due to SST retrievals, emergency space, and special waste handling may sometimes prevent having multiple tanks of feed ready for delivery at certain times during the mission. The availability of contingency feed over time for the operating scenario is assessed in IWFDP Volume 2.

2.8.12 Waste Treatment and Immobilization Plant Emergency Returns

Emergency returns of waste from the WTP back to the DSTs may be required if it is determined that a batch received at WTP after sampling and analysis is out of compliance, or the waste creates processing problems within the WTP. If a batch received into a WTP receipt vessel is determined to be out of compliance, DOE and the WTP contractor will determine and take the actions necessary to adjust the waste or seek DOE approval for emergency return back to the tank farms. Section C.7 of the WTP Contract (DE-AC27-01RV14136) stipulates that the WTP PT Facility has the capability to return process streams back to the DSTs, and Specification 9, also within the WTP Contract, defines the transfer requirements that are applied to emergency waste returns. ICD-19 specifies that the Tank Operations Contractor must provide emergency reserve tank space of 1.1 Mgal that is available to either the WTP or the tank farms.

For planning purposes, the WFD strategy assumes that the 1.265 Mgal of dedicated emergency space reserved in the tank farms (Section 4.6) may be used if an emergency waste return from WTP is required.

2.8.13 Feed Balance

An important aspect of WFD is ensuring that the *volume, composition, and timing* of the delivered feed are appropriately balanced to facilitate optimum[47] operation of the various treatment and pretreatment facilities. Together, the relative volumes, composition, and timing of the HLW and LAW feed influences the rate at which waste can be treated due to complicated interactions between the PT Facility, LAW Facility, HLW Facility, and second LAW facility.

The overall balance of feed is impacted by the assumed ramp-up of treatment facilities, the processing rate of solids through the pretreatment systems, the degree of pretreatment (extent of leaching), the HLW and LAW glass formulation models, the startup date and capacities of the supplemental treatment facilities, and the maintenance cycles within the treatment facilities.

[47] This is a subjective term that generally means that the limiting facility or facilities are operating at their full capacities, the quantities of HLW and LAW glass are acceptable, and mission success criteria (e.g., treatment end date, SST retrieval completion date) are met.

The balance of feed required for delivery changes over time as the pretreatment and treatment facilities startup and reach their full capacities. This change in the balance of feed is especially noticeable when the supplemental LAW treatment facility reaches full capacity, greatly increasing the demand for both HLW and LAW transfers to the WTP. Additionally, the maintenance cycle for the changeout of spent glass melters may cause regular fluctuations[48] in the required balance of feed due to the reduction of throughput during melter changeout and increased treatment rate when all melters are at capacity.

The current WFD process strategy balances the *volume and timing* of feed to the WTP by having LAW and HLW feed ready for delivery at or before the time they are needed; composition is not currently adjusted to manipulate how closely the various treatment facilities operate to their assumed capacities.

One observation on the current Baseline Case operating scenario is that the HLW Facility is underutilized through about 2025 due to limited LAW treatment capacity, as discussed in Section 5.6.2.1 of the System Plan (ORP-11242, Rev. 6). A series of studies are planned to investigate how best to resolve this issue, which may require trade-offs on the timing and sequence of early SST retrievals, the concentration of sodium in delivered HLW feed batches, the operating modes of the PT Facility and degree of pretreatment, the assumed startup dates and ramp-up of the various treatment facilities, the projected quantities of LAW and HLW glass, and treatment end date. Based on the outcome of those studies, refinements should be made to how the WFD process strategy balances feed to the extent that those refinements improve the overall mission metrics.

Meanwhile, near-term refinements to the WFD process strategy that balance certain aspects of the *composition* of the feed (e.g., the sodium concentration in the liquid used to mobilize the solids) should be evaluated and considered for incorporation into future operating scenarios.

2.8.14 Plutonium Oxide Issue

The current criticality safety evaluation reports (CSER) for the tank farms and WTP (RPP-7475, *Criticality Safety Evaluation of Hanford Tank Farms Facility*, and 24590-WTP-CSER-ENS-08-0001, *Preliminary Criticality Safety Evaluation Report for the WTP*, respectively) assume that plutonium in the tank waste is in finely divided forms intermixed with neutron absorbers. Recent studies have determined that large plutonium oxide particles may be present in some of the tank waste. These particles could potentially segregate from the lighter or smaller neutron absorbers during mixing operations in either the tank farms or the WTP, invalidating assumptions in the CSERs.

Future studies will determine the impact and necessary corrective actions regarding waste retrieval and WTP mixing efforts. In the meantime, sludge disturbing activities in Tank S-108, SY-102, TX-101, TX-105, TX-109, TX-118, 244-TX, C-102, and AN-101 must be evaluated prior to authorization to proceed with these types of activities.

[48] The Baseline Case operating scenario is based on the average treatment facility throughput and therefore does not reflect these fluctuations.

The plutonium oxide issue is an emerging issue, the resolution of which may require changes to the WTP and tank farms DSA and associated CSERs, new engineered or administrative controls at the WTP and tank farms, revised WTP waste acceptance criteria, and changes to the WFD strategy and campaign plans.

There are currently no planned or funded activities to support further evaluation of the plutonium oxide issue. Subsequently, there is a need to identify scope, schedule, and costs associated with anticipated studies and evaluations needed to resolve the issue. This effort is currently planned to begin in early 2012 in anticipation of a rebaseline activity in FY 2013.

2.8.15 Waste Composition and Properties

The Baseline Case operating scenario is based on the chemical and radiological composition of the tank waste as established by the BBI, which is based on historical process records and laboratory analysis. These data, along with the water wash and caustic leach factors, are compiled in the Tank Waste Information Network System (TWINS). The BBI is updated quarterly to reflect changes to the contents of the SSTs and DSTs as a result of retrieval activities, tank-to-tank transfers, evaporator operations, sample events, and other operational activities. References to waste rheology and particle size data are also included in TWINS, when such data is available.

There is an opportunity to directly establish the contents of many of the DSTs after they are filled with retrieved SST waste and prior to being used to prepare feed for the WTP. Historically, it has been difficult to obtain representative samples of SSTs due to limited riser access and poor sample recovery. However, once SST waste has been retrieved into a DST, there is easier access to risers, and sample recovery improves since the solids layers within the DST are more homogeneously distributed (radially) as a result of retrieval operations.

Characterizing the DSTs would fill in gaps regarding knowledge of the composition and properties of the tank waste by reducing reliance on historical records and projections, reducing uncertainties associated with how retrieval affects the composition and properties of the waste, and clearly identifying the vertical distribution (layering) of the settled solids.

Refining the operating scenario and preparing the associated campaign flowsheets and process control plans for the deep sludge tanks (Section 4.5.3), metering of high zirconium solids (Section 4.5.4), and Tank C-104 blending (Section 4.5.5), require knowledge of the composition and the vertical distribution of settled solids in the tank waste. Implementation of updated BDGRE controls (Section 2.8.2) will require measurements of density, water content, and in-situ waste shear strength. Additionally, knowledge of waste particle size and density distributions of the retrieved waste may help determine if the proposed campaigns are likely to provide acceptable feed to the WTP or if WFD plans need to be adjusted.

It is recommended that each DST be sampled and characterized after they are filled and prior to being used to prepare feed for the WTP. Characterization should establish liquid and solid composition, including vertical composition distribution of solids for deep sludge tanks, and waste particle size and density distributions.

3.0 WASTE FEED DELIVERY SYSTEM UTILIZATION

This section discusses how the DST system is used to implement the WFD process.

3.1 DOUBLE-SHELL TANK SYSTEM CONFIGURATION

RPP-47172, *Waste Feed Delivery System Description*, provides a description of the existing architecture and the new architecture being developed for the WFD system, and incorporates a number of systems, subsystems, and equipment or components. IWFDP Volume 3 coordinates the projects that will upgrade the current DST system to the planned configuration required to reliably transfer waste to the WTP and other potential new treatment facilities to execute the mission.

3.2 DOUBLE-SHELL TANK CAPABILITY (FUNCTIONS)

Each DST in the WFD system will have capabilities to perform various WFD functions based on its equipment configuration. The DST equipment configuration consists of existing equipment associated with the tank that will not be removed and the planned equipment additions to support the WFD mission.

Beyond installed equipment supporting waste transfers, other tank conditions specific to individual tanks may limit their capabilities. An emerging issue is that the DSTs in the AY and AZ Farms will have total run time limits on mixer pump use due to in-tank equipment fatigue issues. These tanks will also not be able to support deep sludge using the mixer pumps due to exacerbated stresses on the in-tank equipment when the mixer pumps are raised up from their lowest position in the tank (see Appendix B, Section B2.4). The incremental lowering capability may be removed from the AY and AZ Farm tanks in the future due to these tank limitations.

3.3 PROCESS FLOW DIAGRAM (DOUBLE-SHELL TANK USE AND FUNCTIONS)

The WFD functional process flow diagram is shown in Figure 3-1. This diagram shows how the DST system will be used to receive, prepare, stage, and deliver LAW and HLW feeds to the WTP. The rectangular boxes signify functions, which represent one or more process steps, performed in a DST. Each function is discussed in detail in Section 4.0.

DSTs are initially assigned to a function based on their capability, operational conditions, and specific mission needs. The red-shaded boxes represent solids, slurry, or HLW handling functions, and the blue-shaded boxes represent supernate/LAW functions. Red lines in the figure indicate the direction of slurry transfers, and blue lines indicate the direction of supernate transfers. As operational conditions and mission needs change over time, DSTs may be assigned to different functions as depicted by the dashed green lines.

A DST utilization matrix is presented in Figure 3-2. This figure lists the DSTs with their planned equipment configuration according to the functions shown in Figure 3-1. The DST utilization matrix shows which DSTs can perform the various specific functions based on their equipment, availability date, and location. The different DST functions are listed along the left edge of the figure. Following a specific DST function from left to right in the matrix will reveal the transfer and sample equipment required for the function, followed by the DSTs that will be able to perform that function. The 28 DSTs are listed along the top of the figure.

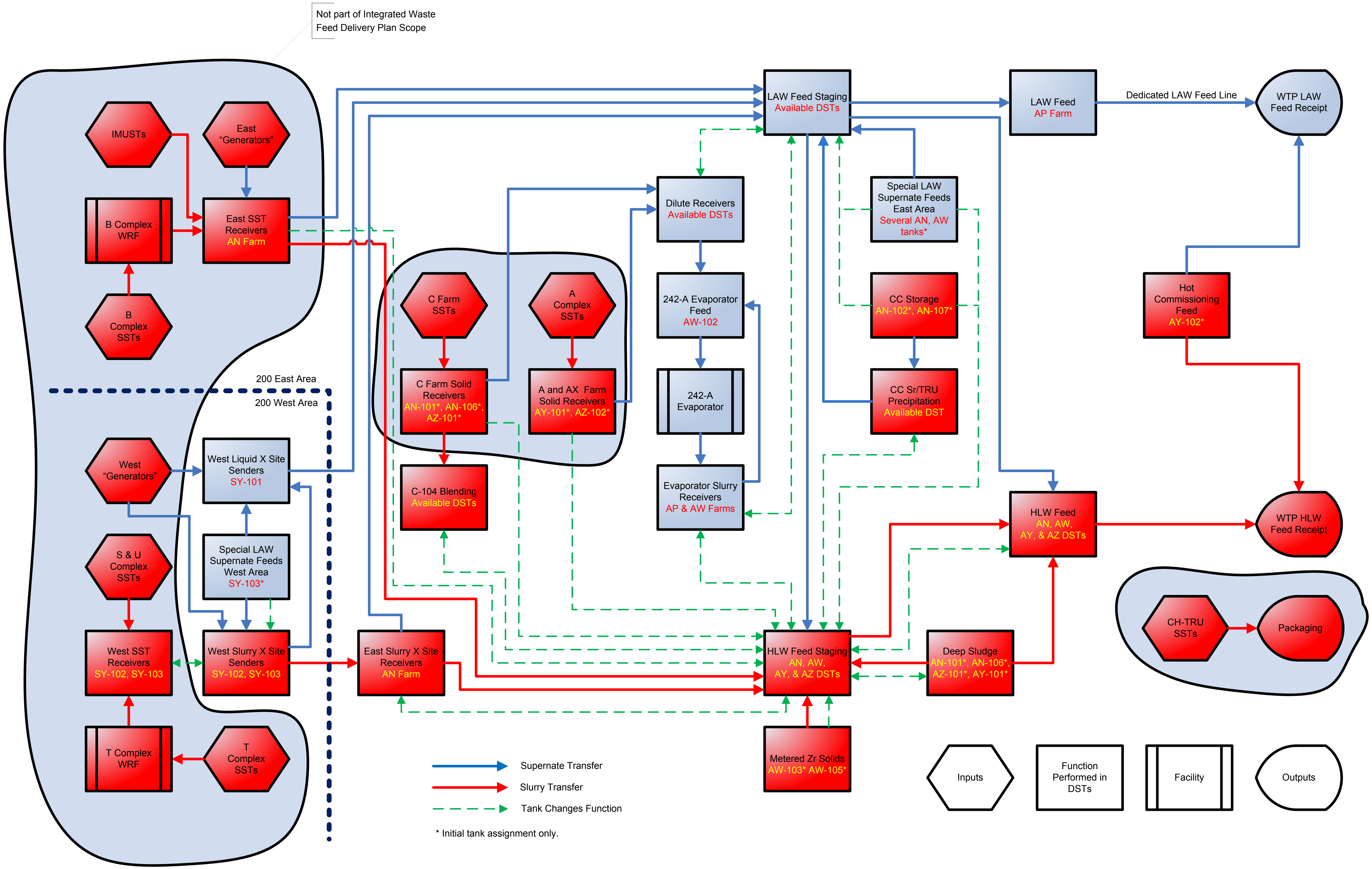

Figure 3-1. Waste Feed Delivery Functional Process Flow Diagram

	AP-101	AP-102	AP-103	AP-104	AP-105	AP-106	AP-107	AP-108	AN-101	AN-102	AN-103	AN-104	AN-105	AN-106	AN-107	AW-101	AW-102	AW-103	AW-104	AW-105	AW-106	AY-101	AY-102	AZ-101	AZ-102	SY-101	SY-102	SY-103
Tank Unavailable Beginning:	11/27/2018	2/1/2019	8/24/2027	9/1/2017	5/29/2024	8/3/2020	8/22/2028	4/30/2021	3/29/2019	10/23/2021	6/29/2020	1/30/2017	1/30/2025	1/29/2015	6/30/2023	1/28/2021	__ [a]	10/1/2013	3/3/2020	3/30/2016	11/25/2022	7/1/2014	8/8/2014	10/1/2013	11/1/2018	5/27/2021	9/26/2017	4/1/2019
Tank Returns to Normal Operation:	4/29/2020	7/1/2020	1/25/2029	1/1/2019	7/30/2026	1/1/2022	1/24/2030	7/1/2023	12/31/2020	6/2/2024	10/24/2022	9/24/2019	9/24/2027	7/29/2017	10/5/2025	1/29/2024	__ [a]	2/29/2016	9/8/2022	1/25/2019	1/29/2025	7/23/2017	9/8/2017	1/25/2016	8/1/2020	8/2/2023	11/23/2020	8/31/2021
Planned Configuration	**AP-101**	**AP-102**	**AP-103**	**AP-104**	**AP-105**	**AP-106**	**AP-107**	**AP-108**	**AN-101**	**AN-102**	**AN-103**	**AN-104**	**AN-105**	**AN-106**	**AN-107**	**AW-101**	**AW-102**	**AW-103**	**AW-104**	**AW-105**	**AW-106**	**AY-101**	**AY-102**	**AZ-101**	**AZ-102**	**SY-101**	**SY-102**	**SY-103**
Mixer Pumps					1			1	2	2	2	2	2	2	1	1	1	2	2	2	1	2	2	2	2	1	2	2
Transfer Pump - Basic[b]	X	X	X	X	X	X	X	X							X	X	X				X					X		
Transfer Pump w/Decant									X	X	X	X	X	X				X	X	X		X	X	X	X		X	X
Transfer Pump for Slurry[c]									X	X	X	X	X	X				X	X	X		X	X	X	X		X	X
Mixer Pump Incremental Lowering Capability									X	X	X	X	X	X		X		X	X	X		X [d]	X [d]	X [d]	X [d]		X	X
Sample Loop									X	X	X	X	X	X				X	X	X		X	X	X	X			
Decant Capability	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Section	HTWOS Function	Decant Capability	Sample Loop	Mixer Pump Incremental Lowering Capability	Transfer Pump for Slurry	Transfer Pump w/Decant	Transfer Pump - Basic	Mixer Pumps	AP-101	AP-102	AP-103	AP-104	AP-105	AP-106	AP-107	AP-108	AN-101	AN-102	AN-103	AN-104	AN-105	AN-106	AN-107
4.3	Hot Commissioning Feed	X			X			2															
4.4.1	LAW Feed	X			X	X	X			X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)											
4.4.2	LAW Feed Staging	X			X	X	X		X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)							X (Full / Balance of Mission Use Only)
4.4.3	Special LAW Supernate Feeds - East Area	X			X			1											X (Initial Use Only)	X (Initial Use Only)	X (Initial Use Only)		
4.4.3	Special LAW Supernate Feeds - West Area	X			X			1															
4.4.4	Dilute Receivers	X			X	X	X		X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)							X (Full / Balance of Mission Use Only)
4.4.5	242-A Evaporator Feed	X			X	X	X																
4.4.7	Evaporator Slurry Receivers				X	X	X		X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)							
4.4.8	West Liquid X-Site Senders	X			X	X	X																
4.5.1	HLW Feed		X		X			2										X (Full / Balance of Mission Use Only)				X (Full / Balance of Mission Use Only)	
4.5.2	HLW Feed Staging	X			X	X		2									X (Full / Balance of Mission Use Only)	X (Transitional Use Only)	X (Full / Balance of Mission Use Only)		X (Full / Balance of Mission Use Only)	X (Transitional Use Only)	
4.5.3	Deep Sludge			X	X			2									X (Initial Use Only)					X (Initial Use Only)	
4.5.4	Metered Zirconium Solids			X	X			2															
4.5.5	C-104 Blending	X		X	X			2									X (Transitional Use Only)					X (Transitional Use Only)	
4.5.6	West Slurry X-Site Senders	X			X			2															
4.5.7	East Slurry X-Site Receivers	X			X			2												X (Full / Balance of Mission Use Only)			
4.5.8	CC Storage	X			X	X	X											X (Initial Use Only)					X (Initial Use Only)
4.5.9	CC Sr/TRU Precipitation	X				X		2											X (Transitional Use Only)				
4.6	Designated Emergency Space																						

Section	HTWOS Function	AW-101	AW-102	AW-103	AW-104	AW-105	AW-106	AY-101	AY-102	AZ-101	AZ-102	SY-101	SY-102	SY-103
4.3	Hot Commissioning Feed								X (Initial Use Only)					
4.4.1	LAW Feed													
4.4.2	LAW Feed Staging	X (Full / Balance of Mission Use Only)					X (Full / Balance of Mission Use Only)							
4.4.3	Special LAW Supernate Feeds - East Area	X (Initial Use Only)			X [e] (Initial Use Only)									
4.4.3	Special LAW Supernate Feeds - West Area													X (Initial Use Only)
4.4.4	Dilute Receivers	X (Full / Balance of Mission Use Only)					X (Full / Balance of Mission Use Only)							
4.4.5	242-A Evaporator Feed		X (Full / Balance of Mission Use Only)											
4.4.7	Evaporator Slurry Receivers	X (Full / Balance of Mission Use Only)					X (Full / Balance of Mission Use Only)							
4.4.8	West Liquid X-Site Senders											X (Full / Balance of Mission Use Only)		
4.5.1	HLW Feed				X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)			X (Initial Use Only)	X (Transitional Use Only)	X (Initial Use Only)			
4.5.2	HLW Feed Staging			X (Full / Balance of Mission Use Only)	X (Transitional Use Only)			X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)			
4.5.3	Deep Sludge							X (Initial Use Only)		X (Initial Use Only)				
4.5.4	Metered Zirconium Solids			X (Initial Use Only)		X (Initial Use Only)								
4.5.5	C-104 Blending				X (Transitional Use Only)									
4.5.6	West Slurry X-Site Senders												X (Full / Balance of Mission Use Only)	X (Full / Balance of Mission Use Only)
4.5.7	East Slurry X-Site Receivers													
4.5.8	CC Storage													
4.5.9	CC Sr/TRU Precipitation													
4.6	Designated Emergency Space					X (Initial Use Only)								

Initial Use Only

Transitional Use Only

Full / Balance of Mission Use Only

Excluded Use

Note - white cells in the main table without "X" indicate tanks that could be used for the stated function, but are tentatively being avoided to simplify mission operations.

| X | X | X | <<--- Implies a logical "OR" - that at least one of these configuration items are needed to support the function.

[a] The start of a 26-month construction period for upgrading Tank AW-102 will be timed to coincide with a planned 242-A Evaporator outage.

[b] Basic Transfer Pumps will be located with their inlets located sufficiently above any solid in the tank to provide decant capability.

[c] The inlet elevation of Transfer Pumps for Slurry may be occasionally adjusted, if needed, to provide decant capability.

[d] Use of incremental lowering in AY- and AZ-Farm DSTs may exacerbate issues with fatiguing of internal tank equipment. Therefore, future operating scenarios will attempt to avoid creating deep sludge tanks in these DSTs.

[e] Although Tank AW-104 is not classified as a Group A tank, it will be processed in the same manner due to it's similar waste type.

Figure 3-2. Double-Shell Tank Utilization Matrix

Following a specific DST from top to bottom shows the period the DST will be unavailable for normal operation (transfers into and out of the tank), and a listing of equipment that will be installed during the time the tank is unavailable. Continuing down the column reveals which functions the DST is capable of performing. DSTs that can perform a specific function are indicated in the matrix wherever the intersection of the DST and function is not shaded with a gray cross-hatch pattern.

DSTs that will perform a specific function early in the mission have their intersection shaded in green. Similarly, tanks that will likely be tasked with functions during the balance of the mission have their intersections shaded in yellow. Tanks that may be tasked with an additional function after their initial use but prior to their function for the balance of the mission have their intersections shaded in blue.

Intersections between DSTs and functions that are not shaded or cross-hatched indicate where a DST may perform a function based on installed equipment, timing of equipment installation, and physical location. However, the DST is not expected to be needed for that function in the current strategy.

4.0 WASTE FEED DELIVERY PROCESS STRATEGY

This section describes the current WFD process strategy, organized according to the functions depicted on the process flow diagram provided in Figure 3-1. The purpose and operating conditions of each DST function are discussed herein. Any assumptions, requirements, constraints, issues or uncertainties, and restrictions on which tanks may be assigned a particular function are also discussed. For presentation purposes, the functions have been categorized into five topical areas, each corresponding to a section in this chapter:

- WTP feed receipt (Section 4.2)
- Hot commissioning feed (Section 4.3)
- Supernate handling (Section 4.4)
- Slurry handling (Section 4.5)
- Dedicated emergency space (Section 4.6).

Each DST function is addressed, as its own subsection, within the topical area to which it most relevantly applies.

The waste acceptance criteria and interface requirements for WFD are addressed in Section 4.1, due to the relevance WTP feed requirements have within the functional performance of the DSTs regarding delivery of waste feed.

4.1 WASTE TREATMENT AND IMMOBILIZATION PLANT WASTE ACCEPTANCE CRITERIA AND INTERFACE REQUIREMENTS

Table 4-1 summarizes the primary waste acceptance criteria imposed on waste transfers from tank farms to the WTP LAW and HLW feed receipt tanks, along with the source of each requirement.

Table 4-1. Waste Feed Delivery Requirements for Waste Acceptance Criteria (2 pages)

Parameter	Waste acceptance criteria item	Requirements		
		LAW limit	HLW limit	Source
Batch volume		≤ 1.125 Mgal	≤ 158,503 gal	WTP Contract,[a] ICD-19 (Rev. 4)[b]
Na concentration	✓	< 10 M		Specification 7 and 8[c]
Solids concentration	✓	≤ 3.8 wt%	≤ 200 g/L	ICD-19 (Rev. 4)[b]
[solids] to [Na] relation[d]	✓	N/A	≤ 144 g/L at 7 M Na	WTP Contract[a]
Bulk density	✓	< 1.46 kg/L	< 1.5 kg/L	ICD-19 (Rev. 4)[b]
pH	✓	> 7		ICD-19 (Rev. 4)[b]
CSL (Pu/metal)	✓	< 6.20 g/kg		24590-WTP-CSER-ENS-08-0001 (Rev 0B)[e]
CSL ($U_{fissile}$/U_{total})	✓	N/A	< 8.4 g/kg	24590-WTP-CSER-ENS-08-0001 (Rev 0B)[e]
CSL (Pu concentration)	✓	< 0.013 g/L		24590-WTP-CSER-ENS-08-0001 (Rev 0B)[e]
Separable organics	✓	No visible layer		ICD-19 (Rev. 4)[b]
Envelope A concentrations[f]		See source	See source	Specification 7 and 8[c]

Table 4-1. Waste Feed Delivery Requirements for Waste Acceptance Criteria (2 pages)

Parameter	Waste acceptance criteria item	Requirements		
		LAW limit	HLW limit	Source
Envelope B concentrations[f]		See source	See source	Specification 7 and 8[c]
Envelope C concentrations[f]		See source	See source	Specification 7 and 8[c]
Envelope D concentrations[f]		N/A	See source	Specification 8[c]
HGR	✓	$< \frac{3.7*10^{-7}\ gmol\ H_2}{L*Hr}$	$< \frac{2.1*10^{-6}\ gmol\ H_2}{L*Hr}$	24590-WTP-M4C-V11T-00011 (Rev. C)[g]
Temperature (in-tank)	✓	< 120°F	< 150°F	ICD-19 (Rev. 4),[b] (Pell 2009)[h]
Temperature change[i]	✓	+/- 20°C		24590-WTP-RPT-MGT-11-014[j]
PCBs	✓	< 50 ppm		ICD-19 (Rev. 4)[b]
Critical velocity[k]	✓	N/A	≤ 4.0 ft/sec	ICD-19 (Rev. 4)[b]
Viscosity[l]	✓	N/A	< 10 cP (consistency) < 1.0 Pa (yield stress)	ICD-19 (Rev. 4)[b]
NH_3 concentration	✓	< 0.04 M		Specification 8,[c] ICD-19 (Rev. 4)[b]
Feed unit dose	✓	< 1500 Sv/L at 10M Na	< 270 Sv/g dry solids	(Pell 2009)[h]
Solids settling rate[m]	✓	> 0.03 ft/min	N/A	Specification 7[c]
Total organic carbon	✓	< 10 wt%		24590-WTP-RPT-MGT-11-014[j]

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

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

[c] Specification 7 and 8 refer to Specification 7 (LAW envelopes definition) and Specification 8 (HLW envelope definition) contained within Section C of the WTP Contract (DE-AC27-01RV14136).

[d] WTP Contract modification 183 requires a linear range of solids content in relation to sodium molarity. WTP is required to manage feed receipt such that receipt vessels are in the range of ≤107 g/L at 0.1 M sodium up to 144 g/L at 7 M sodium.

[e] 24590-WTP-CSER-ENS-08-0001, 2009, *Preliminary Criticality Safety Evaluation Report for the WTP*, Rev. 0B, Bechtel National, Inc., Richland, Washington.

[f] Envelope A, B, C, and D refer to waste envelope definitions found within the WTP Contract (DE-AC27-01RV14136).

[g] 24590-WTP-M4C-V11T-00011, 2010, *Revised Calculation of Hydrogen Generation Rates and Times to Lower Flammability Limit for WTP*, Rev. C, Bechtel National, Inc., Richland, Washington.

[h] Refers to Item 2, which discussed updates to LAW and HLW feed unit dose values and the HLW feed temperature value, in the meeting minutes for "ICD-19 Team Meeting – Finalize Issues to be Included in Rev 5" (Pell 2009).

[i] This is a WTP permit requirement, which stipulates that waste characteristics within WTP not vary substantially within a temperature change of plus or minus 20°C.

[j] 24590-WTP-RPT-MGT-11-014, 2011, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria*, Rev. 0, Bechtel National, Inc., Richland, Washington.

[k] In a nominal 3-in. diameter pipe (in-tank). Critical velocity is defined as the fluid transfer velocity below which pipeline solid particulate deposition occurs.

[l] Consistency and yield stress are values used in WTP design but still under investigation as needed or applicable to waste feed acceptance.

[m] Refers to solids that settle faster than the upper limit.

CSL	=	criticality safety limit.	N/A	=	not applicable.
HGR	=	hydrogen generation rate.	PCB	=	polychlorinated biphenyl.
HLW	=	high-level waste.	WTP	=	Waste Treatment and Immobilization Plant.
LAW	=	low-activity waste.			

Table 4-2 shows how the interface requirements, outlined in Table 4-1, are addressed from a system and long-term planning perspective, and how these requirements will be addressed in future operational planning. The table also refers the reader to specific sections within this document where established controls are addressed in further detail.

For system and long-term planning, control schemes were established and tested using the HTWOS model to simulate an operating scenario as part of both the WFD and system planning processes. Whenever possible, the requirements imposed on the WTP feed are controlled according to the WFD process strategy. Directly controlled parameters are those parameters that may be readily met within the existing degrees-of-freedom (i.e., batch volume, sodium concentration, solids concentration, liquid density or bulk density). Indirectly controlled parameters are those that may require blending to meet requirements, such as the majority of the waste composition and rheology requirements, or in the case of temperature, may need to be indirectly controlled by heating during mixer pump operation and cooling during quiescent periods. The control schemes for certain requirements have not yet been determined; reasons include a lack of reported data from the BBI and limitations in the ability to predict rheological properties of the waste and the tank temperature response given uncertainties in mixer pump performance. Control schemes for these parameters may be incorporated into system and long-term planning if or when appropriate data and models are available. Parameters that are projected by the HTWOS model are screened for potential systematic and campaign-specific issues by comparing the projected values for each campaign and waste feed batch against the relevant waste acceptance criteria and other interface requirements.

For operational planning, the control scheme for each campaign will be established by a process control plan that addresses both the direct and indirect controls. Inputs to the process control plan will include the most recent operating scenario, campaign flowsheet, waste compatibility analysis, waste acceptance criteria, safety-related constraints, and either projected or sampled waste composition and physical properties. Process control samples or process knowledge may be used to plan and control the feed preparation steps, especially if blending or other adjustments are required to meet specific waste acceptance criteria. Samples of prepared feed will be taken and analyzed to verify that the feed meets the waste acceptance criteria prior to delivery. Waste batch volume will be controlled and verified during delivery. There are a few parameters where an operational control scheme has yet to be established or where a method for verifying that the requirement has been met has not been determined. The WFD process strategy for these parameters will be updated as control schemes and verification methods are defined.

A key issue associated with the waste acceptance criteria is that some of the requirements and limits continue to change based on ongoing studies. The need for these requirements and criteria to be finalized is paramount to ensure that the WFD system is ready to prepare and deliver feed to the WTP.

Table 4-2. Preliminary Control Schemes for Waste Treatment and Immobilization Plant Waste Acceptance Criteria

Parameter	System and long-term planning control scheme								Operational planning control scheme										Section cross-reference for additional details[b]
	Directly controlled		Indirectly controlled		To be determined		Screened[a]		Directly controlled		Indirectly controlled		To be determined		Verification method		
	LAW	HLW	LAW	HLW	LAW	HLW	LAW	HLW	LAW	HLW	LAW	HLW	LAW	HLW	LAW	HLW	
Batch volume	✓	✓					✓	✓	✓	✓					MB between sender and receiver tanks	MB between sender and receiver tanks	4.2.1, 4.2.2, 4.4.1, 4.5.1
Sodium concentration	✓	✓					✓	✓	✓	✓					WAC samples	WAC samples	4.4.1, 4.5.1
Maximum solids	✓	✓					✓	✓	✓	✓					WAC samples	WAC samples	4.4.1, 4.4.2, 4.5.1, 4.5.2
[solids] to [Na] relation[c]	N/A		N/A	✓	N/A		N/A	✓	N/A	✓	N/A		N/A		N/A	WAC samples	4.5.1
Bulk density			✓	✓			✓	✓	✓	✓					WAC samples	WAC samples	4.4.2, 4.5.1, 4.5.2
pH			✓	✓							✓	✓			WAC samples	WAC samples	4.4.6
CSL (Pu/metal)					✓	✓	✓	✓			✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
CSL ($U_{fissile}/U_{total}$)	N/A		N/A	✓	N/A		N/A	✓	N/A		N/A	✓	N/A		N/A	WAC samples	4.4.1, 4.5.1, 4.5.5
CSL (Pu concentration)					✓	✓	✓	✓			✓	✓			WAC samples	WAC samples	4.4.1
Separable organics			✓			✓			✓					✓	WAC samples	WAC samples	4.4.1, 4.5.1
Envelope A concentrations							✓	✓			✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
Envelope B concentrations							✓	✓			✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
Envelope C concentrations							✓	✓			✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
Envelope D concentrations	N/A		N/A		N/A		N/A	✓	N/A		N/A	✓	N/A		N/A	WAC samples	4.4.1, 4.5.1
HGR							✓	✓			✓	✓			TBD	TBD	4.4.1, 4.5.1
Temperature (in-tank)					✓	✓							✓	✓	Thermocouple tree	Thermocouple tree	2.8.7
Temperature change[d] (waste feed compatibility)					✓	✓							✓	✓	ASTM D5058-90[e]	ASTM D5058-90[e]	2.8.7
PCBs					✓	✓					✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
Critical velocity	N/A		N/A		N/A	✓	N/A		N/A		N/A		N/A	✓	N/A	WAC samples + calculations	4.4.1, 4.5.1
Viscosity	N/A		N/A		N/A	✓	N/A		N/A		N/A		N/A	✓	N/A	WAC samples	4.4.1, 4.5.1
NH_3 concentration					✓	✓					✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
Feed unit dose					✓	✓					✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1
Solids settling rate		N/A		N/A	✓	N/A		N/A		N/A		N/A	✓	N/A	WAC samples + calculations	N/A	4.4.1, 4.5.1
Total organic carbon					✓	✓					✓	✓			WAC samples	WAC samples	4.4.1, 4.5.1

[a] The values for screened parameters are projected by the HTWOS model and are compared to the associated limits for the purpose of identifying systematic and campaign-specific issues.
[b] Specified section(s) within this volume of the IWFDP.
[c] WTP Contract (DE-AC27-01RV14136) modification 183 requires a linear range of solids content in relation to sodium molarity. WTP is required to manage feed receipt such that receipt vessels are in the range of ≤107 g/L at 0.1 M sodium up to 144 g/L at 7 M sodium.
[d] The evaluation of temperature change is conducted to ensure that no changes in viscosity or potential incompatibilities adversely affect waste processing when tank waste feed is transferred and combined with the waste heel remaining in the WTP feed receipt vessel.
[e] The ASTM D5058-90 method requires observing any temperature changes from mixing 10 mL of staged feed with 10 mL of residual waste from WTP feed receipt tanks.

CSL = criticality safety limit.
HGR = hydrogen generation rate.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
IWFDP = Integrated Waste Feed Delivery Plan.
LAW = low-activity waste.
MB = mass balance.
N/A = not applicable.
PCB = polychlorinated biphenyl.
TBD = to be determined.
WAC = waste acceptance criteria.
WTP = Waste Treatment and Immobilization Plant.

4.2 WASTE TREATMENT AND IMMOBILIZATION PLANT FEED RECEIPT

The following sections describe the batch volumes and the specific requirements related to and planning assumptions for both the LAW and HLW feed receipt systems.

4.2.1 Waste Treatment and Immobilization Plant Low-Activity Waste Feed Receipt

The function of the LAW feed receipt tanks is to receive LAW feed from the tank farms and supply it to pretreatment operations within the WTP. The WTP LAW feed receipt is comprised of four tanks (FRP-VSL-00002A, FRP-VSL-00002B, FRP-VSL-00002C, and FRP-VSL-00002D). Each of the four tanks has a minimum operating volume of 4,391 gal and a maximum operating volume of 375 kgal, and each is equipped to pump out at a rate of 100 gal/min.[49]

When the combined volume of the LAW feed receipt tanks has the capacity to receive a nominal 1 Mgal batch,[50] delivery of an available LAW feed campaign is initiated. Prior to a LAW feed transfer, a 2,500-gal pre-transfer flush[51] of inhibited water[52] is sent to the first LAW feed receipt tank set to receive waste to preheat the transfer line, helping to prevent solids precipitation during the transfer. The designated LAW campaign feed is then transferred into the LAW feed receipt tanks. The delivery of a LAW feed campaign will have to be managed to fill multiple tanks in turn, which may involve multiple transfers, since each of the four LAW feed receipt tanks has a maximum operating volume less than 380 kgal. After the campaign has been received, the last LAW receiving vessel receives a 2,000-gal post-transfer flush of inhibited water to clear any remaining waste from the transfer line. Once prequalifications conducted by the WTP contractor related to downstream operations are completed, the LAW feed receipt tanks may supply the delivered feed to pretreatment operations, as needed. Once the LAW feed receipt system has transferred enough of its contents to receive another 1 Mgal, it will again request feed from the tank farms, repeating the above process.[53]

4.2.2 Waste Treatment and Immobilization Plant High-Level Waste Feed Receipt

The function of the HLW feed receipt tank is to receive HLW feed from the tank farms and supply it to pretreatment operations within the WTP. The HLW feed receipt within WTP is comprised of one tank (HLP-VSL-00022). The tank has a minimum operating volume of 36,500 gal and a maximum operating volume of 166,500 gal, and is equipped to pump out at a rate of 140 gal/min.[54]

[49] WTP vessel parameters are found in Table B-3 of RPP-17152, *Hanford Tank Waste Operations Simulator (HTWOS) Version 6.6.1 Model Design Document*.

[50] The WTP may request waste transfers less than the target volume based on the waste composition prior to transfer.

[51] Flush requirements and purpose are consistent with ICD-19 and TFC-ENG-STD-26.

[52] ICD-19 (Rev. 5), released during the final preparation of this IWFDP, and therefore, not evaluated in this revision of the document, eliminates the requirement for the water flush to explicitly be inhibited water. Future revisions of the IWFDP will evaluate and incorporate the requirements from the most recent revision of ICD-19 that is approved for use in the System Plan.

[53] RPP-17152, Section 6.2.1, describes how LAW feed receipt operations are modeled in HTWOS for system planning purposes.

[54] WTP vessel parameters are found in Table B-3 of RPP-17152.

When the HLW feed receipt tank has the capacity to receive a nominal 120 kgal batch,[55] delivery of an available HLW feed batch is initiated. Prior to an HLW batch transfer, a 2,500-gal pre-transfer flush[56] of inhibited water[57] is sent to HLP-VSL-00022 to preheat the transfer line, helping to prevent solids precipitation during the transfer. The designated HLW batch is then transferred into the HLW feed receipt tank. After the full batch has been received, the HLW feed receipt tank receives a 2,000-gal post-transfer flush of inhibited water to clear any remaining waste from the transfer line. Once prequalifications conducted by the WTP contractor related to downstream operations are completed, the HLW feed receipt tank may supply the delivered feed to pretreatment operations, as needed. Once the HLW feed receipt has transferred enough of its contents to receive another 120 kgal, it will again request feed from the tank farms, repeating the above process.[58]

4.3 HOT COMMISSIONING FEED

The LAW and HLW hot commissioning feed will both be supplied to the WTP from the waste currently in Tank AY-102. The current contents of Tank AY-102 are comprised primarily of solids consolidated from Tank C-106 and supernate from Tank AP-101. Section 2.1 provides a history of the selection of Tank AY-102 wastes.

The sequence of steps involved in WFD of the LAW and HLW hot commissioning batches to WTP is outlined in Table 4-3. The basis for the sequence of hot commissioning feed was developed and documented in the WFD flowsheet completed in September 2010 for Tank AY-102 (RPP-RPT-46020, *Tank 241-AY-102 Waste Feed Delivery Flowsheet*). Hot commissioning includes an initial batch transfer of LAW supernate decanted from Tank AY-102, followed by the delivery of five[59] consecutive HLW batch transfers to the WTP.

The sequence begins with obtaining the current contents of Tank AY-102 through the BBI. The next step represents the time the waste in Tank AY-102 is stored between the initial inventory date to a period approximately one year prior to WFD of the first hot commissioning batch to the WTP. Water is then added to replace water that has evaporated,[60] followed by operation of the mixer pumps and waste sampling to obtain analyses for comparison with waste acceptance criteria for WFD to the WTP.

[55] The WTP may request waste transfers less than the target volume based on the waste composition prior to transfer.

[56] Flush requirements and purpose are consistent with ICD-19 and TFC-ENG-STD-26.

[57] ICD-19 (Rev. 5), released during the final preparation of this IWFDP, and therefore, not evaluated in this revision of the document, eliminates the requirement for the water flush to explicitly be inhibited water. Future revisions of the IWFDP will evaluate and incorporate the requirements from the most recent revision of ICD-19 that is approved for use in the System Plan.

[58] RPP-17152, Section 6.2.1, describes how HLW feed receipt operations are modeled in HTWOS for system planning purposes.

[59] The current flowsheet (RPP-RPT-46020) lists four HLW batch transfers to WTP during hot commissioning. This flowsheet, however, does not incorporate the updated HLW batch volumes (discussed in Section 4.1) that have been incorporated into the current operating scenario.

[60] Preliminary calculations indicate that periodic water additions are required to replace water evaporated during waste storage periods to ensure that HLW batches comply with the waste acceptance solid concentration criterion. This is accomplished in the current flowsheet by adding sufficient dilution water to return the waste liquid phase to a sodium concentration equivalent to the sodium concentration on the inventory initial reference date. The water addition is performed immediately prior to operating mixer pumps in a designated time period.

Table 4-3. Waste Feed Delivery Sequence for Hot Commissioning (2 pages)

Activity type	Description
N/A	Initial basis for BBI inventory, radionuclides decayed from January 1, 2008, to-date obtained for consistency with chemical inventory
Store	Store waste until approximately one year prior to initial waste transfer and install mixer pump/sampling system
Add water	Replace evaporated water immediately before mixing
Mix/sample[a,b]	Run and test mixer pumps to homogenize liquid phase and draw waste acceptance samples using measurement loop and sampler system
Sample	Settle solids for approximately 60 days and perform core sampling to confirm sampler system results
Sample	Dip sample liquid phase approximately 30 days before delivery to confirm wt% solids of decant complies with acceptance criteria
Store	Store waste after mixing for mixer pump testing and waste acceptance sampling
Decant LAW batch	Decant waste transfer of LAW batch to WTP
Store	Store waste after LAW batch waste volume removed
Add water	Replace evaporated water immediately before mixing
Mix	Mix waste for approximately two days[c] in preparation for HLW transfer
Sample	Sample and analyze for g solid/L only, to confirm compliance with acceptance criteria
Transfer HLW batch	Transfer HLW batch to WTP
Store	Store waste after HLW batch volume removed
Add water	Replace evaporated water immediately before mixing
Mix	Mix waste for approximately two days in preparation for HLW transfer
Sample	Sample and analyze for g solid/L only, to confirm compliance with acceptance criteria
Transfer HLW batch	Transfer HLW batch to WTP
Store	Store waste after HLW batch volume removed
Add water	Replace evaporated water immediately before mixing
Mix	Mix waste for approximately two days[c] in preparation for HLW transfer
Sample	Sample and analyze for g solid/L only, to confirm compliance with acceptance criteria
Transfer HLW batch	Transfer HLW batch to WTP
Store	Store waste after HLW batch volume removed
Add water	Replace evaporated water immediately before mixing
Mix	Mix waste for approximately two days[c] in preparation for HLW transfer
Sample	Sample and analyze for g solid/L only, to confirm compliance with acceptance criteria
Transfer HLW batch	Transfer HLW batch to WTP
Store	Store waste after HLW batch volume removed

Table 4-3. Waste Feed Delivery Sequence for Hot Commissioning (2 pages)

Activity type	Description
Add water	Replace evaporated water immediately before mixing
Mix	Mix waste for approximately two days[c] in preparation for HLW transfer
Sample	Sample and analyze for g solid/L only, to confirm compliance with acceptance criteria
Transfer HLW batch	Transfer HLW batch to WTP
Store	Store waste after HLW batch volume removed

[a] The current strategy assumes that a single sampling activity will be able to provide the waste feed needed to confirm the waste acceptance criteria is met for both the HLW and LAW portions of the waste.

[b] There will likely need to be a separate sampling event, after the HLW sample is taken and the tank waste is settled, to confirm LAW waste acceptance criteria, likely through a LAW grab sample. This strategy will be incorporated into future revisions of the IWFDP.

[c] Initial results from the Small-Scale Mixing Demonstration Program indicate that a longer mixing time is needed to prepare the feed for transfer. The time needed for adequate mixing will be determined through future small-scale mixing demonstration testing and through the full-scale demonstration in Tank AY-102.

BBI	=	best-basis inventory.	LAW	=	low-activity waste.
HLW	=	high-level waste.	N/A	=	not applicable.
IWFDP	=	Integrated Waste Feed Delivery Plan.	WTP	=	Waste Treatment and Immobilization Plant.

A time period of approximately one year of storage time passes between obtaining samples for waste acceptance criteria comparisons and the actual transfer of the initial LAW batch. There are two confirmation sampling events that occur during this storage time. A core sample is taken approximately 60 days[61] after the mixer pump operation has been competed for comparison to sample results obtained by the sampling system.[62] A confirmatory liquid phase dip sample is also taken during this time,[63] approximately 30 days prior to the LAW batch transfer. Following these sampling events, a portion of the supernate is decanted from Tank AY-102 and transferred to the WTP, representing the initial LAW batch transfer.[64] The waste transfer is followed by a storage period prior to mixer pump operation in preparation for the subsequent HLW batch transfer.

Before delivery of the first HLW batch to the WTP, water is added to replace water evaporated since the waste acceptance sampling event.[65] The mixer pumps are then operated to blend solid and liquid phases and a confirmation sample, using the sampling system, is taken to be analyzed only for solids concentration.[66] Following the sampling confirmation, the initial HLW batch is transferred from Tank AY-102 to the WTP and is followed by a storage period to wait for the WTP to process the HLW batch.

[61] 60 days is assumed to approximate the time required for the settled solids height to approach the same height prior to operation of the mixer pumps.

[62] Confirmation core samples are considered desirable for Tank AY-102 since use of the sampling system will represent the first time the sampling system is used in a production operating environment.

[63] The liquid phase sample is intended to confirm the decanted liquid phase will comply with the waste acceptance criteria for LAW batch solids content and is analyzed only for wt% solids.

[64] Delivery of the first LAW batch to the WTP will begin on May 11, 2018, per ORP-11242 (Rev. 6), Appendix B.

[65] The HTWOS model does not currently simulate evaporation that occurs over time for the hot commissioning feed, so the associated water additions are not modeled at this time.

[66] This sample is assumed to be warranted to confirm compliance with the waste acceptance criteria after decanting the LAW batch from Tank AY-102.

The steps described above for the initial HLW batch are repeated four times, such that Tank AY-102 delivers a total of five HLW batches to the WTP for hot commissioning.

The most current flowsheet for the Tank AY-102 hot commissioning feed was completed prior to the development of the current operating scenario, as depicted in ORP-11242 (Rev. 6). The flowsheet needs to be revisited to integrate with the most current operating scenario, including initial sampling activities to confirm that both the LAW and HLW feed in Tank AY-102 meet the WTP waste acceptance criteria. A more detailed schedule of hot commissioning activities also needs to be developed.

4.4 SUPERNATE HANDLING

4.4.1 Low-Activity Waste Feed

DSTs will be required to store LAW feed that will be subsequently delivered to the WTP LAW feed receipt tanks. The current strategy is to secure two tanks for this function, although use of three or four DSTs may be investigated. Tanks AP-102, AP-104, AP-106, and AP-108 are good candidates since they will have a direct path to the dedicated LAW feed line. The LAW feed tanks receive decanted supernate waste from LAW feed staging tanks. The waste received by LAW feed tanks targets a solids concentration as low as possible; however, LAW feed may contain up to 3.8 wt% solids.[67] Waste feed delivery to the WTP may take place after there has been sufficient time to ensure that fast-settling solids, greater than 0.03 ft/sec, have settled below the transfer location in the LAW feed tank. No in-line dilution is allowed for LAW feed delivery to WTP. The sodium concentration will be controlled to be less than 10 M sodium.

The current strategy is to secure two DSTs as LAW feed tanks. When a LAW feed tank is emptied and finished transferring to the WTP LAW feed receipt vessel, the tank is then available to accept feed from a LAW feed staging tank. The second LAW feed tank will undergo preparation to be ready to deliver feed as necessary. If this second LAW feed tank cannot make a transfer to WTP for any reason, there is no contingency feed available and ready to deliver to WTP. Securing additional tanks to the LAW feed tank function could provide additional contingency feed available for transfer to WTP.

Supernate bulk density will be indirectly controlled due to the specific gravity controls established for LAW feed staging tanks (described further in Section 4.4.2). Separable organics will be indirectly controlled by ensuring that the transfer pump inlet is located below the surface of the waste.

Screening for criticality safety limits (CSL), feed Envelope A/B/C concentrations, and HGRs will be performed. Additional information is provided in Table 4-1 (Section 4.1).

Control schemes for supernate temperature, polychlorinated biphenyl (PCB) and ammonia concentrations, critical velocity in transfer lines, supernate viscosity, unit dose rate, total organic carbon, and solids settling rate will need to be developed.

[67] Weight-percent solids, in this context, precludes fast-settling solids.

4.4.2 Low-Activity Waste Feed Staging

Waste must be staged prior to transfer into a LAW feed tank. LAW feed staging tanks will receive waste from various sources, including 200 West liquid cross-site tanks, 200 East cross-site slurry receiver tanks, and 200 East SST waste receivers.[68] The waste received into LAW feed staging tanks is evaluated to determine if the waste could be concentrated in the 242-A Evaporator to reduce the waste volume. If the waste is dilute, with a specific gravity less than 1.3, the tank will convert to the dilute receivers function (discussed in Section 4.4.4).

Screening for solids content and supernate bulk density will be performed. The solids content will be directly controlled to be less than 3.8 wt% solids, targeting a solids concentration as low as possible. The bulk density will be indirectly controlled at less than 1.46 kg/L due to the evaporator maximum specific gravity of 1.43.

4.4.3 Special Low-Activity Waste Supernate Feeds

Special LAW supernate feed tanks hold concentrated LAW feed. Tanks located in the 200 East Area that are initially placed in this function include Tanks AN-103, AN-104, AN-105, AW-101, and AW-104. Tanks AN-103, AN-104, AN-105, and AW-101 are Waste Group A tanks. Tank AW-104 is not a Waste Group A tank, but the waste is similar enough to the Waste Group A that it will undergo the same mitigation strategy. To minimize the possibility of a BDGRE, no waste will be added to these tanks until after they have undergone mitigation. Between 750 kgal and 1 Mgal of DST space is required to mitigate a Waste Group A tank.

The strategy used to mitigate the 200 East Area Waste Group A tanks will be to decant off the supernate using in-line dilution with water and transfer the diluted waste to an available LAW feed staging tank. Water will be added to the remaining tank waste to mix and dissolve the solid saltcake layer. Once the waste has been mixed, the tank will convert to the LAW feed staging function. Once the tank has been emptied, it will then either move to the HLW feed staging function, if the installed equipment allows it, or it will continue to serve as a LAW feed staging tank. The mitigation strategy of Waste Group A DSTs will need to be incorporated into the tank farms DSA (RPP-13033).

Tank SY-103 is also currently a Waste Group A tank; however, it is located in the 200 West Area. No new waste will be added to Tank SY-103 until it has been mitigated to minimize its potential for BDGREs. The strategy to mitigate Tank SY-103 is to decant off the supernate using in-line dilution with water and transfer the diluted waste to a 200 West liquid cross-site tank (Tank SY-101). Water will be added and mixed with the remaining waste to dissolve the solid saltcake layer. The dissolved solids will then be transferred to a 200 West liquid cross-site tank. Once the tank has been emptied, it will then convert to the 200 West cross-site function.

4.4.4 Dilute Receivers

Dilute receiver tanks stage dilute supernate for transfer to the evaporator feed tank, Tank AW-102. These tanks can be any tank that also serves the LAW feed staging function. Waste will be staged for 120 days to allow for sampling and analysis of the dilute waste prior to being concentrated. Once the laboratory analysis is completed and the waste is deemed acceptable for processing through the evaporator, the dilute receiver tank will transfer its contents to Tank AW-102.

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[68] 200 East SST waste receivers are DSTs that receive retrieved waste from 200 East Area SSTs.

If a dilute receiver tank is left with less than 250 kgal of pumpable liquid remaining after transferring into Tank AW-102, it will switch to the LAW feed staging function to prevent the free space in the tank from being tied up when the evaporator may be held up due to lack of available downstream space.

Once a dilute receiver is emptied, the tank can return to the LAW feed staging tank function. A dilute receiver can also convert to the evaporator slurry receiver or HLW feed staging function, provided the appropriate equipment is installed to support the new tank function.

4.4.5 242-A Evaporator Feed

Waste from dilute receiver tanks will be transferred to the evaporator feed tank, AW-102, and staged for an evaporator campaign. Transfers into Tank AW-102 are comprised of batches of 250 kgal or larger. Smaller batches, with a minimum 50-kgal batch size, may be used to top off Tank AW-102. Tank AW-102 can also receive waste from evaporator slurry receiver tanks. The minimum evaporator campaign size is 500 kgal of feed. Waste will be accumulated and staged in Tank AW-102 until at least 500 kgal are available. Waste in Tank AW-102 will be sampled and evaluated to determine the appropriate specific gravity setpoint for evaporator operations. The setpoint is based on boil-down tests using samples obtained from the dilute receiver(s) that were the source of the waste in Tank AW-102 (HNF-14755, *Documented Safety Analysis for the 242-A Evaporator*; HNF-15279, *Technical Safety Requirements for the 242 A Evaporator*; and RPP-17152, *Hanford Tank Waste Operations Simulator (HTWOS) Version 6.6.1 Model Design Document*).

4.4.6 242-A Evaporator

The 242-A Evaporator is used for volume reduction of dilute waste. Two primary programmatic goals of the 242-A Evaporator are:

- Evaporate retrieved waste as needed to manage DST space
- Evaporate retrieved waste as needed to concentrate dilute waste to meet the WTP LAW feed specification.

The evaporator is a conventional forced-circulation, vacuum evaporation system. The evaporator targets campaigns under the following conditions (HNF-14755, HNF-15279):

- Feed that would have at least 15 percent waste volume reduction (WVR) at a maximum target specific gravity of 1.43
- Feed that would have at least a 15 percent WVR at 80 percent of the maximum concentration of key radionuclides in the product.

Figure 4-1 shows the operating window for the 242-A Evaporator. The flow rate of the slurry, or bottoms, stream from the evaporator ranges from 30 to 70 gal/min. The lower limit is based on the gravity-driven flow rate from the boiler, and the upper limit is driven by safety limitations placed on the evaporator. The maximum boil-off rate of the evaporator is 40 gal/min. Based on the maximum slurry rate and the maximum boil-off rate, the effective maximum feed rate to the evaporator is approximately 110 gal/min feed.

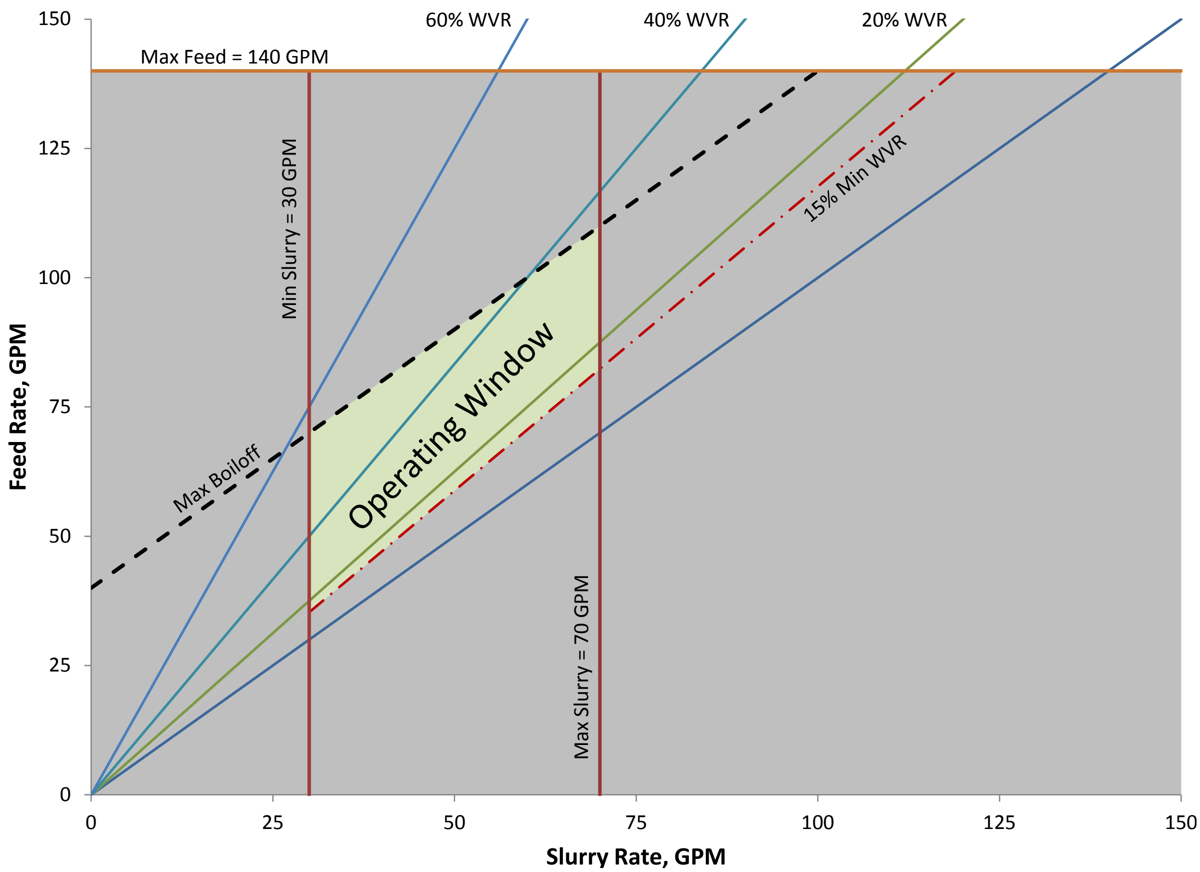

Figure 4-1. Operating Window for the 242-A Evaporator

The bottoms sodium concentration is controlled by using a setpoint for the concentrate to be at or below 9.5 M sodium. Concentration of some waste types may result in solids precipitation. Accumulation of solids could result in retention of flammable gases and potentially result in an uncontrolled release.[69]

4.4.7 Evaporator Slurry Receivers

Evaporator slurry receiver tanks receive evaporator bottoms from the 242-A Evaporator as concentrated slurry. AW and AP Farm tanks can serve as evaporator slurry receiver tanks. The AW and AP Farms were selected as 242-A Evaporator slurry receiver tanks for two reasons: (1) the transfer lines from the 242-A Evaporator to AW and AP Farms are 2-in. lines, and (2) the AW and AP Farms are close to the evaporator. The proximity minimizes temperature drop and helps reduce the potential to precipitate solids. The 2-in. diameter of the transfer lines allows for higher velocity to keep any solids in suspension. Transfer routes from the 242-A Evaporator to the AN, AY, and AZ Farms are 3-in. diameter lines, and these farms are located further away from the 242-A Evaporator than AW and AP Farms. The AN, AY, and AZ Farms were therefore not selected to serve the evaporator slurry receiver function, although they can receive a subsequent transfer of waste from the evaporator slurry receiver tank once an evaporator run is completed.

[69] RPP-17152 (Rev. 6) provides a detailed description of how 242-A Evaporator operations are modeled in HTWOS for planning purposes.

4.4.8 West Liquid Cross-Site Senders

The current strategy is to use Tank SY-101 as the 200 West liquid cross-site tank. Tank SY-101 will be equipped with a typical transfer pump, allowing only liquid transfers to be made. Tank SY-101 receives decanted supernate from the two other 200 West Area DSTs, SY-102 and SY-103, as these tanks build up solids. Tank SY-101 also receives liquid waste from the 222-S Laboratory as needed. Collected supernate in Tank SY-101 is transferred through the supernate cross-site transfer line to a LAW feed staging tank in the 200 East Area, followed by a 24-kgal flush.

4.5 SLURRY HANDLING

4.5.1 High-Level Waste Feed

DSTs will be needed to store waste slurries delivered to the WTP HLW feed receipt tank. The strategy used in the DST system is to secure individual DSTs that will be dedicated to this role, equipped with two mixer pumps capable of incremental lowering into the waste and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps. The operation of the mixer pumps and transfer pumps will need to be incorporated into the tank farms DSA (RPP-13033). The current operating scenario indicates that four dedicated HLW feed DSTs can keep the WTP HLW feed receipt tank fed and avoid HLW glass production outages due to lack of available feed. HLW feed tanks will receive slurries from HLW feed staging tanks and supernates from LAW feed staging tanks to create a blended waste that will meet feed delivery specifications for solids and sodium content.

It is assumed that the DST can deliver batches of HLW feed until the tank has just 72 in. (198 kgal) of waste remaining (Appendix B, Section B2.5). Below 72 in., the speed of the mixer pumps must be reduced to prevent pump cavitation, which will cause some of the solids to settle and change the composition of the feed to be transferred. Therefore, when a full 120-kgal batch of HLW feed cannot be delivered to the WTP HLW feed tank without leaving at least 72 in. of waste in the DST, the current campaign will end and another will begin using another DST dedicated to the HLW feed function. This new tank will become the source of the next group of HLW feed batches, and the emptied HLW feed DST will be refilled with more slurry and supernate to create a tank of HLW feed for a future campaign of HLW feed batches. The slurry in the heel remaining in the tank will provide a modest amount of incidental blending with the next transfer of waste solids pumped into the tank. The steps performed in the HLW feed function will be under control of a future process control plan.

The volume of each HLW feed batch that is delivered, and the mass of solids per unit volume, will be directly controlled to meet limits set for HLW feed deliveries based on samples taken from the HLW feed tank and the DSTs that will be transferring into it. The depth of solids in the HLW feed tank, both before and after transfers, will be measured by a sludge weight or other means. The bulk density, solution pH, and the relationship of solids-to-sodium concentration are controlled indirectly through the control of solids concentration in delivered feed and maintenance of tank chemistry for tank corrosion control. Screening for CSLs, feed envelope concentrations, and HGR will be performed for samples taken once the HLW feed tank has been filled and mixed. The sources of the various waste acceptance criteria requirements and their limits for the various parameters are presented in Table 4-1. 24590-WTP-RPT-MGT-04-001, *Regulatory Data Quality Objectives Optimization Report*, requires a minimum of ten grab samples to complete the regulatory compliance testing for each feed tank.

However, the quantity of samples required to demonstrate compliance with the waste acceptance criteria DQO action limits is uncertain at this time. The plan is to minimize this uncertainty and to minimize the number of samples needed to demonstrate compliance.

Mixing waste to provide representative samples and consistent feed to the WTP is a key issue being managed through the Risk Management Program. The amount of time that a DST will need to be mixed to provide representative samples and consistent feed is uncertain at this time. Mixing demonstration tests are currently underway (described in Section 2.8.8) and may provide some answers to these uncertainties. Use of a sample loop or similar technique will need to be integrated into the transfer system of the tank to facilitate acquisition of feed samples for feed certification purposes. The techniques used will need to be evaluated to determine if they meet sampling and analytical requirements. The operation of the sample loop will need to be incorporated into the tank farms DSA (RPP-13033).

Control schemes will need to be developed for waste temperature upon delivery, critical velocity in transfer lines, slurry viscosity, PCB and ammonia concentrations, unit dose rate, separable organics,[70] total organic carbon, and solids settling rate.

Projected upgrades of the electrical and ventilation systems in the DST farms will support concurrent operation of four mixer pumps and one slurry transfer per farm. This scenario may occur when a slurry transfer is being performed for waste staging or delivery while the mixer pumps in another tank within the same farm are operating to prepare for sampling or other purposes. Since the AY and AZ Farms share common electrical and ventilation systems, these two farms are considered as one in regard to the limitations due to electrical and ventilation system capacity (SVF-1805, *Electrical Power Needs Projection for WFD & SST Retrieval*).

4.5.2 High-Level Waste Feed Staging

Waste slurries from retrieved SSTs are moved into 200 East Area DSTs prior to transfer into the dedicated HLW feed tanks that will deliver HLW feed to the WTP. The strategy used will be to secure DSTs dedicated to this slurry handling role that are equipped with two mixer pumps capable of incremental lowering into the waste, and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps. Solids retrieved from SSTs into the DST system will be routed to a HLW feed staging tank until it is full. Once full, the amount of solids present is assessed and if the amount of solids is too low to make adequate HLW feed, the supernate is decanted to an available LAW feed staging tank to generate additional space.
The process is repeated, with the tank receiving more slurry until the depth of settled solids in the tank approaches 70 in.

Controls will be in place to maintain the settled solids level below 70 in. in depth; however, if the level goes above that, the tank will operate as a deep sludge tank (Section 4.5.3) until the settled solids depth can be reduced to below 70 in. again. This control of the settled solids level serves two primary purposes: (1) to prevent the tank from becoming a deep sludge tank, and (2) to control the solids loading in the HLW feed tanks downstream by controlling the contents transferred to them.

[70] It is not known if mixer-pump operations would allow a low-density separable organic layer to be entrained by the slurry transfer pump.

The mass of solids per unit volume will be controlled directly to limit the depth of settled solids based on samples taken from the HLW feed staging tank and the DSTs that will be transferring into it. The depth of solids in the HLW feed staging tank, both before and after transfers into it, will be measured by a sludge weight or other means. Use of a sample loop or similar technique will need to be integrated into the transfer system of the tank to facilitate acquisition of feed samples for feed characterization purposes. The techniques used will need to be evaluated to determine if they meet sampling and analytical requirements.

Once the HLW feed staging tank contains an adequate amount of solids, it becomes an available source of slurry for an available HLW feed tank. When a HLW feed tank reaches a waste level that precludes sending a full HLW feed batch, available HLW feed staging tanks may be tapped to supply a blend of different waste solids to refill the HLW feed tank. This blending has the potential to increase the WOL in the resulting HLW glass, reducing the total mass of glass produced. The sampling performed to monitor the depth of solids in the HLW feed staging tank will also be designed to characterize the waste for use in planning waste blending strategies. If these samples prove inadequate for this purpose, additional samples will be taken to provide the needed characterization information. The steps performed in the HLW feed staging function will be under control of a future process control plan.

A HLW feed staging tank can transfer slurries with the mixer pumps running until only 36 in., 99 kgal, of waste remains (Appendix B, Section B2.5). However, the speed of the mixer pumps must be reduced once the waste level drops below 72 in., 198 kgal, to prevent cavitation, which will likely lower the concentration of solids in the slurry transferred from the tank once the tank level drops to this point during a transfer. The slurry in the heel remaining in the tank will provide a modest amount of incidental blending with the next transfer of waste solids to be pumped into the tank.

4.5.3 Deep Sludge

Deep sludge tanks are DSTs that contain a settled solids depth greater than 70 in. DSTs may become classified as deep sludge either by the addition of more solids to a tank than expected from precipitation, misrouting, etc.; by design when tank space is limited; or when driven by progress milestones such as C Farm sludges stored in Tanks AN-101 and AN-106. Deep sludge DSTs will be equipped with two mixer pumps capable of incremental lowering into the waste and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps. The increased depth of solids in deep sludge tanks requires extra scrutiny due to potential flammable gas and heat load issues. Additional operations and time will be necessary in the field related to adjusting the height of the mixer and transfer pumps in the tank.

As discussed in Section 2.8.2, the System Plan (Rev. 6) and the IWFDP assume successful implementation of sludge-specific BDGRE controls that allow for accumulations of up to 250 in. of settled sludge, with no restrictions on supernate depth other than the maximum operating level for the DSTs in question.

The increased depth of sludge in deep sludge tanks will produce additional heat load from radioactive decay and will inhibit heat dissipation from the sludge to a greater extent than a tank with a lesser depth of sludge. The tank and waste temperatures will be monitored and will need to be maintained within the limits specified in the DST operating specifications (OSD-T-151-00007).

The mixer pumps will need to be raised above their lowest position in the tank to allow for mobilization of the solids. This elevated position reduces the effectiveness in mixing the entire tank because the pump nozzles will not be effective in moving solids from the bottom of the tank. In addition, changing the elevation of the mixer and transfer pumps is expected to be a challenging, multi-crane operation that will require significantly more time to reconfigure equipment than a typical change in routing. The design of the incremental lowering system for the mixer pumps allows a maximum vertical stroke range of 12 ft (Appendix B, Section B2.6). Based on this, the maximum level of sludge within a DST that can be mobilized by the mixer pumps is just over 200 in. in depth. If the sludge height is greater than this, another form of retrieval, such as enhanced sluicing, will be required to reduce the depth of the sludge to approximately 200 in. Once this is done, the mixer pumps can then be used to mobilize the top layer of sludge in the DST.

An additional concern is the elevated mixer pump positioning required in deep sludge tanks for DSTs in the AY and AZ Farms. These tanks contain air-lift circulators and other in-tank equipment that may be damaged by excessive mixer-pump operation, a concern that is exacerbated when the mixer pumps are elevated above their lowest position (Appendix B, Section B2.4).

Based on these limitations and concerns, the strategy regarding deep sludge tanks will be to minimize their creation when possible. The creation and mitigation of deep sludge tanks, incremental lowering performance of the mixer pumps, and mixer pump operation in elevated positions will need to be incorporated into the tank farms DSA (RPP-13033).

4.5.4 Metered Zirconium Solids

Feed batches with high quantities of zirconium from Tanks AW-103 and AW-105 have been found to limit HLW glass loading. The solids in these tanks will be specifically metered out to distribute the zirconium into more HLW feed tanks to minimize this limitation. The strategy used to accomplish this is to first transfer most of the solids from Tank AW-105 into Tank AW-103, leaving a slurry heel in Tank AW-105 that is then blended with other solids to become early HLW feed batches. The mass of solids in Tank AW-103 is then evenly divided or metered out to HLW feed tanks to distribute the remaining high-zirconium solids to successive HLW feed batches. A sampling strategy will need to be developed to confirm the blending of high-zirconium solids is successfully achieved. Tanks AW-103 and AW-105 will be equipped with two mixer pumps capable of incremental lowering into the waste and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps. As the current sludge volumes of both Tanks AW-103 and AW-105 are greater than 70 in. in depth, operations within each of these tanks will follow the same limitations placed on deep sludge tanks (Section 4.5.3) until the settled sludge depths are reduced to 70 in. or less.

4.5.5 Tank C-104 Blending

Tank C-104 sludge contains a relatively high concentration of fissile ^{233}U that must be mixed with wastes containing a lower concentration of fissile uranium prior to transfer to the WTP. This condition requires the waste to be included on the feed control list (HNF-SD-WM-OCD-015).

More than 90 percent of the Tank C-104 sludge has been retrieved into Tank AN-101.[71] Sludge from Tanks C-112, C-101, C-111, and C-105 are also planned to be retrieved into Tank AN-101 on top of the Tank C-104 sludge. The blending strategy is to first transfer the top layers of low-fissile sludge from Tank AN-101 to an available DST, then transfer half of the original Tank C-104 sludge to another available DST, leaving half of the original Tank C-104 sludge in Tank AN-101. Finally, some of the low-fissile sludge layers removed from Tank AN-101 are transferred back to the DSTs containing the original Tank C-104 sludge. This process creates two DSTs with sufficiently low-fissile blending stock to mitigate the uranium enrichment issue. This process is described in detail in RPP-RPT-43828.

This blending strategy will require full-length core samples to characterize the layering of solids in Tank AN-101. The information gleaned from the core samples will be used to refine the plan for blending away the high-fissile uranium. Sample information from other DST sludges available during the time when the Tank C-104 blending is to occur should be examined, as it may indicate additional improved blending material to mix with the Tank C-104 sludge. The Tank C-104 blending operation will need to be incorporated into the tank farms DSA (RPP-13033).

4.5.6 West Slurry Cross-Site Senders

DSTs in the 200 West Area are needed to receive and store SST wastes being retrieved. These DSTs are then used to transfer the waste slurries from 200 West Area DSTs via the cross-site slurry line. The current strategy is to use Tank SY-102 and Tank SY-103, after it is mitigated and no longer a Waste Group A tank, to receive waste from the 200 West Area SSTs, and then send the waste as a slurry to 200 East Area through the cross-site slurry line (SLL-3160) to a 200 East cross-site receiver. The solids content in cross-site slurry transfers will be controlled using in-line dilution, if necessary, to prevent the creation of a deep sludge tank in the downstream tank. Following a transfer, the cross-site slurry line will be flushed with 24 kgal of inhibited water.

4.5.7 East Slurry Cross-Site Receivers

Tanks in the 200 East Area are needed to receive slurries from the 200 West cross-site senders via the cross-site slurry line. The current configuration of the cross-site slurry line (SLL−3160) connects the SY Farm DSTs in the 200 West Area with a direct drop into riser 010 of Tank AN-104. A project is proposed to tie into SLL-3160 in the AN Farm and provide the capacity to send the slurry to any AN Farm tank, except Tank AN-107.[72] The current strategy is to mitigate Waste Group A Tank AN-104 early in the mission and then repurpose it to serve as the cross-site slurry receiver tank to collect slurries from the 200 West Area. The other AN Farm tanks that can serve as cross-site slurry receivers are considered to be in reserve in case Tank AN-104 cannot be used.

[71] The bulk retrieval of Tank C-104 was completed (to the limits of the initially deployed waste retrieval technology [modified sluicing]) on June 17, 2011 per WRPS-1102627 (Dunning 2011). The remaining waste in Tank C-104 is now considered heel, and exploration into retrieval options for the heel are underway.

[72] Tank AN-107 is excluded from the proposed project because it contains air-lift circulators that would hinder solids removal if used to receive slurries.

4.5.8 Complexed Concentrate Storage

The waste in Tanks AN-102 and AN-107 contain complexed concentrate waste. This waste needs to be segregated per the feed control list (HNF-SD-WM-OCD-015) until it can be pretreated within the DST system. The strategy for storing the complexed concentrate waste is to maintain the waste in Tanks AN-102 and AN-107 until strontium and TRU elements can be precipitated. The degradation of the complexants in these tanks is a consumer of hydroxide beyond consumption due to contact with ventilation air, and therefore caustic additions to maintain tank chemistry controls may be required more frequently.

4.5.9 Complexed Concentrate Strontium/Transuranic Precipitation

The complexed concentrate wastes stored in Tanks AN-102 and AN-107 contain soluble ^{90}Sr and TRU elements that will require removal prior to vitrification to comply with the WTP ILAW feed specification and with the 1997 agreement with the NRC on incidental waste (Paperiello 1997). RPP-24809, *Strontium and TRU Separation Process in the DST System*, recommends performing the removal of ^{90}Sr and TRU elements from the supernate by transferring the supernates into another DST, adjusting the sodium concentration, and precipitating the ^{90}Sr and TRU elements using strontium nitrate and sodium permanganate, respectively. This existing flowsheet targets Tank AP-102 as the tank to perform the precipitation in, which is currently intended to be used only for LAW functions. The current strategy is to precipitate the ^{90}Sr and TRU elements using the chemistry in the existing flowsheet, but using an unspecified DST that is equipped to handle HLW slurries for the precipitation. The flowsheet will need to be updated to direct the precipitation step towards a suitable DST, and controls on the handling of the treated supernate and the precipitated solids need to be developed and established to ensure that during the time period between precipitation and delivery to WTP, the ^{90}Sr and TRU elements do not become significantly re-solvated. This function will be under control of a future process control plan and will need to be incorporated into the tank farms DSA (RPP-13033).

In RPP-RPT-48340, *Evaluation of Alternative Strontium and Transuranic Separation Processes*, several alternative strontium and TRU separation processes were compared against the baseline process identified in RPP-24809. The separation processes were evaluated against each other for separation efficiency, processing conditions, and impact to schedule. The findings of this study support the baseline process over the alternatives.

The study also recommended further testing and evaluation of performing the precipitation step in Tanks AN-102 and AN-107 directly, instead of relying on an additional empty and available DST to perform the precipitation step. Further studies will be needed to determine the preferred reagents, concentrations, timing, and stability of the precipitated components, and to ascertain whether the process can be performed in-tank or if an additional DST will be required. A refined flowsheet will need to be developed based on the study. If the studies reveal that the process can be done in the source tanks, it is conceivable that the treatment could be performed in the near-term while awaiting WTP startup.

4.6 DEDICATED EMERGENCY SPACE

The current strategy is to allocate 1.265 Mgal[73] of DST space for tank farms emergencies and/or emergency returns from WTP. The emergency space is distributed tank space that is available at all times. It is not practical to keep one entire tank empty for emergency space because that would inhibit DST utilization and WFD staging efforts. Currently, Tank AW-105 is the candidate for the bulk of the emergency space. After Tank AW-105 is committed to HLW feed staging duty, the available emergency space will move around between tank farms. There is currently approximately 725 kgal of dedicated space available in Tank AW-105 for emergency use. If needed, any additional space would be distributed among one or more other DSTs with available space. The HTWOS model controls and manages the emergency space projections, as documented in HNF-SD-WM-SP-012. Additionally, Tank AW-102 has been identified as the receiver tank in the event a leak is detected in Tank AW-105 (HNF-3484, *Double-Shell Tank Emergency Pumping Guide*).

[73] The value for the emergency space allocation is based on the maximum volume of waste that can be stored in an AP Farm DST (OSD-T-151-00007).

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5.0 ISSUES AND UNCERTAINTIES

This section presents the issues and uncertainties directly associated with and originating from the WFD process strategy, which will be considered in future revisions of the TOC Risk and Opportunity Management Plan (TFC-PLN-39).

The issues and uncertainties for WFD and the originating assumptions or assertions are presented in Table 5-1 along with a selection of potential mitigating actions. The status of each potential mitigating action is shown in parenthesis following the action statement. This revision of the IWFDP uses three status categories identified as: Planned – Ongoing or Planned – Future, Undetermined, or Refinement.

- **Planned** (ongoing or future) is used to denote that the potential mitigating action is explicitly included within the scope of one or more work breakdown structure elements of the PMB.
- **Undetermined** signifies that the potential mitigating action does not appear to be explicitly addressed within the scope of any work breakdown structure element, and further evaluation is required to determine if the potential mitigating action is indeed part of the PMB scope.
- **Refinements** are improvements to either the operating scenario or to the HTWOS modeling and analysis capabilities that may influence other activities in the PMB; refinements are generally within the routine scope of the system and WFD planning efforts.

Table 5-1 also provides the TOC risk detail numbers, as defined in TFC-PLN-39, associated with each issue identified in this volume of the IWFDP. The listed TOC risk detail numbers are not meant to be all-inclusive or capture every interaction, but provide a crosswalk to some of the primary TOC-level risks that apply to the issues identified in this IWFDP volume. Additional details of the key issues and uncertainties, potential mitigating actions, and status are presented in TFC-PLN-39. Table 5-1 will be updated as the WFD strategy evolves, as existing issues are mitigated, and as new issues or uncertainties emerge.

Table 5-1. Issues/Uncertainties and Mitigating Actions (7 pages)

Item	Assumption/assertion	Issues and uncertainties	Potential mitigating actions (*status category*)	Comments	TOC risk detail number[a]
1	Early WFD to WTP is consistent with hot commissioning planning.	WTP capacity operations for HLW and LAW during hot commissioning have not been demonstrated.	• Develop a more detailed schedule for hot commissioning activities, including size and timing for delivery of waste feed (*Refinement*) • Align the timing, quantities, and types of waste feed delivered during hot commissioning with WTP planning assumptions to meet Consent Decree Milestone A-1, "Achieve initial plant operations for the Waste Treatment Plant"[b] by December 31, 2022 (*Refinement*)		TOC-08-140 TOC-12-019 TOC-12-079
2	Tank waste blending impacts the amount of IHLW produced by WTP.	The current strategy involves waste blending to minimize HLW glass mass; however, blending to maximize waste throughput, or blending to reduce waste variability to improve operations, may be more prudent.	• Conduct additional studies and testing, as needed, to determine and develop the most beneficial blending strategy (*Undetermined*)	Blending recommendations documented in RPP-RPT-49398[c] were implemented within the operating scenario of System Plan (Rev. 6).[d]	TOC-08-152 TOC-12-151 TOC-08-126
3	The 242-A Evaporator will be available to manage DST space throughout the mission. Dilute waste will be concentrated if at least a 15 percent waste volume reduction is achievable, until it reaches a bulk concentration of 1.43 g/ml or 80 percent of the maximum product source term.	An unplanned outage of the 242-A Evaporator, especially in the near-term when DST space is limited (before 2025), may negatively impact WFD and SST retrievals. If the assumed concentration cannot be achieved, on average, through 2025, then less DST space will be available to support SST retrievals and WFD.	• Development of the WFE may enhance DST space management and mitigate a potential failure of the 242-A Evaporator (*Planned – Future*) • Consider coordination of 242-A Evaporator upgrades and maintenance activities to minimize the impact of outages (*Planned – Ongoing*)	The WFE is in the development phase and is following the WFE Technology Maturation Plan (RPP-PLAN-43339[e]). The consequences of various 242-A Evaporator failure scenarios and the potential for mitigation of these scenarios using the WFE were evaluated and documented in RPP-RPT-50812[f] and RPP-RPT-50804.[g]	TOC-01-010 TOC-12-008
4	Waste transfers are consistent with the Waste Compatibility Program requirements.	The current program focuses on DST-to-DST transfers, and not DST-to-WTP transfers. Not all waste compatibility program requirements are explicitly addressed or screened during system and long-term planning. During operational planning and control, a waste compatibility assessment might determine that a proposed transfer is inconsistent with the Waste Compatibility Program requirements. This would then require an unplanned change to the operating scenario.	• Expand program to include DST-to-WTP transfers (*Undetermined*) • Expand planning to reflect more waste compatibility controls (*Refinement*) • Incorporate lacking requirements into future baseline operating scenarios when adequate predictive capability is available to reduce the number of unplanned changes to the operating scenario (*Refinement*)		TOC-12-019 TOC-12-065
5	SST retrievals support WFD.	Current planning for SST retrievals includes two phases of retrieval for some tanks, bulk retrieval and hard heel retrieval, separated by upgrades. This two-phase retrieval system strategy may be increasingly inefficient to implement. The overall projected SST retrieval rates and operating efficiencies require improvements to provide sufficient waste to allow efficient WTP operations.	• Conduct further planning for SST retrieval schedules and methods to optimize retrieval efficiency (*Planned – Ongoing*)	Development and deployment of a mobile arm retrieval system is currently underway in Tank C-107 to retrieve SST waste more efficiently and effectively than previous methods. The current OR model for the tank farms, after expansion to include SST retrievals, will be used to identify improvements needed to meet the overall retrieval rates and operating efficiencies	TOC-02-032 TOC-02-037 TOC-02-038 TOC-02-039 TOC-02-072 TOC-08-139

Table 5-1. Issues/Uncertainties and Mitigating Actions (7 pages)

Item	Assumption/assertion	Issues and uncertainties	Potential mitigating actions (*status category*)	Comments	TOC risk detail number[a]
6	Solid-liquid partitioning impacts planning for transfers and evaporator operations.	Current waste phase equilibriums are approximated for most constituents by limited experimental data and simple split factors.	• Replace the water wash and caustic leach factors with more sophisticated solubility correlations (*Refinement*) • Improve the existing correlations (*Refinement*)	Work is currently underway to replace the water wash and caustic leach factors with more sophisticated solubility correlations and to improve on the existing correlations. Preliminary work is expected to be completed in 2011 and implemented in 2012.	TOC-02-039 TOC-12-019
7	Waste Group A tanks are restricted from having waste transferred into or out of them until they are mitigated and reclassified.	The mitigation strategy has not progressed beyond a draft flowsheet.	• Develop mitigation strategy, and update the tank farms DSA[h] (*Undetermined*)		TOC-01-005
8	The high concentration of fissile uranium from Tank C-104 (retrieved to Tank AN-101) will be blended prior to transfer to the WTP.	The mitigation strategy has not progressed beyond preliminary calculations and conceptual design.	• Characterize the layering of solids in Tank AN-101 using full-length core samples and examine potential additional blend stock to refine blending plan (*Undetermined*)		TOC-12-019
9	The complexed concentrate wastes stored in Tanks AN-102 and AN-107 containing soluble ^{90}Sr and TRU elements will be removed from the supernate prior to WFD.	The current strategy requires use of an additional DST to complete the precipitation steps. There are currently no controls in place to ensure that the ^{90}Sr and TRU elements do not re-solvate during the time between precipitation and delivery to WTP.	• Conduct further studies to determine the preferred reagents, concentrations, timing, and stability of the precipitated components, and ascertain whether the process can be performed in-tank or if an additional DST will be required (*Undetermined*)	A study was conducted to compare various methods of complexed concentrate mitigation; conclusions are documented in RPP-RPT-48340.[i] A development test plan was recently completed for the strontium/TRU precipitation process, documented in RPP-PLAN-51288.[j]	TOC-02-019
10	Criteria have been established to prevent new tanks from potentially being at risk to BDGREs based on low shear-strength salt slurries.	Using existing BDGRE controls may be overly conservative for high shear-strength sludge waste, potentially decreasing the total available space available to fill a DST.	• Update criteria for predicting BDGRE behavior in tanks containing high shear-strength sludge waste and establish new DST fill limits for associated tanks (*Planned – Ongoing*)	Updated criteria for predicting BDGRE behavior in tanks containing high shear-strength sludge waste have been identified (RPP-RPT-26836[k]), but the new sludge-specific BDGRE criteria have not yet been demonstrated or incorporated into the tank farms safety basis. A document is being prepared that describes the approach for implementing a new safety basis to prevent BDGREs in high-shear sludge wastes.	TOC-01-005
11	WFD activities will be consistent with temperature constraints established by the Tank Operations Contractor and WTP.	Maintaining waste temperatures below established limits may limit mixer pump operations and impact WFD. Some tanks may have to be pre-cooled prior to operating the mixer pumps to lower their initial temperature so that the mixed supernate temperature will not exceed the waste feed temperature criterion of 150°F for HLW feed. This may impact operational flexibility within the tank farms.	• Conduct thermal analysis and full-scale mixing demonstration to provide data for the mixer pump impact on the temperature of waste, allowing controls to be developed (*Undetermined*) • Use system model to predict worst-case thermal build-up of waste to be mixed and transferred (*Undetermined*) • Use models developed to determine the pre-cooling times required based on actual tank contents and atmospheric conditions for the time period the mixer pumps are to be started in each tank (*Undetermined*)	A mixer pump test was completed in Tank AZ-101 (2001). No additional full-scale in-tank mixer pump tests have been conducted since the Tank AZ-101 test. Thermal hydraulic evaluations were completed for the following tank farms: • AN Farm (RPP-7171[l]) • AW Farm (RPP-11731[m]) • SY Farm (RPP-43971[n]) • AP Farm (RPP-45912[o]) • AY and AZ Farms (RPP-49579[p]).	TOC-12-019 TOC-12-066

Table 5-1. Issues/Uncertainties and Mitigating Actions (7 pages)

Item	Assumption/assertion	Issues and uncertainties	Potential mitigating actions (*status category*)	Comments	TOC risk detail number[a]
12	HLW and LAW feed delivered to the WTP will meet established waste acceptance criteria action limits necessary for safe and compliant feed receipt.	ICD-19[q] and the waste acceptance criteria DQO[r] are not in their final state, and the intended role of Specification 7 and Specification 8[s] in the waste acceptance process is evolving. Uncertainty exists in the ability to meet all items in the waste acceptance criteria DQOs. Uncertainty exists in the ability to meet all Specification 7 and 8 requirements. Process control schemes for PCBs and ammonia concentrations, critical velocity in transfer lines, supernate viscosity, unit dose rate, separable organics, total organic carbon, temperature change, and the solids settling rate have not been developed.	• Use the DQO process to complete the waste acceptance criteria DQO.[r] If necessary, use the Flowsheet IPT and processes described in the WTP Interface Management Plan[t] to update ICD-19[q] and the WTP Contract[u] to (1) establish consistency in feed requirements between the documents, and (2) ensure a workable set of requirements given that the waste already exists (*Planned – Ongoing*) • Develop process control schemes, and complete waste compatibility assessments and process control plans to ensure that requirements are met (*Undetermined*) • Develop a contingency plan for potential hard-to-mitigate, non-compliant waste feed batches (*Undetermined*)		TOC-12-019 TOC-12-065
13	Slurry mixer pumps have the ability to achieve sufficient mixing in a DST to limit variability between WFD batches. A remote sampler installed on the transfer pump recirculation loop is able to obtain representative waste samples to satisfy the DQOs for meeting the WTP waste acceptance criteria within the confidence requirements for safety and mission success. The delivered waste feed is representative of the bulk tank contents.	The ability of the DST mixer pump system to adequately suspend and homogenously distribute the HLW solid particles within a full-scale DST is uncertain, as is the ability to obtain representative samples of the mixed waste. Erosion of mixer pump internal components may degrade mixing performance or cause premature failure of the pump. Uncertainty exists in the ability to deliver waste that is representative of the bulk tank contents. Uncertainty exists regarding the maximum sludge depth that can be mobilized, and the ability of the mixer pumps to restart when submerged in solids.	• Complete work to determine the capability, through the mixing and sampling program, to adequately mix, sample, and characterize waste (*Planned – Future*) • Conduct studies to evaluate the impact of mixer pump erosion (*Undetermined*) • Consider using grab sampling and core sampling techniques in the event that the remote sampler and recirculation loop are inadequate for sampling waste feed (*Undetermined*) • Make accommodations when developing the process control plan for feed batches where there is a consistent bias in solids concentration or composition in the delivered feed (*Undetermined*) • Expand the scope of the Small-Scale Mixing Demonstration Program to include evaluating the ability of the mixer pumps to mobilize sludge depths greater than or equal to 70 in. (*Undetermined*) • Verify, during simulant testing, the ability of the mixer pumps to startup when submerged in solids (*Undetermined*)	Mixing and sampling tests were accelerated using ARRA funding. Initial results demonstrate representatively bounding sampling can be achieved for the hot commissioning feed in Tank AY-102. Some uncertainties remain and will be addressed in FY 2012.	TOC-12-064 TOC-12-066 TOC-12-067 TOC-12-146
14	A process control sample will be taken prior to each HLW batch delivered to WTP to confirm sodium and solids concentration.	This will increase the required total operational time for mixer pumps per HLW feed campaign, which may complicate feed temperature control and may increase mixer pump wear.	• Confirm the need for the assumed process control samples (*Undetermined*)		TOC-12-019 TOC-12-064

Table 5-1. Issues/Uncertainties and Mitigating Actions (7 pages)

Item	Assumption/assertion	Issues and uncertainties	Potential mitigating actions (*status category*)	Comments	TOC risk detail number[a]
15	Each DST in the WFD system will have the capability to perform various WFD functions based on its equipment configuration.	Mixer pump use in AY and AZ Farms may be limited due to in-tank equipment fatigue issues. These tanks may not support deep sludge using incremental lowering of the mixer pumps due to exacerbated stresses on the in-tank equipment when the mixer pumps are raised up from their lowest position in the tank. Evolving mission architecture/configuration changes may require changes in DST assignments.	• Place run-time limits on mixer pump use in the AY and AZ Farms (*Refinement*) • Minimize the creation of deep sludge tanks as much as possible (*Refinement*)	The rationale and basis for DST capability is being developed. The incremental lowering capability may be removed from the AY and AZ Farm tanks in the future due to these tank limitations.	TOC-12-066 TOC-12-078 TOC-12-086 TOC-12-146
16	There will be two DSTs dedicated as LAW feed tanks.	WFD to WTP may be limited by only having two dedicated LAW feed tanks if an upset event occurs in either tank.	• Allocate additional tanks to the LAW feed tank function to potentially mitigate a lack of contingency feed (*Refinement*)		TOC-12-067 TOC-12-078
17	Evaporator slurry receivers receive evaporator bottoms from the 242-A Evaporator as concentrated slurry.	242-A Evaporator bottoms may experience temperature drops and precipitation of solids during transfer to evaporator slurry receivers.	• Select evaporator slurry receivers to minimize the risk of temperature drops and solids precipitation (*Refinement*)	AW and AP Farm DSTs have been selected as evaporator slurry receivers due to proximity to the evaporator (reduces temperature drop and precipitation) and diameter of transfer lines (allows higher velocity to keep solids suspended).	TOC-12-008
18	Tank SY-103 is currently a Waste Group A tank.	The flowsheet for Waste Group A tanks does not address Tank SY-103.	• Develop mitigation strategy, and update the tank farms DSA[h] (*Undetermined*)	The strategy to mitigate Tank SY-103 is to decant off the supernate using in-line dilution with water and transfer the diluted waste to a 200 West liquid cross-site tank (SY-101). Water will be added and mixed with the remaining waste (saltcake) to dissolve the solids and will then be transferred to a 200 West liquid cross-site tank.	TOC-01-005
19	Implementation of sludge-specific BDGRE controls allow for accumulations of up to 250 in. of settled sludge with no restrictions on supernate depth other than the maximum operating level for the DST.	The increased depth of solids in deep sludge tanks requires extra scrutiny due to flammable gas and heat load issues. Additional operations and time will be necessary in the field related to adjusting the height of the mixer and transfer pumps in the tank. Existing BDGRE controls are more conservative than new controls currently being developed. A discrepancy between the WTP and Tank Operations Contractor flammable gas control strategy may develop if revised flammable gas criteria are implemented by the Tank Operations Contractor.	• Minimize the creation of deep sludge tanks as much as possible (*Refinement*) • Equip deep sludge DSTs with two mixer pumps capable of incremental lowering and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps (*Undetermined*) • Reconcile the disparity between WTP and Tank Operations Contractor flammable gas control strategies (*Undetermined*)	The Baseline operating scenario assumes that deep sludge DSTs are equipped with two mixer pumps capable of incremental lowering and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps.	TOC-01-005 TOC-12-146

Table 5-1. Issues/Uncertainties and Mitigating Actions (7 pages)

Item	Assumption/assertion	Issues and uncertainties	Potential mitigating actions (*status category*)	Comments	TOC risk detail number[a]
20	The high concentrations of zirconium contained in Tanks AW-103 and AW-105 will be metered out to distribute the zirconium into more HLW feed tanks for WFD.	Feed batches with high quantities of zirconium from Tanks AW-103 and AW-105 have been found to limit HLW glass loading.	• Equip Tanks AW-103 and AW-105 with two mixer pumps capable of incremental lowering and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps (*Undetermined*) • Develop a sampling strategy to confirm the blending of high-zirconium solids is successfully achieved (*Undetermined*)	The Baseline operating scenario assumes that Tanks AW-103 and AW-105 are equipped with two mixer pumps capable of incremental lowering and a transfer pump designed to withstand the forces placed on it during operation of the mixer pumps.	TOC-12-019 TOC-12-078
21	Waste Group A Tank AN-104 will be mitigated early in the mission and then repurposed to serve as the cross-site slurry receiver to collect slurries from the 200 West Area.	An unplanned event/outage of Tank AN-104 may delay waste transfers from the 200 West Area to 200 East Area.	• Secure other tanks to serve as potential cross-site slurry receivers in the event Tank AN-104 is unavailable (*Planned – Future*)	A project is proposed to tie into SLL-3160 in the AN Farm and provide the capability to send the slurry to any AN Farm tank except Tank AN-107, instead of directly into Tank AN-104.	TOC-12-013
22	1.265 Mgal of DST emergency space is allocated for tank farm emergencies and/or emergency returns from WTP.	Some of the dedicated space is in the 200 West Area, where it is not readily available.	• Develop a plan to preserve most of the required emergency space in the 200 East Area tank farms (*Refinement*) • As discussed in RPP-RPT-45825,[v] consider the use of sound SSTs[w] to provide emergency tank space or for staging waste; or waive the emergency tank space requirement and rely on the DST annulus liner in the event of a leak of the primary DST tank (*Undetermined*)	Tank AW-105 is the current candidate for the bulk of the emergency space. After Tank AW-105 is committed to a HLW feed staging function, the available emergency space is planned to move around between tank farms.	TOC-01-005
23	WFD equipment availability will support WTP operations without limiting melter throughput.	Current projections show multi-year delays due to equipment failures.	• Identify improvements needed for tank farms operations and maintenance processes using the OR model (*Planned – Ongoing*)	The current OR model is limited to major equipment failure points. Future development will encompass additional constraints.	TOC-12-001 TOC-12-004 TOC-12-006 TOC-12-067
24	DST assignments for WFD functional operations are appropriate to accomplish the RPP mission.	RPP-RPT-50361[x] indicates WFDs from AW Farm exceed operating limits on pressure drop when contingency for conservatism is applied.	• Minimize or eliminate the use of AW Farm DSTs as HLW feed tanks (*Refinement*)		TOC-12-066 TOC-12-078
25	WFD activities are consistent with the tank farms DSA.[h]	Several WFD activities currently lack DSA coverage: • Mixer pump operation/incremental lowering • Deep sludge tanks • Waste Group A tank mitigation • Operation of a sample loop • Precipitation of ^{90}Sr and TRU elements from complexed concentrate waste • Tank C-104 blending • Emerging issues • Unknown issues	• Develop a strategy to add outstanding WFD activities to the tank farms DSA[h] (*Undetermined*)		TOC-12-078

Table 5-1. Issues/Uncertainties and Mitigating Actions (7 pages)

Item	Assumption/assertion	Issues and uncertainties	Potential mitigating actions (*status category*)	Comments	TOC risk detail number[a]
26	Delivered feed should be balanced to facilitate optimum operation of the various treatment and pretreatment facilities. This generally means that the limiting facility or facilities are operating at or near their full capacities, the quantities of HLW and LAW glass are acceptable, and mission success criteria (e.g., treatment end date, SST retrieval completion date) are met.	The Baseline Case operating scenario in the System Plan (Rev. 6)[d] shows that the HLW Facility is underutilized through about 2025 due to limited LAW treatment capacity. The extent to which this is a WFD issue has not been determined.	• Determine how the quantity, composition, and timing of delivered feed influences the interactions between the WTP PT, LAW, HLW, and second LAW facilities; insight from these studies may lead to changes in the WFD process strategy or system-wide trade-offs (*Undetermined*) • As a near-term measure, consider reducing the concentration of sodium in the supernate associated with early HLW feed batches (*Refinement*) • Explicitly address in future operating scenarios the variations in HLW Facility and LAW Facility throughput due to periodic changeout of spent melters (*Refinement*)		TOC-05-134 TOC-08-017 TOC-12-019 TOC-12-078 TOC-12-079 TOC-08-126
27	The physical properties and composition of waste projected to be delivered to the WTP are compatible with WTP design calculations and safety analysis.	Recent studies have determined that large plutonium oxide particles may be present in some of the tank waste. These particles could potentially segregate from the lighter or smaller neutron absorbers during mixing operations in either the tank farms or at the WTP, invalidating assumptions in both CSERs.	• Update the tank farms CSER[y] to address the presence of large plutonium oxide particles (*Undetermined*) • Update the WTP CSER[z] to address the presence of large plutonium oxide particles (*Undetermined*) • Determine necessary corrective actions regarding WRPS waste retrieval and WTP mixing efforts (*Undetermined*) • Evaluate the impacts of those corrective actions on WFD, WTP operation, and the overall waste treatment mission (*Undetermined*)	This issue is a subset of issues identified in DNFSB Recommendation 2010-2.[aa] There are currently no planned or funded activities to support further evaluation of the plutonium oxide issue. Subsequently, there is a need to identify scope, schedule, and costs associated with anticipated studies and evaluations needed to resolve the issue. Plans are to begin this effort early in 2012 in anticipation of a rebaseline activity in FY 2013.	TOC-12-019

[a] TFC-PLN-39, 2011, *Risk and Opportunity Management Plan*, Rev. G, Washington River Protection Solutions, LLC, Richland, Washington.
[b] "Initial plant operations" is defined by the Consent Decree as "over a rolling period of at least 3 months leading to the milestone date, operating the WTP to produce high-level waste glass at an average rate of at least 4.2 metric tons of glass (MTG)/day, and low activity waste glass at an average rate of at least 21 MTG/day."
[c] RPP-RPT-49398, 2011, *High-Level Waste Blending in the Hanford Tank Waste Operations Simulator*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[d] ORP-11242, 2011, *River Protection Project System Plan*, Rev. 6, U.S. Department of Energy, Office of River Protection, Richland, Washington.
[e] RPP-PLAN-43339, 2009, *Wiped Film Evaporator Technology Maturation Plan*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[f] RPP-RPT-50812, 2011, *Analysis of River Protection Project Mission Impact Due to a Loss of the 242-A Evaporator*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[g] RPP-RPT-50804, 2011, *Analysis of River Protection Project Mission Impact Utilizing Wiped Film Evaporators in Strategic Locations*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[h] RPP-13033, 2011, *Tank Farms Documented Safety Analysis*, Rev. 4J, Washington River Protection Solutions, LLC, Richland, Washington.
[i] RPP-RPT-48340, 2011, *Evaluation of Alternative Strontium and Transuranic Separation Processes*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[j] RPP-PLAN-51288, 2012, *Development Test Plan for Sr/TRU Precipitation Process*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[k] RPP-RPT-26836, 2010, *Gas Retention and Release from Hanford Site High Shear Strength Waste*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[l] RPP-7171, 2007, *Thermal Hydraulic Evaluation for 241-AN Tank Farm Primary Ventilation System*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[m] RPP-11731, 2008, *Thermal Hydraulic Evaluation for 241-AW Tank Farm Primary Ventilation System*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[n] RPP-43971, 2010, *Thermal Hydraulic Evaluation for 241-SY Tank Farm Primary Ventilation System*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[o] RPP-45912, 2010, *Thermal Hydraulic Evaluation for 241-AP Tank Farm Primary Ventilation System*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[p] RPP-49579, 2011, *Thermal Hydraulic Evaluation for 241-AY and 241-AZ Tank Farm Primary Ventilation System*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
[q] 24590-WTP-ICD-MG-01-019, 2008, *ICD 19 – Interface Control Document for Waste Feed*, Rev. 4, Bechtel National, Inc., Richland, Washington.
[r] 24590-WTP-RPT-MGT-11-014, 2011, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria*, Rev. 0, Bechtel National, Inc., Richland, Washington.
[s] Specification 7 and 8 refer to Specification 7 (LAW envelopes definition) and Specification 8 (HLW envelope definition) contained within Section C of the WTP Contract (DE-AC27-01RV14136).
[t] 24590-WTP-PL-MG-01-001, 2011, *Interface Management Plan*, Rev. 5, Bechtel National, Inc., Richland, Washington.
[u] DE-AC27-01RV14136, 2010, *Design, Construction, and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*, (as amended through A164), U.S. Department of Energy, Office of River Protection, Richland, Washington.
[v] RPP-RPT-45825, 2010, *Tank Space Alternatives Analysis Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

Notes to Table 5-1 (continued)

[w] 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.

[x] RPP-RPT-50361, 2011, *Tank 241-AW-105 Waste Feed Delivery Preliminary Flowsheet*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[y] RPP-7475, 2008, *Criticality Safety Evaluation of Hanford Tank Farms Facility*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

[z] 24590-WTP-CSER-ENS-08-0001, 2009, *Preliminary Criticality Safety Evaluation Report for the WTP*, Rev. 0B, Bechtel National, Inc., Richland, Washington.

[aa] Winokur, P. S., 2010, Recommendation 2010-2 "Pulse Jet Mixing at the Waste Treatment and Immobilization Plant," (Letter to S. Chu, Secretary of Energy, U.S. Department of Energy, December 17), Defense Nuclear Facilities Safety Board, Washington, D.C.

ARRA = American Recovery and Reinvestment Act.
BDGRE = buoyant displacement gas release event.
CSER = criticality safety evaluation report.
DNFSB = Defense Nuclear Facilities Safety Board.
DQO = data quality objective.
DSA = documented safety analysis.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
FY = fiscal year.
HLW = high-level waste.
IHLW = immobilized high-level waste.
IPT = integrated project team.
LAW = low-activity waste.
OR = Operations Research.
ORP = U.S. Department of Energy, Office of River Protection.
PCB = polychlorinated biphenyl.
PT = pretreatment.
RPP = River Protection Project.
SST = single-shell tank.
TRU = transuranic.
WFD = waste feed delivery.
WFE = wiped-film evaporator.
WRPS = Washington River Protection Solutions, LLC.
WTP = Waste Treatment and Immobilization Plant.

6.0 PATH FORWARD

6.1 FUTURE REFINEMENTS

Several potential refinements have been identified throughout this iteration of the WFD planning process. The refinements listed below will be incorporated into future revisions of this IWFDP and System Plan baseline operating scenarios:

1. Incorporate minor changes (flush water requirements, maximum HLW batch size, etc.) captured through the issuance of ICD-19 (24590-WTP-ICD-MG-01-019, Rev. 5)
2. Replace the first-order approximation water wash factors used to estimate waste solubility behavior throughout the tank farms and WTP with enhanced solubility correlations for select components
3. Minimize or eliminate HLW feed deliveries from AW Farm to WTP
4. Incorporate waste acceptance criteria DQO screening of total organic carbon for waste batches delivered to WTP
5. Incorporate screening of potential phosphate gel formation for projected DST transfers
6. Align the timing, quantities, and types of waste feed delivered during hot commissioning with WTP planning assumptions to meet Consent Decree (2010) Milestone A-1, "Achieve initial plant operations for the Waste Treatment Plant"[74] by December 31, 2022
7. Align waste routing design[75] with WTP flowsheet planning.

6.2 LONG-TERM PLANNING

Future revisions of this IWFDP will include updates to planning assumptions for WFD, tasks completed to resolve existing issues and uncertainties, and emerging issues that arise during ongoing WFD planning activities. The following items must be completed to resolve the issues and uncertainties associated with the IWFDP:

1. Finalize waste feed requirements for waste acceptance
2. Align WFD planning with ongoing WTP hot commissioning planning
3. Complete tank waste mixing and sampling studies to demonstrate DST mixing, sampling, and transfer performance
4. Develop plans to sample and characterize each DST after they are filled with retrieved SST waste and prior to being used to prepare feed for the WTP. Characterization should establish liquid and solid composition, including vertical composition distribution of solids for deep sludge tanks, and waste particle size and density distributions.

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[74] "Initial plant operations" is defined by the Consent Decree as "over a rolling period of at least 3 months leading to the milestone date, operating the WTP to produce high-level waste glass at an average rate of at least 4.2 metric tons of glass (MTG)/day, and low activity waste glass at an average rate of at least 21 MTG/day."

[75] WTP has recently removed the capability of routing HLW from the HLW feed receipt vessel to the front-end evaporators within WTP to preclude transfer of waste with solids that may pose a mixing challenge to the evaporator vessels.

5. Update the tank farms and WTP CSERs to address the presence of large plutonium particles; determine necessary corrective actions regarding WRPS waste retrieval and WTP mixing efforts; and evaluate the impacts of those corrective actions on WFD, WTP operation, and the overall waste treatment mission
6. Conduct studies and testing to refine the waste blending strategy for systematic issues and problematic wastes
7. Explore alternative SST retrieval sequencing rules for potential improvements in meeting overall mission metrics and waste acceptance criteria
8. Continue evaluation and implementation, as appropriate, of DST tank waste management initiatives to increase useable storage space in existing SSTs per RPP-RPT-45825
9. Develop a suite of enhanced solubility correlations to supplant existing water wash and caustic leach factors
10. Complete the flowsheet for the Waste Group A mitigation strategy and update the DSA accordingly
11. Complete the flowsheet and testing of ^{90}Sr and TRU element removal from complexed concentrate tanks
12. Incorporate updated BDGRE criteria into the safety basis, conduct in-situ testing of deep sludge tanks, and evaluate effects on DST space and WFD operations
13. Reconcile the technical approach used for flammable gas evaluation limits in DSTs between the Tank Operations Contractor and WTP
14. Complete thermal analysis and full-scale mixing demonstration to develop a temperature control strategy for WTP feed
15. Complete the rationale and basis for specific DST equipment configuration and capabilities
16. Refine the methodology for retrieving waste from tanks with solids depths greater than assumed mixer pump mobilization capabilities
17. Complete development of the OR model and evaluate implications on WFD operations
18. Determine the limits of performance for the tank farms and WTP equipment with respect to the ability to mix, sample, and transfer waste solids; perform a gap analysis on associated limits and identify mitigating actions
19. Identify tank waste compatibility requirements that may be incorporated into future operating scenarios
20. Add screening capabilities for HLW and LAW glass specifications
21. Develop a strategy to add outstanding WFD activities, such as mixer pump operations, to the tank farms DSA (RPP-13033)
22. Conduct studies to determine the optimum feed balance required to allow WTP treatment facilities to operate closer to their full capacities
23. Explore the benefits and drawbacks associated with balancing feed based on compositional characteristics rather than feed type.

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APPENDIX A

GLOSSARY

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Term (abbreviation)	Definition or expansion
Aging Waste Tank	AY and AZ Farm double-shell tanks (DST) are designated as aging waste tanks. These DSTs were used historically to receive and store neutralized current acid waste from processing conducted at the Hanford Plutonium-Uranium Extraction (PUREX) Plant. Aging waste tanks are equipped with unique support systems beyond those in other DSTs, including condensers in the ventilation system, tank heating coils, and airlift circulators.
Baseline Case	In System Plan (Rev. 6),[a] 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	Intentional blending of HLW feed based solely on the availability of waste.
Buoyant-Displacement Gas Release Event (BDGRE)	Tank waste generates flammable gases through the radiolysis of water and organic compounds, thermolytic decomposition of organic compounds, and corrosion of the carbon steel tank walls. Under certain conditions, this gas may accumulate in a settled solids layer until the waste becomes hydrodynamically unstable (less dense waste near the bottom of the tank). A BDGRE is the rapid release of this gas, partially restoring hydrodynamic equilibrium. The release may result in the temporary creation of a flammable mixture in the headspace of the tank, depending on the size of the release relative to the capacity of the ventilation system.
Caustic Leach Factor	The fraction of an analyte in previously washed solids that will go into solution by caustic leaching. The term, caustic leach factor, as used in the Hanford Tank Waste Operations Simulator (HTWOS) model, is technically a differential caustic leach factor.
Complexed Concentrate (CC)	The term used for wastes with organic chelating agents that were used during strontium recovery operations at B Plant in the 1960s and 1970s. Waste was considered to be complexed concentrate if the total organic carbon concentration exceeded 10 g/L after concentration. Complexed concentrate has the potential to maintain strontium and transuranic elements in solution, requiring additional pretreatment steps prior to treatment and disposal. Tanks AN-102 and AN-107 are identified as complexed concentrate waste.
Cross-Site Transfer	The Hanford waste tanks are located in two physically separated areas called the 200 East Area and 200 West Area, about seven miles apart. The cross-site transfer system includes transfer pipelines and ancillary equipment that is used to transfer supernate and slurry from the 200 West Area to the 200 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]).
Envelope C	Tank waste that contains complexed concentrate, limited to Tanks AN-102 and AN-107.
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 would not have the potential for a spontaneous BDGRE.
High-Level Waste (HLW)	The fraction of the tank waste containing most of the radioactivity that will be immobilized into glass and disposed at an off-site repository. HLW includes the solids remaining after pretreatment plus certain separated radionuclides.

Term (abbreviation)	Definition or expansion
High-Level Waste (HLW) Feed	The slurry stream (sludge plus supernate) that is delivered to the WTP Pretreatment Facility. Any solids remaining after pretreatment are routed to the WTP HLW Vitrification Facility along with separated radionuclides.
Hanford Tank Waste Operations Simulator (HTWOS)	A dynamic event-simulation model that tracks waste as it moves through storage, retrieval, feed staging, and multiple treatment processes from the present day until the end of the River Protection Project (RPP) mission.
Hot Commissioning	The phase in which WTP does production runs using actual tank waste.
Incidental Blending	Blending of HLW that naturally occurs during the retrieval, staging, storage, and delivery of feed without any special effort other than single-shell tank (SST) sequencing. It is sometimes called unavoidable blending.
Inhibited Water	Process water that contains at least 0.01 M sodium hydroxide and 0.01 M sodium nitrite.
Intentional Blending	Any blending that is specifically orchestrated and, therefore, requires additional effort. Examples include pairwise blending (blending of 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.
Low-Activity Waste (LAW)	Waste that remains following the process of separating as much of the radioactivity as practicable from HLW. This stream is transferred from pretreatment to the WTP LAW Vitrification Facility for treatment.
Low-Activity Waste (LAW) Feed	The liquid stream (supernate plus a small amount of entrained solids) that is delivered to the WTP Pretreatment Facility. LAW feed is managed as HLW until it has been pretreated.
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*.[c] After treatment, low-level waste can be disposed in a near-surface facility.
Metered Blending	An intentional blending strategy that mixes small quantities (e.g., meters) of problematic wastes into successive feed campaigns.
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.
Operating Scenario	The current RPP mission scenario that forms the technical basis for both the near-term baseline and the out-year planning estimate range. For this version of the IWFDP, the operating scenario is the System Plan (Rev. 6)[a] Baseline Case.
Project Execution Plan (PEP)	The U.S. Department of Energy's core document for management of a project, which establishes the policies and procedures to be followed to manage and control project planning, initiation, definition, execution, and transition/closeout, and uses the outcomes and outputs from all project planning processes, integrating them into a formally approved document. A PEP includes an accurate reflection of how the project is to be accomplished, resource requirements, technical considerations, risk management, configuration management, and roles and responsibilities.

Term (abbreviation)	Definition or expansion
Projectized Operational Activity (based on Category 2 projectized operational activity)	Expense-funded activities (medium complex to complex) consisting of relatively long duration (months to years) work, which require a focused amount of planning and coordination between multiple organizations to develop performance baselines and accomplish project objectives and goals. These activities generally involve relatively minor impacts on the facility safety basis. They can require design and construction, and a system startup. This category may require a management self-assessment/ readiness assessment to begin operations and includes traditional design/build projects that are no longer considered capital assets.
Retrieval	The process of removing, to the maximum extent practical, all of 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,[d] a tank is officially in "retrieval status" if one of two conditions is met: (1) waste has been physically removed from the tank by retrieval operations, or (2) preparations for retrieval operations are directly responsible for rendering the leak or intrusion monitoring instrument out-of-service.
Saltcake	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	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 several different contexts: • Slurry is a mixture of solids (e.g., sludge or undissolved saltcake) suspended in a liquid. For example, a slurry results when the sludge and supernate in a tank is mixed together. Slurries can be used to transfer solids by pumping though a pipeline. • Slurry can refer to the bottoms stream from the 242-A Evaporator or other evaporator streams. • Slurry also refers to a specific 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 document will use the term "settled salts" or "saltcake" instead of slurry in this context.
Smart Blending	An intentional blending strategy in which blending of HLW feed is based on the composition of waste.
Solids	The product of centrifuging the LAW feed, separating and drying the solids, and removing the dissolved solids contribution.

Term (abbreviation)	Definition or expansion
Specification 7	This WTP contractual specification[e] establishes three LAW feed envelopes: Waste Envelopes A, B, and C. Each waste envelope provides the compositional limits for chemical and radioactive constituents in the waste feed to be provided to the WTP.
Specification 8	This WTP contractual specification[e] establishes the HLW slurry composition and the unwashed solids composition (Envelope D). This waste envelope provides the compositional limits for chemical and radioactive constituents and physical properties in the waste feed to be provided to the WTP.
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 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 hypothetical case in which all of the waste is blended together, pretreated, and the HLW fraction vitrified as a single batch of uniform composition.
Waste Feed Delivery (WFD)	Hanford waste currently stored at the tank farms that will eventually be transferred from the DSTs to WTP.
Waste Feed Delivery (WFD) System	RPP-47172[f] defines the WFD system as being composed of the DST system and the waste retrieval facilities (WRF); however, for the purposes of the IWFDP, WFD system is used to refer to those portions of the WFD system directly supporting preparation and delivery of waste feed to the WTP.
Waste Oxide Loading (WOL)	A measure of the quantity of pretreated waste that can be incorporated into a unit mass of glass. The quantity of pretreated waste is on a non-volatile oxide basis, with all components in their most prevalent oxide form, plus any halogens.
Waste Retrieval Facility (WRF)	A future facility used to support the retrieval of waste involving slurry transfers from SSTs that are located too far to be readily retrieved directly into a DST. The WRF, located near the SSTs, would accumulate and condition retrieved waste before transfer to a DST.
Water Wash Factor	The fraction of an analyte in a solid waste phase that dissolves on contact with water either during retrieval or subsequent processing.

[a] ORP-11242, 2011, *River Protection Project System Plan*, Rev. 6, U.S. Department of Energy, Office of River Protection, 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] *Atomic Energy Act of 1954*, 42 USC 2011, et seq.

[d] OSD-T-151-00007, 2011, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. 7, Washington River Protection Solutions, LLC, Richland, Washington.

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

[f] RPP-47172, 2010, *Waste Feed Delivery System Description*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

APPENDIX B

TECHNICAL RATIONALE

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CONTENTS

FIGURES

TERMS

ALC	air-lift circulator
AWT	aging waste tank
BDGRE	buoyant displacement gas release event
DST	double-shell tank
HLW	high-level waste
HSMP	Hanford submersible mixer pump
HTWOS	Hanford Tank Waste Operations Simulator
RPP	River Protection Project
WFD	waste feed delivery
WTP	Waste Treatment and Immobilization Plant

B1.0 INTRODUCTION

This appendix provides the technical rationale for several key assumptions regarding waste feed delivery (WFD) operations that are not documented elsewhere. Associated key issues and uncertainties are also identified. Some of the assumptions provided are based on conservative engineering judgment and interpretation of currently available data. This appendix will be updated in future revisions as the River Protection Project (RPP) mission planning and the Waste Treatment and Immobilization Plant (WTP) feed acceptance criteria evolve and new test data becomes available.

B2.0 WASTE FEED DELIVERY ASSUMPTIONS

B2.1 MAXIMUM SOLIDS DEPTH FOR WASTE FEED DELIVERY

The maximum solids layer thickness that can be effectively mobilized and well mixed in a double-shell tank (DST) to meet WTP waste acceptance criteria using two Hanford submersible mixer pumps (HSMP) is 70 in.

Rationale: Prior sludge staging plans (SVF-1630, "Sludge Staging Plan, Rev. 0.xlsx") assume a maximum solids layer thickness of 70 in. The ability of mixer pumps to mobilize settled solids is dependent on the depth and properties of the solids. Sampling of slurry with the accuracy required to meet WTP waste acceptance criteria (24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria*) may not be possible in a tank containing a sludge layer greater than 70 in. (SVF-1630).

Issue: This assumption is based on conservative engineering judgment to meet waste acceptance criteria; it has not been confirmed with actual test data. It is unknown if the current mixing and sampling approach will be adequate to meet WTP acceptance criteria (see Section 2.8.8). For some tank wastes, if all 70 in. of solids are suspended and well mixed, the solids concentration in the resulting slurry fed to WTP may still exceed the solids concentration upper limit outlined for WTP waste acceptance criteria. Both the mixer pump capability and the solids concentration of the mixed feed slurry should be evaluated in the planning for solids depths in the HLW feed tanks.

B2.2 MAXIMUM SOLIDS DEPTH FOR HANFORD SUBMERSIBLE MIXER PUMPS STARTUP

HSMPs can be started when in the lowest position, with up to 70 in. of sludge waste in the DST.

Rationale: DSTs needed to store and stage high-level waste (HLW) will accumulate solids. Mixer pumps will be installed in these tanks to suspend and mobilize solids for waste transfers. When the mixer pumps are in the lowest position, it is assumed that the pumps can be started when the settled solids depth is at or below 70 in.

Issue: This is an enabling assumption and has not been confirmed with actual testing. It is uncertain what maximum settled solids depth above the mixer pump will still allow the pump to start. Actual testing needs to be completed to confirm this assumption and establish an operating strategy.

Periodic mixing operations may be required to ensure that solids are suspended and do not settle and impede HSMP startup. The Savannah River Site mixer pumps are periodically operated, which helps ensure that the mixer pumps will start after extended periods of solids settling (WSRC-TR-2003-00087, *CSTF Flammability Control Program*). Hanford HLW tanks may require a similar approach.

B2.3 MAXIMUM MOBILIZATION DEPTH

The maximum solids layer thickness that can be mobilized at one time without incremental lowering using two HSMPs having a fixed discharge jet elevation is 70 in.

Rationale: The ability of mixer pumps to mobilize settled solids is dependent on the depth and properties of the solids. Solids that are too deep may not be effectively mixed, either because the solids layer prevents the pump from drawing in sufficient liquid or the total mass of solids is too great for the available pump horsepower. Computer modeling of the current mixer pumps suggests that a solids depth of up to 125 in. may be mobilized (PNNL-13913, *Optimal Elevation and Configuration of Hanford's Double-Shell Tank Waste Mixer Pumps*).

This assumption was made for planning purposes, and tanks with greater than 70 in. of settled solids may, therefore, require incremental lowering of HSMPs.

Issue: Deep sludge tanks will contain settled solids depths greater than 70 in. (Section 4.5.3). Successful implementation of new buoyant displacement gas release event (BDGRE) controls may allow up to 250 in. of settled sludge. Based on the current assumption, incremental lowering of HSMPs will be required to mix and mobilized deep sludge storage tanks. This is a simplifying assumption reflected in the Hanford Tank Waste Operations Simulator (HTWOS) model, and has not been confirmed with actual test data. The mixing demonstration program will determine the actual limits for sludge mobilization (see Section 2.8.8).

B2.4 HANFORD SUBMERSIBLE MIXER PUMPS OPERATIONS IN AGING WASTE TANKS

Operation of mixer pumps at full power in aging waste tanks (AWT) is constrained to the HSMP installed in the lowest position, AND, limited to nine full tank batch groups.

Rationale: The current strategy to determine the maximum allowable cycles an AWT can undergo, assuming mixer pump operations at full power, is to:

- Identify fragile equipment installed in the AWTs
- Strengthen, replace, or remove fragile equipment
- Determine a limit for the number of times an AWT may be used based on the most fragile equipment remaining.

The structural integrity or metal fatigue of long-length, in-tank equipment subjected to cyclic HSMP jet impingement forces limits cumulative solids mixing operations in AWTs. Mixer pump operations in AWTs are limited based on the capability of in-tank hardware to withstand the mixer pump jet forces.

Thermocouple trees, sludge thermocouples, and the in-tank steam coil have been identified as the most fragile equipment in the AY and AZ Farm tanks. Planned WFD upgrades include replacing these thermocouples and altering/removing the in-tank steam coil. This leaves air-lift circulators (ALC) and the thermowells attached to the ALCs. The portion of the ALC thermowells that extend approximately 28 in. beyond the bottom of the ALCs are more fragile than the ALCs themselves. Thus, the ALC thermowell fragility is used to set the limit on the number of batch groups that can be transferred out of the AY and AZ Farm tanks.

In addition, when the HSMP is installed in the lowest position, it is assumed that stiffeners are installed in the radiation drywells and that steam coils are removed or modified, increasing both the radiation drywells and steam coil fatigue lives beyond that of the ALC thermowells. Consequently, the ALC thermowells form the cycle limit basis for calculation of the number of batch groups until fatigue is reached, which is described further below.

Numerous calculations evaluated AWTs in-tank component structural integrity:

- HNF-SD-W151-DA-008, *Evaluation of the Effect of Project W-151 Mixer Pump Jets on In-Tank Equipment Considering Potential Sludge Buildup on Equipment in Waste Tank 241-AZ-101, Hanford Site, Richland, Washington*
- RPP-7069, *Project W-521 Waste Feed Delivery System Advanced Conceptual Design Report*
- WHC-SD-W151-DA-006, *W-151 Steam Coil Fatigue Analysis for Mixer Pump Jet Loads*
- WHC-SD-W151-ER-001, *Stress Cycles and Forces on In-Tank Components Resulting from Mixer Pump Operation in DST 101-AZ*
- WHC-SD-WM-CAVR-001, *Evaluation of the Effect of Mixer Pump Jets on Internal Equipment in Aging Waste Tanks*
- WHC-SD-WM-ER-216, *Re-Evaluation of Radiation Dry Well for Tank 241-AZ-101 Based on New Predicted Forces and Cycles*
- WHC-SD-WM-RPT-040, *Interim Report, Waste Tank 241-AZ-101 Tank Internals Vibration Analysis.*

The calculations estimate the cycle limits for various tank hardware, such as thermocouples, radiation drywells, steam coils, ALCs, and drain lines. The majority of the analyses assumed that the mixer pump is in the lowest position. One analysis assumed the mixer pump was in a raised position because the pump would likely have to be started in the raised position to mobilize waste to reach the lowest position. Cycle limits will be significantly less for mixer pump operations in the raised position because when the pump is in the lowest position, the jet impingement forces are primarily focused underneath the fragile equipment. When the mixer pump is in the raised position, the jet impingement forces are primarily at the elevation of the equipment, and there will be significantly more fatigue on the equipment.

The cycle limits for various equipment are summarized below:

- Equipment subject to significant jet impingement loads with the HSMP in the lowest installed position:
  - ALC thermowells: ≤170,000 cycle limit (non-removable)

  - Radiation drywells: ≤30,000 cycle limit (non-removable, internal stiffener capability)
  - Steam coil: ≤63,000 cycle limit (removable, high-risk work)
  - Thermocouple trees: New engineered equipment

- Equipment subject to significant jet impingement loads with the HSMP in an elevated position:
  - ALCs: ≤20,000 cycle limit (non-removable)
  - Sluice pit, pump pit, leak detection pit, and annulus pump pit drain lines: ≤ 20,000 cycle limit (non-removable).

Assuming a batch group of sludge stored in a DST undergoes an initial mix/mobilization—mix for a sample, mix to keep solids mobile, and mix to feed five batches to WTP—a conservative estimate of the number of mixer pump operating days required for a batch group is as follows:

- Initial mix/mobilization – 14 days
- Mix for sample – three days
- Mix to keep solids mobile – three days
- Mix to feed five batches to WTP – two days per batch.

The total mixer pump operating duration is 30 days based on the assumptions for the required pump operating days listed above.

The baseline rotational speed of the mixer pump is 0.2 rotations per minute, and the number of mixer pump jet impingements per rotation is two.

Equation 1 calculates the number of jet impingements per batch group. Equation 2 calculates the maximum number of batch groups through an AWT until fatigue occurs, assuming the mixer pump is operated in the lowest position. Equation 2 uses the ALC thermowell cycle limit as the equipment fragility limit because it is assumed that stiffeners are installed in the radiation drywells and the steam coil is removed or modified, increasing their fatigue lives beyond that of the ALC thermowells. Similarly, Equation 3 calculates the maximum number of batch groups through an AWT until fatigue occurs, assuming the mixer pump is operated in the raised position.

$$Number\ of\ impingements\ per\ batch\ group = (30\ days)\cdot\left(\frac{24\ hours}{1\ day}\right)\cdot\left(\frac{60\ minutes}{1\ hour}\right)\cdot\left(\frac{0.2\ rotations}{1\ minute}\right)\cdot\left(\frac{2\ impingements}{rotation}\right) = 17{,}280$$

Equation 1

$$Number\ of\ batch\ groups\ until\ fatigue\ on\ thermowell\ (lowered\ HSMP\ position) = (170{,}000\ jet\ impingements)\cdot\left(\frac{1\ batch\ group}{17{,}280\ impingements}\right) = 9.8$$

Equation 2

$$Number\ of\ batch\ groups\ until\ fatigue\ on\ thermowell\ (raised\ HSMP\ position) = (20{,}000\ jet\ impingements) \cdot \left(\frac{1\ batch\ group}{17{,}280\ impingements}\right) = 1.2$$

Equation 3

Based on results from Equation 1 and Equation 2, the current approach is to round to allow no more than nine batch groups to be transferred out of an AWT. This will leave additional margin for final cleanout activities. This is solely the approach for AWTs with mixer pumps in the lowest installed position. With the HSMP installed in the elevated position (Equation 3), operation at full power in AWTs would be constrained to one full tank batch group.

B2.5 HANFORD SUBMERSIBLE MIXER PUMPS OPERATIONS ALLOWABLE WASTE DEPTH

During normal operations, HSMPs will not be started with less than 102 in. of waste in the tank, and HSMPs will not be operated with less than 72 in. of total waste, solids and supernate combined, in the tank for HLW feed deliveries.

Rationale: HSMP design requires that fluid be present on the upper thrust bearing for pump startup to prevent any damage. To ensure that fluid is present on the upper thrust bearing during HSMP startup, one of the following criteria must be met:

- The tank waste level must be greater than or equal to 102 in., OR
- The flush waster system must be run during the initial 30 seconds of pump startup, which requires safety-significant backflow prevention on the flush water supply.

During HLW feed delivery operations, HSMPs will not be operated with less than 72 in. of total waste, solids and supernate combined, in the tank. The HSMP design calculations indicate HSMPs can be operated with less than 72 in. of waste in the tank, but the speed of the pump must be reduced to prevent cavitation (EM-7324, *Hanford Submersible Mixer Pump (HSMP) Final Design Package*).[76] When the mixer pump speed is reduced and the total waste level is below 72 in., some solids will settle and the composition of feed to be transferred to WTP will change. Consequently, the current strategy will not operate HSMPs with less than 72 in. of total waste in the tank to ensure that a well-mixed HLW feed batch is delivered to the WTP.

B2.6 HANFORD SUBMERSIBLE MIXER PUMPS VERTICAL STROKE LENGTH

The maximum solids depth that can be successfully mixed in a deep sludge DST for a DST-to-DST transfer is approximately 200 in.

Rationale: The maximum solids depth is constrained to approximately 200 in. due to a constrained range of vertical movement, or vertical stroke. The length of the HSMP stroke is limited to 12 ft, due to both radiation shielding and the safety basis enclosure criteria required for operations.

[76] This is based on HSMP design calculations for a waste specific gravity of 1.5 and a waste temperature of 140°F. The design calculations indicate the HSMP power and corresponding waste depth will vary significantly with specific gravity and temperature. EM-7324 provides further HSMP design specifications.

Figure B-1 depicts a simplified representation of a DST with two HSMPs installed, one in the lowest position and one in the highest position. Figure B-1 is not drawn to scale, and is solely included as a visual aid to better understand this assumption.

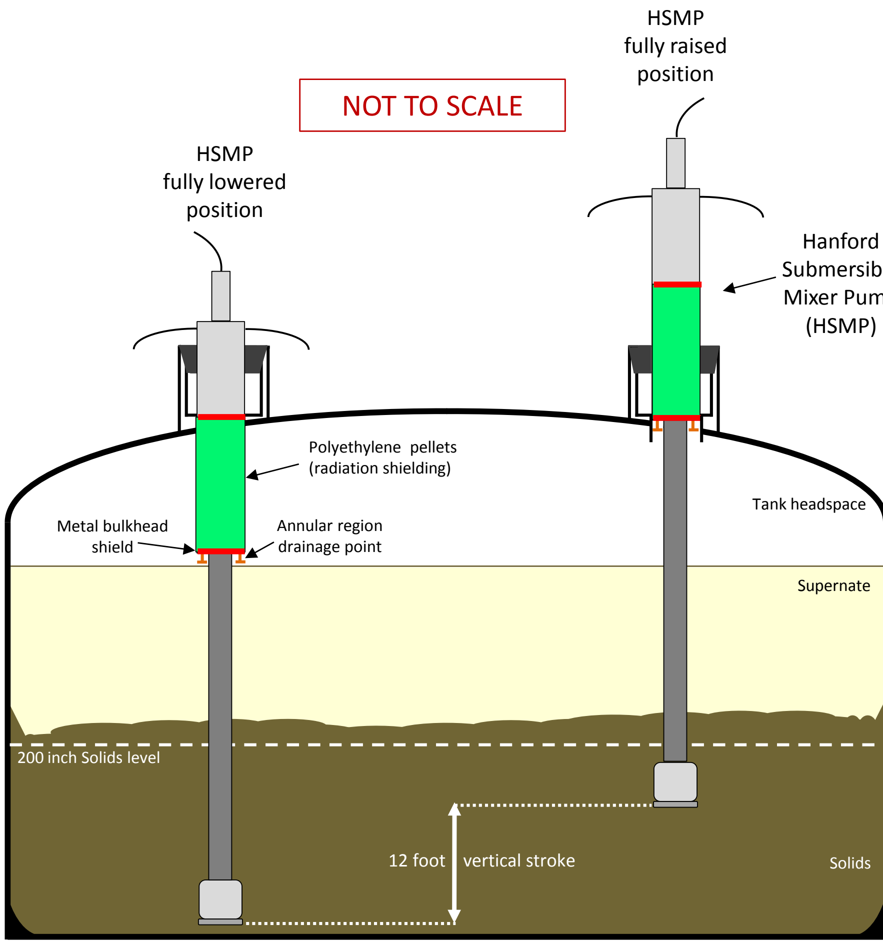

Figure B-1. Hanford Submersible Mixer Pump Vertical Stroke Constraint

Radiation shielding is required for HSMP operations due to the mixer pump and tank riser configuration. Vertical HSMP movement requires radiation shielding distributed along the HSMP column over the entire stroke of the movement.

The radiation shielding solution is to increase the HSMP column diameter to fill the riser. This increased HSMP column diameter is constrained to the top portion of the pump column, where the column fits in the riser. The top portion of the pump column will have a continuous, internal shield comprised of polyethylene pellets. The portions of the HSMPs containing the shielding pellets are illustrated by the green regions in Figure B-1. The pellets fill a section of the larger diameter pump column and are held in place by metal bulkhead shields. The metal bulkhead shields are depicted in Figure B-1 by the red bars on both ends of the radiation shielding. When the pump is in the lowest position, the top metal bulkhead shield will be level with the bottom of the riser pit. When the pump is in the highest raised position, the bottom metal bulkhead shield will be level with the bottom of the riser pit. The metal bulkhead shields provide additional radiation shielding during pumping operations.

Environmental leak detection requirements affect the maximum mixer pump stroke length. A leak detection system is required to be present to detect a leak within 24 hours (RPP-16922, *Environmental Specifications Requirements*). The current HSMP design has a flush water pipe and a sparge water pipe. The flush water supply line extends from the top of the HSMP motor, up through the riser, and to the top of the HSMP apparatus. The sparge water supply line extends from the bottom of the HSMP motor, up through the riser, and to the top of the HSMP apparatus. Both of these water lines are placed in an encasement pipe from the HSMP mounting flange down to the bottom of the radiation shield. The annular region between the water lines and the encasement pipe allows any leak, due to pressurized backflow, to return back to the tank, preventing leaks to the environment. The drainage point for this annular region is located at the bottom of the lower bulkhead radiation shield. The drainage point must be maintained above the top level of the waste to allow for visual leak detection (see Figure B-1, HSMP fully lowered position). The current strategy is to use a video camera to monitor for leaks at the annular region drain location.

The leak detection requirement, combined with the radiation shielding requirement, constrains operations to a maximum 12-ft vertical stroke length. When the mixer pump is in the highest raised position, the 12-ft vertical stroke length (144 in.), combined with the assumed maximum 70 in. of mobilized sludge without incremental lowering (see Section B2.3), is rounded to a maximum sludge depth of approximately 200 in. for DST-to-DST transfers.

Current baseline modeling efforts reflect an approximate 200-in. maximum solids depth. If a solids level greater than 200 in. is necessary, an additional alternative retrieval method, such as enhanced sluicing, may be required to reduce the sludge depth to approximately 200 in.

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