# Waste Feed Delivery Planning at Hanford – 13232

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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, which is integrated with the Baseline Case operating scenario, is comprised of three volumes. Volume 1 – Process Strategy 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 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 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.

## INTRODUCTION

The U.S. Department of Energy (DOE) manages the Hanford Site in Southeastern Washington State where decades of nuclear materials production for the Cold War yielded a legacy of nuclear waste. Today, approximately 212 million liters (56 million gallons) of radioactive waste liquids, solids and salts are stored in 177 underground storage tanks. Of these, 149 are aging single-shell tanks (SST); the other 28 are newer double-shell tanks (DST). Some SSTs are known to have leaked in the past; the resulting soil contamination threatens the nearby Columbia River. In response, the DOE Office of River Protection (ORP) created the River Protection Project (RPP), whose mission is to retrieve and treat Hanford's tank waste and close the tank farms to protect the Columbia River. [1]

The RPP is an integrated system of waste storage, retrieval, treatment, and disposal facilities, which are in varying stages of design, construction, operation, and future planning. These facilities face overlapping technical, regulatory, and financial hurdles to achieve site cleanup and closure. Program execution is ongoing, and completion is currently expected to take approximately forty years. The ORP and Washington River Protection Solutions LLC (WRPS) have planned for the preparation and delivery of waste feed to the Waste Treatment and Immobilization Plant (WTP) in anticipation of the start of its hot commissioning and routine operations. The Integrated Waste Feed Delivery Plan (IWFDP) addresses the challenges of managing limited DST space, coordinating necessary tank farm upgrade projects and operating schedules, and blending wastes from multiple SSTs and DSTs in order to produce a feed stream that meets WTP waste acceptance criteria and supports anticipated WTP processing rates.

To achieve the RPP mission, the waste stored in the 149 SSTs will be retrieved to and consolidated in the 28 DSTs. Some DSTs store only liquid waste, while others contain both liquid and a layer of settled solids. Solid wastes can be divided into saltcake and sludge. Saltcake is mostly soluble sodium nitrate and nitrite salts with some interstitial liquid consisting of concentrated salt solutions. Sludge is mostly low solubility aluminum and iron compounds with relatively dilute interstitial liquid. The predominant radioisotope in supernate is cesium-137, while the predominant radioisotope in sludge is strontium-90 [2].

The DSTs and associated systems and infrastructure must be upgraded to support waste feed delivery (WFD) operations. Waste feed from the DSTs will be prepared and 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 mission and the role performed by a DST may change over time. A key challenge in supporting the mission is to manage the use of the DSTs and the rest of the WFD system efficiently. This includes the following:

- Safely storing the existing tank waste.
- Receiving, storing, and transferring wastes from sources outside of the WFD system (e.g., the 222-S Laboratory and the SSTs).
- Staging feed and receiving concentrated waste from the 242-A Evaporator.
- Incidental and intentional blending or segregation, staging and delivering solids and supernatant tank waste to the WTP.
- Accepting emergency returns from the WTP, if necessary.

Low-activity waste feed[1] is staged in DSTs with provisions to minimize solids transfer. Specifically, LAW waste is staged in a DST with the mixing system off to allow solids settling. Liquid waste is decanted from an elevation above the settled solids layer to minimize solids entrainment. High-level waste feed[1] is a slurry of liquid and insoluble solids. The planned configuration and operation of the WFD system has been established to perform these functions within the DST system.

The Integrated Waste Feed Delivery Plan (IWFDP) defines the necessary systems and infrastructure, identifies the specific upgrades to be performed, and describes the approach to be used to prepare and deliver tank waste feed to the WTP.

The IWFDP is divided into three volumes: Volume 1 – Process Strategy [3], Volume 2 – Campaign Plan [4], and Volume 3 – Project Plan [5]. The purpose and scope of each volume, and the primary inputs to and outputs from the IWFDP as a whole, are shown in Fig. 1.

[1] The terms LAW feed and HLW feed, established by the WTP Contract [6], 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, including "LAW feed" and "HLW feed", is managed as HLW per the *Nuclear Waste Policy Act of 1982*, as amended [7].

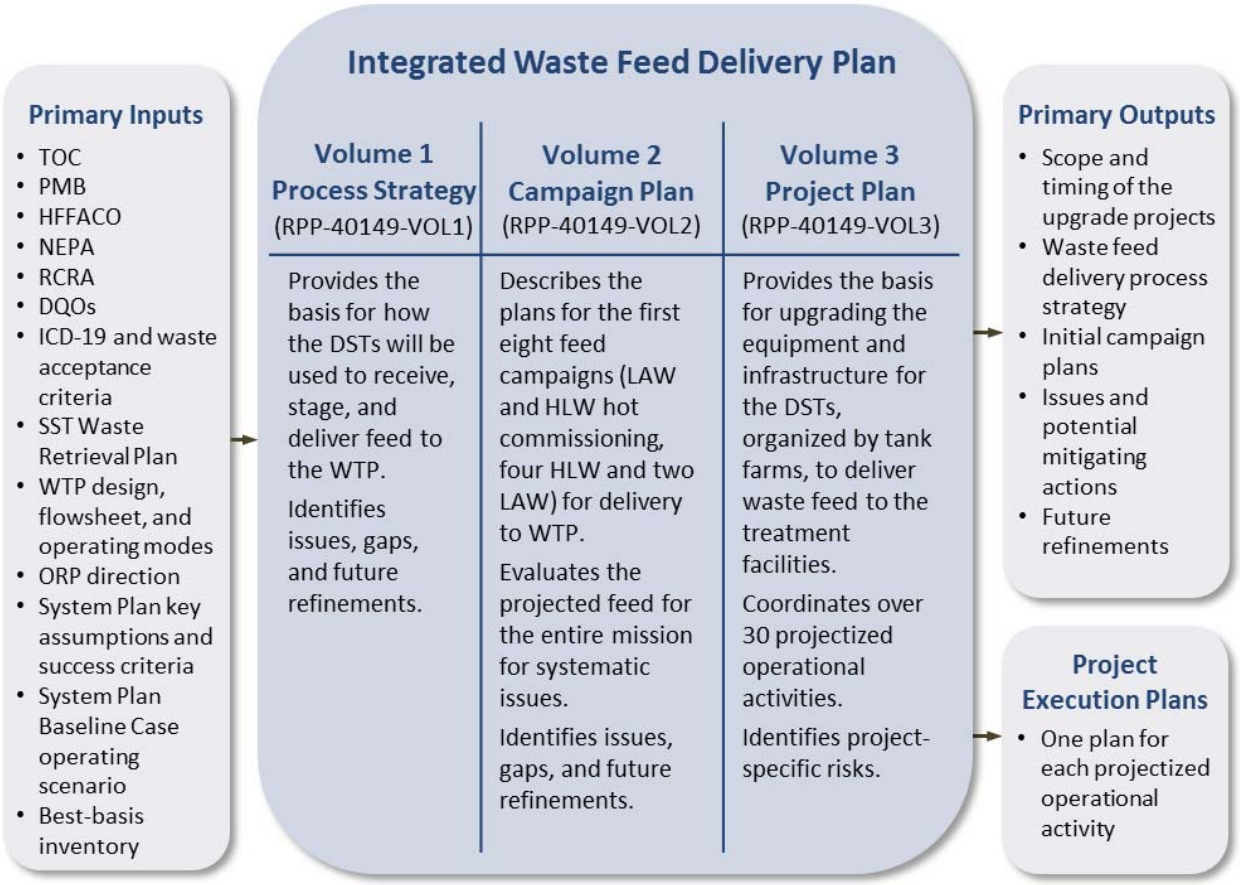


**Fig. 1. Scope and Purpose of the Integrated Waste Feed Delivery Plan.**

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 to maintain efficient operations of the WTP and any supplemental facilities throughout the treatment mission; compliant refers to meeting the WTP waste acceptance criteria. Modifications to existing systems and installation 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 evolving documented safety analysis requirements, waste acceptance criteria and criticality specifications; funding; decisions affecting the overall system configuration; and a better understanding of tank farms mixing, transfer, and sampling capabilities.

The IWFDP draws from ORP direction, technical and programmatic assumptions, and other requirements related 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 eight 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.

## WASTE FEED DELIVERY PLANNING PROCESS

The IWFDP evolves and matures through an ongoing iterative process of successive refinements, as portrayed in Fig. 2, whereby issues are evaluated and potential mitigating actions are established using the risk and opportunities management process. This 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[2], WTP waste acceptance criteria, and other requirements. This approach takes advantage of the existing WFD configuration, upgrade plans and projects, and WFD process strategy.

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 established by Volume 3. The WFD process strategy assumptions are used with other system planning assumptions to form the baseline operating scenario, outlined in the RPP System Plan. Volume 2 of the IWFDP then builds the campaign plan from the baseline operating scenario and evaluates the delivered feed. Volume 3 of the IWFDP establishes the basis for the WFD system architecture (DST equipment, waste transfer systems, and supporting infrastructure and utilities).

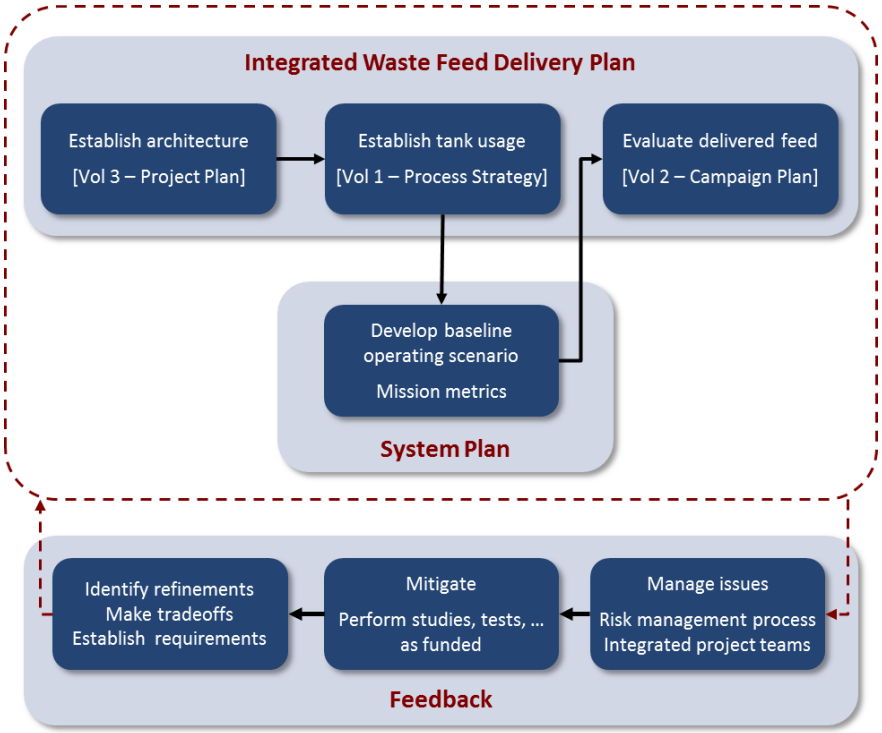


**Fig. 2. Iterative refinement of the Integrated Waste Feed Delivery Plan.**

[2] Success criteria refer to those metrics that are used to determine how well a scenario meets overall mission goals or requirements. For the RPP System Plan [8], 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* [9] and *Consent Decree* [10] milestones.

Issues identified during this process are gathered and managed using the Tank Operation Contractor's (TOC) risk management process [11], the processes defined in the WTP's Interface Management Plan [12], the Flowsheet Integrated Project Team (IPT), and the newly formed One System IPT[3]. 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.

## INTEGRATED WASTE FEED DELIVERY PLAN

The three volumes of the IWFDP are integrated with the assumptions, requirements and baseline operating scenario in the RPP System Plan. The general process for delivering waste feed to the WTP is shown in Fig. 3 and includes the following steps:

- 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
- Perform mixing, sampling, and waste characterization to confirm the tank waste meets prescribed waste acceptance criteria
- Deliver waste feed to the WTP's Low-Activity Waste (LAW) feed or High-Level Waste (HLW) feed receipt tanks.

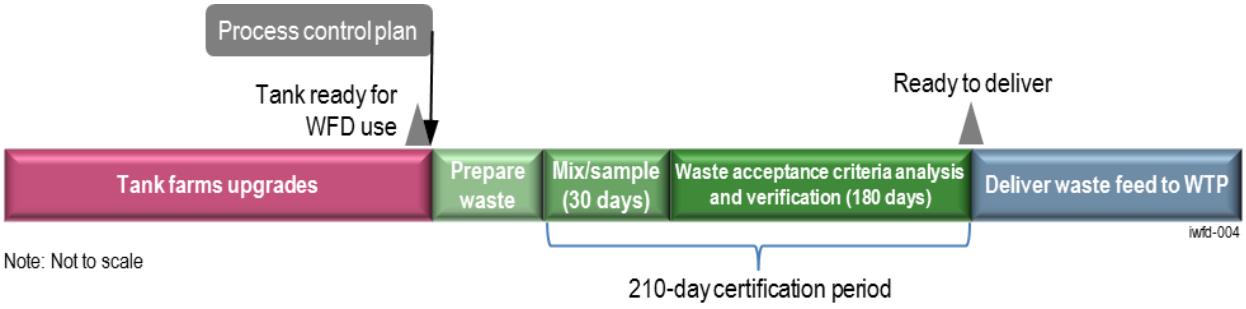


**Fig. 3. General strategy for waste feed delivery to the Waste Treatment and Immobilization Plant.**

Results of the waste feed delivery planning process are documented in the three-volume IWFDP and are summarized in the following three subsections.

[3] The One System IPT serves to integrate between the WTP and TOC organizations and coordinate their respective contracts. The IPT integrates complementary functions to achieve One System goals, while eliminating redundant functions of the two contractors and increases the likelihood of achieving early low-activity waste (LAW) operations and initial plant operations [13].

## Volume 1–Process Strategy

The Process Strategy can be represented as the functional process flow diagram shown in Fig. 4. 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.

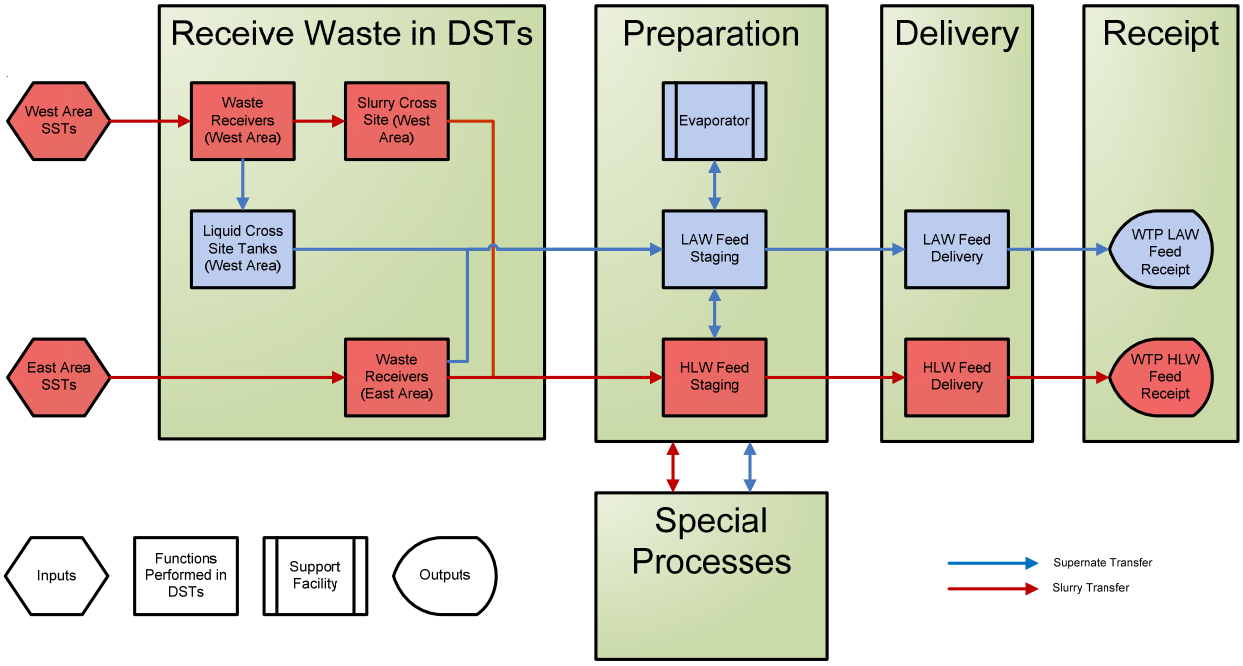


**Fig. 4. Simplified Waste Feed Delivery Functional Process Flow.**

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 or LAW handling 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 to balance the various demands (primarily, SST retrieval and WFD) on the use of the DSTs so that the resulting operating scenario has acceptable mission metrics. Each process function requires a specific architecture or set of tank equipment and supporting infrastructure. The architecture established by the Project Plan (see Fig. 5) therefore defines which DSTs can be used to perform which process function. The detailed assignments for each operating scenario are made dynamically using the Hanford Tank Waste Operation Simulator (HTWOS)[4], consistent with the established architecture and associated construction schedules.

[4] The Hanford Tank Waste Operation Simulator is a dynamic flowsheet model of the waste treatment mission that is often used for mission planning and analysis purposes.

At a summary level, the WFD process flow is as follows:

- Waste retrieved from West Area SSTs is received into West Area DSTs and transferred to East Area DSTs.
- Waste retrieved from East Area SSTs is received into East Area DSTs.
- Supernate is concentrated using the 242-A Evaporator as needed to manage tank space and sodium concentration.
- One million gallons of supernate are accumulated in a DST, sampled and delivered to the WTP as a single LAW feed campaign.
- One million gallons of slurry are accumulated in a DST, sampled and delivered to the WTP in six or seven batches comprising a single HLW feed campaign.
- Special processes address additional preparation steps needed for certain waste currently stored in the DST system. Examples of special processes include blending down the fissile uranium concentration of waste solids to meet WTP criticality specifications, removal of sludge from DSTs containing more sludge than can be mobilized at one time using two mixer-pumps, precipitation of complexed strontium and TRU from comply with the WTP ILAW feed specification and with the 1997 agreement with the NRC on incidental waste [14].

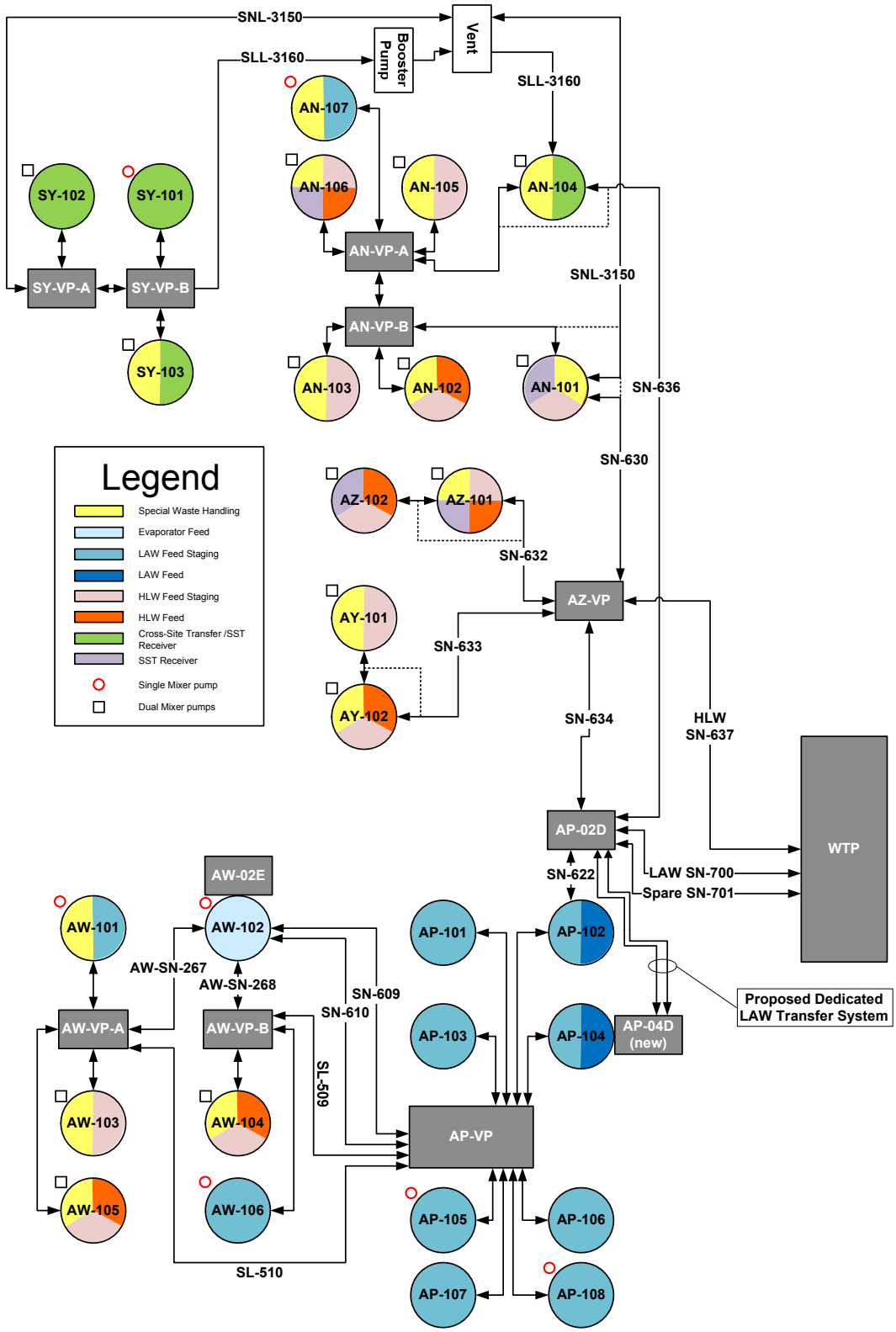


**Fig. 5. Overall Waste Feed Delivery System Architecture.**

## Volume 2 – Campaign Plan

The IWFDP campaign plan describes the plans for the first eight feed campaigns for delivery to the WTP. A campaign consists of a batch of certified LAW feed or multiple batches of certified HLW feed delivered to the WTP from a single source tank. This revision of the IWFDP is integrated with the assumptions, requirements, and baseline operating scenario in the System Plan. The campaign plan also evaluates the projected feed for the entire mission, and identifies issues, gaps, and future refinements.

Fig. 6 represents a typical HLW feed campaign, including upgrading tank equipment, staging (preparation of feed), mixing, sampling, feed certification and subsequent deliveries. Potential sample events for waste compatibility assessments and process control are also shown. The specific DSTs are illustrative.

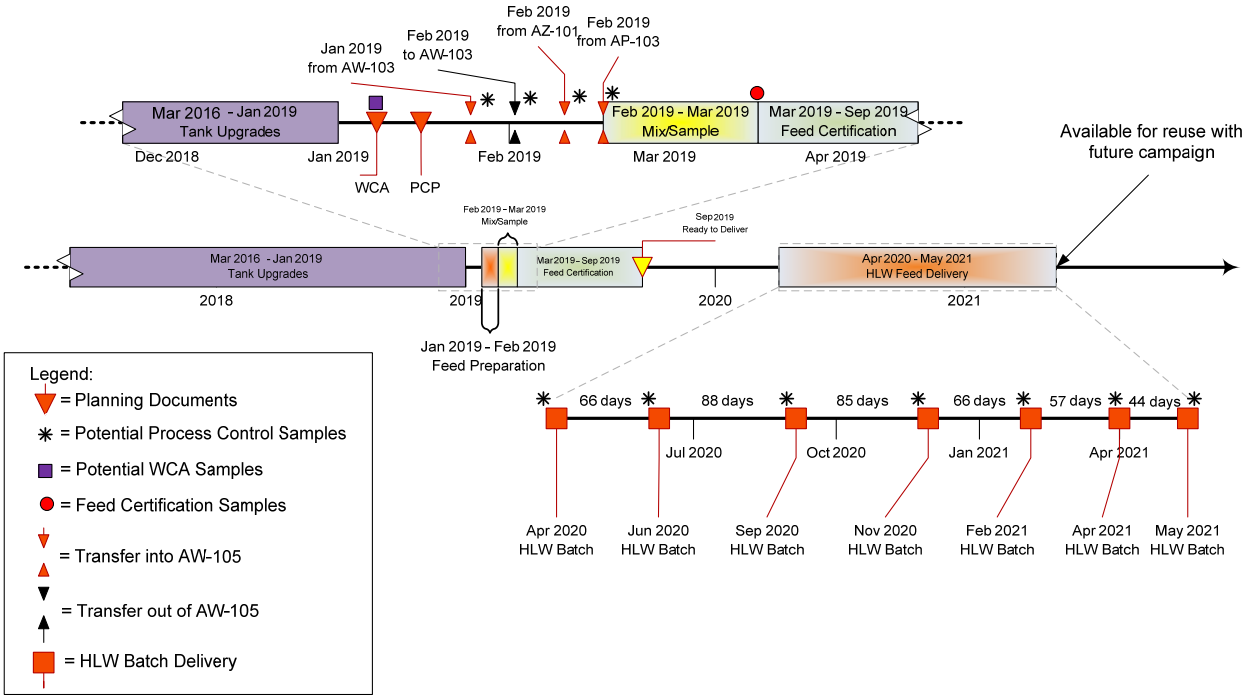


**Fig. 6. Example timeline showing HLW feed campaign logic.**

A feed screening was performed on each projected feed batch delivered to the WTP throughout the entire mission. Two batches failed to meet the subset of waste acceptance criteria items with action limits screened against in this report[5]. One batch exceeded the LAW bulk density limit as

[5] The WTP waste acceptance criteria (WAC) data quality objectives [15] identifies a subset of the interface requirements [16] as action limits – these criteria must be meet for feed to be delivered to the WTP. The composition of feed batches as projected by the HTWOS are screened against most of the action limits; certain limits, including those related to waste rheology and particle size are not yet screened.

currently modeled, but will be rectified by control strategy refinements. The other batch failed to meet the LAW hydrogen generation rate limit because of an ineffective blending strategy.

An analysis was completed to determine the amount of contingency feed available throughout the mission. Early in the mission, until around 2025, sufficient contingency feed is available. Later, very little contingency feed is available since the current strategy does not include consideration of contingency feed.

An evaluation of near-term DST space usage was also completed. Continued SST retrievals minimize DST space. Although 242-A Evaporator campaigns slightly reduce waste volume, available space remains extremely limited prior to and during the startup of WTP. As the DST system nears capacity, it is increasingly difficult to conduct SST retrieval, evaporator, and feed staging operations.

**Volume 3 – Project Plan**

The Project Plan establishes the basis for the WFD system architecture, including DST equipment, waste transfer systems, and supporting infrastructure and utilities. Equipment and infrastructure upgrades are coordinated through more than 30 projectized operational activities (IWFD projects). The project plan also identifies the project execution plans for each of the operational activities.

The primary objective of the project plan is to establish required modifications to existing systems and installations of new systems to meet WTP startup and processing needs associated with WFD. The assumptions for WFD planning, including WTP schedule needs, are consistent with the System Plan. Tank farms WFD upgrades activities support WTP hot commissioning starting in May 2018, with full operation beginning in December 2019.

Additional objectives of the project plan include:

- Assessing safety risks and opportunities on a continuous basis
- Optimizing cost efficiency
- Relying on mature/proven technology
- Integrating upgrades with other tank farms work
- Placing a high priority on operability and maintainability of systems
- Assessing and responding to project performance risks
- Providing flexibility to adapt to evolving requirements and process improvement opportunities.

Modifications and new tank farms hardware systems will provide comprehensive upgrades to the DST farms waste retrieval, mixing, characterization, and transfer systems, and supporting infrastructure. This work includes planning and executing projects over the life of the RPP mission. Decisions on waste retrieval strategies and waste preparation needs, including pretreatment or blending, will be made during the execution of the TOC. The selection and

configuration of treatment, storage, and disposal facilities to disposition the waste will also impact WFD requirements.

The capability to operate these systems will be developed concurrently with the IWFD projects, including training personnel, commissioning waste feed systems and demonstrating readiness, and operating feed systems to meet treatment facility needs. Finally, close integration will be needed externally with the WTP and other Hanford Site contractors, and internally with the tank farms Base Operations and Single-Shell Tank (SST) Retrieval organizations.

An integrated systems approach was taken to establish a step-by-step hardware baseline by evaluating existing DST farm conditions and the status of site infrastructure and storage/retrieval systems, completing an update of system functions and requirements, and holding value engineering workshops to discuss lessons learned. Potential innovations from historical operations in the Hanford tank farms and at the Savannah River Site (SRS) were gleaned from this process.

An SRS site visit was conducted in 2009 to better understand the mixer and transfer pumps used at SRS. The SRS operations experience identified the successful use of submersible mixer pumps for the initial mobilization and suspension of settled sludge in the tanks. These suspended solids were then transferred into dedicated mixing/feed tanks that use continuous mixing via long-shafted mixer pumps to maintain homogeneous mixing of the waste prior to final transfer to the vitrification plant. Lessons learned from SRS experience are incorporated into the Hanford planning.

More than 30 IWFD projects—possible Category 2[6] engineering, procurement, construction, and commissioning projects, organized by tank farm—are identified to construct and commission the systems required for delivering feed from the 28 DSTs to the WTP. The workscope, execution approach, schedule, and cost estimates for each IWFD project are described in this volume of the IWFDP. Consistent with the ongoing approach for implementing SST retrieval projects, these projects have been identified as a series of discrete projects. Because of the duration and magnitude of the WFD and DST upgrades, a series of smaller projects are considered more manageable and will allow closure of specific projects as they are completed.

[6] Category 2 is defined in *Project Categorization and Tailoring* [17], as "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 are traditional design/build projects which are no longer considered capital assets."

**Issues and Uncertainties**

Issues and uncertainties identified during the WFD planning process are captured and managed as discussed in Section WASTE FEED DELIVERY PLANNING PROCESS. Some of the major technical issues and uncertainties that affect WFD planning at Hanford follow:

- **WTP Waste Acceptance Criteria (WAC).** The final set of WAC for the WTP has not been established. The outcome of previously identified technical issues related to the WTP pretreatment facility's ability to safely handle waste solids are anticipated to change the WAC, requiring follow on changes in WFD architecture, process strategy and campaign plans.
- **Waste mixing, sampling and transport.** Small-scale tank waste mixing and sampling studies are underway to demonstrate DST mixing, sampling, and transfer performance. Depending on the outcome of these studies and on a future full-scale in-situ demonstration, adjustments to WFD architecture, process strategy and campaign plans may be required. [18]
- **WTP startup strategy.** The One System Integrated Project Team is revisiting the startup and commissioning strategy for the WTP. WFD architecture, process strategy and campaign plans may require adjustments if the strategy or timing is changed from baseline plans.
- **Tank AY-102 mitigation**. Recently, a slow leak of AY-102's primary tank has been discovered and the leak integrity classification of the tank changed from "sound" to "assumed leaker" [19]. WFD campaign plans and the timing of projects providing infrastructure and tank upgrades will need to be updated to account for the assumed removal of AY-102 from service and to provide an alternative source of feed for WTP hot commissioning (AY-102 contains the baseline hot commissioning feed).
- **WFD transfer system pressure limitations.** The waste transfers for the projected operating scenario are being evaluated for compliance with WFD transfer line pressure limitations. Preliminary evaluations suggest that portions of the transfer system may require rerating or upgrading to support the desired operating scenario, or that the DSTs assigned to handle certain solids handling functions may be changed.
- **Mixer-pump jet impingement.** Four DSTs currently planned for delivering HLW feed contain a large number of in-tank equipment (primarily, air-lift circulations). Ongoing evaluation of the mixer-pump jet impingement forces on the in-tank equipment in four DSTs may limit the total time that mixer-pumps can be operating in those tanks. These limitations may require refining the campaign plans to avoid exceeding those limits.
- **WFD System Operability and Maintainability.** Recent WFD system reliability modeling [20] suggests that changes to the system architecture and maintenance practices can lessen the impact of equipment failures on the WFD system and thereby reduce the risk of potential delays in staging and delivery of WTP feed.

## CONCLUSIONS

Waste feed delivery plans will continue to evolve as WFD and WTP issues and uncertainties are addressed by the One System Integrated Project Team, and in response to changes in the overall RPP mission. Waste feed delivery planning is an iterative process that integrates a complex set of assumptions and requirements to provide the systems and plans necessary to prepare and delivery feed to the WTP.

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