PAIRWISE BLENDING OF HIGH-LEVEL WASTE

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Abstract:

The primary objective of this study is to demonstrate a mission scenario that uses pairwise and incidental blending of HLW to reduce the total mass of HLW glass. Secondary objectives include understanding how recent refinements to the tank waste inventory and solubility assumptions affect the mass of HLW glass and how logistical constraints may affect the efficacy of HLW blending.

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ABSTRACT

The current regulatory agreement, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement or TPA) (Ecology et al. 1996), establishes that the waste treatment complex (WTC) complete the treatment of Hanford Site tank waste by the end of calendar year (CY) 2028. Given the assumption of adequate low-activity waste (LAW) and transuranic (TRU) treatment capacity and feed availability, the treatment end date is then driven by the total mass of high-level waste (HLW) glass that is produced during the treatment mission.

The primary objective of this study is to demonstrate a mission scenario that uses pairwise and incidental blending of HLW to reduce the total mass of HLW glass. Secondary objectives include understanding how recent refinements to the tank waste inventory and solubility assumptions affect the mass of HLW glass and how logistical constraints may affect the efficacy of HLW blending.

EXECUTIVE SUMMARY

In October 2004, the U.S. Department of Energy, Office of River Protection (ORP) directed CH2M HILL Hanford Group, Inc. (CH2M HILL) to evaluate and propose a series of optimization studies that analyze options to improve baseline plans for tank farms that potentially offer lifecycle cost and schedule reductions. CH2M HILL evaluated thirteen options, and on November 17, 2004, proposed six studies that were determined to offer the best options to resolve an overall system productivity issue, or improve the overall baseline plan by reduction of lifecycle cost or schedule reduction (CH2M-0402570 R1).

A Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement or TPA) (Ecology et al. 1996) milestone for the waste treatment complex (WTC) requires that the treatment of Hanford Site tank waste be completed by the end of calendar year (CY) 2028. To that end, ORP is working to provide adequate low-activity waste (LAW) and transuranic (TRU) treatment capacity and feed availability to meet the 2028 requirement. Assuming that ORP meets their goal of providing adequate LAW and TRU treatment capacity, the treatment end date is then driven by the total mass of high-level waste (HLW) glass that is produced during the treatment mission. Recent estimates of the total mass of HLW glass (RPP-20003 Rev. 1, RPP-RPT-23412) exceed the amount of glass that could be produced by 2028 given the currently assumed net HLW glass production rates, pretreatment capacities, and schedule. One way to potentially mitigate this issue is to reduce the total mass of HLW glass by blending of waste in the tank farms before delivery to the Waste Treatment and Immobilization Plant (WTP). The blended waste provides for more efficient HLW glass production.

The primary objective of this study is to demonstrate a mission scenario that uses both incidental and intentional blending of HLW to reduce the total mass of HLW glass produced. A secondary objective includes understanding how logistical constraints may affect the efficacy of blending.

Originally, this study was envisioned to be a trade study-style comparison of several alternatives, each consisting of a specific architecture and associated blending strategy. While framing the study, it was realized that it was premature to commit the time and resources needed to perform the full-up trade study. Therefore, the scope of this study was intentionally limited to pairwise blending of a subset of tanks for the purpose of reducing the mass of HLW glass. Pairwise blending is a type of intentional blending in which a group of tanks are blended, two-at-a-time, with the entire insoluble fraction of waste from each tank used in exactly one blend.

Two benchmarks are used for comparing the mass of HLW glass resulting from different blending scenarios – the “Total Blend” subcase and the “No Blend” subcase. The Total Blend is the hypothetical case in which all of the tank waste is blended together, pretreated, and then vitrified as a single batch of uniform composition. The No Blend is the hypothetical case in which waste from each individual tank is retrieved, pretreated, and vitrified as separate batches – no blending of waste between tanks is permitted.

The Total Blend and No Blend generally bracket the mass of HLW glass that will be produced over the treatment mission for a given set of key assumptions. The key assumptions used throughout this study include:

- The starting tank waste inventory, representing the composition of the waste in the Hanford double-shell tanks (DSTs) and single-shell tanks (SSTs) as of October 1, 2004, was obtained from the Best Basis Inventory and documented in RPP-25191, *Double-Shell and Single-Shell Inventory Input to the HTWOS Model – 2005 Update*.
- The portion of the insoluble solids (sludge) from twenty tanks that has been provisionally identified for packaging and disposal as either contact-handled TRU (CH-TRU) or remote-handled TRU (RH-TRU) waste was not incorporated into HLW waste glass for purposes of this study.
- All HLW solids were assumed to be fully pretreated using the assumed water-wash and caustic-leach factors and oxidative leaching. The leached components do not re-precipitate once leached from the solids.
- The composition of the HLW glass was determined by using the relaxed glass properties model, which assumes that the glass be formulated with a spinel liquidus temperature of up to 1,100 °C and incorporate up to 1-wt % of Cr₂O₃.

A sensitivity analysis was performed to examine the theoretical performance of pairwise blending and how the addition of logistical constraints impact that performance. In this context, logistical constraints refer to the rules that limit which tanks can be blended together – an example of a logistical constraint is only allowing blending between tanks from the same tank farm. The logistical constraints are placeholders for more complicated, unenumerated, constraints such as those resulting from consideration of funding levels, resources, ability to coordinate or conduct multiple activities in multiple areas, retrieval and closure strategy, and the physical capabilities of the tank farms. The sensitivity study found that:

- Pairwise blending of selected waste tanks, if unencumbered with logistical constraints, can closely approach the mass of HLW glass for the Total Blend.
- Addition of logistical constraints, such as no intentional blending between 200 East and 200 West areas, between quadrants, or between tank farms (listed in order of increasing impact), significantly reduces the potential benefit of pairwise blending.

Three mission scenarios were developed using the Hanford Tank Waste Operations Simulator (HTWOS) model of the retrieval and treatment of tank waste and used to evaluate blending performance – each scenario building on the previous one:

- The first scenario (Case 13¹; the reference case for this study) was a rerun of the Development Run (RPP-RPT-23412) using revised assumptions to resolve assumption issues and to incorporate new available data. The revisions include new wash and leach factors for SO₄ and PO₄, updated waste inventory, enforcing the maximum net HLW glass production rate (5 MTG/day), the ultrafilter permeate rate

¹ The case numbering begins at Case 8 in order to maintain continuity with the numbering used in RPP-20003 ended. Cases 8 – 12 were used in Appendix D this blending study as part of the development of Case 13.

(17.7 gpm), and the HLW feed dwell time (210 days), and correcting DST fill heights.

- The second scenario (Case 14) involved the manipulation of the SST retrieval sequence in an attempt to increase the degree of incidental blending.
- The third scenario (Case 15) adds the pairwise blending of wastes from a limited number (25 pairs) of SSTs to attempt to reduce the mass of HLW glass.

The key results and conclusions from the mission scenario evaluation are:

- Pairwise blending (Case 15) reduced the variability of the HLW feed composition in components targeted for blending by the blend pairs. Specifically, the distributions of Al_2O_3 , Fe_2O_3 , and P_2O_5 in the delivered feed on an equivalent oxide basis were slightly flatter than that for the incidental blending in either the reference case (Case 13) or Case 14). This reduction in feed variability may be a benefit to the operation of the WTP irrespective of the resulting mass of HLW glass.
- Cases 14 and 15 showed negligible reductions in the mass of HLW glass over that from the reference case, Case 13. In retrospect, the assumed logistical constraints used to select the blend pairs for Case 15 severely limited the efficacy of pairwise blending for that mission scenario. The problematic constraints were excluding the 38 early SSTs in the retrieval sequence and the DSTs. Many of these tanks could be included in the pairwise blending, contingent upon allocation of adequate tank space for that purpose. The negligible reduction in HLW glass mass for Case 15 is a consequence of the problematic assumptions and is not intrinsic to pairwise blending.
- All three cases produced too much HLW glass to finish the treatment of waste by 2028; the earliest the mission could end, assuming no HLW melter outages, would be the end of 2030 using the previous assumption that hot commissioning of the WTP begins in 2009.
- The range or span between Total Blend and No Blend is an area of opportunity that warrants additional blending evaluations. The three mission scenarios (Cases 13 – 15) are approximately midway between the span defined by the No Blend and Total Blend and produce approximately 8,000 more MTG than the Total Blend. This 8,000 MTG represents the potential reduction in HLW glass mass that might be achievable with the appropriate blending strategy and equates to a potential savings of about 2,500 canisters over a four-year processing period.
- The primary single-component compositional drivers for the mass of HLW glass are SO_3 , Al_2O_3 , P_2O_5 , and Fe_2O_3 , listed in decreasing order of relative impact; the primary multi-component property driver is spinel liquidus temperature. This assumes that water washing and caustic leaching removes much of the aluminum and that oxidative leaching is effective in removing the chromium.

The following key recommendations were made:

- Another mission scenario using pairwise blending should be developed, this time including additional tanks when selecting the blend pairs, to more fairly evaluate the efficacy of pairwise blending. A snapshot² of the contents of the SSTs and DSTs at some point in the near future, reflecting the outcome of newly planned early retrievals, could serve as a starting point for selecting the blend pairs. If possible, additional DSTs should be emptied using supplemental pretreatment and treatment technologies and allocated for blending early in the mission to provide room for blending and supply adequate HLW feed to the WTP. The scenario should be evaluated for operational and programmatic impacts if it is effective in reducing the mass of HLW glass.
- Several alternative architectures and blending strategies should be explored, especially if pairwise blending using existing tanks proves ineffective or too difficult or costly to implement. While the specific alternatives would be developed at a later date, variations on the following alternatives should be considered (all supported by either new tanks specifically designed to support blending or DSTs emptied prior to WTP startup using supplemental pretreatment and treatment technologies): aggressive pairwise blending; a blending circuit; a hybrid strategy, first segregating waste by limiting component and then blending to minimize HLW glass mass; and metered blending of problematic waste (such as if the high-zirconium TRU waste in tanks AW-103 and AW-105 is determined to be incorporated into the HLW glass). Variants of alternatives that reduce or eliminate the required dwell time between sampling a staged batch of HLW and its delivery to the WTP to reduce tank space demand might also be considered.
- The glass property models used for this blending analysis and most recent mission analyses and most of the associated limits were developed circa 1996. Since then, the models have been gradually updated to include larger glass databases and other properties such as toxicity characteristic leaching procedure (TCLP). Additionally, ORP has been exploring the use of alternative properties (such as $T_{1.5\%}$, the temperature at which 1.5-wt% of crystals are present in the glass) to improve HLW waste oxide loading. The available models and limits should be reviewed to determine if the models and limits being used for mission analysis purposes need to be updated.
- The feasibility of refining the operating mode of the WTP ultrafilters to reduce the amount of oxides contributed by the liquid phase of the pretreated HLW should be investigated. The post-leach wash assumptions allow a significant amount of material removed by leaching to report to the HLW glass. An improvement in the post-leach wash efficacy might reduce the total mass of HLW glass.

² This method has already been used to identify three SSTs for blending with the three DSTs predicted to contain retrieved C-Farm waste as an enabling assumption for the mission scenario being developed for the upcoming Baseline Change Request and planned revision to the *Tank Farm Contractor Operation and Utilization Plan* (TFCOUP) (HNF-SD-WM-SP-012).

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LIST OF TERMS

Terms

Glass Factor. Glass factor is equal to the ratio of the mass of HLW glass produced per mass of solids in the delivered feed to the WTP.

Incidental Blending. This refers to the blending that occurs during the retrieval, staging, storage, and delivery of feed without any special effort other than SST sequencing. It is sometimes called unavoidable blending.

No Blend. The hypothetical case in which waste from each individual tank is retrieved, pretreated, and vitrified as a separate batch. No blending of waste between tanks is permitted.

Realized Blend. This refers to the actual blending that is predicted to occur during the evolution of a specific mission scenario. Incidental blending is an example of a realized blend.

Pairwise Blending. This is a simple form of discrete blending in which a group of tanks are blended, two-at-a-time, with the entire insoluble fraction from each tank is used in exactly one blend.

Percent of Span. This is a measure of how well a particular blending strategy reduces the mass of glass. Zero percent of span corresponds to performance the same as the Total Blend; one-hundred percent of span corresponds to No Blend. Smaller is better. It is defined as:

$$(100\%)(\text{Realized Blend Glass} - \text{Total Blend Glass}) / (\text{No Blend Glass} - \text{Total Blend Glass}).$$

Total Blend. The Total Blend represents the hypothetical case in which all of the waste is blended together, pretreated, and then vitrified as a single batch of uniform composition.

Abbreviations and Acronyms

BBI	Best Basis Inventory
BNI	Bechtel National, Inc.
CH-TRU	contact-handled TRU
CH2M HILL	CH2M HILL Hanford Group Inc.
DOE	U.S. Department of Energy
DST	Double-shell tank
DBVS	Demonstration Bulk Vitrification System
ETF	Effluent Treatment Facility
FY	Fiscal year
GPM	glass properties model
HLW	High-level waste
HTWOS	Hanford Tank Waste Operations Simulator
ICD	Interface Control Document
IDF	Integrated Disposal Facility

IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
LAW	Low-activity waste
LERF	Liquid Effluent Retention Facility
LLW	Low-level waste
ORP	U.S. Department of Energy, Office of River Protection
PFP	Plutonium Finishing Plant
RH-TRU	remote-handled TRU
RL	U.S. Department of Energy, Richland Operations Office
RPP	River Protection Project
SALDS	State-Approved Land Disposal Site
SBS	Submerged Bed Scrubber
SST	Single-shell tank
STP	Supplemental Treatment Plant
TCLP	Toxicity characteristic leaching procedure
TFCOUP	<i>Tank Farm Contractor Operation and Utilization Plan</i>
TEDF	Treated Effluent Disposal Facility
TFC	Tank Farm Contractor
TOC	total organic carbon
TOE	total operating efficiency
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i> (or TPA)
TRU	transuranic
TWINS	Tank Waste Information Network System
W&L	wash and leach
WESF	Waste Encapsulation and Storage Facility
WESP	wet electrostatic precipitator
WIPP	Waste Isolation Pilot Plant
WSCF	Waste Sampling and Characterization Facility
WRF	Waste Retrieval Facility
WTP	Waste Treatment and Immobilization Plant

Units

Ci	Curies
ft	feet
ft ³	cubic feet
g	grams
g/mL	grams per milliliter
gal	gallons
gpm	gallons per minute
Kgal	kilogallons
Kg	kilograms
L	liter
M	molarity or moles per liter
m ²	square meters

m ³	cubic meters
Mgal	million gallons
MT	metric tons
MTG	metric tons of glass
MTG/d	metric tons of glass per day
Pa•s	Pascal-seconds
wt%	weight percent
μCi	microcuries
μg	micrograms
°C	degrees Celsius

1.0 OBJECTIVE

In October 2004, the U.S. Department of Energy, Office of River Protection (ORP) directed CH2M HILL Hanford Group Inc. (CH2M HILL) to evaluate and propose a series of optimization studies that analyze options to improve baseline plans for tank farms that potentially offer lifecycle cost and schedule reductions. CH2M HILL evaluated thirteen options, and on November 17, 2004, proposed six studies that were determined to offer the best options to resolve an overall system productivity issue, or improve the overall baseline plan by reduction of lifecycle cost or schedule reduction (letter CH2M-0402570 R1, “River Protection Project Life Cycle Optimization Studies”).

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement or TPA) (Ecology et al. 1996) Milestone M-062-00 requires that ORP complete pretreatment processing and vitrification of Hanford Site high-level (HLW) and low-activity (LAW) tank wastes by December 31, 2028. Given the assumption of adequate LAW and transuranic (TRU) treatment capacity and feed availability, the treatment end date is then driven by the total mass of HLW glass that is produced during the treatment mission. Recent estimates of the total mass of HLW glass (RPP-20003 Rev. 1, *Sensitivity of Hanford Immobilized High-Level Waste Glass Mass to Chromium and Aluminum Partitioning Assumptions*; and RPP-RPT-23412, *Hanford Tank Waste Operations Simulator Model Data Package for the Development Run for the Refined Target Case*) exceed the amount of glass that could be produced by 2028 given the currently assumed net HLW glass production rates and pretreatment capacities. One way to potentially mitigate this issue is to reduce the total mass of HLW glass by blending of waste in the tank farms before delivery to the Waste Treatment and Immobilization Plant (WTP).

The primary objective of this study, one of the six studies mentioned above, is to demonstrate a mission scenario that uses both incidental and intentional blending of HLW to reduce the total mass of HLW glass. Secondary objectives include understanding how recent refinements to the tank waste inventory and solubility assumptions affect the mass of HLW glass and how logistical constraints may affect the efficacy of blending.

In addition to the six tank farm studies being performed by CH2M HILL, Bechtel National Inc. (BNI) has recently completed three studies of alternatives that would increase production capacity of WTP (24590-PTF-RPT-ENG-05-002, -003, -004). The ORP will evaluate the CH2M HILL optimization studies in conjunction with the WTP optimization studies and identify those combinations of options that are most likely to increase production capacity, reduce programmatic risk, shorten the schedule, and reduce life-cycle cost. The combined effects of these selected options may require further evaluation since many of the studies interact in a complex manner.

2.0 INTRODUCTION

This chapter provides an introduction to waste blending and related background material, defines terms and concepts used herein, and describes the scope of the study.

2.1 INFLUENCES

As discussed in Chapter 1.0, the projected treatment end date is driven by the predicted total mass of HLW glass produced given adequate LAW and TRU treatment capacity and feed availability. The predicted quantity of HLW glass depends on the waste composition and quantity, solubility during retrieval and staging, degree of blending, partitioning during pretreatment, and the glass properties model and constraints as shown by the simplified conceptual model in Figure 1. These factors are briefly discussed below.

Figure 1. Conceptual Model.

2.1.1 Waste Composition and Quantity

The Best Basis Inventory (BBI) provides the starting estimated composition and quantity of waste in the double-shell tanks (DSTs) and single-shell tanks (SSTs). A portion of the insoluble solids (sludge) has been provisionally identified for packaging and disposal as contact-handled TRU (CH-TRU) or remote-handled TRU (RH-TRU) waste and, therefore, does not contribute to the HLW glass mass in this study.

2.1.2 Solubility During Retrieval and Staging

The solubility of tank waste during retrieval and staging is an important factor in determining the quantity of solids delivered to the WTP for pretreatment. This chemistry is approximated using water wash factors which describe the solubility of the tank waste when contacted with large quantities of water. They define both how much saltcake is predicted to dissolve during retrieval and staging and how much slightly soluble material is predicted to be removed from sludge when water-washed in the Pretreatment Facility. One limitation of water wash factors is that they are a 0-order approximation that applies only to the specific set of conditions used when they were developed; they cannot accurately reflect complex changes in solid-liquid equilibrium that occur as varying amounts of water are used during retrieval, that occur when mixing different wastes, or that occur from concentration (removal of water) in the 242-A Evaporator or in the WTP. This solubility approximation allows the simulation of the retrieval and staging of all the tank waste in reasonable amount of computer time. CH2M HILL is exploring alternative

methodologies (for example, neural networks) that may improve the accuracy of these solubility approximations.

2.1.3 Degree of Blending

One of the major drivers for predicting the HLW glass mass is the degree of blending that occurs before vitrification of the waste. Previous work (RPP-20003) has shown that the degree of blending can change the predicted mass of HLW by about a factor of two between two bounding cases, the Total Blend and the No Blend cases (under current assumptions, the HLW glass mass for the No Blend case is nominally twice that of the Total Blend case for typical assumption sets).

Previous mission scenarios and the current project baseline rely primarily on “Incidental Blending” – that which occurs during the retrieval, staging, storage, and delivery of feed without any special effort other than SST sequencing (see Section 2.2). The degree of incidental blending in recent mission scenarios³ has typically resulted in a projected HLW glass mass about half-way between the Total Blend and No Blend cases. The degree of incidental blending is sensitive to the configuration (most notably how tank systems are connected) of the retrieval, transfer, and staging systems and the SST retrieval sequence.

The focus of this report is on “Intentional Blending” – any blending that is specifically orchestrated and, therefore, requires special effort. In addition to being sensitive to system configuration and the SST retrieval sequence, Intentional Blending will be sensitive to the myriad of logistical and operational constraints that govern the retrieval and staging of waste, and the operation of the WTP.

Blending (or its intentional absence, called segregation) influences the HLW glass mass by influencing the composition and variability of the pretreated HLW feed batches, thus increasing or decreasing the overall amount of glass formers that must be added to the waste (see Section 2.1.5) during vitrification.

2.1.4 Partitioning During Pretreatment

The purpose of the WTP Pretreatment facility is to partition (separate) the tank waste into two streams. One stream, containing the LAW fraction of the waste, will be sent to either the WTP LAW Vitrification Facility or to the Supplemental Treatment Plant (STP) for treatment (immobilization in glass) and on-site disposal in the Integrated Disposal Facility (IDF). The other stream, containing the HLW fraction of the waste and separated fission products, will be sent to the WTP HLW Vitrification Facility for treatment (immobilization in glass) and eventual disposal at the HLW Geologic Repository.

³ Some recent mission scenarios include the Target Case in System Plan Rev. 2 (ORP-11242 Rev. 2), the *Tank Farm Contractor Operation and Utilization Plan* (TFCOUP) Rev. 5D (HNF-SD-WM-SP-012 Rev. 5D), Case 5 in the Cr and Al wash and leach factor sensitivity report (RPP-20003 Rev. 1), and the Development Run (RPP-RPT-23412 Rev. 0A).

The WTP Pretreatment Facility contains several unit operations which influence the partitioning of waste into pretreated LAW and HLW. These are feed concentration, water washing, caustic leaching, oxidative leaching, post-leach wash, Sr/TRU precipitation, and Cs removal and are briefly discussed below.

A vacuum evaporator is used to concentrate liquid feed to a target sodium concentration (nominally 5 M) when needed. Any solids that precipitate during this step would be incorporated into the HLW glass unless removed by the downstream unit operations. The solid-liquid equilibrium that takes place during this concentration step has not been defined in the WTP Dynamic (G2) Model Design Document (24590-WTP-MDD-PR-01-002) nor modeled in Hanford Tank Waste Operations Simulator (HTWOS).

The ultrafilters are used to remove any remaining water soluble components, caustic soluble (primarily Al and Cr) components, and additional removal of Cr (oxidative leaching) from the solids. For the most part, the water wash factors have already been “applied” during the retrieval and staging of the feed to the WTP Pretreatment facility; little or no additional dissolution is predicted here. The caustic soluble components are removed by contacting the solids with hydroxide ion from a sodium hydroxide solution. The amount of material removed from the solids is approximated using the caustic leach factors, which like water wash factors are a 0-order approximation. Sufficient excess hydroxide must remain to keep the removed material (mostly aluminum) in solution in subsequent processing steps. It has been assumed that additional Cr can be removed during the ultrafilter operating cycles by oxidizing the Cr to a soluble valence by adding sodium permanganate to the waste after caustic leaching is completed.

The final step in the pretreatment of solids in the ultrafilters is a post-leach wash in which the interstitial liquid containing the leached (dissolved) solids is physically diluted and removed from the insoluble solids. The post-leach wash effectiveness depends primarily on the operating modes and parameters selected for the operation of the ultrafilter.

Envelope C waste from tanks AN-102 and AN-107 requires the removal of complexed Sr and TRU from the liquid phase. The ultrafilter system is also used to effect this separation by precipitating the TRU with sodium permanganate and precipitating the Sr using isotopic dilution with $\text{Sr}(\text{NO}_3)_2$. This operation has little impact on the total HLW glass mass but does introduce some process inefficiencies which in turn reduce the overall glass production capability.

2.1.5 Glass Properties Model

The pretreated HLW comprises the water- and caustic-insoluble solids, the separated Cs, the precipitated Sr and TRU, and any dissolved solids remaining in the liquid phase, less any Cr removed by oxidative leaching. In the WTP HLW Vitrification Facility, the pretreated HLW is combined with glass formers, converted to oxides, and incorporated into glass in the HLW melters. The mass and composition of the glass formers is adjusted to produce the minimum mass of HLW for that specific batch of pretreated HLW, subject to a number of constraints on glass properties and composition. The resulting mass of HLW glass depends on the specific glass properties models (i.e., correlations) being used, the allowable ranges for each property, the model domain (region of validity), allowances for uncertainties, and any other limits on glass

composition. One of the main objectives of blending is to level out the various glass-limiting components to reduce the total quantity of glass formers needed to produce an acceptable glass and thus minimize the total mass of HLW glass produced.

2.2 TERMINOLOGY AND CONCEPTS

Table 1 provides a taxonomy of blending-related terms. While not definitive, it is useful in explaining the terminology and concepts used in this and other reports. The four attributes (Type, Intent, Control Cycle, and Nature) will be discussed below.

Table 1. A Blending Taxonomy.

Type	Intent	Locus of Control	Nature
<ul style="list-style-type: none"> • Discrete • Continuous 	<ul style="list-style-type: none"> • Incidental • Intentional • Segregation • Hybrid 	<ul style="list-style-type: none"> • None • Existing • New 	<ul style="list-style-type: none"> • Normal • Hypothetical: <ul style="list-style-type: none"> ○ Total-Blend ○ No-Blend

Type

The blending type refers to whether the blends are comprised of whole tanks or predefined fractions of tanks (“Discrete”) or variable fractions of tanks (“Continuous”). The terms discrete and continuous are taken from the mathematical description of a variable that is constrained to fixed values (discrete) or allowed to take on any value (continuous) and were adopted from TWRSP-94-087, *Study of Potential Blending Strategies for Immobilization of Hanford High-Level Waste*.

Intent

The blending intent is the main distinguishing feature between various blending scenarios. “Incidental Blending” is the blending that occurs during the retrieval, staging, storage, and delivery of feed without any special effort other than SST sequencing. It is sometimes called unavoidable blending. “Intentional Blending” is any blending that is specifically orchestrated and, therefore, requires additional effort. Examples of intentional blending include pairwise blending (blending two tanks at a time) and metered blending (where small amounts of a problematic waste are blended into a number of successive feed batches). “Segregation” refers to intentionally keeping certain waste separated from other wastes. In the extreme, segregation is a degenerate case of intentional blending whereas the waste is blended with a “null” or “empty” tank. An example of a “Hybrid” blending intent is where waste is first segregated according to limiting constituent and then intentionally blended to minimize HLW glass mass.

Locus of Control

The locus of control refers to where the information needed to control the blending (or segregation) is obtained. In the “Existing” locus, existing tank-by-tank inventory information and partitioning information are used to determine which waste is blended together. In the “New” locus, process control samples or other measurements are used to determine which waste

is blended together; this is an example of “on-the-fly” blending. In the “None” locus, blending decisions are made without regard to waste composition.

Nature

Certain blends are identified as having a “Hypothetical” nature. All other blends are identified as “Normal.” Two common hypothetical blends are called the “Total-Blend” and the “No-Blend.” The Total Blend represents the case when all of the waste is blended together, pretreated, and vitrified as a single batch of uniform composition. This theoretical case represents the minimum HLW glass volume for the assumed waste inventory, partitioning assumptions, and assumed glass model and constraints. The “No Blend” represents the case when waste from each individual tank is retrieved, pretreated, and vitrified as a separate batch. No blending of waste between tanks is permitted. This theoretical case represents the maximum HLW glass volume for the identified waste inventory, partitioning assumptions, and assumed glass model and constraints.

2.3 PREVIOUS WORK

Appendix B summarizes a number of reports located during several literature searches for blending related material. Searches were conducted using the Records Management Information System (RMIS), the Hanford Document Control System (HDCS), the Pacific Northwest National Laboratory (PNNL) publications database (<http://www.pnl.gov/main/publications/>), the Westinghouse Savannah River Site scientific and technical information listing (<http://sti.srs.gov/fulltext/fulltext-2005.htm>) for 2005 and prior years, the Office of Scientific and Technical Information’s (OSTI) Science Research Connection database (<https://www.osti.gov/src/>), and general internet searches using Google (<http://www.google.com/>).

The focus was on U.S. Department of Energy (DOE)-specific documents because of time and resource constraints. There is a voluminous amount of industry-specific operational research literature that deals with various aspects of the full-up blending problems and also optimization literature that deals with the mathematical theory and techniques, but in general, that literature was not reviewed nor utilized in this study because of resource and timing constraints. The exception is a journal article by S. E. Buttrey, “Calling the lp_solve Linear Program Software from R, S-Plus® and Excel” (Buttrey 2005) which formed the basis for solving the pairwise blending optimization problem.

2.4 STUDY SCOPE

The general blending problem comprises three interdependent subproblems – a synthesis subproblem, a sequencing and scheduling subproblem, and a blending subproblem. Synthesis is selecting the underlying architecture (equipment and functions) of the Tank Farms and how the equipment is interconnected. Sequencing and scheduling is determining the tank retrieval sequence and timing, associated waste transfers, and how the various tanks and equipment are assigned to support various process functions. The blending subproblem refers to how waste

from various sources are blended together or kept segregated to minimize the mass of glass and address problematic waste.

Originally, this study was envisioned to be a trade study-style comparison of several alternatives, each consisting of a specific architecture and associated blending strategy. While framing the study, it was realized that it was premature to commit time and resources needed to perform the full-up trade study without preliminary study to develop the required tools and determine a workable approach to dealing with this extremely complex formulation problem.

Some of the alternatives considered while framing the study are shown in Table 2. This list is not meant to be exhaustive but only to provide a general feel for the potential range of alternatives that may need to be considered.

Table 2. Some Example Alternatives. (2 Sheets)

Architecture	Blending Strategy [Type – Intent – Locus]⁴	Comments
Existing tanks and transfer systems.	Incidental [Continuous – Incidental – None]	An example is Case 13, the reference case for this study.
Existing tanks and transfer systems	Enhanced Incidental [Continuous – Incidental – Existing]	An example is Case 14, in which the SST Retrieval Sequence was manipulated to attempt to increase incidental blending.
Existing tanks with modified transfer systems.	Pairwise Blending [Discrete – Intentional – Existing]	An example is Case 15, which added a <u>limited</u> number of blend-pairs to Case 14.
Existing tanks and transfer systems.	Based on process control samples, choose sending and receiving tanks for each transfer based on closest approach to total blend of one or more key components. [Discrete – Intentional and Incidental – New]	This is an example of an on-the-fly blending strategy.
Empty tank farm with modified transfer systems.	Pairwise Blending [Discrete – Intentional – Existing]	This is similar to Case 15, except additional tank space is allocated to support multiple blend pair receivers and to attempt to reduce HLW melter outages.
Empty tank farm with modified transfer systems.	Operate as a blending circuit to approximate a large-volume continuous stirred tank in order to dampen out variability in HLW feed. [Continuous – Intentional – Any]	This can be paired with Pairwise blending or another selection scheme to make sure that wastes with different limiting components have an opportunity to be blended in the circuit.

⁴ This is the predominate blending type, intent and locus of control.

Table 2. Some Example Alternatives. (2 Sheets)

Architecture	Blending Strategy [Type – Intent – Locus]⁴	Comments
Empty tank farm with modified transfer systems.	Segregate retrieved waste by limiting component; then blend as waste is staged. [Continuous – Intentional – Any]	Locus of control can be either “New” (on-the-fly) if process control samples are used to formulate the blends, “Existing” if source tank composition is used, or “None,” if the wastes are blending according to a fixed recipe.
Empty tank farm or dedicated blending facility with modified transfer systems.	Segregate retrieved waste by limiting component; then blend as waste is delivered. [Continuous – Intentional – Any]	Locus of control can be either “New” (on-the-fly) if process control samples are used to formulate the blends, “Existing” if source tank composition is used, or “None,” if the wastes are blending according to a fixed recipe.

The informal exploratory work performed to assist with framing this study suggested that (1) relaxing certain SST retrieval sequence constraints can increase the degree of incidental blending between tank farms and that (2) pairwise blending of waste, at least without logistical constraints, can approach the total blend in terms of mass of HLW glass. Therefore, the scope of the study was limited to focus on those two promising lines-of-inquiry. Both of these lines-of-inquiry are further limited to utilize existing tanks and to address only the blending of solids for the purpose of minimizing HLW glass mass – intentional blending to address specific instances of problematic waste such as high hydrogen generation rate or high sulfate to sodium ratio in the liquid phase have been evaluated previously and are addressed elsewhere.

To that end, the body of this report comprises two related evaluations – the names of each evaluation are in bold:

1. **Pairwise Blending Evaluation** – This evaluation examines the sensitivity of HLW glass mass to constraints imposed on a hypothetical pairwise blending strategy. The evaluation will also provide a basis for selecting the specific blend pairs to be implemented in the Mission Scenario Evaluation.
2. **Mission Scenario Evaluation** – This evaluation builds three mission scenarios, one using incidental blending as a reference case, one using improved incidental blending, and one using improved incidental blending along with pairwise blending.

In addition, Appendix D of the report defines the reference case that will be used to evaluate the mission impact of the proposed blending scenarios.

3.0 INPUT DATA

The input data used in this report comprises:

3.1 WASTE INVENTORY

The starting tank waste inventory is provided in RPP-25191, *Double-Shell and Single-Shell Inventory Input to the HTWOS⁵ Model – 2005 Update*. This represents the composition of the waste in the Hanford DSTs and SSTs as of October 1, 2004 and was downloaded from the Tank Waste Information network System (TWINS) on January 27, 2005. This is called the “2005” Inventory.

3.2 WATER WASH AND CAUSTIC LEACH

The baseline set of water wash and caustic leach (differential) factors downloaded from TWINS on August 24, 2004, supplanted with the new water wash and caustic leach factors for SO_4 and PO_4 as provided in RPP-25903, *Review of Phosphate and Sulfate Wash and Leach Factors*, will be used for partitioning waste into solid and liquid phases during retrieval, staging, and pretreatment; the partitioning of strontium will be modeled per RPP-21807, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*.

⁵ HTWOS = Hanford Tank Waste Operations Simulator.

4.0 KEY ASSUMPTIONS

The key assumptions used in this study are presented in this chapter. More detailed assumptions are provided in Appendix A.

4.1 EARLY SST RETRIEVALS

For the three cases in the Mission Scenario Evaluation, the early SST retrievals⁶ will comprise the same tanks as in the Development Run (RPP-RPT-23412), with adjustments made to the sequence as a result of the newer waste inventory and historical transfers and to accommodate blending. This enabling assumption was made to avoid disrupting near-term retrieval plans (specifically, the C-Farm retrieval projects necessary to meet the near term Tri-Party Agreement milestone M-45-00B) and to simplify the near-term modeling associated with this analysis.

4.2 REMAINING SST RETRIEVALS

The two risk-based sorts⁷ on the remainder of SST retrieval sequence are eliminated to remove a legacy constraint that appears to reduce the amount of incidental blending. Instead, the lists will be sorted by decreasing mass of HLW glass and decreasing mass of soluble Na, with adjustments to space out tanks limited by the same HLW glass limiting components.

4.3 TRU PACKAGING

Twenty Tanks (seventeen SSTs and three DSTs) are designated for TRU packaging (eleven as CH-TRU and nine as RH-TRU) and are, therefore, not candidates for blending). None are incorporated into HLW waste glass for purposes of this study.

⁶ The 38 early tanks, in the order retrieved by the mission scenario evaluation are: C-203, S-102, S-112, S-109, C-202, C-103, C-201, C-109, C-204, C-112, C-102, B-201, B-202, U-201, C-104, C-108, U-202, B-203, U-203, U-204, B-204, C-107, T-201, T-202, T-203, C-101, T-204, T-111, U-112, C-111, C-105, T-110, C-110, A-102, SX-115, T-104, AX-102, and AX-103.

⁷ The HTWOS model includes two lists of SSTs, one sorted by decreasing Airborne relative risk and the other by decreasing Groundwater relative risk. The Airborne risk is driven by components that tend to be in the sludge while the Groundwater risk is driven by components that tend to be soluble. The model attempts to retrieve higher risk tanks first, depending on the need for balancing feed to the WTP and other logistical considerations. Since most tanks in a given farm are assigned the same relative risks, the lists are effectively grouped by tank farms. These specific sorts are now obsolete and are being revisited for future analyses.

4.4 WTP PRETREATMENT ASSUMPTIONS

All waste delivered to the WTP will undergo water washing, caustic leaching, and oxidative leaching (or in the case of the liquid fraction of tanks AN-102 and AN-107, undergo Sr and TRU removal) using Development Run (RPP-RPT-23412) assumptions⁸, except:

- The Pairwise Blending Evaluation will make simplifying assumptions of (1) perfect solid-liquid separation, and (2) that the entire contents of each tank will be treated.
- The Mission Scenario and the Pairwise Blending Evaluation will use the TWINS water wash and caustic leach factors, updated with new SO₄ and PO₄ factors.

4.5 HLW GLASS ASSUMPTIONS

The Relaxed Glass Properties Model (Relaxed GPM) will be used for all analysis – this is the same as the Relaxed GPM documented in RPP-20003 Rev. 1 and used in the Development Run (RPP-RPT-23412).

4.6 BLENDING AND RETRIEVAL ASSUMPTIONS

The following blending and retrieval assumptions apply only to the Mission Scenario Evaluation, not the Pairwise Blending Evaluation.

- There will be one DST in West Area (SY-101) and one in East Area (AY-101) designated as blend-pair receivers.
- For the Mission Scenario, pairwise blending will be performed in the blend-pair receivers. The overall retrieval and staging flow will be as shown in Figure 2:
 - Assume that a direct transfer line (e.g., a hose-in-hose transfer line [HIHTL]) is used to transfer waste between source SSTs and the corresponding (in the same area) blend-pair receiver.
 - When a tank is selected for retrieval using one of the SST retrieval sequence lists, first it and then its mate will be retrieved into the appropriate blend-pair receiver.
 - Once a blend-pair is executed, further incidental blending is permitted.
- Specific blend pairs will be obtained from the Pairwise Blending Evaluation:
 - Blend pairs must be located within the same area.
 - For simplicity, the tanks selected for pairwise blending, their timing and sequence will not be constrained by farm-closure or waste management area (WMA)-closure acceleration strategy.
 - For simplicity, the tanks considered for pairwise blending will exclude the TRU-containing tanks, the 38 early SSTs in the retrieval sequence, the DSTs, and the SSTs that are candidates for providing low-curie feed to the STP. After accounting for overlap, this leaves 78 tanks as candidates for pairwise blending

⁸ Implicit in these assumptions is that once the HLW solids are leached, the leached waste components remain in the liquid phase and do not re-precipitate.

4.7 PRODUCTION CAPACITY ASSUMPTIONS

In the Development Run (RPP-RPT-23412), the capacities of the HLW Vitrification Facility and the ultrafilter permeate rate were manipulated to try to meet a 2028 treatment end date. Within the flexibility given to the modelers, the net HLW Vitrification capacity was increased from the baseline value of 5 MTG/d to 6 MTG/d and the ultrafilter permeate rate was increased from 17.7 to 25 gallons per minute.

In the HTWOS runs performed for this blending study, the capacities for the HLW Vitrification Facility and the ultrafilter permeate rate were returned to their baseline values.

Figure 2. Retrieval and Staging Flow for Pairwise Blending.

5.0 METHOD OF ANALYSIS

The methods of analysis for the two evaluations are discussed in this chapter.

5.1 PAIRWISE BLENDING EVALUATION

The pairwise blending evaluation consists of two parts. The first part is a sensitivity study in which the object is simply to pair each of the 156 tanks ($177 - 20 \text{ TRU} - 1$ to yield an even number) with exactly one other tank in such a manner as to minimize the total mass of HLW glass. This idealized problem (no mission dynamics, logistics, or additional blending are addressed), becomes an integer programming problem (IP) which can be solved using a variety of algorithms. The sensitivity study will compare the potential improvements in HLW glass mass relative to the Total Blend and No Blend Cases for a series of blend pair cases, each imposing additional constraints on which blends are permissible:

- No constraints (any of the 156 tanks can be blended with any other tank)
- Area Constrained (200 East tanks can only be blended with 200 East tanks; 200 West with 200 West)
- Quadrant Constrained (tanks can only be blended with other tanks from the same quadrant)
- Farm Constrained (tanks can only be blended with other tanks from the same farm).

The purpose of the sensitivity study is to (1) see how close the no-constraint blend-pair solution will approach the total blend, and (2) demonstrate the degree to which additional constraints have an adverse impact on the HLW glass volume.

The purpose of this second part is to select a practical set of blend pairs for use in the Mission Scenario evaluation. As stated in the assumptions, the blend-pairs proposed for this part will be developed using area constraints and a subset of the tanks. The subset of tanks will exclude the TRU-containing tanks, the 38 early SSTs, the DSTs, and the SSTs that are candidates for providing low-curie feed to the STP. These tanks were excluded to avoid including waste which is not planned to provide HLW feed to the WTP in the instance of TRU-containing tanks and to simplify operational logistics and avoid disrupting near-terms plans in the instances of the other excluded tanks. After accounting for overlap, this leaves 78 candidate tanks⁹ forming up to 39 blend pairs.

The mathematical formulation of the blend-pair problem is as follows:

⁹ The 78 candidate tanks are: A-101, A-103, A-104, A-105, A-106, AX-101, AX-104, B-102, B-104, B-106, B-109, B-112, BX-101, BX-102, BX-103, BX-104, BX-105, BX-106, BX-107, BX-108, BX-109, BX-110, BX-112, BY-101, BY-104, BY-106, BY-107, BY-110, S-101, S-103, S-104, S-106, S-107, S-108, S-110, S-111, SX-101, SX-102, SX-103, SX-104, SX-105, SX-106, SX-107, SX-108, SX-109, SX-110, SX-111, SX-112, SX-113, SX-114, T-101, T-102, T-103, T-106, T-108, TX-101, TX-102, TX-104, TX-106, TX-107, TX-109, TX-113, TX-116, TY-101, TY-103, TY-104, TY-105, TY-106, U-101, U-102, U-103, U-104, U-105, U-106, U-108, U-109, U-110, and U-111.

Maximize, S , the reduction in glass mass relative to the no-blend case.

$$\text{Maximize}(S) \quad (1)$$

$$S = \sum_{j=1}^T \sum_{i=1}^T C_{i,j} R_{i,j} \quad (2)$$

Where,

T = number of tanks (must be even)

$R_{i,j}$ = glass reduction matrix, a T by T matrix

The glass reduction matrix, $R_{i,j}$, is a matrix, the elements of which represent the reduction in glass by blending two tanks (i and j) together relative to the glass mass resulting from those two tanks without blending. For a given set of waste inventory, partitioning, pretreatment and glass formulation assumptions, $R_{i,j}$ is simply a table of constants.

$C_{i,j}$ = blending matrix, a T by T matrix

The blending matrix, $C_{i,j}$, is a matrix of integers, the elements of which indicate which tanks are being blended. If $C_{i,j} = 1$, then tanks i and j are blended together. There are a number of constraints on $C_{i,j}$ that are needed to define the pairwise blending problem.

$$C_{i,j} \in (0, 1) \quad (3)$$

Equation (3) restricts the values of the matrix to either 0 or 1 to prevent formulation of blends with partial tank contents and to avoid blends with negative contributions. This constraint turns the pairwise blending problem into a discrete blending problem.

$$C_{i,j} = 0 \quad \forall j \geq i \quad (4)$$

Equation (4) eliminates blends that would be duplicated because they are permutations of other blends (tank i blended with j is a duplicate of tank j blended with i) and eliminates the null blends (tank i blended with i). In practice, the variables representing the duplicate blends and the null blends are excluded from the model to avoid unnecessary computations.

Equations (5), (6), and (7) specify that each tank will be used in one and only one blend. Equations (5) and (6) address the first and last tank, respectively, while Equation (7) addresses the others.

$$\sum_{i=2}^T C_{i,1} = 1 \quad (5)$$

$$\sum_{j=1}^{T-1} C_{T,j} = 1 \quad (6)$$

$$\sum_{j=1}^{N-1} C_{N,j} + \sum_{i=N+1}^T C_{i,N} = 1 \quad (7)$$

For all N,

$$1 < N < T$$

The pairwise blending optimization problem described above is an Integer Programming (IP) problem. The glass reduction matrix generated for this study is found in the three blend pair calculator spreadsheets (see Table C-3) released under spreadsheet verification forms SVF-1096, SVF-1097, and SVF-1098.

5.2 MISSION SCENARIO EVALUATION

The objective of this evaluation and the primary objective of this report is to demonstrate a mission scenario that uses both incidental and intentional pairwise blending of HLW to reduce the total mass of HLW glass.

The method of analysis is to use the HTWOS model to test the premise that selective use of blend pairs and improvements in incidental blending can reduce the mass of HLW glass produced over the mission.

First, the rerun of the Development Run (RPP-RPT-23412) (same as Case 13 in the Reference Case Evaluation) using the new wash and leach factors and waste inventory was used to establish a reference case that predicts the mass of HLW glass produced using the existing SST retrieval sequence strategy (using risk-based sorts by tank farm) along with the associated degree of incidental blending.

Next, the HTWOS model is rerun (Case 14) with an updated (relaxed) SST retrieval sequence strategy per the assumptions in Section 4.2 and [Appendix A](#). This tests the assertion that the risk-based sort on the SST retrieval sequence is reducing the degree of incidental blending and adversely affecting the mass of HLW glass.

Finally, the HTWOS mission scenario is rerun (Case 15) using both the improved incidental blending and pairwise blending assumptions.

The three cases described above will be compared in terms of the mass of HLW glass produced along with several other metrics: HLW glass production over time, availability of HLW feed, glass factor, variability of HLW feed, glass mass drivers, degree of blending (no metric developed), and operational and programmatic impacts (general discussion only).

Table 3. Study Matrix for Mission Scenarios.

Case	Factors and Levels						Evaluated Subcases		
	SO ₄ W&L ¹		PO ₄ W&L ¹		Inventory ²		Blending		
	Baseline	New	Baseline	New	2004a	2005	Total	No	Realized ³
13 - REF	—	•	—	•	—	•	•	•	Incidental
14	—	•	—	•	—	•	•	•	Incidental + Relaxed SST Sequence
15	—	•	—	•	—	•	•	•	Incidental + Relaxed SST Sequence + Pairwise

Notes:

¹For sulfate and phosphate, the “Baseline” wash and leach factors refer to those used in the Development Run (RPP-RPT-23412), while “New” refers to those proposed by RPP-25903 (which have recently been incorporated into the set of official wash and leach factors maintained in TWINS).

²The 2004a inventory refers to the inventory used in the Development Run as documented in RPP-22760, Rev. 0, with an effective date of April 2004. The 2005 inventory refers to the updated inventory documented in RPP-25191, Rev. 0, with an effective date of October 2004.

³An entry in this column indicates that the HTWOS model was used to evaluate the incidental blending associated with a full mission scenario.

W&L = Wash and Leach

6.0 USE OF COMPUTER SOFTWARE

6.1 PAIRWISE BLENDING EVALUATION

6.1.1 Glass Reduction Matrix

The glass reduction matrix, $R_{i,j}$, is created using several procedures in the HTWOS model.

The specific procedures that were changed to produce the glass reduction matrix are listed in Table C-1. Modules Changed for Reference Case and Pairwise Blending Evaluations, located in Section C2.0, “Computer Software” of Appendix C.

Verification that the HTWOS model used the stated assumptions and the proper input data is documented by the HTWOS model modification forms in Section C3.1, “Reference Case And Pairwise Blending Evaluations,” located in Appendix C.

6.1.2 Integer Programming Problems

The integer programming problems described in Section 5.1 are set up in several spreadsheets that define the objective functions, constraints, and other inputs (i.e., the glass reduction matrix). The problems are then solved using the LPS Software, Implementation 5.6, described and validated in RPP-PLAN-26839, *LPS Software Quality Assurance Plan, Configuration Controls, and Verification and Validation Results*.

The verification of the associated spreadsheets is addressed in Section 6.3.

6.2 MISSION SCENARIO EVALUATION

The three mission scenarios (Cases 13 – 15) use the same HTWOS model code as was used for the Development Run (RPP-RPT-23412), updated per the detailed HTWOS assumptions in Appendix A.

The specific procedures changed for this evaluation are listed in Table C-2. Modules Changed for Mission Scenarios, located in Section C2.0, “Computer Software” of Appendix C.

Verification that the HTWOS model used the stated assumptions and the proper input data is documented by the HTWOS model modification forms in Section C3.2, “Mission Scenarios,” located in Appendix C.

6.3 SPREADSHEETS

Many spreadsheets were used to manipulate and prepare data for input to the various models or for display in this report and also to perform the pairwise blending calculations. These spreadsheets (and their verification number, if applicable) are listed in Section C4.0 of Appendix C.

7.0 RESULTS

7.1 PAIRWISE BLENDING EVALUATION

The following two sections discuss the results of the pairwise blending sensitivity analysis (Section 7.1.1) and the selection of the specific blend pairs (Section 7.1.2) to be used for Case 15 in the Mission Scenario.

More details in the form of intermediate results such as the glass reduction matrix and specific blend pairs can be found in the released spreadsheets listed in Table C-3, specifically SVF-1096, 1097, 1098, and 1099.

7.1.1 Sensitivity Analysis

The pairwise blending evaluation examines the sensitivity of HLW glass mass to successively more restrictive constraints imposed on a hypothetical pairwise blending strategy. This evaluation assumes that the only blending that occurs is that due to the pairwise blending – specifically no incidental or any other intentional blending occurs.

Figure 3 shows the cumulative reduction in HLW glass mass for various sets of constraints. A cumulative reduction of zero MT corresponds to the “No Blend” case; a reduction of about 16,000 MT corresponds to the “Total Blend” case. The blend pairs for each curve are sorted in order of decreasing reduction in HLW glass mass. Keep in mind that the specific blend pairs for each curve are different. Three general observations are (1) that the unconstrained pairwise blending approaches the performance of the Total Blend, (2) that about 80% of the benefit is obtained using about 40% of the blend pairs, and (3) that addition of constraints significantly decreases blending performance.

The actual “No Blend” glass mass for the assumed tank waste inventory (less the 20 TRU tanks), water wash, caustic leach, and oxidative leach assumptions is 43,111 MTG; the “Total Blend” glass mass is 27,080 MTG. The corresponding mass of glass is determined by subtracting the cumulative reduction in glass mass from the “No Blend” glass mass.

As additional constraints are added to restrict the allowable blend pairs, the efficacy of pairwise blending is reduced. The area constraint (blend pairs must be from the same area) slightly reduces the efficacy, while quadrant constraints (blend pairs must be from the same quadrant) and farm constraints (blend pairs must be from the same tank farm) significantly reduce the efficacy. Table 4 compares the final glass mass and the efficacy of the blending measured as a percent of span¹⁰ for each of the constraints.

¹⁰ “Percent of Span” is a measure of how well a particular blending strategy reduces the mass of glass. It is defined as $(100\%)(\text{Realized Blend Glass} - \text{Total Blend Glass}) / (\text{No Blend Glass} - \text{Total Blend Glass})$. Zero percent of span corresponds to performance the same as the Total Blend; one-hundred percent of span corresponds to No Blend. Smaller is better.

Figure 3. Blend-Pair Sensitivity Curves. **Table 4. Effects of Constraining Blend Pairs.**

Constraints on Blend Pairs	HLW Glass, MT	HLW Glass, Percent of Span
Unconstrained	27,750	4
By Area (200E / 200W)	29,951	18
By Quadrant (NE / NW / SE / SW)	32,483	34
By Farm	36,899	61

The maximum HLW glass production through December 31, 2028 is 31,863 MTG using the assumed HLW vitrification ramp-up assumptions in [Appendix A](#) and assuming that there are no outages due to lack of feed or processing of Envelope C waste from tank AN-102 or tank AN-107. Constraining the blend pairs by quadrant or by farm, assuming no additional incidental or intentional blending occurs, will result in the mass of HLW glass exceeding the assumed production capacity at December 31, 2028.

7.1.2 Selection of Blend Pairs

As explained in Section 5.1, the blend-pairs proposed for use in Case 15 were selected by the LPS Software using area constraints and a subset of the 177 tanks. The subset of tanks excluded the TRU-containing tanks, the first 38 SSTs in the existing retrieval sequence, the DSTs, and the SSTs that are candidates for providing low-curie feed to the STP. This leaves 78 tanks (28 tanks¹¹ in 200 East and 50 tanks¹² in 200 West) available for pairwise blending, for a total of up to 39 blend pairs.

The optimal blend pairs, as computed using the LPS Software, are shown in Table 5 along with the reduction in HLW glass for each pair (unblended glass mass minus blended glass mass). Only the tanks contributing a cumulative 97% of the savings attributed to these 39 blend pairs were retained, leaving a total of 29 blend pairs for use in the Mission Scenario Case 15. The remaining ten pairs were subjectively excluded on the basis that little benefit results from the effort needed to orchestrate their retrievals to implement pairwise blending.

The potential glass reduction from the 39 optimal blend-pairs is shown on Figure 3 along with the point corresponding to the 29 selected blend pairs. This shows that the trade-off for excluding tanks (other than the TRU tanks) to simplify operational logistics and avoid disrupting near-terms plans is a significant reduction in the potential blending performance.

Four of the selected blend pairs (highlighted in rose in Table 5) were not executed by the HTWOS model because of programming difficulties. The implemented blend-pair sensitivity curve, which excludes these four blend-pairs from the selected blend pairs, is also shown on Figure 3 for comparison.

In retrospect, the assumptions made to simplify this analysis (notably, excluding the DSTs and early SSTs as blend pair candidates) resulted in poor pairwise blending performance and confounded the interpretation of the Mission Scenario Evaluation.

¹¹ The 28 tanks considered from 200 East are: A-101, A-103, A-104, A-105, A-106, AX-101, AX-104, B-102, B-104, B-106, B-109, B-112, BX-101, BX-102, BX-103, BX-104, BX-105, BX-106, BX-107, BX-108, BX-109, BX-110, BX-112, BY-101, BY-104, BY-106, BY-107, and BY-110.

¹² The 50 tanks considered from 200 West are: S-101, S-103, S-104, S-106, S-107, S-108, S-110, S-111, SX-101, SX-102, SX-103, SX-104, SX-105, SX-106, SX-107, SX-108, SX-109, SX-110, SX-111, SX-112, SX-113, SX-114, T-101, T-102, T-103, T-106, T-108, TX-101, TX-102, TX-104, TX-106, TX-107, TX-109, TX-113, TX-116, TY-101, TY-103, TY-104, TY-105, TY-106, U-101, U-102, U-103, U-104, U-105, U-106, U-108, U-109, U-110, and U-111.

Table 5. Selected Blend-Pairs.

200 East Blend-Pairs			200 West Blend-Pairs		
Tank X	Tank Y	Glass Reduction, MT	Tank X	Tank Y	Glass Reduction, MT
B-104	BY-101	392.3	SX-114	TX-113	978.2
AX-101	BX-107	219.7	SX-103	U-108	423.3
A-105	BY-107	170.8	S-104	TY-103	331.8
A-104	BX-112	120.2	SX-104	TY-101	301.5
A-103	AX-104	114.9	S-101	TY-105	278.2
B-102	BY-104	100.0	SX-109	TX-109	244.3
A-106	BX-110	78.8	S-110	U-105	178.2
B-106	BX-102	58.2	S-108	SX-111	174.9
BX-105	BY-106	54.9	S-111	U-109	167.0
BX-104	BY-110	54.5	S-107	TX-116	160.6
B-109	BX-109	38.5	TX-106	U-103	105.2
BX-101	BX-103	23.9	S-106	SX-112	101.6
B-112	BX-106	6.5	SX-107	TY-104	86.6
A-101	BX-108	6.1	SX-101	SX-110	83.3
			U-102	U-104	55.5
			SX-108	U-110	50.0
			SX-113	T-101	48.2
			TX-101	TX-102	48.0
			SX-105	SX-106	27.4
			SX-102	U-106	24.7
			S-103	T-108	18.4
			TY-106	U-101	16.5
			TX-104	U-111	12.4
			T-103	TX-107	5.5
			T-102	T-106	2.3

Note: Yellow shaded blend pairs were intentionally excluded from Case 15. Rose shaded blend pairs were not executed by the HTWOS model. See text for details.

7.2 MISSION SCENARIO EVALUATION

As discussed in Section 5.2, three cases (Cases 13, 14, and 15) were modeled in HTWOS as part of the Mission Scenario Evaluation. These cases will be compared in terms of the following metrics:

- Mass of HLW glass
- HLW glass production over time
- Availability of HLW feed
- Glass factor

- Variability of HLW Feed
- Glass mass drivers
- Degree of Blending (no workable metric)
- Operational and Programmatic Implications (general discussion only).

7.2.1 Mass of HLW Glass

Figure 4 presents the mass of HLW glass from Cases 13 – 15 for the Mission Scenario Evaluation graphically; Table 6 presents the same information numerically. The mass of HLW glass is shown for the Total Blend and No Blend subcases for each case defined in Table 3, Study Matrix for Mission Scenarios. The white dotted line is a guide to help the reader visualize changes from Case 13 – Realized Blend.

Relative to Case 13, Case 14 reduced the mass of HLW glass by about one percent; Case 15 by about two percent. In the opinion of the authors, this is well within the “noise” level in HLW glass mass resulting from minor changes in incidental blending. Therefore, the results are inconclusive as to whether they were caused by the fundamental assumptions differences among the three cases and fall short of the potential performance of pairwise blending.

Table 6. HLW Glass Mass Ranges for Mission Analysis.

	Case 13 (Ref)	Case 14	Case 15
Total Blend	27,080	27,080	27,080
Realized Blend	35,443	35,158	34,838
No Blend	43,111	43,111	43,111
Percent of Span	52.2	50.4	48.4
Units: All glass is in MT. Percent of Span is in percent.			

Figure 4. HLW Glass Mass Ranges for Mission Scenarios.

7.2.2 HLW Glass Production Over Time

Figure 5 shows the predicted production of HLW glass over time for the three cases along with the theoretical production possible if the production of HLW glass followed the assumed ramp-up curve with no outages. The first four magenta points delineate the changes in production capacity while the last point indicates the theoretical production at the end of 2028.

All three cases make too much HLW glass to finish treatment by the end of 2028. The earliest treatment could be finished, assuming no HLW melter outages, would be the end of 2030.

Cases 13 and 14 production curves, typical of those seen in other recent cases, in which HLW glass production lags approximately two years behind the theoretical ramp-up. Approximately six months of this is due to the impacts of treating the Envelope C waste from tanks AN-102 and AN-107 in the WTP and could be avoided by removing the Sr and TRU from that supernate before delivery to the WTP (RPP-24809, *Strontium and TRU Separation Process in the DST System*). The specific cause or causes for the remainder of the lag has not been determined and represents a potential area for future mission optimization. Since most of this lag is incurred between 2013 and 2017, it may be related to the interaction of the transition feed and the WTP's process capability.

The production curve for Case 15 is similar to those for Cases 13 and 14 until 2021, after which three feed outages incur approximately one additional year of lag. These feed outages are due to multiple bottlenecks in the retrieval, blending, staging, and delivery of feed. The mechanism of the major bottleneck appears to be a backlog of waste prevents decanting of supernate from the blend pair receivers, starving the HLW feed staging tanks for feed. It is hypothesized that operation of the 242-A Evaporator past its assumed 2018 decommissioning date or other changes in system configuration, such as additional DSTs, may be able to mitigate this situation.

The above bottlenecks also appear to starve the WTP of LAW feed and underutilize the STP, an artifact of which is the increase in the length of the treatment mission while the remaining LAW is treated. Near the end of the treatment mission, Case 15 shows a marked reduction in HLW glass production. During this period, the only sources of HLW feed are the separated radionuclides and entrained solids from the LAW. Interpretation of this reduction is confounded since the HTWOS model is executing its rather simple system cleanout procedures at that time.

7.2.3 HLW Feed Availability

HLW feed is staged for delivery to the WTP in a number of DSTs (see Table 7). The waste must remain in the staging tank, without any transfers into or out of the tank, for a minimum of 210 days before delivery to the WTP. The 210-day period comprises 180 days required by the ICD-19 (24590-WTP-ICD-MG-01-019, *Interface Control Document for Waste Feed*) and a 30-day allocation for sampling. The actual period of time that the waste sits in the staging tank is called "dwell time."

Table 7. Assigned HLW Feed Staging Tanks.

Number of Tanks	Tanks	Cases 13 and 14	Case 15
4	AY-101, AY-102, AZ-101, AZ-102	until AY-101 is delivered (2012)	
3	AY-102, AZ-101, AZ-102	until AN-105 becomes a staging tank (2014)	
4	AN-105, AY-102, AZ-101, AZ-102	until AN-103 becomes a staging tank (2018)	until AN-103 becomes a staging tank (2022)
5	AN-103, AN-105, AY-102, AZ-101, AZ-102	Until end of mission	Until end of mission

Note: In Cases 13 and 14, once delivered, AY-101 was not used by the model; in Case 15, AY-101 was used as one of the blend pair receivers.

Figure 6 shows the dwell time for each batch group of HLW feed over time for Cases 13 through 15. A “batch group” refers to the set of consecutive batches of feed delivered to the WTP from a single tank of staged HLW feed. The dwell time is measured from when the staging tank is filled with feed to the start of delivery of the first batch in the corresponding batch group. The 210-day limit is also shown on the figure for comparison. When the dwell time is greater than the limit, a sufficient quantity of feed is being delivered to the WTP. When the dwell time is equal to the limit, the feed is being delivered to the WTP as soon as it is ready – this means that the WTP is potentially being starved for HLW feed. There are three batch groups for Case 15 which are at the 210-day limit. These three batch groups correspond to the three additional feed outages circa 2021-2025 seen on Figure 5 and discussed in Section 7.2.2. The dwell times during the “System Clean-Out” period (shown for completeness) should not be used for decision making purposes since a system clean-out strategy has not yet been established.

Figure 7 presents the dwell times shown in Figure 6 as distribution plots to facilitate comparison. Taken together with the individual batch groups in Figure 6, it can be inferred that: (1) Case 15 has fewer batch groups, each containing more solids, than Cases 13 or 14, and (2) that the larger batch groups increase the availability HLW feed by better utilizing the available staging tanks.

Figure 5. HLW Glass Production for Mission Scenarios. **Figure 6. HLW Feed Dwell Time.**

Figure 7. Distribution of HLW Dwell Times.

7.2.4 Glass Factor

One of the important parameters for the WTP's ultrafilter system is "Glass Factor." As defined in 24590-PTF-RPT-ENG-05-002, the term "glass factor" is equal to the ratio of the mass of HLW glass produced per mass of solids in the delivered feed. The glass factors for each ultrafilter batch were tracked for the three cases and compared via the cumulative distribution plots shown in Figure 8. The glass factors reported by this blending study are not directly comparable with those in 24590-PTF-RPT-ENG-05-002 since each analysis used different HLW glass model constraints and different pretreatment assumptions. Additionally, the blending study tracked the glass factor for each ultrafilter batch while the WTP report looked at feed delivered to the HLW feed receipt tanks.

All three cases have a similar glass factor distribution which, on an individual ultrafilter feed batch basis, ranged from about 0.4 to 6.5 with a median value of 1.6 MTG per MT feed solids. Apparently, the degrees of blending in the three cases were not sufficiently different to significantly affect this metric. This metric may be more useful as other blending options are explored.

The total volume of retrieved and fully water-washed HLW feed for delivery to the WTP can be estimated using the median glass factor and the mass of glass from a realized blend. The purpose

of this rough estimate is to provide a feel of the quantities of solids moving through the tank farms and hence the potential scale of any systematic blending effort. Using the median glass factor of 1.6 and the realized blend glass mass for Case 15, there are about 21,774 MT of solids¹³ in the retrieved waste, with a particle volume of 1.92 Mgal assuming a nominal 3 Kg/L particle density. Fully settled, these solids would occupy approximately 8.3 Mgal as a sludge containing a nominal 40-wt% solids with an interstitial liquid density of 1.35 Kg/L. This sludge could be contained in about eight DSTs if a successive settle – decant approach were used to fill each tank. However, a more reasonable settled solids depth in a DST is approximately $\frac{1}{4}$ of the tank volume for both practical blending (with mixer pumps) and safety considerations. Therefore, approximately 27 DSTs would be required to uniformly blend these solids.

Figure 8. Glass Factor Cumulative Distribution Plots.

7.2.5 HLW Feed Variability

The discussion in Section 2.1.3 states that the degree of blending is one of the major HLW glass mass drivers. One way to assess the degree of blending, apart from its impact on HLW glass

¹³ This back calculation is in reasonable agreement with a direct query of the HTWOS model, reporting 26,443 MT of delivered solids.

mass, is to examine the variability in the feed delivered to the WTP. Feed variability is also important in-and-of-itself due to potential impacts on overall plant operation.

Aluminum was selected as a key component to assess feed variability for this blending study because:

1. Aluminum is one of the major drivers of HLW glass as discussed in the Reference Case Evaluation, specifically, Section D6.2.
2. The chemistry of aluminum in Hanford Site tank waste matrices is complicated and the resulting solid-liquid equilibrium complicates the operations of both the Tank Farms and the WTP.
3. Over half of the selected blend pairs in Table 5 include a tank that would, by itself produce, glass limited in Al_2O_3 even after pretreatment. This increases the likelihood that the effects of blend pairs on feed variability will be seen.

The specific metric chosen was the concentration, in weight percent, of Al_2O_3 in the solid phase of the feed delivered to the WTP, on an equivalent oxide basis. This metric is shown in Figure 9 as a cumulative distribution plot. Cases 13 and 14 exhibit similar variability to each other. The differences seen in Case 15 are attributed to the effects of the pairwise blending implemented for that Case – a general flattening of the distribution. Specifically, the peak concentrations above the 80 percentile are reduced while those in the 30 and 50-60 percentiles are increased (the mass has to go somewhere).

Feed variability plots were also constructed for Fe_2O_3 , P_2O_5 , and SO_3 . The plots for Fe_2O_3 and P_2O_5 exhibited similar behavior (a general flattening of the distribution) as Al_2O_3 , but not as pronounced due to the smaller number of implemented blend pairs involving those components. Because of the ubiquity of SO_3 , the changes in blending among the three cases did not make a significant difference in the appearance of the SO_3 distributions.

Figure 9. Variability in WTP Feed - Al_2O_3 . **Figure 10. Variability in WTP Feed - Fe_2O_3 .**

Figure 11. Variability in WTP Feed - P_2O_5 . **Figure 12. Variability in WTP Feed - SO_3 .**

7.2.6 HLW Glass Drivers for Mission Scenarios

The individual feed batches to the WTP for Cases 13, 14, and 15, Realized Blend subcases, were divided into different groups depending on the constraints that limit the waste loading of the glass from each tank using the same methodology as discussed in Section D6.2 for the Case 13 – No Blend subcase. Table 8, Table 9, and Table 10 summarize the number of waste tanks, waste oxide mass, glass mass, and waste loading for each group of waste batches that are limited by the same constraint for each Realized Blend subcase. More details are provided in HLW_Glass_Output_(Case 13 2005-10-24)_Rev_0, HLW_Glass_Output_(Case 14 2005-10-24)_Rev_0, and HLW_Glass_Output_(Case 15 2005-10-27)_Rev_0.

The glass drivers for all three Realized Blend subcases are similar to each other, are generally unremarkable, and are the same as those already identified for the Case 13 – No Blend subcase.

Table 8. Summary of Case 13 (Realized Blend Subcase) Glass Drivers.

Constraints ¹			Number of waste feed batches	Waste oxide mass ² (MT)	Glass mass (MT)	Waste loading in glass ³
Glass composition constraints	Solubility limited	SO ₃	496	3002.7	10059.7	0.298
		P ₂ O ₅	65	385.0	1298.5	0.296
		Cr ₂ O ₃	0	0.0	0.0	n/a
		Subtotal	561	3387.7	11358.2	0.298
	Model validity limited	Al ₂ O ₃	338	2110.2	6945.9	0.304
		Fe ₂ O ₃	52	330.7	980.0	0.337
		Na ₂ O	39	251.2	600.8	0.418
		SiO ₂	0	0.0	0.0	n/a
		Subtotal	429	2692.0	8526.6	0.316
	Glass composition constraints subtotal		990	6079.7	19884.8	0.306
Glass property constraints	Spinel <i>T_L</i> involved		942	5973.5	14627.1	0.408
	Spinel <i>T_L</i> NOT involved		78	500.1	1193.8	0.419
	Glass property constraints subtotal		1020	6473.5	15820.9	0.409
Case 13 Realized Blend subcase total			2010	12553.3	35705.6	0.352

Notes:

¹Shaded cells indicate the major constraints that drive HLW glass mass.

²In this table, waste oxides refer to the fully pretreated waste, on an oxide basis.

³Represents the weighted average waste loading in the glasses from tanks that are limited by the same (or same group of) constraints. Units are mass fraction.

n/a = not applicable

Table 9. Summary of Case 14 (Realized Blend Subcase) Glass Drivers.

Constraints ¹			Number of waste feed batches	Waste oxide mass ² (MT)	Glass mass (MT)	Waste loading in glass ³
Glass composition constraints	Solubility limited	SO ₃	519	3123.4	9741.9	0.321
		P ₂ O ₅	73	435.3	1518.3	0.287
		Cr ₂ O ₃	0	0.0	0.0	n/a
		Subtotal	592	3558.8	11260.2	0.316
	Model validity limited	Al ₂ O ₃	344	2092.1	7143.5	0.293
		Fe ₂ O ₃	52	330.7	980.0	0.337
		Na ₂ O	35	230.4	589.6	0.391
		SiO ₂	0	0.0	0.0	n/a
		Subtotal	431	2653.2	8713.1	0.305
	Glass composition constraints subtotal		1023	6211.9	19973.2	0.311
Glass property constraints	Spinel T_L involved		990	6043.8	14708.1	0.411
	Spinel T_L NOT involved		44	293.4	715.7	0.410
	Glass property constraints subtotal		1034	6337.3	15423.8	0.411
Case 14 Realized Blend subcase total			2057	12549.2	35397.0	0.355

Notes:

¹Shaded cells indicate the major constraints that drive HLW glass mass.²In this table, waste oxides refer to the fully pretreated waste, on an oxide basis.³Represents the weighted average waste loading in the glasses from tanks that are limited by the same (or same group of) constraints. Units are mass fraction.

n/a = not applicable

Table 10. Summary of Case 15 (Realized Blend Subcase) Glass Drivers.

Constraints ¹			Number of waste feed batches	Waste oxide mass ² (MT)	Glass mass (MT)	Waste loading in glass ³
Glass composition constraints	Solubility limited	SO ₃	519	3223.7	10639.6	0.303
		P ₂ O ₅	87	521.1	1878.7	0.277
		Cr ₂ O ₃	5	29.3	78.8	0.372
		Subtotal	611	3774.1	12597.1	0.300
	Model validity limited	Al ₂ O ₃	297	1809.1	5552.3	0.326
		Fe ₂ O ₃	52	331.8	983.5	0.337
		Na ₂ O	62	352.6	910.4	0.387
		SiO ₂	0	0.0	0.0	n/a
		Subtotal	411	2493.4	7446.1	0.335
	Glass composition constraints subtotal		1022	6267.5	20043.3	0.313
Glass property constraints	Spinel T_L involved		912	5568.7	13945.9	0.399
	Spinel T_L NOT involved		66	413.4	1005.1	0.411
	Glass property constraints subtotal		978	5982.2	14950.9	0.400
Case 15 Realized Blend subcase total			2000	12249.6	34994.2	0.350

Notes:

¹Shaded cells indicate the major constraints that drive HLW glass mass.²In this table, waste oxides refer to the fully pretreated waste, on an oxide basis.³Represents the weighted average waste loading in the glasses from tanks that are limited by the same (or same group of) constraints. Units are mass fraction.

n/a = not applicable

Table 11 provides a summary level comparison of the glass drivers for Cases 13 – 15 along with the average waste oxide loading for each case. Again, the three Realized Blend subcases are very similar to each other. Compared with Case 13 – No Blend, all three Realized Blends have less glass limited by single component solubility and model validity limits and more glass limited by spinel liquidus temperature. Examination of Table 8, Table 9, and Table 10 shows that the blended components are primarily Al₂O₃ and Fe₂O₃.

The difference in waste oxide mass (12,553 MT) for Case 13, Realized Blend subcase (see Table 8) and either the No Blend (10,649 MT) or Total Blend (10,641 MT) subcases (see Table D-3) is due to the differences in solid-liquid separation assumptions. The efficacy of solid-liquid separation for the Realized Blend is driven by the detailed ultrafilter operating mode assumptions while the Total Blend and No Blend assume perfect solid-liquid separation. Therefore, about 18 percent of the waste oxides incorporated into the high-level waste glass are from the liquid phase of the pretreated HLW feed.

Table 11. Summary Comparison of HLW Glass Drivers for Cases 13 – 15.

Constraints	Percent of glass, by glass mass, limited by each group of constraints			
	Cases 13 - 15 ² No Blend (Total Blend)	Case 13 Realized Blend	Case 14 Realized Blend	Case 15 Realized Blend
Solubility limited single-component constraints	36.6	31.8	31.8	36.0
Model validity limited single-component constraints	40.9	23.9	24.6	21.3
Spinel T _L involved multi-component constraints	20.3 (100)	41.0	41.6	39.9
Spinel T _L NOT involved multi-component constraints	2.2	3.3	2.0	2.9
Average waste oxide ¹ loading	0.247 (0.393)	0.352	0.355	0.350

Notes:

¹In this table, waste oxides refer to the fully pretreated waste, on an oxide basis.²Cases 13 – 15 have the same No Blend subcases and the same Total Blend subcases, by definition.

7.2.7 Degree of Blending

The authors were unable to identify or develop any simple metric that captures the overall degree of blending apart from its impact on other metrics such as HLW glass mass or feed variability. A trial metric, which measured the distance of each feed batch from the Total Blend, was built using the information in the feed source tank traceback matrices. The metric showed the expected¹⁴ trends, but differences between the Realized Blend Subcases were so small as to be of questionable utility at this time.

7.2.8 Operational and Programmatic Impacts

It is premature to evaluate the operational and programmatic impacts of pairwise blending since a mission scenario with a notable reduction in glass mass as a result of blending has not yet been demonstrated. However, a general, qualitative, discussion of the types of potential impacts follows.

Pairwise blending adds a new type of constraint to the mission – namely, that the retrieval of generally unrelated tanks needs to be coordinated in such a fashion that their contents can be blended. This means that the retrievals need to take place near the same time or that adequate lag storage (tank space) be provided to hold and isolate the retrieved waste until the blend actually occurs.

From a purely project and operational perspective, it may be desirable to stagger the retrieval of waste by tank farms, with a controlled (minimal) overlap between farms. All three cases have

¹⁴ Case 14 was slightly closer to the Total Blend than Case 13 in terms of the source tanks of the waste. Case 15 was slightly further away from the Total Blend than Case 13, as would be expected since pairwise blending, by definition, does not target the Total Blend in terms of source tanks or composition.

considerable overlap¹⁵ in the period of retrieval for each farm with very little noticeable staggering. The amount of overlap increased slightly from Case 13 to Case 14 and from Case 14 to Case 15. The constraints imposed by pairwise blending will tend make it more difficult to control the overlap of retrieval activities in different farms or to stagger those activities since most blend pairs comprise tanks from two different farms, with many combinations of farms represented. This, in turn, may influence the retrieval and closure strategy and timing for the tanks and farms.

The assumption that waste can be retrieved directly from an SST into a blend pair receiver using direct transfer (e.g., hose-in-hose) lines may turn out to be problematic due to both the distances involved and the constant changing of transfer routes to support the next tank in the blend pair list. It may turn out that waste needs to be first retrieved into a nearby DST (via hose-in-hose transfer lines or a Waste Retrieval Facility) and then transferred to the blend pair receiver. This might require the construction of additional tanks or the reassignment and preparation of additional DSTs as HLW feed staging tanks, including consideration of early treatment of selected DST wastes via supplemental pretreatment and vitrification to empty tanks.

There are two areas of potential impact that affect all of the mission scenarios, i.e., they are not specific pairwise blending. They are:

- The ability of the mixer pumps and transfer pumps designed by Project W-211 to support these scenarios (Cases 13, 14 and 15) has not been evaluated. The general questions are the ability of the mixer pumps to be started after a large quantity of solids have settled out in the blend pair receiver (or for that matter, any other DST), the ability of the mixer pumps to keep the waste reasonably uniformly suspended, and the ability of the transfer pumps to transfer the suspended waste to the downstream destination.
- The authorization basis does not currently support the routine operation of mixer pumps or practical intermediate handling of mixtures of liquids and solids. Changes to the authorization basis will be needed to support the current baseline waste feed delivery plans as well as any of the three mission scenarios, including the possibility of new controls.

If pairwise blending were actually implemented for a significant number of tanks, the proper number of blend-pair receivers would need to be determined. Having only two blend pair receivers provides very little flexibility in the timing of retrievals and may lead to delays in the delivery of HLW feed.

¹⁵ Based on an examination of the SST retrieval dates in the HTWOS transfer files (TAF file) for each case.

8.0 CONCLUSIONS

The primary single-component compositional drivers for the mass of HLW glass are SO_3 , Al_2O_3 , P_2O_5 , and Fe_2O_3 , listed in decreasing order of relative impact; the primary multi-component property driver is spinel liquidus temperature. This assumes that water washing and caustic leaching removes much of the aluminum, that oxidative leaching is effective in removing the chromium, that the components removed by leaching do not re-precipitate, and that the relaxed glass properties model applies.

Pairwise blending of waste, if unencumbered with logistical constraints, can closely approach the mass of HLW glass for the Total Blend. Addition of logistical constraints, such as no intentional blending between 200 East and 200 West areas, between quadrants, or between tank farms (listed in order of increasing impact), significantly reduces the potential benefit of pairwise blending.

The range or span between Total Blend and No Blend is an area of opportunity that warrants additional blending work. The Realized Blends for Cases 13 – 15 are approximately midway between the span defined by the No-Blend and Total Blend subcases. For these cases, the difference between the Realized Blend and Total Blend is approximately 8,000 MTG and represents the potential reduction in HLW glass mass that might be achievable with an appropriate blending strategy.

The realized blends for Cases 14 and 15 showed negligible reductions in the mass of HLW glass over that from the reference case, Case 13. All three cases produced too much HLW glass to finish the treatment of waste by 2028; the earliest the mission could end, assuming no HLW melter outages and that hot commissioning begins in 2009, would be the end of 2030.

In retrospect, the simplifying assumptions used to select the blend pairs for Case 15 severely limited the efficacy of pairwise blending for that mission scenario. The negligible reduction in HLW glass mass for Case 15 is a consequence of the simplifying assumptions and is not intrinsic to pairwise blending strategies. Therefore, the failure of Case 15 to provide a significant reduction in HLW glass mass should not be interpreted as a failure of the pairwise blending strategy.

Most importantly, a basic set of tools for the development of much more sophisticated blending strategies has been developed and demonstrated. With the likely delay of the start of WTP, DOE has time to evaluate and potentially dramatically impact the current waste feed delivery strategy to improve the overall mission lifecycle. Changes to the existing DST storage and transfer systems will likely be required, along with attendant authorization basis upgrades to support them.

Case 15 showed a reduction in the variability of the HLW feed composition in components targeted for blending by the blend pairs. Specifically, the distributions of Al_2O_3 , Fe_2O_3 , and P_2O_5 in the delivered feed on an equivalent oxide basis were slightly flatter than for Cases 13 or

14. This reduction in feed variability may be a benefit to the operation of the WTP irrespective of the resulting mass of HLW glass.

Cases 13, 14, and 15 had similar glass factor (mass of HLW glass produced per mass of solids in the ultrafilter feed) distributions. Glass factor, on an individual ultrafilter feed batch basis, ranged from about 0.4 to 6.5 with a median value of 1.6 MTG per MT feed solids. This assumes that all HLW solids undergo water washing, caustic leaching, and oxidative leaching and that the relaxed glass properties model applies.

Case 15 showed a general improvement in the availability of feed, as measured by dwell time. Feed availability was better, with the exception of three outages discussed below, due to fewer batches of staged HLW feed, each containing more solids. However, this may have been an artifact of the complexities of pairwise blending forcing the modelers to be more thoughtful about the operation of the HLW feed staging tanks and not an inherent benefit of pairwise blending.

Cases 13 and 14 each have a two-year cumulative lag in HLW production, with 0.5-years due to processing of Envelope C feed from tanks AN-102 and AN-107 and 1.5-years due to unexplained causes. This behavior is similar to that seen in other recent model runs.

Case 15 incurs an additional one-year lag in HLW production beyond the two years seen in Cases 13 and 14 due to three feed outages circa 2021 - 2024. These outages are due to multiple bottlenecks in the retrieval, blending, staging, and delivery of feed. The mechanism of the major bottleneck appears to be a backlog of waste prevents decanting of supernate from the blend pair receivers, starving the HLW feed staging tanks for feed. It is hypothesized that operation of the 242-A Evaporator past its assumed 2018 decommissioning date or other system configuration changes, such as additional tank space, may be able to mitigate this situation.

9.0 RECOMMENDATIONS

Another mission scenario using pairwise blending should be developed, this time including additional tanks when selecting the blend pairs, to more fairly evaluate the efficacy of pairwise blending. A snapshot¹⁶ of the contents of the SSTs and DSTs at some point in the near future, reflecting the outcome of newly planned early retrievals, could serve as a starting point for selecting the blend pairs. If possible, additional DSTs should be reserved and allocated for blending early in the mission to ensure adequate HLW feed is available to the WTP. The scenario should be evaluated for operational and programmatic impacts if it is effective in reducing the mass of HLW glass.

Several alternative architectures and blending strategies should be explored, especially if pairwise blending using existing tanks proves ineffective or too difficult or costly to implement. While the specific alternatives would be developed at a later date, variations on the following alternatives should be considered:

- Aggressive pairwise blending, supported by a set of emptied DSTs or new tanks specifically designed to support blending.
- A blending circuit, supported by new tanks specifically designed to support blending.
- A hybrid strategy, first segregating waste by limiting component and then blending to minimize HLW glass mass, supported by a set of emptied DSTs or new tanks specifically designed to support blending.
- Metered blending of problematic waste (such as if the high-zirconium TRU waste in tanks AW-103 and AW-105 is determined to be incorporated into the HLW glass).

In addition, variants of alternatives that reduce or eliminate the required dwell time between sampling a staged batch of HLW and its delivery to the WTP to reduce tank space demand might also be considered.

The glass property models used for this blending analysis and most recent mission analyses and most of the associated limits were developed circa 1996. Since then, the models have been gradually updated to include larger glass databases and other properties such as toxicity characteristic leaching procedure (TCLP). Additionally, ORP has been exploring the use of alternative properties (such as $T_{1.5\%}$, the temperature at which 1.5-wt% of crystals are present in the glass) to improve HLW waste oxide loading. The available models and limits should be reviewed to determine if the models and limits being used for mission analysis purposes need to be updated.

The causes of the one-and-a-half-year cumulative lag in HLW glass production for the reference case should be identified and addressed as appropriate in future mission scenarios.

¹⁶ This method has already been used to identify three SSTs for blending with the three DSTs predicted to contain retrieved C-Farm waste as an enabling assumption for the mission scenario being developed for the upcoming Baseline Change Request and planned revision to the *Tank Farm Contractor Operation and Utilization Plan* (TFCOUP) (HNF-SD-WM-SP-012).

The feasibility of refining the operating mode of the WTP ultrafilters to reduce the amount of oxides contributed by the liquid phase of the pretreated HLW should be investigated. The post-leach wash assumptions allow a significant amount of material removed by leaching to report to the HLW glass. An improvement in the post-leach wash efficacy might reduce the total mass of HLW glass.

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APPENDIX A

**HANFORD TANK WASTE OPERATIONS SIMULATOR MODELING CONSTRAINTS,
REQUIREMENTS, AND ASSUMPTIONS**

A1.0 INTRODUCTION

Appendix A presents a detailed discussion of the assumptions used in the Hanford Tank Waste Operations Simulator (HTWOS) model run performed to support the “Pairwise Blending of High-Level Waste” study, which comprises three evaluations:

1. **Reference Case Evaluation** – This evaluation examines the sensitivity of HLW glass mass to the new SO_4 and PO_4 wash and leach factors and identifies the drivers for HLW glass mass.
2. **Pairwise Blending Evaluation** – This evaluation examines the sensitivity of HLW glass mass to constraints imposed on a hypothetical pairwise blending strategy.
3. **Mission Scenario Evaluation** – This evaluation builds three mission scenarios, one using incidental blending as a reference case, one using improved incidental blending and one using improved incidental blending along with pairwise blending.

This appendix documents the assumptions and defines the major inputs for the HTWOS model to provide the specific data needed to support the three evaluations.

These technical assumptions address the major functions, processes, and interfaces that correspond with the River Protection Project (RPP) system shown in Figure A-1. The availability and capacities of the various systems and processes are defined in the HTWOS model to determine a processing schedule for waste retrieval, delivery, and treatment.

Tables A-1 and A-2 summarize the direction for the modeling and the key assumptions in a concise format to aid the reader.

The Development Run (RPP-RPT-23412) (which provided the starting point for the detailed assumptions and model code) and subsequent modeling efforts identified several instances in which the model run did not properly incorporate the stated assumptions. These deviations will be corrected for the HTWOS runs performed for this blending study whenever practical (see Tables A-1 and A-2 for more details). In any case, several of those deviations need to be corrected to avoid confounding the interpretation of blending results. These are (1) the dwell time for staged HLW feed will be returned to 210 days (180 days per interface control document [ICD] + 30 days for sampling), (2) the fill height of the DSTs will be returned to the assumed values (only AP-Farm fill heights are increased), (3) oxidative leach endpoint calculation, and (4) charge balance calculations during water wash.

A1.1 BRIEF DESCRIPTION OF CASE AND ASSUMPTIONS

Text of Item: See Chapter 5.0 of the body of the report for a description of the method of analysis to be used for each of the evaluations.

Figure A-1. Simplified Schematic of the River Protection Project.

Table A-1. HTWOS Model Change Summary Form.

Case Name	Blending Study Cases 8 - 15		
Objective:	Provide HTWOS model results to support the "Pairwise Blending of High-Level Waste."		
Scenario Change Summary -	This section is focused on changes in key assumptions or key inputs to the model.		
	Revise model assumptions (from the Development Run case documented in RPP-RPT-23412, " <i>Hanford Tank Waste Operations Simulator Model Data Package For The Development Run For The Refined Target Case</i> " Rev. 0A) to resolve assumption discrepancies identified in RPP-RPT-23412, Rev. 0A, to incorporate revised modeling assumptions for I-129 partitioning within STP, to incorporate changes to resolve modeling issues raised since the issuance of RPP-RPT-23412, Rev. 0A, and to, incorporate those changes needed for the "Pairwise High-Level Waste Blending" study. Run the HTWOS model (either the full model or portions of it) and provide results.		
Software Change Summary -	This section is focused on changes in the HTWOS model functionality and includes references to the Scenario Change Summary section where appropriate.		
	Revise the model as needed to implement the changes outlined in the Scenario Change Summary Section above. This includes updating the SST retrieval sequence logic to allow for pairwise blending, correction of legacy code issues regarding oxidative leach endpoint and charge balance during water wash, and coding changes needed to support the Reference Case Evaluation and Pairwise Blending Evaluation. The method of analysis is described in Chapter 5 of the body of the report.		
Requestor or Point of Contact:	- Paul Certa		
	For reporting modeling status and resolving issues.		
Supplemental Information:	The following specific information is requested as an output from the model, organized by evaluation:		
	<ul style="list-style-type: none"> • Reference Case Evaluation (Cases 8 – 13): <ul style="list-style-type: none"> ○ Plot showing mass of HLW glass for each case. Include Total Blend, No Blend, and Incidental Blend ○ HLW glass output file for each case. • Pairwise Blending Evaluation <ul style="list-style-type: none"> ○ Blend-pair sensitivity curve for different sets of constraints. ○ Selected blend pairs. • Mission Scenario Evaluation (Cases 13 – 15). <ul style="list-style-type: none"> ○ Treatment end date ○ HLW glass output files ○ Projected and theoretical HLW, LAW, STP production versus time plots ○ HLW dwell time distribution plot ○ SST Retrieval Sequence Plot ○ DST volume plots (both overall system and individual tanks) ○ Transfer files ○ Traceback matrices. ○ Feed vector to WTP ○ Feed vector converted to an oxide basis (for further analysis) ○ Waste oxide loading distribution comparison ○ Time-phased allocation of DSTs to functions (Case 15 only). ○ The "glass factor" for each ultrafilter batch. 		
Change Approval			
Team Lead:	R. A. Kirkbride <i>Randy A. Kirkbride</i>	Manager:	N. W. Kirch <i>NW Kirch</i>
Customer Point of Contact:	P. J. Certa <i>PJCerta</i>		n/a

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A1.1. Brief Description of Case		
Provide HTWOS model results to support the “Pairwise Blending of High-Level Waste.” A simple schematic of the overall process is shown in Figure A-1.		No
A2.0. Major Facilities		
A2.1. New Waste Generation		
A2.1.1. New Waste Introduced Via 200 East Area		
PUREX – yearly rate for FYs 2010 through 2017	5 Kgal/year	No
B-Plant – yearly rate	No waste anticipated	No
WESF – yearly rate	No waste anticipated	No
300 Area – yearly rate for FYs 2006, 2007, and 2008.	20 Kgal/year	No
Flush for misc. waste	44%	
400 Area	No wastes anticipated	No
WSCF	No wastes anticipated	No
100 Area	No wastes anticipated from 100 N, 100-K Basin, 105-F Basin, or 105-H Basin	No
A2.1.2. New Waste Introduced Via 200 West Area		
222-S Laboratory (through 10/1/2027 ¹)		Yes
Receipt rate	10 Kgal/year	
Flush volume factor	22%	
T-Plant		No
Receipt rate (FYs 2018 through 2021)	15 Kgal/year	
Flush volume factor	22%	
PFP stabilization – not calculated in yearly average dates	2004-2005	No
Total volume	15 Kgal total	
Flush	22%	
Tank Farm Waste Generations		
Tank Farms		No
Yearly Rate	120 Kgal/year	

¹ 222-S Laboratory wastes will be received into the West Area DSTs until 10/1/2027; after that time, laboratory waste generation is assumed to be terminated.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A2.2. Waste Treatment Plant		
Key features for modeling	<p>Key features of the WTP that will be modeled for purposes of mission planning and estimation of secondary waste streams include:</p> <ul style="list-style-type: none"> • LAW Feed Receipt Tanks (simplified – 1.5 Mgal lumped capacity) • HLW Feed Receipt Tank • Front End Evaporator (simplified – no feed tanks) • Ultrafilter System (with modified [OH⁻] endpoint and oxidative leach) • Pretreated HLW Lag Storage and Blend Tanks (simplified – 81 Kgal lumped capacity) • Cesium Ion-Exchange (as a black-box) • Back End Evaporator / Pretreated LAW Storage (simplified and product routing modified to interface with STP) • HLW Melter Feed Preparation (simplified) • HLW Melter (model total capacity, not individual melters) • LAW Melter Feed Preparation (simplified) • LAW Melter (model total capacity, not individual melters) • Off-gas treatment systems (added NH₄⁺ for proper stoichiometry)². • Recycle of LAW SBS and WESP Condensate to back-end evaporator feed tank. • Recycle of HLW SBS and WESP to front-end evaporator feed tank. • Transfer of LAW Caustic Scrubber solution to LERF via WTP PT facility. 	No
Technical Basis for Modeling	<ul style="list-style-type: none"> • The basis for modeled chemical reactions, extents, and split factors for estimating primary and secondary waste streams will be the 24590-WTP-MDD-PR-01-002, Rev. 6, with flowsheet and operating mode modifications as needed to implement other assumptions. 	No – covered elsewhere.

² With the exception that the pretreatment facility off-gas system is not considered a key feature that needs to be modeled at this time.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?																								
A2.2.1. Low-Activity Waste Processing																										
LAW feed delivery dates	Start delivery of the first LAW feed batch on 12/1/2009 and deliver remaining LAW feed as needed to keep the WTP operating within model constraints. The first LAW feed batch will be provided by a decant transfer of all supernatant in tank AY-102 (less ten-inches above the HLW solids) to the LAW feed receipt tanks.	No																								
LAW Pretreatment Ramp Up	Governed by most restrictive of down-stream demand for pretreated LAW and a maximum ultrafilter (UF) permeate rate of 17.7 gpm.	Yes																								
LAW Vitrification Ramp Up ³	<table><tr><td>From</td><td>-</td><td>To</td><td>MTG/d (net rate)</td></tr><tr><td>3/1/2010</td><td>-</td><td>1/31/11</td><td>3.4⁴</td></tr><tr><td>2/1/2011</td><td>-</td><td>12/31/2011</td><td>18.0</td></tr><tr><td>1/1/2012</td><td>-</td><td>12/31/2012</td><td>24.0</td></tr><tr><td>1/1/2013</td><td>-</td><td>12/31/2014</td><td>28.8⁵</td></tr><tr><td>1/1/2015</td><td>-</td><td>12/31/2028</td><td>34.0⁶</td></tr></table>	From	-	To	MTG/d (net rate)	3/1/2010	-	1/31/11	3.4 ⁴	2/1/2011	-	12/31/2011	18.0	1/1/2012	-	12/31/2012	24.0	1/1/2013	-	12/31/2014	28.8 ⁵	1/1/2015	-	12/31/2028	34.0 ⁶	No
From	-	To	MTG/d (net rate)																							
3/1/2010	-	1/31/11	3.4 ⁴																							
2/1/2011	-	12/31/2011	18.0																							
1/1/2012	-	12/31/2012	24.0																							
1/1/2013	-	12/31/2014	28.8 ⁵																							
1/1/2015	-	12/31/2028	34.0 ⁶																							
Complete Waste Processing	Goal is to complete waste processing as soon as possible.	No																								
A2.2.2. LAW Feed Receipt Tanks																										
LAW Feed Receipt Tank Use	1.5 Mgal Total Capacity; be capable of receiving 1 Mgal without interruption while feeding out of the remaining 0.5 Mgal	No																								

³ Melter ramp-up is based on ORP-22339, *River Protection Project Low-Activity Waste Supplemental Treatment Technologies Report*, Rev. A, 90% Draft.

⁴ Melter rate is the average value that produces 188 ILAW packages during hot commissioning.

⁵ This is based on a name-plate capacity of 36 MTG/d and a 0.80 TOE (total operating efficiency).

⁶ This capacity assumes the installation of second-generation LAW melters.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A2.2.3. LAW Pre-Treatment Process		
LAW WTP Process Model	<ul style="list-style-type: none"> The LAW (liquid) fraction of Envelope C waste from tanks AN-102 and AN-107 will be segregated from other waste within the PT facility until the strontium and transuranic components are removed. There will be approximately 300 gallons (2005 lb_m air-dried) of spent cesium ion exchange resin generated for every 300,000 gallons of supernate treated through the cesium ion exchange system.⁷ Spent cesium ion exchange resin will contain the following constituents after being prepared for disposal⁸: <ul style="list-style-type: none"> Cr – 670 µg/g K – 220 µg/g Na – 83,800 µg/g ⁹⁹Tc – 6.74 µg/g⁹ ²³⁸U – 14.8 µg/g⁹ ⁶⁰Co – 1.31 µCi/g ¹³⁷Cs – 60 µCi/g 	No

⁷ This assumes that all supernate is Envelope A and is based on operating the system as four column carousel (lead, lag, polish, regeneration), with the columns swapping function every 100 column volumes, 300 gallons per column volume, resin change-out after the 10th regeneration cycle (24590-WTP-MDD-PR-01-002, Section 4.7.4). Using the air-dried bulk density of SuperLig resin from 4716-1, *Flow Properties Test Report Sodium Form Resin Samples*, Jenike & Johanson, 2003, summary page 2, the bulk density is about 50 pounds per cubic foot of resin

⁸ These are the RCRA listed constituents detected at levels above the minimum reportable quantities during small-scale column testing per 24590-PTF-3PS-MWD0-T0003, Rev. 1, Section 3.4.7.5, page 10.

⁹ The reference states µg/g, not µCi/g.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A2.2.4. ILAW Formulation and Packaging		
ILAW Process	<ul style="list-style-type: none"> During hot commissioning, the total sodium loading, sulfate volatilization and formulation of the LAW glass will be estimated using the Gimpel Model as described in 24590-WTP-MDD-PR-01-002.¹⁰ During hot operations, the total sodium loading of LAW glass from pretreated feed will be determined using the DOE Model (D-03-DESIGN-004), which maximizes the sodium oxide loading in the LAW glass subject to the following constraints: $[Na_2O] \leq 20wt\%$ $[SO_3] \leq 0.8wt\%$ During hot operations, the composition of the LAW glass will be estimated using a glass recipe model similar to that described in 24590-WTP-MRQ-PO-04-0065 (DRAFT). Sulfate volatilization will be estimated using Equation 3.1-5f of 24590-WTP-RPT-PT-02-005. Melter split factor for I-129: assume that 20% of the ¹²⁹I entering the melter is retained in the LAW glass product; the remaining 80% will report to the melter off-gas system.¹¹ One LAW Melter is assumed to fail every 2.5 years and contains 6900 gallons of glass,¹² not to exceed 9 failed LAW melters.¹³ 	No
ILAW Glass Density	<ul style="list-style-type: none"> 2.6 MT/m³ 	No
ILAW Package Net Mass	<ul style="list-style-type: none"> 5.92 MT 	Yes ¹⁴

¹⁰ This is an updated reference from 24590-WTP-MCR-PT-02-002, which was used in ORP-11242, Rev. 2.

¹¹ BNI is in the process of updating the model design document for the WTP dynamic model. One of the parameters being updated is the melter splits for ¹²⁹I. The Configuration Management Group (DOE 2004) has directed that the preliminary splits for ¹²⁹I be adopted since this is a significant change (72.973 % retention, reduced to 20% retention) in a component important to performance of the disposed waste.

¹² Melter failures are already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a five-year minimum design life per 24590-LAW-3PS-AE00-T0001. Volume of glass in the melter does not include an allowance for increased volume due to corrosion of refractory and reflects the set point of 6891 gallons per 24590-WTP-MDD-PR-01-002, Appendix D; other contributions to source term such as plenum deposits are neglected.

¹³ Per 24590-WTP-ICD-MG-01-003, Section 4.2.1.2.

¹⁴ The Development Run did not use the stated ILAW package net mass. This is an assumption deviation that was corrected.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?															
A2.2.5. ILAW Interim Storage Capacity																	
ILAW Interim Storage Capacity	<ul style="list-style-type: none"> No lag storage of ILAW in WTP. 	No															
A2.2.6. High-Level Waste Processing																	
HLW feed delivery dates	Start delivery of the first batch group of HLW feed on 12/15/2009 and deliver remaining HLW feed as needed to keep the WTP operating within model constraints. The first batch group of HLW feed will be provided from AY-102 by adding sufficient water to the decanted solids to yield a solids loading between 10 and 200 grams solids per liter of slurry (150 g/liter nominal).	No															
HLW Vitrification Ramp-up ¹⁵	<table border="1"> <thead> <tr> <th>From</th> <th>To</th> <th>HLW MTG/d (net rate)</th> </tr> </thead> <tbody> <tr> <td>5/17/2010</td> <td>1/31/2011</td> <td>0.69¹⁶</td> </tr> <tr> <td>2/1/2011</td> <td>12/31/2011</td> <td>3.0</td> </tr> <tr> <td>1/1/2012</td> <td>12/31/2012</td> <td>4.0</td> </tr> <tr> <td>1/1/2013</td> <td>9/30/2027</td> <td>5.0¹⁷</td> </tr> </tbody> </table>	From	To	HLW MTG/d (net rate)	5/17/2010	1/31/2011	0.69 ¹⁶	2/1/2011	12/31/2011	3.0	1/1/2012	12/31/2012	4.0	1/1/2013	9/30/2027	5.0 ¹⁷	Yes ¹⁸
From	To	HLW MTG/d (net rate)															
5/17/2010	1/31/2011	0.69 ¹⁶															
2/1/2011	12/31/2011	3.0															
1/1/2012	12/31/2012	4.0															
1/1/2013	9/30/2027	5.0 ¹⁷															
A2.2.7. HLW Feed Receipt Tanks																	
HLW Feed Receipt Tank Usage	<ul style="list-style-type: none"> Sufficient space to receive 160,000 gallons (600 m³) without interruption. HLW feed deliveries will be suspended when the LAW feed receipt tanks contain waste from either AN-102 or AN-107 to segregate the LAW liquids until the Sr and TRU is removed. All HLW batches must be at least 130,000 gallons total volume and contain more than 2 wt% solids. 	No															

¹⁵ Melter ramp-up is based on ORP-22339, *River Protection Project Low-Activity Waste Supplemental Treatment Technologies Report*, Rev. A, 90% Draft.

¹⁶ Melter rate is the average needed to produce 56 canisters of immobilized high-level waste (glass) during Hot Commissioning.

¹⁷ This is based on a nameplate capacity of 6 MTG/d and a 0.84 TOE.

¹⁸ The Development Run increased the average HLW glass production rate up to 6 MTG/day. Cases 13 – 15 will return this parameter to the planned net value of 5 (6 MTG/d times 84% TOE).

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A2.2.8. HLW Pre-Treatment Process		
HLW WTP Process Model	<ul style="list-style-type: none"> The water wash factors in the TWINS on 8/24/2004 will be used for partitioning waste into solid and liquid phases during retrieval and staging. Specific cases will use the new phosphate and sulfate water wash factors from RPP-25903.¹⁹ The caustic leach factors in the TWINS on 8/24/2004 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids and for the entrained solids. Specific cases will use the new phosphate and sulfate differential caustic leach factors from RPP-25903. One HLW Melter is assumed to fail every 2.5 years and contains 1,800 gallons of glass,²⁰ not to exceed 9 failed HLW melters. For planning purposes, all solids delivered with the HLW feed and entrained solids delivered with the LAW feed, except for those associated with the Envelope C waste from AN-102 and AN-107, will undergo caustic and oxidative leaching with the insoluble fraction incorporated into HLW glass. An oxidative leach process that removes Cr from the HLW sludge without impact on cycle time or other species will be implemented in the ultrafilters. Reaction stoichiometry and endpoint (5,000 µg Cr / g dried solids) are described in RPP-15552.²¹ The LAW (liquid) fraction of Envelope C waste from tanks AN-102 and AN-107 will be segregated from other waste within the PT facility until the strontium and transuranic components are removed. 	Yes

¹⁹ An issue was identified that previous versions of HTWOS did not maintain a proper charge balance during water washing. The charge balancing methodology was revised to resolve this issue..

²⁰ Melter failures are already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a five-year minimum design life per 24590-HLW-3PS-AE00-T0001. Volume of glass in the melter includes an allowance for increased volume due corrosion of refractory per 24590-HLW-M5C-HMP-00002, Table 2; other contributions to source term such as plenum deposits are neglected.

²¹ An issue was identified that previous versions of HTWOS did not properly calculate the oxidative leach end point because it was based on the mass of solids present before oxidative leaching was performed. The end point calculation methodology was revised to resolve this issue by basing the calculation on the mass of solids remaining after oxidative leaching.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A2.2.9. IHLW Formulation and Packaging		
Method for Estimating HLW Waste Oxide Loading	<p>Glass Properties Model modified as follows.</p> <ul style="list-style-type: none"> • Increase the maximum spinel liquidus temperature constraint from 1,050 °C to 1,100 °C. • Increase the maximum viscosity constraint from 5.5 Pa•s to 10 Pa•s. • Increase the maximum Cr₂O₃ constraint from 0.5 wt% to 1.0 wt%. • Use a maximum zircon liquidus temperature limit of 1,050 °C. • Use a Product Consistency Test (PCT) upper limit of 2 g/m². 	No
Melter split factor for I-129	<ul style="list-style-type: none"> • Assume that 20% of the ¹²⁹I entering the melter is retained in the HLW glass product; the remaining 80% will report to the melter off-gas system.¹¹ 	No
IHLW Glass Density	<ul style="list-style-type: none"> • 2.7 MT/m³ 	No
IHLW Canister Net Mass	<ul style="list-style-type: none"> • 3.2 MT (thin-walled canister) 	No
A2.2.10. IHLW Interim Storage		
IHLW Interim Storage Capacity	<ul style="list-style-type: none"> • 22 canisters of IHLW can be stored in the WTP before having to ship canisters to an interim storage site on the Hanford Site. 	No
A2.3. Supplemental Treatment		
A2.3.1. TRU/LLW Sludge Packaging		
Contact-Handled Sludge Packaging	<ul style="list-style-type: none"> • The contact-handled Supplemental TRU Treatment and Packaging process will be available on February 28, 2006. • The system will first be located near B-Farm and then moved to T-Farm. There will be a 10-day outage between tanks and 60-day outage to move equipment between farms. • The SSTs assumed to provide contact-handled sludge are [B-201, B-202, B-203, B-204], [T-201, T-202, T-203, T-204], T-111, T-110, and T-104, in the stated order except that the tank order within the [brackets] can be changed.²² • The waste from the B-200 and T-200 series SSTs, T-104, T-110, and T-111 will be retrieved without impact to DST space. • It is assumed that this waste can be treated and packaged as contact-handled TRU and disposed of at WIPP. 	No – covered elsewhere.

²² These are operational considerations.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
Contact-Handled Sludge Packaging, cont.	<ul style="list-style-type: none"> There will be no water or waste sent to the DST system. The process assumptions for the contact-handled sludge treatment system are discussed in the remote-handled section. 	
Remote-Handled Sludge Packaging	<ul style="list-style-type: none"> The remote-handled Supplemental TRU Treatment and Packaging process will be available on 7/1/2012. It is assumed to be located near AW-Farm.²³ All remote-handled sludge will be water-washed prior to treatment to remove soluble waste constituents. The East Area DSTs will be water washed in their respective tanks; the SSTs and SY-102 waste will be retrieved, transferred to a 200E Area DST and then water-washed. No attempt will be made to segregate the remote-handled SST TRU sludge from the remote-handled DST TRU sludge. Supernatant liquid will be decanted from tank AW-103 in August 2011. The waste solids in tank AW-103 will be washed four times over a nine month period starting 9/1/2011 using 273,000 gallons of 0.01 M NaOH solution each time. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of AW-103 waste solids is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness with the added change of using the new phosphate and sulfate water wash factors from RPP-25903. Supernatant liquid will be decanted from tank AW-105 in September 2012. The waste solids in tank AW-105 will be washed four times over a nine-month period starting 10/1/2012 using 263,000 gallons of 0.01 M NaOH solution each time. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of AW-105 waste solids is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness with the added change of using the new phosphate and sulfate water wash factors from RPP-25903. 	Yes

²³ The remote-handled Supplemental TRU Treatment and Packaging process is expected to be a re-deployment of the contact-handled system with additional shielding.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
Remote-Handled Sludge Packaging, cont.	<ul style="list-style-type: none"> Supernatant liquid will be decanted from tank SY-102 by 10/30/2013. The SY-102 solids will be washed three times over a nine month period starting by 11/1/2013 using 290,000 gallons of 0.01 M NaOH solution each time. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of SY-102 waste solids is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness with the added change of using the new phosphate and sulfate water wash factors from RPP-25903. (Note: The solids in SY-102 may be moved to AW-103 for washing, after the washed AW-103 solids are delivered for packaging, if the cross-site transfer does not delay operation of the packaging facility.) The SSTs assumed to provide remote-handled sludge are T-105, T-107, T-112, B-107, B-110, and B-111; the DSTs assumed to provide remote-handled sludge are SY-102, AW-103, and AW-105. The overall process for both contact-handled and remote-handled TRU sludge treatment is assumed to use the “dry batch mode”²⁴ as described in the System Design Description (RPP-20499) and summarized as follows: <ul style="list-style-type: none"> As the CH-TRU sludge is retrieved and transferred, a total of 1 part water by volume is added per original in-tank sludge bulk volume. The slurry (either direct from the SSTs for CH-TRU or via a DST for water washed RH-TRU) will be transferred to the Feed Receipt Process System modeled as a single tank with a working volume of 28,800 gallons.²⁵ The slurry, carrier²⁶ and heat are continuously added to the dryer, while dried product is withdrawn to maintain a product with 20-wt% water and 80-wt% waste loading (both relative to waste, water and carrier). 	

²⁴ “Dry batch mode” is a continuous process.

²⁵ This assumes that only 4 of the 5 feed tanks are used; the 5th tank is kept in reserve.

²⁶ “Carrier” refers to the material added to the waste in the dryer to form a stable mixture with appropriate handling properties.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15	Involves Model Change That Needs to be Verified?
Remote-Handled Sludge Packaging, cont.	<ul style="list-style-type: none"> ○ The capacity of the packaging system will be based on a flow of 4 gpm of waste slurry into the dryer.²⁷ ○ The CH-TRU dried waste product is packaged in standard waste boxes (SWB)²⁸, each SWB holding approximately 2,760 lb_m waste. ○ The RH-TRU dried waste product is assumed to be packaged in 55-gallon drums containing 700 lb_m of product per drum, which are loaded three drums to a RH-72B canister²⁹. • Secondary waste will be estimated using the dryer retention factors as stated in 20843.PCAL.001, Assumption 8 and by applying the decontamination factors (DFs) for the 242-A Evaporator condenser. The dryer retention factors (and equivalent splits for modeling) are presented in Table A-3 the gaseous effluent split factors are presented in Table A-4. • Liquid effluent will either be transferred to the LERF via Tank Truck or recycled to the Retrieval project. For planning purposes, it will be assumed that the liquid effluent is transferred only to LERF (no recycle) and modeled as a continuous transfer. • The washed solids are assumed to be remote handled for packaging. • It is assumed that this waste can be treated and packaged as remote-handled TRU and disposed of at WIPP.

²⁷ The stated dryer capacity is based an undiluted waste rate of 2,880 gallons per day and a one-to-one dilution of waste with water during retrieval.

²⁸ The final package has not been established; 55-gallon drums may also be used.

²⁹ The final package configuration has not been established; the dried waste may also be directly loaded into the RH-72B canister.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A2.3.2. Supplemental LAW Processing		
Supplemental Treatment Demonstration	<ul style="list-style-type: none"> A demonstration facility will be located in the 200 West Area (west of S-Farm) and be operated at a net rate of 3.92 MTG/d starting on 5/31/2005 to process 260 MT Na from the low-curie waste from tank S-109. 	No
Supplemental Treatment Demonstration, cont.	<ul style="list-style-type: none"> The demonstration facility will be fed directly from S-109 with no solids entrained out of S-109. The feed will be delivered at 5 M Na. The S-109 waste retrieval will be controlled to limit the total activity in the retrieved waste to 0.0062 Ci per liter (at the 5 M Na feed concentration) for the demonstration.³⁰ Retrieval of the low-Cs waste from S-109 will generate about 100 Kgal of Cs-rich wastes that will be sent to tank SY-102.³¹ The Supplemental Treatment Demonstration process assumptions (other than process rate) will be the same as that used for the full-scale Supplemental Treatment Process. 	
Supplemental Treatment Process	<ul style="list-style-type: none"> A production process facility will be located in the 200 East Area. The production facility, consisting of eight melter lines, starts operating after 1/31/2011, and operates at a combined net rate of 31.4 MTG/day³². The feed to the Supplemental Treatment process includes: <ul style="list-style-type: none"> Low-curie feed from the selective dissolution and solid/liquid separation of SST waste.³³ 	No

³⁰ The demonstration project will probably target a lower ¹³⁷Cs concentration in the low-curie feed from S-109 for shielding considerations.

³¹ The demonstration project is expected to increase the estimated amount of Cs-rich waste from S-109 to about 250 Kgal.

³² If necessary, the treatment rate may be ramped up by two additional melter lines (for an increase of 7.84 MTG/day) on a date agreed to by the requestor.

³³ The amount of low-curie feed may be increased if needed to finish waste treatment by 12/31/2028, not to exceed the available amount of low-curie feed. The estimated amount of low-curie feed required is about 3,500 MT Na.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
	<ul style="list-style-type: none"> ○ “Excess” pretreated LAW from the WTP³⁴ - this feed source should be preferentially used. ● Low-Cs waste in the 200 West Area will be moved cross-site to feed the process when dedicated DST space is available to transfer low-Cs waste without contamination (through an SY-Farm tank to an East Area DST used as a feed tank). 	
WTP Process Considerations	The WTP pretreatment facility will be configured so that a portion of concentrated pretreated LAW from the Treated LAW Concentrate Tank can be transferred to the Supplemental Treatment Plant (STP) as feed. This is downstream of the point to which LAW SBS and WESP condensate is recycled, so the STP feed will include a proportional fraction of the SBS and WESP condensate.	No
STP Process Basis	<p>The process will be modeled using a flowsheet that implements the overall mass balances (elemental, NO_x, and activity) as shown in Section 3.2 of the process flowsheet (RPP-20528) using the process design criteria provided in 145579-A-DC-002, with the following exceptions or clarifications:</p> <ul style="list-style-type: none"> ● The Tri-mer scrubber (provides backup off-gas treatment) is assumed to not be operated. ● The splits for the dryer will be set equal to the splits used for the WTP evaporators.³⁵ ● 20 wt% waste Na₂O loading.³⁶ ● About 35% of the ¹²⁹I in the melter feed will be retained in the glass. ● No ¹²⁹I is recycled from the sintered metal filter. ● Melter reactions involving ¹⁴C, NH₃, NO₂, and NO₃ will be implemented.³⁷ ● The ³H partitioning factor will be revised so that all of it reports to the off-gas and none remains in the glass.³⁷ 	Yes

³⁴ The amount of “excess” pretreated LAW that is available is the difference between the assumed LAW pretreatment capacity of 2,950 MT Na/year and the demand from the WTP LAW Vitrification facility expressed in MT Na/year and depends on the glass formulation for each specific LAW melter batch.

³⁵ The referenced flowsheet assumes that 50% of the ¹²⁹I in the dryer feed reports to dryer offgas stream – this is an overly conservative value. Additionally, only ¹²⁹I is partitioned (not conservative). Since the dryer operates in a similar temperature and pressure regime as both the 242-A Evaporator and the WTP evaporators, it is assumed that using the evaporator splits will provide a better estimate of the partitioning that will take place until the flowsheet is updated or supplanted. The Configuration Management Team provided verbal concurrence with this change on December 27, 2004 with the understanding that approval will be indicated by ORP’s concurrence with these assumptions. For simplicity, the HTWOS model will use the published WTP Evaporator splits rather than the more complicated 242-A Evaporator partitioning coefficients.

³⁶ It is assumed that the target waste sodium oxide loading of 17.6-wt% in 145579-A-DC-002 is increased by flowsheet refinements such as low-sodium soil to the nominal value of 20-wt% assumed in ORP-22339. No allowance is made for potentially lower oxide loadings during the supplemental treatment system demonstration.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
STP Process Basis, cont.	<p>These mass balances cover both primary and major secondary waste streams from the process which will be modeled as a single lumped process train comprising the following unit operations:</p> <ul style="list-style-type: none"> • Feed Tank • Dryer • Condenser for Dryer Offgas • Melter • Sintered Metal Filter with recycle to dryer (modeled as to dryer feed tank) • Hydrosonic Scrubber • HEPA Filter • Carbon Filter • NOx Removal 	
Feed Staging ³⁸ and Solids Return	<ul style="list-style-type: none"> • The low-Cs tanks that are candidates for feed are: B-105, T-109, B-103, B-101, S-109, B-108, S-105, TY-102, TX-117, BY-112, BY-105, BY-102, BY-111, BY-108, TX-118, BY-109 BX-111, BY-103, and TX-114. • The following tanks can be considered candidate Low-Cs Tanks after 1/1/2011: TX-112, TX-111, and TX-110. • The following tanks can be considered candidate Low-Cs Tanks after 1/1/2018: TX-105, TX-115, U-107, TX-108, and TX-103. 	No

³⁷ The Development Run did not implement these melter reactions and they were implemented in the HLW blending study.

³⁸ The list of candidate SSTs and selective dissolution assumptions are provided by 7F300-04-RER-001 R1.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
	<ul style="list-style-type: none"> Selective dissolution will be used during the retrieval of candidate feed tanks using the planning assumptions in Table A-5 for splits – use average values when ranges are provided. First, the “higher” curie fraction will be retrieved from the SST and stored in the DST system for later delivery to the WTP. Then, the remainder of the waste (the low-curie fraction) will be retrieved and staged in a separate 200E area DST for delivery to the Supplemental Treatment Process. 	
Product and Packaging	<p>Bulk vitrification is used as the supplemental treatment process to immobilize LAW. The following will be used to estimate bulk vitrification product volume and package count.</p> <ul style="list-style-type: none"> Glass density is 2.7 MT/m³. Packaged in 35 m³ roll-off boxes, each filled with 43.8 MT glass. External volume of box is 1,920 ft³ (8 ft by 10 ft by 24 ft, ~ 54.4 m³). 	No
A2.4. Waste Disposal Sites		
ILAW Facility Need Dates (Integrated Disposal Facility; IDF)	<ul style="list-style-type: none"> The IDF is assumed to be operational on 2/28/2006. The ILAW produced by the Supplemental Treatment demonstration can be safely stored until the IDF is available. 	No
IHLW Facility Need Dates (Project W-464)	<ul style="list-style-type: none"> The need date for IHLW interim storage facility (the Canister Storage Building [CSB]) will be the date on which the 1st IHLW is produced [5/17/2010]. The demand for interim storage space will be established assuming that 22 canisters of WTP-provided IHLW is used. The shipping date of IHLW to Yucca will be the date on which the CSB is full (880 canisters + 22 canisters in WTP-provided lag storage), but no earlier than 1/1/2012. Canisters will be shipped to Yucca at a rate of 2 canisters per day, first priority given to shipping the newly created IHLW from the WTP – any excess shipping capacity will be used to empty the IHLW stored in the CSB. 	No
A2.5. Cesium and Strontium Capsule Processing		
Cesium and Strontium Capsules	Cesium and strontium capsules are disposed separately by RL and not incorporated into HLW glass in the WTP.	No
A3.0. Retrieval and Closure		
A3.1. SST Interim Stabilization		
Saltwell liquid pumping	None; saltwell pumping was completed in March 2004.	No

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A3.3. SST Retrieval Sequence Basis		
Retrieval sequence basis – Case 13	<p>Give priority to SST retrieval as listed below:</p> <ul style="list-style-type: none"> Retrieve the remaining Pool tanks, balancing logistics, tanks space and feed to the various treatment processes. Retrieve the remaining SSTs, risk-based, balancing logistics, tank space and feed to the various treatment processes. <p>Table A-6 provides the list of SSTs in the SST retrieval pool. Table A-7 provides starting assumptions for sequence and retrieved waste volumes for near term SST retrievals. Table A-11 provides the sorted risk-based ordering of SSTs that was input to both the Development Run Rev. 0A and the TFCOUP Rev. 5D (HNF-SD-WM-SP-012).</p>	No
Retrieval sequence basis – Case 14	<p>Give priority to SST retrieval as listed below:</p> <ul style="list-style-type: none"> Retrieve TRU tanks in sequence and timing provided by assumption A2.3.1 Retrieve low-curie tanks in the sequence and timing provided by assumptions A2.3.2 Retrieve the first 38 early³⁹ tanks per “current” plans with adjustments as needed to reflect the new starting inventory and historical transfers. Retrieve the remaining SSTs, balancing logistics, tank space, and feed to the various treatment processes. The two input sequences (see Table A-11), developed during the study and incorporated by reference, shall be sorted on HLW glass mass and on soluble sodium, with clusters of tanks that produce glass limited in aluminum or sulfate separated. 	Yes
Retrieval sequence basis – Case 15	<p>Same as Case 14, except:</p> <ul style="list-style-type: none"> When a tank that has a designated blend pair is selected for retrieval, its mate will also be selected for retrieval as soon as possible after the first tank is retrieved. 	Yes

³⁹ The early tanks refer to those tanks whose retrieval plans were being scheduled outside of the HTWOS model. They are: C-203, S-102, S-112, S-109, C-202, C-103, C-201, C-109, C-204, C-112, C-102, B-201, B-202, U-201, C-104, C-108, U-202, B-203, U-203, U-204, B-204, C-107, T-201, T-202, T-203, C-101, T-204, T-111, U-112, C-111, C-105, T-110, C-110, A-102, SX-115, T-104, AX-102, and AX-103.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A3.4. Waste Retrieval Facilities		
Waste Retrieval Facility (WRF) Availability Dates	<p>B-Complex WRF: 6/1/2018 T-Complex WRF: 6/1/2018</p> <p>Wastes retrieved from tanks in the B or T complexes before the WRFs are available will be at lower insoluble solids loadings as defined in the Retrieved Waste Composition assumptions (see Section A3.8 of HNF-SD-WM-SP-012).</p> <p>Compliant transfer lines will be constructed to support retrievals from B and T complex before the WRFs are made available; one line for each complex.</p> <p>Waste retrieved from tanks that are on the blend pair lists will be retrieved directly into the designated blend pair receiver, bypassing any WRFs.</p>	Yes
A3.5. SST Farm Upgrades		
Availability Dates for Tank Farms Upgrades	Any SST farm upgrades needed to support the retrieval of SST waste will be completed before the retrieval dates projected by the HTWOS model.	No
A3.6. Constraints on Simultaneous Retrievals		
Simultaneous retrieval	<ul style="list-style-type: none"> The most limiting condition(s) resulting from application of the following constraints:⁴⁰ Retrieval and transfer systems in the NE and NW quadrants can support a maximum of 6 simultaneous retrievals in each tank farm and a total of six simultaneous retrievals in each quadrant (after the WRFs are constructed). 	Yes ⁴¹

⁴⁰ These constraints may be lifted by retrieving several source SSTs into one receiver tank if the modeling indicates that they create a bottleneck in the system.

⁴¹ The modeling of low-curie feed retrieval did not properly implement this constraint and the retrieval logic was revised to include those retrievals in the accounting of simultaneous retrievals.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
Simultaneous retrieval, cont.	<ul style="list-style-type: none"> Retrieval and transfer systems in the SE and SW quadrants can support a maximum of 2 simultaneous retrievals in each tank farm and a total of two simultaneous retrievals in that quadrant. SE - A, AX, and C farms NE - B, BX, and BY farms SW - S, SX, and U farms NW - T, TX, and TY farms A maximum of 7 total simultaneous retrievals can be performed at one time. (This assumes that labor resources are available.) The waste from up to two SSTs may be retrieved to one DST at one time. The waste from one only SST may be retrieved into one WRF tank at a time. Constraints also apply to retrievals going directly from SSTs to supplemental treatment processes. 	
A3.7. Retrieval Rates		
SST Waste Retrieval Rates	<ul style="list-style-type: none"> Minimum retrieval durations are given in Section A3.7 of HNF-SD-WM-SP-012 and based on proposed project schedules or technologies to be used to retrieve the waste. 	No
SST Waste Residuals ⁴²	<ul style="list-style-type: none"> 200 Series SSTs: Best Basis Inventory (BBI) data for tanks where retrieval actions have been completed, when available, or 30 ft³ of “selected phase” as defined in DOE/ORP-2003-02, <i>Inventory and Source Term Data Package - Environmental Impact Statement for Retrieval, Treatment and Disposal of Tank Waste, and Closure of Single-Shell Tank Waste at the Hanford Site Richland WA</i>, Rev. 0; calculated for the BBI used as model input. 100 Series SSTs: BBI data for tanks where retrieval action have been completed, when available, or 360 ft³ of 35-wt% water-washed solids with ½ concentration of bulk as-retrieved supernate. 	Yes ⁴³

⁴² This assumption only applies to the Mission Scenario Study.

⁴³ Although the assumption had not changed from the Development Run, the residuals need to be re-estimated using the newer BBI inventory download (2005 instead of 2004a).

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A3.8. Retrieved Waste Composition		
Retrieval Solution Requirements	<ul style="list-style-type: none"> The amount of retrieval solution needed to retrieve the waste from SSTs listed in Table A-14 in Section A3.3 of HNF-SD-WM-SP-012 will be determined as the amount need to achieve the total retrieved volume given in the table after the application of water wash factors. The amount of retrieval solution needed to retrieve wastes from the S, SX, and U farm SSTs not listed in Table A-14 will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 5 wt% (3.5 volume %) after the application of wash factors. The amount of retrieval solution needed to retrieve wastes from SSTs in the B or T farm complex before the WRFs are available will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 5 wt% after the application of wash factors. 	No
Retrieval Solution Requirements, cont.	<ul style="list-style-type: none"> The amount of retrieval solution needed to retrieve wastes from SSTs in the B or T farm complex after the WRFs are available will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 10 wt% after the application of wash factors. 	
	<ul style="list-style-type: none"> The amount of retrieval solution needed to retrieve wastes from all other SSTs will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 10 wt% after the application of wash factors. 	
A3.9. Retrieval System Reuse		
Retrieval System Availability	<ul style="list-style-type: none"> A sufficient number of retrieval systems are available. Retrieval systems will be reused when cost effective. 	No
A3.X. SST Closure		
SST Closure	<ul style="list-style-type: none"> SSTs will be interim closed in the 10-month period immediately after retrieval has been completed. Closure activities for each tank farm can begin after all tanks in that farm are interim closed.⁴⁴ 	No

⁴⁴ This is an enabling assumption that may need to be refined as closure strategies are developed.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A3.X. SST Waste Leaks		
SST Waste Leaks During Retrieval	No waste is assumed to leak from the SSTs during retrieval.	No
A4.0. Waste Feed Operations		
A4.1. Waste Inventory		
A4.1.1. Initial Inventory		
Date that BBI quarterly update was issued	For all cases, except Cases 8 and 9: Starting tank inventories represents the contents of the tanks as of October 2004 per RPP-25191. This is identified as the “FY 2005” inventory and is based on BBI downloaded from TWINS on 1/27/2005. Cases 8 and 9 will use the older “FY 2004a” inventory documented in RPP-22760.	Yes
IMUST waste total volume (2011-15)	500 Kgal total	No
A4.2. DST Operations		
A4.2.1. Sodium Hydroxide Additions		
Caustic addition <ul style="list-style-type: none"> Planned Additions Caustic Rules for SST Retrievals 	<ul style="list-style-type: none"> No near-term additions are planned. Future evaluations may show the need for caustic additions. Liquids associated with sludge retrievals need to have at least 0.05 M free OH. Saltcake retrievals do not require NaOH addition because waste in DSTs is assumed to contain sufficient OH⁻ as a buffer. 	No
A4.2.2. Flush Volumes		
	Table A-16 in Section A4.2.2 of HNF-SD-WM-SP-012 provides the flush volumes used in the HTWOS model.	No

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A4.2.3. Minimum DST Level		
	<ul style="list-style-type: none"> Liquids or slurries can be removed down to within 12 inches above the bottom of a DST. Wastes can be removed down to the bottom of a DST during final cleanout. Supernatants can be pumped down to within 10 inches of a settled solids layer. SY-101 can only be pumped down to 100 inches (275 Kgal) between now and 10/1/2013. After that date, the transfer pump will be replaced and the waste can be pumped down to 12 inches. SY-102 can only be pumped down to 200 inches (550 Kgal) until the solids are washed before delivery for TRU packaging. After the solids are washed, the waste can be pumped down to within 12 inches. The AZ/AY farm tanks can be pumped down below 64 inches if the annulus ventilation is shut down. The annulus ventilation will be shut down when necessary to deliver feed to the WTP allowing the waste to be pumped down within 12 inches of the bottom. 	No
A4.2.4. Maximum DST Level		
Maximum DST Levels	The maximum fill levels in AP farm DSTs will be raised on 11/1/2004 ⁴⁵ .	Yes ⁴⁶
A4.2.5. Tank Solids Level		
Solids Settling Endpoint	<p>Insoluble solids retrieved from C-Farm SSTs can be settled to a solids loading comparable to that in the source SSTs within 2 days of transferring to a DST. This is accomplished in the model by settling to the same bulk solids volume observed in the SSTs or to an adjusted bulk volume based on mass dissolved during retrieval.</p> <p>Insoluble solids retrieved from other SSTs and currently in the DST system can be settled to 40 wt% solids within 30 days.⁴⁷</p>	No

⁴⁵ The actual dates for raising the levels in the AP-Farm DSTs have been delayed from 11/1/2004 to the staggered schedule given in Table A-8. Reconciliation of the past-projected transfers with now-historical transfers is outside the scope of this study and the 11/1/2004 date was retained for the modeler's convenience and consistency with previous modeling.

⁴⁶ The Development Run did not implement this assumption as stated – this will be fixed for the blending studies.

⁴⁷ The modelers will seek to apply the “wet sludge volume” approach used for the C-Farm retrievals to insoluble solids retrieved from other SSTs if it can be implemented. If it cannot be implemented due to model logic issues, the current approach of settling to 40 wt% solids will be used.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
Solids Management Strategy	<p>Assume that the solids management strategy for the DSTs will allow, on the average:</p> <ul style="list-style-type: none"> DSTs supporting C-Farm retrieval will be operated with a minimal supernatant layer so that they do not become Group A tanks even though they will be filled with significant quantities of solids. DSTs not supporting C-Farm retrieval are assumed to hold up to 10-wt% bulk solids based on the maximum operating level of each DST. 	No
A4.2.6. Tank Space Allocation		
Space Allocation Categories	Use the categories and reasoning given in Table A-19 in Section A4.2.6 of HNF-SD-WM-SP-012 to allocate and track head space above the waste in the DSTs.	No
DST Usage ⁴⁸	<p>WTP Feed Staging tanks: ⁴⁹ AN-101, AN-102, AN-103, AN-104, AN-105, AN-107, AP-101, AP-102, AP-103, AP-104, AP-105, AP-106, AP-107, AP-108, AW-101, AY-101, AY-102, AZ-101, and AZ-102</p> <p>WTP Alternative (Back-up) HLW Feed Staging tanks: AN-103, AN-104 (cross-site receiver), and AN-105. At the modelers' discretion, other DSTs equipped with dual mixer pumps can be used to store and stage HLW feed.</p> <p>Slurry Transfer Limitations: Use AZ, AY, and AN farms, primarily for staging HLW solids. Try to avoid staging solids through AP or AW farms after retrieving the solids currently in those farms.</p> <p>Supplemental Sludge Treatment Process Feed Staging Tanks: AW-103, AW-105, and SY-102.</p> <p>Supplemental LAW Treatment DST Usage: Provide feed directly from S-109 to the Demonstration Bulk Vittrification System. Transfer low-Cs wastes from the West Area and from East Area SSTs when sufficient DST space is available to transfer cross-site without contamination (by flushing out tank heels) and to provide a dedicated feed tank in the East Area. Retrievals and transfers are managed to prevent the entrainment of solids in the feed.</p>	Yes

⁴⁸ The modelers may change the functional assignments of the various DSTs as needed to eliminate mission bottlenecks with the concurrence of the point-of-contact.

⁴⁹ See Section A5.2 for information on project scopes regarding equipment needs.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
	<p>Sludge Transfer for Waste Feed Staging: AN-101 and AN-106 will acquire solids from C-Farm retrieval (except for C-104) and require additional equipment to transfer a portion of those solids into other DSTs for waste feed staging into the WTP.</p> <p>Blend-Pair Receivers: SY-101 will become the West Area blend-pair receiver after it is emptied of its current waste. AY-101 will become the East Area blend-pair receiver after the C-104/AY-101 HLW feed is delivered to the WTP.</p>	
<p>Emergency Space and LAW or HLW Waste Return Space</p> <ul style="list-style-type: none"> • TFC Emergency Space and Emergency Returns from WTP • LAW or HLW Non-Emergency Process Returns from WTP • Contingency space 	<p>Emergency Space and Emergency Returns will be raised from 1.14 Mgal to 1.235 Mgal on 12/27/2005, and will be allocated as shown below:</p> <ul style="list-style-type: none"> • 1.235 Mgal total • None • None 	No
WTP Returns (to the DST system)	No waste streams or wastewaters are returned to DST system from the WTP.	No
<p>DST Space Allocation Categories</p> <ul style="list-style-type: none"> • Evaporator Operational Space • Restricted TRU Head Space • Restricted WTP Feed Tank Space • Safety Basis Head Space 	<ul style="list-style-type: none"> • Supports 242-A operation (AW-102, bottoms receiver, and dilute waste receivers, when used) • TRU solids (AW-103 and AW-105) • Early WTP feed sources or DSTs used to stage WTP feed • Waste has an associated safety issue 	No

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A4.2.7. Waste Segregation or Blending		
<p>Feed Controls</p> <ul style="list-style-type: none"> Blend off high-sulfate supernate (FCL Issue # 1) Blend off high ^{233}U solids (FCL Issue # 2) Prepare and protect hot commissioning feed (FCL Issue # 3) Segregate Envelope C (FCL Issue # 4) Segregate TRU sludge from complexed waste (FCL Issue # 5) 	<p>The feed controls (which specify specific blending and waste segregation requirements) from HNF-SD-WM-OCD-015, Rev. 15A, are modified as needed to support the other mission assumptions and summarized below:</p> <ul style="list-style-type: none"> A portion of supernate from AZ-102 will be decanted and blended with lower $[\text{SO}_4]$ supernate, so that the final $[\text{SO}_4]:[\text{Na}]$ ratio in AZ-102 and in any other tank receiving significant quantities of the high $[\text{SO}_4]$ supernate will be less than a target level of 0.048 mole $\text{SO}_4/\text{mole Na}$ after blending and any evaporator campaigns are completed. Constrain the blending of AZ-102 supernate to start after 4/1/2007. The solids from C-104 will be blended with the solids in AY-101 so that the resulting ^{233}U is less than a target level of $2.0\text{E-}04$ Ci/100 grams equivalent of waste oxides. The two source tanks and the resulting blend will be kept segregated from other sources of solids. The supernate in AY-102 will be removed and replaced with supernate from AP-101, without concentration. It is assumed that the ORP will accept the TFC recommendation to consolidate the supernate in AP-101 with the solids in AY-102. No other waste, other than process condensate, will be mixed with the hot commissioning feed staged in AY-102. The waste in AN-102 and AN-107 shall be segregated from all other wastes until it has been delivered to the WTP. Envelope C waste or other waste capable of complexing TRU shall not be stored with the insoluble solids currently in AW-103, AW-105, or SY-102. For purposes of this control, waste will be considered to be Envelope C if the $[\text{TRU}]:[\text{Na}]$ ratio exceeds $13 \mu\text{Ci}/\text{mole}$ or the $^{90}\text{Sr}:[\text{Na}]$ ratio exceeds $1.19\text{E+}03 \mu\text{Ci}/\text{mole}$ in the liquid phase. 	Yes ⁵⁰

⁵⁰ The Development Run did not properly implement FCL Issue #3 and was fixed in the HLW blending study.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
<ul style="list-style-type: none"> Segregate waste destined for TRU or LLW packaging (FCL Issue # 6) Segregate low-cesium SST waste for supplemental treatment (FCL Issue # 7) 	<ul style="list-style-type: none"> No additional waste shall be added or stored with the insoluble solids currently in AW-103 and AW-105, except that the addition of remote-handled TRU from SSTs or SY-102 is permitted. Avoid mixing the waste in SY-102 with additional solids (other than remote-handled TRU). Do not transfer contact-handled TRU waste into the DST system. Keep the remote-handled TRU waste segregated from insoluble non-TRU solids. Waste from the candidate SSTs containing low-curve waste should be managed to maximize the amount of low-curve (less than 0.05 Ci/liter ¹³⁷Cs). The low-cesium fraction designated for feed to supplemental LAW treatment should be kept segregated from any high-cesium waste. 	
Blending – Cases 13 and 14	There is no deliberate blending of waste to optimize WTP feeds other than the specific blending described in the feed controls. Incidental blending that occurs as waste is moved through the system is relied on to provide benefits such as a significant reduction in HLW glass quantities.	No
Blending – Cases 15	<p>In addition to the specific blending described in the feed controls, there will be pairwise blending of specific SSTs to attempt to reduce the mass of HLW glass. Incidental blending that occurs as waste is moved through the system will also be relied on to provide benefits such as a significant reduction in HLW glass quantities.</p> <p>Waste flow will be per Figure 2 of the body of the report.</p> <p>The specific blend pairs will be developed during the study and incorporated by reference.</p>	Yes
A4.2.8. Availability of DST Space		
DST Integrity	No DST failures or replacements are assumed.	No
A4.2.9. Space Optimization		
Tank Space Options Incorporated (M-46-21 options)	<ul style="list-style-type: none"> Concentrate waste to save space (to 1.44 SpG). Release the ORP restriction on the use of the WTP feed restricted space. Allocate only 1.235 Mgal as emergency space. Implement tank level increases detailed in Table A-8. 	No
A4.2.10. Aging Waste Farm Condensates		
	HTWOS does not account for in-tank evaporation from or the recycle back to the aging waste tanks.	No

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A4.2.11. Common Use of Transfer Lines		
	There are no restrictions on the subsequent use of transfer lines based on waste types (HLW, LAW, TRU, and LLW) and chemistries.	No
A4.2.12. Waste Transfer Routes		
Essential Drawings for DST Waste Transfer System	Transfer system constraints are imposed through the near-term SST retrieval plans.	No
A4.2.13. Waste Transfers		
Cross-site Transfer Rate	<ul style="list-style-type: none"> Wastes transferred cross-site through the supernatant line can be transferred at rates between 50 and 60 gallons per minute. Wastes transferred cross-site through the slurry line can be transferred at rates between 100 and 120 gallons per minute. 	No
SST Retrievals	Wastes retrieved from the SSTs will be retrieved at the capacity of the retrieval system as defined by the minimum durations when DST space is available.	No
DST Transfer Rate	Wastes can be transferred between DSTs or to the WTP at a rate of 140 gallons per minute (excluding cross-site transfers).	No
Transfer Durations	Waste transfer durations will be calculated by dividing the total volume being transferred by the transfer rate.	No
Transfer System Set-up Time	There is a 5-day delay between subsequent uses of transfer routes having common components starting on 11/1/2007 to account for the closeout of one transfer route and the establishment of another route.	No
DST Waste Residuals ⁵¹	100 gallons having the composition of the last waste contained in the tank.	Yes
A4.3. 242-A Evaporator		
A4.3.1. Evaporator Availability		
242-A Evaporator Shutdown and New Evaporator Availability	<ul style="list-style-type: none"> 242-A Evaporator is available until 9/30/2018 No tank farm evaporator is available after 10/1/2018 to support DST space management. 	No

⁵¹ This assumption only applies to the Mission Scenario Study.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A4.3.2. Evaporator Operation		
<ul style="list-style-type: none"> • Training Volume • Average Evaporation Rate • Maximum Evaporation Rate • Bottoms Set Point (g/mL) • Feed Staging Duration • Yearly Evaporation of Waste • SST wastes evaporated 	<ul style="list-style-type: none"> • 82 Kgal of water is evaporated to train personnel if the evaporator has not been operated for 11 months.⁵² Each training run adds 50 Kgal of water to AW-102. • 500 Kgal/month⁵³ • The lesser of 50 gpm boil-off or 140 gpm feed • 1.44⁵⁴. • 3 months minimum;⁵⁵ • Yes • Evaporate retrieved waste as needed to manage DST space until the WTP starts. 	No
A4.3.3. Evaporator Process Chemistry		
Waste Volume Reduction	<ul style="list-style-type: none"> • Water is removed until the specific gravity set point is reached (as calculated by algorithms within the model). Recent issues with solids formation in the evaporator are handled as part of the historical transfer data. • The waste volume reduction factor can be calculated using the following equation: $WVR = \frac{(\rho_B - \rho_F)}{(\rho_B - 1)}$ <p>Where: ρ_B = Evaporator set point (bottoms SpG) ρ_F = Specific gravity of evaporator feed</p> 	No

⁵² The period between evaporator campaigns must be less than 12 months to maintain operator qualifications and avoid the need for a full readiness review. An eleven-month period was chosen in the model to make sure training runs occurred within a 12-month period. About 50 Kgal of water is sent to AW-102 is from seal water (during the run) and emptying the evaporator vessel after the training run. This will be modeled as a 50-Kgal addition after each training run.

⁵³ This is an operational constraint to avoid over committing evaporator campaigns.

⁵⁴ This density is expected to be the average density selected for future evaporator campaigns – it is not an inherent limitation of the evaporator. The feed for each evaporator campaign will be evaluated, and a target density for specific for that feed will be determined considering the ability of the transfer system to maintain solids in suspension and the DSTs ability to stay within buoyant displacement gas release event (BDGRE) controls. In the future, a lower value may be used for waste containing high concentrations of phosphates.

⁵⁵ The evaporator feed may be sampled and staged in one or more DSTs, including AW-102, during the three-month period prior to being run through the evaporator.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
Process Condensate Composition	<ul style="list-style-type: none"> The volume of process condensate will be 1.15 times the waste volume boiled off the feed to account for seal water and the vacuum system steam jets. The composition of process condensate from the 242-A Evaporator will be estimated using the split factors calculated using the following equation: $SF_i = \frac{1}{1 + \frac{Kp_i}{21,579} \left(\frac{(1-WVR)}{WVR} \right)}$ <p>Where:</p> <p>SF_i = split factor for component i; the split factor is the mass or activity of component i in the process condensate to the mass or activity of i in the feed</p> <p>WVR = waste volume reduction factor</p> <p>Kp_i = 242-A evaporator partition coefficients from HNF-14755 and RPP-17239; in the case of tritium and water the Kp_i values are equal to the WVR because they partition equally with water. The partition coefficients are provided in Table A-9.</p> <p>21,579 = a numerical factor accounting for the 15% volume increase and for the ratio of the volume of condensate as a vapor to the volume of condensate as a liquid.</p>	No
Gaseous Effluent	The contributions of the waste to the gaseous effluent stream will be estimated by applying split factors (the reciprocal of decontamination factors) to the process condensate stream. The split factors are derived from decontamination factors that come from a condenser in the WTP evaporator model, which is based on the 242-A Evaporator. The split factors are reported in Table A-4.	No

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A4.3.4. ETF and LERF		
<ul style="list-style-type: none"> Effluent Treatment Facility 	<ul style="list-style-type: none"> ETF (nor the downstream facilities TEDF/SALDS) capacity does not constrain Tank Farm, supplemental treatment, or WTP operations. The processing rate may be varied at the discretion of the modeler. 	No
<ul style="list-style-type: none"> LERF Capacity 	<ul style="list-style-type: none"> The ETF will be modeled as a black-box. Overall partitioning of feed into solid waste and treated effluent will be approximated using overall removal efficiencies for the polisher.⁵⁶ The values used are reported in Table A-10. The LERF will be modeled as two basins⁵⁷, each with a 7.8 Mgal volume, used to provide lag storage of liquid effluents from the 242-A Evaporator and the various treatment processes. One will be used to accumulate effluents while the other is used to feed the ETF. 	
A4.4. Waste Feed Delivery		
A4.4.1. LAW Feed Delivery Plans		
LAW Feed Delivery Sequence and Envelope Designation ⁵⁸ ,	<u>Source Tank (Envelope)</u> AY-102 (containing AP-101; A/D) 1-3 tanks from AP-Farm (A) AN-104 (A) AN-102 (C) AN-105 (A) AN-107 (C) SY-101 (A) AN-103 (A) AW-101 (A) Continue with liquid wastes made available from SST retrieval.	No
A4.4.2. LAW Feed Specifications		
	BNI contract Specification 7 will be used to assess envelope compliance.	No

⁵⁶ Removal efficiencies reported in Table A-7 are taken from HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*, Rev. 0A.

⁵⁷ Two of the three LEFR basins are allocated to support the waste treatment mission; the other basis is set aside for potential use with CERCLA waste.

⁵⁸ The LAW feed sequence may be modified to support accelerated SST retrieval or to improve the availability of feed for the WTP at the discretion of the modeler.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?												
A4.4.3. LAW Entrained Solids														
Entrained Solids Quantity	<ul style="list-style-type: none">0.5 wt% solids are entrained in decanted supernatants.Supernatant liquids from dissolving salts will entrain the same solids concentration as exists in the tank after dissolution, up to a maximum of 2 wt%.	No												
Entrained Solids Composition	Entrained solids have the same composition as the average composition of solids in the tank.	No												
A4.4.4. HLW Feed Delivery Plans														
HLW Feed Delivery Sequence and Retrieval Efficiency ⁵⁹	<table><tr><td>Source Tank</td><td>Initial Retrieval Efficiency</td></tr><tr><td>AY-102 (AP-101)⁶⁰</td><td>90%</td></tr><tr><td>AZ-101</td><td>90%</td></tr><tr><td>AZ-102</td><td>80%</td></tr><tr><td>C-104/AY-101</td><td>100%/100%</td></tr><tr><td colspan="2">Continue with HLW solids made available from SST retrieval.</td></tr></table>	Source Tank	Initial Retrieval Efficiency	AY-102 (AP-101) ⁶⁰	90%	AZ-101	90%	AZ-102	80%	C-104/AY-101	100%/100%	Continue with HLW solids made available from SST retrieval.		No
Source Tank	Initial Retrieval Efficiency													
AY-102 (AP-101) ⁶⁰	90%													
AZ-101	90%													
AZ-102	80%													
C-104/AY-101	100%/100%													
Continue with HLW solids made available from SST retrieval.														
A4.4.5. HLW Feed Specifications														
	BNI contract Specification 8 will be used to assess envelope compliance.	No												
A4.4.6. Feed Compliance Verification														
Compliance Verification Sampling	Staged feed must remain in a DST for 210 days after filling the tank before delivering to the WTP to provide time to complete feed specification compliance sampling and analysis.	Yes ⁶¹												
A5.0. Project Delivery														
A5.1. Project Impacts on DST System Availability ⁶²														
AN-101-01A Pit work (W-314)	9/23/2004 – 4/7/2005	No												
241-A-A Pit work outage (W-314)	9/23/2004 – 4/7/2005	No												
AN-Farm Outage (W-314)	9/23/2004 – 4/7/2005	No												
AP-Farm Outage (W-314)	9/23/2004 – 4/7/2005	No												
Cross-site line outage connects cross-site to AN-Farm (W-314)	9/23/2004 – 4/7/2005	No												
Cross-site to AP-Farm (W-211)	6/1/2004 – 11/1/2004	No												
AW-Farm Outage (W-314)	7/1/2004 – 11/1/2004	No												
SY-Farm Outage (W-314)	7/1/2004 – 11/1/2004	No												
244-S Outage (W-314)	4/10/2003 – 8/1/2004	No												

⁵⁹ The HLW feed sequence may be modified to support accelerated SST retrieval or to improve the availability of feed for the WTP at the discretion of the modeler.

⁶⁰ Consolidation of AP-101 waste into tank AY-102 introduces a risk that there will be insufficient space to receive aging waste farm ventilation condensates from 702-AZ. AY-102 solids are anticipated to be delivered with water for WTP Hot Commissioning feed.

⁶¹ The Development Run did not implement this assumption as stated – this will be fixed for the blending studies.

⁶² These dates are not considered hard constraints because of current efforts to re-plan field schedules. The modeling will be managed to use the latest available schedule data and still meet the completion date.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
	222-S direct routed to SY-Farm after 6/30/2005 PFP can no longer use 244-TX after 3/30/2005	
AY-Farm Electrical Upgrades to support C-104 retrieval	12/1/2005 – 12/1/2006	No
AZ-Farm Electrical Upgrades	9/23/2004 – 12/31/2005	No
A5.2. Feed Staging Tank Upgrades		
	<ul style="list-style-type: none"> The necessary equipment will be available in time to support all planned waste transfers. The DSTs will need a mixer pump, and, a decant/transfer pump (if solids entrainment is a concern) or a fixed intake transfer pump (if solids entrainment is not a problem). Solids retrieval equipment will be installed in AN-101 and AN-106 to move C-Farm solids into WTP waste feed staging tanks. The following DSTs have been identified as requiring expense or capital project work before use as feed staging tanks; AN-101, AN-102, AN-103, AN-104, AN-105, AN-107, AP-101, AP-102, AP-104, AW-101, AY-101, AY-102, AZ-101, and AZ-102 	No
A6.0. HTWOS Model or Data Analysis Assumptions		
A6.1. Estimating Waste Compositions		
	Wastes are homogenized when mixed.	No
A6.2. Water Content of Initial Inventory		
	The water content of initial inventory is determined by calculating a stream density and total stream mass (including water), the total stream mass excluding water, and then obtaining water content by difference.	No
A6.3. Volume of In-Process Streams		
	Volumes of waste streams are calculated from mass using density correlations for liquids and a solid density of 3 g/mL.	No
A6.4. Transuranic Content Accounting		
	TRU quantities for LAW and ILAW are based on Specification 2 and 7 definitions.	No
A6.5. Radionuclide Decay		
	<ul style="list-style-type: none"> The BBI reference decay date of 1/1/2004 is used as the reference decay date in the model. Radionuclides are decayed to the date of delivery for feed specification compliance assessment. Half-life values for decay calculations are taken from the Chart of Nuclides, 15th Edition. 	No

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15		Involves Model Change That Needs to be Verified?
A6.6. Waste Chemistry and Mass Balances		
	<ul style="list-style-type: none"> Dissolution of solids is predicted by the application of water-wash factors from TWINS (and RPP-25903 when applicable) and by use of the Sr solubility model documented in RPP-21807. Chemical charges are balanced when washing solids by the adjustment of bound OH⁻ and then by adjustment of CO₃²⁻.⁶³ TOC (less oxalate) shall be treated as C. HTWOS does not account for solids formation. 	Yes
A6.7. ILAW Package Production		
	ILAW package production rates are based on the glass production rates, glass density, and package fill assumptions.	No
A6.8. IHLW Canister Production		
	IHLW canister production rates are based on the glass production rates, glass density, and package fill assumptions.	No
A6.9. Mission Summary Diagram		
Mission Summary Diagram <ul style="list-style-type: none"> Schedule float Transfer window 	<ul style="list-style-type: none"> Handled external to the model. When possible, allocate 6 months float on either side of feed compliance verification activities for the 1st batch of LAW and the 1st batch of HLW. All other schedule float and project strategy will be developed with guidance from Projects. Two months 	No

⁶³ An issue was identified that previous versions of HTWOS did not maintain a proper charge balance during water washing. The charge balancing methodology was revised to resolve this issue.

Table A-2. Assumptions Matrix. (33 Sheets)

Case name: Blending Study Cases 8 – 15	Involves Model Change That Needs to be Verified?
<p>Terms:</p> <p> BBI = Best Basis Inventory BNI = Bechtel National, Inc. CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980 CH-TRU = Contact-handled TRU DOE = U.S. Department of Energy DST = Double-Shell Tank ETF = Effluent Treatment Facility FCL = Feed Control Limit FY = fiscal year HEPA = high-efficiency particulate air HLW = high-level waste HTWOS = Hanford Tank Waste Operations Simulator IDF = Integrated Disposal Facility IHLW = immobilized high-level waste ILAW = immobilized low-activity waste IMUST = inactive miscellaneous underground storage tanks LAW = low-activity waste LERF = Liquid Effluent Retention Facility LLW = low-level waste ORP = U.S. Department of Energy, Office of River Protection PFP = Plutonium Finishing Plant PT = Pretreatment PUREX = Plutonium-Uranium Extraction Plant RCRA = Resource Conservation and Recovery Act of 1976 RH-TRU = remote-handled TRU RL = U.S. Department of Energy, Richland Operations Office SALDS = State-Approved Land Disposal Site SBS = Submerged Bed Scrubber SpG = specific gravity SST = Single-Shell Tank STP = Supplemental Treatment Plant SWB = Standard Waste Box TEDF = Treated Effluent Disposal Facility TFC = Tank Farm Contractor TFCOUP = <i>Tank Farm Contractor Operation and Utilization Plan</i> TOC = total organic carbon TOE = total operating efficiency TRU = transuranic TWINS = Tank Waste Information Network System WESF = Waste Encapsulation and Storage Facility WESP = wet electrostatic precipitator WIPP = Waste Isolation Pilot Plant (Carlsbad, New Mexico) WRF = Waste Retrieval Facility WSCF = Waste Sampling and Characterization Facility WTP = Waste Treatment and Immobilization Plant </p>	

Table A-3. Transuranic Waste Dryer Retention Factors. (2 Sheets)

Analyte	Fraction Retained	Split Factor ²	Analyte	Fraction Retained	Split Factor
¹⁰⁶ Ru	99.999640%	3.600E-06	Cd ⁺²	99.899690%	1.003E-03
^{113m} Cd	99.899690%	1.003E-03	Ce ⁺³	99.999988%	1.250E-07
¹²⁵ Sb	99.999988%	1.250E-07	Cl ⁻	99.806490%	1.935E-03
¹²⁶ Sn	99.999988%	1.250E-07	CN ⁻	99.719600%	2.804E-03
¹²⁹ I	26.214580%	7.379E-01	Co ⁺³	99.899700%	1.003E-03
¹³⁴ Cs	100.000000%	0.000E+00	CO ₃ ⁻²	99.899700%	1.003E-03
¹³⁷ Cs	100.000000%	0.000E+00	Cr(OH) ₄ ⁻	99.999988%	1.250E-07
^{137m} Ba	100.000000%	0.000E+00	Cr(TOTAL)	99.997130%	2.870E-05
¹⁴ C	99.899680%	1.003E-03	Cs ⁺	100.000000%	0.000E+00
¹⁵¹ Sm	99.999988%	1.250E-07	Cu ⁺²	99.892270%	1.077E-03
¹⁵² Eu	99.999988%	1.250E-07	F ⁻	99.994300%	5.700E-05
¹⁵⁴ Eu	99.999988%	1.250E-07	Fe ⁺³	99.890000%	1.100E-03
¹⁵⁵ Eu	99.999988%	1.250E-07	H ₂ O	Calculated ¹	Calculated ¹
²²⁶ Ra	99.999988%	1.250E-07	Hg ⁺²	99.899640%	1.004E-03
²²⁷ Ac	99.999988%	1.250E-07	K ⁺	99.971130%	2.887E-04
²²⁸ Ra	99.999988%	1.250E-07	La ⁺³	99.999988%	1.250E-07
²²⁹ Th	99.999988%	1.250E-07	Li ⁺	99.999988%	1.250E-07
²³¹ Pa	99.999988%	1.250E-07	Mg ⁺²	99.187720%	8.123E-03
²³² Th	99.999988%	1.250E-07	Mn ⁺⁴	99.897470%	1.025E-03
²³² U	99.899660%	1.003E-03	Mo ⁺⁶	99.899700%	1.003E-03
²³³ U	99.899660%	1.003E-03	Na ⁺	99.996610%	3.390E-05
²³⁴ U	99.899660%	1.003E-03	Nd ⁺³	99.999988%	1.250E-07
²³⁵ U	99.899660%	1.003E-03	NH ₃	11.001890%	8.900E-01
²³⁶ U	99.899660%	1.003E-03	Ni ⁺²	99.899690%	1.003E-03
²³⁷ Np	99.899700%	1.003E-03	NO ₂ ⁻	99.958180%	4.182E-04
²³⁸ Pu	99.999970%	3.000E-07	NO ₃ ⁻	99.883090%	1.169E-03
²³⁸ U	99.899660%	1.003E-03	OH (Bound)	99.999988%	1.250E-07
²³⁹ Pu	99.999970%	3.000E-07	OH ⁻	99.899700%	1.003E-03
²⁴⁰ Pu	99.999970%	3.000E-07	Pb ⁺²	96.760970%	3.239E-02
²⁴¹ Am	99.999930%	7.000E-07	Pd ⁺²	99.999988%	1.250E-07
²⁴¹ Pu	99.999970%	3.000E-07	PO ₄ ⁻³	99.899700%	1.003E-03
²⁴² Cm	99.899700%	1.003E-03	Pr ⁺³	99.999988%	1.250E-07
²⁴² Pu	99.999970%	3.000E-07	Pu ⁺⁴	99.999970%	3.000E-07
²⁴³ Am	99.999930%	7.000E-07	Rb ⁺	99.999988%	1.250E-07
²⁴³ Cm	99.899700%	1.003E-03	Rh ⁺³	99.999988%	1.250E-07
²⁴⁴ Cm	99.899700%	1.003E-03	Ru ⁺³	99.999640%	3.600E-06
³ H	Calculated ¹	Calculated ¹	Sb ⁺⁵	99.999988%	1.250E-07

Table A-3. Transuranic Waste Dryer Retention Factors. (2 Sheets)

Analyte	Fraction Retained	Split Factor ²	Analyte	Fraction Retained	Split Factor
⁵⁹ Ni	99.899690%	1.003E-03	Se ⁺⁶	99.999988%	1.250E-07
⁶⁰ Co	99.899700%	1.003E-03	Si ⁺⁴	99.840100%	1.599E-03
⁶³ Ni	99.899690%	1.003E-03	SO ₄ ⁻²	99.911820%	8.818E-04
⁷⁹ Se	99.899700%	1.003E-03	Sr ⁺²	99.999980%	2.000E-07
⁹⁰ Sr	99.999980%	2.000E-07	Ta ⁺⁵	99.999988%	1.250E-07
⁹⁰ Y	99.999980%	2.000E-07	Tc ⁺⁷	99.899700%	1.003E-03
⁹³ Zr	99.999988%	1.250E-07	Te ⁺⁶	99.999988%	1.250E-07
^{93m} Nb	99.899700%	1.003E-03	Th ⁺⁴	99.999988%	1.250E-07
⁹⁹ Tc	99.899700%	1.003E-03	Ti ⁺⁴	99.999988%	1.250E-07
Ag ⁺	99.999988%	1.250E-07	Tl ⁺³	99.999988%	1.250E-07
Al(OH) ₄ ⁻	99.933110%	6.689E-04	TOC	97.130510%	2.869E-02
Al ⁺³	99.933110%	6.689E-04	U(TOTAL)	99.899690%	1.003E-03
As ⁺⁵	99.999988%	1.250E-07	V ⁺⁵	99.999988%	1.250E-07
B ⁺³	99.894770%	1.052E-03	W ⁺⁶	99.899700%	1.003E-03
Ba ⁺²	99.889560%	1.104E-03	Y ⁺³	99.999980%	2.000E-07
Be ⁺²	99.999988%	1.250E-07	Zn ⁺²	99.897910%	1.021E-03
Bi ⁺³	99.999988%	1.250E-07	Zr ⁺⁴	99.999988%	1.250E-07
Ca ⁺²	98.691590%	1.308E-02	NA	NA	NA

Notes:

- Water and tritium retention in the dried solids and partitioning to the condensate is based on the water content of the dried solids with tritium partitioning in the same proportion as water.
- $SFi = \left(1 - \frac{RFi}{100} \right)$

Where,

SFi = The split factor or component i,*RFi* = The dryer retention factor for component i expressed as a percent,*i* = Index for the component list,

/100 = Converts the value from a percentage to a fraction

NA = not applicable

TOC = total organic carbon

Table A-4. Gaseous Effluent Split Factors for Generic Condenser. (2 Sheets)

Analyte	Split Factor	Analyte	Split Factor
¹⁰⁶ Ru	No Value	Ba ⁺²	0.002016
^{113m} Cd	0.00154	Bi ⁺³	0.0000358
¹²⁵ Sb	0.0000358	C ₂ O ₄ ⁻²	1.53E-06
¹²⁶ Sn	0.0000358	Ca ⁺²	0.05814
¹²⁹ I	0.0011	Cd ⁺²	0.00154
¹³⁴ Cs	0.0000427	Ce ⁺³	0.00154
¹³⁷ Cs	0.0000427	Cl ⁻	0.0001299
^{137m} Ba	0.002	Co ⁺³	0.00154
¹⁴ C	0.00154	CO ₃ ⁻²	0.00154
¹⁵¹ Sm	0.00032	Cr(OH) ₄ ⁻	0.000188
¹⁵² Eu	0.00032	Cr(TOTAL)	0.000188
¹⁵⁴ Eu	0.00032	Cs ⁺	0.0000427
¹⁵⁵ Eu	0.00032	Cu ⁺²	0.000188
²²⁹ Th	0.00154	F ⁻	0.00053
²³² Th	0.00154	Fe ⁺³	0.002
²³² U	0.00154	H ⁺	0.01
²³³ U	0.00154	Hg ⁺²	0.00154
²³⁴ U	0.00154	K ⁺	0.00157
²³⁵ U	0.00154	La ⁺³	0.00154
²³⁶ U	0.00154	Li ⁺	0.0016
²³⁷ Np	0.00154	Mg ⁺²	0.035
²³⁸ Pu	0.00032	Mn ⁺⁴	0.001642
²³⁸ U	0.00154	Mo ⁺⁶	0.001642
²³⁹ Pu	0.00032	Na ⁺	0.0016
²⁴⁰ Pu	0.00032	NH ₃	0.0806
²⁴¹ Am	0.00032	Ni ⁺²	0.00154
²⁴¹ Pu	0.00032	NO ₂ ⁻	0.0000962
²⁴² Cm	0.00154	NO ₃ ⁻	0.0000962
²⁴² Pu	0.00032	OH (Bound)	0.00154
²⁴³ Am	0.00032	OH ⁻	0.00154
²⁴³ Cm	0.00154	Pb ⁺²	0.0000358
²⁴⁴ Cm	0.00154	Pd ⁺²	0.00154
³ H	0.014	PO ₄ ⁻³	0.00154
⁵⁹ Ni	0.00154	Pu ⁺⁴	0.00032
⁶⁰ Co	0.00154	Sb ⁺⁵	0.0000358
⁶³ Ni	0.00154	Si ⁺⁴	0.00435
⁹⁰ Sr	0.0000855	SO ₄ ⁻²	0.0002375
⁹³ Zr	0.002	Sr ⁺²	0.0000855

Table A-4. Gaseous Effluent Split Factors for Generic Condenser. (2 Sheets)

Analyte	Split Factor	Analyte	Split Factor
^{99}Tc	0.00154	Tc^{+7}	0.00154
Ag^{+}	0.00188	Th^{+4}	0.00154
$\text{Al}(\text{OH})_4^{-}$	0.00154	Ti^{+4}	0.002
Al^{+3}	0.00154	U(TOTAL)	0.00154
As^{+5}	0.00154	Zn^{+2}	0.001621
B^{+3}	0.00177	Zr^{+4}	0.002

Table A-5. Selective Dissolution Separation Assumptions.

Specie	Percentage of Tank Waste Low Curie Feed to Bulk Vitrification	Percentage of Waste Feed to Waste Treatment Plant
Chemical		
Aluminum (Al)	40	60
Calcium (Ca)	100	0
Chromate (CrO_4)	45	55
Potassium (K)	80	20
Sodium (Na)	70	30
Nitrate (NO_3)	65	35
Nitrite (NO_2)	40	60
Hydroxide (OH)	40	60
Chloride (Cl)	40	60
Fluoride (F)	100	0
Phosphate (PO_4)	75	25
Sulfate (SO_4)	90	10
Total Inorganic Carbon (TIC)	85	15
Total Organic Carbon (TOC)	90	10
Radionuclide		
^{90}Sr (soluble) ²	100	0
^{99}Tc	40	60
^{129}I	40	60
^{137}Cs ¹	20 to 40	80 to 60
^{241}Am (soluble) ²	100	0
Pu (soluble) ²	100	0

Table A-6. Single-Shell Tank Retrieval Pool Tank List.

A-102	C-108	SX-108
A-106	C-109	SX-110
AX-101	C-110	SX-115
AX-102	C-111	T-104
AX-103	C-112	T-110
AX-104	C-201	T-111
B-201	C-202	T-112
B-202	C-203	T-201
B-203	C-204	T-202
B-204	S-102	T-203
C-101	S-103	T-204
C-102	S-105	U-112
C-103	S-107	U-201
C-104	S-112	U-202
C-105	SX-101	U-203
C-106	SX-105	U-204
C-107	SX-106	-

Table A-7. Single-Shell Tank Retrieval Modeling Assumptions. (2 Sheets)

Order in Sequence ^{1,2}	Single-Shell Tank	Target Destination	Estimated Volume After Retrieval (Kgal) ^{3,4}	Estimated Retrieval Duration (days)
1	C-106	AN-106	485	134
2	S-112	SY-101	2,000	294
3	C-203	AN-106	37	12
4	C-202	AN-106	12	4
5	S-102	SY-102	1,500	184
6	C-201	AN-106	12	4
7	C-204	AN-106	24	8
	S-109 ⁵	SY-102/ Supp Demo	100/ 592	7/ TBD
8	U-201	SY-102	40	5
9	U-202	SY-102	40	5
10	U-203	SY-102	40	5
11	U-204	SY-102	30	4
12	C-103	AN-106	230	38
13	C-102	AN-101	445	164
14	C-105	AN-106	276	38
15	B-201	TRU	[30]	10
16	B-202	TRU	[29]	10
17	B-203	TRU	[51]	17
18	B-204	TRU	[50]	17
19	T-201	TRU	[31]	10
20	C-109	AN-106	280	34
21	T-202	TRU	[21]	7
22	T-203	TRU	[37]	12
23	C-101	AN-101	332	56
24	C-112	AN-106	316	55
25	T-204	TRU	[37]	12

Table A-7. Single-Shell Tank Retrieval Modeling Assumptions. (2 Sheets)

Order in Sequence ^{1,2}	Single-Shell Tank	Target Destination	Estimated Volume After Retrieval (Kgal) ^{3,4}	Estimated Retrieval Duration (days)
26	T-110	TRU	[370]	128
27	C-110	AY-101	374	40
28	C-107	AN-106	420	32
29	C-104	AY-101	1,700	134
30	C-111	AN-101	229	42
31	T-111	TRU	[447]	155
32	C-108	AN-106	279	35
33	U-112	SY-102	555	47
34	SX-115	SY-102	35	7
35	SX-108	SY-102	178	26
36	A-102	AN-101	68	6
37	A-106	AN-101	384	26
38	T-104	TRU	[441]	153
39	SX-110	SY-102	478	25
40	AX-102	AN-101	53	4
41	AX-104	AN-101	97	2
42	AX-103	AN-101	235	14
43	AX-101	AN-101	999	125
44	SX-106	SY-102	979	131
45	SX-105	TBD	984	13
46	SX-101	TBD	1,170	16
47	S-103	TBD	1,300	97
48	S-105	TBD	2,200	239
49	S-107	TBD	2,963	70
50	T-112	TBD	67	23

Notes:

1. Retrieval of waste from tank C-106 has been completed.
2. Sequence numbering applied to SST retrieval pool tanks.
3. Volumes given are net impact to the DST system. The waste in the C-Farm SSTs and tank S-102 will be retrieved using recirculation involving larger volumes. Volumes in brackets [] represent CH-TRU waste that is retrieved directly to the Supplemental TRU Sludge Treatment System without impact to DST tank space.
4. The estimated volume after retrieval may be adjusted with concurrence of the requestor to be consistent with current retrieval performance.
5. Tank S-109 is not in the single-shell tank retrieval pool but some waste is being retrieved from tank S-109 to demonstrate supplementary low-activity waste treatment technologies to support other RRP mission requirements. The impact of the S-109 retrieval to the DST system was modeled as 100 Kgal with the bulk of the as-retrieved volume being fed to a supplemental treatment process.

TBD = to be determined

Table A-8. Maximum DST Fill Levels.

DSTs	Current Fill Height Limit (inches)	New Fill Height Limit (inches)	Level Increase (Date)	Current Fill Volume¹ (Kgal)	New Fill Volume^{1,2} (Kgal)
AP-101	416	449	10/1/2006	1,144	1,235
AP-102	416	449	10/1/2006	1,144	1,235
AP-103	416	449	1/14/2006	1,144	1,235
AP-104	416	449	1/14/2006	1,144	1,235
AP-105	416	449	5/5/2006	1,144	1,235
AP-106	416	449	10/1/2006	1,144	1,235
AP-107	416	449	10/1/2006	1,144	1,235
AP-108	416	449	12/27/2005	1,144	1,235
SY-101	416	416	NA	1,144	1,144
SY-102	421	421	NA	1,158	1,158
SY-103	416	416	NA	1,144	1,144
AN-101	416	416	NA	1,144	1,144
AN-102	416	416	NA	1,144	1,144
AN-106	416	416	NA	1,144	1,144
AN-107	416	416	NA	1,144	1,144
AN-103	416	416	NA	1,144	1,144
AN-104	416	416	NA	1,144	1,144
AN-105	416	416	NA	1,144	1,144
AW-105	416	416	NA	1,144	1,144
AW-106	416	416	NA	1,144	1,144
AW-101	416	416	NA	1,144	1,144
AW-102	409	409	NA	1,125	1,125
AW-103	416	416	NA	1,144	1,144
AW-104	416	416	NA	1,144	1,144
AY-101	364	364	NA	1,001	1,001
AY-102	364	364	NA	1,001	1,001
AZ-101	364	364	NA	1,001	1,001
AZ-102	364	364	NA	1,001	1,001
-	-	-	Total	31,455	32,183

Notes:

1. Fill volumes are calculated from fill heights and are rounded to the nearest 1,000 gallons
2. Existing space and new available space from increasing levels in some DSTs may not be used immediately because of other constraints, such as safety basis constraints, for example.

Table A-9. Partition Coefficients for the 242-A Evaporator. (3 Sheets)

Component Name	Partition Coefficient ¹	Reference
¹⁰⁶ Ru	6.70E+07	HNF-14755, Rev. 0
^{113m} Cd	1.00E+07	RPP-17239, Rev. 0
¹²⁵ Sb	1.00E+07	HNF-14755, Rev. 0
¹²⁶ Sn	1.00E+07	HNF-14755, Rev. 0
¹²⁹ I	4.00E+08	RPP-17239, Rev. 0
¹³⁴ Cs	1.00E+07	RPP-17239, Rev. 0
¹³⁷ Cs	9.30E+11	RPP-17239, Rev. 0
^{137m} Ba	1.00E+07	RPP-17239, Rev. 0
¹⁴ C	1.00E+07	HNF-14755, Rev. 0
¹⁵¹ Sm	1.00E+07	HNF-14755, Rev. 0
¹⁵² Eu	1.00E+07	RPP-17239, Rev. 0
¹⁵⁴ Eu	1.00E+07	RPP-17239, Rev. 0
¹⁵⁵ Eu	1.00E+07	HNF-14755, Rev. 0
²²⁶ Ra	1.00E+07	HNF-14755, Rev. 0
²²⁷ Ac	1.00E+07	RPP-17239, Rev. 0
²²⁸ Ra	1.00E+07	RPP-17239, Rev. 0
²²⁹ Th	1.00E+07	RPP-17239, Rev. 0
²³¹ Pa	1.00E+07	RPP-17239, Rev. 0
²³² Th	1.00E+07	RPP-17239, Rev. 0
²³² U	1.00E+07	RPP-17239, Rev. 0
²³³ U	1.00E+07	HNF-14755, Rev. 0
²³⁴ U	1.00E+07	HNF-14755, Rev. 0
²³⁵ U	1.00E+07	HNF-14755, Rev. 0
²³⁶ U	1.00E+07	RPP-17239, Rev. 0
²³⁷ Np	3.70E+10	RPP-17239, Rev. 0
²³⁸ Pu	3.70E+10	HNF-14755, Rev. 0
²³⁸ U	1.00E+07	HNF-14755, Rev. 0
²³⁹ Pu	3.70E+10	HNF-14755, Rev. 0
²⁴⁰ Pu	1.00E+07	HNF-14755, Rev. 0
²⁴¹ Am	1.40E+10	HNF-14755, Rev. 0
²⁴¹ Pu	1.00E+07	HNF-14755, Rev. 0
²⁴² Cm	1.00E+07	RPP-17239, Rev. 0
²⁴² Pu	1.00E+07	RPP-17239, Rev. 0
²⁴³ Am	1.40E+10	HNF-14755, Rev. 0
²⁴³ Cm	1.00E+07	RPP-17239, Rev. 0
²⁴⁴ Cm	1.00E+07	HNF-14755, Rev. 0
³ H	=WVR ²	RPP-17239, Rev. 0
⁵⁹ Ni	1.00E+07	RPP-17239, Rev. 0
⁶⁰ Co	7.00E+10	RPP-17239, Rev. 0
⁶³ Ni	1.00E+07	HNF-14755, Rev. 0
⁷⁹ Se	1.00E+07	HNF-14755, Rev. 0
⁹⁰ Sr	2.30E+09	RPP-17239, Rev. 0
⁹⁰ Y	1.00E+07	RPP-17239, Rev. 0
⁹³ Zr	1.00E+07	HNF-14755, Rev. 0
^{93m} Nb	1.00E+07	RPP-17239, Rev. 0
⁹⁹ Tc	1.10E+11	RPP-17239, Rev. 0
Ag ⁺	1.00E+07	HNF-14755, Rev. 0
Al(OH) ₄ ⁻	1.00E+07	RPP-17239, Rev. 0
Al ⁺³	1.50E+07	HNF-14755, Rev. 0
As ⁺³	1.00E+07	HNF-14755, Rev. 0

Table A-9. Partition Coefficients for the 242-A Evaporator. (3 Sheets)

Component Name	Partition Coefficient ¹	Reference
B ⁺³	1.00E+07	HNF-14755, Rev. 0
Ba ⁺²	1.00E+07	HNF-14755, Rev. 0
Be ⁺²	1.00E+07	HNF-14755, Rev. 0
Bi ⁺³	1.00E+07	HNF-14755, Rev. 0
Ca ⁺²	1.00E+07	HNF-14755, Rev. 0
Cd ⁺²	1.00E+07	HNF-14755, Rev. 0
Ce ⁺³	1.00E+07	RPP-17239, Rev. 0
Cl ⁻	5.20E+06	HNF-14755, Rev. 0
CN ⁻	1.00E+07	HNF-14755, Rev. 0
Co ⁺³	1.00E+07	RPP-17239, Rev. 0
CO ₃ ⁻²	1.00E+07	HNF-14755, Rev. 0
Cr(OH) ₄ ⁻	1.00E+07	RPP-17239, Rev. 0
Cr(TOTAL)	3.50E+08	HNF-14755, Rev. 0
Cs ⁺	1.00E+07	RPP-17239, Rev. 0
Cu ⁺²	1.00E+07	RPP-17239, Rev. 0
F ⁻	2.40E+08	HNF-14755, Rev. 0
Fe ⁺³	1.00E+07	HNF-14755, Rev. 0
H ⁺	=WVR ²	RPP-17239, Rev. 0
H ₂ O	=WVR ²	RPP-17239, Rev. 0
Hg ⁺²	1.00E+07	HNF-14755, Rev. 0
K ⁺	3.50E+07	HNF-14755, Rev. 0
La+3	1.00E+07	RPP-17239, Rev. 0
Li ⁺	1.00E+07	RPP-17239, Rev. 0
Mg ⁺²	1.00E+07	HNF-14755, Rev. 0
Mn ⁺⁴	1.00E+07	HNF-14755, Rev. 0
MnO ₂	1.00E+07	RPP-17239, Rev. 0
MnO ₄ ⁻	1.00E+07	RPP-17239, Rev. 0
Mo ⁺⁶	1.00E+07	HNF-14755, Rev. 0
Na ⁺	3.00E+08	HNF-14755, Rev. 0
Nd ⁺³	1.00E+07	RPP-17239, Rev. 0
NH ₃	1.10E+03	HNF-14755, Rev. 0
Ni ⁺²	1.00E+07	HNF-14755, Rev. 0
NO ₂ ⁻	2.40E+07	HNF-14755, Rev. 0
NO ₃ ⁻	5.70E+06	HNF-14755, Rev. 0
OH ⁻	1.00E+07	HNF-14755, Rev. 0
Pb ⁺²	3.00E+05	HNF-14755, Rev. 0
Pd ⁺²	1.00E+07	RPP-17239, Rev. 0
PO ₄ ⁻³	1.00E+07	HNF-14755, Rev. 0
Pr ⁺³	1.00E+07	RPP-17239, Rev. 0
Pu ⁺⁴	1.00E+07	RPP-17239, Rev. 0
Rb ⁺	1.00E+07	RPP-17239, Rev. 0
Rh ⁺³	1.00E+07	RPP-17239, Rev. 0
Ru ⁺³	1.00E+07	RPP-17239, Rev. 0
Sb ⁺⁵	1.00E+07	HNF-14755, Rev. 0
Se ⁺⁶	1.00E+07	HNF-14755, Rev. 0
Si ⁺⁴	1.00E+07	HNF-14755, Rev. 0
SO ₄ ⁻²	1.40E+07	HNF-14755, Rev. 0
Sr ⁺²	1.00E+07	RPP-17239, Rev. 0
Ta ⁺⁵	1.00E+07	RPP-17239, Rev. 0
Tc ⁺⁷	1.00E+07	RPP-17239, Rev. 0
Te ⁺⁶	1.00E+07	RPP-17239, Rev. 0

Table A-9. Partition Coefficients for the 242-A Evaporator. (3 Sheets)

Component Name	Partition Coefficient ¹	Reference
Th ⁺⁴	1.00E+07	RPP-17239, Rev. 0
Ti ⁺⁴	1.00E+07	HNF-14755, Rev. 0
Tl ⁺³	1.00E+07	RPP-17239, Rev. 0
TOC	1.00E+07	RPP-17239, Rev. 0
U(TOTAL)	1.00E+07	HNF-14755, Rev. 0
V ⁺⁵	1.00E+07	HNF-14755, Rev. 0
W ⁺⁶	1.00E+07	RPP-17239, Rev. 0
Y ⁺³	1.00E+07	RPP-17239, Rev. 0
Zn ⁺²	1.00E+07	HNF-14755, Rev. 0
Zr ⁺⁴	1.00E+07	HNF-14755, Rev. 0

Notes;

1. The partition coefficient represents the vapor-liquid equilibrium behavior of a component, and is defined as the ratio of the concentration of a component in the concentrated bottoms to the concentration of that same component in the vapor.
2. The entry “=WVR” means “equals the waste volume reduction factor.” The use of “=WVR” indicates that the affected component is split in the same proportions as water.

**Table A-10. Liquid Effluent Retention Facility
Powder Split Factors. (2 Sheets)**

Analyte	Split Factor	Analyte	Split Factor
¹⁰⁶ Ru	0.99999	Be ⁺³	0.999
^{113m} Cd	0.99999	Bi ⁺³	0.999
¹²⁵ Sb	0.99999	C ₂ O ₄ ⁻²	0.999
¹²⁶ Sn	0.99999	Ca ⁺²	0.999
¹²⁹ I	0.99999	Cd ⁺²	0.999
¹³⁴ Cs	0.99999	Ce ⁺³	0.999
¹³⁷ Cs	0.99999	Cl ⁻	0.999
^{137m} Ba	0.99999	Co ⁺³	0.999
¹⁴ C	0.99999	CO ₃ ⁻²	0.999
¹⁵¹ Sm	0.99999	Cr(OH) ₄ ⁻	0.999
¹⁵² Eu	0.99999	Cr(TOTAL)	0.999
¹⁵⁴ Eu	0.99999	Cs ⁺	0.999
¹⁵⁵ Eu	0.99999	Cu ⁺²	0.999
²²⁶ Ra	0.99999	F ⁻	0.999
²²⁷ Ac	0.99999	Fe ⁺³	0.999
²²⁸ Ra	0.99999	Hg ⁺²	0.999
²³¹ Pa	0.999	K ⁺	0.999
²²⁹ Th	0.999	La ⁺³	0.999
²³² Th	0.999	Li ⁺	0.999
²³² U	0.999	Mg ⁺²	0.999
²³³ U	0.999	Mn ⁺⁴	0.999
²³⁴ U	0.999	Mo ⁺⁶	0.999
²³⁵ U	0.999	Na ⁺	0.999

**Table A-10. Liquid Effluent Retention Facility
Powder Split Factors. (2 Sheets)**

Analyte	Split Factor	Analyte	Split Factor
^{236}U	0.999	Nd^{+3}	0.999
^{237}Np	0.999	NH_3	0.999
^{238}Pu	0.999	Ni^{+2}	0.999
^{238}U	0.999	NO_2^-	0.999
^{239}Pu	0.999	NO_3^-	0.999
^{240}Pu	0.999	OH (Bound)	0.999
^{241}Am	0.999	OH^-	0.999
^{241}Pu	0.999	Pb^{+2}	0.999
^{242}Cm	0.999	Pd^{+2}	0.999
^{242}Pu	0.999	PO_4^{-3}	0.999
^{243}Am	0.999	Pu^{+4}	0.999
^{243}Cm	0.999	Rb^+	0.999
^{244}Cm	0.999	Rh^{+3}	0.999
^3H	0.00	Ru^{+3}	0.999
^{59}Ni	0.999	Sb^{+5}	0.999
^{60}Co	0.99999	Se^{+6}	0.999
^{63}Ni	0.99999	Si^{+4}	0.999
^{79}Se	0.99999	SO_4^{-2}	0.999
^{90}Sr	0.999999	Sr^{+2}	0.999
^{90}Y	0.999999	Ta^{+5}	0.999
^{93}Zr	0.99999	Tc^{+7}	0.999
$^{93\text{m}}\text{Nb}$	0.999999	Te^{+6}	0.999
^{99}Tc	0.99999	Th^{+4}	0.999
Ag^+	0.999	Ti^{+4}	0.999
$\text{Al}(\text{OH})_4^-$	0.999	Tl^{+3}	0.999
Al^{+3}	0.999	TOC	0.930
As^{+5}	0.999	U(TOTAL)	0.999
B^{+3}	0.999	Zn^{+2}	0.999
Ba^{+2}	0.999	Zr^{+4}	0.999

Note: Split factor values are based on Polisher removal efficiencies taken from HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*, Rev. 0A.

Table A-11. Input for SST Retrieval Sequence. (4 Sheets)

Order	Case 13 ⁶⁴		Cases 14 - 15 ⁶⁵	
	CAT1	CAT1-ALT	Na Sort	Solid Sort
1	C-102	C-102	TX-113	B-105
2	C-103	C-103	TX-116	SX-104
3	C-105	C-105	SX-103	BY-101
4	AX-102	AX-102	S-106	S-107
5	AX-104	AX-104	BY-106	S-104
6	TY-101	TY-101	BY-101	BY-112
7	TY-102	TY-102	S-108	TX-113
8	TY-103	TY-103	SX-101	SX-111
9	TY-104	TY-104	SX-104	C-107
10	TY-105	TY-105	U-108	SX-107
11	TY-106	TY-106	AX-101	C-104
12	AX-103	AX-103	S-110	T-107
13	AX-101	AX-101	U-103	BX-112
14	SX-101	SX-101	BY-104	BY-109
15	SX-106	SX-106	BY-110	T-111
16	U-101	C-101	U-109	S-110
17	U-102	C-108	SX-105	S-112
18	U-103	C-109	SX-106	B-107
19	U-104	C-110	TX-106	TX-118
20	U-105	C-111	U-105	BY-111
21	U-106	C-112	SX-102	SX-110
22	U-107	A-101	A-101	BX-107
23	U-108	A-102	S-102	BY-105
24	U-109	A-103	A-103	B-108
25	U-110	A-104	BY-107	U-108
26	U-111	A-105	S-111	C-102
27	U-112	A-106	U-102	TX-112
28	BY-101	TX-101	S-103	S-111
29	BY-102	TX-102	S-101	TY-101
30	BY-103	TX-103	BX-110	B-104
31	BY-104	TX-104	U-111	SX-114
32	BY-105	TX-105	SX-109	TX-105
33	BY-106	TX-106	S-109	U-110
34	BY-107	TX-107	TX-112	C-109
35	BY-108	TX-108	B-104	U-103
36	BY-109	TX-109	S-107	TX-115
37	BY-110	TX-110	TX-105	TX-117

⁶⁴ The Case 13 sorts are the same as those used in the Development Run Rev. 0A and the TFCOUP Rev. 5D. The sequence and timing of the “missing” SSTs (see end of the list) were established manually for those model runs.

⁶⁵ The Case 14 and 15 sorts are simple sorts in decreasing quantities of soluble sodium and associated HLW glass. Several tanks have been manually moved to attempt to split up clusters of tanks with the same HLW glass limiting component.

Table A-11. Input for SST Retrieval Sequence. (4 Sheets)

	Case 13⁶⁴		Cases 14 - 15⁶⁵	
Order	CAT1	CAT1-ALT	Na Sort	Solid Sort
38	BY-111	TX-111	TX-109	TX-114
39	BY-112	TX-112	S-105	T-110
40	S-104	TX-113	TX-115	TY-103
41	TX-101	S-109	BY-105	TX-109
42	TX-102	TX-114	TX-102	SX-109
43	TX-103	TX-115	TX-114	TX-110
44	TX-104	TX-116	U-106	T-104
45	TX-105	TX-117	TX-117	BY-103
46	TX-106	TX-118	BY-103	C-112
47	TX-107	SX-102	TX-110	TY-105
48	TX-108	SX-103	B-109	A-104
49	TX-109	SX-104	BX-107	S-108
50	TX-110	B-105	TY-105	AX-101
51	TX-111	SX-105	BY-111	B-111
52	TX-112	SX-107	TX-111	B-110
53	TX-113	SX-108	BY-102	C-111
54	S-101	SX-109	S-104	S-101
55	TX-114	BX-107	B-110	TX-116
56	TX-115	SX-110	BX-109	BX-104
57	TX-116	SX-111	C-104	TX-111
58	TX-117	SX-112	BY-112	B-103
59	TX-118	SX-113	U-107	BY-102
60	BX-101	SX-114	AX-103	BY-110
61	BX-102	SX-115	B-105	BY-107
62	BX-103	U-101	SX-114	BY-104
63	BX-104	U-102	TY-103	BX-111
64	BX-105	U-103	B-111	U-105
65	BX-106	U-104	BY-109	B-106
66	BX-107	U-105	SX-111	SX-103
67	SX-109	U-106	B-107	T-105
68	BX-108	U-107	TX-118	U-102
69	BX-109	U-108	C-102	C-103
70	BX-110	U-109	SX-108	B-101
71	BX-111	U-110	T-107	U-109
72	BX-112	U-111	T-110	BX-110
73	C-101	U-112	T-104	A-105
74	C-108	B-101	BX-105	SX-112
75	C-109	B-102	A-106	BX-105
76	C-110	B-103	BY-108	A-106
77	C-111	B-104	BX-111	C-110
78	C-112	B-106	T-111	BY-108
79	S-103	B-107	C-110	BX-109
80	S-105	B-108	T-101	SX-105
81	S-106	B-109	BX-112	TX-106

Table A-11. Input for SST Retrieval Sequence. (4 Sheets)

	Case 13 ⁶⁴		Cases 14 - 15 ⁶⁵	
Order	CAT1	CAT1-ALT	Na Sort	Solid Sort
82	S-107	B-110	TX-101	C-105
83	S-108	B-111	TY-101	B-109
84	S-109	B-112	U-110	TX-102
85	S-110	BX-101	S-112	TX-101
86	S-111	BX-102	A-105	SX-108
87	SX-102	BX-103	SX-112	AX-104
88	SX-103	BX-104	B-106	A-103
89	SX-104	BX-105	U-104	C-108
90	B-105	BX-106	BX-101	B-102
91	SX-105	BX-108	TX-103	SX-102
92	SX-107	BX-109	SX-110	BY-106
93	SX-108	BX-110	C-101	B-201
94	SX-110	BX-111	TX-108	C-101
95	SX-111	BX-112	C-112	T-201
96	SX-112	S-103	B-101	SX-101
97	SX-113	S-105	TX-107	TY-104
98	SX-114	S-106	SX-107	S-106
99	SX-115	S-101	T-105	B-204
100	A-101	S-104	BX-106	BX-102
101	A-102	BY-112	B-108	T-112
102	A-103	S-107	BX-104	TX-103
103	A-104	S-108	A-102	B-203
104	A-105	S-110	C-109	S-109
105	A-106	S-111	B-102	TX-108
106	T-101	T-101	B-112	SX-106
107	T-102	T-102	BX-108	U-104
108	T-103	T-103	TY-102	T-204
109	T-104	T-104	TX-104	BX-101
110	T-105	T-105	TY-104	U-107
111	T-106	T-106	AX-102	T-101
112	T-107	T-107	C-107	TX-104
113	T-108	T-108	U-112	U-111
114	T-109	T-109	C-108	AX-102
115	T-112	T-112	C-105	T-203
116	B-101	BY-101	T-112	SX-113
117	B-102	BY-102	T-109	AX-103
118	B-103	BY-103	B-103	B-202
119	B-104	BY-104	U-101	BX-108
120	B-106	BY-105	C-111	A-101
121	B-107	BY-106	A-104	SX-115
122	B-108	BY-107	BX-102	BX-103
123	B-109	BY-108	BX-103	A-102
124	B-110	BY-109	T-106	S-105
125	B-111	BY-110	T-108	S-102

Table A-11. Input for SST Retrieval Sequence. (4 Sheets)

	Case 13 ⁶⁴		Cases 14 - 15 ⁶⁵	
Order	CAT1	CAT1-ALT	Na Sort	Solid Sort
126	B-112	BY-111	T-102	S-103
127			TY-106	B-112
128			B-204	U-112
129			B-202	U-106
130			T-103	U-101
131			T-203	T-108
132			T-204	T-202
133			B-201	TY-102
134			T-201	T-106
135			C-103	TY-106
136			T-202	BX-106
137			B-203	T-103
138			AX-104	T-109
139			U-203	T-102
140			U-201	TX-107
141			C-106	C-204
142			U-202	C-106
143			SX-113	C-201
144			SX-115	C-203
145			C-203	C-202
146			C-204	U-203
147			C-201	U-201
148			U-204	U-202
149			C-202	U-204

A1.2 EXCEPTIONS TO ASSUMPTIONS

Text of Item: Several of the assumptions listed in Table A-2 were not implemented in the HTWOS model for various reasons. Only those deviations from the assumptions in Table A-2 that are potentially relevant to the purpose of this study are given in Table A-12. They were evaluated to have a minor impact on assessing the impact of the various blending scenarios upon the RPP mission. Additional detail about these specific deviations may be found in Appendix B on the HTWOS Model Modification form for the particular assumption.

RPP-RPT-23412 contains a list of all deviations previously identified for the Development Run.

Table A-12. Deviations from Approved Assumptions.

Item	Deviation
Selected Blend Pairs for Case 15	Four of the 29 blend pairs for Case 15 were not implemented by the HTWOS model due to programming difficulties. These pairs were B-104 and BY-101; A-103 and AX-104; B-102 and BY-104; B-106 and BX-102.
DST Residual Heel for Case 15	Tank SY-102 had a residual heel of 4,673 gallons of which were 4,573 were solids and 100 gallons were liquids, rather than the assumed 100 gallons of total residual. This should only introduce a small error (less than half a percent) in the calculated mass of HLW glass. In addition, the HTWOS model internally displayed an incorrect residual heel in SY-102 of 24,352 gallons due to a programming error - the model added the wetted solids volume (which should not have been used for that purpose) to the liquid volume instead of adding the solids volume to the liquid volume.

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APPENDIX B

PREVIOUS WORK

B1.0 PREVIOUS WORK

This appendix summarizes a number of reports located during several literature searches for blending related material. Searches were conducted using the Records Management Information System (RMIS), the Hanford Document Control System (HDCS), the Pacific Northwest National Laboratory (PNNL) publications database (<http://www.pnl.gov/main/publications/>), the Westinghouse Savannah River Site scientific and technical information listing (<http://sti.srs.gov/fulltext/fulltext-2005.htm>), the Office of Scientific and Technical Information's (OSTI) Science Research Connection database (<https://www.osti.gov/src/>), and general internet searches using Google (<http://www.google.com/>).

The focus was on U.S. Department of Energy (DOE)-specific documents due to time and resource constraints. There is a voluminous amount of industry-specific operation research that deals with various aspects of the full-up blending problems and also optimization literature that deals with the mathematical theory and techniques, but that literature was not reviewed.

Each of the following sections summarizes selected previous work on blending, sorted from oldest to newest.

B1.1 Geeting and Kurath (1993)

J. G. H. Geeting and D.E. Kurath, *Preliminary Assessment of Blending Hanford Tank Wastes*, March 1993, PNL-8589.

A parametric study of blending tank waste identified possible benefits from blending wastes prior to immobilization as a high level or low level waste form. Track Radioactive Components data were used as the basis for the SST waste composition, while analytical data were used for the DST composition – the Best Basis inventory did not yet exist. Data that were examined showed that blending may substantially decrease the amount of HLW glass product from the Hanford Waste Vitrification Plant (HWVP) and the amount of grouted LAW from the Grout Test Facility (GTF), compared with the same pretreatment without blending.

Results suggest that minimum blending effort may provide near maximum benefit to final waste-volume reduction. However, the waste-form production estimates were highly sensitive to tank chemical composition data and sludge-wash partitioning factors. It was recommended that since the process of selecting tank feeds to blend was based upon finding compatible feed compositions, more precise tank characterization data would be required.

Applicability

There is no direct applicability to the current study due to the now dated nature of the technical and programmatic assumptions. The study did, however, establish the use of the “Total Blend” and “No Blend” subcases as a means to compare the potential benefits due to blending.

B1.2 Johnson (1993)

L. J. Johnson, *Engineering Study for Hanford Site Tank Waste Blending*, WHC-SD-WM-ES-267, October 1993.

The purpose of this study was to determine the facilities required to support an identified retrieval schedule and blending operations. The assumed retrieval schedules were used to determine which tanks would be available to support the blending operation.

Various blending options were studied to help determine which combination for blending would create the most benefit to the overall amount of HLW waste canisters produced by the WTP. Modeling was done for four tanks farms (C-Farm, U-Farm, SX-Farm, and TX-Farm). This modeling determined the volume of waste being produced from each farm using a total blend scenario. In addition to a total blend scenario, C-Farm contained five other scenarios which included two tanks blended at a time up to six tanks at a time. To show the benefit to the overall mission, these blending options were compared to a no blend option.

The preferred alternative for facilities required in this study consisted of using four Interim Waste Retrieval Annex facilities with capability for staging the SST waste to the DST system. The preferred location of the facilities was throughout the 200 West and 200 East areas. These facilities would provide the initial staging location for SST waste before being transferred to a designated DST.

No modeling or analysis was performed to evaluate how the various facility alternatives influence the degree of blending over the lifecycle of the mission and thus the reduction in mass of HLW glass; the modeling tools for such an evaluation did not yet exist.

Applicability

The applicability of this report to the current blending study is limited because (1) the addition of new blending facilities is outside the scope of the current study, (2) the report did not address how the hardware architecture interacts with blending scenarios to influence the mission metrics, and (3) the blending calculations that were performed are based on now dated inventory and processing assumptions.

B1.3 Hoza (1994)

M. Hoza, *Study of Potential Blending Strategies for Immobilization of Hanford High-Level Waste*, September 1994, TWRSP-94-087.

This study is a continuation of a previous study of the blending of HLW. For this study, the effect of blend size on blending benefit was examined, two methods of solving the discrete blending problem were examined, and several blend formulation strategies were evaluated.

In the discrete blending model, it was required that all waste from a given tank goes to a single blend, and that all tank are assigned to some blend. This resulted in a mixed integer nonlinear

programming problem (MINLP). Two methods of solving the resultant problem were examined: the DICOPT++ solver and simulated annealing. In the study, calculations suggested that simulated annealing would be better able to find an optimal or near-optimal solution.

Several different blending strategies were used to determine the best blending scenario, several random sorts, MINLP/DICOPT, Annex/Tank Farm sort, Optiblend/Mass Balance, Simulated Annealing, Continuous Blend, and Total Blend. While blending by tank farm was proven to be somewhat ineffective for formulating blends, the simulated annealing method proved to be the most effective for forming good blends.

Applicability

This study evaluated the effectiveness of several blending strategies under certain conditions, and concluded, most notably, that blending by farm is not particularly effective. It also identified several behaviors that are now taken for granted: blending is most beneficial when the system is tightly constrained by composition constraints, increasing the number of tanks in each blend increases the benefit, the “Total Blend” and “No Blend” bound the performance of discrete blends, blending wastes of radically different composition is beneficial in reducing the amount of glass, and blending strategies can be compared in terms of the amount of high level waste glass produced provided that they are evaluated in the context of the entire waste set.

This study planted the seeds for the pairwise blending methodology used by this report and for the tiered approach that is now being used for evaluating blending (use mathematical tools to define the proposed blending according to a predefined strategy, then test the strategy using a dynamic model).

B1.4 Certa (1995)

P.J. Certa, *Preliminary Retrieval Sequence and Blending Strategy*, WHC-SD-WM-RPT-167, Rev. 0, September 1995.

The study compares the performance of three blending strategies (Incidental Blend, SY-Split, and High Level Waste Input) in terms of high-level waste glass volume. Incidental blending is that which occurs during retrieval, pretreatment and storage activities without any special effort. SY-Split blending is a strategy that directs waste retrieved from West Area into one or more of the three SY-Farm DSTs based on waste composition to attempt to level out the concentrations of water insoluble chromium. HLW-Input blending is a strategy that directs washed sludge into one or more HLW staging tanks without consideration of waste composition. These blending strategies were also compared to the bounding glass volumes associated with Total Blend and No Blend.

Incidental blending proved to be very powerful, providing HLW glass volumes between 5% and 50% of the span between the Total Blend and No Blend cases. SY-Split blending was determined to be ineffective; however, this is due to the way the SY-Split blending was implemented in the cases. In most cases, the SY-Split blending strategy simply swapped one high chromium batch for another. Effective blending of waste before enhanced sludge washing would be difficult to implement since the as-retrieved volumes are large compared with available

storage space. HLW-Input blending proved to be somewhat successful; however, because of the success from Incidental blending, it was considered inappropriate to recommend undirected HLW-Input blending over Incidental blending.

Applicability

The reduction in HLW glass mass due to incidental blending is (and has been) a key feature of most mission scenarios. However, for reasons not well understood now results in glass volumes closer to 50% of span rather than near 7% of span. The many changes that have occurred since this report (new waste inventories, new wash and leach [W&L] factors, new SST retrieval sequences, new glass models and limits, new pretreatment location and assumptions, etc) confound any explanation.

The report identified and documented the sensitivity of incidental blending details to small changes in the amount or timing of earlier retrievals and transfers – a small change early in the mission will cause major changes in which tanks contribute to each subsequent HLW feed batch.

B1.5 Penwell et al. (1996)

D. L. Penwell, et al., *Initial Retrieval Sequence and Blending Strategy*, WHC-SD-WM-RPT-229, Rev. 0, September 1996.

This report documents the initial SST retrieval sequence and confirms the selection of the incidental blending strategy for limiting HLW glass volume. It also identified that the sensitivity of HLW glass volume to minor random retrieval sequence changes is small when compared to the total volume of glass produced.

Two cases were evaluated, FY 1995 baseline retrieval strategy and FY 1996 baseline retrieval strategy. The FY 1996 baseline adopted the two-phased treatment strategy that was to become the privatization approach. This change significantly altered the retrieval and processing requirements from the FY 1995 baseline. This created an overall retrieval rate increase of about 50 percent over what would have been required to meet the retrieval completion milestone using the FY 1995 baseline. The FY 1996 baseline change impacts created an unrealistic retrieval scenario in order to meet Tri-Party Agreement milestones (Ecology et al. 1996).

The complexity of the tank farm operations needed to meet the September 30, 2018, Tri-Party Agreement for completion of SST retrievals was unprecedented, requiring 46 liquid transfers occurring simultaneously in the tank farms and retrieval rates of 32 Mgal per year. However, if these SST retrieval conditions could be met, the HLW, and LLW completions dates would meet the Tri-Party Agreement Milestones that were in effect at the time.

Applicability

The report confirmed that the HLW glass volume is reduced significantly by the use of incidental blending and recommended that incidental blending be incorporated into future blending strategies. It should also be noted that realistic waste feed delivery rates and tank farm operation capabilities should be kept as constraints to produce a realistic Hanford Site mission completion date.

B1.6 Hendrickson et al. (1999)

D. W. Hendrickson, et al., *Alternatives Generation and Analysis for Phase 1 High-Level Waste Feed Tanks Selection*, HNF-4219, Rev. 0, May 1999.

The purpose of this study was to identify an optimum set of HLW feed tanks for meeting the waste feed delivery commitments for Phase 1 vitrification. A total of 31 HLW feed tanks were identified as possible candidates for Phase 1 HLW vitrification, which when combined with 41 different blending scenarios yielded 72 potential waste streams for a total of 12,426 different tank and cost model combinations (cases). Each case was analyzed in terms of the retrieval costs, product yield, and total cost to DOE. Total cost includes the cost of retrieval, BNFL processing cost, cost of interim storage at the Hanford Site, and the disposal of the product glass canisters.

The boundaries of the analysis were as follows:

1. Phase 1 HLW feed tanks will be identified for the Waste Feed Delivery mission.
2. Tanks AZ-101, AZ-102, AY-102/C-106 are to be used for the baseline HLW feed.
3. Additional wastes will be required to supplement the baseline feed.
4. Cost analysis will be based on tank-specific retrieval costs (construction and operation), glass production costs, and waste disposal costs.

Based on the results of the study, the following optimum set of tanks was recommended for satisfying the waste feed delivery requirements for Phase 1:

- 241-AZ-101
- 241-AZ-102
- 241-AY-102/241-C-106 blended with 20 percent of 241-AW-103
- 241-AY-101 blended with 30 percent of 241-AW-103
- 241-SY-102 blended with 40 percent of 241-AW-103.

Applicability

The specific recommendations are based on now dated assumptions. For example, current plans are to package the waste in tanks SY-102 and AW-103 as remote-handled TRU rather than blend and treat with HLW. The analysis focused on the near-term (Phase 1) feed only and did not consider the impacts that any particular blending decision would have on the remaining feed. While the methodology appears to have been suitable for its stated purpose (selecting Phase 1 feed tanks in the context of Privatization), it is not readily adaptable for lifecycle mission analysis of blending.

B1.7 Certa (2001)

Internal Memorandum, P. J. Certa to R. D. Wojtasek, "LAW Blending Pilot Study White Paper," June 25, 2001, 7G300-01-DJW-003.

The purpose of this pilot study was to determine if LAW (supernate) blending is viable and if further work to determine the cost, schedule, benefits, and risks is warranted. The study focuses on the reduction in feed variability and on whether the overall mission is adversely impacted. Refinements of the SST retrieval sequence and the use of DST space were outside the scope of this pilot study as was the evaluation of the LAW melter sulfate issue.

The study found that the use of AP tanks for blending of LAW feed before delivery to the WTP will dampen the concentration variability of key feed constituents. The blending strategy was to separate AP tank farm into two blending circuits. The south circuit (AP-105 through AP-108) provides the first stage of blending and the north circuit (AP-101 through AP-103) provides the second stage of blending. Tank AP-104 would be used as the final blended waste receiver and the staging tank to WTP. By continuing the blending process in the north circuit, it was possible to further dampen the molar ratio of $[\text{SO}_4]:[\text{Na}]$. This is important due to the fact that sulfate is a limiting component in determining the amount of ILAW glass produced by WTP.

Applicability

This study has no applicability to current blending study since the focus is on HLW glass mass and not the systematic blending of LAW.

B1.8 Johnson and Diwekar (2001)

T. L. Johnson and U. M. Diwekar, "Hanford waste blending and the value of research: stochastic optimization as a policy tool," *Journal of Multi-Criteria Decision Analysis*, Volume 10, Issue 2, Pages 87-99, June 28, 2001.

The abstract from the above journal article states:

"A new approach to stochastic, combinatorial optimization is presented through its application to a contemporary policy problem: cleanup of radioactive wastes stored underground at the US Government's Hanford, WA, nuclear fuels processing site. Current plans call for the tank contents to be selectively combined prior to their immobilization in glass; such blending of wastes reduces the amount of extra material required for vitrification, therefore, decreasing the costs of processing and disposal. Uncertainty in the tank contents, the error inherent in the glass property models governing vitrification, and the computationally intensive nature of the problem, however, render determination of an optimal tank-blend assignment a challenge to existing optimization techniques. Previous studies have focused exclusively on minimization of processing and disposal costs, ignoring such policy-related dimensions as the value of reducing select sources of uncertainty. In addition, the stochastic framework employed by these studies could not guarantee that the glass property

requirements (in the guise of model constraints) were met on more than a probabilistic basis. This paper presents a novel stochastic annealing-nonlinear programming framework that incorporates variance - a proxy for the opportunity costs of reducing uncertainty - as an attribute in its objective function. Compared with conventional mathematical programming algorithms, the new optimization framework is seen to be more robust, flexible, and efficient. The algorithm also facilitates analysis of the trade-off between minimizing processing and disposal costs, and reducing the expenses of achieving these savings. Specifically, the prediction error of the glass property models is found to be a more significant source of uncertainty than variation in tank component mass fraction estimates, and constraint violations are traced to specific requirements of the glass property models.”¹

Applicability

The coupled stochastic annealing – nonlinear programming algorithm presented in this journal article and the technique of including variance in the objective function has not been evaluated by us for application to the general blending problem at the Hanford Site. The authors explain “that Hanford is being used as a contextual example; results are, therefore, illustrative of those that would be obtained in an actual decision-making environment.”

The optimization framework, while sufficiently complex to illustrate the algorithm, may require modification to account for a scenario in which (1) tank inventory information along with the associated uncertainties is used to plan the specific blends and (2) the actual blended waste, after pretreatment, is sampled again and that information, presumably with less uncertainty, is used to formulate the glass.

The examples analyzed in the article use a 12-tank subset, grouped into three blends of four tanks each. The extensibility of the algorithm, supporting software and hardware to the full set of tanks containing HLW sludge has not been evaluated.

B1.9 Aromi (2002)

E. S. Aromi to R. J. Schepens, “Contract Number DE-AC27-99RL14047, Feed Blending and Delivery Case for the Tank 241-AZ-102 Liquid,” Letter, August 26, 2002.

This letter estimated the composition that results from blending AZ-101 supernate with AZ-102 supernate. The purpose of the blend was to reduce the sulfate to sodium ratio of the AZ-102 supernate to minimize sulfate corrosion in the LAW melters. The blending of AZ-102 supernate to reduce the sulfate to sodium ratio has since been added to the feed control list (HNF-SD-WM-OCD-015, Rev. 15A).

Applicability

There is no direct application to the current study, although the blending of AZ-102 supernate has been incorporated into the current assumption sets for HTWOS modeling.

¹ Copyright © 2001 John Wiley & Sons, Ltd.

B1.10 Chaudhuri and Diwekar 2004

P. Chaudhuri and U. Diwekar, "Synthesis approach to the determination of optimal waste blends under uncertainty," *AIChE Journal*, Volume 45, Issue 8, Pages 1671-1687, April 16, 2004.

The abstract of the above journal article states:

*"The generalized approach to the problem of synthesis under uncertainty is to formulate it as a stochastic optimization problem that involves optimization of a probabilistic function obtained by sampling over uncertain variables. The computational burden of this approach can be extreme and depends on the sample size used for characterizing the parametric uncertainties. A new and efficient approach for stochastic process synthesis is presented. The goals are achieved through an improved understanding of the sampling phenomena based on the concepts derived from fractal geometry. A new algorithm for stochastic optimization based on these concepts to accelerate the process of synthesis under uncertainty is presented. Apart from the benchmark HDA synthesis problem, a real-world problem of synthesizing optimal waste blends is analyzed to test the applicability of this novel approach in addressing the general problem of synthesis under uncertainty. The solution of this real-world large-scale synthesis problem is presented under uncertainty through the application of the new stochastic annealing algorithm, which takes into consideration novel sampling methods used in probabilistic analysis of process models."*²

Applicability

The journal article develops a technique for determining optimal waste blending subject to uncertainties in the waste composition and in the glass property models using an approach based on stochastic annealing coupled with nonlinear programming. The technique is demonstrated on a discrete blending problem where 21 tanks are blended into three blends of seven tanks each.

The coupled stochastic annealing – nonlinear programming algorithm presented in this journal article and the technique of including a penalty for uncertainty in the objective function has not been evaluated by the authors for application to the general blending problem at the Hanford Site. The extensibility of the algorithm, supporting software and hardware to the full set of tanks containing HLW sludge has not been evaluated.

B1.11 Certa et al. (2005)

P. J. Certa, et al., *Sensitivity Of Hanford Immobilized High-Level Waste Glass Mass To Chromium And Aluminum Partitioning Assumptions*, RPP-20003 Rev. 1, March 2005.

² Copyright © 1999 American Institute of Chemical Engineers (AIChE).

The purpose of this sensitivity study of immobilized HLW glass mass to chromium and aluminum partitioning assumptions was to:

- Identify the impacts of the revised water wash and caustic leach factors for chromium and aluminum on the mass of HLW glass.
- Understand the effect of oxidative leaching on the mass of HLW glass.
- Identify the major influences for HLW glass mass and waste blending.
- Characterize the degree of pretreatment (water washing, caustic leaching, and oxidative leaching) assumed for different source tanks.
- Identify candidate tank for opportunistic sampling and testing to confirm the inventory and better understand the behavior of chromium during retrieval, staging, and subsequent processing.

It was concluded in the study that the application of the revised chromium and aluminum wash and leach factors will increase the HLW glass mass by about 65 to 100 percent (using relaxed glass properties model) to about 150 to 300 percent (using the default glass properties model) above the baseline. Oxidative leaching of chromium, if implementable as assumed, would partially offset the increase in HLW glass mass.

Another HLW volume impact was discovered to be the TRU waste. The HLW glass mass will increase by about 14 percent if the TRU waste from fourteen SSTs and three DSTs currently designated for direct packaging is treated in the WTP as HLW, assuming a hypothetical total blend of all the tank wastes. However, the effect of incidental blending on HLW glass mass was not evaluated for the case involving the TRU tank wastes.

Applicability

The results of this study have been incorporated into the current assumption sets for HTWOS modeling. This includes both the use of the new chromium and aluminum wash and leach factors and the use of oxidative leaching to partially mitigate the increase in HLW glass.

The methodology and presentation techniques for the stepwise analysis and comparison of various cases and the identification of the drivers for HLW glass mass have been adopted by this current blending study.

B1.12 Haigh and Engeman (2005)

P. G. Haigh and J. K. Engeman, *Blending of Tank 241-AZ-101 Solids*, RPP-25856, Rev. 0, June 2005.

The waste stored in tank AZ-101 currently contains high levels of both insoluble strontium-90 and soluble cesium-137 that result in an excessive hydrogen (H₂) generation rate. The WTP acceptance criteria for H₂ generation would result in potentially significant processing restrictions if the waste is not altered.

The purpose of the blending of AZ-101 solids study is to identify one or more waste blending scenarios which produce a waste feed that meets WTP acceptance criteria for H₂ generation rate and do not result in appreciable glass volume increases nor cause significant impacts to the tank farm waste retrieval mission.

Blending of the waste in tank C-102 with the solids in tank AZ-101 results in a mixture with an estimated H₂ generation rate that is approximately 33% of the proposed WTP H₂ generation rate criteria. The resultant waste mixture produces slightly less glass when compared to the reference case (1,180 vs. 1,220 MT). The combined waste meets tank farm waste compatibility criteria for transfer and storage.

Applicability

There is no direct application to the current study. P.G. Haigh's study verifies that blending tanks based on waste chemistry alone can mitigate issues with WTP constraints while also reducing HLW glass volume.

B2.0 REFERENCES

- 7G300-01-DJW-003, 2001, "LAW Blending Pilot Study White Paper," (internal memorandum from P. J. Certa to R. D. Wojtasek, June 25), CH2M HILL Hanford Group, Inc., Richland, Washington.
- Aromi, E. S., 2002, "Contract Number DE-AC27-99RL14047, Feed Blending and Delivery Case for the Tank 241-AZ-102 Liquid," (Letter to R. J. Schepens, ORP, August 26), CH2M HILL Hanford Group, Inc., Richland, Washington.
- Chaudhuri, P., and U. Diwekar, 2004, "Synthesis approach to the determination of optimal waste blends under uncertainty," *AIChE Journal*, Volume 45, Issue 8, Pages 1671-1687, April 16.
- Ecology, EPA, and DOE, 1996, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.
- HNF-4219, 1999, *Alternatives Generation and Analysis for Phase 1 High-Level Waste Feed Tanks Selection*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- HNF-SD-WM-OCD-015, 2004, *Tank Waste Transfer Compatibility Program*, Rev. 15A, CH2M HILL Hanford Group, Inc., Richland, Washington.
- Johnson, T. L., and U. M. Diwekar, 2001, "Hanford waste blending and the value of research: stochastic optimization as a policy tool", *Journal of Multi-Criteria Decision Analysis*, Volume 10, Issue 2, Pages 87-99, June 28.

PNL-8589, 1993, *Preliminary Assessment of Blending Hanford Tank Wastes*, Pacific Northwest Laboratory, Richland, Washington.

RPP-20003, 2005, *Sensitivity of Hanford Immobilized High-Level Waste Glass Mass to Chromium and Aluminum Partitioning Assumptions*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-25856, 2005, *Blending of Tank 241-AZ-101 Solids*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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WHC-SD-WM-RPT-167, 1995, *Preliminary Retrieval Sequence and Blending Strategy*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-RPT-229, 1996, *Initial Retrieval Sequence and Blending Strategy*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX C

CALCULATIONS AND SOFTWARE

CALCULATIONS AND SOFTWARE

This appendix documents the overall calculation review for the study, and the various calculation reviews and software verifications for the analyses performed for this study.

C1.0 CALCULATION REVIEW CHECKLISTCalculation Reviewed: Pairwise Blending of High-Level WasteScope of Review: Entire Document, including appendices
(e.g., document section or portion of calculation)Engineer/Analyst: Paul J. Certa *Paul J. Certa* Date: 2/17/06Organizational Manager: Nick W. Kirch *NW Kirch* Date: 2/21/2006This document consists of 188 pages and the following attachments (if applicable):NoneYes No NA*

☒	☐	☐	1.	Analytical and technical approaches and results are reasonable and appropriate.
☒	☐	☐	2.	Necessary assumptions are reasonable, explicitly stated, and supported.
☒	☐	☐	3.	Ensure calculations that use software include a paper printout, microfiche, CD ROM, or other electronic file of the input data and identification to the computer codes and versions used, or provide alternate documentation to uniquely and clearly identify the exact coding and execution process.
☒	☐	☐	4.	Input data were checked for consistency with original source information.
☒	☐	☐	5.	For both qualitative and quantitative data, uncertainties are recognized and discussed.
☒	☐	☐	6.	Mathematical derivations were checked, including dimensional consistency of results.
☒	☐	☐	7.	Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information.
☒	☐	☐	8.	Software verification and validation are addressed adequately.
☒	☐	☐	9.	Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references.
☒	☐	☐	10.	Conclusions are consistent with analytical results and applicable limits.
☒	☐	☐	11.	Results and conclusions address all points in the purpose.
☒	☐	☐	12.	Referenced documents are retrievable or otherwise available.
☒	☐	☐	13.	The version or revision of each reference is cited.
☒	☐	☐	14.	The document was prepared in accordance with Attachment A, "Calculation Format and Preparation Instructions."
☐	☐	☒	15.	Impacts on requirements have been assessed and change documentation initiated to incorporate revisions to affected documents, as appropriate.
☒	☐	☐	16.	All checker comments have been dispositioned and the design media matches the calculations.

Jeanne A Lechelt *Jeanne A Lechelt* 2/17/2006
 Checker (printed name and signature) Date

* If No or NA is chosen, an explanation must be provided on or attached to this form.

The following is an explanation of any “No” or “NA” items from the preceding checklist:

Item 15

This report provides “What-If” information to management for strategic planning purposes and does not establish requirements nor directly affect the design or operating modes of the tank farms. Therefore, no change documentation is needed.

C2.0 COMPUTER SOFTWARE

This section contains the tables of computer software (specifically, HTWOS modules) discussed in Sections D5.0, USE OF COMPUTER SOFTWARE; 6.1.1, Glass Reduction Matrix; and 6.2, Mission Scenario EVALUATION. Only modules that were modified since the RPP-20003 Rev. 1 (for Table C-1) or the Development Run (for Table C-2) are listed.

Table C-1. Modules Changed for Reference Case and Pairwise Blending Evaluations.

Module Name	Module Version
BOM-LOGIC-MODULE	Module Version 2.0.2.1
HTWOS-COMMON-MODULE	Module Version 4.8.2.1.3.1
TANK-FARMS-A-MODULE	Module Version 1.1.2.1.4.1.8.1.10.1
TANK-FARMS-COMMON-MODULE	Module Version 2.2.2.1
TANK-FARMS-RSW-MODULE	Module Version 1.2.3.1
V-AND V-MODULE	Module Version 1.0.3.1

Table C-2. Modules Changed for Mission Scenarios.

Module Name	Module Version
BOM-LOGIC-MODULE	Module Version 2.6
HTWOS-COMMON-MODULE	Module Version 6.3
TANK-FARMS-A-MODULE	Module Version 1.1.2.1.4.1.8.1
TANK-FARMS-COMMON-MODULE	Module Version 3.4
TANK-FARMS-RSW-MODULE	Module Version 1.4
V-AND V-MODULE	Module Version 1.1

C3.0 MODEL MODIFICATION FORMS

This section contains the completed Hanford Tank Waste Operations Simulator (HTWOS) Model Modification Record forms along with any necessary supporting data. These forms were prepared in accordance with "HTWOS Model Assumption Validation," (TFC-ENG-CHEM-D-39).

The signatures below signify acceptance with the content and verification of the Model Modification Forms that follow in this appendix.

Section C3.1
(Reference Case and Pairwise Blending
Evaluations)

Modeler:
N. W. Kirch for T. M. Hohl

Section C3.2
(Mission Scenarios)

S. L. Orcutt

Verifier:
S. L. Orcutt

J. A. Lechelt

C3.1 REFERENCE CASE AND PAIRWISE BLENDING EVALUATIONS

The following model modification forms apply to the reference case and pairwise blending evaluations.

HTWOS Model Modification Form

Modification Title: HTWOS Procedures and Modules Updated																																																																	
Description of Modification: The starting point for modeling the effect of updated phosphate and sulfate wash and leach factors as well as calculating the HLW glass savings from blending pairs of tanks was that used for the Chromium and Aluminum Wash and Leach Factor study (RPP-20003, Rev. 1). From this starting point, procedures were modified to accommodate the changed assumptions for this study.																																																																	
Method Used to Check Modification: Reviewed the model module version numbers against module version numbering of RPP-20003, Rev. 1.																																																																	
Result of Checking Modification: HTWOS module version numbers from model used in RPP-20003, Rev. 1 were: <table border="0"> <tr><td>BNFL-FLOWSHEET-MODULE</td><td>Module Version 1.1</td></tr> <tr><td>BOM-LOGIC-MODULE</td><td>Module Version 2.0</td></tr> <tr><td>CHANGES-MODULE</td><td>Module Version 1.1</td></tr> <tr><td>ETF-FLOWSHEET-MODULE</td><td>Module Version 1.0</td></tr> <tr><td>GKA-WTP-COMMON-MODULE</td><td>Module Version 1.3</td></tr> <tr><td>HELPDESK-MODULE</td><td>Module Version 1.0</td></tr> <tr><td>HLW-STAGING-LOGIC-MODULE</td><td>Module Version 1.1</td></tr> <tr><td>HTWOS</td><td>Module Version 1.1</td></tr> <tr><td>HTWOS-COMMON-MODULE</td><td>Module Version 4.8.2.1</td></tr> <tr><td>INITIAL-ASSUMPTIONS-MODULE</td><td>Module Version 2.7</td></tr> <tr><td>INITIAL-INVENTORY-MODULE</td><td>Module Version 2.5</td></tr> <tr><td>LAW-STAGING-LOGIC-MODULE</td><td>Module Version 1.4</td></tr> <tr><td>MENU-DEFINITIONS-MODULE</td><td>Module Version 3.0</td></tr> <tr><td>OWVP-LOGIC-MODULE</td><td>Module Version 1.5.1.1</td></tr> <tr><td>PIPING-MODULE</td><td>Module Version 3.8</td></tr> <tr><td>TANK-FARMS-A-MODULE</td><td>Module Version 1.1.2.1.4.1.8.1</td></tr> <tr><td>TANK-FARMS-B-MODULE</td><td>Module Version 1.0</td></tr> <tr><td>TANK-FARMS-C-MODULE</td><td>Module Version 1.0</td></tr> <tr><td>TANK-FARMS-COMMON-MODULE</td><td>Module Version 2.2</td></tr> <tr><td>TANK-FARMS-MB-LOGIC-MODULE</td><td>Module Version 1.1.2.1</td></tr> <tr><td>TANK-FARMS-RSW-MODULE</td><td>Module Version 1.2</td></tr> <tr><td>TANK-INVENTORY-MODULE</td><td>Module Version 1.3</td></tr> <tr><td>TEMP-DCW</td><td>Module Version 1.0</td></tr> <tr><td>TO-DATABASE-MODULE</td><td>Module Version 1.4</td></tr> <tr><td>V-AND-V-MODULE</td><td>Module Version 1.0</td></tr> <tr><td>WTP-COMMON-MODULE</td><td>Module Version 1.0</td></tr> </table> <p>Six of the above modules were modified and their version numbers updated to archive the changes made to them in the course of this study. The modified modules and their updated version numbers are:</p> <table border="0"> <tr><td>BOM-LOGIC-MODULE</td><td>Module Version 2.0.2.1</td></tr> <tr><td>HTWOS-COMMON-MODULE</td><td>Module Version 4.8.2.1.3.1</td></tr> <tr><td>TANK-FARMS-A-MODULE</td><td>Module Version 1.1.2.1.4.1.8.1.10.1</td></tr> <tr><td>TANK-FARMS-COMMON-MODULE</td><td>Module Version 2.2.2.1</td></tr> <tr><td>TANK-FARMS-RSW-MODULE</td><td>Module Version 1.2.3.1</td></tr> <tr><td>V-AND V-MODULE</td><td>Module Version 1.0.3.1</td></tr> </table> <p>The changes represented by these updated versions allow the model to use the new phosphate and sulfate wash and leach factors, correctly employ chromium oxidative leaching, and perform the Blend/No-Blend HLW glass processing.</p>		BNFL-FLOWSHEET-MODULE	Module Version 1.1	BOM-LOGIC-MODULE	Module Version 2.0	CHANGES-MODULE	Module Version 1.1	ETF-FLOWSHEET-MODULE	Module Version 1.0	GKA-WTP-COMMON-MODULE	Module Version 1.3	HELPDESK-MODULE	Module Version 1.0	HLW-STAGING-LOGIC-MODULE	Module Version 1.1	HTWOS	Module Version 1.1	HTWOS-COMMON-MODULE	Module Version 4.8.2.1	INITIAL-ASSUMPTIONS-MODULE	Module Version 2.7	INITIAL-INVENTORY-MODULE	Module Version 2.5	LAW-STAGING-LOGIC-MODULE	Module Version 1.4	MENU-DEFINITIONS-MODULE	Module Version 3.0	OWVP-LOGIC-MODULE	Module Version 1.5.1.1	PIPING-MODULE	Module Version 3.8	TANK-FARMS-A-MODULE	Module Version 1.1.2.1.4.1.8.1	TANK-FARMS-B-MODULE	Module Version 1.0	TANK-FARMS-C-MODULE	Module Version 1.0	TANK-FARMS-COMMON-MODULE	Module Version 2.2	TANK-FARMS-MB-LOGIC-MODULE	Module Version 1.1.2.1	TANK-FARMS-RSW-MODULE	Module Version 1.2	TANK-INVENTORY-MODULE	Module Version 1.3	TEMP-DCW	Module Version 1.0	TO-DATABASE-MODULE	Module Version 1.4	V-AND-V-MODULE	Module Version 1.0	WTP-COMMON-MODULE	Module Version 1.0	BOM-LOGIC-MODULE	Module Version 2.0.2.1	HTWOS-COMMON-MODULE	Module Version 4.8.2.1.3.1	TANK-FARMS-A-MODULE	Module Version 1.1.2.1.4.1.8.1.10.1	TANK-FARMS-COMMON-MODULE	Module Version 2.2.2.1	TANK-FARMS-RSW-MODULE	Module Version 1.2.3.1	V-AND V-MODULE	Module Version 1.0.3.1
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LAW-STAGING-LOGIC-MODULE	Module Version 1.4																																																																
MENU-DEFINITIONS-MODULE	Module Version 3.0																																																																
OWVP-LOGIC-MODULE	Module Version 1.5.1.1																																																																
PIPING-MODULE	Module Version 3.8																																																																
TANK-FARMS-A-MODULE	Module Version 1.1.2.1.4.1.8.1																																																																
TANK-FARMS-B-MODULE	Module Version 1.0																																																																
TANK-FARMS-C-MODULE	Module Version 1.0																																																																
TANK-FARMS-COMMON-MODULE	Module Version 2.2																																																																
TANK-FARMS-MB-LOGIC-MODULE	Module Version 1.1.2.1																																																																
TANK-FARMS-RSW-MODULE	Module Version 1.2																																																																
TANK-INVENTORY-MODULE	Module Version 1.3																																																																
TEMP-DCW	Module Version 1.0																																																																
TO-DATABASE-MODULE	Module Version 1.4																																																																
V-AND-V-MODULE	Module Version 1.0																																																																
WTP-COMMON-MODULE	Module Version 1.0																																																																
BOM-LOGIC-MODULE	Module Version 2.0.2.1																																																																
HTWOS-COMMON-MODULE	Module Version 4.8.2.1.3.1																																																																
TANK-FARMS-A-MODULE	Module Version 1.1.2.1.4.1.8.1.10.1																																																																
TANK-FARMS-COMMON-MODULE	Module Version 2.2.2.1																																																																
TANK-FARMS-RSW-MODULE	Module Version 1.2.3.1																																																																
V-AND V-MODULE	Module Version 1.0.3.1																																																																
Modeler Name: <u>T. M. Hohl</u>																																																																	
Verifier Name: <u>S. L. Orcutt</u>																																																																	

HTWOS Model Modification Form**Modification Title:** Wash and Leach Factors**Description of Modification:**

- The water wash factors in the TWINS on 8/24/2004 will be used as the baseline factors for partitioning waste into solid and liquid phases during retrieval and staging. The Phosphate (PO_4) and Sulfate (SO_4) wash factors in RPP-25903 will be used as the revised factors for the sensitivity study.
- The caustic leach factors in the TWINS on 8/24/2004 will be used as the baseline caustic leach factors. The Phosphate (PO_4) and Sulfate (SO_4) leach factors in RPP-25903 will be used as the revised factors for the sensitivity study.

Baseline wash and leach factors were used in sensitivity cases 8, 9, and 10. Revised SO_4 wash and leach factors were used in sensitivity case 11. Revised PO_4 wash and leach factors were used in sensitivity case 12. Revised (both PO_4 and SO_4) wash and leach factors were used in sensitivity case 13. The wash and leach factors used in Case 13 are also used for developing the Blending Glass Reduction Matrix (BGRM). The specific options used for a specific case are visually presented in Table 2 in the main body of the document.

Method Used to Check Modification: The HTWOS model generates a file named “wash-and-leach-used.csv” that reports the initial wash and leach factors in the model at the start of a model run. This HTWOS output file was reviewed for each case against baseline and revised assumption values.

Result of Checking Modification:

The “wash-and-leach-used.csv” files generated for each case were reviewed. The expected wash and leach factors used corresponded with those chosen for each specific case. A short sample is presented below:

Case Wash Factors,AZ-102,AZ-101,AY-102,AY-101

Case 8 PO_4 -3,0.0,3.33588957e-1,6.9292257e-1,8.55050068e-1

Case 9 PO_4 -3,0.0,3.33588957e-1,6.9292257e-1,8.55050068e-1

Case 10 PO_4 -3,0.0,3.33588957e-1,6.9292257e-1,8.55050068e-1

Case 11 PO_4 -3,0.0,3.33588957e-1,6.9292257e-1,8.55050068e-1

Case 12 PO_4 -3,6.7e-2,4.2e-1,6.9292257e-1,8.55050068e-1

Case 13 PO_4 -3,6.7e-2,4.2e-1,6.9292257e-1,8.55050068e-1

BGRM PO_4 -3,6.7e-2,4.2e-1,6.9292257e-1,8.55050068e-1

Case 8 SO_4 -2,9.4860683e-1,7.80913905e-1,9.46154232e-1,9.4860683e-1

Case 9 SO_4 -2,9.4860683e-1,7.80913905e-1,9.46154232e-1,9.4860683e-1

Case 10 SO_4 -2,9.4860683e-1,7.80913905e-1,9.46154232e-1,9.4860683e-1

Case 11 SO_4 -2,9.25e-1,6.6e-1,9.46154232e-1,9.4860683e-1

Case 12 SO_4 -2,9.4860683e-1,7.80913905e-1,9.46154232e-1,9.4860683e-1

Case 13 SO_4 -2,9.25e-1,6.6e-1,9.46154232e-1,9.4860683e-1

BGRM SO_4 -2,9.25e-1,6.6e-1,9.46154232e-1,9.4860683e-1

Case Leach Factors,AZ-102,AZ-101,AY-102,AY-101

Case 8 Phosphate,4.88657584e-1,7.51590116e-1,6.6891701e-1,0.0

Case 9 Phosphate,4.88657584e-1,7.51590116e-1,6.6891701e-1,0.0

Case 10 Phosphate,4.88657584e-1,7.51590116e-1,6.6891701e-1,0.0

Case 11 Phosphate,4.88657584e-1,7.51590116e-1,6.6891701e-1,0.0

Case 12 Phosphate,4.88745981e-1,0.0,6.6891701e-1,0.0

Case 13 Phosphate,4.88745981e-1,0.0,6.6891701e-1,0.0

BGRM Phosphate,4.88745981e-1,0.0,6.6891701e-1,0.0

HTWOS Model Modification Form**Modification Title:** Wash and Leach Factors

Case 8 Sulfate,1.0e0,1.0e0,1.0e0,1.0e0

Case 9 Sulfate,1.0e0,1.0e0,1.0e0,1.0e0

Case 10 Sulfate,1.0e0,1.0e0,1.0e0,1.0e0

Case 11 Sulfate,1.0e0,9.70588235e-1,2.5e-1,2.5e-1

Case 12 Sulfate,1.0e0,1.0e0,1.0e0,1.0e0

Case 13 Sulfate,1.0e0,9.70588235e-1,2.5e-1,2.5e-1

BGRM Sulfate,1.0e0,9.70588235e-1,2.5e-1,2.5e-1

The remaining wash and leach factors were also checked against the baseline set and were found to be correct.

Modeler Name: T. M. Hohl**Verifier Name:** S. L. Orcutt

HTWOS Model Modification Form

Modification Title: Correct Oxidative Leach Process to Achieve 0.5 wt% Chromium on an After-Oxidative Leach Basis.

Description of Modification:

Scrutiny of the oxidative leach process showed that the adjustment required to achieve 0.5 wt% chromium was calculated on a before- oxidative leach basis instead of an after-oxidative leach basis. RPP-15522 states: “Independent of the starting concentration of chromium, oxidative leaching of Hanford tank waste will achieve less than 5000 µg Cr / g dried solids provided sufficient permanganate is added.” The leach reaction on page B-21 of the reference will be used to estimate the amount of permanganate to be added to the sludge – one mole of solid MnO₂ was formed for every mole of chromium leached from the sludge. Partitioning of analytes other than chromium during oxidative leaching, and competing reactions will not be addressed.

The “HTWOS-oxidative-leach-cr” procedure in the model was modified to account for the mass of manganese added during this process and achieve a weight percent chromium of 0.5% on an after-oxidative leach basis.

Method Used to Check Modification: The “HTWOS-oxidative-leach-cr” procedure in the model produces an output that obtained data on chromium and MnO₂ mass fractions before and after the oxidative leaching step and reported it in a file named “oxidative-leach-cr-before-and-after.internal-write.” This file was reviewed to verify that the oxidative leaching step performed as expected.

The oxidative leach procedure in Case 8 intentionally used the incorrect endpoint. Cases 9 through 13 had the corrected algorithm and yielded the correct chromium endpoint. Small samples of the “oxidative-leach-cr-before-and-after.internal-write” file are presented for Cases 8 through 13 and the repair is clearly shown.

Result of Checking Modification:

Small samples of “oxidative-leach-cr-before-and-after.internal-write” file output for Cases 8 through 13.

Case 8:

On 1/1/2001 at 1554.0 days In tank ,AX-103, Solid chrome mass before ox-leach = ,1435.603, kg, Solid MnO₂ mass before ox-leach = ,0.0, kg, Total solid mass before ox-leach = ,15798.162, kg, Mass solid Cr/Total solid mass before ox-leach = ,9.087, percent, Solid chrome mass after ox-leach = ,72.174, kg, Solid MnO₂ mass after ox-leach = ,2279.641, kg, **Mass Cr/Total mass after ox-leach = ,0.457, percent**

Case 9:

On 1/1/2001 at 1554.0 days In tank ,AX-103, Solid chrome mass before ox-leach = ,1435.603, kg, Solid MnO₂ mass before ox-leach = ,0.0, kg, Total solid mass before ox-leach = ,29078.616, kg, Mass solid Cr/Total solid mass before ox-leach = ,4.937, percent, Solid chrome mass after ox-leach = ,149.714, kg, Solid MnO₂ mass after ox-leach = ,2149.995, kg, **Mass Cr/Total mass after ox-leach = ,0.5, percent**

Case 10:

On 1/1/2001 at 1554.0 days In tank ,AX-103, Solid chrome mass before ox-leach = ,1435.603, kg, Solid MnO₂ mass before ox-leach = ,0.0, kg, Total solid mass before ox-leach = ,29078.616, kg, Mass solid Cr/Total solid mass before ox-leach = ,4.937, percent, Solid chrome mass after ox-leach = ,149.714, kg, Solid MnO₂ mass after ox-leach = ,2149.995, kg, **Mass Cr/Total mass after ox-leach = ,0.5, percent**

Case 11:

On 1/1/2001 at 1554.0 days In tank ,AX-103, Solid chrome mass before ox-leach = ,1435.603, kg, Solid MnO₂ mass before ox-leach = ,0.0, kg, Total solid mass before ox-leach = ,29078.616, kg, Mass solid Cr/Total solid mass before ox-leach = ,4.937, percent, Solid chrome mass after ox-leach = ,149.714, kg, Solid MnO₂ mass after ox-leach = ,2149.995, kg, **Mass Cr/Total mass after ox-leach = ,0.5, percent**

HTWOS Model Modification Form

Modification Title: Correct Oxidative Leach Process to Achieve 0.5 wt% Chromium on an After-Oxidative Leach Basis.

Case 12:

On 1/1/2001 at 1554.0 days In tank ,AX-103, Solid chrome mass before ox-leach = ,1435.603, kg, Solid MnO₂ mass before ox-leach = ,0.0, kg, Total solid mass before ox-leach = ,30792.429, kg, Mass solid Cr/Total solid mass before ox-leach = ,4.662, percent, Solid chrome mass after ox-leach = ,158.254, kg, Solid MnO₂ mass after ox-leach = ,2135.716, kg, **Mass Cr/Total mass after ox-leach = ,0.5, percent**

Case 13:

On 1/1/2001 at 1554.0 days In tank ,AX-103, Solid chrome mass before ox-leach = ,1435.603, kg, Solid MnO₂ mass before ox-leach = ,0.0, kg, Total solid mass before ox-leach = ,30792.429, kg, Mass solid Cr/Total solid mass before ox-leach = ,4.662, percent, Solid chrome mass after ox-leach = ,158.254, kg, Solid MnO₂ mass after ox-leach = ,2135.716, kg, **Mass Cr/Total mass after ox-leach = ,0.5, percent**

Review of this output from the model verifies that the correction made to the oxidative leaching procedure was correctly implemented.

Modeler Name: T. M. Hohl

Verifier Name: S. L. Orcutt

HTWOS Model Modification Form

Modification Title: Modify Water Washing Procedure to Correctly Maintain Charge Balance
<p>Description of Modification:</p> <p>The procedure that water washes solids in the waste tanks is coded to maintain a charge balance in the liquid phase at the end of the procedure by consuming free hydroxide, and if necessary, carbonate ion to balance the charge. For non-negative wash factors, there are three possible logic paths that each solid component can follow in the water washing procedure based on the component's wash factor: 1) a wash factor between 1.0 and 0.0, 2) a wash factor equal to zero, and 3) a wash factor equal to 1.0. The charge balance function worked correctly in the first two paths, but the charge balance function was left out of the logic path followed when the wash factor was equal to 1.0. This would result in incorrect quantities of free hydroxide and carbonate being needlessly moved between the liquid and solid phases.</p> <p>The HTWOS procedure, "WATER-DISSOLVE-SOLIDS," was modified by adding the charge balance function to the logic path executed when the wash factor was equal to 1.0.</p>
<p>Method Used to Check Modification: The water washing procedure in Case 8 lacked the correct function for a wash factor equal to 1.0. This was intentionally left in the incorrect state. Cases 9 through 13 had the corrected procedure and yielded a charge balanced liquid phase. The liquid phase inventories after water washing was performed were checked for charge balance to verify that the change was effected.</p>
<p>Result of Checking Modification:</p> <p>Review of the liquid phase composition and checking the resulting charge balance showed that the change to the procedure was correctly implemented. The checks were performed in a spreadsheet named "Check charge balance.xls."</p>
<p>Modeler Name: <u>T. M. Hohl</u></p> <p>Verifier Name: <u>S. L. Orcutt</u></p>

HTWOS Model Modification Form	
Modification Title:	Glass Property Model Constraints
Description of Modification:	<ul style="list-style-type: none"> The Relaxed Glass Properties Model constraints identified in Table 2 of RPP-20003 Rev. 1 will be used to bound the HLW glass formation. The constraints listed in the assumption matrix for this study matches those of RPP-20003. <p>Relaxed Glass Property Model constraints are applied in all cases.</p>
Method Used to Check Modification:	The HTWOS model generates a file named “output-glass.csv” that reports the amount of glass created from each batch of waste set to the HLW melter. This file also reports out the glass properties, limits, and constraints used for each model run. This HTWOS output file is reviewed to verify the Glass Property Model constraint values for each case against the assumed values. Outputs from all cases will be visually inspected against assumptions for each individual case.
Result of Checking Modification:	Review of the output files showed that correct Glass Properties Model constraints were used for each case.
Modeler Name:	<u>T. M. Hohl</u>
Verifier Name:	<u>S. L. Orcutt</u>

HTWOS Model Modification Form

Modification Title: Tanks Treated
Description of Modification: <p>Cases 8 through 13 model the treatment of all tank wastes except those targeted for treatment through a Transuranic Waste Packaging Facility. The tank selection for the blending pairs analysis was performed outside the HTWOS model and is not addressed in this model modification form.</p>
Method Used to Check Modification: <p>The HTWOS model generates a file (named uniquely for each run) that lists each HLW batch by its unique tank name. The HTWOS output file was reviewed to ensure that only the specified 157 (non-TRU) tanks were represented for all the cases. Individual files for each case (named CaseX.csv, with the "X" representing the Case number) were inspected to check this modification.</p>
Result of Checking Modification: <p>The files for Cases 8 through 13 contained 160 rows (157 tanks, one header row, one blank row, and one total row). The individual tanks listed in these output files matched the tanks specified in the assumptions. Review of this output verifies that the correct selection of tanks for each run was correctly implemented.</p>
Modeler Name: <u>T. M. Hohl</u> Verifier Name: <u>S. L. Orcutt</u>

HTWOS Model Modification Form

Modification Title: Waste Inventory Treated
Description of Modification: For Cases 8 and 9, the 2004a inventory was used. For Cases 10 through 13, the 2005 inventory was used. The inventory used for the blending pairs analysis was the 2005 inventory.
Method Used to Check Modification: Individual component inventories for each case will be spot checked against the inventory source. Also, the last inventory file loaded into the model is traceable through the procedure that loads the inventories into the model. This will be reviewed to indicate the filename of the inventory that is loaded into the model and compare it against the known filename for the correct inventory.
Result of Checking Modification: Review of the model showed that the correct inventory was used for all cases.
Modeler Name: <u>T. M. Hohl</u> Verifier Name: <u>S. L. Orcutt</u>

HTWOS Model Modification Form

Modification Title: Mobilizing all Solid Layers of Tank AY-102
Description of Modification: In RPP-20003 ten percent of the solids in Tank AY-102 were not processed in order to match an assumption used for the baseline case in that study. For this and future studies, the immobile heel in Tank AY-102 will be mobilized.
Method Used to Check Modification: The Projected Glass model was run for tank HLW estimates; both before and after the modification to the handling of the AY-102 solids. Review of these glass output files will be inspected to verify that the desired change was effected.
Result of Checking Modification: Case 13: For AY-102 without the immobile layer included in the HLW canister calculation, the total MT of feed oxides was 204.7, which produced 770.2 MT of glass, which corresponds to 240.7 HLW canisters. For AY-102 with the immobile layer included in the HLW canister calculation, the total MT of feed oxides was 227.4, which produced 855.8 MT of glass, which corresponds to 267.4 HLW canisters. The overall result is that the feed oxides, glass oxides, and canisters when all the solids were included were 11.1% greater than when the immobile heel was left in AY-102. This is the expected result and shows that the modification was successfully implemented.
Modeler Name: T. M. Hohl Verifier Name: S. L. Orcutt

HTWOS Model Modification Form**Modification Title:** Pairwise Blending Glass Reduction Matrix**Description of Modification:**

The HTWOS model has the capacity to calculate the reduction in HLW glass that results from blending pairs of tanks. The "Blending Glass Reduction Matrix" is an array of the glass reduction data from pairwise blending of all 177 waste tanks in every possible combination. This array is used as input to the linear programming software.

Method Used to Check Modification:

Several random tank pairs were evaluated using the HTWOS model Blend/no-blend procedure. The glass savings realized from these blends were calculated, and these values were compared against the corresponding values present in the Blending Glass Reduction Matrix.

Result of Checking Modification:

<u>Tank 1</u>	<u>Tank 2</u>	<u>Glass Savings From Array (MT)</u>	<u>Glass Savings from alternate calc. (MT)</u>
B-105	SX-104	944.053	944.053
TX-113	BX-107	403.477	403.477
SX-103	T-107	137.899	137.9
BX-102	TX-112	82.019	82.019
BY-103	A-104	236.711	236.711
SX-107	S-108	174.915	174.916

Four of the comparisons matched up, while two of the pairings differed by 0.001 MT. The difference can be attributed to rounding error. This is the expected result and shows that the modification was successfully implemented.

Modeler Name: T. M. Hohl**Verifier Name:** S. L. Orcutt

C3.2 MISSION SCENARIOS

The following model modification forms apply to the Mission Scenario Study, Cases 13 – 15, Realized Blend subcases.

HTWOS Model Modification Form

Modification Title: New Waste Introduced Via 200 West Area – 222-S Laboratory	
Description of Modification: 222-S laboratory will introduce 10 Kgal of waste per year to the DST system through 10/1/2027, with a flush volume factor of 22%.	
Method Used to Check Modification: On the OWVP workspace under West Waste Receipts verify that S-Plant contributes 10,000 gallons per year with a flush volume factor of 22%, through 10/1/2027	
Result of Checking Modification: S-Plant: 2500 gallons every 3 months with a 22% flush fraction, through 10/1/2027.	
Modeler Name:	S.L. Orcutt
Verifier Name:	J. A. Lechelt

HTWOS Model Modification Form

Modification Title: LAW Pretreatment Ramp Up	
Description of Modification: Changed the UF by removing ramp-up rate and setting the permeate rate to a flat value of 17.7 gpm.	
Method Used to Check Modification: In the procedure named ADJUST-UF-SOLIDS-PERCENT verify that the permeate [sic] rate is set to 17.7.	
Result of Checking Modification: Verified permeate [sic] rate was set to 17.7 in the procedure named ADJUST-UF-SOLIDS-PERCENT	
Modeler Name:	S.L. Orcutt
Verifier Name:	J. A. Lechelt

HTWOS Model Modification Form

Modification Title: ILAW Package Net Mass
Description of Modification: Change the ILAW package net mass from 6.0 MT to 5.92 MT
Method Used to Check Modification: On the Initial Assumptions workspace under glass assumptions, verify that the ILAW package net mass = 5.92 MT
Result of Checking Modification: From the above workspace, the LAW glass density = 2.6 MT/m ³ and the LAW canister volume = 2.277 m ³ , yielding a package mass of 5.92 MT
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: HLW Vitrification Ramp-up								
Description of Modification: Modified the HLW vitrification ramp-up rate to not exceed the 5.0 MTG/day.								
Method Used to Check Modification: On the Enhanced HTWOS WTP Flowsheet, under Startup dates and ramp multipliers verify that the HLW ramp-up rates are: <table> <tr> <td>5/17/2010</td> <td>0.69 MTG/d</td> </tr> <tr> <td>2/1/2011</td> <td>3.0 MTG/d</td> </tr> <tr> <td>1/1/2012</td> <td>4.0 MTG/d</td> </tr> <tr> <td>1/1/2013</td> <td>5.0 MTG/d</td> </tr> </table>	5/17/2010	0.69 MTG/d	2/1/2011	3.0 MTG/d	1/1/2012	4.0 MTG/d	1/1/2013	5.0 MTG/d
5/17/2010	0.69 MTG/d							
2/1/2011	3.0 MTG/d							
1/1/2012	4.0 MTG/d							
1/1/2013	5.0 MTG/d							
Result of Checking Modification: The HLW ramp-up rates are: <table> <tr> <td>5/17/2010</td> <td>(0.69)*(1.0) = 0.69 MTG/d</td> </tr> <tr> <td>2/1/2011</td> <td>(0.69)*(4.348) = 3.0 MTG/d</td> </tr> <tr> <td>1/1/2012</td> <td>(0.69)*(5.797) = 4.0 MTG/d</td> </tr> <tr> <td>1/1/2013</td> <td>(0.69)*(7.246) = 5.0 MTG/d</td> </tr> </table>	5/17/2010	(0.69)*(1.0) = 0.69 MTG/d	2/1/2011	(0.69)*(4.348) = 3.0 MTG/d	1/1/2012	(0.69)*(5.797) = 4.0 MTG/d	1/1/2013	(0.69)*(7.246) = 5.0 MTG/d
5/17/2010	(0.69)*(1.0) = 0.69 MTG/d							
2/1/2011	(0.69)*(4.348) = 3.0 MTG/d							
1/1/2012	(0.69)*(5.797) = 4.0 MTG/d							
1/1/2013	(0.69)*(7.246) = 5.0 MTG/d							
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____								

HTWOS Model Modification Form

Modification Title: HLW WTP Process Model – Oxidative Leach
Description of Modification: Modify the oxidative leach calculation code.
Method Used to Check Modification: Verify that the corrected oxidative leach calculations code is incorporated in model. The procedure is named vector-components-to-oxides-new.
Result of Checking Modification: Procedure vector-components-to-oxides-new is incorporated in the model.
Modeler Name: _____ S.L. Orcutt _____
Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: HLW WTP Process Model – Phosphate and Sulfate Wash and Leach Factors
Description of Modification: Use new phosphate and sulfate water wash and caustic leach factors from RPP-25903
Method Used to Check Modification: Before the model has started launch write-wash-and-leach-factors. This will create a new output named wash-and-leach-used.csv. Verify data in wash-and-leach-used.csv matches that found in RPP-25903.
Result of Checking Modification: Verified HTWOS output matches that found in RPP-25903. Check is found in the Study-6 results directory on samwise.
Modeler Name: _____ S.L. Orcutt _____
Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Remote and Contact-Handled Sludge Packaging
Description of Modification: The capacity of the packaging system is based on a flow of 4 gpm of waste slurry into the dryer.
Method Used to Check Modification: Verify the flow out of the SUP-TRU-FEED tanks on the Supplemental TRU sludge processing workspace is set to 4.0 gpm.
Result of Checking Modification: The flow out of the SUP-TRU-FEED tanks on the Supplemental TRU sludge processing workspace is set to 4.0 gpm.
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: STP Process Basis – Melter Reactions and Tritium Partitioning
Description of Modification: <ol style="list-style-type: none"> 1. Modify model so that ^{14}C, NH_3, NO_2, and NO_3 melter reactions are implemented. 2. Modify ^3H partitioning factor so that no ^3H remains in the glass.
Method Used to Check Modification: <ol style="list-style-type: none"> 1. Go to KB-WORKSPACE-XXX-584. Right click on the icon for the reactions of interest. Select Show Reaction. Confirm 100% reaction, reaction is balanced. 2. SHOW Enhance HTWOS WTP Flowsheet. Click on HTWOS Melter. Right click and Show/Edit Splits. Confirm that 100% of ^3H goes to the melter off-gas.
Result of Checking Modification: Confirmed melter reactions are implementation and ^3H is partitioned as 100% to the off-gas with none remaining in the glass.
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form**Modification Title:** Retrieval Sequence Basis – Case 14**Description of Modification:**

Modified SST Retrieval Sequence – Initial-tank-retrieval-list and Initial-tank-retrieval-list-alternative.

Method Used to Check Modification:

On the Balance of Mission Retrieval Assumptions workspace, verify the SST retrieval sequence matches that found in Table A-11 of this document.

Result of Checking Modification:

Case 14 retrieval sequence matches that found in Table A-11 of this document.

Case 14 and Case 15 Sequence			Case 13 Sequence		
	Solid Sort	Na Sort		CAT1	CAT1-ALT
1	B-105	TX-113	1	C-102	C-102
2	SX-104	TX-116	2	C-103	C-103
3	BY-101	SX-103	3	C-105	C-105
4	S-107	S-106	4	AX-102	AX-102
5	S-104	BY-106	5	AX-104	AX-104
6	BY-112	BY-101	6	TY-101	TY-101
7	TX-113	S-108	7	TY-102	TY-102
8	SX-111	SX-101	8	TY-103	TY-103
9	C-107	SX-104	9	TY-104	TY-104
10	SX-107	U-108	10	TY-105	TY-105
11	C-104	AX-101	11	TY-106	TY-106
12	T-107	S-110	12	AX-103	AX-103
13	BX-112	U-103	13	AX-101	AX-101
14	BY-109	BY-104	14	SX-101	SX-101
15	T-111	BY-110	15	SX-106	SX-106
16	S-110	U-109	16	U-101	C-101
17	S-112	SX-105	17	U-102	C-108
18	B-107	SX-106	18	U-103	C-109
19	TX-118	TX-106	19	U-104	C-110
20	BY-111	U-105	20	U-105	C-111
21	SX-110	SX-102	21	U-106	C-112
22	BX-107	A-101	22	U-107	A-101
23	BY-105	S-102	23	U-108	A-102
24	B-108	A-103	24	U-109	A-103
25	U-108	BY-107	25	U-110	A-104
26	C-102	S-111	26	U-111	A-105
27	TX-112	U-102	27	U-112	A-106
28	S-111	S-103	28	BY-101	TX-101
29	TY-101	S-101	29	BY-102	TX-102
30	B-104	BX-110	30	BY-103	TX-103
31	SX-114	U-111	31	BY-104	TX-104
32	TX-105	SX-109	32	BY-105	TX-105

Case 14 and Case 15 Sequence			Case 13 Sequence		
	Solid Sort	Na Sort		CAT1	CAT1-ALT
33	U-110	S-109	33	BY-106	TX-106
34	C-109	TX-112	34	BY-107	TX-107
35	U-103	B-104	35	BY-108	TX-108
36	TX-115	S-107	36	BY-109	TX-109
37	TX-117	TX-105	37	BY-110	TX-110
38	TX-114	TX-109	38	BY-111	TX-111
39	T-110	S-105	39	BY-112	TX-112
40	TY-103	TX-115	40	S-104	TX-113
41	TX-109	BY-105	41	TX-101	S-109
42	SX-109	TX-102	42	TX-102	TX-114
43	TX-110	TX-114	43	TX-103	TX-115
44	T-104	U-106	44	TX-104	TX-116
45	BY-103	TX-117	45	TX-105	TX-117
46	C-112	BY-103	46	TX-106	TX-118
47	TY-105	TX-110	47	TX-107	SX-102
48	A-104	B-109	48	TX-108	SX-103
49	S-108	BX-107	49	TX-109	SX-104
50	AX-101	TY-105	50	TX-110	B-105
51	B-111	BY-111	51	TX-111	SX-105
52	B-110	TX-111	52	TX-112	SX-107
53	C-111	BY-102	53	TX-113	SX-108
54	S-101	S-104	54	S-101	SX-109
55	TX-116	B-110	55	TX-114	BX-107
56	BX-104	BX-109	56	TX-115	SX-110
57	TX-111	C-104	57	TX-116	SX-111
58	B-103	BY-112	58	TX-117	SX-112
59	BY-102	U-107	59	TX-118	SX-113
60	BY-110	AX-103	60	BX-101	SX-114
61	BY-107	B-105	61	BX-102	SX-115
62	BY-104	SX-114	62	BX-103	U-101
63	BX-111	TY-103	63	BX-104	U-102
64	U-105	B-111	64	BX-105	U-103
65	BX-109	BY-109	65	BX-106	U-104
66	B-106	SX-111	66	BX-107	U-105
67	SX-103	B-107	67	SX-109	U-106
68	T-105	TX-118	68	BX-108	U-107
69	U-102	C-102	69	BX-109	U-108
70	C-103	SX-108	70	BX-110	U-109
71	B-101	T-107	71	BX-111	U-110
72	U-109	T-110	72	BX-112	U-111
73	BX-110	T-104	73	C-101	U-112
74	A-105	BX-105	74	C-108	B-101
75	SX-112	A-106	75	C-109	B-102
76	BX-105	BY-108	76	C-110	B-103
77	A-106	BX-111	77	C-111	B-104

Case 14 and Case 15 Sequence			Case 13 Sequence		
	Solid Sort	Na Sort		CAT1	CAT1-ALT
78	C-110	B-106	78	C-112	B-106
79	BY-108	T-111	79	S-103	B-107
80	SX-105	C-110	80	S-105	B-108
81	TX-106	T-101	81	S-106	B-109
82	C-105	BX-112	82	S-107	B-110
83	B-109	TX-101	83	S-108	B-111
84	TX-102	TY-101	84	S-109	B-112
85	TX-101	U-110	85	S-110	BX-101
86	SX-108	S-112	86	S-111	BX-102
87	AX-104	A-105	87	SX-102	BX-103
88	A-103	SX-112	88	SX-103	BX-104
89	C-108	U-104	89	SX-104	BX-105
90	B-102	BX-101	90	B-105	BX-106
91	SX-102	TX-103	91	SX-105	BX-108
92	BY-106	SX-110	92	SX-107	BX-109
93	B-201	C-101	93	SX-108	BX-110
94	C-101	TX-108	94	SX-110	BX-111
95	T-201	C-112	95	SX-111	BX-112
96	SX-101	B-101	96	SX-112	S-103
97	TY-104	TX-107	97	SX-113	S-105
98	S-106	SX-107	98	SX-114	S-106
99	B-204	T-105	99	SX-115	S-101
100	BX-102	BX-106	100	A-101	S-104
101	T-112	B-108	101	A-102	BY-112
102	TX-103	BX-104	102	A-103	S-107
103	B-203	A-102	103	A-104	S-108
104	S-109	C-109	104	A-105	S-110
105	TX-108	B-102	105	A-106	S-111
106	SX-106	B-112	106	T-101	T-101
107	U-104	BX-108	107	T-102	T-102
108	T-204	TY-102	108	T-103	T-103
109	BX-101	TX-104	109	T-104	T-104
110	U-107	TY-104	110	T-105	T-105
111	T-101	AX-102	111	T-106	T-106
112	TX-104	C-107	112	T-107	T-107
113	U-111	U-112	113	T-108	T-108
114	AX-102	C-108	114	T-109	T-109
115	T-203	C-105	115	T-112	T-112
116	SX-113	T-112	116	B-101	BY-101
117	AX-103	T-109	117	B-102	BY-102
118	B-202	B-103	118	B-103	BY-103
119	BX-108	U-101	119	B-104	BY-104
120	A-101	C-111	120	B-106	BY-105
121	SX-115	A-104	121	B-107	BY-106
122	BX-103	BX-102	122	B-108	BY-107

Case 14 and Case 15 Sequence			Case 13 Sequence		
	Solid Sort	Na Sort		CAT1	CAT1-ALT
123	A-102	BX-103	123	B-109	BY-108
124	S-105	T-106	124	B-110	BY-109
125	S-102	T-108	125	B-111	BY-110
126	S-103	T-102	126	B-112	BY-111
127	B-112	TY-106			
128	U-112	B-204			
129	U-106	B-202			
130	U-101	T-103			
131	T-108	T-203			
132	T-202	T-204			
133	TY-102	B-201			
134	T-106	T-201			
135	TY-106	C-103			
136	BX-106	T-202			
137	T-103	B-203			
138	T-109	AX-104			
139	T-102	U-203			
140	TX-107	U-201			
141	C-204	C-106			
142	C-106	U-202			
143	C-201	SX-113			
144	C-203	SX-115			
145	C-202	C-203			
146	U-203	C-204			
147	U-201	C-201			
148	U-202	U-204			
149	U-204	C-202			

Modeler Name: _____ **S.L. Orcutt**
Verifier Name: _____ **J. A. Lechelt**

HTWOS Model Modification Form

Modification Title: Retrieval Sequence Basis – Case 15
Description of Modification: Added blend pairs to Case 14 SST retrieval sequence basis, and removed any blend pairings from the near-term retrievals.
Method Used to Check Modification: On the Balance of Mission workspace, make sure that Run Blend Pair has been selected. Verify that AY-101 is the east-blend-pair-receiver and that SY-101 is the west-blend-pair-receiver. Verify that the retrievals to each of these tanks do isolate the solids portion of each blend-pair in the transfer file.
Result of Checking Modification: The button for Run blend pair algorithm was selected. Tank AY-101 is designated the East Blend Pair Receiver and tank SY-101 is designated the West Blend Pair Receiver. A spot check of the transfer file revealed that the solids of each blend pair were isolated.
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Waste Retrieval Facility (WRF) Availability Dates
Description of Modification: If an SST is on the blend-pair1 or the blend-pair2 list, retrieve it directly to the area blend-pair-receiver and do not go through WRFs.
Method Used to Check Modification: Verify that the retrievals go directly to the area blend-pair receiver in the transfer file.
Result of Checking Modification: East Area blend pair tanks retrieved directly to AY-101 and West Area blend tanks retrieved directly to SY-101.
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Simultaneous Retrieval
Description of Modification: Same constraint of 7 maximum simultaneous retrievals. However, the SST retrievals to supplemental treatment must be included in the total maximum, which shall not exceed the 7 simultaneous retrievals.
Method Used to Check Modification: Click on any SST and “show retrieval machine utilization”. This will generate a plot of retrieval machines with time. Verify that this number does not exceed 7.
Result of Checking Modification: No more than 7 simultaneous retrievals occur in the runs.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: SST Waste Residuals
Description of Modification: The residual SST volumes for 200 series tanks = 30 ft ³ and for 100 series tanks = 360 ft ³ . Exceptions for near-term retrievals were due to projected retrieval volumes and endpoints from the C-Farm retrieval flowsheet work. Any exceptions had smaller residual volumes than that stated for the respective SST types.
Method Used to Check Modification: Click on any SST not in C-Farm and verify that the residual volume is 360 ft ³ (approximately 2693 gal).
Result of Checking Modification: SST residual volume is approximately 2693 gal.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Date that BBI quarterly update was issued
Description of Modification: Used FY 2005 inventory.
Method Used to Check Modification: Go to the "SST-inventory-file-name" and the "DST-inventory-file-name" and make sure that the table shows the file name as the FY 2005 inventory (shown as *05.csv). A table on this item will show the last inventory read into the model.
Result of Checking Modification: Verified the last inventory read into HTWOS is the FY 2005 inventory.
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Maximum DST Levels
Description of Modification: Corrected Maximum DST fill levels for AP Farm to correctly reflect assumptions.
Method Used to Check Modification: In the procedure named "change-dst-fill-limits", verify the following: call wait-until-this-date ("11/1/2004"); conclude that the maximum-volume of ap-101 = 1.235e6; conclude that the maximum-volume of ap-102 = 1.235e6; conclude that the maximum-volume of ap-103 = 1.235e6; conclude that the maximum-volume of ap-104 = 1.235e6; conclude that the maximum-volume of ap-105 = 1.235e6; conclude that the maximum-volume of ap-106 = 1.235e6; conclude that the maximum-volume of ap-107 = 1.235e6; conclude that the maximum-volume of ap-108 = 1.235e6;
Result of Checking Modification: The maximum DST fill volumes listed above have been verified.
Modeler Name: _____ S.L. Orcutt Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: DST Usage
Description of Modification: SY-101 will become the West Area blend-pair receiver after it is emptied of its current waste. AY-101 will become the East Area blend-pair receiver after the initial HLW feed is delivered to the WTP.
Method Used to Check Modification: On the Balance of Mission logic block, verify that SY-101 is assigned to west-blend-pair-receiver and that AY-101 is assigned to east-blend-pair-receiver for Phase-2.
Result of Checking Modification: SY-101 is assigned to west-blend-pair-receiver and AY-101 is assigned to east-blend-pair-receiver. Further, implemented blend pairs were confirmed to retrieve directly to them.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Waste Segregation or Blending
The supernate in AY-102 will be removed and replaced with supernate from AP-101, without concentration. It is assumed that the ORP will accept the TFC recommendation to consolidate the supernate in AP-101 with the solids in AY-102. No other waste, other than process condensate, will be mixed with the hot commissioning feed staged in AY-102.
Method Used to Check Modification: Verify that AP-101 is added to AY-102 without evaporating AP-101 in the transfer file.
Result of Checking Modification: Supernate is transferred from AP-101 to AY-102 and the AP-101 supernate is not evaporated prior to consolidation.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Blending – Case 15
Description of Modification: Pairwise blending of SSTs modeled.
Method Used to Check Modification: <ol style="list-style-type: none"> 1. Verify blend pair lists are loaded into the model. 2. Verify that the blends were implemented using the transfer file and traceback matrix. 3. Verify flow in Figure 2 of RPP-RPT-26040 was implemented for the stated blendpairs.
Result of Checking Modification: <ol style="list-style-type: none"> 1. Blend pair lists were confirmed to be loaded into the model. 2. Blend pairs were implemented for the majority of planned blends. <i>Four blend pairs were not implemented. These are B-104/BY-101, A-103/AX-104, B-102/BY-104, and B-106/BX-102.</i> 3. The flow in Figure 2 was implemented for the stated blend pair tanks except those noted above. See also Table 5 of the RPP-RPT-26040.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: DST Waste Residuals
Description of Modification: DST waste residuals are 100 gallons.
Method Used to Check Modification: Click on any DST to verify that the tanks have been cleaned out with only 100 gallons remaining.
Result of Checking Modification: DST residual volumes are 100 gallons, <i>with the exception tank SY-102. DST SY-102 contained approximately 24,352 gallons of waste at the end of the mission – 2,573 gallons of solids with the remainder liquids. The rough size of the impact can be estimated using the median glass factor of 1.6 and solids density of 3.0 Kg/L, yielding about 80 MTG.</i>
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Compliance Verification Sampling
Description of Modification: Staged feed must remain in a DST for 210 days after filling the tank before delivering to the WTP to provide time to complete feed specification compliance sampling and analysis.
Method Used to Check Modification: In the procedure settle time of staging tank, verify the wait time of 210 days. Refer also to SVF-1082 Rev 0, "HLW Dwell-Time Plots for Blending Study Rev 0.xls."
Result of Checking Modification: HLW feed remains in staging tank for a minimum of 210 days.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

HTWOS Model Modification Form

Modification Title: Waste Chemistry and Mass Balances
Description of Modification: 1. Use new wash and leach factors from RPP-25903. 2. Correct charge balance code.
Method Used to Check Modification: 1. Previously confirmed new wash and leach factors were incorporated in the model. See Model Modification Form titled HLW WTP Process Model – Phosphate and Sulfate Wash and Leach Factors. 2. HTWOS procedure "water-dissolve-solids" was modified by adding charge balance function to the logic path.
Result of Checking Modification: New wash and leach factors were incorporated in the model and corrected charge balance code was used.
Modeler Name: _____ S.L. Orcutt _____ Verifier Name: _____ J. A. Lechelt _____

C4.0 SPREADSHEETS

This section contains the list of spreadsheets discussed in Section 6.3, Spreadsheets and in D5.0, USE OF COMPUTER SOFTWARE.

Table C-3. List of Spreadsheets. (3 Sheets)

File Name	Spreadsheet Verification Form Number	Purpose / Comments
Check charge balance.xls	N/A	Exempt from verification
HLW_Glass_Output (Case-10-FIX)_v_1.xls	SVF-1072 r 1	Glass output report for Case 10, No-Blend/Total-Blend subcases.
HLW_Glass_Output (Case-13-FIX)_v_1.xls	SVF-1073 r 1	Glass output report for Case 13, No-Blend/Total-Blend subcases.
Case-13-FIX-output-glass Drivers Rev 1.xls	SVF-1074 r 1	Identifies and tallies drivers for HLW glass mass, Case 13, No-Blend Subcase.
HLW_Glass_Output_(Case 13 2005-10-24)_v_1.xls	SVF-1088 r 0	Glass output report for Case 13, Realized Blend subcase. Specific instance of multi-use spreadsheet: HLW_Glass_Output (MASTER) Rev 0.xls under SVF-1031 r 0.
HLW_Glass_Output_(Case 14 2005-10-24)_v_1.xls	SVF-1089 r 0	Glass output report for Case 14, Realized Blend subcase. Specific instance of multi-use spreadsheet: HLW_Glass_Output (MASTER) Rev 0.xls under SVF-1031 r 0.
HLW_Glass_Output_(Case 15 2005-10-27)_v_1.xls	SVF-1090 r 0	Glass output report for Case 15, Realized Blend subcase. Specific instance of multi-use spreadsheet: HLW_Glass_Output (MASTER) Rev 0.xls under SVF-1031 r 0.
HLW_Glass_Output_(Case 13 2005-10-24 Drivers)_v_1.xls	SVF-1091 r 0	Identifies and tallies drivers for HLW glass mass, Case 13, Realized Blend subcase.
HLW_Glass_Output_(Case 14 2005-10-24 Drivers)_v_1.xls	SVF-1092 r 0	Identifies and tallies drivers for HLW glass mass, Case 14, Realized Blend subcase.
HLW_Glass_Output_(Case 15 2005-10-27 Drivers)_v_1.xls	SVF-1093 r 0	Identifies and tallies drivers for HLW glass mass, Case 15, Realized Blend subcase.
Glass Factor Plots for Blending Study v 1.xls	SVF-1094 r 0	Compares glass factor distribution plots for Cases 13, 14 and 15.
HLW Glass Plots for Blending Study v 1.xls	SVF-1095 r 0	Compares HLW glass production plots for Cases 13, 14 and 15, Realized Blend Subcases, with that from the theoretical ramp-up.

Table C-3. List of Spreadsheets. (3 Sheets)

File Name	Spreadsheet Verification Form Number	Purpose / Comments
HLW Dwell-Time Plots for Blending Study Rev 0.xls	SVF-1082 r 0	Compares HLW dwell time distribution plots for Cases 13, 14 and 15.
Relaxed SST Sequence Input (2005-08-11) v 1.xls	SVF-1100 r 0	Used to create the relaxed SST retrieval sequence lists (sodium sort and solid sort) used in the assumptions for Cases 14 and 15, Realized Blends.
Summary_Glass_Mass_Results_for_Blending_Study_v_1.xls	SVF-1103 r 0	Plots the Total Blend – Realized Blend – No Blend glass masses for Cases 8 – 15. Also, shows same information in tabular format.
Blend Sensitivity Plots FLX (2005-11-16).xls	SVF-1099 r 0	This spreadsheet aggregates the results from the use of the three blend pair calculator spreadsheets and presents the results as a family of curves.
Blend Pair Calculator – Full – v 1 (26040).xls	SVF-1096 r 0	Blend pair calculator loaded with glass reduction matrix for Pairwise blending study. Specific instance of multi-use spreadsheet: Blend Pair Calculator – Full – Rev 0 (MASTER).xls
Blend Pair Calculator – East – v 1 (26040).xls	SVF-1097 r 0	Blend pair calculator loaded with glass reduction matrix for Pairwise blending study. Specific instance of multi-use spreadsheet: Blend Pair Calculator – East – Rev 0 (MASTER).xls
Blend Pair Calculator – West – v 1 (26040).xls	SVF-1098 r 0	Blend pair calculator loaded with glass reduction matrix for Pairwise blending study. Specific instance of multi-use spreadsheet: Blend Pair Calculator – West – Rev 0 (MASTER).xls
Traceback Matrix – v 1 (BS-Case 13).xls	SVF-1085 r 0	Interprets and displays traceback matrices from Case 13, Realized Blend Subcase. Specific instance of multi-use spreadsheet: Traceback Matrix - Rev 0 (MASTER).xls under SVF-1051 r 0.
Traceback Matrix – v 1 (BS-Case 14).xls	SVF-1086 r 0	Interprets and displays traceback matrices from Case 14, Realized Blend Subcase. Specific instance of multi-use spreadsheet: Traceback Matrix – Rev 0 (MASTER).xls under SVF-1051 r 0.

Table C-3. List of Spreadsheets. (3 Sheets)

File Name	Spreadsheet Verification Form Number	Purpose / Comments
Traceback Matrix – v 1 (BS-Case 15).xls	SVF-1087 r 0	Interprets and displays traceback matrices from Case 15, Realized Blend Subcase. Specific instance of multi-use spreadsheet: Traceback Matrix - Rev 0 (MASTER).xls under SVF-1051 r 0.
WTP_Feed_Variability_Rev_0.xls	SVF-1083 r 0	Plots the distribution of selected constituents in the WTP feed, on an equivalent oxide basis.

C5.0 REFERENCES

RPP-15522, 2003, *Hanford Tank Waste Oxidative Leach Behavior Analysis*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20003, 2005, *Sensitivity of Hanford Immobilized High-Level Waste Glass Mass to Chromium and Aluminum Partitioning Assumptions*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-25903, 2005, *Review of Phosphate and Sulfate Wash and Leach Factors*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ENG-CHEM-D-39, “HTWOS Model Assumption Validation,” CH2M HILL Hanford Group, Inc., Richland, Washington.

APPENDIX D

REFERENCE CASE EVALUATION

D1.0 REFERENCE CASE EVALUATION

The primary purpose of this evaluation is to establish the reference case that will be used to evaluate the mission impacts of the proposed blending scenarios. A secondary purpose is to understand how the newly update inventory and the new SO₄ and PO₄ wash and leach factors change the range of HLW glass that may be produced separately from the potential improvements due to blending.

D2.0 INPUT DATA

The input data used in this evaluation comprises:

D2.1 WASTE INVENTORY

The starting tank waste inventory is provided in RPP-25191, *Double-Shell and Single-Shell Inventory Input to the HTWOS⁸⁴ Model – 2005 Update*. This represents the composition of the waste in the Hanford DSTs and SSTs as of October 1, 2004 and was downloaded from the Tank Waste Information network System (TWINS) on January 27, 2005. This is called the “2005” Inventory.

An older starting inventory, to be used for sensitivity purposes, is provided in RPP-22760, *Double- and Single-Shell Tank Inventory to the HTWOS Model -2004a Update*. This represents the composition of the waste in the Hanford DSTs and SSTs as of April 2004 and was downloaded from TWINS on August 10, 2004. This is called the “2004a” Inventory.

D2.2 WATER WASH AND CAUSTIC LEACH

The baseline set of water wash and caustic leach (differential) factors downloaded from TWINS on August 24, 2004 will be used for partitioning waste into solid and liquid phases during retrieval, staging, and pretreatment; the partitioning of strontium will be modeled per RPP-21807, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*.

Certain cases (discussed in D4.0) will use the new water wash and caustic leach factors for SO₄ and PO₄ as provided in RPP-25903, *Review of Phosphate and Sulfate Wash and Leach Factors*.

⁸⁴ HTWOS = Hanford Tank Waste Operations Simulator.

D3.0 KEY ASSUMPTIONS

The key assumptions used in this study are presented in this chapter. More detailed assumptions are provided in Appendix A.

D3.1 TRU PACKAGING

Twenty Tanks (17 SSTs and 3 DSTs) are designated for TRU packaging (11 as CH-TRU and 9 as RH-TRU) and are therefore not candidates for blending). None are incorporated into HLW waste glass for purposes of this study.

D3.2 WTP PRETREATMENT ASSUMPTIONS

All waste delivered to the WTP will undergo water washing, caustic leaching, and oxidative leaching using Development Run assumptions, except:

- The Total-Blend / No-Blend calculations for this evaluation will make simplifying assumptions of (1) perfect solid-liquid separation, and (2) that the entire contents of each tank will be treated.
- This evaluation will use various combinations of the existing wash and leach factors in TWINS along with the new SO_4 and PO_4 factors as defined in Table D-1.

D3.3 HLW GLASS ASSUMPTIONS

The Relaxed Glass Properties Model (Relaxed GPM) will be used for all analysis – this is the same as the Relaxed GPM documented in RPP-20003 Rev. 1, *Sensitivity of Hanford Immobilized High-Level Waste Glass Mass to Chromium and Aluminum Partitioning Assumptions*, and used in the Development Run.

D4.0 METHOD OF ANALYSIS

A parametric analysis of HLW glass mass was performed. The HLW glass masses for a variety of blending Subcases (“Total Blend,” “No Blend,” and “Realized Blend”) were calculated for various Cases (combinations of other factors). The factors and their associated levels for each Case and the blending Subcases are detailed in Table D-1. The shaded cells indicate the factors and levels for each Case and the selected blending Subcases.

The methodology described herein is the same as that documented in RPP-20003, Rev. 1. The case numbering begins where the numbering used in RPP-20003 finished facilitating future comparison.

Case 8 corresponds to the Development Run; Case 13 will be used as the reference case in this study for evaluating the performance of the proposed blending strategies. The other cases are used to help understand the response of the HLW glass masses to changes in the other factors, namely waste inventory and wash and leach factors.

The approach used in this portion of the analysis was to calculate and compare the mass of HLW glass that would be produced for the various cases, varying the factors as shown in Table D-1. For example, a comparison of the mass of HLW glass produced by Case 10 with Case 13 will show the impact of using the revised wash and leach factors while a comparison of Case 8 with Case 13 will show the overall impact of using the revised wash and leach factors, the 2005 BBI Inventory download, and correction of the legacy coding issues.

One of the major drivers for HLW glass mass is the degree of blending that occurs before vitrification of the waste. Therefore, a series of blending subcases were used to account for blending and to facilitate the comparisons. These subcases were the Total Blend, No Blend, and Realized Blend. The following is a detailed description of how these methods were employed.

For the Total Blend, the wastes from all the tanks were blended together to create a single large uniform batch of feed. This feed was processed according to the specific case assumptions, and the corresponding amount of HLW glass was determined for each case.

For the No Blend, the waste from each tank was kept segregated in separate batches. Each of these individual tank batches was processed separately according to the specific case assumptions, and the corresponding amount of HLW glass was determined for each tank for each case. The total amount of HLW glass produced for a given case was determined by summing the HLW glass produced from each of the tanks.

The Total Blend and No Blend glass masses are hypothetical because neither subcase can be realistically achieved. For glass models that only include single component solubility limits and model domain limits, the Total Blend represents the minimum glass that can be produced and the No Blend represents the maximum glass. The introduction of non-linear glass properties as used by the current glass properties model confounds this interpretation in that the Total Blend and No Blend do not necessarily provide the absolute mathematical minimum or maximum glass masses. In any case, for most intents and purposes, the Total Blend and No Blend glass masses can be considered as representing the minimum and maximum glass masses for a given case.

For the Realized Blend, the HTWOS model was used to simulate the delivery of HLW feed to the WTP using the baseline retrieval sequence logic, and waste feed staging and delivery strategy. The HTWOS model accounts for the blending that occurs during the retrieval, staging, and delivery of each feed batch to the WTP (most of this blending is incidental to those activities, hence the term Incidental Blending). Each of these individual feed batches was processed through the WTP according to the specific case assumptions, and the corresponding

amount of HLW glass was determined for each batch for each case. The total amount of HLW glass produced for a given case was determined by summing the HLW glass produced from each of the feed batches.

The glass output report for the Case 13 – No Blend subcase was reviewed to identify the specific constraints and analytes that may be driving the HLW glass mass. Patterns in the distribution of these analytes among the different tanks may suggest alternative approaches towards blending or segregation and suggest which water wash and caustic leach factors should be reevaluated in future work. The 157 waste tanks were divided into different groups depending on the constraints that limit the waste loading of each batch.

Table D-1. Study Matrix for Parametric Analysis.

Case	Factors and Levels						Evaluated Subcases		
	SO ₄ W&L ¹		PO ₄ W&L ¹		Inventory ²		Blending		
	Baseline	New	Baseline	New	2004a	2005	Total	No	Realized ³
8	•	—	•	—	•	—	•	•	•
9 ⁴	•	—	•	—	•	—	•	•	—
10	•	—	•	—	—	•	•	•	—
11	—	•	•	—	—	•	•	•	—
12	•	—	—	•	—	•	•	•	—
13 - REF	—	•	—	•	—	•	•	•	•

Notes:

¹For sulfate and phosphate, the “Baseline” wash and leach factors refer to those used in the Development Run, while “New” refers to those proposed by RPP-25903 (which have recently been incorporated into the set of official wash and leach factors maintained in TWINS).

²The 2004a inventory refers to the inventory used in the Development Run as documented in RPP-22760, Rev. 0, with an effective date of April 2004. The 2005 inventory refers to the updated inventory documented in RPP-25191, Rev. 0, with an effective date of October 2004.

³An entry in this column indicates that the HTWOS model was used to evaluate the incidental blending associated with a full mission scenario.

⁴Case 9 uses the same assumptions as Case 8, except that two legacy coding issues have been corrected: The oxidative leach endpoint is properly implemented and proper charge balance is maintained during water washing. All subsequent cases use the corrected code.

W&L = Wash and Leach

D5.0 USE OF COMPUTER SOFTWARE

The Wash and Leach Factor sensitivity study uses the same HTWOS code developed for RPP-20003, Rev. 1, Appendix D, Section D5.0, "Use of Computer Software," updated to use the new 2005 inventory and old/new sets of SO_4 and PO_4 wash and leach factors.

The specific modules changed for this study are listed in Table C-1. Modules Changed for Reference Case and Pairwise Blending Evaluations, located in Section C2.0, "Computer Software" of Appendix C.

Verification of proper input data and assumptions is documented by the HTWOS model modification forms in Section C3.1, "Reference Case And Pairwise Blending Evaluations," located in Appendix C.

Many spreadsheets were used to manipulate and prepare data for input to the various models or for display in this report. These spreadsheets (and their verification number, if applicable) are listed in Section C4.0 of Appendix C.

D6.0 RESULTS

D6.1 MASS OF HLW GLASS

Figure D-1 presents the results of the parametric analysis for the Reference Case Evaluation graphically; Table D-2 presents the same information numerically. The mass of HLW glass is shown for the Total Blend and No Blend subcases for each case defined in Table, Study Matrix for Parametric Analysis.. The three white dotted lines are guides to help the reader visualize changes from Case 8 (same as Revision 0A of the Development Run).

Case 9 corrects two legacy coding issues in the HTWOS model, namely the oxidative leach endpoint approximation was made exact, and an error in the charge balance routine during application of the water wash factors was corrected. Relative to Case 8, the Total-Blend increased by less than one percent and the No-Blend decreased by less than one percent. This is a negligible change considering all of the other sources of uncertainty in our estimates.

Case 10 switches from the 2004a BBI download to the more recent 2005 inventory download. Relative to Case 8, the updated inventory increased the mass of HLW glass by about five percent: the Total Blend increased by about six percent, and the No Blend by about four percent.

Case 11 shows the impacts of switching to the new SO_4 wash and leach factors. Compared with Case 10, the Total Blend has decreased by about one fifth of one percent while the No Blend has decreased by about four percent.

Case 12 shows the impacts of switching to the new PO_4 wash and leach factors. Compared with Case 10, the Total Blend has increased by about one percent while the No Blend has increased by about two percent.

Case 13 shows the combined impacts of switch to the new SO_4 and PO_4 wash and leach factors. Compared with Case 10, the Total Blend has increased by about one percent while the No Blend has decreased by about two percent.

Comparison of Case 13 with Case 8 shows that the overall impact of switching to the newer inventory, SO_4 and PO_4 wash and leach factors, and correcting the legacy coding issues is to increase the Total Blend by about seven percent and the No Blend by about two percent.

The mass of HLW glass resulting from a complete rerun of the Development Run using the Case 13 assumptions is also shown as the “Realized Blend,” which in this case, simply reflects the degree of incidental blending (this is discussed in more detail in Section 7.2, “Mission Scenario Evaluation”). Compared to Case 8, the Realized Blend has also increased by about seven percent.

Figure D-1. HLW Glass Mass Ranges for Parametric Analysis.

Table D-2. HLW Glass Mass Ranges for Parametric Analysis.

	Case 8 (BL)	Case 9	Case 10	Case 11	Case 12	Case 13 (Ref)
Total Blend	25,401	25,611	26,841	26,791	27,129	27,080
Realized Blend	34,775	-	-	-	-	35,443
No Blend	42,233	42,105	43,833	42,197	44,767	43,111
Percent of Span	55.7	—	—	—	—	52.2

Notes: BL = baseline

Ref = Reference

Units: All glass is in MT. Percent of Span is in percent.

D6.2 DRIVERS FOR HLW GLASS MASS – CASE 13 – NO BLEND

The drivers for the No Blend subcase provides a starting point for understanding which properties and constraints are driving the mass of the glass and thus influence blending decisions. As previously stated, the reported glass masses assume that all solids are fully pretreated (under gone water washing, caustic leaching and oxidative leaching) and use the relaxed glass properties model.

The 151 waste tanks⁸⁵ involved in Case 13 – No Blend were divided into different groups depending on the constraints that limit the waste loading of the glass from each tank. Table D-3 summarizes the number of waste tanks, waste oxide mass, glass mass, and waste loading for each group of waste batches that are limited by the same constraint. More details are provided in Table E-2, Appendix E and the spatial distribution of No-Blend glass mass and limiting constraints is given in Figure F-1 and Figure F-2 of Appendix F. Table D-3 also includes the results from the Case 13, Total Blend subcase, for comparison.

Among glass composition constraints, the SO₃ and P₂O₅ constraints were the main drivers that limited waste loading based on the largest number (41+16 = 57 out of a total of 151) of waste tanks, largest mass of glass (11,701+3,779 = 15,480 MT out of a total of 43,077 MT), and the low weighted average waste loading of 0.180 and 0.188, respectively. This very low average waste loading in these glasses implies that any relaxation of the SO₃ or P₂O₅ constraints (i.e., increase in their incorporation into the glass) has a very high potential for waste loading increase. Likewise, changes in the partitioning assumptions for sulfate and phosphate would also affect the HLW glass mass.

The next significant composition constraints that have impact on waste loading were the model validity constraints for Al₂O₃ and Fe₂O₃. The average waste loadings in these glasses are moderate (e.g., compared to the spinel liquidus temperature [T_L] involved glass property constraint), which suggests that the reduction of glass mass expected from expanded model

⁸⁵ 177 tanks – 20 TRU containing tanks – 6 tanks that contain no insoluble solids.

validity (i.e., relaxed Al_2O_3 and Fe_2O_3 constraints) will be less significant compared to SO_3 and P_2O_5 limited wastes.

Among the 51 tanks that are limited by property constraints for Case 13 (No Blend), 45 tanks involved the spinel T_L constraint which was the major limiting property in Hanford Site waste in a previous study (PNNL-13582, *High-Level Waste Melter Study Report*). It was shown in PNNL-13582 that the increase of waste loading by relieving or removing the constraints other than T_L is smaller compared to the spinel T_L constraint. Based on this past study, it is expected that the spinel T_L constraint would be the most dominant driver for glass mass in the 45 batches with the T_L spinel constraint involved. There are six batches that are limited by the constraints other than spinel T_L and account for only a very small fraction of glass mass. As expected, the zircon T_L constraint was never met. This is because the high zirconium waste contained in tanks AW-103 and AW-105 are designated as remote-handled TRU tank waste and were excluded from this study. Since both the remote-handled and contract-handled TRU tank wastes are assumed to be treated and packaged for disposal at the Waste Isolation Pilot Plant (WIPP), the WTP does not receive a HLW feed that would be constrained by the zircon T_L property constraint. If a decision is made to treat these RH-TRU tanks along with the HLW, additional blending (perhaps a combination of pairwise and metered blending) would be required to limit the impact to HLW glass mass.

Table D-3. Summary of Case 13 (No-Blend Subcase) Glass Drivers.

Constraints ¹			Number of waste feed tanks	Waste oxide mass ² (MT)	Glass mass (MT)	Waste loading in glass ³
Glass composition constraints	Solubility limited	SO ₃	41	2,107.0	11,701.1	0.180
		P ₂ O ₅	16	710.2	3,779.1	0.188
		Cr ₂ O ₃	3	177.0	317.7	0.557
		Subtotal	60	2,994.1	15,798.0	0.190
	Model validity limited	Al ₂ O ₃	18	2,550.8	12,001.3	0.213
		Fe ₂ O ₃	13	846.8	3,134.6	0.270
		Na ₂ O	6	629.3	2,313.1	0.272
		SiO ₂	3	133.0	182.1	0.731
		Subtotal	40	4,160.0	17,631.1	0.236
	Glass composition constraints subtotal		100	7,154.1	33,429.1	0.214
Glass property constraints	Spinel T_L involved		45	3,156.1	8,747.0	0.361
	Spinel T_L NOT involved		6	339.1	935.3	0.363
	Glass property constraints subtotal		51	3,495.2	9,682.3	0.361
Case 13 No-Blend subcase total			151	10,649.2	43,111.4	0.247
Case 13 Total-Blend subcase total			--	10,641.1	27,079.5	0.393

Notes:

¹Shaded cells indicate the major constraints that drive HLW glass mass.²In this table, waste oxides refer to the fully pretreated waste, on an oxide basis.³Represents the weighted average waste loading in the glasses from tanks that are limited by the same (or same group of) constraints. Units are mass fraction.

The distribution of waste oxide⁸⁶ mass and glass mass for four major groups of wastes are plotted in Figure D-2. Figure D-2 shows that the solubility limited glass composition constraints and the model validity limited glass composition constraints are the main drivers for the glass mass and together account for 77.5% of total glass mass resulting from 67.2% of the pretreated waste. Especially, as shown in Table 4, the SO₃ and Al₂O₃ constraints are the two most dominant drivers for the glass mass accounting for 54.9% of the total glass mass resulting from 43.7% of the pretreated waste.

⁸⁶ In this discussion, waste oxides refer to the fully pretreated waste, on an oxide basis.

Figure D-2. Distribution of Waste Oxide Mass and Glass Mass for Each Group of Tanks in Case 13 (No Blend).

D7.0 CONCLUSIONS

The overall impact of recent refinements in assumptions and methodology (switching to the newer tank waste inventory, SO_4 and PO_4 wash and leach factors, and correcting legacy coding issues) is to increase the mass of HLW glass between two percent (No Blend) and about seven percent (Total Blend).

The primary single-component compositional drivers for the mass of HLW glass are SO_3 , Al_2O_3 , P_2O_5 , and Fe_2O_3 , listed in decreasing order of relative impact; the primary multi-component property driver is spinel liquidus temperature. This assumes that water washing and caustic leaching removes much of the aluminum, that oxidative leaching is effective in removing the chromium, that the components removed by leaching do not re-precipitate, and that the relaxed glass properties model is applied.

D8.0 REFERENCES

PNNL-13582, 2001, *High-Level Waste Melter Study Report*, Pacific Northwest National Laboratory, Richland, Washington.

RPP-20003, 2005, *Sensitivity of Hanford Immobilized High-Level Waste Glass Mass to Chromium and Aluminum Partitioning Assumptions*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21807, 2004, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22760, 2004, *Double- and Single-Shell Tank Inventory Input to the HTWOS Model - 2004a Update*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-25191, 2005, *Double- and Single-Shell Tank Inventory Input to the HTWOS Model – 2005 Update*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-25903, 2005, *Review Of Phosphate And Sulfate Wash And Leach Factors*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

APPENDIX E

GLASS OUTPUT REPORTS

This appendix contains the formatted glass output reports for two of the cases:

Table E-1. Case 10 Glass Output for the Total Blend and No Blend Subcases.

Table E-2. Case 13 Glass Output for the Total Blend and No Blend Subcases.

Table E-1. Case 10 Glass Output for the Total Blend and No Blend Subcases. (3 Sheets)

Upper Limit: Lower Limit:	1100	1050	1	10	100	2	2	2	2	2	0.57	0.2	0.2	0.4	0.17	0.15	0.1	0.08	0.15	0.1	0.01	1	0.03	0.005	0.0025	0.0025	1	1								
	850	-	0.62	4.5	10	-	-	-	-	-	0.38	0.05	0.05	0.01	0	0.02	0	0	0	0.01	0	0	0	0	0	0	0	0								
	Physical characteristics										Normalized Elemental Releases										Simple Limits (weight fraction in glass)															
HLW Glass Batch Number	Arrival Date	Glass (MT)	Frit (MT)	Feed Oxides (MT)	Waste oxide loading (x m ³ each)	number of canisters	Liquidus Temp. (Spin'd) (degrees C)	Liquidus Temp. (Zirc) (degrees C)	Wt. Fr. SiO ₂ (SiO ₂ +Na ₂ O+Al ₂ O ₃)	Glass Viscosity (Pa-s)	Elect. Cond. (ohm-m) ⁻¹	silicon (g/m ²)	boron (g/m ²)	lithium (g/m ²)	sodium (g/m ²)	SiO ₂	B ₂ O ₃	Na ₂ O	Li ₂ O	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	ZrO ₂	Others	Cr ₂ O ₃	F	P ₂ O ₅	SO ₃	Rh ₂ O ₃	Rb ₂ O ₃ + Rb ₂ O	Pu (g/L)				
A-101	none	985.5812	660.94578	0.62	9.976945	43.519762	0.170844	0.342849	0.03002	0.28275	0.03002	0.009676	0.590055	0.38	0.05	0.145369	0.04	0.137839	0.02	0.017452	0	0	0.127267	0.003559	0	0.001301	0.005	0	0.001301	0.0005	0	0.0025	0.0025	0.0025	0.314939	
A-102	none	1100	741.81909	0.65681329	6.113003	33.624368	0.270959	2.0009676	0.590055	0.38	0.05	0.14499	0.000893	0.38	0.05	0.14499	0.01	0.053562	0.111682	0.003632	0	0.002595	0.24354	0.004501	0	0.000893	0	0.000893	0	0.004501	0	0.002051	0.002051	0.002051	0.314939	
A-103	none	1100	834.35515	0.62	9.460555	15.614057	0.062015	0.551424	0.153533	0.555435	0.414133	0.555435	0.414133	0.05	0.05	0.108496	0.01	0.114835	0.02	0.024201	0.01475	0.002749	0.060344	0.005205	0.000159	0.000225	0.0005	0	0.000225	0.000225	0.000225	0.000159	0.000159	0.000159	0.000159	
A-104	none	1100	884.28376	0.632270032	5.378965	16.938849	0.055835	1.032857	1.009022	0.592876	0.38	0.05	0.108496	0.05	0.05	0.108496	0.01	0.114835	0.15	0.005403	0.001682	9.06E-05	0.032244	0.000292	0	0.000225	0	0.000225	0.000225	0.000225	0.000225	0.000225	0.000225	0.000225	0.000225	
A-105	none	1100	775.38965	0.7240349	9.738317	29.347926	0.52968	1.227796	0.451725	0.88598	0.517579	0.88598	0.517579	0.05	0.05	0.162606	0.017026	0.034669	0.15	0.012557	0	0.0073	0.048263	0.002151	0	0.001369	0	0	0.001369	0	0.001369	0	0.001369	0	0.001369	
A-106	none	1100	798.21286	0.62	4.5	38.862192	0.355212	1.023704	0.468417	0.875303	0.435617	0.875303	0.435617	0.05	0.05	0.191748	0.014704	0.066631	0.146571	0.027686	0.018455	0.00627	0.056369	0.007527	0	0.003583	0	0	0.003583	0	0.003583	0	0.003583	0	0.003583	
AX-101	none	850	783.45013	0.62814949	9.617069	18.411187	0.077619	1.169084	0.257492	0.823675	0.435617	0.823675	0.435617	0.05	0.05	0.123278	0.01	0.134598	0.02	0.00486	0.000756	0.000287	0.070604	0.001292	0	0.001896	0.005	0	0.001896	0.005	0	0.001896	0	0.001896	0	0.001896
AX-102	none	992.86402	741.58595	0.79325577	9.393102	30.018034	0.514314	0.977566	0.378801	0.826365	0.56322	0.826365	0.56322	0.05	0.05	0.116161	0.04	0.03063	0.15	0.005422	0.001727	0.000159	0.042682	0.001895	0	0.002418	0	0	0.002418	0	0.002418	0	0.002418	0	0.002418	
AX-103	none	1100	756.82307	0.717457	4.518575	38.595157	0.307105	1.386532	0.054043	0.666397	0.430531	0.666397	0.430531	0.05	0.05	0.121969	0.035277	0.04758	0.15	0.010901	0	0.004647	0.149096	0.005091	0	0.000936	0	0	0.000936	0	0.000936	0	0.000936	0	0.000936	
AX-104	none	1100	879.85915	0.62364045	4.635756	18.937197	0.062479	1.398614	1.491026	0.761082	0.38	0.05	0.105765	0.05	0.05	0.105765	0.01	0.110002	0.15	0.004223	0.000992	0.001976	0.023484	0.000138	0	0.000183	0	0	0.000183	0	0.000183	0	0.000183	0	0.000183	
B-101	none	967.52638	762.57494	0.81348905	7.047281	16.79912	0.163535	1.152997	0.256521	0.761288	0.530805	0.761288	0.530805	0.05	0.05	0.174472	0.032812	0.087077	0.039494	0.003017	0	0.002439	0.18615	0.0047	0.011033	0.000469	0	0.011033	0.000469	0.011033	0.000469	0.011033	0.000469	0.011033	0.000469	0.011033
B-102	none	1004.2531	783.11447	0.8438161	9.518001	15.807222	0.188421	0.69424	0.460588	0.501176	0.57	0.172071	0.05	0.05	0.15325	0.01	0.028076	0.107708	0.001006	0.012832	0.005475	0.005	0.005	0.005	0.005	0.005	0.005	0	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
B-103	none	1100	795.2729	0.65	4.508015	35.712548	0.103848	0.465187	0.63353	0.207283	0.400658	0.207283	0.400658	0.05	0.05	0.1306	0.04	0.125445	0.15	0.000841	0	0.007169	0.028094	0.002125	0.000981	0.012657	0.005519	0.005	0	0.005519	0.005	0	0.005519	0.005	0.005519	
B-104	none	971.52148	738.50255	0.74402895	5.566215	34.079838	0.367681	0.634634	0.046332	0.522501	0.54169	0.522501	0.54169	0.05	0.05	0.113446	0.01	0.116478	0.063367	0.007302	0.002264	0.000256	0.104887	0.001282	0.005535	0.022769	0.005	0	0.005535	0.022769	0.005535	0.022769	0.005535	0.022769	0.005535	0.022769
B-106	none	1100	811.97628	0.62	8.836204	44.820803	0.173463	0.422053	0.083353	0.263164	0.451462	0.263164	0.451462	0.05	0.05	0.15325	0.01	0.028076	0.107708	0.001006	0.012832	0.005475	0.005	0.005	0.005	0.005	0.005	0.005	0	0.005	0.005	0.005	0.005	0.005	0.005	
B-108	none	1100	874.52395	0.62099211	5.28256	19.84096	0.075566	1.703634	0.197131	0.880007	0.38	0.05	0.113446	0.05	0.05	0.15325	0.01	0.028076	0.107708	0.001006	0.012832	0.005475	0.005	0.005	0.005	0.005	0.005	0.005	0	0.005	0.005	0.005	0.005	0.005	0.005	
B-109	none	1100	641.08796	0.83103294	8.993891	10.853653	0.143895	1.446318	0.681787	0.996511	0.511001	0.996511	0.511001	0.05	0.05	0.174472	0.032812	0.087077	0.039494	0.003017	0	0.002439	0.18615	0.0047	0.011033	0.000469	0	0.011033	0.000469	0.011033	0.000469	0.011033	0.000469	0.011033	0.0004	

Table E-2. Case 13 Glass Output for the Total Blend and No Blend Subcases. (3 Sheets)

Upper Limit:	1	10	100	2	2	2	0.2	0.4	0.17	0.15	0.1	0.08	0.15	0.1	0.01	1	0.03	0.005	0.0025	0.0025	1	1																						
Lower Limit:	0.62	4.5	10	-	-	-	0.05	0.01	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0																						
	Physical characteristics											Normalized Elemental Releases											Domain (weight fraction in glass)											Simple Limits (weight fraction in glass)										
HLW Glass Batch Number	Arrival Date	Glass (MT)	Frit (MT)	Feed Oxides (MT)	Waste oxide loading	number of canisters (x m³ each)	Liquidus Temp. (Spindel) (degrees C)	Liquidus Temp. (Zircro) (degrees C)	Wt Fr. SiO2/(SiO2+Na2O+Al2O3)	Glass viscosity (Pa-s)	Elect. Cond. (ohm-m)⁻¹	silicon (g/m²)	boron (g/m²)	lithium (g/m²)	sodium (g/m²)	SiO₂	B₂O₃	Na₂O	Li₂O	Al₂O₃	Fe₂O₃	CaO	MgO	ZrO₂	Others	Cr₂O₃	F	P₂O₅	SO₃	Rb₂O₃	Rb₂O₃ + Ru₂O₃	Pu (g/L)												
none	none	49.9	30.1	19.7	0.396	15.6	1100	660.05852	0.62	4.5	43.10569	0.218225	0.884893	0.007233	0.541019	0.395398	0.05	0.14805	0.026368	0.094291	0.023162	0.03242	0	0	0.230312	0.006601	0	0.005595	0	0	2.012E-16	0.009244	0.089863											
none	none	45.5	26.7	18.7	0.412	14.2	1100	740.24899	0.65461124	6.099804	33.913388	0.272022	0.884893	0.007233	0.541019	0.395398	0.05	0.146142	0.010263	0.054355	0.110263	0.003585	0	0.002562	0.243093	0.004469	0	0.003533	0	0	1.289E-17	0.002025	0.310936											
none	none	126.1	83.2	43.0	0.341	39.4	1100	805.12116	0.69954805	9.921083	24.838139	0.286972	0.744968	0.278336	0.638493	0.480423	0.05	0.157111	0.01049228	0.15	0.024317	0.014821	0.002762	0.061338	0.005237	0.00016	0.000981	0.005	0	3.34E-17	0.001201	0.044294												
none	none	279.6	215.5	64.1	0.229	87.4	1064.8237	811.13186	0.88165487	9.973085	16.433309	0.232904	0.635248	0.417732	0.414152	0.568617	0.124981	0.05	0.04	0.026326	0.15	0.005403	0.001682	9.06E-05	0.032901	0.000292	0	0.000902	0	0	8.877E-18	0.004	0.108635											
none	none	181.7	127.7	54.0	0.297	56.8	1083.196	777.43445	0.70590507	9.952475	29.186351	0.582709	1.423351	0.490538	0.901366	0.507959	0.05	0.176958	0.01034669	0.15	0.012557	0	0.0073	0.050558	0.002151	0	0.003664	0	0	1.409E-16	0.019451	0.142195												
none	none	170.8	74.2	96.6	0.565	53.4	1100	791.08621	0.62	4.5	39.189522	0.388886	1.164019	0.421256	0.932226	0.421733	0.05	0.194288	0.013372	0.064194	0.141212	0.026674	0.01778	0.006041	0.064707	0.007353	0	0.013866	0	0	2.034E-15	0.00294	0.273024											
none	none	272.3	243.9	28.4	0.104	85.1	1100	842.29117	0.62	4.5	20.63839	0.060675	0.305619	0.217507	0.160652	0.39326	0.12315	0.163071	0.01	0.117959	0.15	0.004884	0.000759	0.000288	0.076629	0.001354	0	0.007624	0	0.005	0	8.922E-17	0.000905	0.019646										
none	none	60.6	46.2	14.4	0.238	18.9	987.54746	730.01743	0.62	4.5	34.397812	0.271156	0.3051924	0.501733	0.523238	0.44542	0.38	0.169842	0.04	0.097233	0.15	0.005422	0.001727	0.000159	0.049863	0.001895	0	0.009599	0	0	6.076E-15	0.003117	0.119009											
none	none	56.9	37.3	19.6	0.345	17.8	1043.5929	784.48336	0.62	4.5	30.296177	0.155901	1.341702	0.124828	0.484542	0.38	0.117023	0.153503	0.01	0.0794	0.113276	0.008232	0	0.003509	0.135057	0.004064	0	0.03	0	1.864E-16	0.005989	0.075772												
none	none	129.2	103.6	25.5	0.198	40.4	1100	820.23936	0.88533396	8.908656	16.234077	0.250835	0.754614	0.567024	0.493145	0.57	0.134953	0.05	0.04	0.023825	0.15	0.004223	0.000992	0.001976	0.024032	0.000138	0	0.00073	0	0	1.23E-16	0.007236	0.096932											
none	none	183.8	136.7	47.1	0.256	57.4	1100	755.87575	0.7383118	9.999653	29.908108	0.172713	0.339688	0.128726	0.563978	0.426873	0.05	0.107342	0.04	0.07163	0.146342	0.010706	0	0.000128	0.068909	0.002123	3.91E-05	0.000622	0.005	0	2.217E-15	0.000762	0.250878											
none	none	122.7	108.2	14.6	0.119	38.4	1100	873.95259	0.80641561	9.944945	10.577513	0.10484	1.107095	0.639365	0.860833	0.504516	0.2	0.065349	0.01	0.055763	0.133394	0.00078	0	7.3E-05	0.030125	0.001011	0.012892	0.000914	0.005	0	7.062E-24	6.09E-05	0.001776											
none	none	241.2	210.7	30.5	0.126	75.4	852.09971	741.79583	0.66018811	9.30903	35.846524	0.578695	1.481533	0.782558	0.779928	0.495426	0.05	0.2	0.01	0.055005	0.15	0.000845	0	7.2E-05	0.038652	0.000985	0.012717	0.000922	0.005	0	6.966E-24	6.06E-05	0.009435											
none	none	404.7	308.0	96.7	0.239	126.5	1100	742.14618	0.62	4.5	37.034761	0.127987	0.727436	0.196761	0.316129	0.409009	0.135962	0.120965	0.04	0.129718	0.070022	0.002082	0	0.000424	0.091818	0.001497	0.006213	0.000923	0.005	0	4.443E-23	0.000306	0.009504											
none	none	1408.1	1,259.5	148.6	0.106	440.0	850	743.22769	0.80517204	7.896516	18.382973	0.237916	1.609122	0.766986	1.285698	0.57	0.2	0.070449	0.04	0.067474	0.02	0	0	8.02E-05	0.031997	0.001003	0.012962	0	0.005	0	7.949E-24	6.48E-05	0.001967											
none	none	116.9	75.7	41.2	0.352	36.5	1100	717.63737	0.62	4.5	44.856804	0.34257	1.573985	0.066609	0.755977	0.402831	0.05	0.174625	0.019835	0.072271	0.108223	0.012471	0.003866	0.000437	0.155441	0.00219	0.009453	0.018734	0.005	0	3.4E-23	0.000325	0.007071											
none	none	112.7	77.9	34.8	0.309	35.2	1100	683.94136	0.62	10	39.617649	0.154554	0.371503	0.048623	0.219561	0.456495	0.084717	0.134998	0.04	0.144789	0.02	0.003099	0	0.000572	0.11533	0.00047	0.058077	0.005663	0	0	4.561E-20	0.004241	0.000683											
none	none	148.1	84.1	64.1	0.433	46.3	1100	641.59151	0.62	4.5	58.706235	0.41212	1.84182	0.033214	0.866744	0.426873	0.05	0.173265	0.033634	0.088367	0.040079	0.003062	0	0.000242	0.184478	0.00477	0.051229	0.006685	0.004842	0	5.673E-20	0.005156	0.005815											
none	none	40.3	24.9	15.4	0.382	12.6	1100	695.87552	0.62	4.5	46.96459	0.4340801	0.483771	2	0.113665	0.84645	0.436604	0.05	0.199986	0.01	0.06761	0.090634	0.006646	0	7.23E-05	0.138447	0.004312	0.013317	0.008246	0.004198	0	5.216E-18	0.000728	0.000399										
none	none	75.3	18.9	56.4	0.749	23.5	1100.																																					

Table E-2. Case 13 Glass Output for the Total Blend and No Blend Subcases. (3 Sheets)

[illegible]

APPENDIX F

DISTRIBUTION OF WASTE

F1.0 DISTRIBUTION OF WASTE

This appendix contains two figures that provide a summary of the contents of all of the tanks along with information useful for understanding the resulting HLW glass volume. These figures show the distribution of waste, HLW glass, and glass limiting components among the various tank farms. Figure F-1 addresses the tanks in 200 West Area while Figure F-2 addresses those in 200 East.

The figures are based on the figures periodically published in HNF-EP-0182. They show the volume of waste in each tank, the physical form of the waste (sludge, saltcake or supernate), the assumed disposition of the waste (how the waste will be treated), and the leak status, all as of December 31, 2004 (HNF-EP-0182).

The figures have been modified to include the amount of HLW glass that would be produced if that tank were to be retrieved, pretreated and processed by the WTP without any blending (shown by the central black bar¹) and the glass limiting component if the mass of the HLW glass is driven by a single composition limit (shown by the color of the tank shell)².

¹ The height of the central black bar is proportional to the mass of HLW glass associated with each tank. The bottom of the tank corresponds to zero MTG; the underside of the tank dome corresponds to 1,500 MTG.

² Only the top five limiting components are shown, namely, SO_3 , Al_2O_3 , P_2O_5 , Fe_2O_3 , and Na_2O , listed in general order of decreasing importance.

F2.0 REFERENCE

HNF-EP-0182, 2004, *Waste Tank Summary Report for Month Ending December 31, 2004*, Rev. 201, CH2M HILL Hanford Group, Inc., Richland, Washington.

Figure F-1. 200 West Tank Waste Contents and Associated HLW Glass.

Figure F-2. 200 East Tank Waste Contents and Associated HLW Glass.

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