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1	1	Cog.Eng. P. J. Certa	P J Certa	8/8/96	H5-61	G. A. Meyer	[signature]	12 AUG 96	S2-48	1	1
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Low-Level Waste Feed Staging Plan

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Abstract: The *Preliminary Low-Level Waste Feed Staging Plan* was updated to reflect the latest requirement in the Tank Waste Remediation Privatization Request for Proposals (RFP) and amendments. The updated plan develops the sequence and transfer schedule for retrieval of DST supernate by the management and integration contractor and delivery of the staged supernate to the private low-activity waste contractors for treatment. Two DSTs are allocated as intermediate staging tanks. A transfer system conflict analysis provides part of the basis for determining transfer system upgrade requirements to support both low-activity and high-level waste feed delivery. The intermediate staging tank architecture and retrieval system equipment are provided as a planning basis until design requirements documents are prepared. The actions needed to successfully implement the plan are identified. These include resolution of safety issues and changes to the feed envelope limits, minimum order quantities, and desired batch sizes.

Approved for Public Release

WHC-SD-WM-RPT-224
Revision 0

LOW-LEVEL WASTE FEED STAGING PLAN

August 1996

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G. K. Allen performed an independent technical review of the dynamic simulation model used to evaluate the feed delivery transfer system conflicts. K. M. Eager performed the independent technical review of the remainder of the report.

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EXECUTIVE SUMMARY

This document establishes the operating scenario for the delivery of feed to the private low-activity waste contractors. Staging a batch of feed begins as soon as the previous batch of feed is transferred from the intermediate feed staging tanks (241-AP-102 and 241-AP-104) and delivered to the private contractors' feed tanks (241-AP-106 and 241-AP-108). Typically, waste from selected double-shell tanks (excluding sludge) is mobilized with mixer pumps, retrieved and transferred using in-line dilution to the intermediate feed staging tanks. The waste is then mixed and sampled to confirm composition, mass of sodium, and envelope classification. After successful evaluation of the sample results, the feed is ready for delivery. However, the waste cannot be delivered until the private contractors finish processing the previous batch of feed. The slack between when the feed is ready for delivery and when the private contractors' feed tanks are empty is used to absorb the inevitable delays in feed staging activities and to correct out-of-specification feed batches. The sequence in which the feed is retrieved and processed satisfies requirements from the Request for Proposals. The sequence is presented in Section 2.11 and the transfer schedule is presented in Section 3.1.

This report identified several actions concerning requirements from the Request for Proposals or the Contractor Support Team. These actions should be reflected in either the contracts currently being negotiated between the U.S. Department of Energy-Richland Operations Office and the private contractors or the interface control documents. The actions are highlighted below and discussed in more detail in Section 4.1:

- *Reduce the minimum order quantity of Envelope A to 2,000 MT sodium per contractor (was 2,600 MT sodium per contractor).*

- *Increase the maximum [SO_4]/[Na] limit for Envelope C to 0.02 mole/mole (was 0.0097 mole/mole).*

- *Increase the size of the first batch of Envelope B feed to allow delivery of between 100 - 250 MT sodium per contractor (was 100 - 130 MT sodium per contractor).*

- *Increase the size of the first batch of Envelope C feed to allow delivery of between 100 - 600 MT sodium per contractor (was 100 - 130 MT sodium per contractor).*

- *Define time and conditions of the transfer of custody of 241-AP-106 and -108 to the private contractors.*

- *Clearly define which radionuclides are used to calculate transuranics for envelope classification purposes.*

- *Require the private contractors to empty their feed tanks (241-AP-106 and -108) to a maximum heel of 0.1 ML (10 in.) of waste before accepting delivery of the next feed batch when switching feed envelopes.*

- *Better define the requirement that "The insoluble solids fraction will not exceed 5 vol% of the waste transferred as waste Envelopes A, B, and C."*

- *Explicitly state whether the envelope composition limits apply to the bulk composition of the delivered feed or for only the liquid phase.*

Other actions are needed to successfully implement the feed staging plan. They result from the requirements developed by the technical analysis, are needed to resolve issues identified during the analysis, or are associated with the assumptions and requirements used to develop the plan. They are discussed in Section 4.1; the more significant ones are highlighted below:

- *Resolve any safety and administrative concerns so that feed may be obtained from Watch List tanks and tanks affected by the flammable gas unreviewed safety question.*

- *The regulatory status of the final feed delivery transfers (from the intermediate feed staging tanks to the private contractors feed tanks) needs to be determined. Applicable requirements need to be identified.*

- *Rigorously determine the amount and type of dilution required for safe retrieval and transfer of feed and to re-dissolve major soluble sodium salts while not precipitating out other solids (such as gibbsite). This requires both thermodynamic modeling and observation of the behavior and physical properties of waste samples undergoing dilution in the laboratory. Concentrate upon the following tanks--the most important tanks are listed first: 241-AN-105, 241-AN-104, 241-AW-101, 241-AN-103, 241-AN-107, and 241-AN-102.*

- *Rigorously determine the equipment required to retrieve the target feed leaving the excluded waste (sludge) behind.*

- *Perform an engineering study to validate the requirements and architecture for the intermediate feed staging tanks. Implement the upgrades before October 2000.*

- *Resolve the emerging issue of the presence of a separable organic phase or soluble tributyl phosphate in the double-shell tanks.*

- *Implement the recommended transfer system upgrades (Low-Level Waste Option 4, High-Level Waste Option 3). This combination is called Alternative K in this report.*

- *Take the necessary actions to keep the maximum transfer setup time for all transfers at or below about 25 days and the median time about 1 or 2 days. This will require, at the least; (a) insuring that a failed pump or jumper can be repaired or replaced under typical (often windy) weather conditions within 25 days and (b) completing the upgrades needed so that all transfers can be setup using valves rather than pit entries and jumper changes.*

- *Avoid changing the composition of the targeted waste in tanks that already contain significant quantities of potential feed. These tanks are 241-AN-102, -103, -104, -105 and -107; and 241-AW-101. Additionally, avoid changing the composition of the neutralized current acid waste supernate, other than by blending with other neutralized current acid waste supernate.*

- *Before the start of feed staging activities, place no waste in 241-AP-102, -104, -106, and -108 that will require dilution for removal. Also, waste requiring mixing equipment for removal should not be stored in 241-AP-106 and -108.*

The following are additional highlights from the report:

The projected double-shell tank supernate (or retrieved slurry) were classified according to feed envelope. Table ES-1 compares the quantity of sodium classified according to each envelope with the minimum and maximum order quantities. Eighty-four percent of the available double-shell tank supernate (sodium mass basis) fits within the feed envelopes. Thirty-nine percent belongs to Envelope A, three percent to Envelope B, and forty-two percent to Envelope C. Sixteen percent fits within none of the envelopes. The "point" estimates show that there is sufficient sodium to satisfy the minimum order quantities for each envelope and the maximum combined order quantity for all envelopes.

The double-shell tanks within 10 percent of the envelope specifications are referred to as "borderline" double-shell tanks for this report. Table ES-2 shows how the available sodium is affected by this uncertainty. The quantity of feed classified as Envelope A could be as low as 3,920 MT sodium, which would not be sufficient to meet the minimum order quantities for two contractors (5,200 MT sodium).

Table ES-1. Available Sodium in Double-Shell Tank Feed.

	Available sodium in double-shell tank supernate (MT)[a]	Percentage of total available sodium (%)	Minimum sodium required for two contractors (MT)	Maximum sodium required for two contractors (MT)
Envelope A	5,400	39	5,200	9,800
Envelope B	440	3	200	2,000
Envelope C	5,800	42	200	4,800
Sub-Total	11,600	84	N/A	10,200[b]
Excluded	2,200	16		
Total	13,800	100		

[a]*The MT sodium reported represents the total mass contained in the double-shell tank supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste retrieval and transfer operations.*

[b]*The maximum combined quantity of Envelopes A, B, and C to be processed by the two contractors shall not exceed 10,200 MT sodium.*

Table ES-2. Summary of Total Available Sodium with Uncertainties.[g]

	Envelope A		*Envelope B*		*Envelope C*	
	Minimum	*Maximum*	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Available sodium in double-shell tanks (MT)[a,c,d]	*3,920*	*6,640*	*439*	*1,100*	*1,750*	*5,814*
Available sodium in single-shell tanks (MT)[a,e,f]	*11,890*	*17,318*	*3,860*	*2,510*	*0*	*0*
Total available sodium (MT)[a]	*17,050*	*23,958*	*3,610*	*4,299*	*4,780*	*5,814*
Sodium required for two contractors (MT)[b]	*5,200*	*9,800*	*200*	*2,000*	*200*	*4,800*

[a] *The MT sodium reported represents the total mass contained in the tank supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste transfer operations.*

[b] *The maximum combined quantity of Envelopes A, B, and C to be processed by the two contractors shall not exceed 10,200 MT sodium.*

[c] *The minimum double-shell tank values were determined by subtracting the borderline double-shell tank sodium inventories inside envelope limits from the values listed in Table ES-1. The minimum double-shell tank values for Envelopes A and C also subtract the sodium inventories of the double-shell tanks with low quality projections.*

[d] *The maximum double-shell tank values were determined by adding the borderline double-shell tank sodium inventories outside envelope limits to the values listed in Table ES-1.*

[e] *The minimum single-shell tank values were determined by subtracting the borderline single-shell tank sodium inventories inside envelope limits from the values listed in Table ES-4.*

[f] *The maximum single-shell tank values were determined by adding the borderline single-shell tank sodium inventories outside envelope limits to the values listed in Table ES-4.*

[g] *All values in this table are specific to the assumed inventories and feed envelope limits.*

The feed staging plan delivers supernate containing a total of 10,095 MT sodium to the private contractors. Sufficient feed from each envelope is available to provide the minimum order quantities and the combined maximum order quantity. However, to meet the minimum order quantities, 1,240 MT of sodium in Envelope A feed is provided from tanks with low quality (uncertain) projections or from borderline tanks.

A schedule was prepared (see Section 3.1) to show the various feed staging transfers and other activities, including each private contractor's campaigns. Table ES-3 summarizes the supernate delivered to the private contractors' feed tanks during these campaigns.

Table ES-3. Summary of Supernate Delivered to the Private Contractors.

	Envelope	Contractor 1 (MT Na)	Contractor 2 (MT Na)	Totals (MT Na)
Proof-of-Concept	A	2,659	2,634	5,293
	B	121	121	242
	C	124	124	248
	Subtotal	2,904	2,879	5,783
Extension	C	1,918	2,195	4,113
	B	199	0	199
	Subtotal	2,117	2,195	4,312
	TOTAL	5,021	5,074	10,095
By Envelope	A	2,659	2,634	5,293
	B	320	121	441
	C	2,042	2,319	4,361

Tank 241-AP-108 is projected to remain empty between Fiscal Year 1997 and Fiscal Year 2001 when it is filled with the first feed batch. Tank 241-AP-106 will be used for waste storage until Fiscal Year 2001 when it is emptied and refilled with the first feed batch. This was based upon last year's projection (Koreski and Strode 1995), a special waste volume projection (Strode 1996), and the Projected Double-Shell Tank Supernate Composition and Inventory for Phase I Privatization (Shelton 1996). The Operational Waste Volume Projection being prepared for release in September 1996 will help determine (1) the earliest the first feed batches can be delivered to 241-AP-106 and 241-AP-108, *(2) whether the tanks can be emptied for the custody transfer, and (3) the length of time, if any, the tanks can remain empty before the first feed batches are delivered.*

The waste compatibility Data Quality Objective rules were applied to the projected double-shell tank supernate and to the proposed staging schedule to identify potential problems. The proposed staging schedule conflicts to some degree with several of the non-safety related rules in the waste compatibility Data Quality Objective (see Section 2.7). The conflicts are not specific to the proposed feed staging schedule. The rules that may present problems are: (1) Transuranic Segregation, (2) Complexed Waste Segregation, and (3) Tank Waste Type.

Twelve alternative transfer system upgrades, developed elsewhere, were studied using a Monte Carlo simulation. In this type of analysis, many variables are allowed to vary randomly within a specified range to account for uncertainty. The analysis accounted for transfer system conflicts during feed staging for both the high-level waste and low-activity waste private contractor processes. The fraction of the cases for which the feed was delivered within the 30 day feed delivery window was used as a performance measure. The results were combined with the hydraulic performance and cost data from the "Decision Document for Phase I Privatization Transfer System Needs" (Galbraith et al. 1996). Alternative K (Low-Level Waste Option 4 and High-Level Waste Option 3) was selected to support Phase I privatization feed staging.

Seven sensitivity cases suggest that the recommended transfer system upgrades decision is robust with respect to changing assumptions. One of the sensitivity cases showed the system's ability to deliver feed on time is strongly influenced by the time required to setup transfers. A parametric study examined this in more detail.

Results show that the behavior of the system is driven by the assumed transfer setup times. The performance of the transfer system can be significantly improved If the maximum time to setup all transfers is kept at or below about 25 days and the median time of about 2 days. This will require, at the least, insuring that a failed pump or jumper can be repaired or replaced under typical (often windy) weather conditions within 25 days.

The feed delivery study also concluded that the minimum scheduled campaign length (processing time) should be kept larger than 100 days to avoid increases in the length of the outage. This corresponds to a feed batch containing 200 MT sodium. The Request for Proposals requires that the initial feed batches of Envelopes B and C each contain only 100 MT sodium.

A heel mixing study investigated the maximum heel that could remain in the intermediate feed staging tanks and the private contractors' feed tanks when switching over to a new feed envelope. The full range of waste composition permitted by the three feed envelopes was explored in addition to using the projected waste compositions. Switching from Envelope B or C to any other envelope requires as small a heel as is reasonable (about 0.1 ML [10 in.]) to ensure that the new feed batch remains in the intended envelope for most of the switches. A case-by-case evaluation of all envelope switches using the actual waste compositions is required to identify any the troublesome cases and take preventative action such as dilution and removal of a portion of the heel.

The single-shell tank supernate inventories also were classified according to the double-shell tank feed envelope specifications. The objective was to determine which single-shell tanks, if retrieved during Phase I, could provide feed to the low-activity waste private contractors (Table ES-4). The tank-by-tank single-shell tank compositions used for this exercise are all considered to be uncertain and should not be used for critical planning purposes.

Table ES-4. Available Sodium in Potential Single-Shell Tank Feed.

	Available sodium in single-shell tank supernate (MT)[a]	*Percentage of total available sodium in single-shell tanks*
Envelope A	*14,000*	*25%*
Envelope B	*2,700*	*5%*
Envelope C	*0*	*0%*
Excluded	*40,000*	*70%*
Total	*57,000*	*100%*

[a]The MT sodium reported represents the total mass contained in the single-shell tank supernate (the soluble portion of the single-shell tanks after retrieval and dilution water have been added according to the Tank Waste Remediation System Process Flowsheet). The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste transfer operations.

Solid-liquid equilibria were not considered in preparation of the low-level waste feed staging plan. A limit of 7M sodium in the retrieved double-shell tank waste was used as a proxy to insure safe retrieval and transfer of the waste and dissolution of soluble sodium salts. Dilution requirements need to be verified using thermodynamic models and actual waste samples.

CONTENTS

APPENDIXES

FIGURES

TABLES

TABLES (CONTINUED)

GLOSSARY

Acronym, abbreviation, or term	Explanation
ANN	Aluminum Nitrate Nonahydrate
Base Case	The set of assumptions around which an analysis is performed. Sensitivity studies are used to explore deviations from the base case.
Baseline	The set of assumptions that have been officially incorporated into a program or project.
Batch	A discrete quantity of supernate transferred to the private contractor's feed tank for processing. One batch is processed completely (except for the heel) before another batch is provided.
Bq	Becquerel. 1 Bq = 1 disintegration/second.
Campaign	A campaign is the period during which a private contractor processes a batch of supernate.
CC	Complexed Concentrate
C_d	Facility design capacity (the maximum instantaneous processing rate).
$C_d(POE)$	Average rate at which the facility processes feed when feed is available.
Ci	Curie. 1 Ci = 3.7×10^{10} Bq.
Constraint	Constraints are external requirements imposed on a system.
Contingency	In this analysis, contingencies refer to unplanned events that interfere with the staging of waste.
CP	Concentrated Phosphate waste
CST	Contractor Support Team
CSWL	Complexed Salt-Well Liquor
DC	Dilute Complexant Waste
Direct Staging	A staging alternative in which all transfers, dilution, mixing, sampling, etc., take place in the private contractors' feed tanks.
DN	Dilute non-complexant waste
DP	Dilute phosphate waste
DRD	Design Requirements Document
DQO	Data Quality Objective
DSC	Differential Scanning Calorimetry
DSS	Double-Shell Slurry Waste

GLOSSARY

Acronym, abbreviation, or term	Explanation
DSSF	Double-Shell Slurry Feed Waste
DST	Double-Shell Tank
Enabling Assumption	An assumption made to permit continued analysis where information concerning a decision, constraint, or requirement is lacking.
Envelope	In this analysis, an Envelope is a set of limits that must be met by the supernate provided to the private contractors as feed.
Extension	Refers to the optional period during which RL may request the private contractors to process waste beyond the minimum order quantities.
FAE	Feed Availability Efficiency. The fraction of the time that the approved feed is available in the private contractors' feed tanks.
FRD	Functions and Requirements Document.
FY	Fiscal Year (starting October 1)
HDW-EIS	Hanford Defense Waste-Environmental Impact Statement
HTCE	Historical Tank Contents Estimates
ICD	Interface Control Document
Indirect Staging--ASAP	A variation on *Indirect Staging*. The waste transfers begin as soon as the intermediate staging tank is free (i.e., as soon as the previous feed batch is transferred to the private contractor).
Indirect Staging	A staging alternative in which waste is transferred to an intermediate staging tank for blending, dilution, adjustment, mixing, and sampling before decant/transfer to the private contractors' feed tanks.
Indirect Staging--When Notified	A variation on *Indirect Staging*. The waste transfers begin after notification is received from the private contractors.
Inches of Waste	Volume of waste in a DST is often reported as the liquid level measured from the tank bottom (1 in. of waste = 2,750 gal = 10,410 L).
ISSTRS	Initial Single-Shell Tank Retrieval System
LANL	Los Alamos National Laboratory
LAW	Low-Activity Waste
LLW	Low-Level Waste

GLOSSARY

Acronym, abbreviation, or term	Explanation
M&I	Management and Integration
ML	Million liters
MT	Metric ton
NCAW	Neutralized Current Acid Waste
NCRW	Neutralized Cladding Removal Waste
NCSWL	Non-Complexed Salt-Well Liquor
NVO	Non-Volatile Oxides
NVOL	Non-Volatile Oxides less sodium and silicon
OSD	Operating Specification Document
Outage	In this analysis, outage refers to the time period during which no feed is available in a private contractor's feed tank.
OWVP	Operational Waste Volume Projection
Parametric Study	A study in which one or more variables are varied to identify trends in system behavior.
PBFC	Performance Based Fee Criteria
Phase I	The first portion of TWRS Privatization during which a proof-of-concept demonstration is performed and additional feed is processed using relatively small-scale processing facilities.
Phase II	The final portion of the TWRS Privatization during which full-scale production facilities are operated.
POE	Plant Operating Efficiency. Ratio of the facility's average throughput (after adjusting for reduced rate operation, startup, and shutdown transients and all plant outages planned or otherwise, except for lack of feed) to the design capacity.
Privatization	A business strategy in which private contractors provide the capital for building plants and treating waste. The private contractors assume much of the financial and technical risk.
Proof-of-Concept	The first part of Phase I B during which the minimum quantities of waste are processed to demonstrate that privatization is viable from technical, regulatory, and financial aspect.
PT	TRU Solids from Plutonium Finishing Plant operations.
Requirement	Requirements are internal limits that are imposed on a system.

GLOSSARY

Acronym, abbreviation, or term	Explanation
RFP	Request for Proposals
RL	U.S. Department of Energy, Richland Operations Office
RMS	Root mean square
Sensitivity Case	A deviation from base case assumptions used to examine the behavior of the system under study against changing assumptions.
Simplifying Assumption	An assumption made to make calculations or analysis easier.
SL	Slurry pipeline
SN	Supernate pipeline
SpG	Specific Gravity
SST	Single-Shell Tank
TBP	Tributyl Phosphate
TGA	Thermal Gravimetric Analysis
TIC	Total Inorganic Carbon
TLM	Tank Layer Model
TOC	Total Organic Carbon
TOE	Total Operating Efficiency
TRAC	Track Radioactive Components
TRU	Transuranic
TWRS	Tank Waste Remediation System
USQ	Unreviewed Safety Question
W-151	241-AZ-101 Waste Retrieval System Project
W-211	DST Initial Retrieval System Project
W-314	Tank Farm Restoration and Safe Operations Project Waste Transfer System Upgrades
W-320	241-C-106 Retrieval Systems Project
W-454	AW-Valve Pit Manifold Systems Project
WHC	Westinghouse Hanford Company
WTD	Waste Transfer Date

LOW-LEVEL WASTE FEED STAGING PLAN

1.0 INTRODUCTION

The U.S. Department of Energy, Richland Operations Office (RL), is pursuing a new business strategy for remediation of Hanford Site tank waste. This strategy, commonly called privatization, involves hiring private contractors to perform the Tank Waste Remediation System (TWRS) functions on a pay-for-product basis. RL has issued a Request for Proposal (RFP) and Amendments (DOE-RL 1996a, b, and c) that solicit bids for the Phase I portion of TWRS Privatization. During Phase I, the technical, regulatory, and financial viability of the privatization concept will be demonstrated by processing a portion of the waste stored in the double-shell tank (DST) system. DST supernate would be provided to two private contractors for pretreatment and immobilization into a low-activity waste (LAW) product. Optionally, pretreated solids would be processed by one of the two private contractors into a high-level waste (HLW) product. The scope of Phase II is being defined by RL.

The management and integration (M&I) contractor is required to provide the two Phase I LAW private contractors with the appropriate quantities of feed of a specified composition at the proper times. The *Preliminary Low-Level Waste Feed Staging Plan* (Certa et al. 1996) established the feed staging strategy and recommended changes to improve the delivery of feed to the private contractors, based upon requirements from the draft RFP. This report updates the preliminary plan (Certa et al. 1996) for the delivery of this feed to the private contractors to reflect current requirements and assumptions.

1.1 SCOPE

The Low-Level Waste (LLW) Feed Staging Plan activity (Kirkbride 1995) includes four deliverables for Fiscal Year (FY) 1996 (Table 1-1). The first deliverable showed that it was feasible to deliver feed to the private contractors. The second deliverable was a draft of the third. The third deliverable, the *Preliminary Low-Level Waste Feed Staging Plan*, was based upon the draft RFP. It developed the feed staging strategy (which is still valid), prepared a preliminary supernate processing sequence, retrieval and staging schedule, and recommended changes to the RFP. The fourth deliverable was intended to be a confirmation of the *Preliminary Low-Level Waste Feed Staging Plan*. There were, however, extensive changes in the feed envelope specifications, minimum and maximum order quantities, envelope processing order and feed delivery timing between the draft and final RFP and amendments. These changes required extensive revision to the *Preliminary Low-Level Waste Feed Staging Plan*, with the exception of the feed staging strategy. This revision is being issued as a new report, titled *Low-Level Waste Feed Staging Plan*. For convenience, the projected waste inventories used by the *Low-Level Waste Feed Staging Plan* were issued as separate report, titled *Projected Double-Shell Tank Supernatant Composition and Inventory For Phase I Privatization* (Shelton 1996).

The basic scope of the *Low-Level Waste Feed Staging Plan* includes the following items:

- Classify supernate according to feed envelope.
- Review and comply with the waste compatibility data quality objective (DQO) rules.
- Compare transfer system upgrades in terms of their ability to deliver feed according to schedule for both the private LAW and HLW contractors.
- Prepare an operating scenario that shows the schedule for retrieval, staging and processing of feed.
- Select the DSTs that will be used as intermediate feed staging tanks, establishing upgrade requirements and recommendations.
- Recommend retrieval upgrades.
- Identify the actions needed to successfully implement the plan.

Table 1-1. Low-Level Waste Feed Staging Activity Deliverables.*

Deliverable	Activity	Milestone type	Control number	Completion date
Issue Feed Staging Feasibility Study	L1W02742A	DOE-RL	T32-96-020	11/1/95 (completed)
Issue Draft Preliminary Feed Staging Plan	L1W02744A	WHC Key	T32-96-021	1/15/96 (completed)
Issue Preliminary Feed Staging Plan	L1W02746A	DOE-RL	T32-96-022	2/15/96 (completed)
		Performance Based Fee Criteria	96-418	2/5/96 (completed)
Confirmation of Preliminary Feed Staging Plan (this report)	L1W02748A	DOE-RL	T32-96-023	8/15/96
Addendum to Feed Staging Plan				Early Calendar Year 1997
Revision to Feed Staging Plan				Late Fiscal Year 1997

*Shaded deliverables are proposed for Fiscal Year (FY) 1997, pending approval of work scope and availability of funds.

1.2 ORGANIZATION

Figure 1-1 is an influence and data flow diagram for this analysis. It depicts the influences that have been considered and shows which elements of the study are affected. This diagram can be used as a road map since it is cross-referenced to the various sections in the report.

Section 2.1 highlights the major assumptions used in this report. The complete set of assumptions is listed in Appendix A along with their basis. When appropriate, the assumptions are discussed further and issues identified.

Section 2.2 describes the feed staging strategy that was recommended by the *Preliminary Low-Level Waste Feed Staging Plan* and approved by the TWRS Decision Board.

The DST supernate inventories are projected to near the start of staging activities (FY 2002) in Section 2.3. The inventories are shown in Appendix B; their basis is provided in a separate report (Shelton 1996).

Estimated inventories of the soluble fraction of single-shell tank (SST) waste after retrieval is discussed in Section 2.4. The inventories are shown in Appendix C. They are taken from the *TWRS Process Flowsheet* (Orme 1995).

Projected DST supernate is then classified according to feed envelope as is the soluble portion of retrieved SST waste (Section 2.5). Borderline cases are discussed along with an analysis of the available sodium in each envelope.

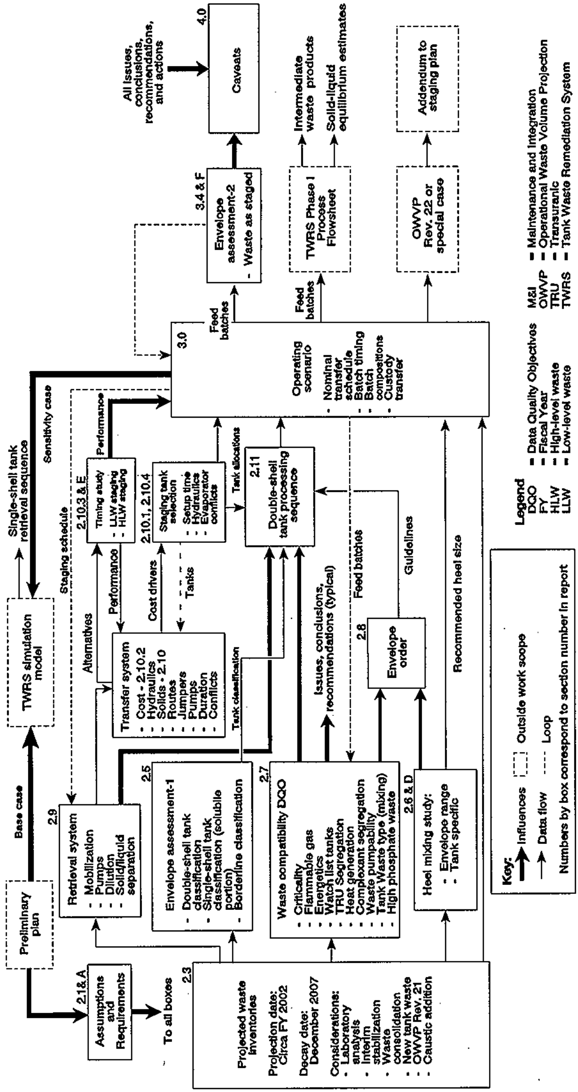
Next, a heel mixing study is performed (Section 2.6). This study determines the maximum heel that may remain in the intermediate feed staging tanks and the private contractors' feed tanks when switching envelopes. The study used a Monte Carlo approach to explore both the full range of compositions belonging to each envelope and the projected waste compositions. Details are shown in Appendix D.

A review of the waste compatibility DQO was performed to identify potential problems that could affect feed staging transfers (Section 2.7). The decision rules were executed for the projected supernate compositions and when appropriate, the staged feed compositions.

The envelope order provided by the draft RFP was reviewed (Section 2.8).

The general requirements (more accurately a planning basis) for the retrieval of waste from the source DSTs were developed (Section 2.9). Tank specific issues were identified.

Figure 1-1. Influence and Data Flow Diagram.



The transfer system and intermediate staging tank upgrades are discussed (Section 2.10). Section 2.10.1 selects two DSTs for use as intermediate staging tanks. Section 2.10.2 performs a cost-benefit analysis on the transfer system upgrade alternatives developed by Galbraith et al. (1996). A feed delivery timing study (for both LAW and HLW) is summarized in Section 2.10.3. Section 2.10.4 identifies the upgrades needed for the intermediate feed staging tanks. The timing study and cost-benefit analysis are documented in Appendix E.

A processing sequence for DST supernate was prepared using tradeable and non-tradeable criteria (Section 2.11). Using this sequence, a schedule of feed staging and processing activities for both private contractors was prepared (Section 3.1). Issues concerning the custody transfer of 241-AP-106 and 241-AP-108 are discussed in Section 3.2 and infrastructure support in Section 3.3. The composition of the staged supernate was compared with the envelope limits (Section 3.3).

Section 4.1 contains the actions needed to successfully implement the low-level waste feed staging plan.. These actions result from the requirements developed by the technical analysis, are needed to resolve issues identified during the analysis, or are associated with the assumptions and requirements in Appendix A. Section 4.2 contains caveats for the study.

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2.0 DISCUSSION

2.1 ASSUMPTIONS

All of the major assumptions are documented in Appendix A along with their basis, a discussion, and related issues. Other "lower-level" technical assumptions are documented at the point of use. The more important assumptions are listed below:

- The functional flow block diagram derived from the TWRS Function and Requirements Document defines the interfaces and overall sequence of activities involved with feed staging.

- The proof-of-concept demonstration begins June 1, 2002, and ends June 1, 2007. The extension period begins when the minimum order quantities have been processed and ends June 1, 2011.

- The minimum and maximum order quantities from the RFP in MT of sodium are as follows:

Envelope	Minimum (per contractor)	Maximum (per contractor)
A	2,600	4,900
B	100	1,000
C	100	2,400
Sum of A, B and C		5,100

*The maximum combined quantity of Envelopes A, B, and C to be processed by each contractor shall not exceed 5,100 MT sodium.

- The envelope order and corresponding batch sizes for one private contractor were obtained from the RFP unless otherwise indicated. They are as follows:

	Envelope	Required mass of sodium	Period
One Batch	A	≥500 MT	Proof-Of-Concept Demonstration
Until minimum order quantity is reached	A	≥100 MT	
One Batch	B	≥100 MT; ≤130 MT[a]	
One Batch	C	≥100 MT; ≤130 MT1[a]	
Until maximum order quantity is reached	C[b]	≥100 MT	Extension Period
Until maximum order quantity is reached	A[b]	≥100 MT	
Until maximum order quantity is reached	B[b]	≥100 MT	

[a]Specified by the CST.
[b]Assumed by the Feed Staging Plan based upon heel mixing considerations.

- The private contractors must provide at least 60 days notice in advance of the waste transfer date (WTD). The M&I contractor must begin delivery of feed no earlier than the later of the WTD and the date the contractor is actually ready to receive feed. Delivery must be completed within 30 days.

- Tanks 241-AP-106 and 241-AP-108 are turned over to the private contractors.

- Facility processing rates are estimated using the 600 MT/day per vendor system capacity requirement. It was necessary to allocate the 60 percent total operating efficiency (TOE) into a facility attribute (plant operating efficiency [POE] 75 percent) and a system attribute (feed availability efficiency [FAE] 80 percent). This critical assumption needs to be formally controlled and allocated using the system engineering process.

- The feed specification envelopes are provided by the RFP and amendments. The maximum [SO4]/[Na] for Envelope C was increased to 0.02 mole/mole so that 241-AN-102 and 241-AN-107 would meet Envelope C specifications. For planning purposes, additional constraints (see assumption A5.1 in Appendix A and Table 2-4 Section 2.51) were imposed to exclude delivery of Envelope A waste as Envelope B or C.

- The Waste Compatibility Program and DQO define permissible transfers of waste within the DST system (Fowler 1995a and 1995b).

- The DST supernate inventories were projected through FY 2002. The starting values are consistent with the TWRS Flowsheet Inventory, however, the most recent sample and historical data are used whenever possible. The projections are consistent with the latest formal Operational Waste Volume Projection (OWVP) (Koreski and Strode 1995) as modified by Section 2.3. Supernate in 241-AW-102 and 241-AW-106 was not estimated, since these tanks are actively used as evaporator feed and slurry tanks. The assumptions provided for the OWVP (Rev. 22) were used for the pretreatment of 241-AZ-101, 241-AZ-102, and 241-AY-102/241-C-106 sludge. NCRW and TRU consolidation was not performed.

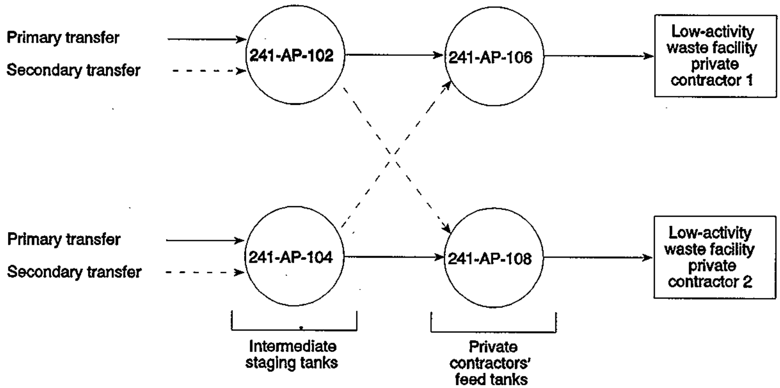
- Solid-liquid equilibria is ignored. A 7*M* [Na] rule was used as a proxy limit to ensure that transferred waste is below saturation in major components. Entrained solids are not tracked, although provisions are made for dealing with them.

- It is assumed that two LAW facilities and one HLW facility are built and operate successfully during the proof-of-concept and extension periods.

2.2 FEED STAGING STRATEGY

Three alternative feed staging strategies were analyzed and compared (Certa et al. 1996). The recommended alternative, *Indirect Staging--As Soon As Possible,* was reviewed and accepted by the TWRS Decision Board (WHC 1996a). In this alternative, waste is staged in a pair of intermediate staging tanks before delivery to the private contractors' feed tanks (Figure 2-1). The allocation of two specific DSTs for use as intermediate staging tanks is established in Section 2.12.

Figure 2-1. Waste Staging.



Fresh feed is retrieved and transferred to the intermediate staging tank as soon as the intermediate staging tank is emptied of its previous feed batch. The waste is mixed, sampled, analyzed and adjustments are made if needed. Staged feed is transferred to the feed tank from the intermediate staging tank as soon as the feed tank is emptied of the previous feed batch.

This alternative provides a relatively large amount of slack time (contingency) between when the approved feed is ready for transfer to the feed tank and when the feed tank has been emptied by the private contractor. This contingency may be used to absorb delays due to retrieval difficulties, transfer difficulties (pump failures, weather problems, and conflicts with other operations), or adjusting or restaging an out-of-specification feed batch.

2.3 PROJECTED DOUBLE-SHELL TANK WASTE INVENTORIES

A set of DST supernatant composition estimates projected to FY 2002 has been derived from sample results, historical transaction sheets, waste profile data sheets, and operational waste volume projections (Shelton 1996). The projected composition estimates for selected components are shown in Appendix B. The SY101-SOL, and SY103-SOL designations indicate what is expected to be the soluble portion of the entire waste content of these two tanks. These are included because it is unlikely that only the supernatant portions of these tanks will be retrieved separately. Inventories for 241-AW-102 and 241-AW-106 were not estimated since they are actively used as evaporator feed and slurry tanks.

The series of steps performed to arrive at projected compositions for the DSTs are summarized as follows:

- A set of initial DST supernate compositions was derived, beginning with the most reliable sample data and supernate volumes at the time of sampling.

- Historical transaction records that chronicle transfers of waste into and out of the DST system, in addition to transfers made between DSTs, were used to project supernate compositions to July 1995. Compositions for wastes entering the DST system from facilities were taken from waste profile data sheets that are used to assess waste compatibility before transfer. Compositions for saltwell liquids were taken from Sederburg (1995).

- The OWVP (Koreski and Strode 1995) were used in combination with composition estimates for facility wastes and saltwell liquids from SST stabilization efforts to project DST supernate compositions to FY 2002.

The reliability of these compositions depend primarily on the number of transactions involved with a given tank, the accuracy of average waste compositions reported by the various facilities, and the future validity of the assumptions used in the OWVP. Although the projections in the OWVP represent the most comprehensive source of information regarding future DST system activity, some of the assumptions will likely change as events unfold. For example, several OWVP assumptions pertaining to aging waste consolidation have been modified to agree with current plans. Equipment failures, revision of volume estimates, waste incompatibilities and other safety concerns are a few examples of how OWVP assumptions (and these inventory and composition projections) may have to change in the future. A projection quality of high, medium, or low has been assigned to each tank. This provides a subjective indication of the reliability of the projected compositions and inventory.

The main differences between the inventories used in the Preliminary LLW Feed Staging Plan (Certa et al. 1996) and Shelton (1996) are: different projection dates and different assumptions pertaining to aging waste consolidation. The DST compositions in Certa et al. 1996 are, in most cases, projected to May 1997 while the compositions prepared for this report are projected to FY 2002. This results in an increase of 3.74E+06 L of non-complexed saltwell liquid, 4.97E+06 L of complexed saltwell liquid, and 5.40E+06 L of dilute wastes from decommissioning of facilities into the DST system. This equates to an increase of over 960 MT of sodium.

The saltwell liquid compositions used in Shelton (1996) did not include estimates of the radionuclides. Therefore, the radionuclide inventories for tanks receiving significant quantities of this waste will be underestimated by about two orders-of-magnitude.

The OWVP assumed that the high-heat sludges in 241-AY-102, 241-AZ-101, 241-AZ-102, and SST 241-C-106 would be consolidated into one of the aging waste tanks--generating large volumes of supernatant in the process that would be distributed among several DSTs (Strode 1995). This set of assumptions has been replaced by plans not to consolidate these sludges. These new assumptions impact the projected supernatant compositions for these tanks and several others.

Projected compositions for many tanks went unchanged or virtually unchanged because little transfer activity is expected for them. Tanks unaffected include 241-AN-102 through 241-AN-105, 241-AN-107, 241-AP-102, 241-AP-103, 241-AW-101, and 241-SY-101.

2.4 ESTIMATED SINGLE-SHELL TANK INVENTORIES

Estimated SST inventories will be used in Section 2.5.5 to identify which SSTs, if retrieved, could supply feed to the LAW private contractors during Phase I. There are no plans to process the soluble portion of retrieved SST waste during Phase I. The SST inventories used in this report are taken directly from the TWRS Process Flowsheet (Orme 1995) and are included in Appendix C.

The tank-by-tank inventory estimates for SSTs were taken from Shelton (1995), developed in support of the TWRS Process Flowsheet (Orme 1995). These estimates are based on the Historical Tank Content Estimates (HTCE) developed by Los Alamos National Laboratory (LANL) (Brevick 1994) that were normalized so that the total SST inventory agreed closely with the Hanford Defense Waste Environmental Impact Statement (HDW-EIS) (RHO 1985). LANL has used tank transaction records and a set of defined waste types to produce a Tank Layer Model (TLM) that predicts tank compositions by identifying the different waste layers that were added to a tank and assigning a composition for the individual layers from the defined waste type list (Agnew 1994).

To separate the waste into soluble and insoluble fractions, the bulk inventory estimates in the HTCE were first partitioned into salt cake/sludge fractions. This was accomplished by summing the salt cake layers separate from the sludge layers as determined by the TLM. Mass weighted average sludge washing factors, obtained from sludge washing experiments of core samples from 27 SSTs (Colton 1995), were applied to the sludge fractions, while the salt cake was assumed to be 99 percent soluble for all components.

Finally, the HTCE component totals (with the exception of aluminum) were normalized to make them consistent with the 1987 HDW-EIS. For components not given in the HDW-EIS, totals from the Track Radioactive Components (TRAC) model were used to normalize (Jungfleish 1984). The normalization was done because the differences between the two inventory estimates have not yet been reconciled by a delegated authority. The HTCE estimate for total aluminum was adopted for now because in an independent study, Borsheim found that his aluminum estimate agreed closely with the HTCE (Borsheim 1994).

The confidence level for the soluble portion of the SST inventories is low for several reasons. First, the HTCE estimates have not been verified or validated and revisions of the estimates are expected. Secondly, the normalization of the HTCE creates some anomalies, for example, in situations where enough mass is added to a tank as to make the new mass difficult to reconcile with reported volumes. Finally, the mass weighted average sludge washing factors do not reflect the solubility of all sludges in the SSTs. They represent the average removal efficiency for a small fraction of Hanford Site sludges.

2.5 TANK CLASSIFICATION AND FEED ENVELOPE ASSESSMENT

Three waste envelopes, entitled A, B, and C, have been defined in the *TWRS Privatization Request for Proposals* (RFP) (DOE-RL 1996a) and its amendment (DOE-RL 1996b) for LAW. This section evaluates the feasibility of the Hanford tank waste supernate fitting within Envelopes A, B, and C as defined in the RFP (DOE-RL 1996a).

Section 2.5.1 discusses the envelope specifications used for the feed envelope assessment. Section 2.5.2 explains how the DSTs were classified according to feed Envelopes A, B, or C and lists the results of the classification. Section 2.5.3 identifies the DSTs within 10 percent of the feed envelope limits. A comparison of the DST feed envelope classifications resulting from the final RFP feed envelope limits (DOE-RL 1996a) and the preliminary RFP feed envelope limits (DOE-RL 1995) is presented in Section 2.5.4.

The SST supernate inventories were also classified according to the DST feed envelope specifications to determine which SSTs, if retrieved during Phase I, can provide feed to the LAW private contractors. Section 2.5.5 identifies the SSTs that fit within Envelopes A, B, or C. The borderline SSTs within 10 percent of the feed envelope limits are identified in Section 2.5.6. Finally, the results of the tank waste supernate classification and feed envelope assessment are summarized in Section 2.5.7.

2.5.1 Feed Envelope Specifications

Envelope A represents waste that will test the production capacity and fission product removal efficiency of the plants while producing a final product in which the waste loading will be limited by sodium. Envelope B addresses the same treatment objectives as Envelope A but will produce a final product in which the waste loading will be limited by minor component concentrations and/or a cesium decontamination factor > 1,000. Envelope C represents waste with organic complexing agents that may interfere with ^{90}Sr and/or TRU decontamination, thus requiring demonstration of organic destruction or some other acceptable mitigation technology (McKee et al. 1995).

The sodium concentration for all envelopes must remain between 3*M* and 14*M*. Tables 2-1 and 2-2 list the maximum envelope composition limits for chemicals and radionuclides, respectively. All maximum envelope composition limits were obtained from the TWRS Privatization RFP except where noted. Table 2-3 lists the minimum composition limits for each envelope. The minimum limits are necessary to exclude the DST waste satisfying Envelope A from also satisfying Envelopes B and C (see Appendix A, Assumption A5.1). The chemical analyte limits are in units of [mole analyte]/[mole sodium]. The radionuclide limits are in units of [Bq radionuclide]/[mole sodium].

2.5.2 Double-Shell Tank Supernate Classification

The projected DST supernatant composition estimates discussed in Section 2.3 and listed in Appendix B were used along with the envelope limits shown in Tables 2-1, 2-2, and 2-3 to determine the envelope classification for each DST. The calculations were performed using three separate spreadsheets representing Envelopes A, B, and C.

The envelope limits listed in Tables 2-1 through 2-3 are in units of [mol analyte or Bq radionuclide]/[mole sodium]. The first step was to convert the projected DST supernatant inventory to the same units as the envelope limits. This converted inventory was pasted into each of the three spreadsheets representing Envelopes A, B, C. The maximum and minimum limits for each envelope also were entered in the corresponding spreadsheet. The ratio of $analyte_i$ to sodium in DST_j was then compared to the maximum and minimum Envelope A, B, and C limits for $analyte_i$ to determine the envelope classification for each DST.

Table 2-1. Low-Activity Waste Maximum Chemical Composition Limits.

Chemical analyte	Maximum ratio (mole analyte/mole sodium)[a,b]		
	Envelope A	Envelope B	Envelope C
Al	1.9 E-01	1.9 E-01	1.9 E-01
Ba	1.0 E-04	1.0 E-04	1.0 E-04
Ca	4.0 E-02	4.0 E-02	4.0 E-02
Cd	4.0 E-03	4.0 E-03	4.0 E-03
Cl	3.7 E-02	8.9 E-02	3.7 E-02
Cr	6.9 E-03	2.0 E-02	6.9 E-03
F	9.1 E-02	2.0 E-01	9.1 E-02
Fe	1.0 E-02	1.0 E-02	1.0 E-02
Hg	1.4 E-05	1.4 E-05	1.4 E-05
K	1.8 E-01	1.8 E-01	1.8 E-01
La	8.3 E-05	8.3 E-05	8.3 E-05
Ni	3.0 E-03	3.0 E-03	3.0 E-03
NO2	3.8 E-01	3.8 E-01	3.8 E-01
NO3	8.0 E-01	8.0 E-01	8.0 E-01
OH	7.0 E-01[d]	7.0 E-01[d]	7.0 E-01[d]
Pb	6.8 E-04	6.8 E-04	6.8 E-04
PO4	3.8 E-02	1.3 E-01	3.8 E-02
SO4	9.7 E-03	7.0 E-02	2.0 E-02[e]
TIC[c]	3.0 E-01	3.0 E-01	3.0 E-01
TOC	6.0 E-02[f]	6.0 E-02[f]	5.0 E-01[f]
U	1.2 E-3	1.2 E-3	1.2 E-3

[a]All envelope composition limits were obtained from DOE-RL 1996a except where noted.
[b]Shading highlights differences among the three LAW envelopes.
[c]Total Inorganic Carbon (TIC) = fraction of carbon in CO_3. Moles TIC = moles $CO_3 \times MW_C/MW_{CO3}$
[d]OH values were obtained from DOE-RL 1996b.
[e]A maximum Envelope C [SO4]/[Na] limit of 0.02 is used in this study to include DSTs 241-AN-102 and 241-AN-107 in Envelope C (Appendix A, Assumption A5.2).
[f]TOC values were obtained from DOE-RL 1996b.

Table 2-2. Low-Activity Waste Maximum Radionuclide Composition Limits.

Radionuclide	Maximum Ratio, radionuclide (Bq) to sodium (mole)[a,b]		
	Envelope A	Envelope B	Envelope C
TRU[c]	6.0 E+05	6.0 E+05	3.0 E+06
^{137}Cs	4.3 E+09	6.0 E+10	4.3 E+09
^{90}Sr	5.7 E+07	5.7 E+07	8.0 E+08
^{99}Tc	7.1 E+06	7.1 E+06	7.1 E+06

[a]All maximum radionuclide composition limits were obtained from DOE-RL (1996a).
[b]Shading highlights differences among the three LAW envelopes.
[c]Transuranic elements (TRU) = ^{237}Np + ^{238}Pu + ^{239}Pu + ^{240}Pu + ^{241}Am. The ^{238}Pu contribution was not estimated in the projected inventories.

Table 2-3. Low-Activity Waste Minimum Composition Limits.*

	Analyte	Minimum analyte: sodium ratio
Envelope A	No minimum limits	N/A
Envelope B At least one minimum Envelope B limit must be satisfied	Cl	3.7 E-02 mol Cl/mol Na
	Cr	6.9 E-03 mol Cr/mol Na
	F	9.1 E-02 mol F/mol Na
	PO_4	3.8 E-02 mol PO_4/mol Na
	SO_4	9.7 E-03 mol SO_4/mol Na
	^{137}Cs	4.3 E+09 Bq ^{137}Cs/mol Na
Envelope C	TOC	6.0 E-02 mol C/mol Na

*The minimum limits are necessary to exclude waste satisfying Envelope A from also satisfying Envelopes B and C (Appendix A, Assumption A5.1).

The feed envelope classification was performed for 26 of the 28 DSTs. As mentioned in Section 2.3, two DSTs (241-AW-102 and 241-AW-106) are assumed to be evaporator feed/product tanks with varying inventories and are excluded from the envelope classification. In addition, the waste in tanks 241-AY-101 and 241-SY-103 will be retrieved as a mixture of supernatant, solids, and retrieval/dilution water rather than supernatant only. The inventories for tanks 241-SY-101 and 241-SY-103 therefore represent the soluble portion of the total inventory and are designated as 101-SY-SOL and 103-SY-SOL.

For the DST supernate to meet the specifications of Envelope A, all the maximum Envelope A limits must be satisfied. Envelope B requires the DST supernate to satisfy all the maximum Envelope B limits and at least one of the minimum Envelope B limits. For the DST supernate to meet the specifications of Envelope C, the supernate must satisfy all the maximum Envelope C limits as well as the minimum TOC limit for Envelope C.

Tables 2-4 and 2-5 summarize the feed envelope classification for DST supernate. Table 2-4 lists the total available sodium in each of the DST feed envelopes and compares the totals to the minimum and maximum sodium requirements specified in the RFP (DOE-RL 1996a). It can be seen from Table 2-4 that there is sufficient waste to meet the minimum order quantities for all envelopes. However, Envelope A just barely meets the minimum order quantities and Envelope C exceeds the maximum sodium requirement order quantity. Table 2-5 shows which DSTs belong to Envelopes A, B, or C, as well as the mass of available sodium each individual DST contributes to the designated envelope.

Table 2-4. Available Sodium in Double-Shell Tank Feed.

	Available sodium in double-shell tank supernate (MT)[a]	Percentage of total available sodium (%)	Minimum sodium required for two contractors (MT)[b]	Maximum sodium required for two contractors (MT)[b]
Envelope A	5,400	39	5,200	9,800
Envelope B	440	3	200	2,000
Envelope C	5,800	42	200	4,800
Sub-Total	11,600	84	N/A	10,200[c]
Excluded	2,200	16		
Total	13,800	100		

[a]The MT sodium reported represents the total mass contained in the DST supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste retrieval and transfer operations.

[b]The minimum and maximum quantities of DST supernate provided to each contractor were obtained from the TWRS Privatization RFP (DOE-RL 1996a), Sections H.9.a, H.9.b, H.9.c, and H.9.e.

[c]The maximum combined quantity of Envelopes A, B, and C to be processed by the two contractors shall not exceed 10,200 MT sodium (DOE-RL 1996a, Section H.9.e).

Table 2-5. Double-Shell Tank Envelope Classification Summary.

Double-shell tank supernate source	Sodium in double-shell tank supernate (MT)[c]			
	Envelope A	Envelope B	Envelope C	Excluded
241-AN-101				220
241-AN-102			1,000	
241-AN-103	1,200			
241-AN-104	830			
241-AN-105	1,200			
241-AN-106			1,500	
241-AN-107			780	
241-AP-101			600	
241-AP-102			420	
241-AP-103		1		
241-AP-104	240			
241-AP-105			33	
241-AP-106	1,000			
241-AP-107			1,500	
241-AP-108			1	
241-AW-101	910			
241-AW-102[a]	Not Assessed			
241-AW-103				11
241-AW-104			10	
241-AW-105				0
241-AW-106[a]	Not Assessed			
241-AY-101		440		
241-AY-102				8
241-AZ-101				14
241-AZ-102				8
241-SY-101 (SOL)[b]				1,190
241-SY-102			2	
241-SY-103 (SOL)[b]				710
Total Sodium (MT)	5,400	440	5,800	2,200
Total DSTs	6	2	10	8

[a]Tanks 241-AW-102 and 241-AW-106 are assumed to be evaporator feed/product tanks with varying inventories, and are therefore not included in this study.

[b]It is unlikely that supernate alone can be retrieved from tanks 241-SY-101 and 241-SY-103. This study assumes the contents of the two DSTs will be retrieved as a mixture of supernate and solids. The supernate sources labeled 241-SY-101 (SOL) and 241-SY-103 (SOL) represent the soluble fraction of the DST contents after retrieval water has been added.

[c]The MT sodium reported represents the total mass contained in the DST supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste transfer operations.

2.5.3 Borderline Double-Shell Tanks

The DSTs within 10 percent of the envelope specifications are referred to as "borderline" DSTs for this report, and are listed in Tables 2-6 and 2-7. The tables identify the limiting analyte(s), the actual ratio of moles analyte per mole sodium, and the envelope specification for that analyte. The available sodium in the supernate from each borderline DST is also reported to indicate the significance of the DST envelope classification uncertainty (i.e., the greater the sodium content, the greater the significance).

Table 2-6 identifies the borderline DSTs that do not belong to any envelope. These tanks are just outside the envelope limits (i.e., DST waste inventories that are up to 10 percent greater than the maximum envelope limits or up to 10 percent less than the minimum envelope limits). The DSTs are listed according to envelope classification to show the number of tanks that may potentially meet the specifications of each envelope.

Table 2-6 shows that given a 10 percent uncertainty, the following additional DSTs and sodium may fit within Envelopes A, B, and C:

- Three additional DSTs (241-AN-101, 241-AP-101, 241-AP-102) and an additional 1,240 MT sodium may fit within Envelope A.
- Two additional DSTs (241-AP-102, 241-AP-104) and an additional 660 MT sodium may fit within Envelope B.
- One additional DST (241-AZ-101) and an additional 14 MT sodium may fit within Envelope C.

However, it is not possible for the above mentioned additions to occur simultaneously for both Envelopes A and B. Tank 241-AP-102 is borderline for both Envelopes A and B. Thus, depending on the uncertainty of SO_4 and TOC compositions, the 420 MT sodium in tank 241-AP-102 may fit within Envelope A or B.

Table 2-7 identifies the borderline DSTs that have been determined to fit within an envelope and are included in Tables 2-4 and 2-5, but are within 10 percent of the envelope limits. These DST waste inventories are up to 10 percent less than the maximum envelope limits or up to 10 percent greater than the minimum envelope limits specified in the RFP (DOE-RL 1996a).

Table 2-7 shows that given a 10 percent uncertainty, the following DSTs and sodium may not fit within Envelopes A, B, and C, as listed in Table 2-5:

- One DST (241-AP-104) and 240 MT sodium may not fit within Envelope A.
- One DST (241-AP-103) and 1 MT sodium may not fit within Envelope B.
- Two DSTs (241-AP-101, 241-AP-102) and a total of 1,020 MT sodium may not fit within Envelope C.

Table 2-6. Borderline Double-Shell Tank Waste Inventories Outside Envelope Limits.[a]

Potential envelope classification	Double-shell tank	Available sodium in double-shell tank supernate (MT)[c,f]	Limiting analyte[b]	Analyte to sodium ratio (mol or Bq per mol Na)[c]	Envelope limit (analyte to sodium ratio)
A	241-AN-101	220	TOC	6.47 E-02	≤6.0 E-02[d]
A	241-AP-101	600	TOC	6.12 E-02	≤6.0 E-02[d]
A	241-AP-102	420	SO_4	1.06 E-02	≤9.7 E-03[d]
			TOC	6.16 E-02	≤6.0 E-02[d]
B	241-AP-102	420	TOC	6.16 E-02	≤6.0 E-02[d]
B	241-AP-104	240	Cl	3.37 E-02	≥3.7 E-02[e]
C	241-AZ-101	14	SO_4	2.20 E-02	≤2.0 E-02[d]

[a]This table identifies the borderline DSTs with waste inventories up to 10 percent greater than the maximum envelope limits or up to 10 percent less than the minimum envelope limits specified in the RFP.

[b]The "limiting analyte" column lists the component(s) preventing a DST from meeting the criteria of the "potential envelope."

[c]The available sodium in DST supernate and analyte to sodium ratio were determined from Table 2-1 of WHC-SD-WM-TI-751 (Shelton 1996).

[d]Maximum chemical composition limit (see Table 2-1).

[e]Minimum composition limit (see Table 2-3).

[f]Total available sodium in DSTs is 13,800 MT (see Table 2-4).

Table 2-7. Borderline Double-Shell Tank Waste Inventories Inside Envelope Limits.[a]

Envelope classification	Tank	Available sodium in double-shell tank supernate (MT)[c,f]	Limiting analyte[b]	Analyte to sodium ratio (mol or Bq per mol Na)[c]	Envelope Limit (analyte to sodium ratio)
A	241-AP-104	240	Cl	3.37 E-02	≤3.7 E-02[d]
B	241-AP-103	1	K	1.69 E-01	≤1.8 E-01[d]
C	241-AP-101	600	TOC	6.12 E-02	≥6.0 E-02[e]
C	241-AP-102	420	TOC	6.16 E-02	≥6.0 E-02[e]

[a]This table identifies the borderline DSTs with waste inventories up to 10 percent less than the maximum envelope limits or up to 10 percent greater than the minimum envelope limits specified in the RFP.

[b]The "limiting analyte" column lists the component that may prevent the DST from meeting the envelope criteria, given an uncertainty range of 10 percent or more.

[c]The available sodium in DST supernate and the analyte to sodium ratio were determined from Table 2-1 of WHC-SD-WM-TI-751 (Shelton 1996).

[d]Maximum chemical composition limit (see Table 2-1).

[e]Minimum chemical composition limit (see Table 2-3).

[f]Total available sodium in DSTs is 13,800 MT (see Table 2-4).

2.5.4 Sensitivity of Double-Shell Tank Classification

The available sodium reported in Table 2-4 for each of the feed envelopes is significantly different than the sodium content reported in Table 2-6 of the *Preliminary LLW Feed Staging Plan* (Certa et al. 1996). The *Preliminary LLW Feed Staging Plan* was based upon a different inventory and a different set of envelope specifications. Table 2-8 compares the "old" inventory and envelope specifications from the *Preliminary LLW Feed Staging Plan* with the "new" inventory and envelope specifications.

Table 2-8. Comparison of Old/New Inventory with Old/New Envelope Specifications.

	Case 1	Case 2	Case 3	Case 4
Double-shell tank supernate inventory	New[a]	New[a]	Old[b]	Old[b]
Envelope specifications	New[c]	Old[d]	New[c]	Old[d]
Envelope A (MT sodium)	5,400	6,580	6,470	7,570
Envelope B (MT sodium)	440	1,580	430	430
Envelope C (MT sodium)	5,800	1,780	1,000	1,780
Excluded (MT sodium)	2,200	3,860	5,080	3,200
Total (MT sodium)	13,800	13,800	13,000	13,000

[a]"New Inventory" represents the projected DST supernate composition listed in WHC (Shelton 1996). The total sodium content in the "new inventory" is 13,800 MT. The inventory is projected through FY 2002.

[b]"Old Inventory" represents the projected DST supernate composition listed in Appendix C of WHC-SD-WM-RPT-210, Rev.0 (Certa et al. 1996). The total sodium content in the "old inventory" is 13,000 MT. The inventories projected through FY 1998.

[c]"New Envelope Specifications" represent the envelope limits listed in Tables 2-1, 2-2, and 2-3. They are based on the final Request For Proposal as amended.

[d]"Old Envelope Specifications" represent the envelope limits listed in Tables 2-3 and 2-4 of WHC-SD-WM-RPT-210, Rev. 0 (Certa et al. 1996). They are based on the draft Request For Proposal as amended.

The data in Table 2-8 were correlated to identify how the inventory changes and specifications changes affected each sodium inventory (Table 2-9). Two new variables were constructed to represent the old and new inventories and specifications. Each was assigned a value of zero for the old set and unity for the new set. The change in total sodium is due entirely to the inventory changes as is expected. The quantity of excluded sodium was reduced primarily by the switch to the new inventory. The quantity of sodium in Envelope A was reduced roughly equally by the changes in both inventory and envelope specifications. The quantity of sodium in Envelope B was equally increased by the new inventory and decreased by the new feed specifications yielding no net change. The quantity of sodium in Envelope C was increased by both the inventory changes (more complexed salt-well liquor [CSWL] was pumped) and the envelope specification changes.

Table 2-9. Correlation of Waste Classification with Inventory and Specification.

	Inventory	Specification
Envelope A	-0.67	-0.74
Envelope B	0.58	-0.57
Envelope C	0.64	0.43
Excluded	-0.53	0.05
Total	1.00	0.00

2.5.5 Single-Shell Tank Supernate Classification

The SST supernate inventories were also classified according to the DST feed envelope specifications. The objective was to determine which SSTs, if retrieved during Phase I, can provide feed to the LAW private contractors. The same method used to classify DST supernate was also applied to SSTs. The SST inventory is taken from the TWRS Process Flowsheet (Orme 1995) and included Appendix C.

Tables 2-10 and 2-11 summarize the feed envelope classification for SST supernate. It was determined that no SST waste belongs to Envelope C. Table 2-10 lists the percentage of total available sodium in each of the SST feed envelopes. Table 2-11 shows which SSTs belong to Envelopes A or B, as well as the mass of available sodium each individual SST contributes to the designated envelope.

Table 2-10. Available Sodium in Single-Shell Tank Feed.

	Available sodium in single-shell tank supernate (MT)[a]	Percentage of total available sodium in single-shell tanks
Envelope A	14,000	25%
Envelope B	2,700	5%
Envelope C	0	0%
Excluded	40,000	70%
Total	57,000	100%

[a]The MT sodium reported represents the total mass contained in the SST supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste transfer operations.

Table 2-11. Single-Shell Tank Supernate Summary.[a]

Envelope A		Envelope B	
Single-shell tank supernate source	Sodium in single-shell tank supernate (MT)[b]	Single-shell tank supernate source	Sodium in single-shell tank supernate (MT)[b]
241-AX-101	1,300	241-AX-103[c]	190
241-S-102	1,000	241-B-104	280
241-S-103	430	241-B-105	490
241-S-105	930	241-B-106	190
241-S-106	1,100	241-B-109	140
241-S-108	1,200	241-BX-112	160
241-S-109	1,100	241-T-102	510
241-SX-104	970	241-T-108	60
241-TX-117	1,300	241-T-109	100
241-TY-102	130	241-T-110	300
241-U-102	690	241-T-111	240
241-U-103	850	241-T-112	30
241-U-105	660		
241-U-106	400		
241-U-108	790		
241-U-109	780		
241-U-111	570		
241-U-201	2		
241-U-202	2		
241-U-203	1		
241-U-204	1		
TOTAL: 21 SSTs	14,000	TOTAL: 12 SSTs	2,700

[a]The supernate (after dilution during retrieval and transfer) waste inventories of the 149 Hanford Site SSTs were screened against the constraints of Envelopes A, B, and C. This table lists only the SSTs that meet the criteria of Envelopes A and B. No SSTs fit within Envelope C.

[b]The MT sodium reported represents the total mass contained in the SST supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste transfer operations.

[c]Tank 241-AZ-103 is one of the tanks proposed for the Initial Single-Shell Tank Retrieval System (ISSTRS).

2.5.6 Borderline Single-Shell Tanks

The SSTs within 10 percent of the envelope specifications are referred to as "borderline" SSTs for this report, and are listed in Tables 2-12 and 2-13. The tables identify the limiting analyte(s), the actual ratio of moles analyte per mole sodium, and the envelope specification for that analyte. The available sodium in the supernate of each borderline SST is reported to indicate the significance of the DST envelope classification uncertainty (i.e., the greater the sodium content, the greater the significance).

Table 2-12 identifies the borderline SSTs just outside the envelope limits (i.e., SST waste inventories that are up to 10 percent greater than the maximum envelope limits or up to 10 percent less than the minimum envelope limits). The SSTs are listed according to envelope classification to show the number of tanks that may potentially meet the specifications of each envelope. No SSTs are within 10 percent of the Envelope C specifications.

Table 2-12 shows that given a 10 percent uncertainty, the following additional SSTs and sodium may fit within Envelopes A, B, and C:

- Five additional SSTs (241-BY-109, 241-TX-104, 241-TX-107, 241-TX-113, 241-TX-114) and an additional 3,318 MT sodium may fit within Envelope A.

- Two additional SSTs (241-BY-109, 241-T-104) and an additional 1,160 MT sodium may fit within Envelope B.

However, it is not possible for the above mentioned additions to occur simultaneously for both Envelopes A and B. Tank 241-BY-109 is borderline for both Envelopes A and B. Thus, depending on the uncertainty of SO_4 and ^{90}Sr compositions, the 840 MT sodium in tank 241-BY-109 may fit within Envelope A or B.

Table 2-13 identifies the borderline SSTs that have been determined to fit within an envelope and are included in Tables 2-10 and 2-11, but are within 10 percent of the envelope limits. The SST waste inventories are up to 10 percent less than the maximum envelope limits or up to 10 percent greater than the minimum envelope limits specified in the RFP (DOE-RL 1996a).

Table 2-13 shows that given a 10 percent uncertainty, the following SSTs and sodium may not fit within Envelopes A, B, and C, as listed in Table 2-10:

- Three SSTs (241-TX-117, 241-TY-102, 241-U-102) and 2,110 MT sodium may not fit within Envelope A.

- One SST (241-AX-103) and 190 MT sodium may not fit within Envelope B.

Table 2-12. Borderline Single-Shell Tank Waste Inventories Outside Envelope Limits.[a]

Potential envelope classification	Single-shell tank	Available sodium in single-shell tank supernate (MT)[c,f]	Limiting analyte[b]	Analyte to sodium ratio (mol or Bq per mol Na)[c]	Envelope limit (analyte to sodium ratio)
A	241-BY-109	840	SO_4	9.86 E-03	≤9.7 E-03[d]
			^{90}Sr	5.86 E+07	≤5.7 E+07[e]
A	241-TX-104	120	NO_3	8.15 E-01	≤8.0E-01[d]
A	241-TX-107	68	NO_3	8.30 E-01	≤8.0E-01[d]
A	241-TX-113	1,110	NO_3	8.08 E-01	≤8.0E-01[d]
A	241-TX-114	1,180	NO_3	8.17 E-01	≤8.0E-01[d]
B	241-BY-109	840	^{90}Sr	5.86 E+07	≤5.7E+07[e]
B	241-T-104	320	^{90}Sr	6.22 E+07	≤5.7E+07[e]

[a]This table identifies the borderline SSTs with waste inventories up to 10 percent greater than the maximum envelope limits or up to 10 percent less than the minimum envelope limits specified in the RFP.

[b]The "limiting analyte" column lists the component(s) preventing a SST from meeting the criteria of the "potential envelope."

[c]The available sodium in SST supernate and analyte to sodium ratio were determined from Appendix A of the *TWRS Process Flowsheet* (Orme 1995).

[d]Maximum chemical composition limit (see Table 2-1).

[e]Maximum radionuclide composition limit (see Table 2-2).

[f]Total available sodium in SSTs is 57,000 MT (see Table 2-10).

Table 2-13. Borderline Single-Shell Tank Waste Inventories Inside Envelope Limits.[a]

Envelope classification	Single-shell tank	Available sodium in single-shell tank supernate (MT)[c,f]	Limiting analyte[b]	Analyte to sodium ratio (mol or Bq per mol Na)[c]	Envelope limit (analyte to sodium ratio)
A	241-TX-117	1,290	NO_3	7.74 E-01	≤8.0 E-01[d]
A	241-TY-102	130	PO_4	3.58 E-02	≤3.8 E-02[d]
A	241-U-102	690	NO_3	7.57 E-01	≤8.0 E-01[d]
B	241-AX-103[g]	190	^{90}Sr	5.18 E+07	≤5.7 E+07[e]

[a]This table identifies the borderline SSTs with waste inventories up to 10 percent less than the maximum envelope limits or up to 10 percent greater than the minimum envelope limits specified in the RFP.

[b]The "limiting analyte" column lists the component(s) preventing a SST from meeting the envelope criteria, given an uncertainty range of 10 percent or more.

[c]The available sodium in SST supernate and analyte to sodium ratio were determined from Appendix A of the *TWRS Process Flowsheet* (Orme 1995).

[d]Maximum chemical composition limit (see Table 2-1).

[e]Maximum radionuclide composition limit (see Table 2-2).

[f]Total available sodium in SSTs is 57,000 MT (see Table 2-10).

[g]Tank 241-AX-103 is one of the tanks proposed for Initial Single-Shell Tank Retrieval System.

2.5.7 Conclusions

Table 2-14 summarizes the feasibility of the Hanford tank waste supernate fitting within Envelopes A, B, and C as defined in the RFP (DOE-RL 1996a) and modified by Amendment 1 (DOE-RL 1996b) and CST direction (Appendix A). The borderline tanks and DSTs with "low quality projections" are included in the summary table as a range of available sodium. The minimum value represents the amount of sodium remaining if all the borderline tanks inside the envelope limits and DSTs with "low-quality projections" do not meet the envelope specifications. The maximum value represents the amount of sodium in each envelope if all the borderline tanks outside the envelope limits meet the envelope specifications.

Table 2-14 shows that the available sodium in the DST supernate easily fits within the minimum and maximum sodium requirements specified for Envelope B in the RFP (DOE-RL 1996a). There is sufficient Envelope C waste to supply the maximum order quantities, if desired. However, there is a possibility the available sodium in the DST supernate will not meet the minimum Envelope A quantity (see the thick-bordered cell). This may be resolved by retrieving additional supernate from the SSTs meeting Envelope A specifications (see Table 2-11), adjustment of the feed envelopes, or reduction in the minimum order quantity for Envelope A feed.

Table 2-14. Summary of Total Available Sodium.[g]

	Envelope A		Envelope B		Envelope C	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Available Sodium in DSTs (MT)[a,c,d]	3,920	6,640	439	1,100	1,750	5,814
Available Sodium in SSTs (MT)[a,e,f]	11,890	17,318	3,860	2,510	0	0
Total Available Sodium (MT)[a]	17,050	23,958	3,610	4,299	4,780	5,814
Sodium Required for two Contractors (MT)[b]	5,200	9,800	200	2,000	200	4,800

[a]The MT sodium reported represents the total mass contained in the tank supernate. The sodium values do not account for the fraction of waste left behind in the tanks as a result of waste transfer operations.

[b]The requirements for minimum and maximum quantities of DST supernate provided to each contractor were obtained from the TWRS Privatization RFP (DOE-RL 1996a), Sections H.9.a, H.9.b, H.9.c, and H.9.e.

[c]The minimum DST values were determined by subtracting the borderline DST sodium inventories inside envelope limits (Table 2-7) from the base values listed in Table 2-4. The minimum DST values for Envelopes A and C also subtract the sodium inventories of the DSTs with low quality projections (see Appendix B). The amount of sodium subtracted from Envelope A due to low quality projections is 1,240 MT; the amount subtracted from Envelope C is 3,035 MT. The Envelope B projections are of high quality.

[d]The maximum DST values were determined by adding the borderline DST sodium inventories outside envelope limits (Table 2-6) to the base values listed in Table 2-4.

[e]The minimum SST values were determined by subtracting the borderline SST sodium inventories inside envelope limits (Table 2-13) from the base values listed in Table 2-10.

[f]The maximum SST values were determined by adding the borderline SST sodium inventories outside envelope limits (Table 2-12) to the base values listed in Table 2-10.

[g]All values in this table are specific to the assumed inventories and feed envelope limits.

Changes in the envelope specifications or the compositions and inventories of the tanks with low quality projections can cause significant shifts in the availability and classification of feed.

2.6 HEEL MIXING STUDY

This study (see Appendix D) examines the effect that the combined heel remaining in the private contractor's feed staging tank and the intermediate feed staging tank has when switching envelopes. That basic question is: what is the minimum volume of waste from one envelope that can be mixed with the heel from a different envelope so that the resulting mixture belongs to the first envelope?

Six mixing scenarios were explored, each corresponding to one of the six permutations of envelopes: A → B, A → C, B → A, B → C, C → A and C → B. Two sets of analyses were performed. In the first, waste compositions were restricted only by requiring that they satisfy the feed envelope limits. In the second, waste compositions were further restricted to correspond to the projected waste compositions.

For each mixing scenario, the maximum combined heel[1] that can remain in the private contractor's feed staging tank and the intermediate feed staging tank was calculated so that a full tank of waste would satisfy the desired envelope limits.

2.6.1 Using Full Envelope Range

In this analysis, the full range of waste compositions permitted by the feed envelopes was explored. A Monte-Carlo method was used to generate 500 pairs of waste compositions for each mixing scenario. The maximum combined heel for each composition pair and mixing scenario was then calculated (see Appendix D for details). The analysis assumes that there is a sufficient volume of waste available to stage a full tank feed.

Figure 2-2a shows the fraction of cases (composition pairs) that are successful for each heel volume. The curves for switching from Envelope A to B or C show that for combined heels of up to 2.6 ML (250 in.), 90 percent of the cases satisfy the desired envelope limits. For combined heels of up to 0.21 ML (20 in.) (0.1 ML [10 in.] per tank), nearly 100 percent of the cases are successful. No problems are anticipated when switching *from* Envelope A *to* B or C, provided that the composition of the B or C waste is not close to the minimum envelope limits (i.e., the waste is only borderline within the envelope classifications).

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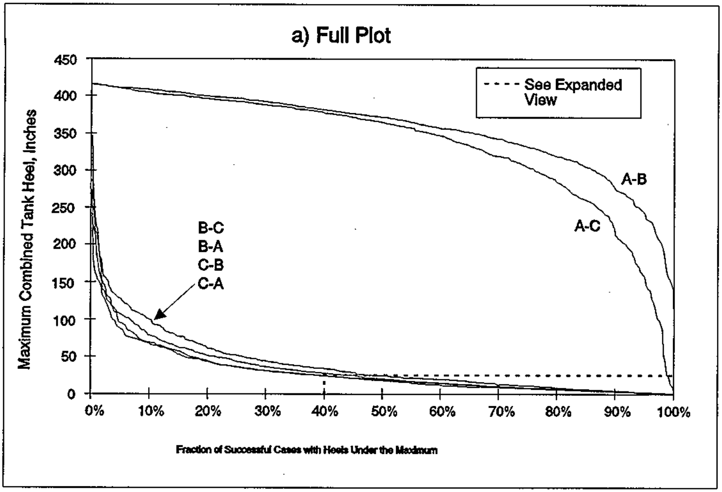
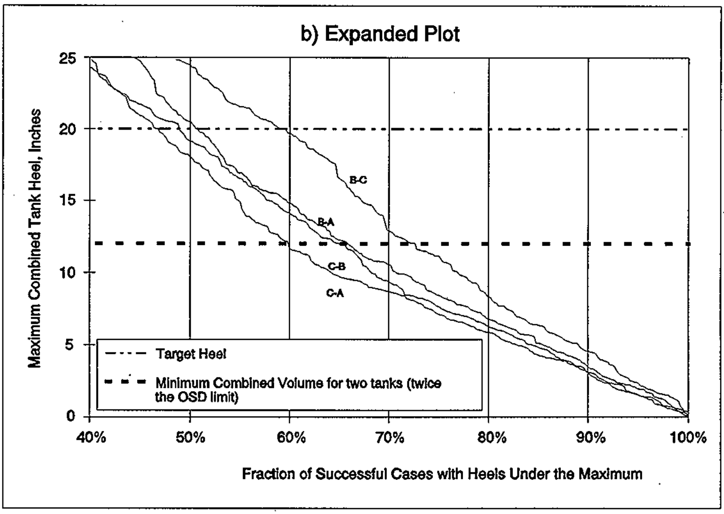
[1]Combined heel refers to the sum of the heels remaining in one private contractors feed staging tank and the corresponding intermediate feed staging tank.

Figure 2-2. Heel Mixing Results Using Envelope Ranges.





The lower right-hand corner of Figure 2-2a is expanded in Figure 2-2b. Mixing scenarios switching *from* Envelope A *to* B or C have been removed for clarity. This figure shows that for a 0.21 ML (20-in.) combined heel (0.1 ML [10 in.] per tank), the fraction of successful cases for the remaining mixing scenarios ranges from about 45 and 60 percent. For 90 percent of the cases to be successful, the maximum combined heel must be between 0.03 ML and 0.05 ML (3 and 5 in.), which is less than the combined minimum tank operating volume. In the unsuccessful cases, the composition of the heel or added waste is near one or more of their upper limits.

2.6.2 Using Projected Waste Compositions

In this analysis, the projected waste compositions and envelope classification are used instead of the full range of compositions permitted by the envelopes. The maximum combined heel for each composition pair and mixing scenario was calculated using these compositions. (See Appendix D for details). The analysis assumes that there is a sufficient volume of waste available to stage a full tank of feed.

Figure 2-3a shows that the worst case maximum combined heels are larger when using the projected waste compositions rather than the full envelope ranges and that the best case maximum combined heels are smaller.

Figure 2-3b expands the lower right hand side of Figure 2-3a. For two of the heel mixing scenarios (A→C and C→B), the maximum combined heels are 0.08 ML and 0.1 ML (8 in. and 10 in.) at a 90 percent success rate. The remaining scenarios have maximum combined heels larger than 0.21 ML (20 in.). All cases with a maximum combined heel of less than 0.21 ML (20 in.) are considered problematic.

Table 2-15 segregates the problematic cases according to heel mixing scenarios. For combined heels less than or equal to 0.21 ML (20 in.), one of the tanks in each pair is a tank whose envelope classification was determined to be borderline in Section 2.5 (specifically, 241-AP-101, 241-AP-102, 241-AP-103 and 241-AP-104). An important exception is the Envelope C → B switch, which is aggravated by the small volume of Envelope B feed batches.

2.6.3 Conclusions

As a guideline, reduce the number of the following envelope switches when possible: B → A, B → C, C → A and C → B.

It is not possible to specify a maximum combined heel volume that is small enough to avoid all potential heel mixing problems. However, a reasonable value for the combined heel can be specified so that: (1) most of the heel mixing scenarios are successful, (2) the individual heels are larger than each tanks minimum operating volume (0.06 ML [6 in.] per requirement A3.2), and (3) can be easily achieved using an appropriate pump (0.1 ML [10 in.] per assumption A7.6).

Figure 2-3. Heel Mixing Results Using Projected Compositions.

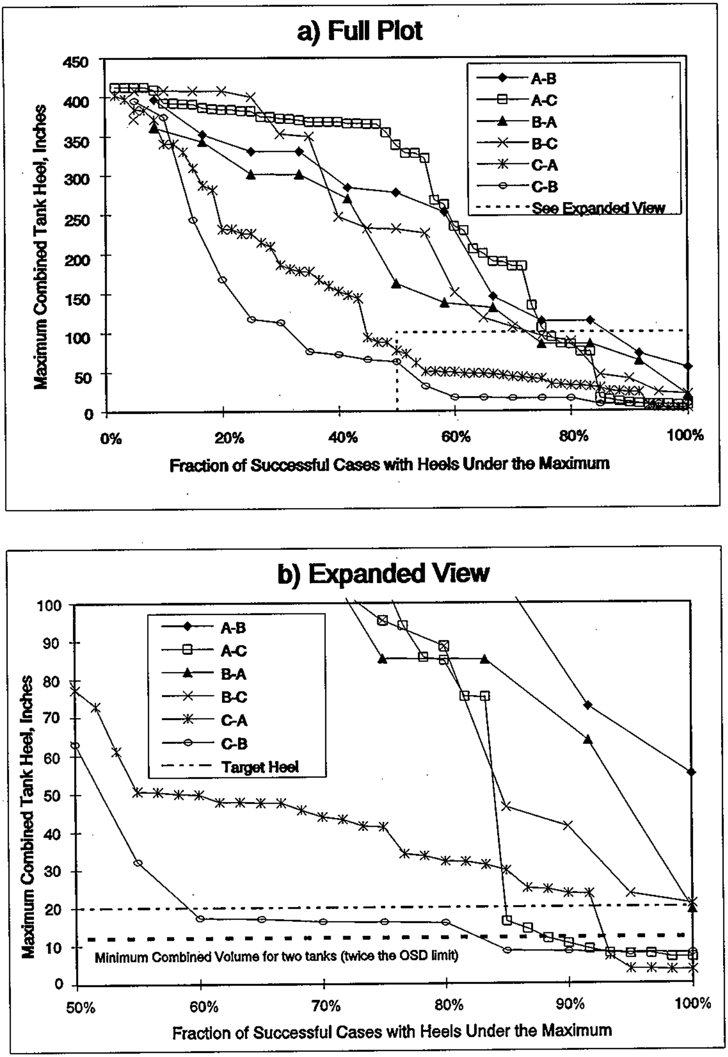


Table 2-15. Problematic Heel Mixing Scenarios Using Projected Compositions.[a]

Heel Mixing Scenario Heel Envelope → New Envelope										
A → B	A → C		B → A		B → C		C → A		C → B	
none	241-AP-106	241-AP-101	241-AY-101	241-AP-104	241-AY-101[b]	241-AP-101	241-AN-102	241-AP-104	241-AN-107	241-AY-101
	241-AP-106	241-AP-102					241-AN-107	241-AP-104	241-AP-107	241-AY-101
	241-AN-103	241-AP-101					241-AP-107	241-AP-104	241-AN-106	241-AY-101
	241-AN-103	241-AP-102					241-AN-106	241-AP-104	241-AP-105	241-AY-101
	241-AN-104	241-AP-101					241-AP-105	241-AP-104	241-AN-102	241-AP-103
	241-AN-104	241-AP-102							241-AN-107	241-AP-103
	241-AW-101	241-AP-101							241-AP-107	241-AP-103
	241-AN-105	241-AP-102							241-AN-106	241-AP-103
	241-AW-101	241-AP-102							241-AP-105	241-AP-103
	241-AN-105	241-AP-101								

General: Shaded cells indicate tanks that are borderline in their envelope classification. Within each heel mixing scenario, tanks are listed in order of decreasing maximum heels.

[a]Problematic heel mixing scenarios are those for which the maximum combined heel is less than 0.21 ML (20 in.).

[b]The maximum combined heel for this pair of tanks was 0.23 ML (22 in.).

For a combined heel of 0.21 ML (20 in.), most of the heel mixing scenarios using projected waste compositions should be successful. The heel calculations all assume that a full tank of feed is being batched. Maximum combined heels sizes must be reduced proportionally for smaller feed batches or the resulting increase in unsuccessful or problematic cases accepted.

The private contractors' feed tanks should contain only minimal heels of Envelope B or C whenever an envelope change will occur. A reasonable value for this heel is 0.1 ML (10 in.) of waste.

The intermediate feed staging tanks should contain only minimal heels of Envelope B or C whenever an envelope change will occur. A reasonable value for this heel is 0.1 ML (10 in.) of waste.

Most unsuccessful cases correspond to situations where one of the tanks contains waste that is only borderline within its envelope. These cases should be avoided if possible. The Envelope C → B scenario should also be avoided if possible. If not, other methods may be required for a successful envelope switch. For example, the heel in the intermediate feed staging tank could be flushed and transferred to the private contractors feed tank (or another DST) immediately after delivery of the bulk of the feed batch. The private contractor could also dilute the waste remaining in his feed tank near the end of the campaign.

The M&I contractor is required to *deliver* waste of the proper envelope, not to insure that the resulting mixture in the private contractors feed tank remains within envelope limits. None-the-less, it is prudent that the M&I's waste staging plan accounts for all heels to avoid tainting a batch of waste.

2.7 WASTE COMPATIBILITY

Before transfer of waste within the DST system (transfer is being used in the general sense and is not limited to the definition of 4.2.1.3 Transfer Managed Tank Waste), a series of decision rules must be reviewed. These rules are documented in Fowler 1995a and 1995b and consolidate requirements from many sources. These rules, or their successors will need to be verified before each staging transfer. The discussions in the following sections are a cursory review that attempt to identify potential problems that may interfere with the staging of feed. Results are summarized in Table 2-16.

2.7.1 Criticality Decision Rule

The rule for when the plutonium inventory[1] in the destination tank is less than 10 Kg will be satisfied if the total plutonium in the transfer is less than 15 g or the [Pu] in

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[1]Plutonium inventory is calculated using plutonium equivalents as defined in WHC 1994.

Table 2-16. Summary of Waste Compatibility Data Quality Objectives Evaluation.[a]

Rule → Tank name	Criticality[b] equiv Pu (g/L)	Flammable gas SpG	Energetics	Corrosion	Watch list or status (USQ)	TRU segregation[b] TRU nCi/g	Heat generation BTU/h	Complexant segregation CC waste?	Pumpability	Waste type	High PO_4
241-AN-101	0.002	1.10	Not Evaluated. Many DSTs have received organic wash waste from PUREX. This means that there could be soluble tributyl phosphate or separate phase PUREX-type solvent in the supernate in some DSTs.	OK		170.	20,000		Not evaluated. Insufficient waste characterization data (such as physical properties as a function of water or caustic dilution).	In General, all envelope switches may be problematic unless tanks that have been pumped down to the heels are considered empty.	
241-AN-102	0.001	1.38		OK		100.	17,000	Y			
241-AN-103	0.00006	1.50		OK	Y (USQ)	3.	30,000				
241-AN-104	0.0001	1.46		OK	Y (USQ)	8.	27,000				
241-AN-105	0.0001	1.46		OK	Y (USQ)	8.	26,000				
241-AN-106	0.	1.40		OK		0.	12				
241-AN-107	0.0004	1.33		OK		470.	16,000	Y			
241-AP-101	0.00004	1.28		OK		8.	11,000				
241-AP-102	0.	1.21		OK		0.	11,000				Y
241-AP-103	0.	1.01		OK		0.	7				
241-AP-104	0.	1.13		OK		0.	0				
241-AP-105	0.000002	1.40		OK		0.	6				
241-AP-106	0.000003	1.44		OK		0.	5				
241-AP-107	0.00005	1.40		OK		9.	6,000				
241-AP-108	0.	1.01		OK		0.	3				
241-AW-101	0.00002	1.51		OK	Y (USQ)	2.	21,000				
241-AW-103	0.	1.02		OK		0.	100				
241-AW-104	0.	1.01		OK	(USQ)	0.	0				
241-AW-105	0.	1.02		OK		0.	1				
241-AY-101	0.0003	1.21		OK	(USQ)	30.	74,000				
241-AY-102	0.	1.01		OK		0.	6				
241-AZ-101	0.0007	1.05		OK		430	4,000				
241-AZ-102	0.0007	1.01		OK		2.	1,000				
101-SY-SOL	0.00002	1.36		OK	Y (USQ)	9.	17,000	Y			
241-SY-102	0.	1.05		OK		0.	0				
103-SY-SOL	0.00004	1.26		OK	Y (USQ)	20.	15,000	Y			

[a]Shaded tanks are projected to contain excluded waste (not belonging to Envelopes A, B or C). Shaded table entries (other than tank name) indicate potential waste compatibility concerns. See appropriate section in report for details.

[b]Entrained solids were not considered in evaluating this rule. Entrained solids are likely to be the major contributors to Pu and TRU in the waste.

the source waste is less than 0.013 g/L (there are other ways to satisfy the criticality rule that are not being addressed here).

A review of the projected inventories for tanks 241-AP-102, 241-AP-104, 241-AP-106, and 241-AP-108 show the estimated plutonium inventory to be near zero. A review of the projected supernate/slurry inventories for each DST show that the maximum estimated equivalent [Pu] to be 0.002 g Pu/L and the maximum equivalent quantity of plutonium in any single transfer (not including entrained solids) is about 8,400 g plutonium. Table 2-16 lists the projected equivalent [Pu].

Another source of Pu that has not been evaluated is the entrainment of Pu bearing solids during retrieval and transfer. Also, the radionuclide inventory estimates upon which this assessment has been based are incomplete.

The criticality decision rule should not interfere with or otherwise influence staging of Phase I DST supernate unless entrained solids (which were not projected) contain significant quantities of plutonium.

2.7.2 Flammable Gas Accumulation Decision Rule

If the specific gravity of the source tanks is less than 1.3 or the weighted mean specific gravity of the resulting blend is less than or equal to 1.41, then the transfer may proceed. A detailed technical evaluation is required to transfer waste exceeding the specific gravity limit. The operative rule will require that the specific gravity of the source tank, plus any in-line dilution, be less or equal to 1.41 since most staging transfers will transfer the waste into a nearly empty tank.

The estimated supernate/slurry specific gravity of five of the tanks exceed the 1.41 SpG limit. All of these tanks (241-AN-103, 241-AN-104, 241-AN-105, 241-AP-106 and 241-AW-101) are needed to supply Envelope A feed. These five tanks will require dilution with water to satisfy the flammable gas rule (see Section 2.12 for estimated dilution water requirements). Table 2-16 shows the estimated specific gravity--tanks not belonging to any of the three feed envelopes have been shaded.

The specific gravity of the staged feed batches range from 1.21 to 1.37 (Appendix E). These values are acceptable.

2.7.3 Energetics

The waste must have no separable organic and the source and destination tanks must have endotherms in excess of exotherms. The energetics of the system are dependent on the organic speciation. A prediction of DSC and TGA behavior from the projected inventories is not recommended.

An emerging issue is that 22 DSTs received PUREX organic wash waste based on transaction records through January 1, 1994 (Agnew 1996). This means that there could be soluble tributyl phosphate or separate phase PUREX-type solvent in the supernate in some DSTs. Additionally, in 1985 B. M. Mauss observed that a surface sample from 241-AW-105 contained an organic phase (Herting 1990). The DSTs identified in Agnew's report include 241-AN-101 through 241-AN-107, 241-AP-101 through 241-AP-103, 241-AP-105, 241-AP-106, 241-AP-108, 241-AW-101, 241-AW-102, 241-AW-105, 241-AW-106, 241-AY-101, 241-AZ-101, 241-AZ-102, 241-SY-101, and 241-SY-103. Some of these are candidate tanks for privatization Phase I feed.

2.7.4 Corrosion Decision Rule

The decision rule provides three sets of relationships between [NO_2^-], [NO_3^-] and [OH^-] that must be satisfied (the [OH^-] is relaxed when the temperature is less than 167 °F). The set in use depends upon the [NO_3^-]. All of the projected supernate/slurry compositions satisfy the decision rule. The predicted staged waste compositions in Appendix E also satisfy the corrosion specifications (solid/liquid equilibria has not been considered). If significant quantities of solids precipitate during staging, chemical additions may required to prevent the precipitation or maintain waste within the corrosion specifications.

This rule should not interfere with feed staging plans, but may influence chemical additions.

2.7.5 Watch List Tanks Decision Rule

This rule restricts the transfer of waste into a watch list tank without DOE approval. Staging of DST supernate does not require transfer of waste into current watch list tanks.

Currently, six DSTs are on the watch list (Hanlon 1996). They are 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, 241-SY-101, and 241-SY-103 (See Table 2-16). The supernate from all but 241-SY-101 and 241-SY-103 is used for Envelope A feed.

Currently, eight DSTs are associated with a flammable gas unreviewed safety question (USQ). These tanks are 241-SY-101, 241-SY-103, 241-AW-101, 241-AW-104, 241-AN-103, 241-AN-104, 241-AN-105, and 241-AY-101 (See Table 2-16). For all practical purposes, these tanks are treated as if they were on the watch list. Supernate from tanks 241-AW-101, 241-AN-103, 241-AN-104, and 241-AN-105 is used for Envelope A feed. The safety and administrative issues associated with the watch list designation or USQ should be reviewed to understand (and plan to avoid) potential impacts on feed staging activities.

2.7.6 Transuranic Segregation Rules

This rule requires that waste with a [TRU] ≥100 nCi/g be transferred to a TRU storage tank. Otherwise the waste must be transferred to a non-TRU tank unless an analysis demonstrates that TRU segregation will not be jeopardized. The definition of TRU is "without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay" (DOE 1988). Decay mode and half-lives were obtained from Walker 1977.

The estimated [TRU] exceeded the rule limit for three tanks (241-AN-101, 241-AN-107, and 241-AZ-101). Tank 241-AN-102 was within 5 percent of the limit; the rest were well within the limit. Table 2-16 shows the estimated [TRU] - tanks not belonging to any of the three feed envelopes have been shaded.

As with the criticality rule, there is potential for higher [TRU] due to inadvertent or intentional entrainment of sludges during retrieval and transfer. The radionuclide inventory estimates upon which this assessment has been based are not definitive.

Staging of supernate from 241-AN-102 and 241-AN-107 (Envelope C) will require an analysis that determines that TRU segregation will not be jeopardized.

2.7.7 Heat Generation Rate Rule

This rule requires that the heat generation rate in each AP-Farm tank must be less than or equal to 70,000 BTU/h.

The heat generation rates for all projected supernate/slurry inventories were less than 70,000 BTU/h with the exception of 241-AY-101 at 74,000 BTU/h. This waste fits into Envelope B as is (no dilution or concentration required). The heat generation limit will be satisfied since the 241-AY-101 supernate is split into several batches.

2.7.8 Complexant Waste Segregation Rule

This rule requires transfer of complexant waste to a complexant waste receiver tank. Complexant waste is defined as waste with a mean [TOC] > 10 g/L at the double-shell slurry feed composition (Fowler 1995b). Waste classified as Envelope C is expected to meet the definition of complexant waste since the minimum [TOC]/[Na] limit for Envelope C was estimated from this rule.

Envelope C supernate can not be staged unless the intermediate feed staging tanks and the private contractor's feed tanks are temporarily designated as complexant waste receiver tanks.

2.7.9 Waste Pumpability Rule

The rule requires that N_{Re} for the transfer line be greater than or equal to 20,000 and the volume percent solids less than or equal to 30. The N_{Re} limit has been used as one of the measures in the transfer systems upgrades analysis (Galbraith et al. 1996).

This rule has not been evaluated on a case-by-case basis for the feed staging transfers since physical properties as a function of water (or dilute caustic) dilution are not known. It was assumed that the dilution of the waste to 7*M* [Na] will satisfy this rule (Appendix A, Assumption A7.13).

2.7.10 Tank Waste Type

The rule provides a compatibility matrix for mixing of wastes of different types. The matrix must be followed to the extent practicable. To successfully stage DST supernate, this rule must permit mixing a heel of "incompatible" waste with the feed being staged. A heel of Envelope C waste (CC) can not be mixed with Envelope A waste (most often DSSF/DSS). A heel of Envelope B waste (mostly NCAW) can not be mixed with CC or DSSF/DSS. A heel of CP (CP is currently in 241-AP-102) can not be mixed with DSSF/DSS or CC.

Generally, this rule prevents switching waste envelopes unless "to the extent practicable" permits mixing of an "incompatible" heel. Current practice is to treat tanks that have been pumped down to the heels as empty for the purposes of this rule. The interpretation and intent of this rule should be documented well in advance of feed staging activities. If technically justified, an exception or deminimus limit should be explicitly provided.

2.7.11 High Phosphate Waste

This rule prevents mixing waste with $[PO_4^{-3}] > 0.1M$ with waste containing a $[Na^+] > 8M$. The projected supernate composition of the waste in 241-AP-102 contains a $[PO_4^{-3}]$ of 0.122*M*. This waste is initially moved out of the way. As long as the initial batch of feed transferred to 241-AP-102 is retrieved at 7*M* $[Na^+]$, this rule will not be challenged.

The concentrated phosphate waste in 241-AP-102 was transferred from 241-AN-106. There was a significant layer of crystals remaining on the 241-AN-106 tank walls. The crystals were discovered during the transfer between 241-AN-106 and 241-AP-102 when the transfer exceeded material balance limits. Crystal formation was confirmed using in tank photography. It is prudent to empty 241-AP-102 as soon as possible so that the tank can be inspected for the presence of solids.

2.8 ENVELOPE ORDER

The envelope order provided by the RFP (Envelope A, B, then C) is workable provided:

- The potential waste compatibility issues identified in Section 2.7 are resolved.
- The intermediate staging tanks and the private contractors' feed staging tanks are emptied to near the 0.1 ML (10-in.) maximum heel as recommended in Section 2.6.

The RFP does not specify the envelope order during the extension. The order provided by Assumption A4.7 (Appendix A) appears reasonable. The following guidelines should be considered when (if) changing this order:

- The number of times that waste envelopes are switched should be kept as small as practicable.
- Heels of Envelope B or C waste are significantly more likely to cause the following feed batch (of a different envelope) to fall out-of-specification than the same size heel of Envelope A waste.
- Envelope switches involving waste that barely meets the envelope limits are problematic and should be avoided if possible.
- The Envelope C → B switch should be avoided if possible.
- Feed batches that are limited in size (by either RFP requirements or a lack of sufficient waste) require a proportionately smaller heel.
- The envelope classification of all proposed feed batches should be verified after accounting for the presence of tank heels.

2.9 RETRIEVAL CONSIDERATIONS

The retrieval requirements for providing feed to the privatized LAW contractors, presented herein, are limited to the identification of the general types of equipment. This information is one of the factors considered in developing the DST processing sequence (Section 2.11).

2.9.1 Double-Shell Tanks Identified for Phase I LAW Feed

Tanks scheduled for use as Phase I LAW Feed (See Section 2.11.2) are shown in Table 2-17. This table lists the DSTs, the projected waste type, and the associated waste envelope. The targeted fraction (for retrieval and processing) of the tank is identified along with dilution needs. The fraction of waste excluded as feed (and therefore retrieval) is also identified. For this analysis, DSSF waste is considered to be a slurry, even though the amount of undissolved salt may be small. Dilution is required, either to meet transfer density/viscosity requirements, to satisfy the flammable gas rule, or to insure that major sodium salts are dissolved and available for feed. Sludge is considered the insoluble oxide layer settled on the tank bottom.

Table 2-17. Feed Scheduled for and Excluded from Phase I Low-Activity Waste Processing.[a]

Tank[b]	Waste type	Waste envelope	Dilution required	Target feed	Excluded waste
241-AN-104[c]	DSSF	A	Yes	3.02 ML DSSF	1.00 ML Sludge
241-AW-101[c]	DSSF	A	Yes	3.94 ML DSSF	0.32 ML Sludge
241-AN-105[c]	DSSF	A	Yes	4.29 ML DSSF	---
241-AN-103[c]	DSS	A	Yes	3.62 ML DSS	---
241-AP-104	DN	A	No	4.22 ML Supernate	---
241-AP-106	DSSF	A	Yes	4.10 ML DSSF	---
241-AY-101	NCAW	B	No	4.18 ML NCAW Supernate	0.31 ML Sludge
241-AN-107	CC	C	Yes	3.68 ML CC	0.51 ML Sludge
241-AN-102	CC	C	Yes	3.84 ML CC	0.34 ML Sludge
241-AN-106	CC	C	Yes	4.00 ML CC	0.05 ML Sludge
241-AP-107	CC	C	Yes	4.10 ML CC	---

[a]This table summarizes information from Table 2-21.
[b]Tank contents are projected through FY 2002.
[c]Watch list tanks.

2.9.2 Retrieval Equipment

The target feed, dilution requirements, and excluded waste provide enough information to broadly identify the types of equipment and the operations required to effect the retrieval. Table 2-18 describes the types of equipment required beginning with the least difficult or complicated retrieval and finishing with the most difficult. This table can be used as a planning basis while appropriate engineering studies rigorously determine the retrieval equipment and dilution control system needs. Tank specific issues are discussed below:

241-AP-104

This tank content projection is of low quality. The only reason this waste is processed is because it is needed to meet the minimum order quantities of Envelope A. The equipment for this tank will be driven by the use of this tank as an intermediate staging tank, not by its projected contents (see Section 2.10.4).

241-AN-106

Retrieval equipment needs may change because the tank contents projection is of low quality. The location of this waste, even if used as feed, may also change.

241-AP-106

Retrieval equipment needs may change because the tank contents projection is of low quality. The location of this waste, even if used as feed, may also change.

241-AN-104

This tank is on the watch list as a flammable gas generator. An analysis is required to determine how well a slurry distributor[1] can mobilize the targeted feed without retrieving the excluded sludge. Two possible answers, at opposite extremes are (1) the slurry distributor is not needed to retrieve the targeted feed or (2) a mixer pump is needed along with settling and decanting of the feed in the intermediate staging tanks.

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[1]A slurry distributor directs waste entering a tank to different areas to avoid buildup of solids under the riser. In this application, it will be used to recirculate diluted waste to different areas in the tank to assist with mobilization of the pretreated feed.

Table 2-18. Retrieval Equipment Planning Basis.

<table>
<tr><th>Targeted feed</th><th>Excluded waste</th><th>Dilution[c]</th><th>Tank[a]</th><th>Equipment/requirement[b]</th></tr>
<tr><td>Supernate</td><td>No</td><td>No</td><td>241-AP-104[d]</td><td rowspan="2">Supernate decant pump with inlet approximately 0.1 ML (10 in.) above the tank bottom or sludge layer, whichever is higher. Transfer line equipped with instrumentation for monitoring flow, pressure, density, temperature and viscosity. A return leg is provided to recirculate the waste back to the tank if the instrumentation reveals that the waste does not meet transfer system limits.</td></tr>
<tr><td>Supernate</td><td>Yes</td><td>No</td><td>241-AY-101</td></tr>
<tr><td rowspan="4">Supernate</td><td rowspan="4">Yes</td><td rowspan="4">Yes</td><td>241-AN-107</td><td rowspan="4">Supernate decant pump with inlet approximately 0.1 ML (10 in.) above the tank bottom or sludge layer, whichever is higher. Transfer line equipped with instrumentation for monitoring flow, pressure, density, temperature and viscosity. A return leg is provided to recirculate the waste back to the tank if the instrumentation reveals that the waste does not meet transfer system limits. In-line water dilution capability.</td></tr>
<tr><td>241-AN-102</td></tr>
<tr><td>241-AN-106</td></tr>
<tr><td>241-AP-107</td></tr>
<tr><td rowspan="2">DSSF</td><td rowspan="2">No</td><td rowspan="2">Yes</td><td>241-AN-105</td><td rowspan="2">300-hp mixer pumps (2 for 241-AN-105, 1 for 241-AP-106). Slurry transfer pump with inlet approximately 0.1 ML (10 in.) above the tank bottom. Transfer line equipped with instrumentation for monitoring flow, pressure, density, temperature and viscosity. A return leg is provided to recirculate the waste back to the tank if the instrumentation reveals that the waste does not meet transfer limits. In-line water dilution capability.</td></tr>
<tr><td>241-AP-106[e]</td></tr>
<tr><td rowspan="2">DSSF</td><td rowspan="2">Yes</td><td rowspan="2">Yes</td><td>241-AN-104</td><td rowspan="2">Slurry transfer pump with inlet approximately 0.1 ML (10 in.) above the tank bottom. Transfer line equipped with instrumentation for monitoring flow, pressure, density, temperature and viscosity. A slurry distributor on the return leg is provided to recirculate the waste back to the tank both to mobilize the waste and recirculate waste not meeting transfer limits. In-line water dilution capability.</td></tr>
<tr><td>241-AW-101</td></tr>
<tr><td>DSS</td><td>No</td><td>Yes</td><td>241-AN-103</td><td>Two, 300-hp mixer pumps. Slurry transfer pump with inlet approximately 0.1 ML (10 in.) above the tank bottom or mobilized solids level. Transfer line equipped with instrumentation for monitoring flow, pressure, density, temperature and viscosity. A return leg is provided to recirculate the waste back to the tank if the instrumentation reveals that the waste does not meet transfer limits. In-line water dilution capability. Incremental insertion of the mixer pumps may be required.</td></tr>
</table>

[a]Shaded tanks contain waste with low quality projections. Their composition and identities are likely to change.

[b]All equipment requirements are subject to change upon further evaluation and 241-AZ-101 process test. Those in italics are speculative.

[c]An analysis is required for all tanks requiring dilution water to determine the amount of dilution needed to satisfy transfer system requirements, the flammable gas waste compatibility rule, and to dissolve soluble salts. The analysis should also determine if the dilution requires addition of caustic to prevent the precipitation of gibbsite or other solids.

[d]This applies only to the initial emptying of 241-AP-104. The equipment for this tank will be driven by its use as an intermediate staging tank (see Section 2.10.4)

[e]Waste requiring dilution or mixer pumps to remove should not be placed in 241-AP-106 before start of feed staging activities, as does the current projections.

241-AW-101

This tank is on the watch list as a flammable gas generator. An analysis is required to determine how well a slurry distributor can mobilize the targeted feed without retrieving the excluded sludge. Two possible answers, at opposite extremes are (1) the slurry distributor is not needed to retrieve the targeted feed or (2) a mixer pump is needed along with settling and decanting of the feed in the intermediate staging tanks.

241-AN-103

This tank is on the watch list as a flammable gas generator. The waste in 241-AN-103 has a measured shear strength that indicates that two 300 hp mixer pumps will achieve only 51 percent retrieval (Grams 1995). Analysis should be conducted to look

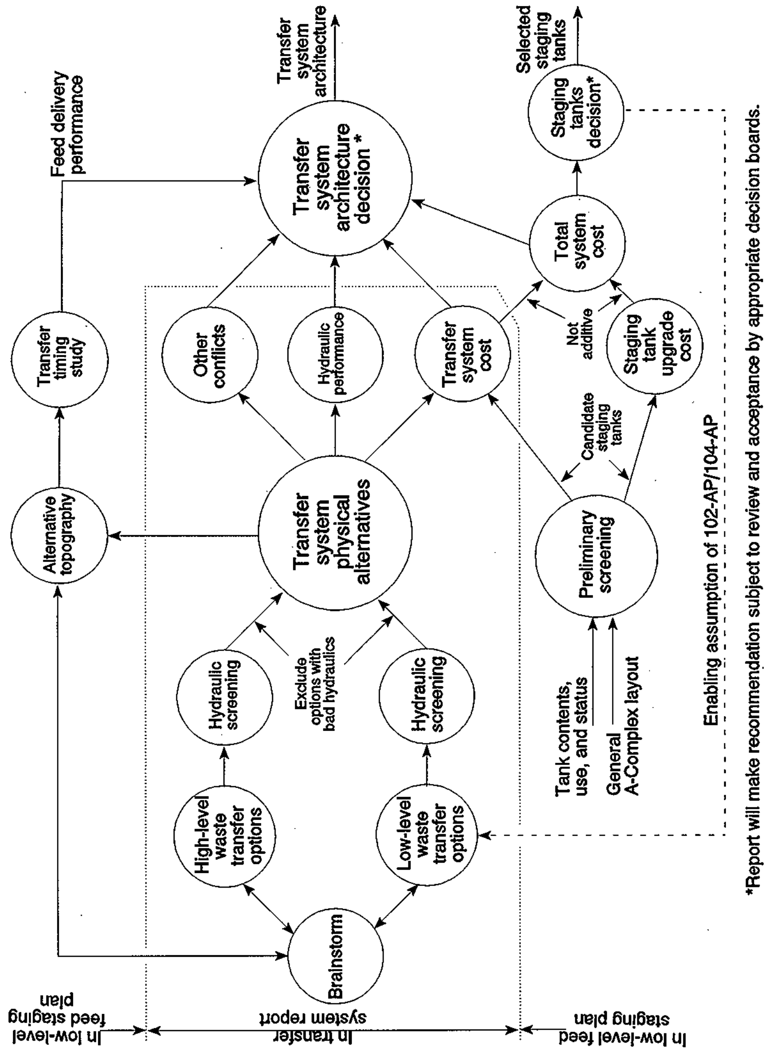
at dilution, incremental insertion of mixer pumps, and possibly use of the sonic probe to enhance mobilization to maximize retrieval.

2.10 TRANSFER SYSTEM AND STAGING TANK UPGRADES

Figure 2-4 is the influence diagram for the transfer system upgrades decision and the allocation of two DSTs as intermediate feed staging tanks. The decision statements and decision criteria for each decision are as follows:

- Which two DSTs should be allocated for use as intermediate LLW feed staging tanks?
    - The cost to upgrade the two DSTs and transfer system
    - Complications due to existing tank contents
    - Potential for transfer conflicts with non-modeled activities (such as 242-A Operations.
- What type of A-Farm Complex waste transfer system upgrades will be required to support the staging of LLW and HLW for Phase I privatization, as well as routine waste management transfers?
    - Hydraulics (Re_d, flow rate, line pressure)
    - Transfer System Upgrade Cost
    - Potential for conflicts with non-modeled transfers
    - Ability to deliver HLW and LLW feed batches according to RFP timing requirements.

Figure 2-4. Transfer System Upgrades and Intermediate Staging Tank Allocation Influence Diagram.



2.10.1 Intermediate Staging Tank Allocations

This section describes the selection of two DSTs for use as intermediate staging tanks so that the *Indirect Staging--ASAP* strategy can be implemented. This decision interacts with and can not be fully separated from the selection of which transfer route upgrades are needed to support LAW Feed Staging, HLW Feed Staging and other tank farm operations.

The following are operative measures for this decision:

1. Complications due to existing tank contents, intended use, or status
2. Potential for transfer conflicts
3. Cost of upgrading DSTs and Transfer System.

Measures (1) and (2) were used as a preliminary screening to exclude tanks from further consideration. Tanks 241-AP-101, 241-AP-102, 241-AP-103, 241-AP-104, 241-AP-105, and 241-AP-107 passed the preliminary screening (see Table 2-19).

It is desirable to avoid using tanks containing concentrated waste or large volumes of solids for LAW feed staging. Removal of concentrated waste will require large amounts of dilution water that will increase the tank space demands at a time when tank space is scarce. Large amounts of solids will need to be removed to provide working volume for staging and to avoid changing the composition of the staged waste. Tanks that have been designated for specific purposes (such as evaporator feed) should be avoided. A tank being on the Watch List is probably sufficient cause to avoid selecting the tank as an intermediate staging tank. However, Watch List tanks always had other factors that were sufficient to exclude the tank from further consideration.

To consistently deliver feed within the 30 days of the waste transfer date, the final staging transfer must be quick to setup and must avoid delays due to conflicting transfers. The further from AP-Farm the intermediate staging tanks are located, the more valving operations and potential jumper changes are required to set up the transfer. This also increases the chance that the transfer will conflict with other activities. Selection of west area DSTs would require frequent cross-site transfers both into and out of the staging tanks.

Rigorous evaluation of measure (3), the cost of upgrading DSTs and transfer system, is complicated because of the interaction between the selection of the staging tanks decision and the transfer system upgrades decision (see Figure 2-4). It turns out that the selection of the intermediate staging tanks (based upon the relative total system upgrade cost) is independent of both the measures from the timing study and the transfer feasibility as determined by the hydraulic analysis. This permits the intermediate staging tanks to be selected using a qualitative analysis.

Table 2-19. Preliminary Selection of Intermediate Staging Tanks.

Tank	Waste type	Supernate volume (ML)	Solids volume (ML)	Why Excluded
241-AN-101	DN	4.09	0.00	Potential transfer conflict.
241-AN-102	CC	3.76	0.34	Tank contents. Potential transfer conflict.
241-AN-103	DSS	0.07	3.55	Tank contents. Potential transfer conflict. WL.
241-AN-104	DSSF	3.01	1.00	Tank contents. Potential transfer conflict. WL.
241-AN-105	DSSF	4.27	0.00	Tank contents. Potential transfer conflict. WL.
241-AN-106	DSSF	1.51	0.06	Potential transfer conflict.
241-AN-107	CC	3.49	0.51	Tank contents. Potential transfer conflict.
241-AP-101	DSSF	2.79	0.00	
241-AP-102	CP	4.16	0.00	
241-AP-103	DN	0.09	0.00	
241-AP-104	DN	4.26	0.00	
241-AP-105	DSSF	0.58	0.00	
241-AP-106	DN	0.41	0.00	Private contractor feed tank.
241-AP-107	DN	0.09	0.00	
241-AP-108	DN	0.11	0.00	Private contractor feed tank.
241-AW-101	DSSF	3.95	0.32	Tank Contents. WL.
241-AW-102	DN	0.35	0	Evaporator Feed Tank
241-AW-103	DN/PD	0.56	1.37	Tank contents (TRU solids)
241-AW-104	DN	3.16	1.10	Tank contents.
241-AW-105	DN/PD	0.36	1.12	Tank contents (TRU solids)
241-AW-106	DN	0.91	0.80	Evaporator Slurry Tank.
241-AY-101	DC	3.22	0.31	Tank contents. Aging waste. Potential transfer conflict.
241-AY-102	DN	2.62	0.12	Tank contents. Aging waste. Potential transfer conflict.
241-AZ-101	AGING	3.34	0.13	Tank contents. Aging waste. Potential transfer conflict.
241-AZ-102	AGING	3.25	0.36	Tank contents. Aging waste. Potential transfer conflict.
241-SY-101	CC	0.07	4.12	Tank contents. Cross-site. WL.
241-SY-102	DN/PT	1.17	0.27	Tank contents (TRU solids). Cross-site.
241-SY-103	CC	0.63	2.18	Tank contents. Cross-site. WL.

CC = Complexed concentrate
DN = Dilute non-complexant waste
DN/PD = Dilute non-complexant waste/Plutonium-Uranium Extraction decladding waste
DN/PT = Dilute non-complexant waste/transuranic solids from Plutonium Finishing Plant operations.
DSS = Double-shell slurry
DSSF = Double-shell slurry feed
TRU = Transuranic
WL = Watch List Tank
Tank data obtained from Hanlon 1996.
Shaded tanks are excluded from further consideration.

The relative cost of upgrading the intermediate staging tanks is driven primarily by the cost of the electrical upgrades for the mixer system pump and the installation of a new transfer pump pit. Tank 241-AP-102 has both of these upgrades installed; however, the mixer pump has failed. Tank 241-AP-104 has the electrical upgrades in place and a design for the transfer pump pit. Tanks 241-AP-101, 241-AN-103, 241-AP-105, and 241-AP-107 have neither upgrade installed or designed.

The comparative cost of the transfer system upgrades will be driven primarily by the difficulty in routing transfer lines to the selected tanks, if new lines are required. If the existing transfer system in AP-farm is found adequate, then the transfer system upgrade costs are the same regardless of which tanks are chosen for intermediate staging. If new transfer lines are required, the upgrade cost is related to amount of new line and the number of obstacles (other buried lines) that must be crossed. Examination of the physical layout of AP-Farm (see Galbraith et al. 1996) show the following comparative costs (least to most expensive): 241-AP-102/241-AP-104, 241-AP-101/241-AP-102, 241-AP-101/241-AP-104, 241-AP-101/241-AP-103, 241-AP-103/241-AP-104 followed by any combination using 241-AP-105 or 241-AP-107.

Since both tanks upgrade costs and transfer system upgrade costs favor the selection of 241-AP-102 and 241-AP-104, no trade-offs are needed. The actual costs for each do not need to be calculated and compared. Therefore, it is recommended that tanks 241-AP-102 and 241-AP-104 be used as the two intermediate LAW staging tanks.

The decision to accept this recommendation is documented in the *Decision Document for Phase I Privatization Transfer System Needs* (Galbraith et al. 1996).

2.10.2 Transfer System Cost Benefit

The *Decision Document for Phase I Privatization Transfer System Needs* (Galbraith et al. 1996) developed four LLW transfer systems and four HLW transfer system alternatives for a total of 16 combinations. Four of these combinations were excluded due to unacceptable hydraulics. The remaining 12 alternatives were evaluated in terms of hydraulic performance, transfer system cost, and potential for non-modeled transfer conflicts. A fourth measure (or benefit), the ability of the transfer system to deliver HLW and LLW feed batches according to the timing requirements in the RFP, is needed to perform the cost-benefit analysis of the transfer system alternatives. The determination of this benefit is summarized in Section 2.10.3, LLW and HLW Feed Delivery Timing Study, and discussed in more detail in Appendix E.

In general, the cost benefit plots show that alternatives [F, H], [B, K], I, and [L and D] dominate the others (they are cheapest for any given level of performance) and keep the same rankings with respect to both cost and benefit. Alternatives grouped within brackets [] have the same cost and benefit. The dominant alternatives are listed in order of increasing cost and benefit: F and H are the least expensive and poorest performers, while L and D are the most expensive and best performers. Diagrams of the dominant physical alternatives are included in Appendix H.

Table 2-20 compares the dominant alternatives after discarding alternatives with marginal hydraulics whenever there was another of equal cost and performance with good hydraulics. Based upon these trades, the decision makers recommended that Alternative K be adopted (Galbraith et al. 1996).

Table 2-20. Transfer System Upgrades Trade-Offs.

Alternative[a]		Option		Cost $ millions	Re_d marginal	Conflict potential[b]
Physical	Conflict diagram	Low-level waste	High-level waste			
L	3	4	4	13.2		
I	2d	2	4	10.1	✓	✓
▸ K	2b	4	3	7.8		
H	2c	2	3	4.7		✓

[a]Listed in decreasing order of dynamic performance and robustness.

[b]This refers to the potential for conflict with other tank farm activities that were not included in the feed delivery model. All alternatives have a similar potential for conflicts with the 242-A Evaporator when receiving waste from AW Farm.

2.10.3 Low-Level Waste and High-Level Waste Feed Delivery Timing Study

The ability of the 12 transfer system alternatives that passed the initial hydraulic screening to deliver HLW and LLW feed to the private contractors according to the timing requirements in the RFP was estimated using a computer model. Full details of the model and results are discussed in Appendix E.

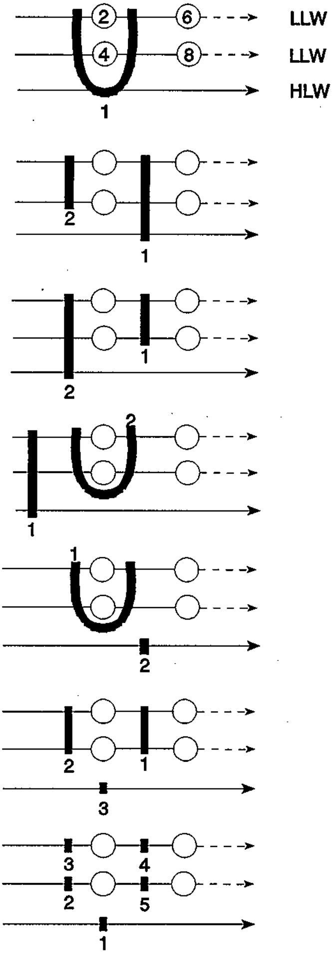
Alternatives

Each of the 12 transfer system *physical* alternatives has a particular topography. The topography of the system defines which transfers conflict with each other, which in turn determines the ability of the system to deliver feed on time. Figure 2-5 shows the five conflict diagrams and their mapping to the physical alternatives. The physical system alternatives and options are fully defined in Galbraith et al. (1996) and will not be explained here. For convenience, diagrams of the dominant physical alternative are included in Appendix H.

The transfer conflicts resulting from each alternative topography and their mapping to the physical system configurations are shown in Figure 2-5. In each alternative, the two left-most circles represent the two intermediate feed staging tanks (241-AP-102 and 241-AP-104). The two right-most circles represent the two private contractor feed tanks (241-AP-106 and 241-AP-108). The lines represent transfer pathways. The two dotted lines are provided by the private contractors and not included in this analysis. The remaining five transfer pathways are within the scope of this analysis. A heavy black stripe that touches one or more transfer pathways indicated that they are on a common node. This means that these transfers conflict with each other--only one transfer (setup and actual pumping) may occur at a time for a given node.

Figure 2-5. Transfer System Alternatives.

Conflict Diagram / **Physical Systems**



Conflict Diagram	Alternatives	Option LLW	Option HLW
1	E	1	2
	A	2	2
2a	C	3	2
	J	4	2
2b	K	4	3
	B	3	3
2c	F	1	3
	G	1	4
	H	2	3
2d	I	2	4
3	D	3	4
	L	4	4
5	No physical alternative generated		

The alternatives are named after the number of nodes, with a small letter being used to distinguish between the four 2-node alternatives. The small numbers next to each node are used to distinguish between the nodes within a specific alternative.

For example, the 1-node alternative corresponds to physical alternatives E (comprised of LLW option 1 and HLW option 2) and A (comprised of LLW option 2 and HLW option 2). In the 1-node alternative, all five transfers conflict with each other (as indicated by the black stripe touching all five transfer paths), therefore only one of these transfers may take place at a given time.

The 5-node alternative does not correspond to any of the physical systems that were studied (Galbraith et al. 1996). Its purpose is to provide a control in which there are no transfer conflicts. The 5-node alternative represents the best that the system can perform for any given set of assumed parameter distributions. This alternative can also be used to compare the results in feed staging strategy analysis in the Preliminary LLW Feed Staging Plan (Certa et al. 1996).

Summary of Results, Conclusions, and Caveats

The success rate (fraction of simulation cases in which feed is staged within the 30-day feed delivery window) is the discriminating measure between the alternative transfer systems. The success rate for different alternatives typically spans about 15 percentage points for any given case. The root-mean-square (RMS) success rate was used. The LAW results were weighted twice that of the HLW results to account for the assumption that there will be two LAW plants and one HLW plant operating during Phase I.

In general, the relative performance of the alternatives is nearly the same for all sensitivity cases. The fewer transfer conflicts, the better the performance. Transfer conflicts with the final feed staging transfers are more critical than those with the intermediate feed staging transfers.

In general, the robustness of the alternatives to changes in assumptions follows their performance (the better performing alternatives perform better under most conditions).

The behavior of the system is driven by the assumed transfer setup times. The performance of the transfer system can be significantly improved if the maximum time to setup all transfers is kept at or below about 25 days and the median time about 2 days. This will require, at the least, insuring that a failed pump or jumper can be repaired or replaced under typical (often windy) weather conditions within 25 days.

The estimated values for outage, contingency, successful cases and feed availability efficiency are dependent upon the assumed parameter distributions, especially the assumed transfer setup times. Decisions should not be made solely on the absolute value of these measures, but upon the relative performance of the alternatives.

To avoid increasing the length of the LAW outage, the LAW campaign length should be kept greater than 100 days. This corresponds to 200 MT sodium in a feed batch.

2.10.4 Intermediate Staging Tank Upgrades

Tanks 241-AP-102 and 241-AP-104 will require upgrades to support their use as intermediate feed staging tanks. The upgrades are driven by feed makeup requirements, feed verification requirements, feed delivery requirements and the assumption that the system should be able to deal with anticipated problems.

The upgrades should provide the following capabilities (those in *italics* are either needed to reduce the program risk due to insufficient data, mitigate anticipated problems or otherwise require further validation; all other are needed to support baseline operations). This scope of work will probably be performed by W-211 initial DST retrieval systems.

Feed Makeup Requirements

- Receive a batch of waste transferred from one or more source DSTs via the recommended transfer system upgrade Alternative K (See Galbraith et al. 1996, LLW Option 4, HLW Option 3).

Feed Makeup and Verification Requirements

- Mix the waste to:
  - Blend waste from two or more source DSTs.
  - *Dissolve soluble salts that did not dissolve during retrieval and transfer from the source DSTs.*
  - *Dissolve solids such as gibbsite that may have precipitated during retrieval and transfer.*
  - *Support chemical adjustment of the waste with NaOH, $NaNO_2$, $NaNO_3$, and H_2O.*
  - Support sampling protocol.

The time allocated for mixing should be consistent with the feed delivery study (Appendix E) and require no more than 14 days with a median value of 7 days or an equivalent distribution.

Feed Verification Requirements

- Take the proper number, location, and type of samples to:
  - Insure that the waste composition meets envelope requirements.
  - Satisfy regulatory requirements, if any, for delivery of feed to the private contractors.
  - Satisfy the OSD and waste compatibility DQO for transfer and storage of waste in the intermediate staging tanks.
  - Establish the official composition of the waste for assessing the private contractor's performance.
  - Establish the quantity of sodium delivered to the private contractor.

The time needed to obtain samples and deliver them to the laboratory should be consistent with the feed delivery study (Appendix E) and require no more than 5 days with a median value of 2 days or an equivalent distribution.

Feed Delivery Requirements

- Transfer the supernate and insoluble solids (if the solids content and composition is acceptable) to the private contractor's feed tank. Transfer setup time should be consistent with the feed delivery study's recommended case (Appendix E) or equivalent distributions. This requires no more than 25 days to setup, including the time needed to repair or replace failed jumpers or pumps. Half of the time the transfer should be setup within one day. The transfer pump rate should be 0.76 ML/day (140 gal/min).

- Decant and transfer the supernate to the private contractors feed tank leaving all or some of the solids behind. The time needed to settle out entrained solids should be no longer than 30 days. Transfer setup time should be consistent with the feed delivery study's recommended case (Appendix E) or equivalent distributions. This requires no more than 25 days to setup, including the time needed to repair or replace failed jumpers or pumps. Half of the time the transfer should be setup within one day. The transfer pump rate should be 0.76 ML/day (140 gal/min).

- The feed delivered to the private contractor's feed tank shall have no more than five volume percent of insoluble solids as determined by Method 2540F, Settleable Solids (Greenberg et al. 1992).

- Follow each feed delivery transfer with a line flush of 1.5 line volumes.

- After delivery of a feed batch to the private contractors, the liquid heel remaining in the intermediate staging tanks should be no more than 0.1 ML (10 in.) of waste.

- *Transfer the entire tank's contents (excluding the heel) to another DST if the waste is out-of-specification and must be removed or set aside for later disposition.*

- *Remove problematic (due to quantity, composition or physical properties) solids that were intentionally or inadvertently retrieved and transferred from the source DSTs or that precipitated during or after the transfer. These solids would be transferred to another DST for future processing.*

- *Provide for a flush or other means to remove or dilute a potentially problematic supernate heel before switching feed envelopes.*

The specific architecture needed to implement these requirements has not been selected. For planning purposes, the following architecture should be assumed for each intermediate staging tank, pending completion of a engineering study for the upgrades of 241-AP-102 and 241-AP-104. The study will be issued in September 1996 as the *Phase I Intermediate Feed Staging Tank Upgrade Requirements Study*. Only major equipment is called out--all ancillary and interfacing equipment is implied.

- One 300 hp mixer pump installed in the central 107-cm (42-in.) riser.

- One deep-well turbine flex and float pump. The pump should be able to leave a liquid heel between 0.06 ML and 0.1 ML (6 in. and 10 in.).

- A connection that can be used to hook-up a skid mounted chemical makeup or addition system. This can be shared between both intermediate staging tanks.

- A turbidity sensor or other means to detect when excessive solids are being entrained in feed being delivered to the private contractors feed tanks.

- Provisions for pulling up 2 to 6 grab samples (250 ml each) using existing sampling methodology and equipment for each feed batch if well mixed, otherwise 4 to 28.

- A water connection that can be used to flush the transfer lines after delivery of feed to the private contractors or to add dilution water to the intermediate staging tanks.

2.11 DOUBLE-SHELL TANK PROCESSING SEQUENCE

2.11.1 Criteria

The following criteria were used to establish the order that DST supernate is provided to the private contractors; the first group of criteria was considered non-tradeable, the second group was considered tradeable.

Non-tradeable

- The waste must belong to the proper envelope.
- The minimum and maximum order quantities of sodium must be satisfied.
- Free up an AN-Farm DST early for use as a receiver tank by the Initial SST Retrieval System (ISSTRS).[1]

Tradeable

- Stage tanks that are easier to retrieve early.
- Avoid staging tanks with low quality projections early.
- Avoid staging tanks with borderline envelope classification early.
- Avoid staging tanks with sludge early.
- Process dilute waste (lower specific gravity) early.
- Avoid switching envelopes
- Avoid "tank-hopping." Finish emptying each DST promptly.

[1]This supports Tri-Party Agreement milestones M-45-04A, M-45-04-T01, -T02, and -T03, and M-45-05-T01 through M-45-05-T08.

2.11.2 Target Sequence

Table 2-21 shows how these criteria were applied to develop the processing sequence. The list of tanks was sorted by Envelope, Early Retrieval Desirability[1] (more desirable first), and then increasing specific gravity. The list was reviewed for consistency with the non-tradeable and tradeable criteria and deviations from the sorted order made when appropriate. These deviations are discussed below along with the transfers needed to "bootstrap" the first two feed batches.

First waste interfering with feed staging activities needs to be relocated. Waste in 241-AP-102 is transferred to 241-AP-103. Waste projected to be in 241-AP-104 is transferred to 241-AW-102 for use as evaporator feed. This may take more than one transfer to satisfy evaporator feed tank OSDs. The concentrated product (50 percent WVRF) is assumed to be held in 241-AW-106. Waste projected to be present in 241-AP-106 initially has no place to go.

The first tank was selected to be 241-AN-105. Tanks 241-AN-104 and 241-AW-101 were skipped because (1) they contain sludges that may be difficult to deal with if inadvertently retrieved before sufficient tank space is available for recovery, (2) neither is sufficient to provide the 1,000 MT of sodium (500 MT per contractor) needed for the first feed batch, and (3) the assumed retrieval method (mobilization of slurry with slurry distributors) has not been performed before.

The waste projected to be in 241-AP-106 interferes with staging of the first batch of feed since its as-retrieved volume is estimated to require 1.5 DSTs of storage space. A portion of the waste from 241-AP-106 must be transferred into 241-AP-104 (after the first batch of feed from 241-AP-104 is transferred to 241-AP-108). There is no other DST space available at that time (based upon the projected inventories (Shelton 1996) and last year's OWVP (Koreski and Strode 1995) other than 241-AP-105, which is used to hold the rest of 241-AP-106. This forces the second feed batches to include waste from 241-AP-106 even though it has a low quality projection. The remainder of the sodium

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[1]A measure, called "Early Retrieval Desirability," was constructed from the first three tradeable criteria to facilitate spreadsheet manipulation of the processing sequence. This measure is read from the matrix (Table 2-21) of retrieval difficulty scores and projection quality (tanks with borderline envelope classification were treated as low quality projections for this purpose).

The retrieval difficulty score is based upon the relative difficulty associated with each of the various retrieval considerations. A binary number was constructed by reading the patterns of "x"s and blanks as "1"s and "0"s, respectively. "Incremental insertion" was considered the most difficult and assigned to the most significant bit (16); "Supernate\Slurry Transfer or Decant Pump" was considered the least difficult and assigned to the least significant bit (1). The other considerations were assigned to bits 8, 4, and 2. The retrieval difficulty score is the natural logarithm of one plus the base 10 value of the binary number. This score should only be used for ranking (a larger number means more difficult). It is not meant to represent the proportional or relative increases in difficulty.

Table 2-21. Double-Shell Tank Processing Sequence.

Projections					Targeted Feed			Dilution Ratio			Retrieved Feed			Projections				Retrieval Considerations					Sequencing			
Tank	Waste Type	Waste Envelope	Borderline Classification?	Feed Available (Date of Projection)	(Na), (M)	SpG	Volume, (L)	Na Based Final:Original Volume	SpG Based Final:Original Volume	Limiting Final:Original Volume	(Na), (M)	SpG	Volume, (L)	Na, (MT)	Projection Quality	Description of waste Targeted as Potential Feed	Description of Waste Excluded from Retrieval	Incremental Insertion	Mixer Pump(s)	Mobilize with Slurry Distributors in Recirc. Loop	In-Line Dilution	Supernate\Slurry Transfer or Decant Pump	Retrieval Difficulty Score	Early Retrieval Desirability	Desired Processing Sequence	Tank
104AN	DSSF	A		FY96	12.0	1.46	3.02E+06	1.71	1.25	1.71	7.00	1.31	5.18E+06	834	H	Slurry	1.00 ML Sludge			x	x	x	3.00	2	3	104AN
101AW	DSSF	A		FY96	10.0	1.51	3.94E+06	1.43	1.34	1.43	7.00	1.38	5.63E+06	906	H	Slurry	0.32 ML Sludge (0.1 may be salts)			x	x	x	3.00	2	4	101AW
105AN	DSSF	A		FY96	12.0	1.46	4.29E+06	1.71	1.31	1.71	7.00	1.33	7.36E+06	1185	H	Slurry - Entire tank (may have new solids)	-		x		x	x	3.58	3	1	105AN
103AN	DSS	A		FY96	14.6	1.50	3.62E+06	2.09	1.53	2.09	7.00	1.32	7.55E+06	1216	H	Slurry - Entire tank	-	x	x		x	x	4.81	5	5	103AN
104AP	DN	A	Y	FY02	2.4	1.13	4.22E+06	0.35	0.27	1.00	2.43	1.13	4.22E+06	236	L	Supernate - Entire tank	-					x	1.00	6	2	104AP
106AP	DSSF	A		FY97	10.6	1.44	4.10E+06	1.52	1.17	1.52	7.00	1.33	6.22E+06	1002	L	Slurry - Entire tank	-		x		x	x	3.58	6	2	106AP
101AY	NCAW	B		FY02	4.5	1.21	4.18E+06	0.65	-1.00	1.00	4.53	1.21	4.18E+06	436	H	Supernate	0.31 ML Sludge					x	1.00	0	6,12;6	101AY
103AP	DN	B	Y	FY96	0.2	1.01	1.02E+05	0.03	0.02	1.00	0.23	1.01	1.02E+05	1	H	Supernate Heel	-	-	-	-	-	-	-	9		103AP
107AN	CC	C		FY97	9.2	1.33	3.68E+06	1.31	0.72	1.31	7.00	1.27	4.83E+06	778	H	Supernate	0.51 ML Sludge				x	x	2.00	1	7-8	107AN
102AN	CC	C		FY96	11.4	1.38	3.84E+06	1.62	0.87	1.62	7.00	1.28	6.23E+06	1003	H	Supernate	0.34 ML Sludge				x	x	2.00	1	9	102AN
104AW	DN	C		FY02	0.2	1.01	2.27E+06	0.03	0.02	1.00	0.20	1.01	2.27E+06	10	M	Supernate	0.68 ML Sludge & 0.42 ML salts					x	1.00	3		104AW
102AP	CP	C	Y	FY96	4.4	1.21	4.16E+06	0.63	0.40	1.00	4.43	1.21	4.16E+06	424	H	Supernate - Entire tank	-					x	1.00	6		102AP
101AP	DSSF	C	Y	FY97	6.1	1.28	4.31E+06	0.87	0.66	1.00	6.06	1.28	4.31E+06	601	M	Slurry - Entire tank	-					x	1.00	6		101AP
106AN	CC	C		FY00	16.1	1.40	4.00E+06	2.31	1.06	2.31	7.00	1.27	9.23E+06	1486	L	Supernate	0.05 ML Sludge				x	x	2.00	6	10-11;10	106AN
107AP	CC	C		FY99	15.5	1.40	4.10E+06	2.21	1.06	2.21	7.00	1.27	9.05E+06	1456	L	Supernate - Entire tank	-				x	x	2.00	6	11;11-12	107AP
108AP	DN	C		FY98	0.3	1.01	1.02E+05	0.04	0.02	1.00	0.25	1.01	1.02E+05	1	M	Supernate Heel	-	-	-	-	-	-	-	9		108AP
102SY	DN	C		FY02	0.9	1.05	9.98E+04	0.12	0.10	1.00	0.87	1.05	9.98E+04	2	L	Supernate Heel	0.27 ML Sludge	-	-	-	-	-	-	9		102SY
105AP	DSSF	C		FY99	14.4	1.40	9.99E+04	2.05	0.94	2.05	7.00	1.27	2.05E+05	33	L	Supernate Heel	0.58 ML Solids	-	-	-	-	-	-	9		105AP
102AY	DN/SLURRY			FY03	0.1	1.01	2.90E+06	0.02	0.06	1.00	0.13	1.01	2.90E+06	8	M	Supernate	.71 - 1.78 ML Fluffed Sludge					x	1.00	3		102AY
102AZ	DN/SLURRY			FY01	0.3	1.01	1.16E+06	0.04	-1.00	1.00	0.29	1.01	1.16E+06	8	M	Supernate	0.35 - .88 ML Fluffed Sludge.					x	1.00	3		102AZ
103SY-SOL	CC			FY96	7.0	1.26	4.42E+06	1.00	-1.00	1.00	7.00	1.26	4.42E+06	712	H	Soluble portion after retrieval of entire tank	Insoluble portion.		x		x	x	3.58	3		103SY-SOL
101SY-SOL	CC			FY96	7.0	1.36	7.37E+06	1.00	0.92	1.00	7.00	1.36	7.37E+06	1187	H	Soluble portion after retrieval of entire tank	Insoluble portion.		x		x	x	3.58	3		101SY-SOL
105AW	NCRW			TBD	0.1	1.02	1.00E+05	0.01	0.04	1.00	0.09	1.02	1.00E+05	0	L	Supernate	1.12 ML Sludge					x	1.00	6		105AW
103AW	NCRW			TBD	0.9	1.02	5.41E+05	0.12	-1.00	1.00	0.85	1.02	5.41E+05	11	L	Supernate	1.37 ML Sludge					x	1.00	6		103AW
101AZ	DN/SLURRY		Y	FY98	1.0	1.05	6.25E+05	0.14	-1.00	1.00	1.00	1.05	6.25E+05	14	M	Supernate	0.25 - 0.62 ML Fluffed Sludge					x	1.00	6		101AZ
101AN	DN		Y	FY97	2.8	1.10	3.46E+06	0.39	0.26	1.00	2.75	1.10	3.46E+06	219	L	Entire tank	-					x	1.00	6		101AN
102AW				na											-	-	-	-	-	-	-	-	-	9		102AW
106AW				na											-	-	-	-	-	-	-	-	-	9		106AW

Early Retrieval Desirability Matrix

Projection Quality*				
H	M	L	-	Retrieval Considerations
9	9	9	9	Waste not retrieved
0	3	6	9	Pump only
1	3	6	9	Pump w/dilution water
2	4	6	9	Pump w/dilution water and slurry dist.
3	4	6	9	Mixer w/anything but incremental
5	5	6	9	Incremental w/anything but mixer
5	5	6	9	Incremental & mixer w/anything.

*Tanks with Borderline Envelope Classification are treated as having L Projection Quality

Sort Order: This list is sorted by Envelope, Early Retrieval Desirability (more desirable first), and then SpG (increasing).

Retrieval Difficulty Score: Larger values are more difficult.

Early Retrieval Desirability: Smaller values are more desirable.

Dilution Water Assumptions

Maximum SpG Limit:	1.40
Maximum [Na] Limit:	7.0 M

Desired Processing Sequence: This sequence differs from the sort order to reflect constraints such as minimum and maximum order quantity, ISSTRS receiver tank in AN-Farm, etc.

Semicolon ";" separates contractor 1 from contractor 2 when feed batches are different. For example "6,10;12" means this tank contributes to batches 6 and 10 for contractor 1 and batch 12 for contractor 2.

SpG Based Dilution Ratio: A negative value for a Spg Based Dilution ratio indicates that the SpG correlation did not yield a physically possible dilution ratio for the specified target Spg. In all such cases, target [Na] was limiting.

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needed to meet the minimum order quantities for Envelope A was provided by the waste originally in 241-AP-104, after concentration in the evaporator. Therefore, the second feed batch consists of a blend of 241-AP-106 and 241-AP-104.

It is not desirable to schedule waste with a low-quality projection or borderline envelope classification as the second feed batch. The waste volume projections currently being prepared (Rev. 22) will attempt to reallocate tank usage between now and 2002 so that the intermediate feed staging tanks and the private contractors tanks are empty before feed staging activities. Another possibility is to transfer the waste projected to be in 241-AP-106 to 241-AW-106 if permitted by evaporator operations.

Feed batches three, four, and five are from 241-AN-104, 241-AW-101, and 241-AN-103, respectively. These batches follow the sorted order of the list. After batch 5, the minimum order quantities of waste in Envelope A have been reached. Note that all available Envelope A waste has been used.

The next batch of waste needs to be waste from Envelope B. The only source for Envelope B waste is 241-AY-101 (241-AP-103 only contains a heel). Therefore, 241-AY-101 is used as batch six. Waste remaining 241-AY-101 after meeting the minimum order quantities for Envelope B is processed near the end of the extension period.

The next batch of waste (Batch 7) must provide the minimum order quantity of Envelope C. This is taken from 241-AN-107. All of the waste from 241-AN-107 is staged in the intermediate staging tanks to save time even though only the minimum order quantities will be delivered to the private contractors feed tanks.

The extension period begins with Envelope C waste (to avoid switching envelopes) unnecessarily. The feed for Batch 8 is the remainder of waste from 241-AN-107 that is already staged. Batch 9 is taken from 241-AN-102.

The next three tanks on the list are skipped. Tank 241-AW-104 is skipped because it is projected to contain only 10 MT of sodium (although more sodium may be available if the precipitated salts were targeted). Tanks 241-AP-101 and 241-AP-102 are skipped because they have a borderline Envelope C classification.

The remaining waste from Envelope C is provided by 241-AN-106 and 241-AP-107. Batch 10 for both contractors is from 241-AN-106. Batch 11 for Contractor 1 is the remainder of 241-AN-106 topped off with 241-AP-107. Batch 11 for Contractor 2 is just 241-AP-107.

Batch 12 for Contractor 1 is the remainder of Envelope B waste from 241-AY-101. Two volumes of flush water were added to the heel remaining in 241-AP-102. This was then pumped to 241-AN-107, leaving a more dilute heel to avoid tainting the Envelope B waste. For Contractor 2, a portion of the waste remaining in 241-AP-107 is provided.

Rough estimates of the sodium delivered to each contractors feed tank broken down by time (proof-of-concept or extension) and envelope is shown in Table 2-22. This table is based upon the feed staging activities described above and neglects the effects of heels in the intermediate staging tanks and the private contractors feed tanks. All quantity limits in the RFP are satisfied.

Table 2-22. Summary of Supernate Delivered to the Private Contractors.

	Envelope	Contractor 1 (MT Na)	Contractor 2 (MT Na)	Totals (MT Na)
Proof-of-Concept	A	2,659	2,634	5,293
	B	121	121	242
	C	124	124	248
	Subtotal	2,904	2,879	5,783
Extension	C	1,918	2,195	4,113
	B	199	0	199
	Subtotal	2,117	2,195	4,312
	TOTAL	5,021	5,074	10,095
By Envelope	A	2,659	2,634	5,293
	B	320	121	441
	C	2,042	2,319	4,361

3.0 RESULTS

3.1 OPERATING SCENARIO

The transfers needed to implement the DST processing sequence established in Section 2.11 are shown on Figure 3-1. This operating scenario provides a starting point for further assessment of DST allocation and space availability and the demands placed upon the transfer and retrieval systems. The durations for activities in the schedule were taken from the Recommended Case simulation results (Appendix E); values near the medians were used. The slack between when a feed batch is ready for delivery and when the waste is actually delivered is the M&O contractor's contingency. The starting date for feed staging transfers is October 1, 2000 (see Section 3.2 for basis and additional discussion). The planning basis is as follows:

- Each transfer takes a total of 10 days for setup and pumping.
- Only one transfer is permitted at a time for the boot-strap transfers (ID numbers 9-11, 13, 15-17, 19, 21, 24-25, and 29).
- Only one intermediate feed staging transfer (into the intermediate feed staging tanks) is permitted at a time.
- Only one final staging transfer (into the private contractors feed tanks) is permitted at a time.
- The intermediate feed staging transfers do not conflict with the final staging transfers.
- Mixing, sampling, settling, analysis, and evaluation take a total of 70 days per intermediate staging tank.
- Waste is processed by the private contractors at $(POE)C_d$ = 2.025 MT sodium per day whenever approved feed is present in their feed tanks.

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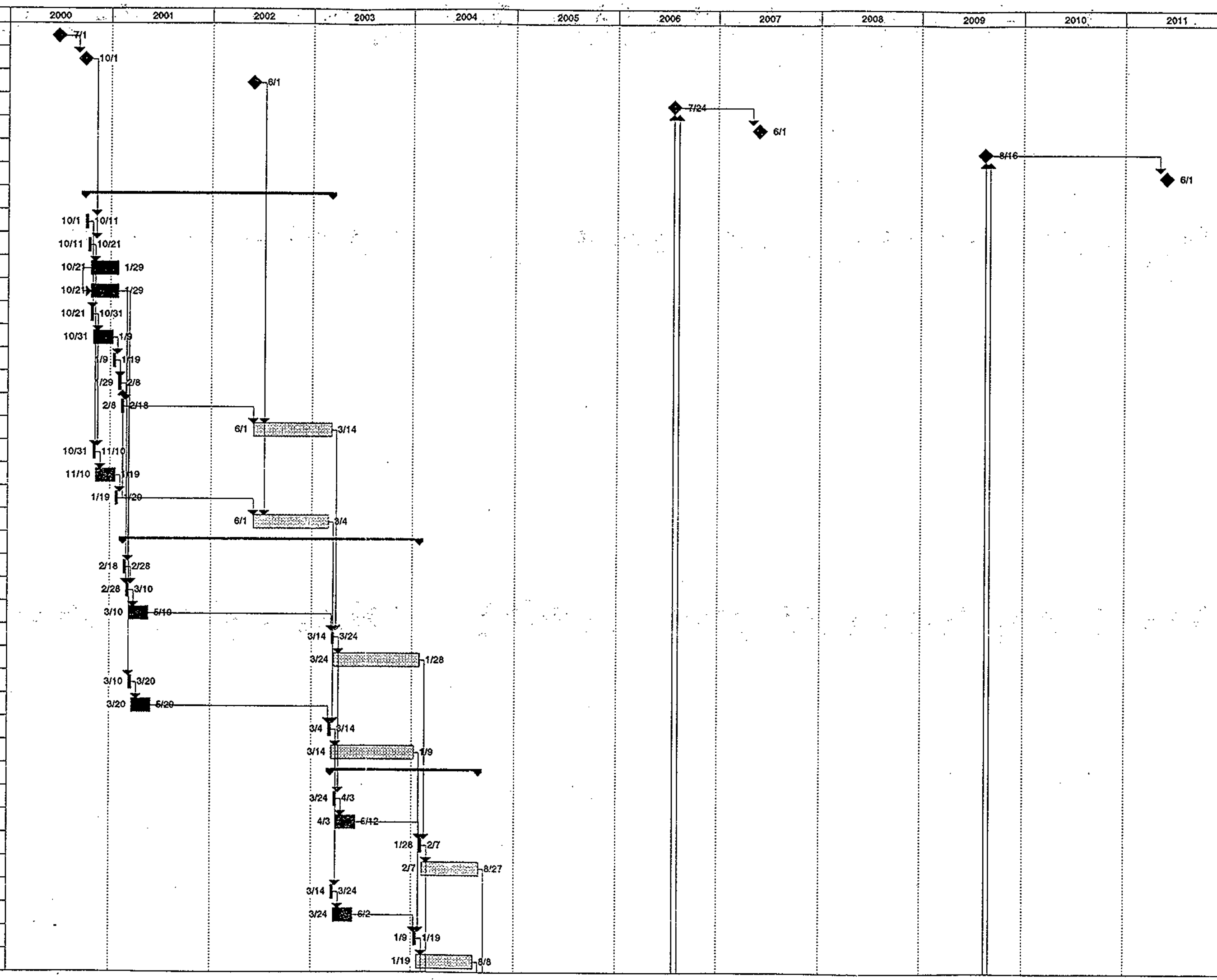
Figure 3-1. Phase I
Double-Shell Tank Supernate
Staging Schedule. (Sheet 1 of 3)

ID	Name	Duration	Env.	Cont.	Vol xfer (ML)	Na xfer (MT)
1	INFRASTRUCTURE READY	0d				
2	START Feed Staging Activities	0d				
3	START Proof-Of-Concept	0d				
4	MEET Minimum Order Quantities	0d				
5	END Proof-Of-Concept	0d				
6	MEET Maximum Order Quantities	0d				
7	END Extension	0d				
8	BOOTSTRAP and PROCESS 1ST BATCH	893.16d				
9	2AP to 3AP	10d			4.06	414
10	4AP to 2AW	10d			4.12	230
11	2AW TO 242-A	100d			4.12	230
12	242-A to 6AW; @ 50% WVR	100d			2.06	230
13	1/2 5AN to 2AP;@1.71	10d			3.63	584
14	Mix.Sample.Settle.Lab.Eval 2AP	70d				
15	1/2 6AP to 5AP;@1.52	10d			3.06	494
16	1/2 6AP to4AP;@1.52	10d			3.06	492
17	2AP to 6AP	10d			3.63	579
18	Process 6AP (5AN)	286d	A	1	3.63	579
19	1/2 5AN to 4AP;@1.71	10d			3.63	584
20	Mix.Sample.Settle.Lab.Eval 4AP	70d				
21	4AP to 8AP	10d			3.63	574
22	Process 8AP (5AN)	276d	A	2	3.63	559
23	BOOTSTRAP and PROCESS 2nd BATCH	1073.16d				
24	5AP to 2AP	10d			3.06	510
25	1/2 6AW to 2AP	10d			1.03	115
26	Mix.Sample.Settle.Lab.Eval 2AP	70d				
27	2AP to 6AP	10d			4.09	626
28	Process 6AP (6AP/4AP)	310d	A	1	4.09	627
29	1/2 6AW to 4AP	10d			1.03	115
30	Mix.Sample.Settle.Lab.Eval 4AP	70d				
31	4AP to 8AP	10d			4.09	608
32	Process 8AP (6AP/4AP)	301d	A	2	4.09	609
33	STAGE and PROCESS 3rd BATCH	531d				
34	1/2 4AN to 2AP;@1.71	10d			2.54	409
35	Mix.Sample.Settle.Lab.Eval 2AP	70d				
36	2AP to 6AP	10d			2.54	408
37	Process 6AP (4AN)	201d	A	1	2.54	407
38	1/2 4AN to 4AP;@1.71	10d			2.54	409
39	Mix.Sample.Settle.Lab.Eval 4AP	70d				
40	4AP to 8AP	10d			2.54	408
41	Process 8AP (4AN)	201d	A	2	2.54	406



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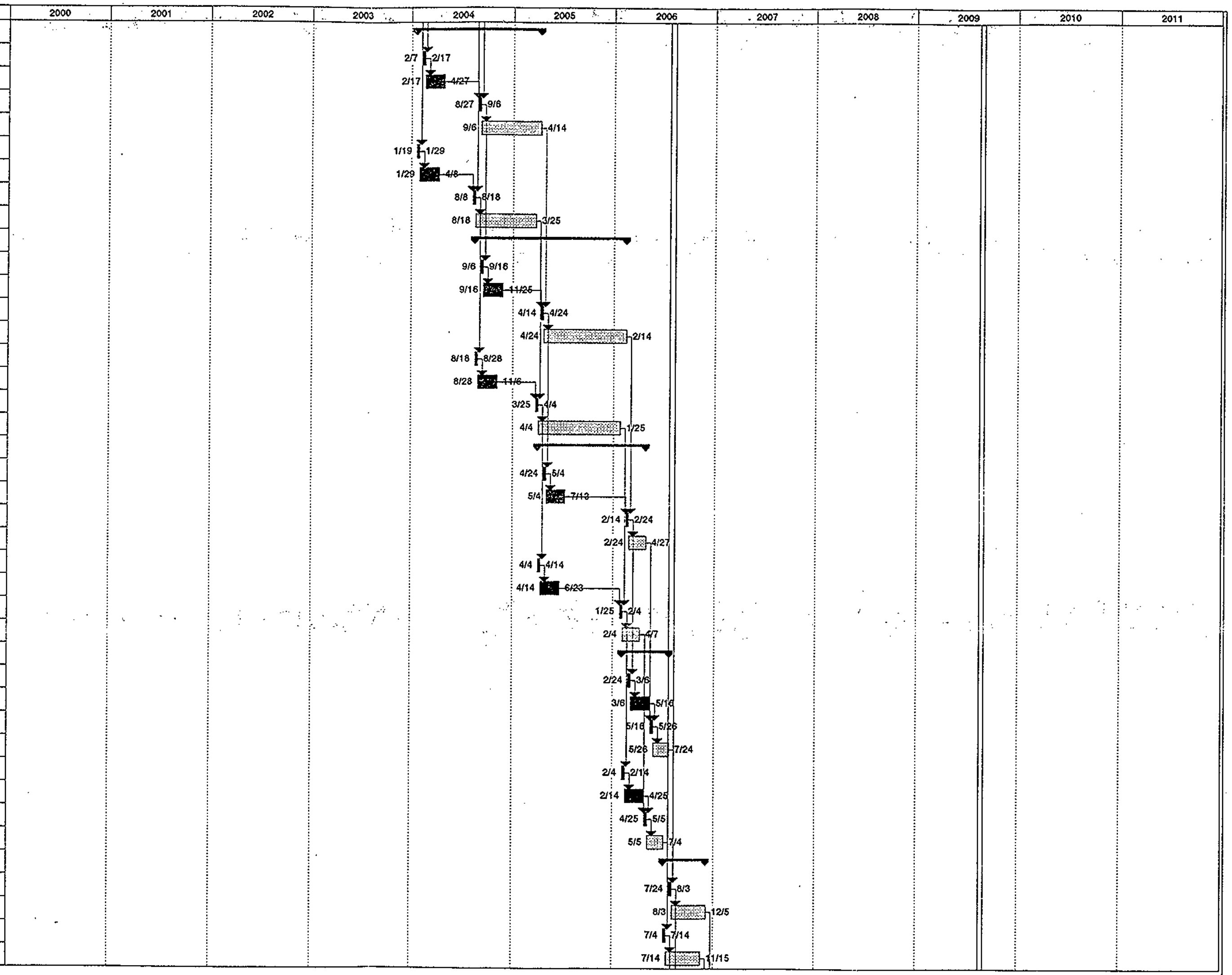
Env. = Envelope, Cont. = Contractor, Vol xfer (ML) = Volume of waste transferred; Na xfer (MT) = mass of Na in transfer; @xxx = final:original volume ratio; @xxx % WVR = waste volume reduction factor, (xx) = source DST(s).

Figure 3-1. Phase I
Double-Shell Tank Supernate
Staging Schedule. (Sheet 2 of 3)

ID	Name	Duration	Env.	Cont.	Vol xfer (ML)	Na xfer (MT)
42	STAGE and PROCESS 4th BATCH	450d				
43	1/2 1AW to 2AP;@1.43	10d			2.75	446
44	Mix.Sample.Settle.Lab.Eval 2AP	70d				
45	2AP to 6AP	10d			2.75	446
46	Process 6AP (1AW)	220d	A	1	2.75	446
47	1/2 1AW to 4AP;@1.43	10d			2.76	444
48	Mix.Sample.Settle.Lab.Eval 4AP	70d				
49	4AP to 8AP	10d			2.76	444
50	Process 8AP (1AW)	219d	A	2	2.76	444
51	STAGE and PROCESS 5th BATCH	545d				
52	1/2 3AN to 2AP;@2.09	10d			3.73	600
53	Mix.Sample.Settle.Lab.Eval 2AP	70d				
54	2AP to 6AP	10d			3.73	600
55	Process 6AP (3AN)	296d	A	1	3.73	600
56	1/2 3AN to 4AP;@2.09	10d			3.72	600
57	Mix.Sample.Settle.Lab.Eval 4AP	70d				
58	4AP to 8AP	10d			3.72	600
59	Process 8AP (3AN)	296d	A	2	3.72	600
60	STAGE and PROCESS 6th BATCH	388d				
61	Part 1AY to 2AP	10d			1.11	116
62	Mix.Sample.Settle.Lab.Eval 2AP	70d				
63	2AP to 6AP	10d			1.11	121
64	Process 6AP (1AY)	62d	B	1	1.11	126
65	Part 1AY to 4AP	10d			1.11	116
66	Mix.Sample.Settle.Lab.Eval 4AP	70d				
67	4AP to 8AP	10d			1.11	121
68	Process 8AP (1AY)	62d	B	2	1.11	126
69	STAGE and PROCESS 7th BATCH	169d				
70	1/2 7AN to 2AP;@1.31	10d			2.36	381
71	Mix.Sample.Settle.Lab.Eval 2AP	70d				
72	part 2AP to 6AP	10d			0.78	124
73	Process 6AP (7AN)	59d	C	1	0.78	120
74	1/2 7AN to 4AP;@1.31	10d			2.37	381
75	Mix.Sample.Settle.Lab.Eval 4AP	70d				
76	part 4AP to 8AP	10d			0.78	124
77	Process 8AP (7AN)	59d	C	2	0.78	120
78	STAGE and PROCESS 8th BATCH	154d				
79	part 2AP to 6AP	10d			1.58	252
80	Process 6AP (7AN)	124d	C	1	1.58	251
81	part 4AP to 8AP	10d			1.59	252
82	Process 8AP (7AN)	124d	C	2	1.59	251



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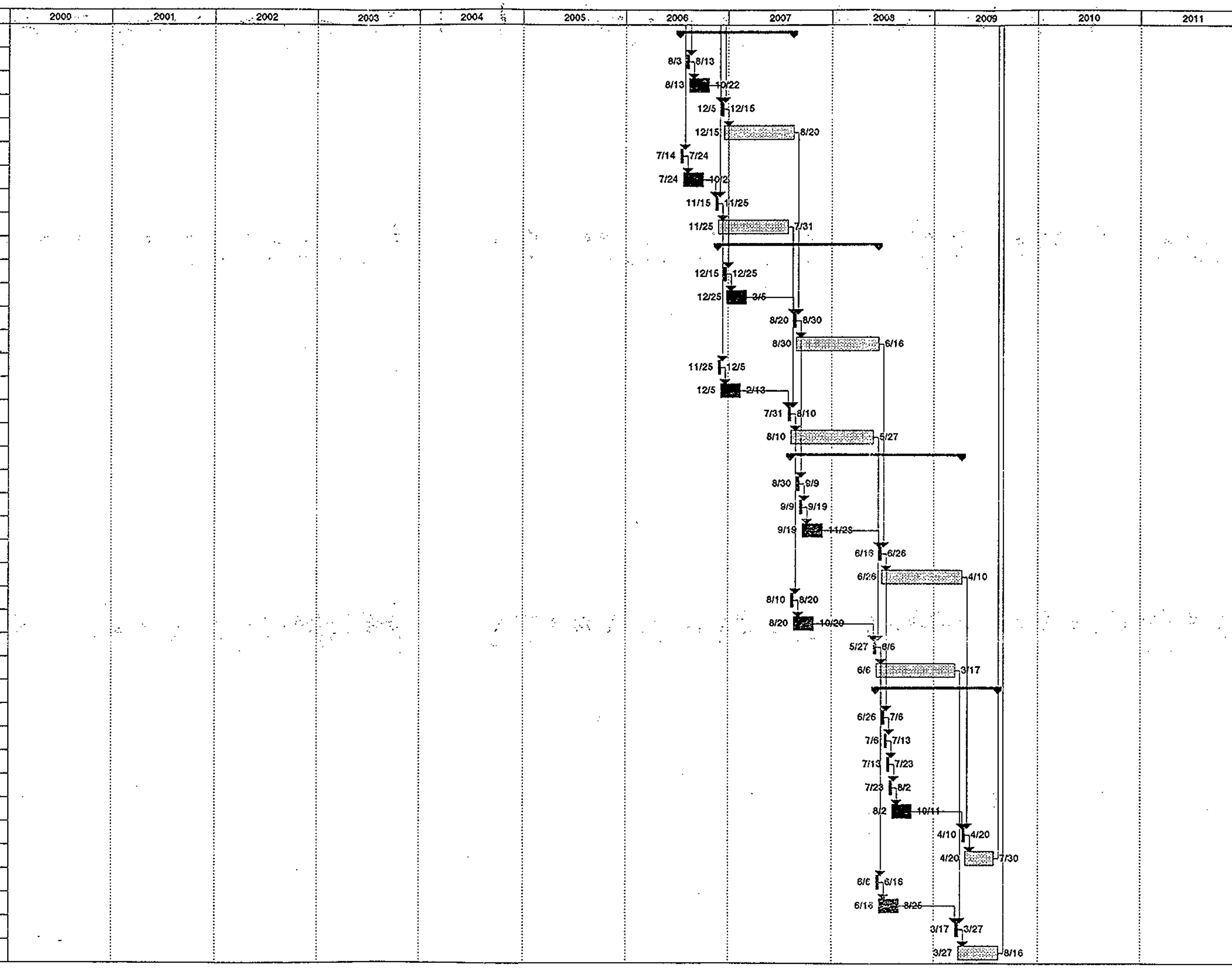
Env. = Envelope, Cont. = Contractor, Vol xfer (ML) = Volume of waste transferred, Na xfer (MT) = mass of Na in transfer; @xxx = final:original volume ratio, @xxx % WVR = waste volume reduciton factor, (xx) = source DST(s).

Figure 3-1. Phase I
Double-Shell Tank Supernate
Staging Schedule. (Sheet 3 of 3)

ID	Name	Duration	Env.	Cont.	Vol xfer (ML)	Na xfer (MT)
83	STAGE and PROCESS 9th BATCH	402d				
84	1/2 2AN to 2AP;@1.62	10d			3.07	495
85	Mix.Sample.Settle.Lab.Eval 2AP	70d				
86	2AP to 6AP	10d			3.07	495
87	Process 6AP (2AN)	248d	C	1	3.07	495
88	1/2 2AN to4AP;@1.62	10d			3.06	492
89	Mix.Sample.Settle.Lab.Eval 4AP	70d				
90	4AP to 8AP	10d			3.06	492
91	Process 8AP (2AN)	248d	C	2	3.06	491
92	STAGE and PROCESS 10th BATCH	568d				
93	2/5 6AN to 2AP;@2.31	10d			3.65	587
94	Mix.Sample.Settle.Lab.Eval 2AP	70d				
95	2AP to 6AP	10d			3.65	587
96	Process 6AP (6AN)	290d	C	1	3.65	587
97	2/5 6AN to 4AP;@2.31	10d			3.65	587
98	Mix.Sample.Settle.Lab.Eval 4AP	70d				
99	4AP to 8AP	10d			3.65	587
100	Process 8AP (6AN)	290d	C	2	3.65	587
101	STAGE and PROCESS 11th BATCH	608d				
102	1/5 6AN to 2AP;@2.31	10d			1.83	296
103	1/5 7AP to 2AP;@2.21	10d			1.79	288
104	Mix.Sample.Settle.Lab.Eval 2AP	70d				
105	2AP to 6AP	10d			3.62	584
106	Process 6AP (6AN/7AP)	288d	C	1	3.62	584
107	2/5 7AP to 4AP;@2.21	10d			3.58	576
108	Mix.Sample.Settle.Lab.Eval 4AP	70d				
109	4AP to 8AP	10d			3.58	576
110	Process 8AP (7AP)	284d	C	2	3.58	576
111	STAGE and PROCESS 12th BATCH	436d				
112	Flush water to 2AP	10d			0.20	0
113	Mix 2AP	7d				
114	2AP to 7AN	10d			0.20	11
115	Part 1AY to 2AP	10d			1.86	194
116	Mix.Sample.Settle.Lab.Eval 2AP	70d				
117	2AP to 6AP	10d			1.86	199
118	Process 6AP (1AY)	101d	B	1	1.86	195
119	1/5 7AP to 4AP;@2.21	10d			1.79	288
120	Mix.Sample.Settle.Lab.Eval 4AP	70d				
121	4AP to 8AP	10d			1.79	288
122	Process 8AP (7AP)	142d	C	2	1.79	288



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Env. = Envelope, Cont. = Contractor, Vol xfer (ML) = Volume of waste transferred, Na xfer (MT) = mass of Na in transfer; @xxx = final:original volume ratio, @xxx % WVR = waste volume reduction factor, (xx) = source DST(s).

3.2 FEED TANK CUSTODY TRANSFER

The date and conditions of the custody transfer of tanks 241-AP-106 and 241-AP-108 are not yet defined. The *Preliminary LLW Feed Staging Plan* (Certa et al. 1996) and the F&R (WHC 1995a) assumed that operational control of these tanks would be transferred with full tanks. The preliminary plan also assumed that the first batch of feed would be staged in each of these tanks by June 1, 2001.

To better understand the tank space issues during Phase I, a special OWVP was performed. The results of this OWVP (Strode 1996) suggested that DST supernate can be successfully staged during Phase I within existing DST tank space, provided that SST retrieval be tailored to fit in the remaining tank space. The intermediate staging tanks (241-AP-102 and 241-AP-104) are available in FY 2000 after waste is transferred to other DSTs. The feed tanks (241-AP-106 and 241-AP-108) become available for staging activities in FY 2001.

Based upon the above information, which is the best available to date, feed staging activities are scheduled to begin on October 1, 2000. As part of preparing the projected DST inventory, waste that was destined to be stored in 241-AP-108 was reallocated to other DSTs, thus emptying 241-AP-108 in FY 1998. A similar reallocation for 241-AP-106 could not be identified.

RL has recently requested that the custody transfer be scheduled for January 1, 1999. Tank modifications are expected to take 1.5 years to complete. It was also requested that the tank modifications occur with the tanks empty, if possible. This significant deviation from the previous plan has not been evaluated with respect to tank space, feed staging logistics, or infrastructure upgrades timing.

It is desirable to stage the first feed batches earlier than shown in Figure 3-1 to allow contingency time for potential feed staging problems that the M&O may experience and to permit as early a custody transfer as possible. Revision 22 of the OWVP will determine (1) the earliest the first feed batches can be delivered to 241-AP-106 and 241-AP-108, (2) if the tanks can be emptied for the custody transfer, and (3) the length of time the tanks can remain empty before the first feed batches are delivered (Washenfelder 1996).

The results of the OWVP (Revision 22) will be used to update the feed staging schedule and determine feasible dates for the custody transfer. This will require revising the projected DST supernate inventories to reflect the new tank allocations and other assumptions used by the OWVP. The tanks will be classified according to envelopes (only the tanks with low quality inventory projections should be affected). The feed staging schedule will be updated to reflect the transfers required to stage the initial batches of feed. The schedule will then be reviewed to verify that the specific physical upgrades or work-arounds are available in time to support the transfer activities. This information will be incorporated into an addendum to the LLW Feed Staging Plan in early calendar year 1997, pending availability of funds and approval of work scope.

3.3 INFRASTRUCTURE SUPPORT SCHEDULE

Infrastructure upgrades are needed to support LAW feed staging. Timing of the upgrades can be inferred from the transfer schedule in Section 3.1. An appropriate lead time should be applied to the date when the infrastructure item is first required to be used. Additional time should be provided to account for possible schedule acceleration (of up to 1 year for the staging of the first two feed batches) and/or construction delays or startup problems.

A draft schedule prepared by Construction Projects shows that the required transfer system upgrades for both HLW and LAW feed staging and the upgrades to the intermediate feed staging tanks can be completed in time to support Phase I privatization, pending availability of funding. The systems would be operational by July 2000, 3 months in advance of the start of staging activities. This schedule is considered aggressive.

Retrieval upgrades that support mobilization of waste should be operational in advance of the scheduled transfer date so that the waste can be mobilized before the transfer needs to begin. This keeps waste mobilization activities, as much as possible, from adding to the time needed to transfer waste from the source DSTs to the intermediate feed staging tanks. Some additional flexibility is also provided in case the private contractors work off feed at a faster rate than assumed.

3.4 ASSESSMENT OF STAGED SUPERNATE

The estimated composition and specific gravity of the supernate as staged in the private contractors' feed tanks are shown in Appendix F. These compositions were compared with the three feed envelopes and were verified to satisfy the appropriate limits, with the exception of Batch 12 for private contractor 1. Batch 12 was intended to process the remaining NCAW supernate (Envelope B); however, the Envelope C heels from Batch 11 raised the TOC above the limit. This was corrected by flushing the heel in 241-AP-102 from Batch 11 with two volumes of water. The flush was transferred to 241-AN-107 for storage.

All of the compositions satisfy the corrosion rule and the specific gravities satisfy the flammability rule in the waste compatibility DQO.

4.0 ACTIONS AND STUDY CAVEATS

4.1 ACTIONS

This section lists the actions necessary to successfully implement the feed staging plan. These actions result from requirements developed by the technical analysis, are needed to resolve issues identified during the analysis, or are associated with the assumptions and requirements in Appendix A. A cross-reference to the source or basis of the action is provided along with a brief statement of the consequence of not performing the action. The actions have been subjectively ranked in order of decreasing programmatic risk.

1. *Action:* Resolve any safety and administrative concerns so that feed may be obtained from Watch List tanks and tanks affected by the flammable gas USQ.

   Basis or Source: Section 2.7.5, Enabling Assumption A7.7.

   Consequence of not performing: This feed would not be available for delivery to the private contractors or delays will be incurred while the issues are resolved. The majority (4,100 MT sodium) of Envelope A feed is supplied from Watch List tanks.

2. *Action:* The regulatory status of the final feed delivery transfers (from the intermediate feed staging tanks to the private contractors feed tanks) needs to be determined. Applicable constraints need to be identified and incorporated into the FRD, ICDs, and the feed staging plan. Neither the FRD nor ICDs allocate specific regulatory constraints to the "Supernates for Pretreatment" interface.

   Basis or Source: Constraint A2.0, Enabling Assumption A7.10.

   Consequence of not performing: Samples or analysis beyond those needed to verify compliance with the feed envelope limits <u>might</u> be required to satisfy regulatory constraints. This could result in an unplanned increase in laboratory workload or increase the amount of time needed to evaluate and approve delivery of the feed to the private contractors.

3. *Action:* Rigorously determine the amount and type of dilution required for safe retrieval and transfer of feed and to re-dissolve major soluble sodium salts while not precipitating out other solids (such as gibbsite). This requires both thermodynamic modeling and observation of the behavior and physical properties of waste samples undergoing dilution in the laboratory. Concentrate upon the following tanks - the most important tanks are listed first: 241-AN-105, 241-AN-104, 241-AW-101, 241-AN-103, 241-AN-107, and 241-AN-102.

   Basis or Source: Sections 2.7.2, 2.7.9, Enabling Assumption A7.13.

Consequence of not performing: Incorrect volume or composition of the diluent may result in any of the following: (1) violation of the flammable gas decision rule, (2) plugging a waste transfer lines, (3) accumulation of gibbsite or sodium salts in the intermediate feed staging tanks which can be corrected by mixing the waste with water and/or caustic, (4) addition of an excessive volume of diluent temporarily increases tank space demand, or (5) addition of excessive caustic may slightly increase the immobilized LAW volume.

4. *Action:* Rigorously determine the equipment required to retrieve the target feed leaving the excluded waste (sludge) behind.

   Basis or Source: Section 2.9.2.

   Consequence of not performing: The retrieval systems may not be effective or may be over designed.

5. *Action:* Reduce the minimum order quantity of Envelope A to 2,000 MT sodium per contractor (was 2,600 MT sodium per contractor).

   Basis or Source: Sections 2.5.2 and 2.5.7.

   Consequence of not performing: The minimum order quantities of Envelope A may not be delivered.

6. *Action:* Perform an engineering study to validate the requirements and architecture for the intermediate feed staging tanks. Implement the upgrades.

   Basis or Source: Section 2.10.4.

   Consequence of not performing: Not validating the requirements may result in over design of the intermediate feed staging tanks' upgrades. Not implementing the validated requirements will compromise the ability to deliver feed to the private contractors and reduce the ability of the system to deal with anticipated problems.

7. *Action:* Increase the maximum [SO_4]/[Na] limit for Envelope C to 0.02 mole/mole (was 0.0097 mole/mole).

   Basis or Source: Requirement A4.1, Enabling Assumption A5.2.

   Consequence of not performing: The waste in tanks 241-AN-102 and -107 will not meet Envelope C limits. These tanks, containing nearly 1,800 MT of sodium, are intended to provide Envelope C feed.

8. *Action:* Increase the size of the first batch of Envelope B feed to allow delivery of between 100 - 250 MT sodium per contractor (was 100 - 130 MT sodium per contractor).

   Basis or Source: Sections 2.8, 2.10.3, and 2.11.2.

Consequence of not performing: The M&I contractor may not be able to deliver the batches following this batch within the 30-day feed delivery window. A full aging waste DST must be used to store the remainder of the Envelope B feed increasing tank space demands.

9. *Action:* Increase the size of the first batch of Envelope C feed to allow delivery of between 100 - 600 MT sodium per contractor (was 100 - 130 MT sodium per contractor).

   Basis or Source: Sections 2.8, 2.10.3, and 2.11.2.

   Consequence of not performing: The M&I contractor may not be able to deliver the batches following this batch within the 30-day feed delivery window.

10. *Action:* Define and time and conditions of the transfer of custody of 241-AP-106 and -108 to the private contractors.

    Basis or Source: Section 3.2, Requirement A4.10, CST Assumption A5.9.

    Consequence of not performing: This will be a point of contention between RL, the M&I contractor, and the private contractors. The private contractors need to know when they may make modifications to the feed tanks.

11. *Action:* Resolve the emerging issue of the presence of a separable organic phase or soluble TBP in the DSTs.

    Basis or Source: Section 2.7.3.

    Consequence of not performing: If the presence of a separable organic phase is confirmed, an additional analysis is required to demonstrate that the waste can be safely retrieved and transferred. The presence of a separable organic phase or soluble TBP may be a point of contention between RL and the private contractors.

12. *Action:* Implement the recommended transfer system upgrades (LLW Option 4, HLW Option 3). The combination is called Alternative K in this report.

    Basis or Source: Galbraith et al. 1996, Section 2.10.2.

    Consequence of not performing: If no upgrades are made then (a) the waste pumpability rule will not be satisfied for most LAW and HLW feed staging transfers, (b) the least capable and least robust system for delivery of feed has been selected. Implementing any of the other dominant alternatives involves trade-offs between cost, ability to deliver feed on time, robustness against changing assumptions, and compliance with the waste pumpability rule (marginal hydraulics versus acceptable hydraulics).

13. *Action:* Take the necessary actions to keep the maximum transfer setup time for all transfers at or below about 25 days and the median time about 1 or 2 days. This will require, at the least, (a) insuring that a failed pump or jumper can be repaired or replaced under typical (often windy) weather conditions within 25 days and (b) completing the upgrades needed so that all transfers can be setup using valves rather than pit entries and jumper changes.

    Basis or Source: Section 2.10.3 and Appendix E, Section E3.0.

    Consequence of not performing: The fraction of feed batches that are successfully staged within the 30-day feed delivery window decreases from about 98 percent for a 25 day maximum to about 86 percent for a 60 day maximum. If the valving upgrades are not implemented, the median setup time will increase from 1 or 2 days to about 14 days.

14. *Action:* Avoid changing the composition of the targeted waste in tanks that already contain significant quantities of potential feed. These tanks are 241-AN-102, -103, -104, -105, and -107; and 241-AW-101. Additionally, avoid changing the composition of the NCAW supernate, other than by blending with other NCAW supernate.

    Basis or Source: These tanks are either at or nearly at capacity. No activities are planned except for consolidation and relocation of NCAW supernate and addition of caustic to 241-AN-107.

    Consequence of not performing: Changing the composition of waste in these tanks may change their envelope classification or exclude them for use as feed. This could require significant changes to the feed staging schedule and thus the deployment of retrieval systems.

15. *Action:* Clearly define which radionuclides are used to calculate TRU for envelope classification purposes. Verify that laboratory procedures are consistent with this definition. Are different TRU definitions needed for different purposes (TRU segregation, NRC rules, custody transfers)?

    Basis or Source: Section 2.7.6, Requirement A4.1, Enabling Assumption A7.14.

    Consequence of not performing: This will become a point of contention between RL, the private contractors, and the M&I contractor.

16. *Action:* The transfer systems in 241-AP-102 and -104 should be designed to empty the tanks to a maximum heel of 0.1 ML (10 in.) of waste.

    Basis or Source: Section 2.6.3.

    Consequence of not performing: The probability of that the heel remaining in the intermediate feed staging tanks will taint the feed and change its envelope classification (or exclude it from use as feed) will significantly increase.

17. *Action:* Require the private contractors to empty their feed tanks (241-AP-106 and -108) to a maximum heel of 0.1 ML (10 in.) of waste before accepting delivery of the next feed batch when switching feed envelopes. Exceptions could be granted on a case-by-case basis.

    Basis or Source: Section 2.6.3.

    Consequence of not performing: The probability of that the heel remaining in the private contractors feed tank will taint the delivered feed and change its envelope classification (or exclude it from use as feed) will significantly increase.

18. *Action:* Review the applicability of the most compatible DQO decision rules to a treatment context as opposed to a waste management context.

    Basis or Source: Requirement A3.6.

    Consequence of not performing: The decision rules only restrict feed staging activities and increase the administrative burden.

19. *Action:* Perform an analysis that demonstrates that staging of waste from 241-AN-102 and 241-AN-107 will not jeopardize TRU segregation, modify the rule to permit staging of TRU supernate through 241-AP-102, -104, -106, and -108 after pumping these tanks to the recommended maximum 0.1 ML (10 in.) heel, or obtain a waiver.

    Basis or Source: Section 2.7.6, Enabling Assumption A7.8.

    Consequence of not performing: The waste in tanks 241-AN-102 and -107, containing nearly 1,800 MT of sodium, will not be available as feed or a thorough clean out of the non-TRU heels in 241-AP-102, -104, -106, and -108 will be required.

20. *Action:* Before the start of feed staging activities, place no waste in 241-AP-102, -104, -106, and -108 that will require dilution for removal. Also, waste requiring mixing equipment for removal should not be stored in 241-AP-106 and -108.

    Basis or Source: Section 2.11.2.

    Consequence of not performing: The presence of such waste exacerbates tank space needs and complicates the initial bootstrap transfers that stage the first batches of feed. If tank space limitations are severe, the ability to deliver the feed batches of the proper envelope and sodium quantity may be compromised.

21. *Action:* Better define the requirement that "The insoluble solids fraction will not exceed 5 vol% of the waste transferred as waste Envelopes A, B, and C."

Basis or Source: CST Assumption A5.3.

Consequence of not performing: Clarification of this requirement is needed so that this parameter can be measured and controlled. This may become a point of contention between the M&I contractor, RL, and the private contractors.

22. *Action:* Obtain radionuclide inventories for saltwell liquor and incorporate into the projected waste inventories.

    Basis or Source: Section 2.3.

    Consequence of not performing: The radionuclide inventories tanks receiving the saltwell liquor will be significantly underestimated, perhaps resulting in incorrect envelope classification.

23. *Action:* Update the projected DST inventories to reflect revision 22 of the operational waste volume projections.

    Basis or Source: Section 2.3.

    Consequence of not performing: There will be significant differences between the feed staging plan and the operations waste volume projections. The bootstrap transfers may change. The envelope classification of certain tanks may change affecting the total amount of sodium available for each envelope.

24. *Action:* Explicitly state whether the envelope composition limits apply to the bulk composition of the delivered feed for only the liquid phase.

    Basis or Source: CST Assumption A5.4.

    Consequence of not performing: Sampling plans may target the wrong phases for confirmation of feed envelope. This may become a point of contention between RL, the M&I contractor, and the private contractors.

25. *Action:* Determine the precision and accuracy needed to demonstrate that the waste meets the intended envelope, satisfies regulatory requirements (if any), and satisfies the private contractors need for feed composition data.

    Basis or Source: Derived Requirement A6.3, Enabling Assumption A7.10.

    Consequence of not performing: The sampling plan and support equipment (such as mixer pumps or air-pulse agitators) may be inadequate to provide the needed precision and accuracy.

26. *Action:* Modify the complexant waste segregation rule to permit staging of complexant waste through 241-AP-102, -104, -106, and -108 without having to designate these tanks as complexant waste receiver tanks.

    Basis or Source: Section 2.7.8, Enabling Assumption A7.8.

Consequence of not performing: These tanks will need to be designated as complexant waste receiver tanks when staging complexant waste (Envelope C).

27. *Action:* Modify the tank waste type compatibly matrix to permit staging of any waste through 241-AP-102, -104, -106, and -108 after pumping these tanks down to the recommended maximum 0.1 ML (10 in.) heel.

    Basis or Source: Section 2.7.10, Enabling Assumption A7.8.

    Consequence of not performing: Potential point of contention over the interpretation of "...to the extent practical."

28. *Action:* Estimate the volume and composition of the combined "Entrained Solids" and "Strontium/TRU" stream returned by the private contractors on a batch-by-batch basis and confirm with the private contractors.

    Basis or Source: Assumption A7.9.

    Consequence of not performing: Slight increase in uncertainty of the operational waste volume projections.

29. *Action:* The envelope classification of all proposed feed batches should be verified after accounting for the presence of heels in both the intermediate feed staging tanks and the private contractors' feed tanks. Provisions for dilution and removal of these heels are required.

    Basis or Source: Section 2.6.3.

    Consequence of not performing: When switching envelopes, the heel remaining in the intermediate feed staging tanks and the private contractors' feed tanks may change the envelope classification of the new feed batch or exclude it from use as feed.

30. *Action:* Confirm that both private LAW contractors and the HLW private contractors will operate their facilities during the proof-of-concept demonstration and extension period, processing the maximum quantities of feed permitted by the RFP and amendments.

    Basis or Source: Enabling Assumptions A7.4 and A7.5.

    Consequence of not performing: If these assumptions change, there will be major changes to the feed staging plans and operational waste volume projections. These changes could impact retrieval of SST waste or other activities that require DST tank space.

31. *Action:* Obtain from the private contractors, the sustained rate their facility can process waste from each envelope when feed is available. This number corresponds to $C_d(POE)$.

Basis or Source: CST Assumption A5.8, Derived Requirement A6.1.

Consequence of not performing: Significant changes from the assumed values of 2.0 MT/day for each LAW private contractor or 0.21 MT NVOL/day for the HLW contractor will change the time scale on the feed staging schedules and impact waste volume projections. Minor changes will cause inconsistency with the private contractors' master schedules.

32. *Action:* Formally control the definitions, use and allocation of TOE, POE, and FAE (or other measures of system efficiency) for both top-down design and bottom-up estimation of system behavior.

    Basis or Source: Derived requirement A6.1, CST Assumption A5.8.

    Consequence of not performing: There will be confusion over the meaning of statements of processing rates or plant capacity. This will diminish after the private contractors size their facilities.

33. *Action:* Validate the correlation used to estimate specific gravity against actual sample data.

    Basis or Source: Section 2.11.2.

    Consequence of not performing: Dilution water estimates can not be refined until results from thermodynamic modeling or laboratory analysis are available. It is expected that dilution water volume estimated by solid/liquid equilibria considerations (or the 7*M* [Na] proxy limit) will be exceed that required by the flammable gas rule (SpG based).

34. *Action:* Defer classification of SST waste until more definitive composition estimates are available.

    Basis or Source: Section 2.4.

    Consequence of not performing: The confidence in the current set of SST composition estimates is low. Classification of SST using these estimates is not effective use of resources.

35. *Action:* Develop a basis for estimating solids entrained during retrieval and subsequent feed staging activities.

    Basis or Source: Simplifying Assumption A8.4.

    Consequence of not performing: Will not be able to predict the amount of entrained solids retrieved from the source DST and the fate of the solids during feed staging activities. This is not critical since the recommended intermediate feed staging tank upgrades provide a means to deal with entrained solids.

36. *Action:* Document the decision to allocate 241-AP-102 and 241-AP-104 as the intermediate feed staging tanks.

Basis or Source: A6.2.

Consequence of not performing: No significant consequences. This action will be completed with the approval and release of Galbraith (1996).

4.2 STUDY CAVEATS

Many significant assumptions were provided informally by the CST or by making enabling assumptions. These are highlighted in Section 2.1 and documented in Appendix A.

The next revision (Revision 22) of the OWVP will verify if there is sufficient tank space for staging feed to the private contractors along with all other demands being placed on the DST storage system.

This study is based on projected DST supernate inventories. Changes to these inventories can significantly affect classification of tanks according to envelope and, thus, the availability of feed during Phase I.

The solid/liquid equilibria of waste during retrieval, transfer, and blending has been ignored. A limit of 7M [Na] maximum in the retrieved feed was used as a proxy.

The proposed staging schedule conflicts to some degree with some of the waste compatibility rules (see Section 2.7). The rules that may present problems are: (1) TRU Segregation Decision Rule, (2) Complexed Waste Segregation Decision Rule, and (3) the Tank Waste Type Decision Rule.

There was insufficient information to fully evaluate the criticality, pumpability, energetics, and TRU decision rules.

The numerical results of the simulation used for the transfer system and feed delivery staging study should not be applied out-of-context. The results show the relative performance of the alternatives and identify important parameters and ranges for which staging activities can be consistently successful. However, the use of these numerical values of the measures in an absolute sense requires distributions that more accurately capture real-world behavior than the simple distributions used in the analysis.

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APPENDIX A

ASSUMPTIONS AND REQUIREMENTS

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CONTENTS

FIGURES

APPENDIX A

ASSUMPTIONS AND REQUIREMENTS

This appendix provides the various assumptions and requirements used throughout the analysis. Other lower-level technical assumptions made during the study are not included here. Occasionally, information was inconsistent or incomplete. In this situation, verbal or written direction from the Contractor Support Team (CST) was given more importance than the content of the final Request for Proposals (RFP) (as amended), the final RFP was given more importance than the current snapshot of the Tank Waste Remediation System (TWRS) Functions and Requirements Document (FRD) (WHC 1996a), and the FRD given more importance than the Interface Control Documents (ICD) (Singh 1996, Graves 1996). Enabling assumptions were made if information was still inconsistent or lacking. Simplifying assumptions were made to maintain a tractable work scope.

The privatization details are still evolving. The FRD and ICDs tend to both lag behind the RFP in some matters and lead in others. This presents a moving target making it difficult to obtain a comprehensive, consistent and traceable set of constraints, requirements and assumptions. Traceability is further complicated by the bi-directional information flow between the RFP, FRD, ICDs and supporting documentation.

Assumptions were frozen as of April 25, 1996.

A1.0 FUNCTIONS AND INTERFACES

The TWRS Functions and Requirements Document (WHC 1996a) was reviewed to identify the functions and interfaces supporting staging of DST supernate during Phase I.

Requirement: The main material movement functions and interfaces supporting staging of DST supernate during Phase I are shown in Figure A1-1. The figure shows which functions support the various aspects of feed staging. Figure A1-2 shows the interfaces controlling the allocation of DSTs to various processing functions.

Issue: The FRD is currently being reviewed to ensure that it is consistent with the RFP. Identification and resolution of the internal and external inconsistencies due to this review are outside the scope of this study.

Figure A-1. Functional Flow Diagram for Double-Shell Tank Supernate Staging (Part 1).

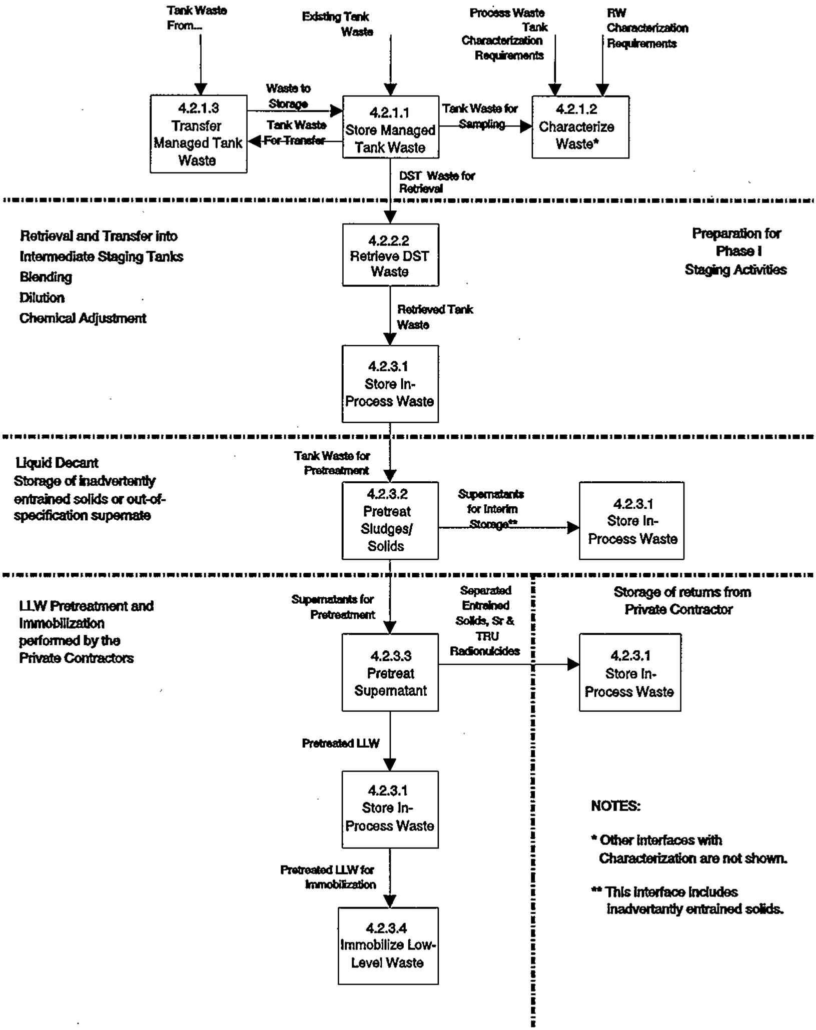
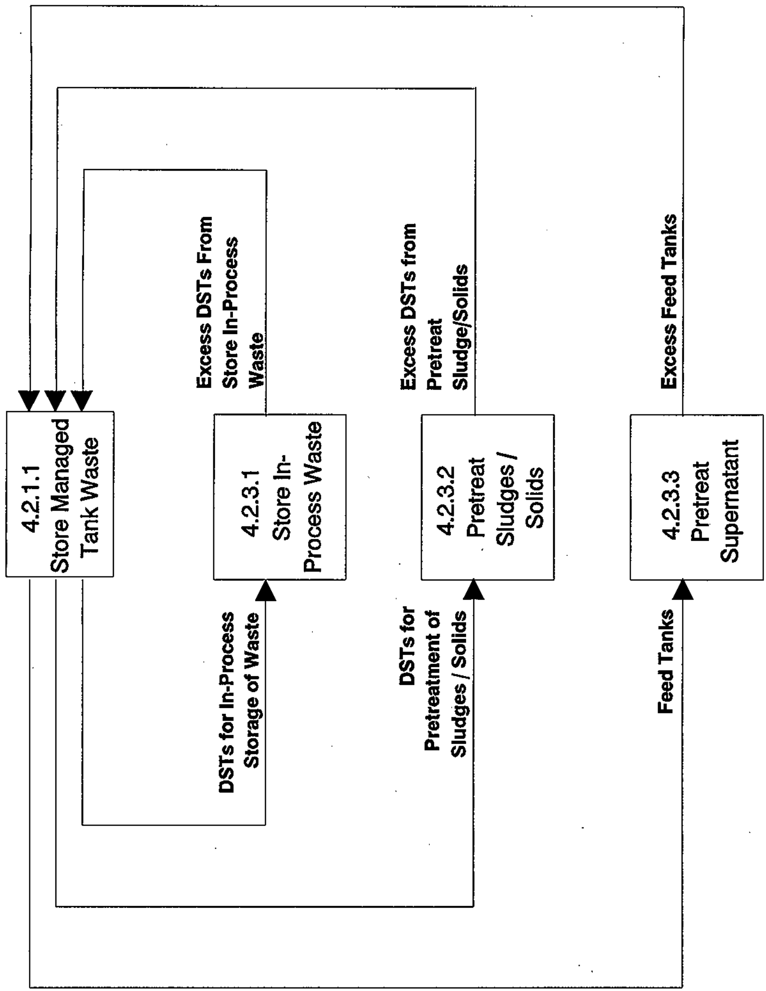


Figure A-2. Functional Flow Diagram for Feed Staging (Part 2).



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A2.0 CONSTRAINTS FROM FUNCTIONS AND REQUIREMENTS DOCUMENT

Applicable constraints from the FRD are identified as part of the ICDs for delivery of supernate to the private contractors (Graves 1996) and for the turnover of feed tanks (Singh 1996). No specific constraints were identified by the ICDs.

Issue: Neither the FRD nor ICDs allocate specific regulatory constraints to the "Supernates for Pretreatment Interface." It is not apparent which regulatory constraints apply to the this interface (implemented as the final staging transfer).

A3.0 REQUIREMENTS FROM FUNCTIONS AND REQUIREMENTS DOCUMENT

Applicable requirements from the FRD are identified as part of the ICDs for delivery of supernate to the private contractors (Graves 1996) and for the turnover of feed tanks (Singh 1996). The FRD is currently being reviewed to ensure consistency with the privatization constraints and requirements. Therefore, the FRD is not yet a definitive source for privatization requirements. However, several requirements from the FRD that directly affect feed staging have been included below.

A3.1 DOUBLE-SHELL TANK VOLUMES--MAXIMUM LIQUID LEVELS

Requirement: The maximum level of waste in AP-Farm DSTs is 4.36 ML (419 in.)

Source: OSD-T-151-00007, Rev. H-16.

Discussion: Calculations will use 4.33 ML (416 in.) (See Assumption A8.3).

A3.2 DOUBLE-SHELL TANK VOLUMES--MINIMUM TANK HEEL

Requirement: A minimum heel of 0.06 ML (6 in.) is required when the ventilation system is running.

Source: OSD-T-151-00007, Rev. H-16.

A3.3 SUPERNATE PRETREATMENT

Requirement: "The feedstock to the Phase I LLW Immobilization process shall have undergone a gravity settling of solids with decantation of the supernatant to the LLW immobilization feed tanks." Traces to 4.2.3.2 Pretreat Sludges/Solids.

Source: WHC (1996a).

A3.4 STORAGE CAPACITY

Requirement: "A storage capacity of 7.5 E+06 L (equivalent to two existing DSTs) shall be provided during Phase I processing for receipt and interim storage of retrieved tank waste." Traces to 4.2.3.1 Store In-Process Waste.

Source: WHC (1996a).

A3.5 TRANSFER OF FEED TANKS

Requirement: "The operational control of the feed staging tanks (full tanks) will be transferred from the M&O to the privatization contractors." Traces to 4.2.3.3 Pretreat Supernate.

Source: WHC (1996a), Singh (1996).

Issue: RL desires that the feed tanks be transferred empty if possible. See requirement A4.10 and assumption A5.9 for more information.

A3.6 WASTE COMPATIBILITY

Requirement: Waste compatibility requirements, documented in *Data Quality Objectives for Tank Farms Waste Compatibility Program* and *Tank Farm Waste Transfer Compatibility Program*, will be used to determine if transfers of waste within the DST system are permissible. See Assumption A7.8 for disposition of issues.

Source: Fowler (1995a), Fowler (1995b).

Discussion: These two documents consolidate requirements from various sources into a set of decision rules. The rules consider criticality, flammable gas accumulation, energetics, corrosion, watch-list tanks, chemical compatibility, tank waste type, TRU waste segregation, heat generation rate, complexant waste segregation, waste pumpability and high phosphate waste.

Issue: The *Preliminary Low-Level Waste Feed Staging Plan* identified several rules that may present problems. They are: (1) Flammable Gas Accumulation, (2) TRU Segregation, (3) Heat Generation Rate, (4) Complexed Waste Segregation, and (5) the Tank Waste Type.

Source: Certa et al. (1996)

Issue: The context under which the decision rules were developed was that of waste management (receipt, storage, transfer, and concentration of waste). These may not be valid under a processing context (retrieval, in-process storage, and partial pretreatment).

A4.0 REQUIREMENTS FROM REQUEST FOR PROPOSAL

The RFP and amendments were reviewed for requirements related to feed staging. These requirements are discussed in the following sections.

A4.1 FEED COMPOSITION

Requirement: Waste supplied to the private contractors during the LAW proof-of-concept demonstration and extension will meet the limits established by feed Envelopes A-C per the RFP. See Assumption A5.2 for an alternative $[SO_4]/[Na]$ limit for Envelope C that will be used in this study.

Source: DOE-RL (1996a), Section C.6, Specification 7.

Source: DOE-RL (1996b), I.20, I.21

Discussion: "Envelope A represents waste that will test the production capacity and fission product removal efficiency of the plants while producing a final product in which the waste loading will be limited by sodium. Envelope B waste is similar to Envelope A but this waste will produce a final product in which the waste loading will be limited by minor component concentrations. Envelope C represents waste with complexing agents that may interfere with ^{90}Sr and/or TRU decontamination requiring demonstration of organic destruction or some other acceptable mitigation technology."

Source: McKee et al. (1995)

Issue: All waste meeting Envelope A requirements will also satisfy Envelope B and Envelope C requirements. See Assumption A5.1 for additional requirements.

Issue: Tanks 102-AN and 107-AN contain waste intended to be classified as Envelope C (Gilbert 1996). Calculations show that the maximum $[SO_4]/[Na]$ ratio excludes this waste from Envelope C. See Assumption A5.2 for an alternative $[SO_4]/[Na]$ limit that will be used in this study.

Issue: The requirement that "The insoluble solids fraction will not exceed 5 vol% of the waste transferred as waste Envelopes A, B, and C" is ambiguous. See Assumption A5.3 for clarification.

Issue: The RFP does not define which radionuclides were used to develop the TRU limits. This should be clearly defined during contract negotiations to avoid creating a point of contention. See enabling assumption A7.14 for TRU calculations.

A4.2 SCHEDULE--LOW-ACTIVITY WASTE PROOF OF CONCEPT DEMONSTRATION

Requirement: Each private contractor will process the minimum quantities of waste (see Section A4.3) through their LAW facility as a *proof-of-concept* demonstration from June 1, 2002 through June 1, 2007.

Source: DOE-RL (1996a), Section F, CLIN 003A, 003B and 003C or CLIN 004A, 004B and 004C.

A4.3 DOUBLE-SHELL TANK SUPERNATE ORDER QUANTITIES

Requirement: The minimum and maximum order quantities of DST supernate provided to each private contractor are (in MT of sodium):

Envelope	Minimum (per contractor)	Maximum (per contractor)
A	2,600	4,900
B	100	1,000
C	100	2,400
Sum of A, B, and C*		5,100

*The maximum combined quantity of Envelopes A, B, and C to be processed by each contractor shall not exceed 5,100 MT sodium.

Source: DOE-RL (1996a), Section H.9.a, H.9.b, H.9.c and H.9.e.

A4.4 PROTOCOL--PRIVATE CONTRACTOR NOTICE

Requirement: The private Contractor will provide notice 60 days in advance of the desired waste transfer date (WTD) and promptly inform RL if the WTD will change.

Source: DOE-RL (1996a), Section H.9.g.

A4.5 PROTOCOL--FEED DELIVERY WINDOW

Requirement: The M&I contractor will transfer a batch to the private contractor's feed tank (1) no earlier than the later of the WTD or the day the Contractor is actually ready to receive and (2) no later than 30 days after the ready date.

Source: DOE-RL (1996a), Section H.9.i.

A4.6 PROTOCOL--FEED COMPOSITION

Requirement: The M&I contractors will provide the waste batch composition before transfer to the private contractors' feed tank.

Source: DOE-RL (1996a), Section C.7, Interface Description 19.

A4.7 FEED ENVELOPE SCHEDULE

Requirement: During the proof-of-concept demonstration and extensions, DST supernate will be provided independently to each private contractor according to the following schedule. The M&I contractor will provide waste containing the stated mass of Na from the stated envelope and in the stated sequence. The value of "i" will be determined so that the minimum order quantity of Envelope A is satisfied during Batch i. See Assumption A5.7 for additional restrictions on the sizes of batches i+1 and i+2.

Batch(es)	Envelope	Required mass of Na	Period
1	A	≥ 500 MT	Proof-Of-Concept Demonstration
2...i	A	≥ 100 MT	
i+1	B	≥ 100 MT	
i+2	C	≥ 100 MT	
i+3...j	C	≥ 100 MT	Extension
j+1...k	A	≥ 100 MT	
k+1...m	B	≥ 100 MT	

Discussion: Feed batches 1...i+2 are for the proof-of-concept demonstration. Feed batches i+3...m are for the extension; the order of batches during the extension are not specified by the RFP and are subject to change during this study.

Source: DOE-RL (1996a), Sections H.9.h.1, H.9.h.2 and H.9.h.3.

A4.8 MINIMUM FEED BATCH SIZE

Requirement: The minimum DST Supernate feed batch size is 100 MT Na. The minimum HLW feed batch size is 5 MT of waste oxide exclusive of sodium and silicon.

Source: DOE-RL (1996a), Sections H.9.h.1(b), H.9.h.2(b), H.9.h.3(b) and H.9.h.4(b).

A4.9 FEED TANK ALLOCATION

Requirement: Tanks 241-AP-106 and 241-AP-108 will be turned over to the control of the private contractors, one to each private contractor.

Source: DOE-RL (1996a), Section C.7, Interface Description 21; H.9.h.1)(a).

A4.10 FEED TANK TURNOVER CONDITION

Requirement: The initial batch of feed may be transferred along with or separately from the feed tank. See Assumption A5.9 for more information.

Source: DOE-RL (1996a), Section C.7, Interface Description 21; H.9.h.1(a).

Issue: This assumption is an important change from the draft RFP. The draft RFP (and thus the FRD and ICD) required that these two tanks would be transferred to the private contractors along with the initial batch of feed. The impacts of this change on the OWVP and feed staging have not yet been studied.

A4.11 RETURNS--ENTRAINED SOLIDS

Requirement: The private contractors may return an "Entrained Solids" product to the M&I contractors for storage in the DST system.

Source: DOE-RL (1996a), Sections C.4.b.1(e), C.6 Specification 3, C.6 Specification 9, C.7 Interface Description 16.

Source: DOE-RL (1996b), I.6 [which adds C.4.b.2(c)], I.18, I.26.

A4.12 RETURNS--STRONTIUM AND TRANSURANICS

Requirement: The private contractors may return a "Strontium and TRU" product to the M&I contractors for storage in the DST system.

Source: DOE-RL (1996a), Sections C.4.b.1(e), C.4.b.2(b), C.6 Specification 6, C.6 Specification 9, C.7 Interface Description 16.

Source: DOE-RL (1996b), Sections I.6, I.19, I.22, I.26.

A4.13 SYSTEM CAPACITY

Requirement: The LAW private contractors will each demonstrate a minimum system capacity of 600 MT Na for Envelope A over a one year period. The HLW private contractor will demonstrate a minimum system capacity of 60 MT waste oxides exclusive of Na and Si (NVOL) over a one year period.

Source: DOE-RL (1996a), Section C.4.d.

A5.0 CONTRACTOR SUPPORT TEAM ASSUMPTIONS

The CST has provided the following assumptions to clarify the intent of the RFP and amendments.

A5.1 FEED COMPOSITION--ESTABLISH EXCLUSIVE ENVELOPES

Assumption: For both planning and technical analysis purposes, the M&I contractor must deliver waste that satisfies the following limits, in addition to those specified in Requirement A4.1:

Envelope C:

$$0.06 \leq \frac{TOC}{Na}, \quad \frac{mol\ C}{mol\ Na}$$

Envelope B:

At least one of these limits must be satisfied		
Analyte	Minimum Analyte: Na ratio	Units
Cl	3.7E-02	mol/mol
Cr	6.9E-03	mol/mol
F	9.1E-02	mol/mol
PO_4	3.8E-02	mol/mol
SO_4	9.7E-03	mol/mol
^{137}Cs	4.3E+09	Bq/mol

Discussion: The only differences in the RFP limits between Envelope A and Envelopes B or C are that the maximum limits for certain analytes have been raised; Envelope A is, therefore, a subset of both Envelopes B and C. This provides RL flexibility in satisfying the provisions of the RFP. The M&I contractor, however, shall not take advantage of this flexibility as it defeats the intended purposes of the three envelopes. The additional limits are those necessary to exclude waste satisfying Envelope A from satisfying Envelopes B or C.

Source: Honeyman (1996b)

A5.2 FEED COMPOSITION--ADJUSTED ENVELOPE C: $[SO_4]/[Na]$

Assumption: A maximum $[SO_4]/[Na]$ limit for Envelope C of 0.02 mole/mole will be used in this study.

Discussion: The published limit (0.0097) excludes the CC waste stored in 102-AN and 107-AN from Envelope C. It is the CST's intent that these tanks be classified as Envelope C. The adjusted limit is not expected to reduce the Na_2O loading in the immobilized waste.

Source: Gilbert (1996); personal communication with R. A. Gilbert (RL) and K. D. Wiemers (PNNL), April 10, 1996.

A5.3 FEED COMPOSITION--SOLIDS LIMIT INTERPRETATION

Assumption: Volume percent settled solids will be measured by Method "2540F Settleable Solids."

Source: Verbal communication with K. D. Wiemers (PNNL).

Discussion: The RFP imposes a 5 vol% settled solids limit, however the condition under which this is to be measured is not specified (DOE-RL 1996a, Section C.6, Specification 7). One reviewer has stated that floating solids have been observed in many samples in the past and would rather see centrifuged solids.

A5.4 FEED COMPOSITION--BULK COMPOSITION

Assumption: The concentration limits specified by the feed envelopes are bulk concentrations (the average composition of each feed batch including solids).

Source: Wiemers (1995a)

Discussion: The staging strategy will be flexible enough to deal with solids. However, solids cannot be dealt with rigorously at this time.

A5.5 INTER-BATCH FEED ENVELOPE HOMOGENEITY

Assumption: Multiple batches of waste provided to a given private contractor do not need to have the same composition. They just need to fall within the proper feed envelope.

Source: Certa (1995)

A5.6 INTER-CONTRACTOR FEED BATCH HOMOGENEITY

Assumption: The two private contractors do not require waste batches of the same composition as long as each receives waste within the proper feed envelope. However, the feed staging plan will attempt to keep the waste similar to avoid unintentional biases and potential legal challenges.

Source: Gilbert (1996).

A5.7 FEED ENVELOPE SCHEDULE--ADDITIONAL RESTRICTIONS

Assumption: The size of batch i+1 and i+2 will be less than or equal to 130 MT Na each.

Discussion: RL intends that the feed delivered during the proof-of-concept demonstration (not the extention) approximate the minimum order quantities.

Source: Gilbert (1996)

Issue: The *Preliminary Low-Level Waste Feed Staging Plan* (Certa et al. 1996) concluded that the minimum schedule campaign length should be kept larger than a) about 200 to 275 days to ensure that enough time is available to restage an out-of-specification feed batch and b) about 90 to 120 days to avoid increases in the nominal outage. Using the facility processing rate from A5.8, 100 MT can be processed in 50 days. There is a significant risk that the feed batch immediately following each of these short duration campaigns may not be delivered within the 30 day time period.

Source: Certa et al. (1996)

A5.8 FACILITY PROCESSING RATES

Assumption: The processing rate for each private contractor will be estimated as $(POE)(C_d)$ while feed is available.

Source: Verbal communication, W. G. Richmond (PNNL).

Discussion: The phase "while feed is available" is equivalent to application of the feed availability efficiency *(FAE)*. For DST supernate, feed is available when it has been shown to meet the envelope limits and has been delivered to the contractor's feed tank. See Assumption A6.1 for the definitions and determination of *POE, FAE* and C_d.

The value of $(POE)(C_d)$ is calculated to be ~2.0 MT/day for the LAW private contractors and ~0.21 MT NVOL/day for the HLW contractor.

A5.9 FEED TANK TURNOVER CONDITIONS

Assumption: On or before June 1, 2002, each feed tank will contain the first batch of feed for each private contractor.

Discussion: The actual turnover date is open to negotiation with the private contractors. Regardless of the actual date of turnover, the first batch of feed will be staged as early as possible.

Source: Verbal communication, R. A. Gilbert (RL), March 19, 1996.

Assumption: If possible, the feed tanks should be transferred to the private contractors empty.

Source: Gilbert (1996).

A5.10 FEED COMPOSITION--INTERFACE POINT

Assumption: The composition of the actual waste *delivered* to the private contractors' feed tank is required to meet the limits established by the envelopes.

Source: Verbal communication, W. G. Richmond (PNNL).

Discussion: For small feed batches, the mixture resulting from blending the newly delivered waste with the heel in the private contractors' tank may fall outside the intended feed envelope. This may result in the private contractors' facilities not being challenged by the intended waste. The heel mixing study in the *Preliminary Low-Level Waste Feed Staging Plan* will be revised to reflect the new feed envelopes and recommend maximum heel volumes.

A6.0 DERIVED REQUIREMENTS

The following requirements have been derived from other requirements or the *Preliminary Low-Level Waste Feed Staging Plan.*

A6.1 FACILITY NAMEPLATE CAPACITY

Assumption: The facility nameplate (design) capacity will be estimated from the following relationship:

$$\frac{TP}{T} = (FAE)(POE)C_d$$

Where,

TP = Throughput (MT of Na in the feed).

T = Time in days (365 days/year, 24 hours/day).

FAE = Feed Availability Efficiency (fraction of the time that feed is available in the private contractors feed tanks). A value of 0.80 is commonly used. The *FAE* used to estimate the plant capacity will be based on the lower of the value corresponding to the recommended feed staging strategy and 0.80.

POE = Plant Operating Efficiency. This is the ratio of the facility's average throughput (after adjusting for reduced rate operation, startup and shutdown transients and all plant outages planned or otherwise, except for lack of feed) to the design capacity. A value of 0.75 is commonly used and will be held constant in this study.

C_d = Facility nameplate or design capacity (the maximum instantaneous processing rate). Units are MT Na in the feed/day.

Source: Derived from Assumption A4.13

Discussion: The Total Operating Efficiency (*TOE*) is the product of the *FAE* and *POE*. Using the common values for *FAE* and *POE*, the *TOE* is 0.60. The FAE is an attribute of the *system*, while the term $(POE)C_d$ is an attribute of the *plant*.

For the LAW private contractors: if *TP/T* is set equal to 600 MT Na/year, then for an *FAE* of 0.8 and a *POE* of 0.75, the C_d = 2.7 MT Na/day. This corresponds to 18 MT/day of 20 wt% Na_2O glass product.

For the HLW private contractor: if *TP/T* is set equal to 60 MT NVOL/year, then for an *FAE* of 0.8 and a *POE* of 0.75, the C_d = 0.27 MT NVOL/day.

Issue: *TOE* should be controlled and allocated by the system engineering process. It is critical that a consistent basis be used for separating the system attribute (FAE) from the private contractors facility attribute *(POE)*C_d. The methodology and values must be controlled. One set of values (conservative, based on a top-down approach) may be used for establishing the facility design basis, while a different set of values (based on a bottom-up approach) may be used to predict system behavior.

The FRD has already identified this as an issue that is named "System Effectiveness" along with a to be determined performance requirement and required analysis of the same name. A change request will be submitted to incorporate this enabling assumption into the FRD.

A6.2 FEED STAGING STRATEGY

Assumption: The feed staging strategy designated as *Indirect Staging - ASAP* will be used.

Discussion: The *Preliminary Low-Level Waste Feed Staging Plan* recommends that the *Indirect Staging - ASAP* feed staging strategy be used to provide feed to the private contractors. The Decision Support Board has recommended that this alternative be adopted.

Source: Certa et al. (1996); WHC 1996b.

A6.3 FEED SAMPLING STRATEGY--CONTRACTUAL

Assumption: The M&I contractor will demonstrate the delivered waste meets the envelopes by sampling and analysis of the waste staged in the intermediate staging tanks.

Source: Derived from Assumptions A4.6 and A6.2

Discussion: The bulk composition of retrieved supernate may be of different composition than estimated due to projection uncertainties, source tank inhomogeneities or large amounts of entrained solids. If dilution water (or dilute caustic) is required for the retrieval/transfer of waste or to meet envelope limits, the composition may be further altered by dissolution or precipitation of solids. A similar concern exists for blending wastes to provide the proper batch sizes or using dilute waste as an alternative to water for dilution. Staging activities may further mix wastes from different source DSTs.

Issue: The precision and accuracy needed to demonstrate that the waste meets the intended envelope, satisfies regulatory requirements (if any), and satisfies the private contractors' needs for feed composition data have not been determined.

A7.0 ENABLING ASSUMPTIONS

Enabling assumptions are made when insufficient information is available to permit the analysis to proceed.

A7.1 STARTING DOUBLE-SHELL TANK COMPOSITION ESTIMATES

Assumption: The starting DST compositions used in this study as a basis for projections will be based upon laboratory analysis and process knowledge. The inventories will not be charge balanced. This inventory will be documented in a separate report.

Source: Shelton (1996)

Discussion: This inventory is consistent with, but not identical to, the inventory used in the 1995 TWRS Process Flowsheet.

Issue: Tank inventory estimates are subject to periodic revisions as new data become available and existing data are re-interpreted. The TWRS Characterization Project is currently preparing official tank inventory estimates for all of the tanks. This effort is expected to be completed by June 1997.

A7.2 SINGLE-SHELL TANK COMPOSITION ESTIMATES

Assumption: The SST compositions used in this study will be the same as those used by the 1995 TWRS Process Flowsheet (Orme 1995).

Discussion: This inventory partitions the waste into a soluble fraction and an insoluble fraction. The inventory includes both chemicals and radionuclides. Tank contents are estimated as of February 1994; radionuclides are then decayed to December 31, 1999. The minimum water necessary to reduce the [Na] to 5*M* or less and the solids concentration to 10 wt% or less has been added.

A7.3 PROJECTED DOUBLE-SHELL TANK COMPOSITION ESTIMATES

Assumption: Inventories will be adjusted to reflect projected DST contents through FY 2002. The date when each DST is available for feed staging will be provided. The decay date for radionuclides will be December 31, 2007 (see assumption A8.1). The inventories will not be charge balanced. These projected inventories will be documented in a separate report.

Source: Shelton (1996)

Discussion: This projection will account for aging waste consolidation (or lack thereof) (Honeyman 1996a), evaporator operations, interim stabilization, caustic addition to 241-AN-102 and 241-AN-107 and receipt of new waste from outside the TWRS.

Issue: The NCRW Consolidation activity (1N1A1B1B01) and 241-SY-102 Retrieval Evaluation activity (1N1A1B1N01) will recommend the extent of consolidation of TRU solids from 241-AW-103, 241-AW-105, and 241-SY-102. Until a decision is reached, the projected DST inventories will assume that the solids in 241-AW-103, 241-AW-105, and 241-SY-102 remain in their current location.

Issue: The NCAW Consolidation activity (1N1A1B0A01) has not yet reached a formal decision. The assumptions provided for the OWVP (Rev. 22) will be used until a decision is reached (Honeyman 1996a).

Issue: Projections are subject to change. Generally, the more complicated the projection, the more likely it is to change. For example, a static tank's projection should be as accurate as the starting inventory, while a tank filled with evaporator bottoms from new tank waste will be more variable.

A7.4 SCHEDULE--LOW-ACTIVITY WASTE EXTENSIONS

Assumption: Each private contractor will process up to the maximum quantities of waste (see Assumption A4.3) through their facility during an *extension* beginning when the minimum quantities have been completed through June 1, 2011.

Source: DOE-RL (1996a), Section I.d.

Issue: Operation of the LAW demonstration facilities during this extension is optional. This study assumes that both facilities operate during this period.

A7.5 NUMBER OF TREATMENT FACILITIES

Assumption: Two private LAW Contractors will independently operate their respective LAW facility, of which will also operate a HLW facility.

Issue: If only one LAW contract is awarded or if one or both LAW Contractors fail to process supernate according to schedule, less space will be made available within the DST system. This may impact the retrieval of SST waste or other activities that require DST space.

A7.6 DOUBLE-SHELL TANK VOLUMES--MINIMUM ACHIEVABLE HEEL

Assumption: The minimum achievable tank volumes (heels) are assumed to be 0.1 ML (10 in.) for standard deep-well turbine pumps, 0.42 ML (40 in.) for current floating suction pumps, and 0.1 ML (10 in.) for the new decant pump.

Discussion: The current floating suction pumps will lose suction with about 0.1 to 0.42 ML (10 to 40 in.) of waste remaining in the tank. The pump will lose prime below 0.75 ML (72 in.) if turned off.

Source: Verbal discussion, M. R. Elmore, D. A. Burbank, J. L. Foster.

Discussion: A new decant pump can probably pump within 0.1 ML (10 in.) of the bottom of the tank or solids level. This is consistent with performance observed during a vendor test of the pump.

Source: T. W. Staehr and H-2-820774, Piping Decant Pump Assembly Elevation and Details, Sheets 1 and 2, Rev. 1.

Discussion: The inlet of most deep-well turbine pumps is about 0.1 ML (10 in.) from the bottom.

A7.7 SAFETY ISSUE RESOLUTION

Assumption: Safety issues concerning DST waste will be resolved in order to permit feed staging activities to occur as planned.

Discussion: It is desired to dispose of waste from Watch List tanks as soon as possible. We should not try to avoid using waste from Watch List tanks for feed to the privatization vendor. Tank space can made available faster, by processing the most dilute of the concentrated wastes first.

Watch List status does not travel with the waste being transferred. Transferring waste from a Watch List tank does not remove the designation and adding waste from a Watch List tank to another tank will not automatically add the receiver to the Watch List. The pre-transfer evaluation should give a basis for recommending to either keep or not keep the WL designation for the source and receiver tanks.

Source: Barton (1996), Fowler (1996)

A7.8 WASTE COMPATIBILITY ISSUES

Assumption: The disposition of the waste compatibility issues raised by the *Preliminary Low-Level Waste Feed Staging Plan* will be as follows:

1. Flammable Gas Accumulation: This rule will not be relaxed and will be followed. Feed staging transfers that could violate the SpG rule will be diluted before or during transfer. Sufficient dilution water will be added to reduce the SpG to 1.40 or lower (the rule specifies 1.41).

2. TRU Segregation: An evaluation determines that tank heels may be neglected when applying the TRU segregation rule or an appropriate waiver to DOE Order 5820.2A Chapter II is obtained.

3. Heat Generation Rate: This rule will not be relaxed and will be followed.

4. Complexed Waste Segregation: An evaluation determines that there is no WVR

penalty since this waste is being removed from the DST system and doesn't require further evaporation and storage.

5. Tank Waste Type: An evaluation of staging activities finds that tank heels may be neglected when applying the waste compatibility matrix.

Discussion:

1. Flammable Gas Accumulation: The four tanks with high Spg waste are already flammable gas Watch List tanks. Therefore, the waste being transferred will have to be evaluated for potential to trap flammable gas in the receiver tank and the source tanks will have to be evaluated to assure that pumping will not adversely affect the safety of the tanks. The focus is on safety and long term stability of the source tank, but also looks at how retrieval may be effected. Currently, the plan is to add this to the new waste compatibility DQO being prepared by RL and Ecology.

   Additionally, alternative flammable gas accumulation rules are being investigated (Estey and Guthrie 1996).

2. TRU Segregation: The DOE Order for TRU segregation was meant to minimize disposal costs by keeping the volume of TRU waste to a minimum. It's basically aimed at solids/sludge but now that it is recognized that we have supernate that meets the TRU definition, we may need a waiver.

3. Heat Generation Rate: The heat generation rate of the problematic transfer proposed by the *Preliminary Low-Level Waste Feed Staging Plan* (Certa et al. 1996) was 90,000 BTU/hr. This is well below the heat generation rate limit of 700,000 BTU/hr for each tank (1,000,000 BTU/hr total) for the source tank and farm (WHC-SD-WM-OSR-004, Rev. 1, Section 5 [WHC 1996c]). The 70,000 BTU/hr limit for non-aging waste tanks is an Authorization Basis limit. The limit is conservative so raising it does not seem unreasonable but will require DOE approval.

4. Complexed Waste Segregation: This rule is to avoid mixing waste which will cause an unwanted waste volume reduction (WVR) penalty. If the WVR penalty is acceptable, or non-existent, this rule can be overridden.

5. Tank Waste Type: The issue of tank heels is not addressed in the current Compatibility Program or DQO. In practice, tank heels have not been deemed to designate the waste type of a tank. Tanks pumped to a minimal heel are usually considered empty. If, however, there is a safety concern with adding a particular waste type to a heel of another type then the heel cannot be neglected. Tank heels is one of the issues that we (Process Engineering) have suggested be addressed in a future revision of the Compatibility Program.

Source: Fowler (1996a), Fowler (1996b), Direct quotes with minor editing.

Issue: Negotiations with RL and Ecology concerning the content of the waste compatibility DQO are in progress. There may be an opportunity to explicitly address waste transfers required for feed staging purposes and structure the DQO accordingly.

A7.9 RETURNS--"ENTRAINED SOLIDS" AND "STRONTIUM/TRU"

Assumption: A single DST will be set aside to receive this combined stream.

Discussion: The volume and composition of this combined stream will be estimated on a batch-by-batch basis as part of the "TWRS Privatization Process Technical Baseline" due in September 1996 (Activity L1W02729A, Milestone Control Number T32-96-018).

Source: Honeyman (1996a)

A7.10 FEED SAMPLING STRATEGY--REGULATORY

Assumption: The samples taken to demonstrate that the waste meets the intended envelope (See A6.3) will bound any required for satisfying regulatory requirements (if any) needed to transfer of waste to the private contractor's feed tank.

Issue: It is unclear if the transfer of feed to the private contractors feed tank is subject to RCRA requirements. The RFP requires that the private contractor request the regulatory agency(ies) to permit the feed tank as a unit separate from the remaining double shell tanks (DOE-RL 1996a). This suggests that the transfer may be subject to RCRA requirements, especially since the operational control of the waste will change from RL to the private contractor. It is prudent to assume that regulatory samples will be required.

A7.11 INTERMEDIATE STAGING TANKS

Assumption: Allocation of DSTs for intermediate feed staging will be performed as part of this study. If there is no clear preference, tanks 241-AP-102 and 241-AP-104 will be used.

Discussion: Tanks 241-AP-102 and 241-AP-104 are good candidates for use as intermediate staging tanks. The transfers from these two tanks to the vendors feed tanks are short, reducing conflict with other tank farm activities and easy to set up.

Source: Certa et al. (1996)

A7.12 COMMON USE OF TRANSFER LINES

Assumption: The prior use of a transfer line for one class of waste (HLW, TRU or DST supernate) does not preclude its use for another class.

A7.13 MASS-BALANCE AND SOLID-LIQUID EQUILIBRIA CALCULATIONS

Assumption: Simple mass balances will be used when mixing waste with other waste or dilution water. Solid-Liquid equilibria will be ignored. Waste diluted to 7*M* [Na] or less is assumed to be below saturation in the major components. Dilution will be accomplished using raw water. If necessary, NaOH, $NaNO_2$, or $NaNO_3$ will be added so that the diluted waste satisfies the tank corrosion specifications.

Discussion: Dilution of aluminate containing waste with water may precipitate gibbsite. For typical samples, the volume fraction of settled gibbsite is on the order of 3 percent. The solubility of gibbsite is primarily a function of the [OH^-]. For the Al-Na-OH-H_2O system, the minimum [OH^-] is about 6*M*. This value is reduced as the ionic strength of the solution increases (by adding additional sodium salts), down to about 2*M* for DSS.

Source: Phone conversation with D. L. Herting, January 6, 1996

Source: Barney (1976)

Discussion: When two samples of waste from 241-AW-101 were diluted 1:1 (water:waste) about 95 percent of the strontium precipitated. This is an example of solid-liquid equilibria of a minor component that may unintentionally alter the composition of the feed delivered to the private contractors.

Source: Bray (1989)

Issue: A better understanding of solid-liquid equilibria in the targeted waste is critical to successful feed staging. The quantity of solids that precipitate during staging activities will need to be estimated (using waste samples or validated software packages) to confirm the validity of this assumption and to estimate the buildup of solids in the intermediate staging tanks. This may also influence dilution water requirements (perhaps by requiring the ability to add caustic) and the disposition of the solids. Understanding the physical properties of the diluted waste is important to proper transfer system design and operation.

Lacking a validated method of estimating the solid-liquid equilibria, the following areas cannot be dealt with in a rigorous manner:

- Estimation of the dissolution of solids in the targeted slurries or entrained in otherwise clear supernate as a function of dilution water.
- Estimation of the precipitation of solids due to dilution during retrieval or due to in-line dilution during transfer.
- Estimation of the degree of saturation of the major waste components as a function of dilution.
- Estimation of the quantity of solids in the waste as-transferred and resultant physical properties such as SpG and viscosity.

- Estimation of the quantity and composition of solids accumulating in the intermediate feed staging tank.

- Estimation of the composition of the supernate in the intermediate feed staging tank to verify that envelope compliance has not been compromised due to solid-liquid equilibria.

A7.14 TRU CALCULATIONS

Assumption: TRU concentrations will be estimated for the liquid phase using the following equation:

$$[TRU] \approx \frac{\sum Inventory_i}{V\rho(1000\ cm^3/l)}(10^9\ nCi/Ci)$$

Where,
Inventory = Projected supernate inventory, Ci.
subscript i = $^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am$
[TRU] = nCi/g

Discussion: DOE Order 5820.2A defines transuranic waste as "without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay."

Source: DOE 1988

A7.15 SPECIFIC GRAVITY CALCULATIONS

Assumption: The specific gravity of the projected supernate was estimated using the following relationship (Agnew and Watkin 1994) and assuming that the reference density is 1.00 g/cm^3:

$$\rho = 1 + 0.2(a[Al]^2 + b[Al] + c[Na]^2 + d[Na] + e[NO_2]^2 + f[NO_2] + g[NO_3]^2 + h[NO_3] + i[OH]^2 + j[OH])$$

Where,

a = -0.0955
b = 0.383
c = -0.0054
d = 0.1096
e = -0.073
f = 0.373
g = 0.00046
h = 0.201
i = 0.0197
j = 0.0077

Density is in g/cm^3.
All concentrations are molarity.

Source: Agnew and Watkin 1994.
Issue: This equation may result in physically impossible results when used for extrapolation.

A8.0 SIMPLIFYING ASSUMPTIONS

A8.1 DECAY DATES FOR ENVELOPE ASSESSMENTS

Assumption: For envelope assessment and tank classification purposes, the nominal decay date for radionuclides will be December 31, 2007.

Discussion: The two short half-life nuclides of interest (^{137}Cs and ^{90}Sr) have half-lives of about 30 years. The duration combined Phase I proof-of-concept demonstration and extension is 9 years. The delivery dates may vary by up to 4.5 years from the nominal decay date. The radionuclide inventory may vary ± 10 percent during this period, a negligible error for this analysis.

A8.2 DOUBLE-SHELL TANK VOLUMES--MAXIMUM LIQUID LEVEL

Assumption: The maximum liquid level in AP-Farm DSTs used by this study will be 4.33 ML (416 in.)

Discussion: The high liquid level alarm is set at 4.36 ML (419 in.) of waste. For planning purposes, this study will assume a 0.03 ML (3-in.) margin below the Operating Specification Document limit.

A8.3 HEEL COMPOSITION

Assumption: The liquid heels in the private contractors' staging tanks and in the M&I contractor's intermediate staging tanks are assumed to have the same composition as the last full batch of waste staged in that tank.

A8.4 SOLIDS TRACKING

Assumption: The amount and composition of entrained solids will not be tracked. The capability to separate entrained solids from liquids during feed staging is assumed to be required.

Discussion: This does not, however, preclude the need for solids/liquid separation (decant) of supernate from the retrieved waste.

Issue: There is insufficient information available to predict the amount of entrained solids retrieved from the source DSTs and the fate of these solids during feed staging activities. It is prudent to require capability to control the amount entrained solids delivered to the private contractors since the RFP imposes a maximum limit on these solids.

A8.5 TRANSFER LINE FLUSHES

Assumption: The duration and volume of transfer line flushes will be neglected in this analysis.

Discussion: The holdup of the longer transfer routes within 200 East Area is about 4,000 L (1,000 gal). A flush of two line-volumes would take about 30 minutes at a 230 L/min (60 gal/min) flush rate. This is negligible compared to the other durations and feed batch volumes.

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APPENDIX B

PROJECTED DOUBLE-SHELL TANK SUPERNATE COMPOSITION AND INVENTORY

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APPENDIX B

PROJECTED DOUBLE-SHELL TANK SUPERNATE COMPOSITION AND INVENTORY

Table B-1 and B-2, compositions and inventories, are taken from Shelton (1996). They reflect the targeted fraction of waste in each double-shell tank. See Section 2.3 for a summary of the development of the compositions, inventories, and explanation of the projection quality. See Table 2-21 of Section 2.11.2 for a description of the targeted fractions versus the excluded fraction.

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Table B-1. Double-Shell Tank Supernate/Slurry Compositions. (Sheet 1 of 3)

Supernatant Source:	101-AN	102-AN	103-AN	104-AN	105-AN	106-AN	107-AN	101-AP	102-AP	103-AP
Units:	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L
Feed Available in:	FY97	FY96	FY96	FY96	FY96	FY00	FY97	FY97	FY96	FY96
Decay Date:	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07
Projection Quality:	L	H	H	H	H	L	H	M	H	H
Component										
Al(OH)4-	9.05E-02	5.39E-01	2.13E+00	1.39E+00	1.74E+00	7.40E-01	4.22E-02	3.17E-01	4.30E-01	9.11E-03
Ba+2	2.22E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.08E-07	0.00E+00	1.67E-05	2.07E-06	0.00E+00
Ca+2	2.77E-03	1.08E-02	2.16E-03	0.00E+00	0.00E+00	3.06E-06	1.30E-02	2.46E-03	0.00E+00	0.00E+00
Cd+2	1.54E-04	0.00E+00	1.42E-04	0.00E+00	0.00E+00	1.22E-06	0.00E+00	1.67E-05	1.31E-05	9.87E-07
Cr(OH)4-	6.55E-03	5.39E-03	1.63E-02	1.30E-02	1.30E-02	2.51E-05	3.10E-03	2.60E-03	1.19E-02	8.44E-05
Fe+3	2.12E-03	0.00E+00	1.26E-03	2.00E-04	2.00E-04	3.19E-05	2.55E-02	4.61E-04	6.82E-05	2.20E-05
Hg+2	3.54E-06	0.00E+00	7.98E-05	0.00E+00	0.00E+00	1.57E-09	0.00E+00	1.33E-08	0.00E+00	2.49E-08
K+	1.09E-02	9.80E-02	3.89E-01	1.83E-01	1.57E-01	3.75E-05	5.14E-02	5.33E-01	3.30E-02	3.89E-02
La+3	1.31E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-04	0.00E+00	0.00E+00
Na+	2.75E+00	1.14E+01	1.46E+01	1.20E+01	1.20E+01	1.61E+01	9.19E+00	6.06E+00	4.43E+00	2.31E-01
Ni+3	4.13E-06	5.88E-03	4.09E-04	0.00E+00	0.00E+00	0.00E+00	7.27E-03	3.64E-04	4.53E-04	0.00E+00
Pb+4	1.16E-04	0.00E+00	3.47E-04	0.00E+00	0.00E+00	3.02E-06	1.51E-03	1.72E-05	1.59E-05	0.00E+00
U, (g/liter)	2.87E-01	0.00E+00	5.18E-04	0.00E+00	0.00E+00	2.13E-04	2.13E-01	3.49E-02	3.52E-03	3.69E-03
CO3-2	1.60E-01	1.10E+00	1.49E-01	4.72E-01	3.63E-01	9.80E-01	1.19E+00	3.35E-01	4.47E-01	4.28E-02
CL-	1.04E-02	1.08E-01	2.71E-01	2.12E-01	2.40E-01	4.52E-04	8.29E-02	4.92E-02	8.18E-02	1.40E-03
F-	3.34E-02	1.08E-01	3.87E-02	0.00E+00	0.00E+00	1.56E-01	0.00E+00	2.09E-01	0.00E+00	6.79E-03
SO4-2	4.96E-02	1.47E-01	1.67E-02	6.82E-02	6.82E-02	1.19E-01	1.35E-01	4.27E-02	4.70E-02	3.64E-03
NO3-	2.56E-01	3.50E+00	2.58E+00	3.10E+00	3.12E+00	4.58E+00	3.63E+00	2.13E+00	1.26E+00	6.52E-02
NO2-	2.94E-01	1.78E+00	3.00E+00	1.92E+00	2.61E+00	2.56E+00	1.02E+00	8.39E-01	8.26E-01	2.83E-02
PO4-3	1.22E-01	5.10E-02	9.77E-03	2.94E-02	2.00E-02	7.83E-02	5.29E-03	8.75E-03	1.22E-01	1.46E-03
OH-	1.64E+00	6.18E-01	5.74E+00	4.09E+00	3.64E+00	5.92E-01	9.98E-01	2.31E+00	5.38E-01	9.94E-02
TOC, (g/liter)	2.14E+00	2.58E+01	7.36E+00	4.61E+00	3.88E+00	5.37E+01	4.07E+01	4.45E+00	3.28E+00	1.12E-01
14C, (Ci/L)	6.01E-06	1.80E-05	2.00E-06	0.00E+00	0.00E+00	4.55E-10	0.00E+00	1.57E-07	4.99E-07	4.46E-09
90Sr, (Ci/L)	3.81E-02	5.61E-02	8.42E-03	6.97E-03	2.29E-03	1.93E-06	6.29E-02	3.11E-02	1.01E-03	1.77E-06
90Y, (Ci/L)	3.81E-02	5.61E-02	8.42E-03	6.97E-03	2.29E-03	1.93E-06	6.29E-02	3.11E-02	1.01E-03	1.77E-06
99Tc, (Ci/L)	9.49E-05	3.04E-04	1.70E-04	1.31E-04	1.31E-04	9.41E-08	2.94E-04	1.17E-04	8.58E-05	1.08E-06
137Cs, (Ci/L)	3.05E-01	1.86E-01	4.98E-01	5.45E-01	3.64E-01	1.81E-04	1.80E-01	1.11E-01	1.63E-01	4.52E-03
137Ba, (Ci/L)	2.89E-01	1.77E-01	4.73E-01	5.18E-01	3.45E-01	1.72E-04	1.71E-01	1.06E-01	1.55E-01	4.29E-03
154Eu, (Ci/L)	2.42E-04	7.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.06E-09	0.00E+00	0.00E+00
235U, (Ci/L)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238U, (Ci/L)	1.06E-07	0.00E+00	1.74E-10	0.00E+00	0.00E+00	7.75E-15	7.16E-08	1.46E-09	1.18E-09	1.24E-09
237Np, (Ci/L)	1.43E-06	0.00E+00	2.00E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238Pu, (Ci/L)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239Pu, (Ci/L)	2.47E-05	5.77E-05	1.90E-06	8.32E-06	8.32E-06	4.11E-11	2.57E-05	2.23E-06	0.00E+00	0.00E+00
240Pu, (Ci/L)	1.07E-06	1.44E-05	4.75E-07	2.08E-06	2.08E-06	1.03E-11	6.43E-06	5.46E-07	0.00E+00	0.00E+00
241Pu, (Ci/L)	3.36E-06	4.86E-05	1.28E-06	6.67E-06	6.67E-06	3.29E-11	2.12E-05	1.72E-06	0.00E+00	0.00E+00
241Am, (Ci/L)	1.57E-04	6.08E-05	2.30E-06	1.52E-06	1.51E-06	8.19E-10	5.94E-04	6.98E-06	4.19E-07	0.00E+00
Volume, (L)	3.46E+06	3.84E+06	3.62E+06	3.02E+06	4.29E+06	4.00E+06	3.68E+06	4.31E+06	4.16E+06	1.02E+05
H2O Estimate	2.98E+06	2.08E+06	1.65E+06	1.54E+06	2.05E+06	1.91E+06	2.12E+06	2.90E+06	3.09E+06	1.00E+05
Spg Estimate	1.10	1.38	1.50	1.46	1.46	1.40	1.33	1.28	1.21	1.01

Table B-1. Double-Shell Tank Supernate/Slurry Compositions. (Sheet 2 of 3)

Supernatant Source:	104-AP	105-AP	106-AP	107-AP	108-AP	101-AW	102-AW	103-AW	104-AW	105-AW
Units:	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L
Feed Available in:	FY02	FY99	FY97	FY99	FY98	FY96	not est.	TBD	FY02	TBD
Decay Date:	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	not est.	12/31/07	12/31/07	12/31/07
Projection Quality:	L	L	L	L	M	H		L	M	L
Component										
Al(OH)4-	2.83E-01	6.59E-01	1.23E+00	7.01E-01	8.06E-03	1.03E+00	not est.	1.54E-03	9.77E-03	1.99E-04
Ba+2	1.37E-15	4.81E-07	2.26E-07	1.27E-05	1.16E-06	0.00E+00	not est.	4.08E-06	2.03E-08	6.94E-09
Ca+2	5.74E-11	6.21E-05	2.84E-04	1.65E-03	1.66E-05	8.26E-04	not est.	1.54E-04	6.68E-07	8.26E-06
Cd+2	4.96E-16	3.59E-08	2.41E-11	9.46E-07	5.16E-05	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
Cr(OH)4-	1.47E-10	1.49E-05	2.69E-04	3.99E-04	1.04E-04	3.10E-03	not est.	1.40E-03	1.31E-07	7.04E-06
Fe+3	4.62E-05	2.28E-06	9.00E-05	6.01E-05	1.25E-04	0.00E+00	not est.	0.00E+00	5.44E-06	8.89E-04
Hg+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
K+	4.90E-08	1.90E-03	9.89E-02	5.20E-02	2.58E-02	1.07E+00	not est.	5.22E-01	2.76E-06	2.63E-03
La+3	0.00E+00	4.96E-06	0.00E+00	1.31E-04	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
Na+	2.43E+00	1.44E+01	1.06E+01	1.55E+01	2.53E-01	1.00E+01	not est.	8.52E-01	1.97E-01	9.47E-02
Ni+3	9.50E-16	1.24E-05	4.62E-11	3.27E-04	6.82E-06	0.00E+00	not est.	5.05E-05	2.07E-09	0.00E+00
Pb+4	5.38E-15	5.93E-08	2.62E-10	1.61E-06	0.00E+00	1.46E-03	not est.	0.00E+00	2.99E-09	0.00E+00
U, (g/liter)	2.06E-03	3.17E-04	6.31E-03	8.40E-03	3.85E-03	2.24E-01	not est.	9.87E-03	2.17E-02	1.99E-02
CO3-2	1.24E-01	8.76E-01	5.40E-01	9.74E-01	4.29E-02	2.05E-01	not est.	7.68E-02	8.05E-03	3.57E-04
CL-	8.19E-02	2.94E-04	3.45E-01	7.77E-03	1.64E-03	1.46E-01	not est.	3.81E-03	5.24E-03	1.16E-03
F-	1.04E-01	1.32E-01	6.23E-01	1.48E-01	1.89E-02	0.00E+00	not est.	9.16E-01	3.56E-04	4.98E-03
SO4-2	1.62E-02	1.06E-01	6.91E-02	1.25E-01	1.55E-03	1.07E-02	not est.	5.86E-04	2.64E-04	2.43E-03
NO3-	6.83E-01	4.08E+00	3.08E+00	4.45E+00	6.91E-02	3.45E+00	not est.	5.66E-02	6.25E-02	3.18E-01
NO2-	4.54E-01	2.28E+00	1.97E+00	2.40E+00	2.51E-02	2.22E+00	not est.	2.65E-02	1.11E-02	1.40E-02
PO4-3	1.59E-02	6.94E-02	5.05E-02	7.24E-02	2.21E-03	2.22E-02	not est.	6.11E-04	2.60E-03	2.41E-03
OH-	8.42E-01	5.26E-01	3.48E+00	8.35E-01	9.15E-02	5.07E+00	not est.	1.88E-01	9.92E-02	4.41E-02
TOC, (g/liter)	1.50E+00	4.79E+01	5.45E+00	4.95E+01	4.99E-01	2.46E+00	not est.	9.35E-01	4.03E-01	2.39E-01
14C, (Ci/L)	3.28E-19	4.96E-10	4.61E-14	1.31E-08	7.60E-15	3.69E-07	not est.	0.00E+00	6.13E-12	0.00E+00
90Sr, (Ci/L)	4.07E-12	1.50E-03	2.87E-08	4.00E-02	5.33E-08	7.13E-04	not est.	1.58E-07	3.02E-09	0.00E+00
90Y, (Ci/L)	4.07E-12	1.50E-03	2.87E-08	4.00E-02	5.33E-08	7.13E-04	not est.	1.58E-07	3.02E-09	0.00E+00
99Tc, (Ci/L)	7.45E-14	3.50E-06	3.64E-09	9.22E-05	2.02E-07	1.51E-04	not est.	2.28E-05	2.32E-09	1.01E-07
137Cs, (Ci/L)	3.36E-09	1.39E-03	6.86E-05	3.70E-02	1.67E-03	3.27E-01	not est.	1.50E-02	3.40E-06	7.86E-04
137Ba, (Ci/L)	3.20E-09	1.32E-03	6.52E-05	3.52E-02	1.59E-03	3.11E-01	not est.	1.43E-02	3.23E-06	7.47E-04
154Eu, (Ci/L)	0.00E+00	0.00E+00	0.00E+00	9.37E-11	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
235U, (Ci/L)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
238U, (Ci/L)	9.90E-19	7.12E-11	4.88E-14	1.88E-09	4.23E-11	7.53E-08	not est.	3.32E-09	2.66E-13	1.90E-11
237Np, (Ci/L)	1.33E-13	0.00E+00	2.39E-09	0.00E+00	4.10E-13	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
238Pu, (Ci/L)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
239Pu, (Ci/L)	7.67E-13	1.05E-07	3.51E-09	2.76E-06	0.00E+00	9.21E-07	not est.	0.00E+00	1.97E-11	0.00E+00
240Pu, (Ci/L)	4.88E-14	2.61E-08	8.75E-10	6.88E-07	0.00E+00	2.30E-07	not est.	0.00E+00	3.87E-13	0.00E+00
241Pu, (Ci/L)	1.21E-13	8.14E-08	2.73E-09	2.19E-06	0.00E+00	6.32E-07	not est.	0.00E+00	1.30E-12	0.00E+00
241Am, (Ci/L)	1.13E-11	3.27E-07	1.01E-10	8.62E-06	9.35E-17	1.20E-06	not est.	0.00E+00	1.43E-10	0.00E+00
Volume, (L)	4.22E+06	9.99E+04	4.10E+06	4.10E+06	1.02E+05	3.94E+06	not est.	5.41E+05	2.27E+06	1.00E+05
H2O Estimate	3.56E+06	5.09E+04	2.09E+06	1.98E+06	9.97E+04	1.92E+06	not est.	5.04E+05	2.24E+06	9.75E+04
Spg Estimate	1.13	1.40	1.44	1.40	1.01	1.51	not est.	1.02	1.01	1.02

Table B-1. Double-Shell Tank Supernate/Slurry Compositions. (Sheet 3 of 3)

Supernatant Source:	106-AW	101-AY	102-AY	101-AZ	102-AZ	101-SY	101SY-TOT	102SY	103SY	103SY-TOT
Units:	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L
Feed Available in:	not est.	FY02	FY03	FY98	FY01	FY96	FY96	FY02	FY96	FY96
Decay Date:	not est.	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07
Projection Quality:		H	M	M	M	H	H	L	H	H
Component										
Al(OH)4-	not est.	2.61E-01	6.68E-05	8.19E-02	5.88E-04	1.58E+00	9.30E-01	8.95E-02	8.17E-01	1.17E+00
Ba+2	not est.	3.64E-07	4.95E-08	3.77E-07	2.14E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.83E-05
Ca+2	not est.	4.52E-05	6.20E-06	2.17E-05	2.55E-05	1.87E-02	1.24E-02	1.34E-12	7.97E-04	4.77E-03
Cd+2	not est.	0.00E+00	3.52E-07	2.85E-07	2.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr(OH)4-	not est.	2:05E-02	2.86E-06	3.82E-03	1.39E-03	1.56E-03	3.08E-03	3.43E-12	1.71E-04	9.07E-02
Fe+3	not est.	1.55E-06	4.85E-06	4.72E-06	5.00E-06	3.51E-04	3.48E-04	6.50E-05	0.00E+00	2.24E-02
Hg+2	not est.	0.00E+00	8.16E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	not est.	7.68E-02	0.00E+00	2.34E-02	6.11E-04	1.27E-01	6.59E-02	1.15E-09	2.71E-02	7.35E-02
La+3	not est.	3.84E-06	2.98E-07	7.15E-07	4.30E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na+	not est.	4.53E+00	1.26E-01	9.96E-01	2.87E-01	1.17E+01	7.00E+00	8.72E-01	1.12E+01	7.00E+00
Ni+3	not est.	9.27E-06	0.00E+00	1.18E-06	1.09E-06	8.86E-04	3.93E-04	0.00E+00	2.24E-04	1.06E-03
Pb+4	not est.	0.00E+00	2.59E-07	2.51E-06	6.36E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U, (g/liter)	not est.	9.46E-01	1.25E-05	4.47E-03	9.89E-02	3.39E-03	0.00E+00	2.90E-03	7.64E-04	3.60E-01
CO3-2	not est.	6.56E-01	1.03E-04	7.11E-02	2.72E-02	0.00E+00	0.00E+00	4.36E-02	5.32E-01	3.53E-01
CL-	not est.	3.76E-03	5.56E-06	6.59E-04	0.00E+00	3.89E-01	1.84E-01	2.87E-02	8.85E-02	1.99E-01
F-	not est.	9.46E-02	1.56E-05	2.25E-02	3.45E-03	0.00E+00	4.96E-03	3.18E-02	8.02E-02	3.95E-02
SO4-2	not est.	2.30E-01	2.69E-05	2.16E-02	1.02E-02	1.43E-02	3.59E-02	6.44E-03	6.42E-02	3.96E-02
NO3-	not est.	1.04E+00	1.19E-04	1.90E-01	2.23E-02	3.68E+00	5.80E-01	2.20E-01	3.26E+00	1.79E-01
NO2-	not est.	1.29E+00	1.10E-02	2.27E-01	5.12E-02	4.26E+00	6.73E-01	1.46E-01	2.23E+00	1.83E+00
PO4-3	not est.	1.04E-02	2.77E-04	2.08E-03	3.18E-05	8.35E-02	5.73E-02	1.11E-02	5.12E-02	9.55E-02
OH-	not est.	5.70E-01	5.57E-01	1.76E-01	1.04E-01	2.42E+00	5.79E+00	3.61E-01	7.67E-01	9.86E-01
TOC, (g/liter)	not est.	1.77E+00	3.93E-03	1.38E-01	9.55E-02	1.37E+01	1.28E+01	9.31E-01	3.18E+01	1.59E+00
14C, (Ci/L)	not est.	1.85E-06	0.00E+00	5.75E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90Sr, (Ci/L)	not est.	2.09E-03	3.26E-06	1.09E-01	7.27E-05	2.52E-03	4.18E-03	5.21E-12	3.47E-04	1.44E-02
90Y, (Ci/L)	not est.	2.09E-03	3.26E-06	1.09E-01	7.27E-05	2.52E-03	4.18E-03	5.21E-12	3.47E-04	1.44E-02
99Tc, (Ci/L)	not est.	3.65E-04	8.29E-08	6.54E-05	1.26E-05	1.11E-04	3.49E-04	0.00E+00	3.00E-05	4.25E-04
137Cs, (Ci/L)	not est.	1.08E+00	1.13E-04	2.73E-01	6.08E-02	4.26E-01	1.32E-01	1.12E-10	4.65E-02	1.87E-01
137Ba, (Ci/L)	not est.	1.02E+00	1.07E-04	2.59E-01	5.78E-02	4.04E-01	1.26E-01	1.06E-10	4.42E-02	1.77E-01
154Eu, (Ci/L)	not est.	2.88E-03	0.00E+00	4.80E-04	2.62E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
235U, (Ci/L)	not est.	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238U, (Ci/L)	not est.	3.18E-07	0.00E+00	0.00E+00	3.74E-08	1.14E-09	0.00E+00	0.00E+00	2.57E-10	0.00E+00
237Np, (Ci/L)	not est.	7.78E-08	0.00E+00	4.95E-07	4.43E-07	0.00E+00	0.00E+00	3.12E-15	0.00E+00	0.00E+00
238Pu, (Ci/L)	not est.	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239Pu, (Ci/L)	not est.	1.33E-05	4.71E-08	7.12E-08	1.50E-06	1.17E-07	1.19E-06	8.34E-13	9.01E-09	2.58E-06
240Pu, (Ci/L)	not est.	3.31E-06	6.22E-12	1.78E-08	3.76E-07	2.92E-08	3.24E-07	1.14E-15	2.25E-09	7.04E-07
241Pu, (Ci/L)	not est.	7.07E-06	2.11E-11	6.11E-08	1.29E-06	8.34E-08	7.94E-07	3.74E-15	4.88E-09	2.09E-06
241Am, (Ci/L)	not est.	2.02E-05	9.37E-10	4.47E-04	8.96E-08	7.30E-07	1.09E-05	1.70E-11	3.22E-07	1.86E-05
Volume, (L)	not est.	4.18E+06	2.90E+06	6.25E+05	1.16E+06	6.81E+04	7.37E+06	9.98E+04	6.43E+05	4.42E+06
H2O Estimate	not est.	3.06E+06	2.86E+06	5.86E+05	1.14E+06	2.97E+04	5.00E+06	9.39E+04	3.52E+05	3.00E+06
Spg Estimate	not est.	1.21	1.01	1.05	1.01	1.41	1.36	1.05	1.39	1.26

Table B-2. Double-Shell Tank Supernate/Slurry Inventories. (Sheet 1 of 3)

Supernatant Source:	101-AN	102-AN	103-AN	104-AN	105-AN	106-AN	107-AN	101-AP	102-AP	103-AP
Units:	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT
Feed Available in:	FY97	FY96	FY96	FY96	FY96	FY00	FY97	FY97	FY96	FY96
Decay Date:	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07
Projection Quality:	L	H	H	H	H	L	H	M	H	H
Component										
Al(OH)4-	2.97E+01	1.97E+02	7.33E+02	3.99E+02	7.09E+02	2.81E+02	1.48E+01	1.30E+02	1.70E+02	8.85E-02
Ba+2	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.24E-04	0.00E+00	9.89E-03	1.18E-03	0.00E+00
Ca+2	3.84E-01	1.66E+00	3.13E-01	0.00E+00	0.00E+00	4.91E-04	1.92E+00	4.25E-01	0.00E+00	0.00E+00
Cd+2	5.97E-02	0.00E+00	5.79E-02	0.00E+00	0.00E+00	5.51E-04	0.00E+00	8.10E-03	6.11E-03	1.13E-05
Cr(OH)4-	2.72E+00	2.48E+00	7.08E+00	4.71E+00	6.70E+00	1.21E-02	1.37E+00	1.34E+00	5.93E+00	1.04E-03
Fe+3	4.09E-01	0.00E+00	2.55E-01	3.37E-02	4.79E-02	7.12E-03	5.24E+00	1.11E-01	1.58E-02	1.26E-04
Hg+2	2.46E-03	0.00E+00	5.79E-02	0.00E+00	0.00E+00	1.26E-06	0.00E+00	1.15E-05	0.00E+00	5.11E-07
K+	1.48E+00	1.47E+01	5.50E+01	2.16E+01	2.63E+01	5.87E-03	7.41E+00	8.99E+01	5.37E+00	1.55E-01
La+3	6.28E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.07E-02	0.00E+00	0.00E+00
Na+	2.19E+02	1.00E+03	1.22E+03	8.34E+02	1.18E+03	1.49E+03	7.78E+02	6.01E+02	4.24E+02	5.43E-01
Ni+3	8.39E-04	1.32E+00	8.68E-02	0.00E+00	0.00E+00	0.00E+00	1.57E+00	9.21E-02	1.11E-01	0.00E+00
Pb+4	8.29E-02	0.00E+00	2.61E-01	0.00E+00	0.00E+00	2.50E-03	1.15E+00	1.54E-02	1.37E-02	0.00E+00
U	9.92E-01	0.00E+00	1.87E-03	0.00E+00	0.00E+00	8.51E-04	7.85E-01	1.50E-01	1.46E-02	3.77E-04
CO3-2	3.31E+01	2.53E+02	3.24E+01	8.56E+01	9.35E+01	2.35E+02	2.62E+02	8.66E+01	1.11E+02	2.63E-01
CL-	1.27E+00	1.47E+01	3.47E+01	2.27E+01	3.65E+01	6.40E-02	1.08E+01	7.51E+00	1.21E+01	5.06E-03
F-	2.20E+00	7.86E+00	2.66E+00	0.00E+00	0.00E+00	1.18E+01	0.00E+00	1.71E+01	0.00E+00	1.32E-02
SO4-2	1.65E+01	5.42E+01	5.79E+00	1.98E+01	2.81E+01	4.57E+01	4.79E+01	1.77E+01	1.88E+01	3.58E-02
NO3-	5.49E+01	8.33E+02	5.79E+02	5.81E+02	8.30E+02	1.14E+03	8.28E+02	5.70E+02	3.25E+02	4.13E-01
NO2-	4.68E+01	3.15E+02	4.99E+02	2.67E+02	5.15E+02	4.70E+02	1.72E+02	1.66E+02	1.58E+02	1.33E-01
PO4-3	4.01E+01	1.86E+01	3.36E+00	8.43E+00	8.15E+00	2.97E+01	1.85E+00	3.58E+00	4.83E+01	1.42E-02
OH-	9.64E+01	4.04E+01	3.53E+02	2.10E+02	2.66E+02	4.02E+01	6.25E+01	1.69E+02	3.81E+01	1.73E-01
TOC, (MT C)	7.40E+00	9.89E+01	2.66E+01	1.39E+01	1.67E+01	2.15E+02	1.50E+02	1.92E+01	1.36E+01	1.14E-02
14C, (Ci)	2.08E+01	6.89E+01	7.24E+00	0.00E+00	0.00E+00	1.82E-03	0.00E+00	6.76E-01	2.08E+00	4.56E-04
90Sr, (Ci)	1.32E+05	2.16E+05	3.05E+04	2.11E+04	9.82E+03	7.70E+00	2.32E+05	1.34E+05	4.20E+03	1.81E-01
90Y, (Ci)	1.32E+05	2.16E+05	3.05E+04	2.11E+04	9.82E+03	7.70E+00	2.32E+05	1.34E+05	4.20E+03	1.81E-01
99Tc, (Ci)	3.28E+02	1.17E+03	6.15E+02	3.96E+02	5.62E+02	3.76E-01	1.08E+03	5.03E+02	3.57E+02	1.11E-01
137Cs, (Ci)	1.05E+06	7.16E+05	1.80E+06	1.65E+06	1.56E+06	7.26E+02	6.64E+05	4.80E+05	6.77E+05	4.62E+02
137Ba, (Ci)	1.00E+06	6.80E+05	1.71E+06	1.56E+06	1.48E+06	6.89E+02	6.31E+05	4.56E+05	6.43E+05	4.39E+02
154Eu, (Ci)	8.38E+02	3.00E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-02	0.00E+00	0.00E+00
235U, (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238U, (Ci)	3.66E-01	0.00E+00	6.30E-04	0.00E+00	0.00E+00	3.10E-08	2.64E-01	6.27E-03	4.92E-03	1.27E-04
237Np, (Ci)	4.93E+00	0.00E+00	7.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238Pu, (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239Pu, (Ci)	8.54E+01	2.22E+02	6.88E+00	2.51E+01	3.57E+01	1.64E-04	9.47E+01	9.59E+00	0.00E+00	0.00E+00
240Pu, (Ci)	3.71E+00	5.54E+01	1.72E+00	6.28E+00	8.93E+00	4.11E-05	2.37E+01	2.35E+00	0.00E+00	0.00E+00
241Pu, (Ci)	1.16E+01	1.87E+02	4.63E+00	2.02E+01	2.86E+01	1.32E-04	7.81E+01	7.39E+00	0.00E+00	0.00E+00
241Am, (Ci)	5.44E+02	2.33E+02	8.32E+00	4.58E+00	6.49E+00	3.28E-03	2.19E+03	3.01E+01	1.74E+00	0.00E+00
Volume, (L)	3.46E+06	3.84E+06	3.62E+06	3.02E+06	4.29E+06	4.00E+06	3.68E+06	4.31E+06	4.16E+06	1.02E+05
Na Molarity	2.75E+00	1.14E+01	1.46E+01	1.20E+01	1.20E+01	1.61E+01	9.19E+00	6.06E+00	4.43E+00	2.31E-01
H2O Estimate	2.98E+06	2.08E+06	1.65E+06	1.54E+06	2.05E+06	1.91E+06	2.12E+06	2.90E+06	3.09E+06	1.00E+05
Spg Estimate	1.10	1.38	1.50	1.46	1.46	1.40	1.33	1.28	1.21	1.01

Table B-2. Double-Shell Tank Supernate/Slurry Inventories (Sheet 2 of 3)

Supernatant Source:	104-AP	105-AP	106-AP	107-AP	108-AP	101-AW	102-AW	103-AW	104-AW	105-AW
Units:	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT
Feed Available in:	FY02	FY99	FY97	FY99	FY98	FY96	not est.	TBD	FY02	TBD
Decay Date:	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	not est.	12/31/07	12/31/07	12/31/07
Projection Quality:	L	L	L	L	M	H		L	M	L
Component										
Al(OH)4-	1.13E+02	6.25E+00	4.77E+02	2.73E+02	7.77E-02	3.87E+02	not est.	7.92E-02	2.11E+00	1.89E-03
Ba+2	7.93E-13	6.60E-06	1.27E-04	7.16E-03	1.62E-05	0.00E+00	not est.	3.03E-04	6.33E-06	9.52E-08
Ca+2	9.71E-09	2.49E-04	4.67E-02	2.71E-01	6.73E-05	1.30E-01	not est.	3.34E-03	6.08E-05	3.31E-05
Cd+2	2.35E-13	4.03E-07	1.11E-08	4.36E-04	5.89E-04	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
Cr(OH)4-	7.43E-08	1.79E-04	1.32E-01	1.96E-01	1.26E-03	1.46E+00	not est.	9.09E-02	3.56E-05	8.45E-05
Fe+3	1.09E-02	1.27E-05	2.06E-02	1.37E-02	7.11E-04	0.00E+00	not est.	0.00E+00	6.91E-04	4.96E-03
Hg+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
K+	8.08E-06	7.42E-03	1.59E+01	8.33E+00	1.02E-01	1.65E+02	not est.	1.10E+01	2.45E-04	1.03E-02
La+3	0.00E+00	6.88E-05	0.00E+00	7.44E-02	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
Na+	2.36E+02	3.30E+01	1.00E+03	1.46E+03	5.90E-01	9.06E+02	not est.	1.06E+01	1.03E+01	2.18E-01
Ni+3	2.35E-13	7.26E-05	1.11E-08	7.85E-02	4.06E-05	0.00E+00	not est.	1.60E-03	2.76E-07	0.00E+00
Pb+4	4.70E-12	1.23E-06	2.22E-07	1.37E-03	0.00E+00	1.19E+00	not est.	0.00E+00	1.41E-06	0.00E+00
U	8.70E-03	3.17E-05	2.59E-02	3.44E-02	3.91E-04	8.83E-01	not est.	5.34E-03	4.93E-02	1.99E-03
CO3-2	3.14E+01	5.25E+00	1.33E+02	2.39E+02	2.61E-01	4.85E+01	not est.	2.49E+00	1.10E+00	2.14E-03
CL-	1.22E+01	1.04E-03	5.02E+01	1.13E+00	5.89E-03	2.04E+01	not est.	7.31E-02	4.22E-01	4.10E-03
F-	8.37E+00	2.50E-01	4.85E+01	1.15E+01	3.64E-02	0.00E+00	not est.	9.42E+00	1.54E-02	9.45E-03
SO4-2	6.58E+00	1.02E+00	2.72E+01	4.92E+01	1.51E-02	4.06E+00	not est.	3.05E-02	5.75E-02	2.34E-02
NO3-	1.79E+02	2.53E+01	7.82E+02	1.13E+03	4.35E-01	8.43E+02	not est.	1.90E+00	8.81E+00	1.97E+00
NO2-	8.80E+01	1.05E+01	3.72E+02	4.53E+02	1.17E-01	4.02E+02	not est.	6.60E-01	1.16E+00	6.46E-02
PO4-3	6.39E+00	6.59E-01	1.97E+01	2.82E+01	2.13E-02	8.31E+00	not est.	3.14E-02	5.62E-01	2.29E-02
OH-	6.04E+01	8.94E-01	2.42E+02	5.81E+01	1.58E-01	3.40E+02	not est.	1.73E+00	3.83E+00	7.51E-02
TOC, (MT C)	6.34E+00	4.78E+00	2.23E+01	2.03E+02	5.07E-02	9.69E+00	not est.	5.06E-01	9.16E-01	2.39E-02
14C, (Ci)	1.38E-12	4.95E-05	1.89E-07	5.35E-02	7.72E-10	1.45E+00	not est.	0.00E+00	1.39E-05	0.00E+00
90Sr, (Ci)	1.72E-05	1.50E+02	1.18E-01	1.64E+05	5.41E-03	2.81E+03	not est.	8.55E-02	6.85E-03	0.00E+00
90Y, (Ci)	1.72E-05	1.50E+02	1.18E-01	1.64E+05	5.41E-03	2.81E+03	not est.	8.55E-02	6.85E-03	0.00E+00
99Tc, (Ci)	3.14E-07	3.50E-01	1.49E-02	3.78E+02	2.05E-02	5.94E+02	not est.	1.23E+01	5.26E-03	1.01E-02
137Cs, (Ci)	1.42E-02	1.39E+02	2.81E+02	1.52E+05	1.70E+02	1.29E+06	not est.	8.14E+03	7.72E+00	7.86E+01
137Ba, (Ci)	1.35E-02	1.32E+02	2.67E+02	1.44E+05	1.61E+02	1.22E+06	not est.	7.74E+03	7.33E+00	7.46E+01
154Eu, (Ci)	0.00E+00	0.00E+00	0.00E+00	3.84E-04	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
235U, (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
238U, (Ci)	4.18E-12	7.12E-06	2.00E-07	7.69E-03	4.29E-06	2.97E-01	not est.	1.79E-03	6.04E-07	1.90E-06
237Np, (Ci)	5.61E-07	0.00E+00	9.78E-03	0.00E+00	4.16E-08	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
238Pu, (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	not est.	0.00E+00	0.00E+00	0.00E+00
239Pu, (Ci)	3.23E-06	1.04E-02	1.44E-02	1.13E+01	0.00E+00	3.63E+00	not est.	0.00E+00	4.47E-05	0.00E+00
240Pu, (Ci)	2.06E-07	2.61E-03	3.59E-03	2.82E+00	0.00E+00	9.07E-01	not est.	0.00E+00	8.80E-07	0.00E+00
241Pu, (Ci)	5.12E-07	8.13E-03	1.12E-02	8.95E+00	0.00E+00	2.49E+00	not est.	0.00E+00	2.96E-06	0.00E+00
241Am, (Ci)	4.78E-05	3.27E-02	4.15E-04	3.53E+01	9.50E-12	4.73E+00	not est.	0.00E+00	3.25E-04	0.00E+00
Volume, (L)	4.22E+06	9.99E+04	4.10E+06	4.10E+06	1.02E+05	3.94E+06	not est.	5.41E+05	2.27E+06	1.00E+05
Na Molarity	2.43E+00	1.44E+01	1.06E+01	1.55E+01	2.53E-01	1.00E+01	not est.	8.52E-01	1.97E-01	9.47E-02
H2O Estimate	3.56E+06	5.09E+04	2.09E+06	1.98E+06	9.97E+04	1.92E+06	not est.	5.04E+05	2.24E+06	9.75E+04
Spg Estimate	1.13	1.40	1.44	1.40	1.01	1.51	not est.	1.02	1.01	1.02

Table B-2. Double-Shell Tank Supernate/Slurry Inventories. (Sheet 3 of 3)

Supernatant Source:	106-AW	101-AY	102-AY	101-AZ	102-AZ	101-SY	101SY-TOT	102SY	103SY	103SY-TOT
Units:	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT
Feed Available in:	not est.	FY02	FY03	FY98	FY01	FY96	FY96	FY02	FY96	FY96
Decay Date:	not est.	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07	12/31/07
Projection Quality:		H	M	M	M	H	H	L	H	H
Component										
Al(OH)4-	not est.	1.04E+02	1.84E-02	4.86E+00	6.47E-02	1.02E+01	6.52E+02	8.49E-01	4.99E+01	4.92E+02
Ba+2	not est.	2.09E-04	1.97E-05	3.24E-05	3.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-02
Ca+2	not est.	7.57E-03	7.20E-04	5.44E-04	1.18E-03	5.11E-02	3.68E+00	5.35E-12	2.06E-02	8.45E-01
Cd+2	not est.	0.00E+00	1.15E-04	2.00E-05	3.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr(OH)4-	not est.	1.03E+01	9.94E-04	2.87E-01	1.93E-01	1.28E-02	2.72E+00	4.11E-11	1.32E-02	4.81E+01
Fe+3	not est.	3.63E-04	7.85E-04	1.65E-04	3.23E-04	1.34E-03	1.43E-01	3.62E-04	0.00E+00	5.52E+00
Hg+2	not est.	0.00E+00	4.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	not est.	1.26E+01	0.00E+00	5.71E-01	2.77E-02	3.37E-01	1.90E+01	4.48E-09	6.81E-01	1.27E+01
La+3	not est.	2.23E-03	1.20E-04	6.21E-05	6.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na+	not est.	4.36E+02	8.39E+00	1.43E+01	7.63E+00	1.83E+01	1.19E+03	2.00E+00	1.66E+02	7.12E+02
Ni+3	not est.	2.28E-03	0.00E+00	4.32E-05	7.44E-05	3.54E-03	1.70E-01	0.00E+00	8.45E-03	2.76E-01
Pb+4	not est.	0.00E+00	1.55E-04	3.25E-04	1.53E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U	not est.	3.96E+00	3.63E-05	2.79E-03	1.15E-01	2.31E-04	0.00E+00	2.90E-04	4.91E-04	1.59E+00
CO3-2	not est.	1.65E+02	1.80E-02	2.66E+00	1.89E+00	0.00E+00	0.00E+00	2.61E-01	2.06E+01	9.37E+01
CL-	not est.	5.57E-01	5.72E-04	1.46E-02	0.00E+00	9.40E-01	4.82E+01	1.02E-01	2.02E+00	3.12E+01
F-	not est.	7.52E+00	8.59E-04	2.67E-01	7.59E-02	0.00E+00	6.95E-01	6.03E-02	9.81E-01	3.32E+00
SO4-2	not est.	9.26E+01	7.48E-03	1.30E+00	1.13E+00	9.33E-02	2.54E+01	6.17E-02	3.97E+00	1.68E+01
NO3-	not est.	2.69E+02	2.13E-02	7.37E+00	1.60E+00	1.55E+01	2.65E+02	1.36E+00	1.30E+02	4.91E+01
NO2-	not est.	2.48E+02	1.47E+00	6.52E+00	2.73E+00	1.34E+01	2.28E+02	6.70E-01	6.59E+01	3.73E+02
PO4-3	not est.	4.13E+00	7.63E-02	1.23E-01	3.50E-03	5.40E-01	4.01E+01	1.05E-01	3.13E+00	4.01E+01
OH-	not est.	4.06E+01	2.75E+01	1.87E+00	2.05E+00	2.81E+00	7.26E+02	6.13E-01	8.40E+00	7.41E+01
TOC, (MT C)	not est.	7.42E+00	1.14E-02	8.63E-02	1.11E-01	9.33E-01	9.44E+01	9.30E-02	2.05E+01	7.04E+00
14C, (Ci)	not est.	7.73E+00	0.00E+00	3.59E+00	1.64E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90Sr, (Ci)	not est.	8.76E+03	9.46E+00	6.83E+04	8.42E+01	1.72E+02	3.08E+04	5.20E-07	2.23E+02	6.37E+04
90Y, (Ci)	not est.	8.76E+03	9.46E+00	6.83E+04	8.42E+01	1.72E+02	3.08E+04	5.20E-07	2.23E+02	6.37E+04
99Tc, (Ci)	not est.	1.53E+03	2.40E-01	4.08E+01	1.46E+01	7.56E+00	2.57E+03	0.00E+00	1.93E+01	1.88E+03
137Cs, (Ci)	not est.	4.51E+06	3.28E+02	1.70E+05	7.05E+04	2.90E+04	9.75E+05	1.12E-05	2.99E+04	8.25E+05
137Ba, (Ci)	not est.	4.28E+06	3.12E+02	1.62E+05	6.69E+04	2.76E+04	9.26E+05	1.06E-05	2.84E+04	7.83E+05
154Eu, (Ci)	not est.	1.21E+04	0.00E+00	3.00E+02	3.03E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
235U, (Ci)	not est.	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238U, (Ci)	not est.	1.33E+00	0.00E+00	0.00E+00	4.33E-02	7.77E-05	0.00E+00	0.00E+00	1.65E-04	0.00E+00
237Np, (Ci)	not est.	3.26E-01	0.00E+00	3.09E-01	5.14E-01	0.00E+00	0.00E+00	3.11E-10	0.00E+00	0.00E+00
238Pu, (Ci)	not est.	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239Pu, (Ci)	not est.	5.54E+01	1.37E-01	4.45E-02	1.74E+00	7.95E-03	8.81E+00	8.33E-08	5.80E-03	1.14E+01
240Pu, (Ci)	not est.	1.39E+01	1.80E-05	1.11E-02	4.35E-01	1.99E-03	2.39E+00	1.14E-10	1.45E-03	3.11E+00
241Pu, (Ci)	not est.	2.96E+01	6.11E-05	3.81E-02	1.49E+00	5.68E-03	5.85E+00	3.74E-10	3.14E-03	9.25E+00
241Am, (Ci)	not est.	8.44E+01	2.72E-03	2.79E+02	1.04E-01	4.97E-02	8.03E+01	1.70E-06	2.07E-01	8.21E+01
Volume, (L)	not est.	4.18E+06	2.90E+06	6.25E+05	1.16E+06	6.81E+04	7.37E+06	9.98E+04	6.43E+05	4.42E+06
Na Molarity	not est.	4.53E+00	1.26E-01	9.96E-01	2.87E-01	1.17E+01	7.00E+00	8.72E-01	1.12E+01	7.00E+00
H2O Estimate	not est.	3.06E+06	2.86E+06	5.86E+05	1.14E+06	2.97E+04	5.00E+06	9.39E+04	3.52E+05	3.00E+06
Spg Estimate	not est.	1.21	1.01	1.05	1.01	1.41	1.36	1.05	1.39	1.26

APPENDIX C

ESTIMATED SINGLE-SHELL TANK INVENTORY

(Soluble Fraction Only, Retrieval Water Added per TWRS Process Flowsheet)

(TRU Concentrations are peak values)

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Source	101-A	102-A	103-A	104-A	105-A	106-A	101-AX	102-AX	103-AX	104-AX
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	8.97E+04	3.01E+03	2.81E+04	0.00E+00	0.00E+00	2.97E+03	6.47E+04	2.67E+03	6.06E+03	0.00E+00
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.27E+02	4.52E+00	6.09E+01	2.69E-01	1.84E-01	1.05E+01	1.06E+02	5.13E+00	1.65E+01	6.78E-02
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	4.87E+03	1.75E+02	1.48E+03	5.78E+00	3.58E-01	3.87E+02	3.55E+03	1.30E+02	4.00E+02	1.32E-01
FE+3	3.54E+02	1.35E+01	1.67E+02	1.55E+01	3.88E+01	4.95E+01	3.09E+02	2.94E+01	7.34E+01	1.43E+01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	2.87E+03	1.03E+02	9.37E+02	0.00E+00	0.00E+00	2.26E+02	2.13E+03	8.04E+01	2.53E+02	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	1.68E+06	6.17E+04	6.38E+05	1.77E+04	3.13E+04	1.57E+05	1.31E+06	5.34E+04	1.89E+05	1.15E+04
NI+3	7.85E+01	2.77E+00	3.76E+01	4.21E-01	2.85E-01	6.54E+00	6.52E+01	3.03E+00	1.03E+01	1.05E-01
PB+4	2.73E+02	9.81E+00	8.63E+01	0.00E+00	0.00E+00	2.14E+01	2.01E+02	7.48E+00	2.33E+01	0.00E+00
CO3-2	5.19E+04	1.97E+03	1.79E+04	4.16E+02	2.83E+02	5.51E+03	3.92E+04	2.05E+03	5.02E+03	1.05E+02
CL-	1.76E+04	6.56E+02	6.42E+03	7.03E+01	5.99E+00	1.69E+03	1.35E+04	5.51E+02	1.73E+03	2.21E+00
F-	1.51E+04	5.41E+02	4.85E+03	0.00E+00	0.00E+00	1.18E+03	1.11E+04	4.18E+02	1.31E+03	0.00E+00
SO4-2	5.06E+04	1.82E+03	2.44E+04	1.17E+02	8.18E+03	4.44E+03	4.63E+04	1.95E+03	1.26E+04	3.02E+03
NO3-	2.35E+06	8.40E+04	1.01E+06	8.71E+03	5.87E+02	1.93E+05	1.88E+06	8.30E+04	2.69E+05	2.17E+02
NO2-	3.19E+05	1.15E+04	1.01E+05	1.50E+00	3.09E+00	2.51E+04	2.34E+05	8.76E+03	2.73E+04	1.14E+00
PO4-3	4.77E+04	1.71E+03	1.50E+04	8.31E+01	0.00E+00	3.81E+03	3.50E+04	1.32E+03	4.05E+03	0.00E+00
OH-	4.47E+05	1.91E+04	1.47E+05	1.04E+04	2.24E+04	6.77E+04	3.44E+05	1.23E+04	5.33E+04	8.26E+03
TOC	3.68E+04	2.39E+03	1.16E+04	0.00E+00	0.00E+00	1.25E+04	2.82E+04	1.01E+03	3.24E+03	0.00E+00
Sr90	1.64E+06	4.14E+06	1.12E+04	2.16E+06	1.64E-02	2.77E-03	1.84E-06	8.30E-11	1.15E+04	5.35E+06
Tc99	0.00E+00	1.38E+02	4.13E+01	3.78E-17	6.22E+00	1.27E-07	1.08E-08	9.51E-16	7.92E+00	1.81E+01
Cs137	0.00E+00	8.16E+04	5.33E+03	3.89E-14	9.75E+03	7.54E-05	8.00E-07	1.12E-12	4.68E+03	3.17E+04
TRU	3.14E+03	2.37E+03	7.10E+02	1.11E+03	4.52E-02	1.37E+03	3.20E+02	1.52E+02	1.27E+01	3.91E+02
H2O	1.31E+07	4.82E+05	4.93E+06	1.55E+05	2.76E+05	1.23E+06	1.02E+07	4.13E+05	1.48E+06	1.02E+05
Volume (L)	1.46E+07	5.36E+05	5.55E+06	1.54E+05	2.72E+05	1.37E+06	1.14E+07	4.65E+05	1.64E+06	1.00E+05

Source	101-B	102-B	103-B	104-B	105-B	106-B	107-B	108-B	109-B	110-B
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	9.16E+02	1.85E+02	0.00E+00	4.17E+03	2.29E+02	0.00E+00	6.91E+03	1.40E+03	2.56E+03	0.00E+00
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	3.16E+01	9.87E+00	2.30E+01	2.61E+01	1.14E+02	4.76E+01	5.81E-01	2.47E+01	3.46E+01	1.49E+00
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	1.51E+02	4.86E+01	1.12E+02	1.65E+02	5.64E+02	2.32E+02	3.21E+01	1.27E+02	1.71E+02	4.73E+01
FE+3	1.29E+02	2.80E+01	6.31E+01	1.46E+02	3.22E+02	1.30E+02	4.20E+01	7.58E+01	1.03E+02	1.18E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	1.45E+05	4.26E+04	9.61E+04	2.80E+05	4.87E+05	1.94E+05	1.37E+05	1.28E+05	1.43E+05	2.08E+05
NI+3	2.16E+01	6.11E+00	1.42E+01	1.69E+01	7.07E+01	2.93E+01	7.57E-01	1.53E+01	2.15E+01	2.17E+00
PB+4	3.52E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	4.68E+03	1.08E+03	2.09E+03	3.55E+03	9.17E+03	3.73E+03	8.97E+02	2.12E+03	2.95E+03	2.30E+03
CL-	9.77E+02	2.37E+02	5.48E+02	1.16E+03	2.80E+03	1.13E+03	1.88E+03	6.47E+02	8.41E+02	8.61E+02
F-	6.59E+03	2.11E+03	4.92E+03	1.54E+04	2.58E+04	1.02E+04	6.84E+03	6.68E+03	7.38E+03	1.23E+04
SO4-2	7.26E+03	2.45E+03	5.22E+03	6.52E+03	2.43E+04	1.00E+04	9.55E+02	5.39E+03	7.28E+03	2.13E+03
NO3-	1.38E+05	3.87E+04	8.96E+04	1.72E+05	4.53E+05	1.85E+05	3.56E+04	1.03E+05	1.38E+05	1.27E+05
NO2-	2.96E+03	9.72E+02	2.16E+03	5.21E+03	1.12E+04	4.48E+03	3.85E+03	3.12E+03	3.82E+03	3.25E-01
PO4-3	4.70E+04	1.52E+04	3.51E+04	8.74E+04	1.80E+05	7.22E+04	4.01E+04	4.57E+04	5.24E+04	4.85E+04
OH-	3.68E+04	9.77E+03	2.11E+04	9.45E+04	1.06E+05	4.07E+04	5.98E+04	3.33E+04	2.93E+04	7.99E+04
TOC	6.54E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr90	3.24E-26	1.89E+02	5.66E+03	4.66E+03	7.00E+02	9.19E+01	1.38E+04	2.47E+04	3.21E+03	3.60E+04
Tc99	1.17E-28	5.72E-01	3.17E+00	1.11E+00	8.76E+00	4.13E-01	7.98E+00	1.67E+01	5.77E+00	1.85E+02
Cs137	2.86E-26	6.69E+02	2.70E+03	1.26E+03	1.05E+04	4.76E+02	1.23E+04	8.62E+03	3.47E+03	1.73E+04
TRU	6.84E+02	6.51E+01	2.32E+02	9.63E+01	9.69E+00	1.19E+00	3.71E+01	7.00E+00	1.65E+00	1.07E+03
H2O	1.19E+06	3.49E+05	7.87E+05	2.38E+06	3.99E+06	1.59E+06	1.19E+06	1.06E+06	1.16E+06	1.77E+06
Volume (L)	1.26E+06	3.70E+05	8.36E+05	2.44E+06	4.24E+06	1.69E+06	1.19E+06	1.12E+06	1.24E+06	1.80E+06

Source	111-B	112-B	201-B	202-B	203-B	204-B	101-BX	102-BX	103-BX	104-BX
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	0.00E+00	6.35E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.37E+02	9.92E+02	1.59E+03	0.00E+00
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.55E+00	6.37E+00	2.73E-01	2.64E-01	4.88E-01	4.78E-01	3.08E-01	1.97E-01	3.07E-01	1.57E-01
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	4.37E+01	2.03E+02	6.18E+00	5.97E+00	1.10E+01	1.08E+01	3.52E+00	5.16E+00	8.03E+00	4.99E+00
FE+3	1.34E+02	2.39E+01	1.40E+01	1.36E+01	2.51E+01	2.46E+01	1.76E+01	9.10E+00	1.43E+01	6.72E+00
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	3.42E+01	2.39E+02	2.31E+02	4.27E+02	4.19E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	1.63E+00	1.58E+00	2.92E+00	2.86E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	2.09E+05	4.46E+04	2.15E+04	2.08E+04	3.84E+04	3.77E+04	3.06E+04	2.86E+04	4.42E+04	3.23E+04
NI+3	2.17E+00	4.05E+00	4.21E-01	4.07E-01	7.51E-01	7.37E-01	1.26E+00	2.82E-01	4.42E-01	2.13E-01
PB+4	7.06E-05	4.32E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	2.39E+03	7.75E+02	4.21E+02	4.07E+02	7.52E+02	7.38E+02	3.46E+03	3.51E+03	5.43E+03	4.01E+03
CL-	7.96E+02	2.73E+02	1.12E+02	1.09E+02	2.01E+02	1.97E+02	1.13E+02	2.12E+01	3.33E+01	1.61E+01
F-	1.13E+04	9.29E+02	8.71E+03	8.42E+03	1.56E+04	1.53E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SO4-2	6.80E+03	1.32E+03	1.29E+01	1.25E+01	2.30E+01	2.26E+01	3.73E+03	4.31E+03	6.66E+03	5.05E+03
NO3-	1.17E+05	7.67E+04	2.12E+04	2.05E+04	3.79E+04	3.72E+04	9.65E+03	4.11E+03	6.45E+03	2.96E+03
NO2-	3.54E+00	3.84E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E+01	2.19E+02	3.51E+02	0.00E+00
PO4-3	4.46E+04	3.62E+03	7.72E+02	7.46E+02	1.38E+03	1.35E+03	2.41E+03	2.88E+03	4.45E+03	3.38E+03
OH-	8.65E+04	7.38E+03	3.03E+03	2.93E+03	5.41E+03	5.31E+03	1.82E+04	1.69E+04	2.61E+04	1.98E+04
TOC	2.45E+00	1.64E+02	7.64E+02	7.39E+02	1.36E+03	1.34E+03	2.76E+02	0.00E+00	0.00E+00	0.00E+00
Sr90	6.64E-05	7.77E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.58E-16	7.35E+04	1.43E+05	1.08E+04
Tc99	1.89E+03	1.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.76E-17	3.97E+02	2.38E-16	2.05E+03
Cs137	1.54E+05	6.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-15	7.13E+04	2.46E-13	1.70E+05
TRU	4.90E+01	2.84E+01	0.00E+00	2.32E+02	7.32E-01	7.32E+00	6.09E+02	4.73E+02	1.44E-03	9.12E+01
H2O	1.79E+06	3.44E+05	1.77E+05	1.71E+05	3.16E+05	3.10E+05	2.61E+05	2.47E+05	3.82E+05	2.81E+05
Volume (L)	1.82E+06	3.88E+05	1.87E+05	1.81E+05	3.34E+05	3.28E+05	6.76E+05	4.80E+05	7.33E+05	4.32E+05

Source	105-BX	106-BX	107-BX	108-BX	109-BX	110-BX	111-BX	112-BX	101-BY	102-BY
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	0.00E+00	0.00E+00	1.45E+04	1.10E+03	6.74E+03	8.82E+03	1.11E+04	5.55E+03	1.89E+04	1.69E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.76E-01	1.19E-01	1.22E+00	9.23E-02	1.09E+01	1.70E+01	7.07E+01	1.36E+01	1.37E+02	1.23E+02
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	5.59E+00	3.77E+00	6.74E+01	5.10E+00	1.57E+02	5.54E+02	2.25E+03	9.00E+01	4.37E+03	3.90E+03
FE+3	7.53E+00	5.08E+00	8.82E+01	6.67E+00	9.75E+02	8.53E+01	2.03E+02	6.96E+01	3.85E+02	3.41E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.95E+01	3.84E+02	0.00E+00	7.47E+02	6.67E+02
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	3.62E+04	2.44E+04	2.87E+05	2.17E+04	6.97E+05	2.18E+05	4.03E+05	1.63E+05	7.62E+05	6.69E+05
NI+3	2.39E-01	1.61E-01	1.59E+00	1.20E-01	1.62E+01	1.10E+01	4.42E+01	8.70E+00	8.59E+01	7.66E+01
PB+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+01	4.85E+01	0.00E+00	9.43E+01	8.42E+01
CO3-2	4.49E+03	3.03E+03	1.88E+03	1.42E+02	2.90E+04	2.53E+03	7.40E+03	1.75E+03	1.77E+04	1.43E+04
CL-	1.80E+01	1.22E+01	6.13E+02	4.64E+01	8.73E+03	8.61E+02	2.56E+03	5.48E+02	4.88E+03	4.36E+03
F-	0.00E+00	0.00E+00	1.43E+04	1.09E+03	6.66E+03	7.05E+03	3.77E+03	8.31E+03	4.74E+03	4.23E+03
SO4-2	5.66E+03	3.82E+03	2.00E+03	1.52E+02	1.01E+05	4.16E+03	1.42E+04	3.54E+03	3.17E+04	2.65E+04
NO3-	3.32E+03	2.24E+03	7.47E+04	5.66E+03	8.76E+05	2.17E+05	7.91E+05	7.96E+04	1.53E+06	1.36E+06
NO2-	0.00E+00	0.00E+00	8.08E+03	6.11E+02	3.75E+03	1.37E+04	4.38E+04	4.34E+03	8.38E+04	7.48E+04
PO4-3	3.78E+03	2.56E+03	8.42E+04	6.37E+03	5.13E+04	4.02E+04	1.70E+04	5.22E+04	2.08E+04	1.74E+04
OH-	2.21E+04	1.50E+04	1.27E+05	9.62E+03	2.10E+05	6.60E+04	4.90E+04	5.98E+04	9.03E+04	7.34E+04
TOC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E+02	1.98E+03	0.00E+00	3.93E+03	3.52E+03
Sr90	2.32E+06	9.49E+05	2.56E+04	2.80E+03	2.26E+05	1.26E+05	1.26E+05	2.57E+03	1.97E+05	8.06E+04
Tc99	9.59E+02	1.49E+03	3.29E+00	7.63E-02	2.81E+00	2.02E+02	2.08E+02	1.25E+00	2.67E+02	7.72E+01
Cs137	4.07E+04	1.52E+06	3.73E+03	1.23E+02	4.22E+03	1.00E+05	1.03E+05	1.87E+03	1.32E+05	3.83E+04
TRU	2.27E+03	1.60E+03	4.28E+01	4.28E+00	6.89E+01	5.67E+01	4.21E+01	1.32E+01	5.18E+01	1.50E+01
H2O	3.15E+05	2.13E+05	2.51E+06	1.90E+05	5.58E+06	1.79E+06	3.04E+06	1.40E+06	5.71E+06	4.99E+06
Volume (L)	4.91E+05	5.44E+05	2.50E+06	1.89E+05	6.06E+06	1.89E+06	3.51E+06	1.42E+06	6.63E+06	5.82E+06

Source	103-BY	104-BY	105-BY	106-BY	107-BY	108-BY	109-BY	110-BY	111-BY	112-BY
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	2.31E+04	9.38E+03	1.40E+04	2.67E+04	5.99E+03	0.00E+00	2.09E+04	9.06E+03	2.34E+04	1.46E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.54E+02	1.02E+02	1.34E+02	2.15E+02	5.99E+01	2.67E+01	1.52E+02	8.37E+01	1.70E+02	1.08E+02
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	4.89E+03	3.21E+03	4.23E+03	6.80E+03	1.88E+03	8.08E+02	4.84E+03	2.63E+03	5.42E+03	3.43E+03
FE+3	4.30E+02	4.09E+02	4.93E+02	6.71E+02	2.69E+02	2.04E+02	4.26E+02	3.61E+02	4.75E+02	3.10E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	8.36E+02	5.47E+02	7.21E+02	1.16E+03	3.18E+02	1.35E+02	8.28E+02	4.45E+02	9.27E+02	5.86E+02
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	8.22E+05	7.00E+05	8.75E+05	1.24E+06	4.25E+05	3.11E+05	8.41E+05	6.30E+05	9.30E+05	5.90E+05
NI+3	9.61E+01	6.67E+01	8.66E+01	1.36E+02	4.01E+01	2.08E+01	9.52E+01	5.62E+01	1.06E+02	6.75E+01
PB+4	1.06E+02	6.91E+01	9.11E+01	1.47E+02	4.02E+01	1.70E+01	1.05E+02	5.62E+01	1.17E+02	7.40E+01
CO3-2	1.59E+04	1.31E+04	1.78E+04	2.36E+04	8.65E+03	5.42E+03	1.91E+04	1.12E+04	2.00E+04	1.19E+04
CL-	5.47E+03	4.42E+03	5.52E+03	8.18E+03	3.01E+03	1.93E+03	5.41E+03	3.96E+03	6.05E+03	3.91E+03
F-	5.30E+03	1.14E+04	1.21E+04	1.23E+04	6.03E+03	9.09E+03	5.25E+03	1.20E+04	5.87E+03	4.03E+03
SO4-2	3.05E+04	6.27E+04	6.87E+04	6.82E+04	3.65E+04	4.79E+04	3.46E+04	5.60E+04	3.70E+04	2.45E+04
NO3-	1.71E+06	1.21E+06	1.56E+06	2.44E+06	7.51E+05	3.95E+05	1.69E+06	1.03E+06	1.89E+06	1.21E+06
NO2-	9.42E+04	6.14E+04	8.09E+04	1.30E+05	3.57E+04	1.51E+04	9.28E+04	5.08E+04	1.04E+05	6.57E+04
PO4-3	1.99E+04	2.40E+04	2.89E+04	3.44E+04	1.38E+04	1.45E+04	2.27E+04	3.01E+04	2.42E+04	1.50E+04
OH-	8.13E+04	1.38E+05	1.58E+05	1.67E+05	8.33E+04	1.07E+05	9.77E+04	1.42E+05	1.02E+05	6.42E+04
TOC	4.42E+03	7.48E+03	8.15E+03	1.04E+04	5.98E+03	8.28E+03	4.35E+03	9.46E+03	4.89E+03	3.28E+03
Sr90	4.04E+05	1.65E+05	1.38E+05	2.10E+05	9.01E+04	2.92E+04	5.79E+04	1.92E+05	1.93E+05	4.38E+04
Tc99	1.25E+01	2.72E+02	2.12E+02	2.70E+02	9.83E+01	1.19E+02	8.63E+01	2.41E+02	2.73E+02	5.01E+01
Cs137	6.36E+03	1.35E+05	1.05E+05	1.34E+05	4.89E+04	6.33E+04	4.27E+04	1.20E+05	1.35E+05	2.48E+04
TRU	1.08E+03	2.82E+02	1.81E+02	1.08E+02	7.10E+01	9.02E+01	1.68E+01	1.30E+02	5.33E+01	9.71E+00
H2O	6.12E+06	5.36E+06	6.67E+06	9.34E+06	3.24E+06	2.47E+06	6.29E+06	4.86E+06	6.95E+06	4.41E+06
Volume (L)	7.15E+06	6.09E+06	7.61E+06	1.08E+07	3.69E+06	2.71E+06	7.31E+06	5.48E+06	8.09E+06	5.13E+06

Source	101-C	102-C	103-C	104-C	105-C	106-C	107-C	108-C	109-C	110-C
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	6.77E+03	6.97E+04	6.33E+03	3.43E+04	2.49E+04	2.48E+03	9.14E+03	7.59E+02	4.22E+02	7.88E+03
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.16E+00	4.84E+00	7.00E-01	3.12E+00	1.30E+00	2.09E+00	1.10E+00	7.96E-01	1.65E+00	6.63E-01
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	1.52E+01	7.75E+01	1.19E+01	4.24E+01	2.85E+01	2.99E+01	4.81E+01	1.11E+01	3.34E+00	3.66E+01
FE+3	8.94E+01	2.79E+02	3.74E+01	1.74E+02	7.48E+01	1.31E+02	7.45E+01	6.15E+01	2.31E+01	4.79E+01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	8.04E+01	0.00E+00	1.51E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E+01	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	4.79E+04	1.49E+05	1.59E+04	1.61E+05	4.96E+04	8.83E+04	2.23E+05	5.07E+04	3.66E+04	1.56E+05
NI+3	1.79E+00	7.67E+00	1.11E+00	4.32E+00	2.00E+00	6.03E+00	1.13E+00	1.47E+00	7.08E+00	8.62E-01
PB+4	0.00E+00	0.00E+00	0.00E+00	2.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E+03	0.00E+00
CO3-2	2.75E+03	8.38E+03	1.08E+03	6.94E+03	2.25E+03	4.81E+03	2.46E+03	1.96E+03	2.55E+03	1.02E+03
CL-	6.51E+02	1.08E+03	1.18E+02	1.45E+03	3.36E+02	9.29E+02	6.86E+02	5.64E+02	4.08E+02	3.33E+02
F-	0.00E+00	1.97E+04	0.00E+00	4.04E+04	0.00E+00	0.00E+00	1.02E+04	7.51E+02	4.17E+02	7.79E+03
SO4-2	7.20E+03	4.69E+03	8.57E+01	9.48E+02	2.06E+03	4.42E+03	1.79E+03	6.11E+03	2.29E+02	1.09E+03
NO3-	7.06E+04	1.84E+05	1.46E+04	1.16E+05	6.22E+04	7.78E+04	5.74E+04	5.82E+04	5.99E+04	4.06E+04
NO2-	1.49E+03	1.86E+04	1.67E+03	1.22E+04	1.32E+04	4.60E+03	5.81E+03	5.21E+02	1.71E+03	4.39E+03
PO4-3	9.43E+02	1.25E+03	7.41E+01	6.22E+02	2.44E+02	7.78E+02	6.00E+04	5.20E+03	3.41E+03	4.57E+04
OH-	1.18E+04	1.94E+04	5.57E+03	6.66E+04	9.30E+03	4.15E+04	1.18E+05	1.67E+04	1.87E+04	6.90E+04
TOC	0.00E+00	4.54E+00	0.00E+00	1.77E+04	0.00E+00	8.56E+02	9.39E+03	4.09E+02	6.99E+03	0.00E+00
Sr90	4.05E+04	6.05E+05	2.35E+05	2.17E+05	1.65E+06	3.18E+05	4.93E+04	1.32E+04	4.04E+01	7.17E+03
Tc99	2.97E+01	1.99E-08	1.60E-08	5.13E-09	6.90E+02	0.00E+00	1.34E+00	9.14E-04	9.21E-01	1.74E-10
Cs137	4.63E+04	3.68E-05	3.55E-05	1.14E-05	7.10E+04	0.00E+00	2.17E+03	1.16E+00	1.39E+03	3.24E-07
TRU	1.58E+02	2.86E+03	4.06E+02	1.29E+03	7.83E+03	5.59E+02	3.35E+02	1.14E+02	9.58E-01	1.33E+02
H2O	3.70E+05	1.14E+06	1.27E+05	1.29E+06	3.74E+05	7.29E+05	1.93E+06	4.09E+05	2.65E+05	1.36E+06
Volume (L)	8.78E+05	8.11E+06	9.87E+05	5.79E+06	2.47E+06	2.72E+06	1.94E+06	4.41E+05	5.58E+05	1.36E+06

Source	111-C	112-C	201-C	202-C	203-C	204-C	101-S	102-S	103-S	104-S
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	4.30E+03	3.81E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E+04	6.65E+04	2.77E+04	4.68E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	3.89E-01	2.75E+00	7.67E-03	3.84E-03	1.92E-02	1.15E-02	3.44E+01	7.02E+01	3.57E+01	1.99E+00
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	1.02E+01	6.43E+00	2.43E-01	1.22E-01	6.08E-01	3.65E-01	4.23E+03	3.25E+03	1.92E+03	5.79E+03
FE+3	1.40E+01	3.27E+01	3.28E-01	1.64E-01	8.19E-01	4.91E-01	1.46E+02	9.26E+01	9.74E+01	1.12E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	7.48E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.59E+02	2.11E+03	8.66E+02	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	3.82E+04	5.74E+04	1.57E+03	7.87E+02	3.94E+03	2.36E+03	4.71E+05	9.98E+05	4.34E+05	1.15E+05
NI+3	1.04E+00	1.11E+01	1.04E-02	5.20E-03	2.60E-02	1.56E-02	2.20E+01	4.10E+01	2.20E+01	2.88E+00
PB+4	0.00E+00	4.78E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-01	3.17E-01	1.30E-01	0.00E+00
CO3-2	6.00E+02	4.26E+03	1.95E+02	9.76E+01	4.88E+02	2.93E+02	1.90E+04	4.01E+04	1.90E+04	3.07E+03
CL-	1.19E+02	6.07E+02	7.85E-01	3.92E-01	1.96E+00	1.18E+00	4.67E+03	1.02E+04	4.12E+03	1.54E+03
F-	1.50E+03	6.24E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.82E+03	5.40E+03	2.12E+03	0.00E+00
SO4-2	2.27E+02	2.72E+02	2.46E+02	1.23E+02	6.16E+02	3.69E+02	6.88E+03	1.68E+04	7.25E+03	5.62E+02
NO3-	1.94E+04	9.41E+04	1.44E+02	7.22E+01	3.61E+02	2.17E+02	7.94E+05	1.38E+06	6.32E+05	2.70E+05
NO2-	3.14E+03	3.33E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.06E+04	2.18E+05	8.62E+04	0.00E+00
PO4-3	8.91E+03	5.16E+03	1.65E+02	8.23E+01	4.12E+02	2.47E+02	7.06E+03	2.06E+04	8.16E+03	0.00E+00
OH-	1.57E+04	2.65E+04	9.64E+02	4.82E+02	2.41E+03	1.35E+03	8.29E+04	2.56E+05	1.04E+05	0.00E+00
TOC	6.69E+02	1.00E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E+03	1.39E+04	5.43E+03	0.00E+00
Sr90	5.26E+04	2.21E+04	3.60E+00	3.14E-14	3.77E+02	1.55E-01	3.44E+05	3.14E+04	1.74E-04	2.85E+05
Tc99	7.05E-01	5.82E-01	4.09E-04	1.19E-16	1.17E-09	1.77E-05	1.24E+02	1.70E-07	2.55E-07	6.39E+00
Cs137	1.08E+03	9.34E+02	4.68E-01	1.11E-13	1.47E-06	2.02E-02	2.41E+04	9.86E-05	7.59E-05	8.60E+03
TRU	7.88E+01	7.80E+01	2.45E-02	6.74E-02	6.74E-03	2.38E-05	4.40E+02	2.60E+01	2.90E+00	2.44E+02
H2O	3.23E+05	4.16E+05	1.37E+04	6.86E+03	3.43E+04	2.08E+04	3.59E+06	7.81E+06	3.38E+06	8.04E+05
Volume (L)	5.14E+05	9.30E+05	2.11E+04	1.05E+04	5.26E+04	2.05E+04	4.10E+06	8.67E+06	3.77E+06	4.78E+06

Source	105-S	106-S	107-S	108-S	109-S	110-S	111-S	112-S	101-SX	102-SX
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	5.41E+04	6.66E+04	4.37E+04	7.17E+04	6.82E+04	5.04E+04	6.58E+04	7.57E+04	6.66E+04	6.41E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.01E+02	1.21E+02	4.10E+01	1.32E+02	1.27E+02	6.22E+01	9.64E+01	1.39E+02	2.15E+01	1.13E+02
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	4.46E+03	4.98E+03	4.56E+03	4.51E+03	5.41E+03	4.21E+03	4.73E+03	5.21E+03	5.50E+03	1.56E+04
FE+3	2.77E+02	7.22E+02	1.96E+02	1.97E+02	6.32E+02	1.98E+02	2.23E+02	2.79E+02	1.42E+02	7.51E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	1.56E+03	1.76E+03	5.13E+02	2.06E+03	1.91E+03	9.53E+02	1.54E+03	2.17E+03	4.59E+02	1.70E+03
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	9.27E+05	1.05E+06	4.40E+05	1.22E+06	1.13E+06	6.06E+05	9.41E+05	1.29E+06	3.57E+05	9.99E+05
NI+3	6.24E+01	8.75E+01	2.96E+01	7.81E+01	8.39E+01	3.88E+01	5.56E+01	8.42E+01	1.45E+01	8.55E+01
PB+4	2.35E-01	2.64E-01	3.80E-02	3.10E-01	2.87E-01	1.43E-01	2.31E-01	3.26E-01	6.90E-02	2.55E-01
CO3-2	4.88E+04	5.55E+04	9.84E+03	6.43E+04	5.98E+04	3.06E+04	4.85E+04	6.78E+04	1.29E+04	5.06E+04
CL-	7.14E+03	8.08E+03	3.18E+03	9.42E+03	8.73E+03	4.98E+03	7.39E+03	9.92E+03	4.04E+03	8.25E+03
F-	3.24E+03	3.64E+03	4.80E+04	4.27E+03	3.95E+03	1.97E+03	3.18E+03	4.49E+03	1.11E+03	3.65E+03
SO4-2	1.52E+04	1.71E+04	5.07E+03	2.00E+04	1.86E+04	9.49E+03	1.51E+04	2.11E+04	4.61E+03	1.61E+04
NO3-	1.54E+06	1.74E+06	8.00E+05	2.03E+06	1.88E+06	1.06E+06	1.59E+06	2.13E+06	7.17E+05	1.63E+06
NO2-	1.37E+05	1.55E+05	4.18E+04	1.80E+05	1.67E+05	8.32E+04	1.37E+05	1.90E+05	4.52E+04	1.53E+05
PO4-3	1.31E+04	1.47E+04	3.33E+03	1.73E+04	1.60E+04	7.97E+03	1.29E+04	1.82E+04	4.28E+03	1.46E+04
OH-	1.84E+05	2.07E+05	3.52E+04	2.42E+05	2.25E+05	1.04E+05	1.78E+05	2.55E+05	3.25E+04	2.03E+05
TOC	8.09E+03	9.07E+03	1.74E+03	1.07E+04	9.87E+03	4.74E+03	7.81E+03	1.12E+04	2.60E+03	9.31E+03
Sr90	2.83E+04	7.47E+03	3.88E+05	4.36E+04	4.99E+04	3.40E+05	4.28E+05	8.42E+05	4.28E+05	1.21E+06
Tc99	1.83E+01	3.57E+01	2.55E-07	1.04E+02	3.60E+02	2.38E+02	2.22E+02	1.55E+03	6.87E-09	7.14E-01
Cs137	2.37E+04	4.66E+04	3.76E-05	6.31E+04	3.55E+05	3.96E+05	3.65E+05	1.23E+06	3.99E-06	1.09E+02
TRU	1.92E+01	2.68E+00	1.38E+03	1.26E+02	1.32E+02	1.31E+02	1.86E+01	6.66E+02	2.84E+02	2.93E+01
H2O	7.13E+06	8.06E+06	3.34E+06	9.41E+06	8.73E+06	4.62E+06	7.22E+06	9.91E+06	2.63E+06	7.69E+06
Volume (L)	8.06E+06	9.12E+06	4.25E+06	1.06E+07	9.86E+06	5.27E+06	8.18E+06	1.12E+07	4.25E+06	8.69E+06

Source	103-SX	104-SX	105-SX	106-SX	107-SX	108-SX	109-SX	110-SX	111-SX	112-SX
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	8.14E+04	7.90E+04	8.11E+04	5.80E+04	1.49E+04	1.66E+04	1.83E+04	3.84E+03	1.19E+04	1.06E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	1.21E+02	9.98E+01	1.42E+02	4.87E+01	8.37E-01	8.91E-01	8.54E+01	1.34E+01	1.79E+01	7.99E+00
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	6.76E+03	6.60E+03	8.16E+03	3.11E+03	3.92E+03	4.06E+03	8.66E+03	4.40E+03	6.30E+03	3.93E+03
FE+3	3.57E+02	3.14E+02	4.11E+02	8.75E+01	5.11E+01	5.40E+01	1.69E+02	6.19E+01	9.29E+01	5.73E+01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	1.86E+03	1.53E+03	2.10E+03	1.90E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	1.14E+06	9.69E+05	1.31E+06	8.38E+05	4.33E+04	4.74E+04	5.87E+05	1.29E+05	1.91E+05	1.02E+05
NI+3	7.48E+01	6.22E+01	8.78E+01	2.94E+01	1.21E+00	1.28E+00	4.15E+01	7.35E+00	1.01E+01	4.89E+00
PB+4	2.79E-01	2.30E-01	3.16E-01	2.86E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	5.87E+04	4.90E+04	6.66E+04	3.00E+04	1.29E+03	1.38E+03	5.95E+03	1.81E+03	2.74E+03	1.64E+03
CL-	9.09E+03	7.92E+03	1.02E+04	9.29E+03	6.69E+02	7.31E+02	1.09E+03	3.73E+02	7.31E+02	5.50E+02
F-	3.84E+03	3.17E+03	4.44E+03	5.11E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SO4-2	1.83E+04	1.52E+04	2.12E+04	1.42E+04	2.39E+02	2.62E+02	3.82E+02	1.15E+02	2.44E+02	1.90E+02
NO3-	1.95E+06	1.69E+06	2.22E+06	1.08E+06	1.02E+05	1.12E+05	1.56E+06	3.40E+05	4.99E+05	2.63E+05
NO2-	1.62E+05	1.34E+05	1.87E+05	2.04E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO4-3	1.55E+04	1.28E+04	1.78E+04	1.92E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OH-	2.10E+05	1.68E+05	2.46E+05	2.33E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOC	9.38E+03	7.62E+03	1.09E+04	1.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr90	4.17E+05	4.29E+04	2.19E+05	9.61E+04	1.07E+06	6.64E+05	2.00E+05	4.36E+05	6.11E+05	7.06E+05
Tc99	1.35E+03	1.89E+02	4.24E+02	1.60E+02	2.05E-06	4.08E-06	2.05E-06	1.27E-07	6.08E-14	4.62E-01
Cs137	4.61E+05	3.14E+04	6.49E+04	6.33E+04	1.83E-03	3.53E-03	3.76E-03	6.79E-05	1.25E-10	7.64E+02
TRU	1.78E+03	5.47E+02	6.46E+02	2.71E+02	5.71E+02	6.15E+02	3.09E+02	7.47E+02	9.61E+02	3.89E+02
H2O	8.73E+06	7.38E+06	1.00E+07	6.61E+06	3.04E+05	3.33E+05	4.20E+06	9.19E+05	1.36E+06	7.25E+05
Volume (L)	9.92E+06	8.42E+06	1.14E+07	7.29E+06	1.76E+06	1.92E+06	5.10E+06	1.12E+06	1.66E+06	1.18E+06

Source	113-SX	114-SX	115-SX	101-T	102-T	103-T	104-T	105-T	106-T	107-T
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	3.12E+02	7.05E+03	7.16E+02	6.98E+03	3.37E+03	3.71E+03	1.52E+04	1.89E+01	2.11E+03	5.52E+03
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	9.97E-03	7.11E+01	4.77E+00	4.47E-01	2.19E-01	1.74E+00	1.34E+00	5.01E-01	8.60E-02	4.64E-01
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	2.69E+01	8.96E+03	1.42E+03	6.62E+00	3.32E+00	1.00E+02	9.62E+01	2.03E+01	4.14E+00	2.57E+01
FE+3	5.29E-01	1.60E+02	2.80E+01	2.40E+01	1.17E+01	1.58E+01	8.90E+01	3.75E+01	4.46E+00	3.36E+01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	7.49E+02	5.20E+05	2.57E+04	9.89E+03	5.14E+03	1.58E+04	3.23E+05	7.27E+04	1.05E+04	1.09E+05
NI+3	1.37E-02	3.58E+01	3.65E+00	7.14E-01	3.50E-01	1.29E+00	1.65E+00	7.06E-01	1.20E-01	6.04E-01
PB+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	1.54E+01	5.44E+03	3.62E+02	8.74E+02	5.20E+02	5.46E+02	2.06E+03	7.73E+02	1.33E+02	7.16E+02
CL-	1.13E+01	7.86E+02	7.15E+01	7.24E+01	2.62E+01	9.45E+01	8.63E+02	3.11E+02	3.59E+01	2.33E+02
F-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.58E+01	1.64E+04	4.50E+03	3.22E+02	5.46E+03
SO4-2	4.35E+00	2.54E+02	2.20E+01	2.62E+02	2.52E+02	3.09E+02	2.86E+03	5.63E+02	7.57E+01	7.62E+02
NO3-	1.75E+03	1.39E+06	6.78E+04	1.43E+04	5.55E+03	3.37E+04	1.09E+05	4.24E+04	6.49E+03	2.84E+04
NO2-	0.00E+00	0.00E+00	0.00E+00	1.54E+03	7.42E+02	1.83E+03	1.15E+04	7.52E+02	2.02E+03	3.08E+03
PO4-3	0.00E+00	0.00E+00	0.00E+00	1.65E+02	1.64E+02	1.58E+02	9.01E+04	1.85E+04	1.59E+03	3.21E+04
OH-	0.00E+00	0.00E+00	0.00E+00	1.30E+03	1.17E+03	7.83E+02	1.37E+05	2.73E+04	3.68E+03	4.84E+04
TOC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr90	1.86E+05	6.40E+05	4.59E+05	1.49E+03	2.53E+01	1.25E+04	2.36E+04	2.88E+03	1.47E+02	2.08E+04
Tc99	7.64E+01	6.08E-14	1.49E+02	4.78E+01	8.10E-01	4.48E+00	2.16E+00	2.04E-16	1.12E-01	1.05E-16
Cs137	1.14E+05	1.20E-10	2.31E+05	6.87E+03	1.16E+02	5.58E+02	2.91E+03	2.08E-13	1.64E+02	2.10E-13
TRU	8.83E+01	9.48E+02	2.18E+02	5.89E+01	1.00E+00	5.73E+00	1.41E+02	1.78E+02	1.98E+01	4.12E+01
H2O	5.26E+03	3.72E+06	1.83E+05	7.15E+04	3.86E+04	1.14E+05	2.80E+06	6.22E+05	8.70E+04	9.55E+05
Volume (L)	2.83E+04	4.53E+06	2.23E+05	7.65E+05	3.68E+05	3.38E+05	2.81E+06	6.32E+05	2.25E+05	9.51E+05

Source	108-T	109-T	110-T	111-T	112-T	201-T	202-T	203-T	204-T	101-TX
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	8.69E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	9.75E+00	2.45E+01	2.42E+00	4.27E+00	6.56E-01	2.73E-01	2.05E-01	3.41E-01	3.70E-01	2.82E+00
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	4.91E+01	1.14E+02	7.75E+01	1.43E+02	2.31E+01	6.18E+00	4.64E+00	7.71E+00	8.37E+00	1.09E+03
FE+3	3.18E+01	6.68E+01	1.84E+02	3.17E+02	4.98E+01	1.40E+01	1.06E+01	1.75E+01	1.90E+01	2.64E+01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	8.56E+01	3.07E+02	0.00E+00	2.39E+02	1.80E+02	2.99E+02	3.24E+02	0.00E+00
LA+3	0.00E+00	0.00E+00	5.84E-01	2.10E+00	0.00E+00	1.63E+00	1.23E+00	2.04E+00	2.21E+00	0.00E+00
NA+	5.65E+04	9.93E+04	3.07E+05	2.40E+05	2.02E+04	2.15E+04	1.62E+04	2.69E+04	2.92E+04	4.82E+04
NI+3	6.06E+00	1.51E+01	3.55E+00	6.59E+00	1.03E+00	4.21E-01	3.16E-01	5.25E-01	5.70E-01	2.02E+00
PB+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	8.61E+02	1.89E+03	3.74E+03	6.58E+03	1.01E+03	4.21E+02	3.17E+02	5.26E+02	5.71E+02	1.11E+03
CL-	2.57E+02	5.56E+02	1.34E+03	1.62E+03	2.10E+02	1.12E+02	8.45E+01	1.40E+02	1.52E+02	5.50E+02
F-	2.94E+03	5.23E+03	2.10E+04	2.24E+04	8.74E+02	8.71E+03	6.55E+03	1.09E+04	1.18E+04	4.29E+01
SO4-2	2.16E+03	5.16E+03	1.91E+03	2.07E+03	2.82E+02	1.29E+01	9.69E+00	1.61E+01	1.75E+01	8.10E+02
NO3-	4.16E+04	9.42E+04	1.99E+05	2.36E+05	2.89E+04	2.12E+04	1.60E+04	2.65E+04	2.88E+04	1.18E+05
NO2-	1.36E+03	2.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO4-3	1.98E+04	3.71E+04	7.07E+04	4.44E+04	3.32E+03	7.72E+02	5.80E+02	9.63E+02	1.05E+03	3.68E+02
OH-	1.59E+04	2.10E+04	1.13E+05	6.63E+04	3.86E+03	3.03E+03	2.28E+03	3.78E+03	4.11E+03	0.00E+00
TOC	0.00E+00	0.00E+00	2.55E+02	8.87E+02	0.00E+00	7.64E+02	5.75E+02	9.54E+02	1.04E+03	3.21E+01
Sr90	2.09E+03	4.21E+01	2.14E+03	1.81E+03	2.70E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.05E+03
Tc99	1.99E-01	1.24E+00	6.23E-11	0.00E+00	3.22E-36	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.38E-08
Cs137	3.40E+02	1.43E+03	6.38E-08	0.00E+00	2.57E-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-05
TRU	4.12E+00	4.65E-01	1.61E+02	1.24E+02	2.14E+02	0.00E+00	3.11E-01	3.11E+00	0.00E+00	1.09E-03
H2O	4.72E+05	8.12E+05	2.61E+06	1.98E+06	1.61E+05	1.77E+05	1.33E+05	2.21E+05	2.40E+05	3.42E+05
Volume (L)	4.92E+05	8.63E+05	2.67E+06	2.08E+06	1.76E+05	1.87E+05	1.41E+05	2.34E+05	2.54E+05	1.01E+06

Source	102-TX	103-TX	104-TX	105-TX	106-TX	107-TX	108-TX	109-TX	110-TX	111-TX
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	7.14E+03	9.95E+03	2.96E+03	3.87E+04	2.95E+04	1.74E+03	8.24E+03	1.62E+04	2.84E+04	2.21E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	3.39E+01	4.72E+01	1.41E+01	1.84E+02	1.37E+02	8.28E+00	3.34E+01	1.36E+00	1.30E+02	9.99E+01
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	2.15E+03	3.00E+03	8.93E+02	1.17E+04	8.78E+03	5.24E+02	2.47E+03	7.54E+01	8.25E+03	6.34E+03
FE+3	9.28E+01	1.29E+02	4.13E+01	5.03E+02	3.99E+02	2.38E+01	3.30E+01	9.86E+01	3.61E+02	2.78E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	2.54E+05	3.54E+05	1.19E+05	1.37E+06	1.02E+06	6.83E+04	2.95E+05	3.21E+05	9.92E+05	7.69E+05
NI+3	2.09E+01	2.91E+01	8.76E+00	1.13E+02	8.47E+01	5.13E+00	1.56E+01	1.77E+00	8.03E+01	6.17E+01
PB+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	2.87E+03	4.02E+03	2.87E+03	1.56E+04	1.09E+04	1.69E+03	3.35E+03	2.10E+03	1.04E+04	8.04E+03
CL-	1.52E+03	2.12E+03	6.37E+02	8.25E+03	6.15E+03	3.72E+02	1.79E+03	6.86E+02	5.90E+03	4.57E+03
F-	5.96E+02	8.30E+02	2.47E+02	3.23E+03	2.40E+03	1.45E+02	6.88E+02	1.60E+04	3.56E+03	3.14E+03
SO4-2	4.22E+03	5.90E+03	3.86E+03	2.25E+04	1.61E+04	1.95E+03	5.34E+03	2.24E+03	1.55E+04	1.20E+04
NO3-	6.09E+05	8.72E+05	2.61E+05	3.39E+06	2.53E+06	1.53E+05	7.27E+05	8.36E+04	2.41E+06	1.86E+06
NO2-	2.41E+04	3.35E+04	9.98E+03	1.31E+05	9.70E+04	5.86E+03	2.78E+04	9.03E+03	9.33E+04	7.21E+04
PO4-3	1.85E+03	2.60E+03	2.18E+03	9.80E+03	6.91E+03	1.07E+03	1.66E+03	9.42E+04	1.31E+04	1.18E+04
OH-	7.62E+03	4.37E+03	9.53E+03	1.57E+04	8.64E+03	4.89E+03	3.96E+03	1.42E+05	1.82E+04	1.66E+04
TOC	5.28E+02	7.36E+02	2.13E+02	2.87E+03	2.13E+03	1.26E+02	6.07E+02	0.00E+00	1.99E+03	1.51E+03
Sr90	1.93E+02	4.30E+02	3.79E-05	1.89E+03	3.11E-06	5.86E-04	3.04E+03	8.72E+04	6.11E+04	2.88E+04
Tc99	6.64E+00	9.54E-01	1.02E-06	6.11E+01	6.02E+00	2.91E-07	2.28E+01	5.81E+02	2.08E+02	3.08E+01
Cs137	5.71E+02	7.93E+02	1.33E-04	5.53E+03	8.96E+03	2.65E-04	3.32E+04	2.38E+05	1.00E+05	2.27E+04
TRU	2.80E-02	7.33E-02	3.63E-04	2.63E-01	4.46E-02	1.35E-06	1.33E+00	2.34E+02	4.11E+01	4.31E+00
H2O	1.84E+06	2.55E+06	8.76E+05	9.91E+06	7.34E+06	5.02E+05	2.13E+06	2.80E+06	7.18E+06	5.57E+06
Volume (L)	2.21E+06	3.08E+06	1.03E+06	1.20E+07	8.86E+06	5.94E+05	2.56E+06	2.79E+06	8.62E+06	6.69E+06

Source	112-TX	113-TX	114-TX	115-TX	116-TX	117-TX	118-TX	101-TY	102-TY	103-TY
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	4.02E+04	3.46E+04	3.05E+04	4.06E+04	1.77E+04	2.66E+04	2.36E+04	0.00E+00	2.18E+03	2.63E+03
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	2.01E+02	1.30E+02	1.69E+02	1.93E+02	2.24E+02	2.12E+02	9.69E+01	2.00E+01	2.29E+01	1.78E+01
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	1.22E+04	8.24E+03	9.29E+03	1.22E+04	6.21E+03	8.56E+03	5.99E+03	9.14E+01	7.36E+02	1.06E+03
FE+3	5.49E+02	4.00E+02	4.63E+02	5.36E+02	6.11E+02	5.78E+02	2.72E+02	7.18E+01	6.26E+01	1.34E+02
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	1.46E+06	1.11E+06	1.18E+06	1.44E+06	1.20E+06	1.29E+06	7.29E+05	2.00E+05	1.29E+05	2.45E+05
NI+3	1.24E+02	8.06E+01	1.04E+02	1.19E+02	1.38E+02	1.31E+02	5.99E+01	1.43E+01	1.41E+01	1.30E+01
PB+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	1.59E+04	1.12E+04	1.33E+04	1.55E+04	1.74E+04	1.66E+04	8.58E+03	2.45E+03	1.79E+03	4.22E+03
CL-	8.80E+03	6.13E+03	7.04E+03	8.75E+03	7.03E+03	7.67E+03	4.79E+03	4.99E+02	7.58E+02	1.47E+03
F-	5.53E+03	9.89E+03	7.93E+03	3.39E+03	3.06E+04	2.00E+04	2.20E+03	8.83E+03	2.80E+03	3.35E+03
SO4-2	2.45E+04	1.62E+04	2.21E+04	2.37E+04	3.90E+04	3.26E+04	1.16E+04	4.30E+03	3.83E+03	1.02E+04
NO3-	3.57E+06	2.43E+06	2.76E+06	3.57E+06	2.15E+06	2.70E+06	1.79E+06	8.06E+04	2.45E+05	3.75E+05
NO2-	1.37E+05	9.62E+04	1.05E+05	1.37E+05	7.47E+04	9.90E+04	6.72E+04	2.43E+03	8.70E+03	1.22E+04
PO4-3	2.49E+04	5.11E+04	4.53E+04	9.72E+03	2.11E+05	1.32E+05	8.52E+03	6.84E+04	1.91E+04	2.72E+04
OH-	2.04E+04	7.52E+04	3.10E+04	1.36E+04	1.20E+05	7.78E+04	7.59E+03	8.25E+04	1.10E+04	5.50E+04
TOC	2.98E+03	1.90E+03	2.23E+03	3.01E+03	1.31E+03	1.96E+03	1.44E+03	2.13E+03	1.61E+02	1.61E+03
Sr90	4.57E+03	4.89E+03	4.58E+02	1.78E+04	2.32E+04	4.41E+04	4.55E+05	1.01E+04	7.17E+03	6.46E+04
Tc99	1.57E+01	5.25E+00	1.47E+01	7.01E+00	3.53E+00	1.44E+00	5.46E+02	1.32E+00	1.55E+02	4.32E+02
Cs137	1.76E+04	6.02E+03	1.75E+04	9.81E+03	4.17E+03	1.69E+03	2.78E+05	1.62E+03	1.87E+04	3.73E+04
TRU	3.33E-01	4.81E+01	4.90E+00	5.66E-01	2.83E-02	1.91E-02	2.03E+03	2.12E+02	4.08E+00	2.65E+02
H2O	1.06E+07	8.26E+06	8.58E+06	1.04E+07	9.20E+06	9.65E+06	5.26E+06	1.72E+06	9.77E+05	1.92E+06
Volume (L)	1.27E+07	9.70E+06	1.02E+07	1.25E+07	1.05E+07	1.13E+07	6.34E+06	1.74E+06	1.12E+06	2.13E+06

Source	104-TY	105-TY	106-TY	101-U	102-U	103-U	104-U	105-U	106-U	107-U
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component										
AL(OH)4-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.48E+04	5.04E+04	0.00E+00	3.80E+04	2.19E+04	4.38E+04
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	5.96E-01	2.19E+00	2.22E-01	8.41E-02	7.43E+01	7.65E+01	1.53E-01	4.45E+01	4.13E+01	2.15E+01
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	7.24E+00	2.66E+01	2.70E+00	2.66E+00	4.73E+03	3.75E+03	4.86E+00	3.27E+03	1.81E+03	2.20E+03
FE+3	5.37E+01	1.97E+02	2.00E+01	3.59E+00	2.54E+02	2.14E+02	6.55E+00	1.43E+02	1.17E+02	5.12E+01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.08E+02	1.54E+03	0.00E+00	1.13E+03	6.37E+02	1.18E+03
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	3.24E+04	1.19E+05	1.21E+04	1.73E+04	6.89E+05	8.45E+05	3.15E+04	6.62E+05	3.98E+05	5.68E+05
NI+3	8.92E-01	3.28E+00	3.32E-01	1.14E-01	4.75E+01	4.73E+01	2.08E-01	2.82E+01	2.55E+01	1.07E+01
PB+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.12E-02	2.31E-01	0.00E+00	1.70E-01	9.57E-02	1.77E-01
CO3-2	1.62E+03	5.94E+03	6.02E+02	2.14E+03	1.47E+04	4.19E+04	3.91E+03	1.96E+04	2.24E+04	1.95E+04
CL-	4.86E+02	1.78E+03	1.81E+02	8.60E+00	4.80E+03	7.01E+03	1.57E+01	6.44E+03	2.83E+03	5.91E+03
F-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E+03	3.54E+03	0.00E+00	3.57E+03	1.32E+03	3.37E+03
SO4-2	5.73E+03	2.11E+04	2.13E+03	2.70E+03	1.58E+04	1.75E+04	4.92E+03	1.46E+04	9.39E+03	1.35E+04
NO3-	4.84E+04	1.78E+05	1.80E+04	1.58E+03	1.41E+06	1.26E+06	2.89E+03	9.73E+05	6.27E+05	6.71E+05
NO2-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.14E+04	1.46E+05	0.00E+00	1.42E+05	5.56E+04	1.43E+05
PO4-3	6.98E+02	2.57E+03	2.60E+02	1.81E+03	1.57E+04	1.65E+04	3.29E+03	1.83E+04	7.47E+03	1.56E+04
OH-	8.83E+03	3.25E+04	3.29E+03	1.06E+04	7.47E+04	1.99E+05	1.93E+04	1.56E+05	8.74E+04	1.70E+05
TOC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.12E+03	9.00E+03	0.00E+00	8.69E+03	3.27E+03	8.60E+03
Sr90	3.66E+03	1.52E+05	5.57E+03	7.95E+03	3.04E+04	1.25E+00	2.15E-04	1.94E+00	1.25E-03	4.54E+04
Tc99	2.84E-01	6.06E+00	3.19E-08	1.16E+01	2.92E+01	4.55E-03	7.22E-08	8.41E-03	3.19E-08	5.75E+01
Cs137	4.25E+02	7.41E+03	4.68E-05	1.61E+04	4.04E+04	6.61E+00	9.70E-05	1.24E+01	6.79E-05	2.28E+04
TRU	9.36E+00	7.69E+01	8.54E+00	7.17E+00	3.64E+00	2.54E-04	1.86E-07	1.59E-01	3.83E-05	9.77E+01
H2O	2.53E+05	9.31E+05	9.43E+04	1.50E+05	5.14E+06	6.58E+06	2.74E+05	5.14E+06	3.08E+06	4.51E+06
Volume (L)	2.82E+05	1.03E+06	1.05E+05	2.31E+05	5.99E+06	7.35E+06	4.21E+05	5.75E+06	3.46E+06	4.94E+06

Source	108-U	109-U	110-U	111-U	112-U	201-U	202-U	203-U	204-U
Units	kg	kg	kg	kg	kg	kg	kg	kg	kg
Component									
AL(OH)4-	5.51E+04	5.27E+04	4.62E+03	3.88E+04	3.68E+03	8.29E+02	8.29E+02	4.15E+02	4.15E+02
BA+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA+2	6.59E+01	5.72E+01	4.70E-01	3.90E+01	1.79E-01	2.07E-02	2.07E-02	1.03E-02	1.03E-02
CD+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR(OH)4-	3.49E+03	3.31E+03	4.38E+01	2.54E+03	1.01E+02	7.75E-01	7.75E-01	3.87E-01	3.87E-01
FE+3	1.97E+02	9.88E+01	2.65E+01	9.22E+01	1.15E+01	9.67E-01	9.67E-01	4.83E-01	4.83E-01
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	1.56E+03	1.48E+03	0.00E+00	1.17E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA+	7.93E+05	7.77E+05	1.16E+05	5.65E+05	3.26E+04	2.20E+03	2.20E+03	1.10E+03	1.10E+03
NI+3	4.10E+01	3.01E+01	5.33E-01	2.34E+01	2.40E-01	2.99E-02	2.99E-02	1.49E-02	1.49E-02
PB+4	2.34E-01	2.23E-01	0.00E+00	1.76E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	3.54E+04	3.52E+04	1.55E+03	2.22E+04	2.77E+02	3.19E+01	3.19E+01	1.60E+01	1.60E+01
CL-	7.23E+03	6.90E+03	3.82E+02	5.60E+03	1.05E+02	5.94E+00	5.94E+00	2.97E+00	2.97E+00
F-	3.77E+03	3.62E+03	5.70E+03	3.42E+03	1.33E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SO4-2	1.35E+04	1.54E+04	2.38E+03	9.42E+03	2.04E+02	1.80E+00	1.80E+00	8.99E-01	8.99E-01
NO3-	1.16E+06	1.10E+06	5.04E+04	7.77E+05	1.72E+04	1.64E+03	1.64E+03	8.19E+02	8.19E+02
NO2-	1.55E+05	1.53E+05	5.12E+03	1.22E+05	2.15E+03	9.34E+02	9.34E+02	4.67E+02	4.67E+02
PO4-3	1.48E+04	1.59E+04	2.89E+04	1.26E+04	7.82E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OH-	1.89E+05	1.95E+05	4.78E+04	1.45E+05	1.24E+04	6.91E+02	6.91E+02	3.46E+02	3.34E+02
TOC	9.66E+03	9.26E+03	0.00E+00	7.66E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr90	2.97E+04	5.28E+02	1.84E+05	2.37E+04	1.63E+03	1.03E+01	9.49E+00	8.78E+00	2.74E+00
Tc99	1.23E-02	3.58E+00	1.99E-01	1.51E+01	1.97E+01	3.08E+00	3.22E+00	2.84E+00	7.48E-01
Cs137	1.79E+01	5.56E+03	2.88E+02	6.05E+03	2.63E+04	4.14E+03	4.35E+03	3.83E+03	1.02E+03
TRU	1.85E+01	2.44E-01	2.72E+02	3.06E+01	6.96E-01	2.28E-02	2.39E-02	2.10E-02	5.58E-03
H2O	6.17E+06	6.08E+06	9.98E+05	4.42E+06	2.77E+05	1.76E+04	1.76E+04	8.78E+03	8.82E+03
Volume (L)	6.89E+06	6.76E+06	1.01E+06	4.91E+06	4.65E+05	8.44E+04	8.44E+04	4.30E+04	3.54E+04

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APPENDIX D

HEEL MIXING STUDY

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APPENDIX D

HEEL MIXING STUDY

When feed envelopes are changed, feed from the "new" envelope will be mixed with quantities of the "old" envelope that are contained in the tank heels present in the private contractors' feed tanks and the intermediate feed staging tanks. Potentially this combination could result in a batch that no longer meets the feed requirements of the "new" envelope. The purpose of this study is to quantify what effect the heel has when envelopes are switched.

Sections D1.1 through D1.5 that follow describe the calculation of "sample" envelope compositions, the necessary "new" to "old" volume ratios, and the maximum allowable heels. Also included is an analysis of the results and a section for conclusions and recommendations. The methodology described in Sections D1.1 through D1.5 explores the full range of the envelopes without regard to actual waste composition or charge balance. This is purely a mathematical simulation of what may occur based upon the envelope limits.

Section D1.6 offers preliminary heel mixing results using estimated tank compositions. However, these data are preliminary at this time and should not be taken as the final results. It is included to show that the composition ranges in the actual waste are anticipated to be much narrower than what is permitted by the envelope limits.

D1.1 CALCULATION OF ENVELOPE COMPOSITIONS

First a Monte-Carlo method was used to generate "sample" sets of compositions that meet all envelope specifications. The feed envelope limits are provided by Requirement A4.1 and Contractor Support Team (CST) Assumptions A5.1 and A5.2 (See Appendix A). The actual feed envelopes limits used in this analysis are shown in Section 2.5, Feed Envelope Assessment and Tank Classification.

Limits for each analyte are stated as a mole analyte to sodium mole ratio; radionuclide limits are stated as Becquerels to sodium mole ratio. To calculate "sample" sets of compositions, each components' maximum limit was multiplied by a uniformly distributed random number between 0 and 1. This procedure was performed for all envelopes to insure that their components were at or below their maximums. However, Envelopes B and C had additional specifications imposed by CST Assumption A5.1. These additional specifications are used to insure that the envelopes are mutually independent from one another. The paragraphs that follow describe these additional specifications and how they were incorporated into the calculation procedure.

Envelope B

The definition for Envelope B states that its composition will be controlled so that sodium will not be the limiting component in the glass or that the liquid will require a cesium decontamination factor (DF) in excess of 1000. The components that may be limiting instead of sodium are chloride, chromium, fluoride, phosphate, and/or sulfate. The definition for Envelope A states that its composition will be controlled so that only sodium will be limiting and that the cesium DF required will be less than 1,000. Thus, the Envelope A maximums for chloride, chromium, fluoride, phosphate, sulfate, and cesium define the point where above which the component is limiting. Therefore the composition of the B "sample" must be calculated so that at least one of these components exceeds its Envelope A maximum.

To do this the compositions for all of the limiting components except cesium are calculated via the Monte-Carlo procedure described above. If none exceed their Envelope A maximums, cesium is set so that it will. This is done by taking the difference between cesium's Envelope B and Envelope A maximums, multiplying the result by a uniformly distributed random number between 0 and 1, and then adding this to its Envelope A maximum. If any do exceed their A maximums, then cesium is calculated via the normal Monte-Carlo procedure.

Cesium was chosen as the deciding component because its Envelope B maximum is over an order of magnitude greater than its Envelope A maximum (14 times). This difference is greater than any of the other limiting components. Because of this large range there is only a 7.2 percent chance that the calculated cesium ratio would be at or below the Envelope A maximum. Therefore ,it was assumed that forcing the cesium concentration to satisfy the Envelope B specifications would not significantly skew the results.

Envelope C

Envelope C is defined so that its organic carbon composition is greater than either Envelope A or B. Therefore, it also has a minimum value that it must meet or exceed. Since Envelope A and B are not intended to be limited by organic carbon, their maximums define Envelope C's minimum. Therefore Envelope C's organic carbon composition is calculated by taking the difference between the Envelope C and Envelope A maximums, multiplying the result by a uniformly distributed random number between 0 and 1, and then adding this to the Envelope A maximum.

The sulfate limit for Envelope C is increased in order to include the complexant concentrate (CC) waste in tanks 241-AN-102 and 241-AN-107 as discussed by CST Assumption A5.1 (Appendix A). These tanks are intended to be "prototypical" Envelope C feed.

Envelope C also has different maximums for Transuranics and Sr^{90}. However, these components are not defined as being limiting so their ratios are calculated normally.

D1.2 CALCULATION OF VOLUME OF WASTE ADDED

The volume of waste that needs to be added ("new" envelope) to the heel of the "old" envelope in order to meet all constraints of the "new" envelope is calculated in two parts. The first calculation insures that all components are less than or equal to their maximums. The second calculation insures that Envelopes B and C meet their limiting component constraints. The second calculation is only necessary when the "new" envelope is either B or C. The results from these two calculations are summed together and this gives the volume required to meet the "new" envelope specifications. The procedures for these calculations are defined below. All envelope compositions used in these calculations were calculated previously via the procedure defined in Section D1.1.

First the volume needed to meet the maximum limits for each component is calculated. This is accomplished by first calculating a sodium molarity for the "new" and the "old" envelopes. The RFP states that the feed will be between 3 and 14 molar sodium (Requirement A4.1, Appendix A). The sodium molarity for each envelope is calculated by taking the difference between the upper and lower sodium molarity limits, multiplying the result by a uniformly distributed random number between 0 and 1, and then adding this to the lower sodium molarity limit. The sodium molarity for each envelope needs to be known because the component compositions are given as component to sodium mole ratios. Without the sodium molarity, the component compositions would be dimensionless and unquantifiable.

The following equation shows the calculation of the resulting component i to sodium ratio:

$$R_i = (S_oV_oC_{oi} + S_nV_nC_{ni})/(S_oV_o + S_nV_n) \qquad \text{Eq 1}$$

where:

- i = The Component of Interest
- R = Resulting Component to Sodium Ratio
- S = Sodium Molarity
- V = Volume in Liters
- C = Component to Sodium Ratio
- o = "Old" Envelope (Heel)
- n = "New" Envelope

Solving the above equation for the volume of the "new" envelope (V_n) gives:

$$V_n = S_oV_o/S_n*(C_{oi}-R_i)/(R_i-C_{ni}) \qquad \text{Eq 2}$$

Assuming that V_o equals 1 L, the value for V_n is calculated for each component. The maximum V_n determines the volume of "new" envelope necessary to dilute the "old" envelope heel to meet the "new" envelope component constraints. This will be defined as the V_n'. If all V_ns are negative, the V_n' is set to 0. Negative V_ns occur when the component in the heel already meets the constraints of the "new" envelope. However if all the envelopes are unique (which presently they are) V_n' will always be a positive non-zero number.

The first calculation effectively dilutes any component in the heel that exceeds the maximum allowable for the "new" envelope. The second calculation, which is described below, calculates the amount of the "new" envelope that has to be added to insure that the limiting (minimum) component specifications are met.

The second calculation works off of the results of the first calculation. Based upon the V_n' calculated previously, an overall sodium molarity and individual component ratios are calculated. This results in an intermediate stream. This intermediate stream is then used in place of the heel in the calculations above to determine the additional volume, if any, needed to insure that the minimum limits are satisfied. New V_ns are calculated based upon meeting the minimum requirements (R_i in the above equations) as stated previously. For Envelope B the V_n'' is the MINIMUM of the new V_ns calculated and for Envelope C it is the V_n calculated for organic carbon. The V_n'' for Envelope B is set to the minimum because only one of the limiting components needs to exceed its minimum.

The values for V_n' and V_n'' are summed together and this product is the overall V_n required. The "new" envelope to "old" envelope volume ratio is defined as the overall V_n divided by the heel volume. Since the heel volume assumed was 1 L, the overall V_n equals the volume ratio ($R_{f/h}$).

D1.3 CALCULATION OF MAXIMUM ALLOWABLE HEELS

Five hundred "new" to "old" volume ratios were calculated for each of the six envelope switching scenarios (A to B, A to C, B to A, B to C, C to A, and C to B). These six scenarios encompass all possibilities for envelope switching. The results were used to calculated the maximum allowable heel in inches of waste, assuming that the maximum liquid level is 4.33 ML (416 in.) (Assumption A8.2, Appendix A) and the tanks are flat bottomed. Another assumption is that there is sufficient feed of the "new" envelope to make up a full tank. The equations below describe the calculations.

The maximum allowable heel is defined as the maximum volume of "old" envelope that when mixed with the volume of "new" envelope required to meet all "new" envelope specifications results in an overall volume that equals the maximum allowable tank volume. This relationship is shown in the following equation:

$$V_m = V_n + V_o \qquad \text{Eq 3}$$

where:

V = Tank Volume in ML (inches)
m = Maximum Tank Volume = 4.33 ML (416 in.)
o = "Old" Envelope (Heel)
n = "New" Envelope

Any unit of measurement for volume can be used, but inches is preferred because the heel height is restricted by the transfer pump inlet depth.

Since the volume ratio is defined as:

$$R_{f/h} = V_n/V_o \qquad \text{Eq 4}$$

where:

$R_{f/h}$ = "New" to "Old" Volume Ratio (Dimensionless)

solving for V_n gives:

$$V_n = V_o R_{f/h} \qquad \text{Eq 5}$$

Substituting equation 5 into equation 3 and solving for V_o gives:

$$V_o = V_m/(1 + R_{f/h}) \qquad \text{Eq 6}$$

Using the above equation, the maximum allowable heels were calculated for each of the 500 runs for each of the 6 scenarios.

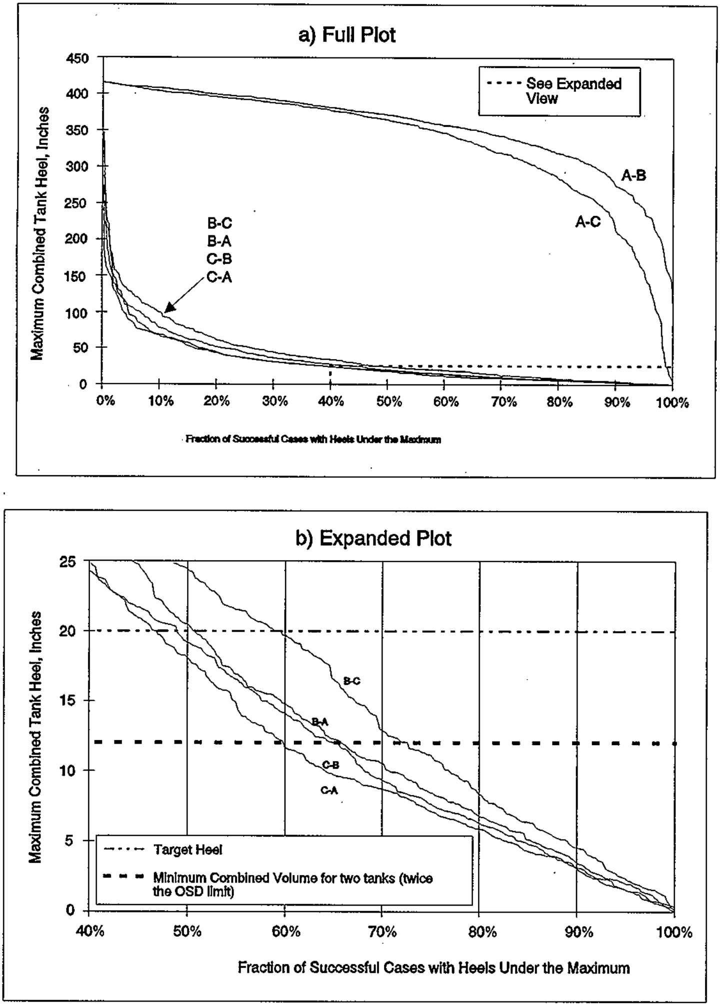
D1.4 RESULTS

The maximum allowable heels calculated in Section D1.3 were sorted in descending order and graphed. The results are shown in Figure D-1. Figure D-1a shows the full range of the results and Figure D-1b shows a blowup section of Figure D-1 with only 4 of the 6 scenarios.

Figure D-1a shows that when the "old" envelope is Envelope A, nearly 100 percent of the cases will meet the "new" envelope specifications with the heel being 0.52 ML (50 in.) or less. If the heel is less than 2.6 ML (250 in.), 90 percent of the cases satisfy the "new" envelope. This value is 60 percent of the maximum allowable tank volume and is extremely high for a heel. Therefore it is concluded that switching from Envelope A to any other envelope will not be an operational concern.

Figure D-1 also shows that any other envelope switch will require a significant reduction in the amount of heel that can be left. Figure D-1b shows that if the tank heel is 0.1 ML (10 in.) the fraction of successful cases meeting the "new" envelope specifications ranges between 64 and 76 percent. At 0.21 ML (20 in.), this range decreases to 47 and 59 percent. For 90 percent of the cases to be successful, the tank heel must be between 0.03 ML and 0.05 ML (3 in. and 5 in.). For 70 percent, the tank heel must be between 0.09 ML and 0.13 ML (9 and 13 in.).

Figure D-1. Heel Mixing Results Using Envelope Ranges.



D1.5 CONCLUSIONS AND RECOMMENDATIONS

Switching from Envelope A should not cause a problem if at least one of the limiting components and/or the organic carbon ratios are not close to their minimums.

The number of envelope switches from B or C should be minimized in order to decrease the risk of tainting feed batches with heels. If switches are necessary, the amount of heel should be kept as low as possible (0.06 ML to 0.09 ML [6 in. to 9 in.] depending on the switch). This may require flushing to remove the heel.

The ranges may be altered by incorporation of better tank characterization data. Presently the maximums for some of the radionuclides (Envelope B cesium and Envelope C strontium) are more than an order of magnitude greater than the other envelope maximums. For example, Envelope B's cesium concentration is nearly 14 times either of the other envelope's maximums. This increased range may be much greater than what is actually achievable. Decreasing the maximums will increase the calculated maximum heels allowable.

Since Envelope B's cesium concentration is 14 times the other envelope's maximums there is only a slight chance (7.2 percent) that the calculated value for B will equal or be below the other envelopes. This may cause the calculated values to be, on average, much higher than they should be. A possible solution is to use actual mean values to base the Monte-Carlo simulations around. This would remove the bias that the high limit places on the envelope compositions.

It must be understood that the waste compositions used in this study explore the full range of envelope compositions. Therefore it is possible that an Envelope B waste high in sulfate may be mixed with an Envelope A waste that is very near its upper limit for sulfate. This is equivalent to diluting 100 with 0.999 to achieve a final value of 1. Actual waste is expected to have a more restricted range and may permit larger heels on a case by case basis.

Additionally it must be understood that the amount of heel is additive. If the M&I contractor makes up the batches in one tank and transfers it to the private contractors tank, the total heel is the sum of the heels in the two tanks assuming that the two heels are similar in composition. The M&I contractor is required to *deliver* waste of the proper envelope, not to insure that the mixture in the private contractors feed tank is of the proper envelope. However best efforts should be taken to avoid tainting the private contractors feed batch.

D1.6 PRELIMINARY RESULTS USING ACTUAL WASTE COMPOSITIONS

The project supernate composition estimates for the DSTs were used to determine the "actual" maximum allowable heels. To do this the tanks first were classified according to envelope (See Section 2.5) and then all permutations of envelope switches were examined. This section describes the process and results of this exercise.

Envelope Groupings

The 26 tank compositions (Tanks 241-AW-102 and 241-AW-106 are not included) were examined to determine what envelope they would fall into. The results of this exercised are shown in Table D-2. Of the 26 tanks, 6 were classified as A, 2 were classified as B, and 10 were classified as C. The remaining 8 tanks did not fall into any envelope. Of these 8, 7 were excluded because they had non-varying component (hydroxide, nitrate, potassium, strontium, and/or transuranic) ratios that exceeded the maximum for all three envelopes. The last 1 had a TOC concentration that met the C limit, but some of the limiting component ratios exceeded the C limits. If the non-varying component ratios for the first 7 were all met, 3 would still not fit any envelope. These three meet the C limit for TOC, but some of the limiting component ratios exceed the C limits.

Heel Calculations

A spreadsheet was built that calculated volume ratios required (as defined in Section D1.2) for all combinations of tanks that met envelope specifications (i.e., all Envelope A tanks were paired with all Envelope B and so forth). These results were then used to calculate the maximum allowable heel volumes as defined in Section D1.3. The results of these calculations are shown in Figure D-2.

Table D-2.

Envelope	A	B	C	Excluded
Tank	241-AN-103 241-AN-104 241-AN-105 241-AP-104 241-AP-106 241-AW-101	241-AP-103 241-AY-101	241-AN-102 241-AN-106 241-AN-107 241-AP-101 241-AP-102 241-AP-105 241-AP-107 241-AP-108 241-AW-104 241-SY-102	241-AN-101 241-AW-103 241-AW-105 241-AY-102 241-AZ-101 241-AZ-102 101-SY-SOL* 103-SY-SOL*

*The compositions for these tanks reflect the soluble portion of the entire tank after addition of retrieval water to reduce the sodium molarity to 7*M* or less and the solids content to 10 wt% or less, whichever is limiting.

Results

Figure D-2a shows that the actual waste compositions are not as restrictive as what was calculated previously based upon the envelope ranges. Figure D-2b (a blowup of Figure D-2a) shows that at a confidence level of 80 percent, the minimum heel volume allowable for any scenario is 0.17 ML to 0.19 ML (16 in. to 18 in.). At 90 percent the minimum drops to about 0.08 ML (8 in.) for one scenario and 0.1 ML (10 in.) for another, but all of the others are above 0.21 ML (20 in.).

Figure D-2b also shows that only a small number of tank switching cases have maximum allowable heels at or below 0.1 ML (10 in.) These cases appear in the A-C, C-A, and C-B switching scenarios and are documented in Table D-3. Explanations for the results shown in Table D-3 are given below.

Table D-3.

A - C		C - A		C - B	
241-AN-104	241-AP-102	241-AN-102	241-AP-104	241-AN-107	241-AP-103
241-AN-104	241-AP-101	241-AN-107	241-AP-104	241-AP-107	241-AP-103
241-AW-101	241-AP-102	241-AP-107	241-AP-104	241-AN-106	241-AP-103
241-AN-105	241-AP-102	241-AN-106	241-AP-104	241-AP-105	241-AP-103
241-AW-101	241-AP-101	241-AP-105	241-AP-104		
241-AN-105	241-AP-101				

The first tank is the heel tank.

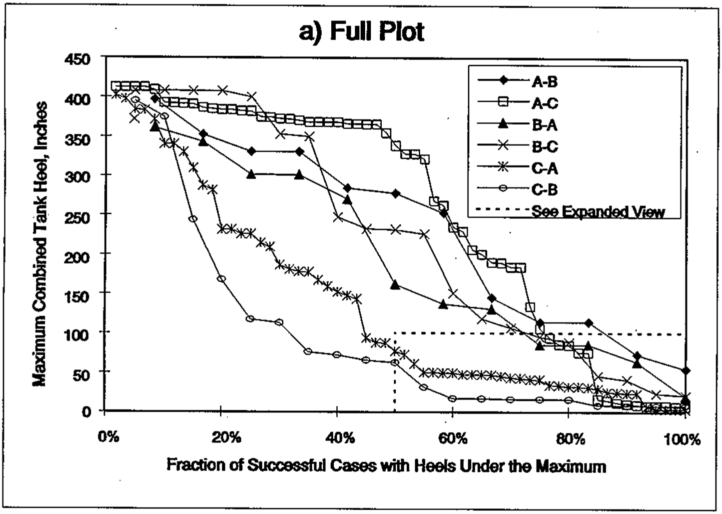
Switching from A - C

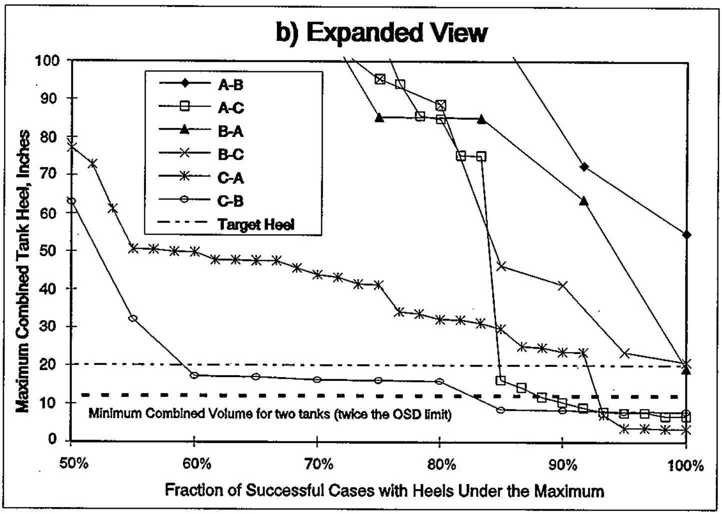
The problem with switching to 241-AP-101 or 241-AP-102 (Envelope C) from the Envelope A tanks listed in Table D-3 is 241-AP-101 and 241-AP-102 have TOC limits very near Envelope C's minimum (the minimum is 0.06 and 241-AP-101 and 241-AP-102 are at 0.061 and 0.062 respectively). Switching from an Envelope A tank that has a relatively low TOC concentration to these tanks will be a concern. A possible solution to this problem is to mix 241-AP-101 and 241-AP-102 with enough Envelope A heel so that the resulting solution meets the Envelope A limits.

Switching from C - A

The tank that causes the greatest problem when switching from Envelope C to Envelop A is 241-AP-104. The reason for this is four-fold: (1) the TOC ratio in 241-AP-104 is relatively high (0.05), (2) the sodium molarity is low (> 3.0), (3) the TOC ratio in the Envelope C tanks are high (0.19 - 0.37), and (4) their sodium molarities are high (9 - 16).

Figure D-2. Heel Mixing Results Using Projected Compositions.





To explain this, equation 1 must first be solved for V_n:

$$V_n = S_o V_o / S_n * (R_i - C_{oi}) / (C_{ni} - R_i) \qquad \text{Eq 7}$$

From equation 7 it can be seen that (assuming the volume of old feed (V_o) is 1) the volume of new feed (V_n) is directly proportional to the old feed's sodium molarity (S_o) and indirectly proportional to the new feed's sodium molarity (S_n). Therefore as the difference between S_o and S_n increases, V_n increases. Also from equation 7 it can be seen that V_n is indirectly proportional to the difference between the new feed's component ratio (C_{ni}) and the required ratio (R_i) and directly proportional to the difference between the old feed's component ratio (C_{oi}) and the required ratio (R_i). Therefore as the old feed's component ratio increases - V_n increases, and as the new feed's component ratio nears R_i - V_n increases.

Switching from C - B

The tank of greatest concern when switching from Envelope C to Envelope B is 241-AP-103. The reason for this is four-fold as defined above: (1) the TOC ratio in 241-AP-103 is relatively high (0.04), (2) the sodium molarity is low (> 3.0), (3) the TOC ratio in the Envelope C tanks are high (0.27 - 0.37), and (4) their sodium molarities are high (9 - 16).

This phenomena was explained in the previous section.

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APPENDIX E

FEED DELIVERY TIMING STUDY

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APPENDIX E

FEED DELIVERY TIMING STUDY

The purpose of this analysis is to determine the impact that different transfer system topographies have upon the timing of the transfer of HLW and LLW feed to the private contractors' plants (HLW) or feed tanks (LLW). This information will be used in conjunction with the hydraulic performance and transfer system upgrade costs (see Section 2.10) to perform a cost-benefit analysis for recommending the transfer system upgrades. A secondary purpose is to identify those parameters that significantly impact the results of the feed delivery performance.

The alternative topographies are compared in terms of median length of outage required for feed staging, median time available for contingencies (such as correcting a bad feed batch), the robustness of the alternatives to changes in assumptions, the fraction of successful feed staging cases, and an estimated feed availability efficiency.

A computer simulation was built that models the staging of feed using each alternative transfer topography based upon the durations of the underlying activities. The durations used by the simulation are not point estimates. They either span a range of values or are calculated from parameters that span a range of values. A Monte-Carlo simulation approach was used to address this aspect (stochastic nature) of feed staging.

E1.0 ALTERNATIVES

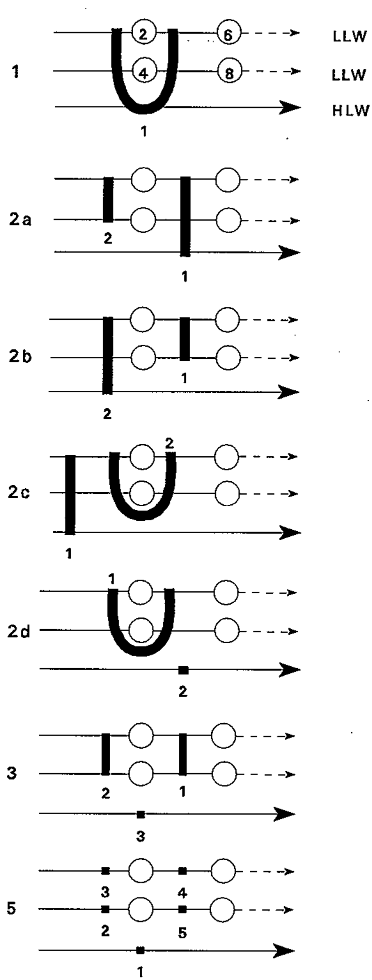
The transfer conflicts resulting from each alternative topography and their mapping to the physical system configurations are shown in Figure E-1. In each alternative, the two left-most circles represent the two intermediate feed staging tanks (241-AP-102 and 241-AP-104). The two right-most circles represent the two private contractor feed tanks (241-AP-106 and 241-AP-108). The lines represent transfer pathways. The two dotted lines are provided by the private contractors and not included in this analysis. The remaining five transfer pathways are within the scope of this analysis. A heavy black stripe that touches one or more transfer pathways indicated that they are on a common node. This means that these transfers conflict with each other -- only one transfer (setup and actual pumping) may occur at a time for a given node.

The alternatives are named after the number of nodes, with a small letter being used to distinguish between the four 2-node alternatives. The small numbers next to each node are used to distinguish between the nodes within a specific alternative.

The 5-node alternative does not correspond to any of the physical systems that were studied (Galbraith et al. 1996). Its purpose is to provide a control in which there are no transfer conflicts. The 5-node alternative represents the best that the system can perform for any given set of assumed parameter distributions. This alternative can also be used to compare the results in feed staging strategy analysis in the *Preliminary Low-Level Waste Feed Staging Plan* (Certa et al. 1996).

Figure E-1. Alternative Transfer System Topographies.

Conflict Diagram



Physical Systems

Alternatives	Option LLW	Option HLW
E	1	2
A	2	2
C	3	2
J	4	2
K	4	3
B	3	3
F	1	3
G	1	4
H	2	3
I	2	4
D	3	4
L	4	4
No physical alternative generated		

E2.0 TECHNICAL ASSUMPTIONS

The following low-level technical assumptions were made in addition to the assumptions and requirements provided in Appendix A. Tables E-1 through E-12 show the random variable distributions used in the Base Case and various Sensitivity cases. The following sections provide a brief description of each case along with the basis for the assumed distributions. See Section E4.0 for detailed calculations and parameter definitions. The performance of all of the alternative topographies are evaluated for each of these cases.

E2.1 BASE CASE

The Base Case was chosen to correspond as closely to that used in the Preliminary Low-Level Waste Feed Staging Plan as possible after accounting for differences in the purposes of the analysis and assumption changes. Therefore, the transfer setup times used in the Base Case assume that the jumper manifold systems are NOT installed.

The parameters for the Base Case are shown in Table E-1.

The maximum for the *Batch Volume* (LLW) corresponds to the maximum assumed operating liquid level of 4.33 ML (416 in.) less the assumed tank heel of 0.10 ML (10 in.). The minimum corresponds to the volume of 100 MT Na (the minimum batch size) at 14 *M* [Na] (the maximum [Na]). The median corresponds to a typical batch size of about 3.0 ML.

The minimum *Batch Volume* (HLW) corresponds to the minimum permitted batch size, maximum *Feed Density as Transferred*, and *Ratio of g NVOL to g NVO in Delivered Feed* (Manuel 1996). The maximum corresponds to an estimate of the largest receiver tank a private contractor is likely to construct (Manuel 1996). The arithmetic mean was used for the median.

The *Intermediate Staging Transfer Setup Time* (LLW only) is based on current operating experience (Foster 1996) and is consistent with the assumption of NO jumper manifold systems. The distribution was changed from a two-segment uniform distributions (see Section E4.0) to a two-segment log-uniform distribution to better match expected pump failure rates for the sensitivity cases; for the Base Case, the two-segment uniform, and log-uniform distributions are similar.

The distribution for the *Intermediate Staging Transfer Pump Rate* (LLW only) is based on transfer system performance (Galbraith et al. 1996). The maximum corresponds to the maximum transfer rate expected from AN-Farm to AP-Farm using 3-in. line and the prototype pump (140 gal/min @ 450 ft of head). The minimum corresponds to the case where there are multiple line sizes (a combination of 2-in. and 3-in. pipe). The arithmetic mean was used for the median.

Table E-1. Random Variable Distribution for Base Case.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.133	0.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	14.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	14.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C_d*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.1 for more information.

Table E-2. Random Variable Distribution for Sensitivity Case 1.
Distribution Check: Medians at most favorable of minimum or maximum values.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.400	0.400	0.31	4.23	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	1.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.76	0.76
T^i_{mix}	days	In-tank mixing				0.0	0.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	1.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	14.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	1.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	1.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.76	0.76	0.49	0.76	0.76
R^i_P	See note	Processing Rate, *(POE)C$_d$*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	100.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.8	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.2 for more information.

Table E-3. Random Variable Distribution for Sensitivity Case 2.
Distribution Check: Medians at least favorable of minimum or maximum values.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.063	0.400	0.31	0.31	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	60.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.49	0.76
T^i_{mix}	days	In-tank mixing				0.0	14.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	5.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	5.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	30.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	60.0	60.0	1.0	50.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.63	0.76	0.49	0.49	0.76
R^i_P	See note	Processing Rate, *(POE)C_d*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	25.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.4	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	3.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.2 for more information.

Table E-4. Random Variable Distribution for Sensitivity Case 3. All inter-farm transfers use valving manifolds.

Para-meter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.133	0.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	2.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	2.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C*$_d$. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.3 for more information.

Table E-5. Random Variable Distribution for Sensitivity Case 4. Maximum Lab Time is doubled.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	.133	.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	14.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	120.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	14.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C_d*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.4 for more information.

Table E-6. Random Variable Distribution for Sensitivity Case 5.
Retrieval Problems decrease average intermediate staging transfer pump rate by factor of 2.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	.133	.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	14.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.25	0.32	0.38
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	14.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, $(POE)C_d$. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.5 for more information.

Table E-7. Random Variable Distribution for Sensitivity Case 6.
Bounding case, jumper manifolds, and no transfer equipment failures.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	.133	.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	2.0	2.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	2.0	2.0	1.0	1.0	1.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C_d*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.6 for more information.

Table E-8. Random Variable Distribution for Sensitivity Case 7. Correlated Low-Level Waste Feed, otherwise same as Base Case.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.133	0.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	14.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	14.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C$_d$*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. Parameters with heavy borders are fully correlated for i=B and C. See Section E2.7 for more information.

The time required for *In-Tank Mixing* (LLW only) was provided by the Characterization Program (Kruger 1996). The maximum also corresponds to that assumed by the Grout Sampling Plan (Hendrickson 1993).

The distribution for the *Time Needed to Sample and Deliver to the Laboratory* (LLW only) was provided by Operations (Foster 1996).

The distribution for the *Time Needed to Analyze and Report on the Samples* (LLW only) was provided by the Characterization Program based on past experience (Kruger 1996).

This distribution for the *Time Needed to Interpret and Evaluate Sample Results* (LLW only) was provided by the Characterization Program based on past experience (Kruger 1996).

The maximum for the *Time Needed to Settle out Excessive Entrained Solids* (LLW only) is consistent with the settling time used in the TWRS Process Flowsheet (Orme 1995). The minimum and median were set so that half of the batches do not require settling.

The distribution for the *Final Transfer Setup Time* (LLW) was based on operating experience for intra-AP transfers (Foster 1996). This distribution for HLW is the same as the *Intermediate Staging Transfer Setup Time* for LLW. Two segment log-uniform distributions were used.

The distribution for the *Final Transfer Pump Rate* (LLW) is the same as the *Intermediate Staging Transfer Pump Rate*. For HLW, the maximum is the same as the LLW. The minimum for HLW was chosen to correspond to the flowrate where the Re_d becomes marginal (approx 18,000) (Galbraith et al. 1996). The arithmetic mean was used for the median.

The *Processing Rate* (LLW and HLW) are both set to their respective (POE)C_d. These parameters were held constant at point values provided by assumption A5.8 (Appendix A).

The distributions for the *Feed Density as Transferred* (HLW only) is based on the Envelope D limits in the RFP (DOE-RL 1996a). The arithmetic mean was used for the median.

The distributions for the *Ratio of g NVOL to g NVO in Delivered Feed* (HLW only) is based upon the estimated compositions of pretreated HLW feed (Manuel 1996).

The minimum *Sodium Concentration in the Delivered Feed* (LAW only) corresponds to the minimum [Na] permitted by the RFP. The median and maximum values correspond to the proxy limit used to ensure that the waste can be retrieved and transferred (assumption A7.13, Appendix A).

The distributions for the *Minimum Mass of [Each] Feed Batch* (LAW and HLW) are set to their respective point values provided by assumption A4.8 (Appendix A).

E2.2 SENSITIVITY CASES 1 AND 2

The purpose of these two sensitivity cases is to analyze the effect of the shape of the random variable distributions. The method used is to set the median values of each random variable to either the minimum or maximum value. In Sensitivity Case 1, the most favorable of the minimum or maximum are used. Sensitivity Case 2 uses the least favorable of the minimum or maximum.

The parameters for Sensitivity Cases 1 and 2 are shown in Tables E-2 and E-3. Differences from the Base Case are shaded.

E2.3 SENSITIVITY CASE 3

This case updates the Base Case so that all inter-farm transfers use valving manifolds for transfer setup. This is consistent with the current plans of Projects W-314 and W-454. The median values of both the *Intermediate Staging Transfer Setup Time* (LLW only) and the *Final Transfer Pump Rate* (HLW) was reduced so that half of the time, the transfers can be setup in 1 or 2 days. The maximum were left the same to account for the problems such as replacement of failed pumps.

Extreme service pumps can be expected to fail to start about 0.001 per demand and fail to run (given start) about 0.001 per hour (Oswald et al. 1982). This is reasonable considering that the maximum observed lifetime for our pumps is about 2,000 hours. For a nominal 5 day transfer, the pump will fail to run about 0.12 times per transfer. The upper end of the two-segment log-uniform distribution is consistent with 0.12 failures per transfer if the mean time to repair a failed pump is on the order of 30 days.

The parameters for Sensitivity Case 3 is shown in Table E-4. Differences from the Base Case are shaded.

E2.4 SENSITIVITY CASE 4

This case tests sensitivity to typical changes that increase the amount of time needed to prepare the staged feed for delivery. The maximum *Time Needed to Analyze and Report on the Samples* (LLW only) was doubled for Sensitivity Case 4.

The parameters for Sensitivity Case 4 is shown in Table E-5. Differences from the Base Case are shaded.

E2.5 SENSITIVITY CASE 5

This case tests sensitivity to typical changes that increase the amount of time needed to retrieve the waste. The *Intermediate Staging Transfer Pump Rate* (LLW only) was uniformly decreased in half.

The parameters for Sensitivity Case 5 is shown in Table E-6. Differences from the Base Case are shaded.

E2.6 SENSITIVITY CASE 6

This case was a bounding case in which all inter-farm transfers use valving manifolds and in which there are NO transfer equipment failures. This is similar to Sensitivity Case 3, except the maximum values for the *Intermediate Staging Transfer Setup Time* (LLW only) and the *Final Transfer Setup Time* (LLW and HLW) were reduced to the medians to remove the time allocated for correcting failures.

The parameters for Sensitivity Case 6 is shown in Table E-7. Differences from the Base Case are shaded.

E2.7 SENSITIVITY CASE 7

This case tests the sensitivity to correlated LLW feed batches. All parameters are the same as the Base Case, however the Batch Volume (LLW only) and the *Sodium Concentration in Delivered Feed* (LLW only) are the same for each LAW private contractor. That is, the nth batch of feed delivered to each contractor are the same size and composition. This reflects the desire to provide similar feed batches to each contractor (assumption A5.6, Appendix A).

The parameters for Sensitivity Case 7 is shown in Table E-8. Differences from the Base Case are shaded.

E2.8 SENSITIVITY CASES 8-17

The purpose of these cases is to establish the amount of time in which feed transfers must be setup in order for the system to perform well and to provide a basis for how quickly failed equipment must be replaced/repaired. The maximum setup time for the *Intermediate Staging Transfer Setup Time* (LLW only) and the *Final Transfer Setup Time* (LLW and HLW) in Sensitivity Case 3 (inter-farm valving manifolds) is replaced with a parameter. The parameter is allowed to take on a series of values.

These sensitivity cases were only run for the recommended transfer system alternative (Alternative K, 2b-node).

The parameters for Sensitivity Cases 8 through 17 are shown in Table E-9. Differences from the Base Case are shaded.

Table E-9. Random Variable Distribution for Sensitivity Case 8 through 17. Maximum Transfer setup time parameter sweep. X=60, 45, 30, 25, 20, 15, 10, 7, 5, and 2. Includes jumper manifolds.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.133	0.400	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	2.0	X
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	2.0	X	1.0	1.0	X
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C*$_d$. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.8 for more information.

E2.9 RECOMMENDED CASE

The Recommended Case updates Sensitivity Case 3 to estimate system performance if all recommendations are followed.

The minimum *Batch Volume* (LLW only) is recalculated at a 7 *M* [Na] in the feed. This is consistent with the proxy limit used to ensure that the waste can be retrieved and transferred (assumption A7.13, Appendix A).

The maximum setup times for the *Intermediate Staging Transfer Setup Time* (LLW only) and the *Final Transfer Setup Time* (LLW and HLW) are set to 25 days as is recommended by Section E3.0.

The transfer pump rates are tightened up to correspond to the recommended transfer system alternative (Alternative K). Specifically, the *Final Transfer Pump Rate* (LAW and HLW) are set to 0.76 ML/day. The *Intermediate Staging Transfer Pump Rate* is set to range between 0.70 ML/day to 0.76 ML/day.

This sensitivity case was only run for the recommended transfer system alternative (Alternative K, 2b-node).

The parameters for the Recommended Case are shown in Table E-10. Differences from the Base Case are shaded.

E2.10 SENSITIVITY CASES 18 THROUGH 35

The purpose of these cases is to examine the performance of the system as a function of *Batch Volume* (HLW only). The minimum, median, and maximum values were replaced by 0.9X, X, and 1.1X respectively. The parameter X was allowed to take in a series of values from 0.063 ML to 0.400 ML. This parameter sweep was applied to both the Base Case and the Recommended Case. The parameters for these cases are shown in Tables E-11 and E-12.

These sensitivity cases were only run for the recommended transfer system alternative (Alternative K, 2b-node).

Table E-10. Random Variable Distribution for Recommended Case.
Maximum Transfer setup time = 25. Transfer pump rates correspond to Alternative K. Includes jumper manifolds.
Minimum feed batch volume adjusted for 7 M [Na] feed.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.063	0.133	0.400	0.54	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	2.0	25
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.70	0.73	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	2.0	25	1.0	1.0	25
R^i_{FX}	ML/day	Final transfer pump rate.	0.76	0.76	0.76	0.76	0.76	0.76
R^i_P	See note	Processing Rate, *(POE)C*$_d$. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.9 for more information.

Table E-11. Random Variable Distribution for Sensitivity Cases 18 through 26.
High-Level Waste Batch Volume parameter sweep. X = 0.063, 0.075, 0.1, 0.16, 0.2, 0.25, 0.3, 0.35, and 0.4.
Sweep performed around Base Case

Parameter	Units	Notes	HLW - i=A			LLW i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.9X	1.0X	1.1X	0.31	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	14.0	60.0
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.49	0.63	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	14.0	60.0	1.0	1.0	50.0
R^i_{FX}	ML/day	Final transfer pump rate.	0.63	0.70	0.76	0.49	0.63	0.76
R^i_P	See note	Processing Rate, *(POE)C$_d$*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Shaded cells don't apply. Values changed from Base Case are shaded. See Section E2.10 for more information.

Table E-12. Random Variable Distribution for Sensitivity Cases 27 through 35. High-Level Waste Batch Volume parameter sweep. X = 0.063, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, and 0.4. Sweep is performed around the Recommended Case.

Parameter	Units	Notes	HLW - i=A			LLW - i=B,C		
			Minimum	Median	Maximum	Minimum	Median	Maximum
V^i_{batch}	ML	Batch Volume.	0.9X	1.0X	1.1X	0.54	3.0	4.23
T^i_{IS}	days	Intermediate staging transfer setup time.				1.0	2.0	25
R^i_{IS}	ML/day	Intermediate staging transfer pump rate.				0.70	0.73	0.76
T^i_{mix}	days	In-tank mixing				0.0	7.0	14.0
T^i_{sample}	days	Time needed to sample and deliver to laboratory.				1.0	2.0	5.0
T^i_{lab}	days	Time needed to analyze and report on the samples.				14.0	60.0	60.0
T^i_{eval}	days	Time needed to interpret and evaluate sample results.				1.0	3.0	5.0
T^i_{settle}	days	Time needed to settle out excessive entrained solids.				0.0	0.0	30.0
T^i_{FS}	days	Final transfer setup time.	1.0	2.0	25	1.0	1.0	25
R^i_{FX}	ML/day	Final transfer pump rate.	0.76	0.76	0.76	0.76	0.76	0.76
R^i_P	See note	Processing Rate, *(POE)C_d*. HLW: MT NVOL/day; LLW: MT Na/day	0.21	0.21	0.21	2.0	2.0	2.0
ρ	g NVO/l	Feed density as transferred.	25.0	63.0	100.0			
α	g NVOL / g NVO	Ratio of g NVOL to g NVO in delivered feed.	0.4	0.6	0.8			
c^i	mol Na/l	Sodium concentration in delivered feed.				3.0	7.0	7.0
M^i_{min}	See note	Minimum mass of feed batch. HLW: MT NVOL; LLW: MT Na	5.0	5.0	5.0	100.0	100.0	100.0

All distributions except for T^i_{IS} and T^i_{FS} are two-segment uniform distributions. Distributions for T^i_{IS} and T^i_{FS} are two-segment log-uniform distributions. Cross-hatched cells don't apply. Values changed from Base Case are shaded. See Section E2.10 for more information.

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E3.0 RESULTS

Summary results for all of the cases are shown in Table E-13. The reported outage times and contingency times are the *medians* (in days) observed in the Monte-Carlo simulation. The success rates are the fraction of successful simulation cases (those in which approved feed is delivered within the 30-day feed delivery window). The feed availability efficiency is estimated by the fraction of the total time that approved feed is present in the private contractors feed tank.

The median outage time and contingency times do not discriminate between the alternative topographies or transfer system upgrade alternatives. The large variation seen in these measures between alternative feed staging strategies (Certa et al. 1996) are not seen when comparing transfer system topographies for the *Indirect Staging - As Soon As Possible* feed staging strategy.

The success rate is the discriminating measure between the alternative transfer system topographies. The success rate for different alternatives typically spans about 15 percentage points for any given case.

The feed availability efficiency is highly correlated with the success rate (correlation coefficient of >0.97), is not an independent measure, and therefore not used as a discriminator.

In general, the relative performance of the alternatives is the same (or nearly so) for all sensitivity cases. The fewer transfer conflicts, the better the performance. Transfer conflicts with the final feed staging transfers are more critical than those with the intermediate feed staging transfers. Table E-14 ranks each of the alternative topographies (as measured by the RMS success rate) according to decreasing performance. For any give case, alternatives that performed the same are shown in the same box. Only the order of alternatives can be compared between columns.

In general, the robustness of the alternatives to changes in assumptions follows their performance (the better performing alternatives perform better under all conditions).

Sensitivity Case 6 was a bounding case in which all inter-farm transfers use valving manifolds and in which there are NO transfer equipment failures. All cases were successful nearly 100 percent of the time. The absolute values of the results are dependent upon the distributions used for the *Intermediate Staging Transfer Setup Time* (LLW only) and the *Final Transfer Setup Time* (LLW and HLW). This also suggests that the overall performance of the system can be improved by taking action to keep the transfer setup times as small as is reasonable.

Comparison of Sensitivity Case 7 with Sensitivity Case 1 shows that correlation of the feed batches does not degrade system performance.

Table E-13. Feed Delivery Timing Study Summary Results. (2 Sheets)

		Outage Time		Contingency Time	Success Rate			FAE	
Case	Alternative	LAW	HLW	LAW	LAW	HLW	RMS	LAW	HLW
BASE	1	14	16	105	72%	71%	71%	90%	69%
	2A	11	11	110	77%	79%	78%	91%	74%
	2B	8	15	105	84%	72%	81%	93%	70%
	2C	9	14	105	81%	72%	78%	92%	70%
	2D	9	9	109	81%	81%	81%	92%	75%
	3	8	9	110	85%	80%	84%	93%	75%
	5	8	9	111	87%	80%	85%	93%	75%
SENSITIVITY 1	1	8	3	197	84%	86%	85%	94%	89%
	2A	8	2	199	87%	87%	87%	94%	90%
	2B	8	2	197	89%	88%	88%	95%	90%
	2C	8	2	196	88%	87%	88%	95%	90%
	2D	8	2	197	87%	89%	88%	95%	91%
	3	8	2	200	89%	89%	89%	95%	91%
	5	7	2	201	90%	89%	90%	95%	91%
SENSITIVITY 2	1	110	73	0	5%	16%	10%	52%	37%
	2A	69	59	1	15%	33%	23%	63%	48%
	2B	58	60	0	18%	28%	22%	64%	44%
	2C	78	60	0	13%	25%	18%	59%	42%
	2D	65	36	0	15%	48%	30%	62%	56%
	3	56	37	1	22%	47%	33%	67%	56%
	5	54	36	6	27%	48%	35%	70%	56%
SENSITIVITY 3	1	9	3	116	81%	86%	82%	92%	81%
	2A	9	2	118	83%	90%	85%	93%	84%
	2B	8	2	117	87%	89%	87%	93%	83%
	2C	8	2	116	85%	89%	86%	93%	83%
	2D	8	2	119	85%	91%	87%	93%	86%
	3	8	2	119	87%	91%	88%	93%	86%
	5	8	2	120	88%	91%	89%	94%	86%
SENSITIVITY 4	1	17	17	90	67%	70%	68%	88%	69%
	2A	11	11	91	75%	78%	76%	90%	74%
	2B	8	15	90	79%	73%	77%	91%	71%
	2C	10	15	89	75%	72%	74%	90%	70%
	2D	9	9	91	77%	81%	78%	91%	75%
	3	8	9	92	80%	80%	80%	91%	75%
	5	8	9	94	82%	81%	81%	92%	75%
SENSITIVITY 5	1	15	18	102	69%	68%	68%	89%	67%
	2A	11	10	104	77%	79%	77%	91%	74%
	2B	8	16	101	83%	70%	79%	92%	69%
	2C	9	16	102	78%	71%	76%	91%	69%
	2D	9	9	105	80%	80%	80%	92%	75%
	3	8	9	105	84%	81%	83%	93%	75%
	5	8	9	107	86%	80%	84%	93%	75%
SENSITIVITY 6	1	6	2	129	98%	100%	99%	97%	95%
	2A	6	2	129	98%	100%	99%	97%	96%
	2B	6	2	129	98%	100%	99%	97%	96%
	2C	6	2	129	98%	100%	99%	97%	96%
	2D	6	2	129	98%	100%	99%	97%	96%
	3	6	2	129	98%	100%	99%	97%	96%
	5	6	2	129	98%	100%	99%	97%	96%
SENSITIVITY 7	1	13	17	101	74%	70%	72%	90%	69%
	2A	10	11	106	78%	79%	78%	91%	74%
	2B	8	15	102	85%	71%	81%	93%	70%
	2C	9	15	101	81%	73%	78%	92%	70%
	2D	8	9	105	83%	80%	82%	92%	75%
	3	8	9	106	86%	80%	84%	93%	75%
	5	7	9	107	87%	80%	85%	94%	75%

Table E-13. Feed Delivery Timing Study Summary Results. (2 Sheets)

		Outage Time		Contingency Time	Success Rate			FAE	
Case	Alternative	LAW	HLW	LAW	LAW	HLW	RMS	LAW	HLW
SENSITIVITY 8	2B	8	2	118	85%	88%	86%	93%	83%
SENSITIVITY 9	2B	8	2	120	88%	92%	89%	94%	85%
SENSITIVITY 10	2B	8	2	123	93%	99%	95%	95%	89%
SENSITIVITY 11	2B	7	2	123	96%	100%	97%	95%	90%
SENSITIVITY 12	2B	7	2	124	97%	100%	98%	95%	91%
SENSITIVITY 13	2B	7	2	127	98%	100%	98%	96%	92%
SENSITIVITY 14	2B	7	2	128	98%	100%	99%	96%	93%
SENSITIVITY 15	2B	7	2	128	98%	100%	99%	96%	94%
SENSITIVITY 16	2B	7	2	128	98%	100%	99%	96%	95%
SENSITIVITY 17	2B	6	2	129	98%	100%	99%	97%	96%
RECOMMENDED	2B	6	2	122	97%	100%	98%	95%	90%
SENSITIVITY 18	2B	8	22	100	83%	58%	76%	92%	47%
SENSITIVITY 19	2B	8	16	105	84%	75%	81%	92%	57%
SENSITIVITY 20	2B	8	15	105	84%	73%	81%	92%	58%
SENSITIVITY 21	2B	8	16	101	84%	73%	80%	92%	62%
SENSITIVITY 22	2B	8	16	104	84%	71%	80%	93%	65%
SENSITIVITY 23	2B	8	19	104	85%	68%	79%	93%	67%
SENSITIVITY 24	2B	8	19	105	84%	67%	79%	92%	70%
SENSITIVITY 25	2B	8	18	105	84%	68%	79%	93%	73%
SENSITIVITY 26	2B	8	19	105	83%	67%	78%	92%	75%
SENSITIVITY 27	2B	6	4	120	97%	100%	98%	95%	78%
SENSITIVITY 28	2B	6	2	122	97%	100%	98%	95%	84%
SENSITIVITY 29	2B	6	2	120	97%	100%	98%	95%	84%
SENSITIVITY 30	2B	6	2	120	97%	100%	98%	95%	86%
SENSITIVITY 31	2B	6	3	122	97%	99%	98%	95%	87%
SENSITIVITY 32	2B	6	3	122	97%	100%	98%	95%	89%
SENSITIVITY 33	2B	6	3	122	97%	100%	98%	95%	90%
SENSITIVITY 34	2B	6	3	121	96%	100%	97%	95%	91%
SENSITIVITY 35	2B	6	3	122	97%	100%	98%	95%	92%

Table E-14. Alternative Topographies Ranked According to Decreasing Performance.[a,b]

Base	Sen 1	Sen 2	Sen 3	Sen 4	Sen 5	Sen 6	Sen 7
5	5	5	5	5	5	5	5
3	3	3	3	3	3	3	3
2B	2B	2D	2B	2D	2D	2D	2D
2D	2D	2A	2D	2B	2B	2B	2B
2C	2C	2B	2C	2C	2A	2C	2A
2A	2A	2C	2A	2A	2C	2A	2C
1	1	1	1	1	1	1	1

[a]In this table, performance is measured by Root Mean Square success rate.
[b]For any column, these alternatives in the same cell have nearly identical performance.

The Base Case and Sensitivity Cases 1 through 7 were used for the cost-benefit analysis of the transfer system upgrades. The benefit was the root-mean-square (RMS) success rate with the LAW results weighted twice that of the HLW results. This weighing accounts for the assumption that there will be two LAW plants and one HLW plant operating during Phase 1 (assumption A7.5, Appendix A). The cost data were obtained from Galbraith et al. (1996) and corresponds to the incremental cost needed to upgrade the transfer systems after subtracting the cost of upgrades allocated to Project W-314.

Figures E-2 through E-8 show the cost-benefit plots for Base Case and Sensitivity Cases 1 through 7. Alternatives with marginal hydraulics ($Re_d < 20{,}000$) may be acceptable if the waste pumpability criteria can be relaxed (Galbraith et al. 1996). Sensitivity Case 3 more closely represents the expected transfer system behavior since it assumes that the valving manifolds to be provided by Projects W-314 and W-454 are available.

In the Base Case and Sensitivity Cases 1, 3, 4, 5, and 7 Alternatives [F, H], [B, K], [I], and [L and D] dominate the others (they are the cheapest for any given level of performance) and kept the same rankings with respect to both cost and benefit. The cost-benefit trade-offs will be made between these alternatives in Section 2.10.2 of this report.

In Sensitivity Case 2, the behavior is similar - Alternatives [F, H], [B, K], [J, C], [I], and [L andD] dominate the others. The rankings remain the same. The only difference is that Alternatives J and C are no longer dominated by the others.

The consistent list and ranking of alternatives between the various cases suggests that the transfer system upgrades decision will be robust with respect to changing assumptions of the type that were modeled.

Figure E-2. Transfer System Cost-Benefit for Base Case.

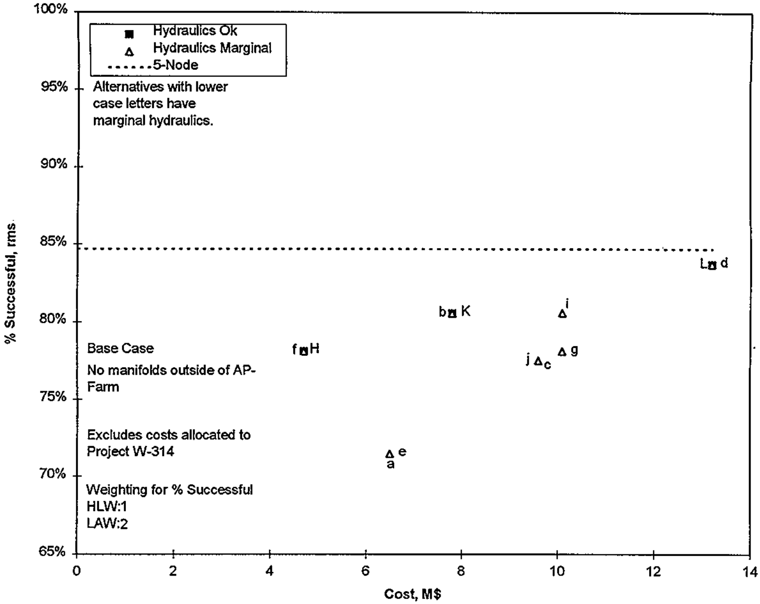


Figure E-3. Transfer System Cost-Benefit for Sensitivity Case 1.

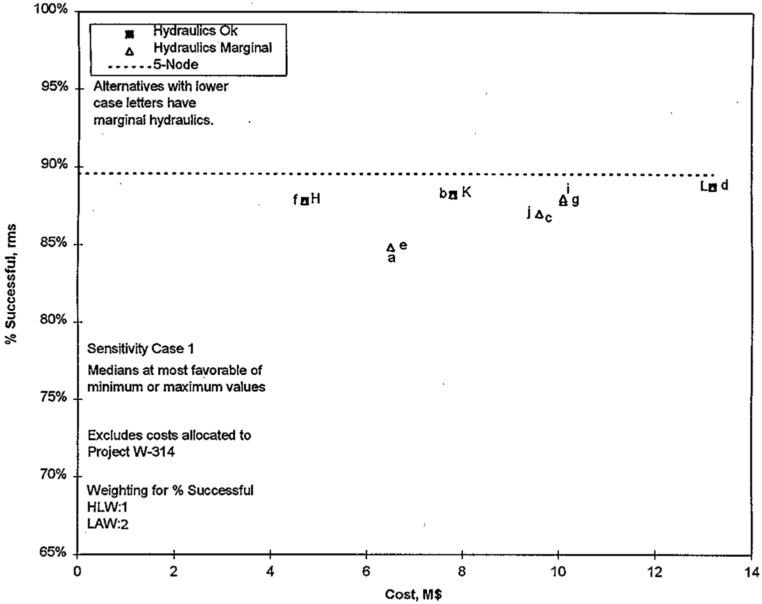


Figure E-4. Transfer System Cost-Benefit for Sensitivity Case 2.

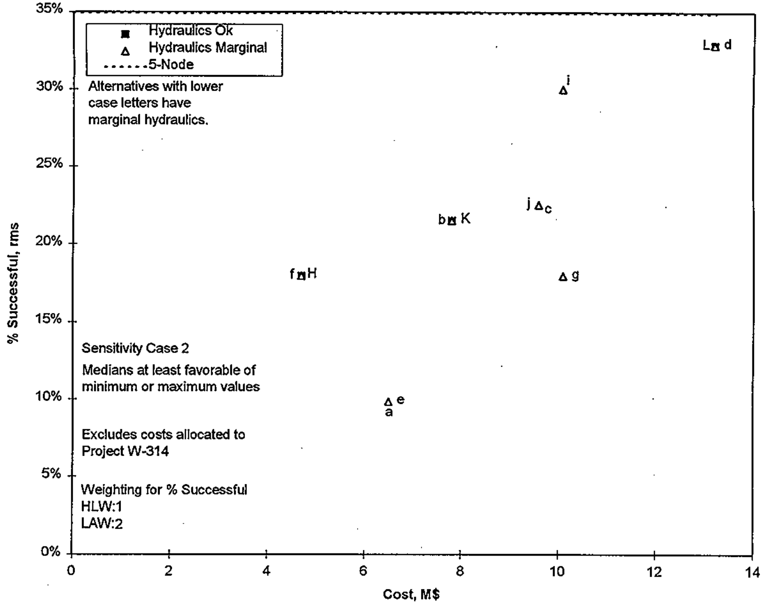


Figure E-5. Transfer System Cost-Benefit for Sensitivity Case 3.

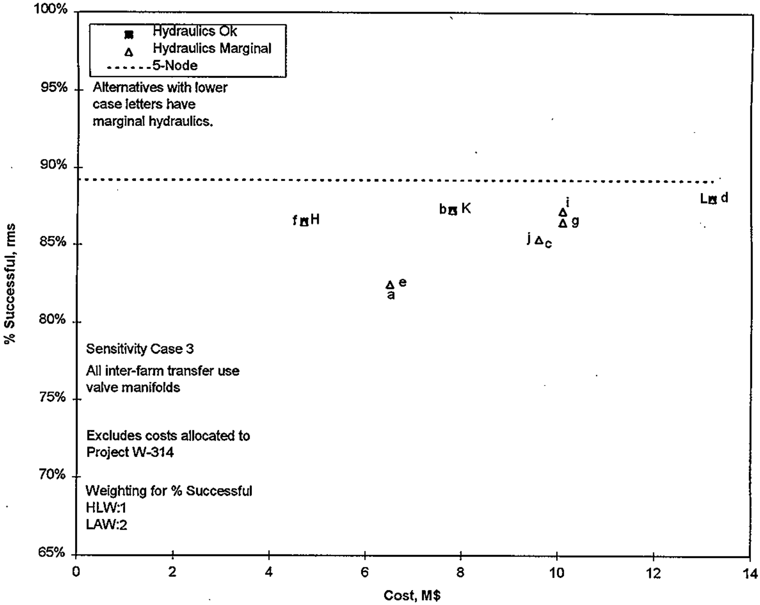


Figure E-6. Transfer System Cost-Benefit for Sensitivity Case 4.

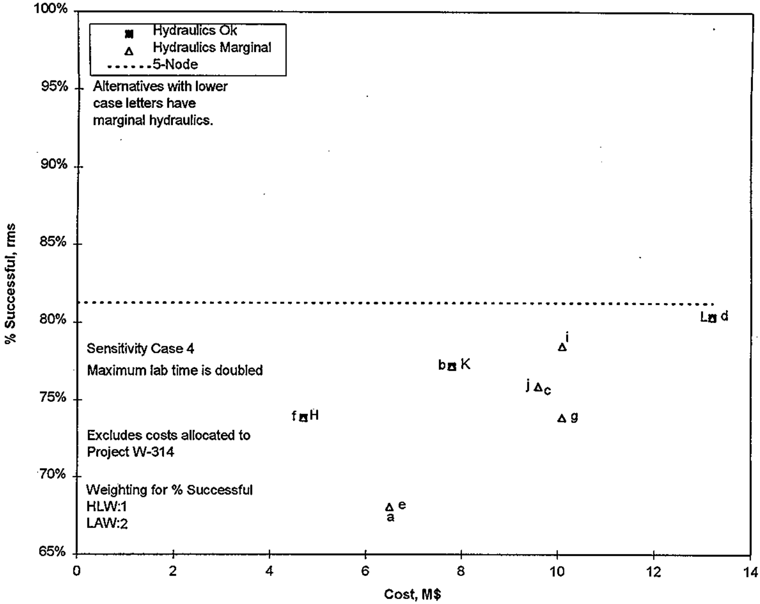


Figure E-7. Transfer System Cost-Benefit for Sensitivity Case 5.

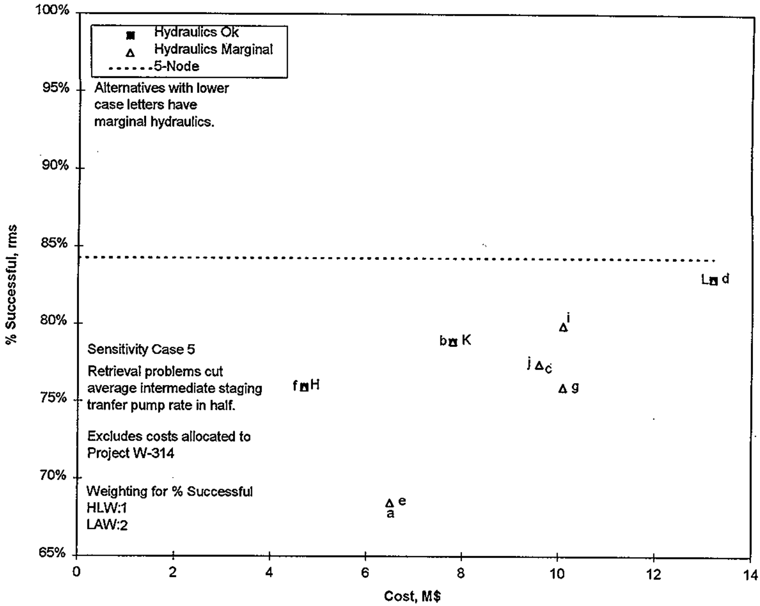


Figure E-8. Transfer System Cost-Benefit for Sensitivity Case 6.

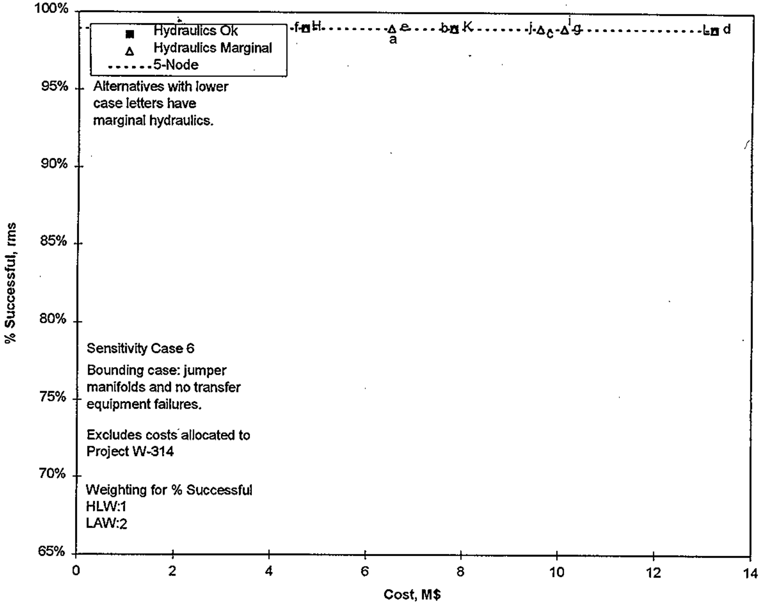
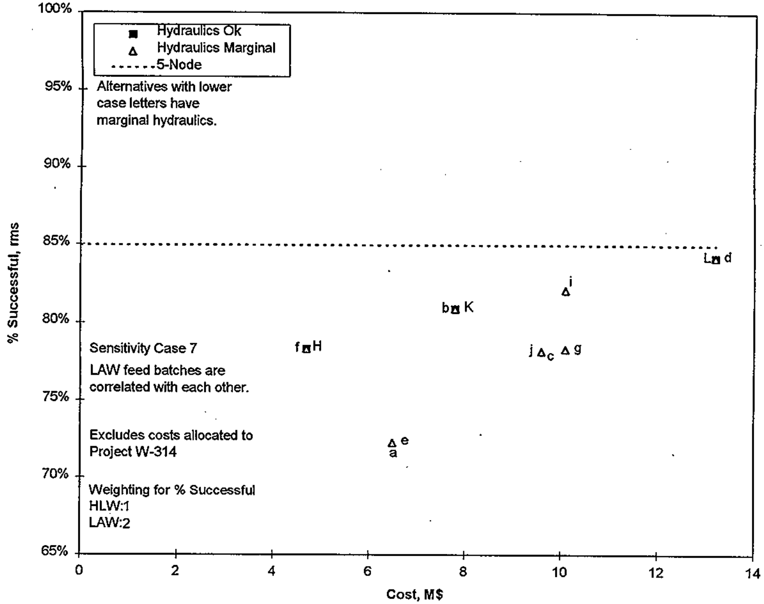
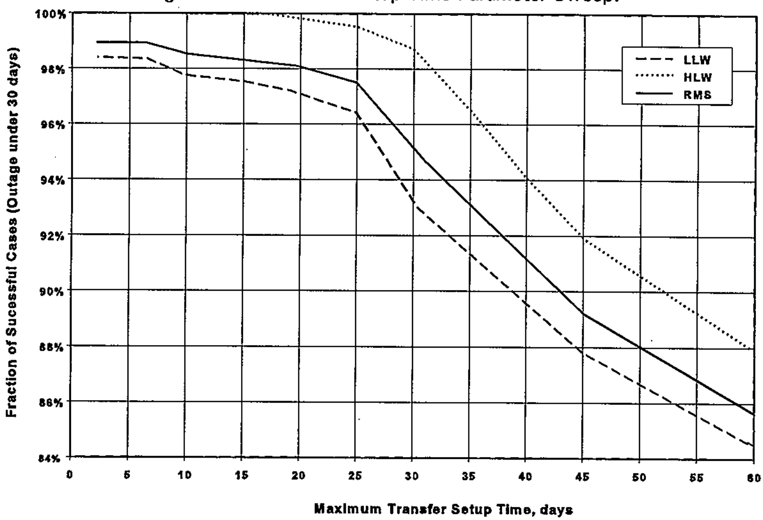


Figure E-9. Transfer System Cost-Benefit for Sensitivity Case 7.



A parametric study (Sensitivity Cases 8 through 17) examined the dependence of system performance on the maximum transfer setup times. The maximum transfer setup times for all transfers were varied from 60 days to 2 days and the results for the 2b-node (that corresponds to the recommended transfer system Alternative K) were plotted in Figure E-10. For the assumed distributions, most of the potential improvement is obtained with a reduction in the maximum transfer setup time from 60 to 25 days. Operations should investigate and implement a means to maintain transfer setup time as low as is reasonable. This will require, at the least, insuring that a failed pump or jumper can be repaired or replaced under typical (often windy) weather conditions within 25 days.

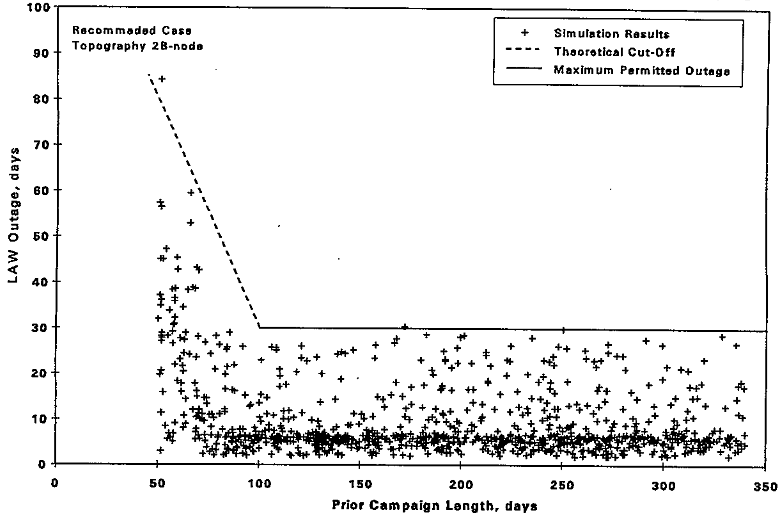
Figure E-10. Transfer Setup Time Parameter Sweep.



The Recommended Case assumes that the recommended transfer system alternative, Alternative K, is implemented along with the actions needed to reduce the maximum transfer setup times to 25 days.

Figure E-11 shows the relationship between the length of the LAW outage and the time required to process the previous feed batch (that is directly proportional to the amount of Na in that feed batch) for the Recommended Case. The outage begins to increase beyond the "noise" from all of the other variables when the length of the previous campaign is smaller than about 100 days, that corresponds to a feed batch of 200 MT Na. The slope of this line is theoretically -1; for each day the run length is reduced, the outage increases a day.

Figure E-11. Low-Activity Waste Outage Duration versus Length of Prior Campaign.



The observed distributions of the length of the outage and contingency for the Recommended Case are shown in Figures E-12 and E-13.

Table E-15 shows the idle time for each node and alternative for the Base Case. The larger the idle time, the more time this node is available to support non-modeled activities. Note that Alternatives 1, 2C, and 2D each have a node with a median idle time of 0 to 3 days. This implies that a lot of transfers through these nodes are occurring back-to-back, that is, the nodes are heavily utilized.

Figure E-12. Outage Distributions for the Recommended Case.

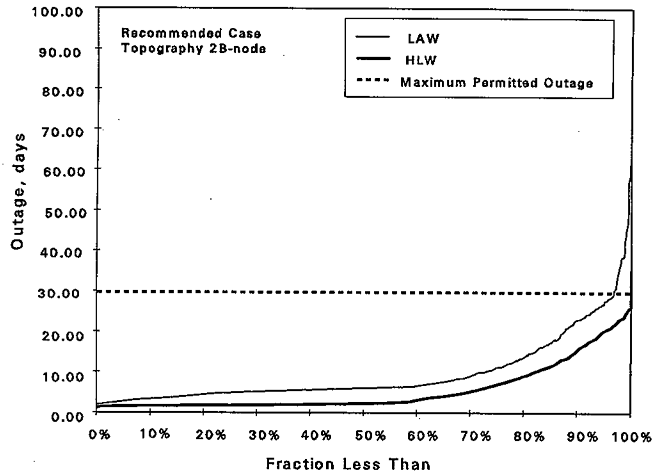


Figure E-13. Contingency Distributions for Recommended Case.

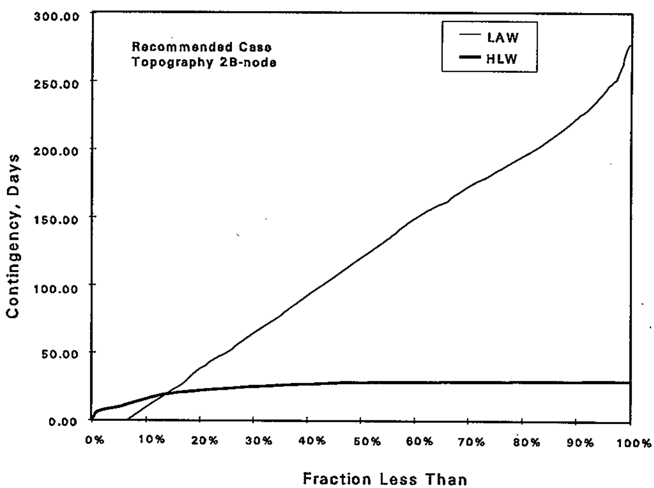


Table E-15. Base Case Node Usage.

Base Case Alternative topography	Node	Idle time (%)	Median idle time (days)	Median pump time (days)
1	1	46.1	0	9
2A	1	65.3	26	8
	2	78.5	75	18
2B	1	89.3	86	7
	2	54.9	21	13
2C	1	55.2	21	13
	2	67.8	3	10
2D	1	67.7	0	10
	2	75.3	42	9
3	1	89.3	84	7
	2	78.1	73	18
	3	75.3	42	9
5	1	75.2	42	9
	2	89.0	187	18
	3	88.9	182	18
	4	94.6	195	7
	5	94.6	198	7

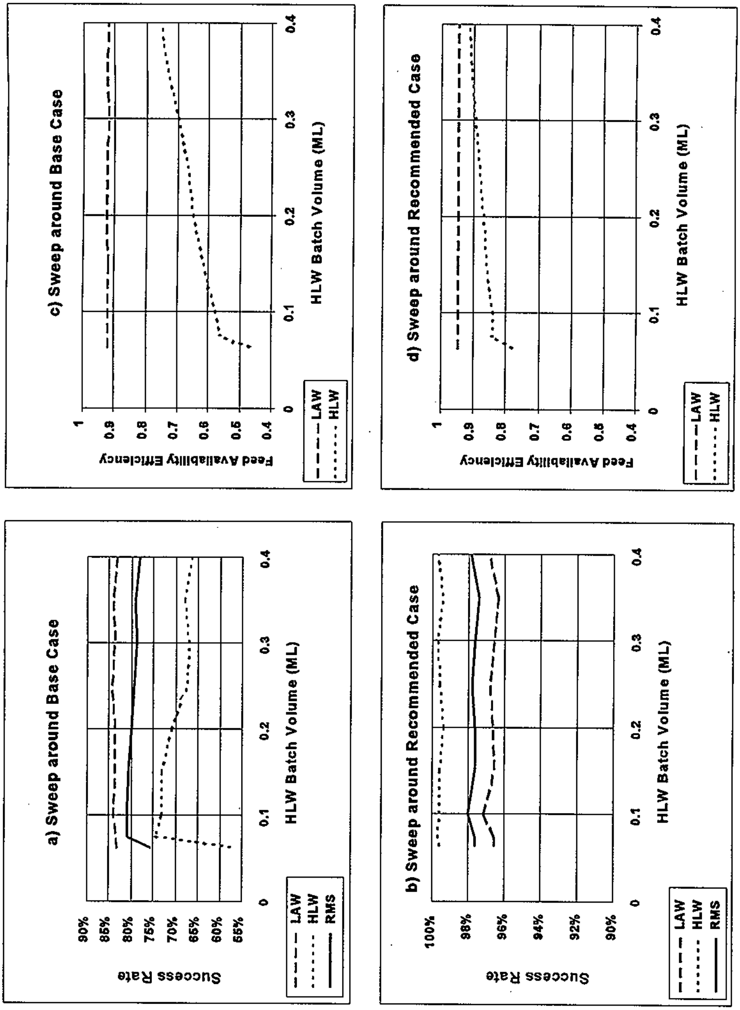
A parametric study (Sensitivity Cases 18 through 35, Tables E-11 and E-12) examined the dependence of system performance on the HLW Batch Volume. The median batch volume was varied from 0.063 ML to 0.4 ML; the minimum and maximum values were maintained at ± 10 percent of the median. The minimum mass in each feed batch was maintained at or above the 5 MT minimum required by the RFP. The parameter sweep was performed around both Base Case and Recommended Case assumptions. It is important to understand that this parametric study tests the ability of the transfer system to deliver feeds on time. It is not meant to establish the volume of the HLW batches delivered to the private contractor or confirm the availability of sufficient HLW feed.

Figure E-14 shows how the fraction of successful cases (for which the feed waste delivered in under 30 days) and how the feed availability vary with the HLW batch volume. In general, as the HLW batch volume is decreased the mass of the HLW feed batch is decreased. Less time is required for the private contractors to work off the feed resulting in less time between HLW feed transfers. The HLW feed availability efficiency (FAE) decreases since the transfer setup time is independent of the batch size. This behavior is seen in Figures E-14c and d. The decrease in FAE for the Recommended Case is less than that seen in the Base Case since the transfer setup times are significantly smaller for the Recommended Case.

Figure E-14a, c, and d show a sharp drop in feed delivery performance below a HLW batch volume of 0.075 ML. Additional analysis is needed to identified the reason for this drop. It is suspected that this is the result that at the minimum batch volume, the parameters α and ρ must both be at their maximum values. It is recommended that a new sweep be performed using the mass of the HLW feed batch (proportional to the time needed to process a HLW batch) as the parameter. Since the HLW processing time is explicitly included in the FAE calculation, the system performance should be very sensitive to this parameter.

All that can be concluded from this is that the feed delivery system should perform reasonably for any HLW batch volume between 0.063 ML and 0.4 ML provided the minimum mass in each HLW is greater than or equal to 5 MT NVOL.

Figure E-14. High-Level Waste Batch Volume Parameter Sweep.



E4.0 CALCULATIONS

The following sections describe the calculations and computer model used to quantify the measures used to compare the alternatives. Also included is a section describing trends witnessed and a recommendation and conclusion section.

Node configurations

The alternative topographies and node configurations has been discussed in Section E.1 along with the nomenclature.

Variables

Tables E-1 through E-12 describe the variables used in the simulation as well as which type of waste (LAW or HLW) they apply to. Ranges for each variable are given as minimums, medians, and maximums. These values were used to generate valid test cases for each batch via the procedure described below.

Initially three files were created that contained a large quantity of random numbers (> 6,000) between 0 and 1. These random numbers were used in the simulations to calculate the batch variables as described below. Each of the three transfer "trains" (1 HLW and 2 separate LAWs) used their own set of random numbers. This was done so that each run would use the same variables for the batches and therefore comparing alternatives (and sensitivities) would reflect changes to the configurations and not changes to the set of random numbers used.

For all variables in Tables E-1 through E-12 (except for the intermediate and final setup times) the batch values were calculated by a two-segment uniform distribution. This entailed obtaining a random number between 0 and 1 for each variable from the files mentioned above. If this random number was less than or equal to 0.5 Equation 1 was used to obtain the batch value and if it was greater than 0.5 Equation 2 was used:

$$X = 2R*(X_e - X_m) + X_m \qquad \text{Equation 1}$$
$$X = 2*(R\text{-}0.5)*(X_x - X_e) + X_e \qquad \text{Equation 2}$$

where:

X = Variable of Concern
m = Minimum Value of Variable from Tables E-1 through E-12
e = median Value of Variable from Tables E-1 through E-12
x = Maximum Value of Variable from Tables E-1 through E-12
R = Random Number

For the intermediate and final setup times the batch values were calculated by a two-segment log-uniform distribution. This also entailed obtaining a random number between 0 and 1 for each variable from the files. If this random number was less than or equal to 0.5 Equation 3 was used to obtain the batch value and if it was greater than 0.5 Equation 4 was used:

$$X = 10\text{^}(2R * (\log(X_e) - \log(X_m)) + \log(Xm)) \qquad \text{Equation 3}$$
$$X = 10\text{^}(2 * (R\text{-}0.5) * (\log(X_x) - \log(X_e)) + \log(X_e)) \qquad \text{Equation 4}$$

where:

X = Variable of Concern
m = Minimum Value of Variable from Tables E-1 through E-12
e = median Value of Variable from Tables E-1 through E-12
x = Maximum Value of Variable from Tables E-1 through E-12
R = Random Number

The calculated values were next checked to insure that they met or exceeded the minimum mass of feed batch as given in Tables E-1 through E-12. If the variables did not, that batch was dropped and the process was repeated until a batch was created that did. For LAW the test is shown in Equation 5; for HLW, Equation 6. See any of the Tables E-1 through E-12 for variable definition.

$$(1.0\ \text{L·MT/ML·g})C^iV^i_{batch} \geq M^i_{min},\ i = B,C \qquad \text{Equation 3}$$
$$(1.0\ \text{L·MT/ML·g})\rho\alpha\ V^i_{batch} \geq M^i_{min},\ i = A \qquad \text{Equation 4}$$

Simulation Description

The simulation program used for this exercise was G2[1]. G2 is an object oriented, rule based program. The variables calculated above were used along with several processing rules (defined below) to obtain the necessary data for the alternatives shown in Figure E-1.

In the simulation program the user first chooses which alternative he/she wishes to simulate. The program then initiates and the transfers are made according to the order of availability. As each batch is processed through the private contractors tanks, information about the batch is written to a file for later use. The program runs until one of the LAW private contractor tanks has 500 batches processed through it.

Connections

The tank-to-tank connections shown in Figure E-1 are the only connections allowed in the simulation.

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[1]G2 version 4.0 is a registered trademark of Gensym Corporation.

Start-Up

Initially all tanks start empty. Once the simulation is initiated, the variables for the batches are calculated as stated above and the retrieval tanks[2] (not shown on Figure E-1) are considered "full". The logic in the program states that when a retrieval tank is "full" and its destination tank is "empty" and the applicable node is "ready" a transfer may take place. However, in order to avoid biasing the data by dictating which retrieval tank is "full" first, a random number is generated for each retrieval tank and the tanks are considered "full" in order of this decreasing number.

Transfers

When a tank is "full" and its destination tank is "empty", the tank is placed on a list that dictates the order the transfers tank place. A separate list is made for each node in the simulation. When a node becomes "ready", the first transfer on its list is initiated.

As stated previously, each retrieval tank contains all of the variables for that batch. These variables are transferred to the downstream tanks as the simulation proceeds. the length of time the transfers take are dictated by the batch volume, transfer rate, and setup time. It is assumed in the simulation that during the transfer setup times, the node will be unavailable.

For the HLW transfer, the length of time the node is in use is equal to the batch volume divided by the final transfer pump rate plus the final transfer setup time. For the LAW tanks there are two transfers. The first transfer (retrieval tank to intermediate tank) node time equals the batch volume divided by the intermediate staging transfer pump rate plus the intermediate staging transfer setup time. The second transfer (intermediate tank to private contractors tank) node time is equal to the batch volume divided by the final transfer pump rate plus the final transfer setup time.

All transfers assume that setting up the tank farm for a transfer will not begin until both tanks are ready for the transfer.

Intermediate Tank Delay Time

The intermediate tanks have a delay associate with them. After the transfer from the retrieval tanks, the intermediate tanks are not "full" of approved feed until sufficient time has elapsed to allow for mixing, settling, sampling, laboratory analysis, and evaluation. The length of this delay is given by Equation 7:

$$T_x = T_{mix} + T_{sample} + \max(T_{lab} + T_{eval}, T_{settle}) \qquad \text{Equation 7}$$

[2]The "retrieval tank" is the source double-shell tank being retrieved to supply the feed.

where:

T_x	= Total Delay Time (days)
T_{mix}	= In-Tank Mixing Time (days)
T_{sample}	= Time Needed to Tank and Deliver Sample (days)
T_{lab}	= Time Needed to Analyze and Report on the Sample (days)
T_{eval}	= Time Needed to Interpret Sample Results (days)
T_{settle}	= Time Needed to Settle Out Excessive Entrained Solids (days)

Once this time has elapsed, the tank is considered "full" of approved feed and is ready for transfer.

Retrieval Tanks

There is no associated delay time with the retrieval tanks. Immediately after a retrieval tank is "empty" new batch variables are calculated. This means that any equipment needed to retrieve and transfer waste from a source tank, all necessary procedures, and safety or waste compatibility related approvals have been obtained in advance of the transfer.

Private Contractor Tanks

Once a private contractor tank is full it begins processing. For the HLW tank, the processing time equals the batch volume time rho times alpha divided by the processing rate. For the LAW tanks, the processing time equals the batch volume times the sodium molarity time the molecular weight of sodium divided by the sodium processing rate. After the processing time has elapsed, the tanks are considered "empty" and are ready for the next batch.

Calculation of Outage and Contingency Times

In the simulation, outage is defined as the length of time between processing campaigns. This time equals the total time that elapses between when the private contractor tanks are "empty" and when processing begins. This time includes the amount of time it takes to setup and transfer the batch to the private contractor tanks. Therefore even if a node is connected to a single private contractor tank (Alternatives 5 and 6) there will still be an outage.

Contingency time is defined as the length of time approved feed is ready to be transferred from the intermediate staging tanks, but the downstream private contractor tank is not yet ready for feed. This time equals the total time that elapses between when the intermediate staging tanks are "full" of approved feed and when the downstream private contractor tank is done processing. Negative values for contingency are reported as zero. the reader must remember that the intermediate tanks are not considered "full" until after the intermediate tank delay time has elapsed.

E5.0 CONCLUSIONS AND CAVEATS

The behavior of the system is driven by the assumed transfer setup times. The performance of the transfer system can be significantly improved If the maximum time to setup all transfers is kept at or below about 25 days and the median time about 1 or 2 days. This will require, at the least, insuring that a failed pump or jumper can be repaired or replaced under typical (often windy) weather conditions within 25 days.

The estimated values for outage, contingency, successful cases, and feed availability efficiency are dependent upon the assumed parameter distributions, especially the assumed transfer setup times. Decisions should not be made solely on the absolute value of these measures, but upon the relative performance of the alternatives.

In general, transfer system Alternatives [F, H], [B, K], [I], and [L and D] dominate the others (they are the cheapest for any given level of performance) and kept their same relative rankings with respect to both cost and benefit. [F and H] are the cheapest and poorest performers; [L and D] are the most expensive and best performers.

The Recommended Case consists of transfer system Alternative K (2b-node), all transfer routes are setup with valve manifolds (no pit work), and the necessary actions to reduce the maximum transfer setup times to about 25 days.

In order to avoid increasing the length of the LAW outage, the LAW campaign length should be kept greater than 100 days. This corresponds to 200 MT Na in a feed batch.

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E6.0 REFERENCES

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Manuel, A. M., 1996, *Phase I HLW Pretreatment and Feed Staging Plan*, WHC-SD-WM-ES-370, Rev. 1 (DRAFT), Westinghouse Hanford Company, Richland, Washington.

Oswald, A. J., C. D. Gentillon, S. D. Matthews, and T. R. Meachum, 1982, *Generic Data Base for Data and Models Chapter of the National Reliability Evaluation Program (NREP) Guide*, EGG-EA-5887, EG&G Idaho, Idaho National Engineering Laboratory, Idaho.

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APPENDIX F
ESTIMATED COMPOSITION OF STAGED FEED

(in the private contractors feed tanks, decayed to process start date, the nominal 0.1 ML heel has been subtracted from the batch size.)

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Contractor Batch Process Date Chemical	C1 BATCH1 1-Jun-02 MT	C1 BATCH2 3-Apr-03 MT	C1 BATCH3 17-Feb-04 MT	C1 BATCH4 16-Sep-04 MT	C1 BATCH5 4-May-05 MT	C1 BATCH6 6-Mar-06 MT	C1 BATCH7 5-Jun-06 MT	C1 BATCH8 13-Aug-06 MT	C1 BATCH9 25-Dec-06 MT	C1 BATCH10 9-Sep-07 MT	C1 BATCH11 6-Jul-08 MT	C1 BATCH12 30-Apr-09 MT
Al(OH)4-	3.43E+02	2.92E+02	1.94E+02	1.92E+02	3.56E+02	4.01E+01	6.09E+00	6.95E+00	9.18E+01	1.11E+02	1.10E+02	4.53E+01
Ba+2	2.89E-05	3.15E-04	1.46E-05	8.37E-07	3.93E-08	4.68E-05	5.03E-06	3.38E-06	3.83E-07	8.39E-05	1.39E-03	1.32E-04
Ca+2	7.30E-04	2.93E-02	1.36E-03	5.99E-02	1.51E-01	8.83E-03	2.65E-01	6.01E-01	8.41E-01	5.24E-02	5.29E-02	4.84E-03
Cd+2	1.39E-04	1.17E-04	5.37E-06	3.05E-07	2.71E-02	1.29E-03	1.21E-04	5.18E-05	5.52E-06	2.06E-04	1.96E-04	6.71E-06
Cr(OH)4-	3.26E+00	2.44E-01	2.15E+00	8.35E-01	3.37E+00	2.46E+00	4.51E-01	6.01E-01	1.22E+00	8.09E-02	4.23E-02	4.13E+00
Fe+3	2.31E-02	1.83E-02	1.61E-02	1.22E-03	1.19E-01	5.78E-03	7.22E-01	1.64E+00	1.98E-01	1.21E-02	4.39E-03	2.94E-04
Hg+2	0.00E+00	3.47E-07	1.62E-08	9.24E-10	2.71E-02	1.29E-03	1.21E-04	5.18E-05	5.52E-06	7.22E-07	2.72E-07	9.19E-09
K+	1.27E+01	8.26E+00	1.02E+01	7.63E+01	3.11E+01	4.23E+00	1.45E+00	2.57E+00	7.12E+00	4.50E-01	1.58E+00	5.09E+00
La+3	0.00E+00	1.89E-03	8.80E-05	5.03E-06	2.36E-07	4.99E-04	5.36E-05	3.61E-05	4.08E-06	1.89E-07	1.39E-02	1.37E-03
Na+	5.79E+02	6.27E+02	4.07E+02	4.46E+02	6.00E+02	1.26E+02	1.20E+02	2.51E+02	4.95E+02	5.87E+02	5.84E+02	1.95E+02
Ni+3	2.52E-03	2.15E-03	9.87E-05	5.61E-06	4.06E-02	2.45E-03	2.17E-01	4.91E-01	6.73E-01	4.18E-02	1.64E-02	1.47E-03
Pb+4	3.12E-04	7.45E-05	3.28E-06	5.47E-01	1.61E-01	7.22E-03	1.59E-01	3.60E-01	4.36E-02	3.01E-03	8.52E-04	2.87E-05
U	7.38E-04	1.69E-02	7.88E-04	4.05E-01	2.95E-02	8.86E-01	2.03E-01	3.09E-01	3.69E-02	2.06E-03	6.68E-03	1.59E+00
CO3-2	4.83E+01	8.26E+01	4.26E+01	2.54E+01	1.69E+01	3.76E+01	4.01E+01	8.45E+01	1.27E+02	9.60E+01	9.42E+01	6.92E+01
CL-	1.81E+01	2.93E+01	1.17E+01	1.02E+01	1.70E+01	9.26E-01	1.58E+00	3.42E+00	7.21E+00	4.75E-01	2.43E-01	2.31E-01
F-	7.58E-01	2.64E+01	1.23E+00	7.03E-02	1.25E+00	1.74E+00	1.86E-01	1.24E-01	3.65E+00	4.66E+00	4.63E+00	3.17E+00
SO4-2	1.40E+01	1.73E+01	9.78E+00	2.59E+00	2.88E+00	2.08E+01	8.82E+00	1.64E+01	2.71E+01	1.88E+01	1.88E+01	3.77E+01
NO3-	4.07E+02	4.85E+02	2.86E+02	4.08E+02	2.99E+02	7.41E+01	1.22E+02	2.63E+02	4.17E+02	4.51E+02	4.49E+02	1.23E+02
NO2-	2.50E+02	2.33E+02	1.32E+02	1.94E+02	2.47E+02	6.71E+01	3.07E+01	5.83E+01	1.53E+02	1.86E+02	1.83E+02	1.06E+02
PO4-3	5.21E+00	1.27E+01	4.42E+00	4.14E+00	1.86E+00	1.01E+00	3.62E-01	6.48E-01	8.68E+00	1.17E+01	1.15E+01	2.05E+00
OH-	1.29E+02	1.46E+02	1.02E+02	1.64E+02	1.77E+02	1.74E+01	1.03E+01	2.05E+01	2.12E+01	1.64E+01	1.93E+01	1.69E+01
TOC	8.44E+00	1.82E+01	7.16E+00	4.97E+00	1.28E+01	2.27E+00	2.09E+01	4.70E+01	5.15E+01	8.36E+01	8.29E+01	5.81E+00
14C (Ci)	4.73E-02	6.55E-03	2.76E-04	6.66E-01	3.43E+00	1.89E+00	2.01E-01	1.31E-01	3.19E+01	2.03E+00	9.16E-02	3.10E+00
90Sr (Ci)	6.61E+03	6.26E+03	1.38E+04	3.02E+03	2.22E+04	4.46E+03	4.48E+04	1.01E+05	1.50E+05	9.32E+03	4.39E+04	7.61E+03
90Y (Ci)	6.61E+03	6.26E+03	1.38E+04	3.02E+03	2.22E+04	4.46E+03	4.48E+04	1.01E+05	1.50E+05	9.32E+03	4.39E+04	7.61E+03
99Tc (Ci)	2.71E+02	2.48E+01	1.81E+02	2.86E+02	3.08E+02	3.55E+02	1.87E+02	3.64E+02	5.84E+02	3.66E+01	7.23E+01	6.14E+02
137Cs (Ci)	1.03E+06	6.12E+04	1.04E+06	9.62E+05	1.34E+06	1.77E+06	3.14E+05	4.09E+05	4.97E+05	3.12E+04	4.10E+04	3.05E+06
137Ba (Ci)	9.80E+05	5.82E+04	9.86E+05	9.14E+05	1.27E+06	1.68E+06	2.98E+05	3.89E+05	4.72E+05	2.96E+04	3.89E+04	2.90E+06
154Eu (Ci)	0.00E+00	2.10E-04	9.77E-06	5.58E-07	2.62E-08	2.69E+03	2.89E+02	1.95E+02	1.41E+03	8.92E+01	3.56E+00	4.83E+03
235U (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238U (Ci)	1.12E-04	2.01E-04	9.32E-06	1.36E-01	9.90E-03	2.98E-01	6.83E-02	1.04E-01	1.24E-02	5.86E-04	1.46E-03	5.33E-01
237Np (Ci)	1.53E-04	4.45E-03	2.07E-04	1.18E-05	3.39E-02	7.44E-02	7.97E-03	5.32E-03	6.02E-04	2.78E-05	9.76E-07	1.30E-01
238Pu (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239Pu (Ci)	1.67E+01	1.19E+00	1.14E+01	2.54E+00	3.38E+00	1.26E+01	1.44E+01	3.05E+01	1.06E+02	6.69E+00	2.38E+00	2.23E+01
240Pu (Ci)	4.17E+00	2.98E-01	2.86E+00	6.34E-01	8.45E-01	3.14E+00	3.59E+00	7.62E+00	2.66E+01	1.67E+00	5.95E-01	5.57E+00
241Pu (Ci)	2.63E+01	1.88E+00	1.80E+01	4.00E+00	5.33E+00	1.98E+01	2.26E+01	4.80E+01	1.67E+02	1.05E+01	3.74E+00	3.51E+01
241Am (Ci)	3.07E+00	1.07E+00	2.12E+00	2.33E+00	4.06E+00	1.91E+01	3.03E+02	6.84E+02	1.91E+02	1.08E+01	7.03E+00	3.41E+01
Volume, (L)	3.62E+06	4.10E+06	2.53E+06	2.77E+06	3.73E+06	1.11E+06	7.81E+05	1.58E+06	3.07E+06	3.65E+06	3.63E+06	1.86E+06
Na (M)	6.95E+00	6.65E+00	6.99E+00	6.99E+00	6.99E+00	4.92E+00	6.69E+00	6.91E+00	7.01E+00	6.99E+00	6.99E+00	4.54E+00
SpG	1.33E+00	1.31E+00	1.31E+00	1.37E+00	1.32E+00	1.23E+00	1.26E+00	1.27E+00	1.28E+00	1.27E+00	1.27E+00	1.21E+00
Proc. Time (days)	286	310	201	220	296	62	59	124	244	290	288	96
Corrosion Spec Met?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Envelope	A	A	A	A	A	B	C	C	C	C	C	B

Contractor Batch Process Date Chemical	C2 BATCH1 1-Jun-02 MT	C2 BATCH2 14-Mar-03 MT	C2 BATCH3 19-Jan-04 MT	C2 BATCH4 18-Aug-04 MT	C2 BATCH5 4-Apr-05 MT	C2 BATCH6 4-Feb-06 MT	C2 BATCH7 5-May-06 MT	C2 BATCH8 14-Jul-06 MT	C2 BATCH9 25-Nov-06 MT	C2 BATCH10 10-Aug-07 MT	C2 BATCH11 6-Jun-08 MT	C2 BATCH12 27-Mar-09 MT
Al(OH)4-	3.34E+02	2.92E+02	1.94E+02	1.91E+02	3.56E+02	4.01E+01	6.09E+00	6.95E+00	9.12E+01	1.11E+02	1.08E+02	5.39E+01
Ba+2	1.58E-05	3.09E-04	1.44E-05	8.25E-07	3.89E-08	4.68E-05	5.03E-06	3.38E-06	3.82E-07	8.39E-05	2.69E-03	1.41E-03
Ca+2	6.55E-05	2.96E-02	1.38E-03	5.96E-02	1.51E-01	8.83E-03	2.65E-01	6.01E-01	8.35E-01	5.24E-02	1.03E-01	5.34E-02
Cd+2	5.73E-04	1.25E-04	5.46E-06	3.05E-07	2.71E-02	1.29E-03	1.21E-04	5.18E-05	5.52E-06	2.06E-04	1.74E-04	8.62E-05
Cr(OH)4-	3.13E+00	2.38E-01	2.15E+00	8.32E-01	3.37E+00	2.46E+00	4.51E-01	6.01E-01	1.21E+00	8.09E-02	7.66E-02	3.87E-02
Fe+3	2.33E-02	1.85E-02	1.62E-02	1.22E-03	1.19E-01	5.78E-03	7.22E-01	1.64E+00	1.98E-01	1.21E-02	5.62E-03	2.72E-03
Hg+2	0.00E+00	3.47E-07	1.62E-08	9.26E-10	2.71E-02	1.29E-03	1.21E-04	5.18E-05	5.52E-06	7.23E-07	3.39E-08	1.27E-09
K+	1.24E+01	8.45E+00	1.02E+01	7.60E+01	3.11E+01	4.23E+00	1.45E+00	2.57E+00	7.07E+00	4.50E-01	3.14E+00	1.64E+00
La+3	0.00E+00	1.83E-03	8.52E-05	4.87E-06	2.29E-07	4.99E-04	5.36E-05	3.61E-05	4.08E-06	1.90E-07	2.78E-02	1.46E-02
Na+	5.59E+02	6.09E+02	4.06E+02	4.44E+02	6.00E+02	1.26E+02	1.20E+02	2.51E+02	4.91E+02	5.87E+02	5.76E+02	2.88E+02
Ni+3	3.95E-05	1.95E-03	9.11E-05	5.20E-06	4.06E-02	2.45E-03	2.17E-01	4.91E-01	6.68E-01	4.18E-02	3.10E-02	1.55E-02
Pb+4	1.06E-13	5.66E-05	2.64E-06	5.45E-01	1.61E-01	7.22E-03	1.59E-01	3.60E-01	4.36E-02	3.02E-03	6.37E-04	2.74E-04
U	5.76E-04	1.72E-02	8.04E-04	4.03E-01	2.94E-02	8.86E-01	2.03E-01	3.09E-01	3.69E-02	2.07E-03	1.30E-02	6.78E-03
CO3-2	4.46E+01	7.94E+01	4.25E+01	2.53E+01	1.69E+01	3.76E+01	4.01E+01	8.45E+01	1.26E+02	9.60E+01	9.47E+01	4.74E+01
CL-	1.73E+01	2.99E+01	1.17E+01	1.02E+01	1.70E+01	9.26E-01	1.58E+00	3.42E+00	7.16E+00	4.75E-01	4.41E-01	2.23E-01
F-	2.23E-01	2.68E+01	1.25E+00	7.15E-02	1.25E+00	1.74E+00	1.86E-01	1.24E-01	3.63E+00	4.66E+00	4.55E+00	2.28E+00
SO4-2	1.33E+01	1.67E+01	9.75E+00	2.58E+00	2.88E+00	2.08E+01	8.82E+00	1.64E+01	2.69E+01	1.88E+01	1.94E+01	9.73E+00
NO3-	3.92E+02	4.71E+02	2.85E+02	4.06E+02	2.99E+02	7.41E+01	1.22E+02	2.63E+02	4.15E+02	4.51E+02	4.47E+02	2.23E+02
NO2-	2.43E+02	2.28E+02	1.32E+02	1.93E+02	2.47E+02	6.71E+01	3.07E+01	5.83E+01	1.52E+02	1.86E+02	1.79E+02	8.95E+01
PO4-3	3.97E+00	1.23E+01	4.40E+00	4.12E+00	1.86E+00	1.01E+00	3.62E-01	6.48E-01	8.62E+00	1.17E+01	1.12E+01	5.57E+00
OH-	1.26E+02	1.48E+02	1.02E+02	1.63E+02	1.77E+02	1.74E+01	1.03E+01	2.05E+01	2.10E+01	1.64E+01	2.26E+01	1.15E+01
TOC	7.97E+00	1.41E+01	6.97E+00	4.95E+00	1.28E+01	2.27E+00	2.09E+01	4.70E+01	5.12E+01	8.36E+01	8.03E+01	4.01E+01
14C (Ci)	7.51E-10	3.96E-03	1.85E-04	6.63E-01	3.43E+00	1.89E+00	2.01E-01	1.31E-01	3.17E+01	2.03E+00	1.01E-01	1.34E-02
90Sr (Ci)	6.48E+03	6.05E+03	1.38E+04	3.01E+03	2.22E+04	4.46E+03	4.48E+04	1.01E+05	1.49E+05	9.32E+03	8.74E+04	4.58E+04
90Y (Ci)	6.48E+03	6.05E+03	1.38E+04	3.01E+03	2.22E+04	4.46E+03	4.48E+04	1.01E+05	1.49E+05	9.32E+03	8.74E+04	4.58E+04
99Tc (Ci)	2.63E+02	2.40E+01	1.80E+02	2.85E+02	3.08E+02	3.55E+02	1.87E+02	3.64E+02	5.80E+02	3.66E+01	1.43E+02	7.45E+01
137Cs (Ci)	1.01E+06	5.99E+04	1.04E+06	9.59E+05	1.34E+06	1.77E+06	3.14E+05	4.09E+05	4.94E+05	3.12E+04	8.03E+04	4.16E+04
137Ba (Ci)	9.60E+05	5.69E+04	9.86E+05	9.11E+05	1.27E+06	1.68E+06	2.98E+05	3.89E+05	4.69E+05	2.96E+04	7.63E+04	3.96E+04
154Eu (Ci)	0.00E+00	2.10E-04	9.79E-06	5.60E-07	2.64E-08	2.69E+03	2.89E+02	1.95E+02	1.40E+03	8.91E+01	3.56E+00	1.25E-01
235U (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
238U (Ci)	4.18E-06	1.89E-04	8.82E-06	1.35E-01	9.89E-03	2.98E-01	6.83E-02	1.04E-01	1.24E-02	5.89E-04	2.90E-03	1.52E-03
237Np (Ci)	5.31E-08	4.58E-03	2.14E-04	1.22E-05	3.39E-02	7.44E-02	7.97E-03	5.32E-03	6.01E-04	2.80E-05	9.82E-07	3.20E-08
238Pu (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239Pu (Ci)	1.67E+01	1.18E+00	1.14E+01	2.53E+00	3.38E+00	1.26E+01	1.44E+01	3.05E+01	1.06E+02	6.69E+00	4.49E+00	2.23E+00
240Pu (Ci)	4.17E+00	2.96E-01	2.86E+00	6.33E-01	8.45E-01	3.14E+00	3.59E+00	7.62E+00	2.64E+01	1.67E+00	1.12E+00	5.57E-01
241Pu (Ci)	2.63E+01	1.86E+00	1.80E+01	3.99E+00	5.33E+00	1.98E+01	2.26E+01	4.80E+01	1.66E+02	1.05E+01	7.06E+00	3.51E+00
241Am (Ci)	3.03E+00	1.04E+00	2.12E+00	2.32E+00	4.06E+00	1.91E+01	3.03E+02	6.84E+02	1.90E+02	1.08E+01	1.36E+01	6.97E+00
Volume, (L)	3.62E+06	4.09E+06	2.53E+06	2.76E+06	3.73E+06	1.11E+06	7.81E+05	1.58E+06	3.05E+06	3.65E+06	3.58E+06	1.79E+06
Na (M)	6.71E+00	6.47E+00	6.98E+00	6.99E+00	6.99E+00	4.92E+00	6.69E+00	6.91E+00	7.01E+00	6.99E+00	7.00E+00	7.00E+00
SpG	1.32E+00	1.31E+00	1.31E+00	1.37E+00	1.32E+00	1.23E+00	1.26E+00	1.27E+00	1.28E+00	1.27E+00	1.27E+00	1.27E+00
Proc. Time (days)	276	301	201	219	296	62	59	124	243	290	284	142
Corrosion Spec Met?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Envelope	A	A	A	A	A	B	C	C	C	C	C	C

APPENDIX G

MISCELLANEOUS CORRESPONDENCE

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APPENDIX G

MISCELLANEOUS CORRESPONDENCE

Allen 1996

Author: Gail K Allen at ~WHC300
Date: 7/1/96 2:19 PM
Priority: Normal

TO: Paul J Certa at ~WHC156

CC: Eric J Slaathaug at ~WHC302, Randy A Kirkbride at ~WHC133, Gail K Allen

Subject: REVIEW OF WHC-SC-WM-RPT-224 REV 0.
------------------------------ Message Contents ------------------------------

The attached ascii file contains my review of the subject document.

I have completd a review of Appendix E - Feed Delivery Timimg Study of WHC-SD-WM-RPT-224 Rev 0.

My review of the body of Appendix E consisted only of spot checking some of the basic assumptions for the sensitivity cases as I am not very knowlegible on the statistical methods used. The basic assumptions that I checked were correct and seemed appropriate for the study. The assumptions that I checked included the maximum sodium concentration of 14 Molar for LLW batches, the typical batch size of LLW feed of 3 ML, and the intermediate staging transfer pump rate of 140 GPM. I also checked the data presented in Tables E-1 through E-10 for consistancy in the G2 model. Everything check ok.

The main part of my review dealt with section E.4 which discussed the G2 model that Eric Slaathaug used to evaluate the timing cases for the various connection options. In this review, I checked the G2 rules and procedures to make sure that they were operating as outlined in Appendix E. The rules and procedures worked as documented except for equation 2 and 4 in Appendix E. Each of these equations have a "(1-R)" term in Appendix E, but the term in the G2 model is "(R-0.5)". Talking with Eric, the "(R-0.5)" is the correct value. I also checked the timing issues associated with firing the rules and procedures within G2 and the output that was generated by the model. Everything seemed correct. The output the the G2 model generates also seemed correct and worked as documented.

It seems that the use of G2 was a very good choice to model the performance of the tank transfer system. It has unique capabilities which enable this system to be modeled with a minimum amount of effort.

There were also some minor typos I marked on the review copy attached to this DSI.

Barton 1996

Author: W B (Blaine) Barton at ~WHC12
Date: 1/10/96 4:22 PM
Priority: Normal

TO: James P Sloughter at ~WHC128, Paul J Certa at ~WHC53, Dennis J Washenfelder at ~WHC53

CC: Walter L Knecht at ~WHC288, Jeffry A Voogd at ~WHC347, Michael L Elliott at ~PNL88

Subject: Re[2]: Privatization, Watch List Waste
------------------------------ Message Contents ------------------------------

It is highly desirable to dispose of watchlist waste as soon as possible. Since few additional controls are imposed in watchlist waste we should not feel constrained against using "watchlist waste" for feed to the privatization vendor. Space considerations push in the direction of processing the most dilute of the concentrated wastes first.

Blaine Barton

______________________________ Reply Separator _________________________________
Subject: Re: Privatization, Watch List Waste
Author: Walter L Knecht at ~WHC288
Date: 1/10/96 11:40 AM

I have learned from Jerry Johnson that Blaine Barton is responsible what type of waste is put into the feed tanks for Phase 1 privatization. Therefore, I am sending this message along to resolve my original question which was, do we want to impose "watch list" requirements on the private contractors.

Thanks, Walter Knecht, 376-9874

I am assuming that safety issues will be resolved in time to support staging of LLW feed during Phase I. I don't expect to be able to avoid watch-list or USQ DSTs for feed during Phase I - I will have a better idea in a few weeks. Waste can not be arbitarily diluted and still meet the feed envelopes and draft RRP batch size and timing requirments. Most envelopes permit a large range of dilution for the projected feed. But, the more dilute the waste, the smaller the batch size (MT of Na) which means shorter campaigns. There are also mimimum batch size limits. Make the campaing short enough and its you lose time for contingencies during staging.

CC:Mail Message
From W B (Blaine) Barton
Page 2

______________________ Reply Separator ______________________
Subject: Privatization, Watch List Waste
Author: Walter L Knecht at ~WHC288
Date: 1/9/96 11:49 AM

Mike Elliott,

A decision needs to be made, or may have been already made, relative to putting "watch list waste" into the feed tanks. I am assuming that the waste will be "non-watch list" to eliminate the additional restrictions that would be required for the feed tanks. It appears to be simpler to dilute the waste so that it would not fall under this category than to place additional requirements on the Contractors. Please let me know what the decision is.

Thanks, Walter

<u>Certa 1995</u>

MEETING MINUTES

Subject: LLW Feed Staging Feasibility Study Discussion				
TO: Distribution		BUILDING -		
From P. J. Certa		Chairman P. J. Certa		
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Disposal Engineering	Rhld	Day	9/25/1995	5

Those attending:
N. R. Brown (RL) K. D. Wiemers (PNL)
R. A. Gilbert (RL) T. W. Wood (PNL)

The purpose of this meeting was to obtain background information concerning the LLW Feed Staging Plan activity being conducted by WHC. The first formal deliverable is *Issue LLW Feed Staging Feasibility Study* due November 1, 1995. To support this date, I am assembling the study basis and assumptions for review staring October 2, 1995. The other deliverables are *Issue Draft Preliminary Feed Staging Plan* (January 15, 1996), *Issue Preliminary Feed Staging Plan* (February 15, 1996) and *Confirmation of Preliminary Feed Staging Plan* (August 15, 1996).

We discussed the following:

PURPOSE OF REPORT

- Feasibility Study

  Show that it is feasible to provide 19,000 MT glass equivalent (~4 million gallons) of the specified feeds to two phase one LLW vendors according to schedule. It is expected to be feasible, but may require resolution of issues or specific actions. *<Action-PJC: Verify that 19,000 MT is the proper value>*

  Questions the CST expects answered by the feasibility study or plan:

  a) Is the M&O confident about meeting the limits provided by the feed envelopes?

  b) Are any important waste constituents being overlooked?

MEETING MINUTES (Continued)

- Feed Staging Plan

  Document the tanks selected to provide feed for the demonstration and the specific transfers and staging/blending activities required to provide feed to the vendors. Address tank farm configuration and operational constraints and any needed issues or actions.

  Ron Gilbert stated that the feasibility study should have less detail that the Plan *<Action-PJC: Better define the scope of the feasibility study with input from RAG>.*

GOALS OF THE PHASE I DEMONSTRATION

- Demonstrate the financial feasibility of Phase II to potential vendors by providing the LLW Phase I Vendors with both production challenges and technical challenges.

TARGET FEED ENVELOPES

- Composition Ranges

  The Contract Support Team (CST) has prepared four draft feed envelopes. The LLW product from treatment of wastes bound by these envelopes account for 99% of the total LLW product. One envelope corresponds to the production challenge; the other three envelopes correspond to the technical challenges of producing glass limited in compounds other than sodium, of processing waste with complexed radionuclides and of demonstrating solids/liquid separation on strontium and TRU bearing suspended solids. The envelopes are currently designated as A-D, respectively.

  The CST has identified candidate DSTs meeting the discriminating criteria used to describe each envelope. *<Action-TWW: Provide PJC with a list of the candidate DSTs around 9/27; include PJC on distribution of discriminating limit letter.>*

  Upper, lower and expected values of all relevant waste constituents have been developed. These will be written into the Request for Proposal (RFP). *<Action-KDW: Provide PJC with the feed envelopes and comparison of limits with candidate tank inventories (in about a week).>*

MEETING MINUTES (Continued)

Third-hand information I obtained at a meeting last week suggested that RL wants to keep costs down by avoiding difficult to treat waste (such as high TOC waste) while the CST wanted to include such waste as a technical challenge. RL's position was supposed to be in an issue paper prepared by Neil Brown. This is incorrect - there is no disagreement. Neil Brown (RL), Rob Gilbert (RL), Tom Wood (PNL) and Karyn Wiemers (PNL) agree on the goals for the Phase I demonstration and that the feed envelopes support those goals.

- Intra-Vendor Batch Homogeneity
  Multiple batches of waste provided to a specific vendor do not need to have the same composition - they just need to fall within the proper feed envelope. This is representative of the batch to batch variability expected in Phase II.

- Inter-Vendor Batch Homogeneity
  The two vendors do not require waste batches of the same composition as long as each receives waste within the envelope.

  It may be desirable, though, to keep the waste similar to avoid unintentional biases.

- Tank Inventory Data
  The CST used DST inventory data provided by L. W. Shelton. *<Action-PJC: identify which version of Shelton's inventory was used.> <Action-KDW: provide PJC copies of spreadsheets used for assigning tanks to envelopes>*

  Once the feed envelopes are placed into the RFP and written into a contract, they will become binding. The most current feed inventories should be used for this work.

- How sharp of a transition between waste envelopes or between batches within an envelope is required?
  (Not discussed)

- Blend tanks, stream splitters, tank heels, line flushes.
  Prior to transfer to the vendor, the M&I needs to be assured that the waste falls within the appropriate envelope. This may require a M&I staging or blend tank.

MEETING MINUTES (Continued)

FEED SCHEDULE

- Sequence of envelopes
  The overall sequence of the envelopes will probably be established in the RFP. CST Suggests A,B,C, then D.

- Campaign length for each envelope
  PNL suggests that waste be supplied for 27 months for the production challenge, then 1 month for each of the technical challenges. The basis for the duration of the technical challenges was that it would take 1 - 2 weeks for a plant to reach equilibrium. The one month period should be considered as a minimum duration - logistics considerations (such as the desire to empty source DSTs completely) or scheduling constraints may dictate longer durations.

  More third-hand information stating that RL (Don Vieth) wants 6 months for each envelope could not be verified since Don was not present. *<Action-PJC: Contact Don Vieth.>*

- Volume of waste from each envelope
  Consistent with campaign lengths for each envelope.

- What if vendors become out-of-phase in their processing?
  The M&I should be able to continue to provide feed to both vendors independently. There is a feed request protocol in the draft RFP. *<Action-PJC: Contact Jeff Voogd to discuss protocol>*.

- Build in any additional slack time beyond that from TOE?
  No, the 19,000 MT glass equivalent required the full 2.5 year duration at a 60% TOE. However, it will be necessary to allow a short duration outage for staging of the next feed batch.

PLANT OPERATION SCHEDULE

<Action-KDW: Provide name of CST member knowledgeable about the schedule>

- July 2002 - January 2005 [from Baseline System Description] *<Action-PJC: confirm dates with draft RFP>*.

- Potential Extensions of Phase I
  The LLW Feed Staging Plan should not include detail plans for providing feed for the two potential extensions. However, it should be feasible to provide addition feed should these extensions be granted.

MEETING MINUTES (Continued)

- Single Vendor, 17 MT/day max instantaneous rate; 60% TOE applied to a 365 day year, 24 hours/day. For two vendors, this is equivalent to about 19,000 MT of glass for the 2.5 year demonstration.

TANK ALLOCATION TO VENDORS

- Feed Staging Tanks

  The RFP states that tanks 2 & 4 AP will be allocated to the vendor for feed staging. The feasibility study and plan will use 2 & 4 AP.

  Issue: WHC Operations wants 6 & 8 AP. Need to understand each parties basis and then get direction from RL. *<Action-PJC: Contact Jeff Voogd or Tom Hoertkorn to discuss feed staging tanks>.*

- Vendor Receipt Tank

  At least one DST will be allocated for receipt of incidental solids. This tank will be common to both vendors. Operations suggests 7 AP (assuming that 6 & 8 AP are selected as feed staging tanks). Separated Cs and Tc will be stored as a dry product.

- Battery Limits:

  The two feed staging DSTs are outside the control of the M&I; the receipt Tank is controlled by the M&I.

INTERFACE WITH REST OF SYSTEM

- An Operational Waste Volume Projection will be needed for the proposed staging plan.

- Additional modeling may be needed for transfer line usage or tracking waste composition changes. (Not discussed).

- HLW Demonstration

  Assume that the HLW demonstration occurs during Phase I.

- Characterization

  The WHC Characterization Project should be given a heads-up concerning this study and potential impacts on future characterization needs.

- Another question that the CST wished considered: Should certain DSTs be kept "inactive" until needed to be used for Phase I LLW Demonstration feed?

Eager 1996a

DON'T SAY IT --- *Write It!*

DATE: June 19, 1996

TO: P. J. Certa

FROM: Kevin Eager
Westinghouse Hanford Company
Disposal Engineering
MSIN: H5-27
Telephone: (509) 372-1715
FAX: (509) 376-8652

cc: R. A. Kirkbride

SUBJECT: Technical Review Of Heel Mixing Study

An independent technical review was conducted of the Heel Mixing Study portion of the LLW Feed Staging Plan (section 2.6, and Appendix D of WHC-SD-WM-RPT-224). The basic logic, assumptions, calculation methods, calculations, results and conclusions of this study are deemed valid by this review. No problems were identified which would invalidate the results or conclusions of the study within the constraints of the given scope and assumptions. The following aspects of the Heel Mixing Study were reviewed in detail:

Basic Study Logic

The study explores the effects of liquid "heels" left in the vendor feed tanks when change from feeding one envelope to another. Specifically what volume ratios of new feed envelope to old feed envelope can be mixed under the expected ranges of molarity sodium, and key component concentrations, such that the resulting mixture still remains within the waste envelope specifications. The first part of the study randomly assumes sodium molarity and concentrations of key analytes of both the heel and the diluent, then calculates the minimum dilution ratio necessary to still meet the envelope criteria. Sodium molarity and key analyte concentrations are essentially selected over the ranges identified in the RFP for privatization. The second part of the study uses expected compositions of actual tank waste as input to the calculations. No fault is found with the basic logic of this study.

Don't Say It--Write It
From Keven Eager
Page 2

Basic Assumptions

- The assumption that tanks can be pumped out to a liquid level of 10" (nominal) was verified by a discussion with W. H. Grams of Retrieval Engineering.

- Assumption that 416 inches is the working volume of the DST feed tank was verified in Slankas et. al. (1995).

- The feed envelope composition limits were verified with the RFP.

- DSTs are flat bottomed, with a diameter of 22.9 meters, maximum liquid level of 35 ft (420 inches) (Slankas 1995). Therefore the assumption of a 416 inch fill limit is deemed valid.

- The assumption that there is always sufficient feed to fill the tank (to the 416 inch maximum) as it is mixed with the heel should be is valid for envelopes A, and C, but should be qualified for envelope B by stating that only enough volume of envelope B feed has been identified to fill 409 inches.

CALCULATIONS

The following calculations of the first part of the Heel Mixing Studied (Using Full Envelope Range) were verified by this review:

- The choice of 500 pairs of heel/diluent composition combination for each mixing scenario appears to be adequate based on information that 100 was first tried with a resulting jagged curve. The choice of 500 resulted in a smooth curve.

- Selection and use of sodium molarities in calculating compositions and volumes.

- Method of calculating cesium concentration for env B.

- Calculation of waste volume added and final volume.

- Calculation of final composition.

- Calculation of maximum allowable heels

RESULTS AND CONCLUSIONS

All results and conclusions of the study are deemed valid. The following conclusions are also suggested:

Envelope changes should be studied and planned on a case by case basis. The defense of this is that for each envelope change e.g. A-B, A-C, B-C, etc. there are specific problematic, and non-problematic combinations. It is also worth mentioning that the work and degree of difficulty involved with identifying specific tank combinations does not appear to be extremely difficult.

Although it may appear to be overly obvious; perhaps it should be stated in the recommendations that the number of changes between envelopes of any type, should be minimized. The justification would be the potential heel contamination, the cost of extra work involved, etc.

The following aspects of the Heel Mixing Study were not reviewed in detail:

- The projected actual tank compositions used in the second part of the study.
- Detailed calulations of the second part of the study (Using Projected Waste Compositions). The calculation logic, method and accuracy which was verified in the spreadsheet for the first part of the study (Using Full Envelope Range) was assumed to be the same.

REFERENCES

Slankas, J. T., Kupfer, M. J., and W. W. Schulz 1995, *Data Needs and Attendant Data Quality Objectives for Tank Waste pretreatment and Disposal*, WHC-SD-WM-DQO-022, Rev. 0, June 1995, Westinghouse Hanford Company, Richland, Washington.

Eager 1996b

DON'T SAY IT --- *Write It!*

DATE: August 6, 1996

TO: P. J. Certa

FROM: Kevin Eager

Westinghouse Hanford Company
Disposal Engineering
MSIN H5-27

Telephone: (509) 372-1715
FAX: (509) 376-8652

cc: R. A. Kirkbride

SUBJECT: Technical Review Of LLW Feed Staging Plan

An independent technical review was conducted of the LLW Feed Staging Plan (WHC-SD-WM-RPT-224). This DSI serves to document the results of that review.

Assumptions

All assumptions listed with appropriate caveats in Appendix A appear to be reasonable and valid for use in this study. Not all assumptions were checked in detail.

This plan assumes dilution of DSSF to 7 M Na^+. This is a valid assumption i.e. the results of the study are not compromised by this assumption, as long as provisions are available to either deal with precipitated gibbsite which is highly likely to form, or to deal with the added caustic necessary to prevent such precipitation of gibbsite. Provisions or contingencies for dealing with precipitated gibbsite, and or added caustic are both addressed by the recommended options of this Feed Staging Plan.

The addition of NaOH to the DSSF will;

- Not change the volume of the waste. The required amount of NaOH is such that it can be added at about 3.3 M NaOH.
- Not change the OH^-/Na^+ mole ratio.

Don't Say It--Write It
From Kevin Eager
Page 2

- Reduce the component/sodium mole ratios of all components other than OH^-. This result will not effect the ability of any DSSF waste to meet the specified envelopes because all DSSF is classified as envelope A which have only maximum limits, except for AP-101, and AP-105 which are DSSF waste classified as meeting envelope C. Preliminary calculations based on the given tank inventory show that addition of sodium hydroxide to AP-105 for the purpose of preventing gibbsite precipitation will probably not preclude this waste from meeting the envelope C definition. AP-101 however which is borderline (low) in TOC would likely loose it's envelope C classification upon caustic addition to prevent gibbsite precipitation based on the current inventory estimates. This does not effect the recommended feed staging plan/schedule since AP-101 was not selected based on it's borderline status.

Dilution of a DSSF simulant with both water and caustic was shown necessary to prevent solids formation upon lowering the temperature from 50°C to 20°C (Kurath et. al. 1995). In these tests a simulant was made up to represent DSSF at 10 M Na^+. Sodium nitrate precipitated from the 10 M Na^+ formulation upon cooling below 50°C. The sodium nitrate in the DSSF simulant was found to be soluble at 20°C after dilution to 7 M Na^+. Sodium hydroxide addition was also found to be necessary to prevent precipitation of gibbsite upon dilution. Sodium hydroxide was added before water dilution to maintain a free hydroxide concentration of 1.75 M in the 7 M Na^+ DSSF solution. At this free hydroxide concentration (1.75 M) the DSSF simulant at 7 M Na^+ was considered near the point of maximum aluminum solubility.

Feed Staging Strategy

The selection process leading to the decision to use the *Indirect Staging--As Soon As Possible* staging strategy was not reviewed.

Double-Shell Tank Compositions/Classifications

The validity of the projected DST compositions was not reviewed. The logic of classifying the DST and SST waste into the envelopes defined by the RFP is clear and direct. The envelope classification of tanks AN-105, AN-106, and AY-101 were checked and were found to be classified correctly based on the given tank compositions and envelope definitions.

The sensitivity of DST classification, i.e. use of "old" and "new" inventory and envelope specifications were not reviewed.

Single-Shell Tank Compositions/Classifications

Some explanation should be given of the value of going through the exercise of classifying the SST tanks into envelopes and even into borderline cases when the confidence level of the SST inventory data is considered low. Of the 43 SSTs mentioned in the LLW Feed Staging Plan as either being within an envelope, or borderline, only 10 can be associated with an approved Tank Characterization report. Of those 10 most do not have data on key anaylytes such as phosphorous, sulfate, nitrate, etc.. Furthermore as analyses of actual tank samples are being completed significant deviations are being seen between actual tank compositions and those previously predicted by the Tank Layer Model which is the main basis for the SST inventory used in the LLW Feed Staging Plan. The result is that the likelihood of the specific 43 SSTs mentioned as being within certain envelopes or borderline cases, remaining there once tank sample data is re-analyzed is not very great.

An important point of this exercise is to show that the SSTs represent a significant potential source of sodium for Phase I. This is shown using the SST inventory as based (mainly) on the TLM. If the differences between the SST inventory, based on sample analyses, and that based on the TLM, are random, or do not effect specific envelope definitions, the same relative portion of the SST sodium inventory can be expected to fall within envelope boundaries when the SST inventory is updated to reflect sample analyses data.

Heel Mixing Study

The heel mixing study was reviewed in a separate effort (Eager 1996).

Waste Compatibility

The conclusion that the criticality decision rule would not influence staging of Phase I DST supernates was verified to be valid by checking rules in the waste compatibility document (Fowler 1995) and Pu inventories in DST supernates per Orme (1995).

Furthermore the sensitivity of the criticality decision rule toward entrained solids was checked by choosing the AZ tanks as a test case. The AZ tanks were chosen because both these tanks have a total tank (solids and supernate) Pu inventory that is among the highest for the DSTs (Orme 1995), and therefore should represent the worst DST case.

Calculations show that even if all the NCAW solids were entrained with the supernate transfers, the Pu limits would still be met, specifically the ratio of the total mass of solids to the total mass of Pu would be greater than 1,000 and the Pu concentration would be less than 0.013 g Pu/liter. The conclusions is that entrained solids should not represent a concern to meeting the criticality rules except perhaps in a few unique cases.

The following waste compatibility rules were not reviewed in detail: Flammable Gas Accumulation, Energetics, Corrosion, Watch List Tanks, Heat Generation, Complexant Waste Segregation rule, Tank Waste Type, and the high Phosphate Waste rules.

As a spot check the TRU concentrations of the several tanks were calculated using Orme (1995) as a source of inventories and are presented in Table 1. The results verify the assertion that the listed tanks have a potential problem of meeting the TRU segregation rule if applied, i.e. over 100 nCi TRU/g of supernate.

Table 1. Estimated TRU Content of Transfers[1]

tank	nCi TRU per gram supernate	nCi TRU per gram supernate with 100 ppm solids carryover
AN-102	742	742
AN-107	480	480
AZ-101	354	355

1 Based on Inventories in The TWRS Flowsheet (Orme 1995)

The effect of entrained solids depends on the amount of entrainment. If a value of 100 pmm of entrained solids is used (which was suggested by some technical experts), the effect of entrained solids is shown to be negligible. AZ-101 can be considered the worst case of the DSTs because it contains the highest inventory of TRU solids. In the case of AZ-101 only about 1 nCi/g of TRU is estimated to be added by entraining 100 ppm of solids in the transfer. If however a worst case senario of 2 vol. % entrained solids is used about 200 nCi/g of TRU activity are added to the AZ-101 case. The question then becomes one of what level of solids entrainment can really be expected in a reasonable worst case senario.

The Waste Pumpability Rule may require addition of caustic to DSSF to prevent precipitation of gibbsite. Such caustic addition does not however appear to impact the recommended feed staging plan/schedule.

Retrieval Equipment

The ranking of tanks by relative difficulty of retrieval is deemed appropriate and valid based on the given assumptions.

Intermediate Staging Tank Allocation

The selection of the intermediate staging tanks was reviewed. The criteria and process used for selection are deemed valid. The specific criteria for preliminary screening to exclude tanks from further consideration are: tanks containing concentrated waste, tanks containing sludge, tanks listed as watch list tanks, tanks identified for some conflicting purpose such as evaporator feed or receiver tank, tanks in west area which would require cross-site transfers, and tanks with potential for transfer conflicts. These criteria were reviewed and found to be valid.

The criteria to exclude tanks with concentrated waste should be further defined. This criteria could probably be defined as tanks with high inventories of sodium such that dilution would be required to achieve a 7 M Na^+ solution. This definition along with the other criteria were used to check the list of preliminarily excluded DSTs in Table 2-20 with the conclusion that the preliminary selection is valid. Most tanks which are excluded have more than one negative attribute.

The criteria to exclude tanks with potential transfer conflicts is carried out in the LLW feed staging plan by assigning this negative attribute to all tanks in the AN, AW, AY, and AZ farms. This is a valid assignment considering that transfers from these farms to the contractor tanks in the AP farm would require use of valve pits and transfer line segments common to several other tanks and/or the evaporator.

The criteria of cost of upgrading DSTs and transfer system which lead to the selection of AP-102 and AP-104 over the other AP tanks was not reviewed in detail.

Transfer System Cost Benefit

The transfer system cost benefit was reviewed as background for the review of the LLW Feed Staging Plan. The details of the transfer system cost benefit (e.g. cost data) were not reviewed in detail nor was the decision evaluated. The choice of Alternative K appears to be valid based on the given cost, hydraulic, and conflict potential criteria.

Low Level Waste and High Level waste Feed Delivery Timing Study

The logic and equations used to randomly selected variables as input to the computer simulation which model and are used to evaluate the performance of the feed delivery alternatives were reviewed and found to be valid correct as used.

Parameter inputs to the Feed Delivery Timing Study e.g. *Time Needed to Sample and Deliver to the Laboratory* were not verified.

Detailed calculations leading to the results of the Feed Delivery Timing Study were not reviewed. The simulation model was reviewed earlier by Allen (1996).

Don't Say It--Write It
From Kevin Eager
Page 6

Intermediate Staging Tank Upgrades

Feed makeup requirements pertaining to the cost benefit of the transfer system cannot be commented on as this section was not reviewed as part of this effort. Other feed makeup and verification requirements are deemed to be appropriate and valid. A more valid approach is likely to be to prevent gibbsite formation by adding caustic at the point of dilution which would impact the retrieval and or transfer system design.

Feed delivery requirements were not reviewed in detail as part of this effort.

Double-Shell Tank Processing Sequence

All proposed DST waste transfers listed in the schedule (Figure 3-1) were reviewed in detail. No tank volume conflicts were found upon review of these scheduled transfers i.e. based on the assumed tank inventories and volumes and assuming that no other waste is added to the affected tanks.

In this plan several heels of waste of a different envelope are mixed with feed batches which are processed: For example a heel of AP-102 (envelope C) is mixed with the first batch (envelope A). A heel of AP-108 (envelope C) is combined with the other half of the first batch (envelope A). A heel of AP-105 (envelope C) is combined with half of the second batch (envelope A). In these particular cases, a detailed analyses was done to verify that the heels do not change the envelope classification of the feed to the vendor. Other mixing cases are evident within the plan (i.e. envelope changes) and while not each was reviewed in detail as long as the rules as outlined in the Heel Mixing Study are followed, no feed envelope should be jeopardized.

Conclusions and Recommendations

The conclusion that feed is available in the DSTs to meet the minimum sodium requirements for two contractors for envelopes A, B, and C based on the assumed DST inventory and with the caveat that a small fraction of the sodium to meet the envelope A limit is from a tank which is marginally within the envelope, was verified and is found to be a valid conclusion.

The recommendations to impose additional minimum requirements on Envelopes B and C so that they are mutually exclusive from Envelope A needs to be explained in more detail, e.g. specify assumptions A.5.1, and A.5.2.

Don't Say It--Write It
From Kevin Eager
Page 7

The recommendation to "consider the specific hypothetical limit changes discussed in Section 2.5.3 need to be clearly explained. Upon review of section 2.5.3 it is not clear what these limit changes are.

The recommendations to limit maximum transfer set-up times to 25 days and to keep the minimum campaign length larger than 100 days are a valid conclusion based on the results of the Feed Delivery Timing Study.

REFERENCES

Allen, G. K., 1996, "Review Of WHC-SC-WM-RPT-224. Rev. 0", (cc: mail, to P. J. Certa, July 1, 1996), Westinghouse Hanford Company, Richland, Washington.

Eager, M. K., 1996, "Technical Review Of Heel Mixing Study", (DSI, to P. J. Certa, June 19, 1996), Westinghouse Hanford Company, Richland, Washington.

Kurath, D. E., et al., 1994, *Experimental Data and Analysis to Support the Design of an Ion Exchange Process for the Treatment of Hanford Tank Waste Supernatant Liquids*, PNL-10187, UC-721, December 1994, Pacific Northwest Laboratory, Richland, Washington.

Orme, R. M., 1995, *TWRS Process Flowsheet*, WHC-SD-WM-TI-613, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Foster 1996

Author: James L Foster at ~WHC352
Date: 1/8/96 11:55 AM
Priority: Normal

TO: Paul J Certa at ~WHC53

CC: James L Foster

Subject: Verify Assumptions for Preliminary LLW Feed Staging Plan
------------------------------ Message Contents ------------------------------

Jim,

I've assembled a bunch of assumptions talking with different people that concern things within Operations jurisdiction. Would you look over the assumptions below and let me know if you agree with them. If not, would you provide the proper assumptions. If you have a referencable basis for these assumptions (or your changes) would you let me know. Otherwise, I will cite your response (assuming you respond by ccMail). Could you respond by close-of-business this Wed?

These are some of the assumptions I'm using to compare several different feed staging alternatives. Rather than using point-values for all variables, I am using ranges from some of them to account for uncertainty. To establish the range, I need a Minimum, Maximum, and Median value. The Median is the value which half of the time you are above and half of the time you are below. Its a nominal value.

1) The time needed to set up for a transfer of supernate from any DST (not in AP farm) to a DST in AP farm.
   Minimum: 1 day
   Median: 3 days
   Maximum: 30 days.

   Many transfers from outside AP farm will require jumper changes which are generally scheduled far in advance of the transfer. Generally plan for one jumper change for each transfer. These generally take three days to complete. Those three days do not account for planning time, scheduling time or weather delay time. As an example we have been trying to set up a transfer from AN farm to AP farm to support one of our next campaigns. We started planning it approx. 2 months ago and have tried to schedule it several times, each time it is delayed due to priorities. There is no hard and fast answer to this question. Minimum is one day if no jumper changes are required. Median is probably closer to two weeks, and that is if all packages are ready to work and planned (scheduled earlier). The maximum is probably closer to two months or more.

CC:Mail Message
From James L Foster
Page 2

2) The time needed to setup, take samples, and deliver the samples to the lab. Assume we are talking about 6 grab samples from a tank in AP-farm. They will probably need to be tank from different risers and at different depths.
   Minimum: 1 day
   Median: 1 day
   Maximum: 5 days

   Median is probably two days. Otherwise your assumptions are pretty close.

3) The time needed to setup for a transfer within AP-Farm. I've assumed that this is essentially 0. You can suggest other values if you wish.
   Minimum: 0 days
   Median: 0 days
   Maximum: 0 days

   How can you have zero days? I suggest one day for minimum and median. The maximum should probably be 2 months, similar to above, to allow for possible failed pumps or unexpected problems.

For the remaining assumptions I've used point values. You can suggest ranges (minimum, median, and maximum) if you wish.

4) The pumping rate of supernate from any DST not in AP-farm to a DST in AP-farm.
   Minimum: 130 gpm 120gpm
   Median: 130 gpm about right
   Maximum: 130 gpm 180gpm

5) The rate at which dilution water can be added to a tank in AP-farm.
   Minimum: 60 gpm
   Median: 60 gpm about right
   Maximum: 60 gpm

6) The pumping rate of supernate from a DST in AP-farm to another DST in AP-farm.
   Minimum: 140 gpm same as 4 above
   Median: 140 gpm
   Maximum: 140 gpm

Thank-you for your help. Contact me if you need additional background information. You will be on review and distribution of the final report so you'll get another chance to review the assumptions and how I use them.

Paul Certa
376-5429

Herting 1996

Author: Daniel L Herting at ~WHC167
Date: 1/9/96 8:34 AM
Priority: Normal

TO: Paul J Certa at ~WHC53, Daniel A Reynolds at ~WHC140

CC: David E Bowers at ~WHC23

Subject: Re[2]: Dilution Water pH Requirements
------------------------------ Message Contents ------------------------------

The only "setting up" from Al(OH)3 gel that I've ever heard about happened in REDOX when the acid waste was neutralized with NaOH before shipping to tank farms. They plugged the waste line pipes a number of times, and had to get the fire department to "blow" the lines with pressurized water. (That's when they went to reverse strike neutralization, and it stayed that way through most of PUREX operations, even though it was no longer necessary. REDOX waste was loaded with Al because ANN was used as a salting agent for the solvent extraction.)

I have seen a number of cases where dilution of a sample with water caused Al to precipitate as Gibbsite, but never as a gel. The precipitation occurs so slowly, apparently, that it goes to Gibbsite as fast as it precipitates. The only Al(OH)3 gels I've seen in the laboratory occurred when acid was added to aluminate solution, or base was added to ANN solution, so that the Al(OH)3 formed virtually instantaneously.

The crystalline Gibbsite that forms when water is added to a solution of aluminate should not cause much of a problem. In the lab samples, it settles neatly out of solution, leaving the solution nice and clear. The particles are easily re-suspended. They behave more-or-less like real fine sand.

Dan Herting

____________________ Reply Separator ____________________
Subject: Re: Dilution Water pH Requirements
Author: Daniel A Reynolds at ~WHC140
Date: 1/9/96 8:01 AM

As near as I know, there have been no tanks that has been "set" up due to aluminum gel. I do not know if there have been line pluggage due to aluminum gel but I have never looked into that very close.

My understanding is that several waste samples have turned to gel when dilution water was added at the laboratories.

CC:Mail Message
From Daniel L Herting
Page 2

My understanding is the aluminum first forms an amorphous aluminum hydroxide phase which behaves like a gel. This slowly transforms to the mineral gibbsite which is thermodynamically more favorable. I expect that gibbsite is less of a problem than the gel phase.

The aluminum phase diagram in G. Scot Barney's document ARH-ST-133 (affectionately called the Barney diagram) is the best to demonstrate what happens when dilution water is used. It can be used to make a case that the amount of aluminum and other salts are of only minor considerations. The amount of caustic is the controlling analyte.

Barney's work is easier to understand but Dr.. Dan Herting's work is closer to the reality we find in the tank farms. Over the years he has studied equilibrium and reaction rates of both gibbsite and aluminate.

Dan Reynolds
373-3115

____________________________ Reply Separator _________________________________
Subject: Dilution Water pH Requirements
Author: Paul J Certa at ~WHC53
Date: 01/07/96 01:46 PM

Dan,

Staging of LLW for feed to the private contractors typically requires a nominal dilution of 1-part water to 1-part waste to meet the feed specifciations.

I understand that if raw water is added to certain DST waste, the local reduction in pH may cause gibbsite to precipiate. Even if pH is OK after the water & waste is fully mixed, the dissolution kinetics are very slow.

For what types of DST supernates does this concern apply (DN, DSS, DSSF, NCAW, CC)? Does this concern apply to retrieved saltcake?

Is gibbsite the solid that is precipitated?

What pH water is required to prevent the precipitation of these solids?

Can you provide citations?

Thanks,
Paul

Kirkbride 1995

Schedule Activity Planning Form

Page 1 of 2
Rev.__

Date: 9/15/95 Prepared by: RA Kirkbride

Schedule Act. No.: L1W02742-2748	PMS Act. No.:	FDS CAP No.: 1D6102	
Activity Title: LLW Feed Staging Plan	Activity Type: [ ] DNFSB [ ] Fieldwork [ ] Safety Initiative[ ] Other		
	WBS (SMS) No.: 1.1.1.3.2.1.2.9	Duration:	
Responsible Manager:	ADS No.: 1230	Constraint Date:	

Activity Scope:

Evaluate DST supernate compositions and Hanford tank farm configuration to identify how to provide 4 million gallons of liquid LLW feed to two DSTs assigned to two private vendors. The workscope includes and initial feasibility study, preparation and approval of a LLW feed staging plan, and revision of the staging plan to address bidder comments. The 4 million gallons will include waste from 3 LLW types. The work includes identifying the waste transfers and transfer routings and performing a mass balance for the transfer. Manage LLW pretreatment work performed by Disposal Engineering.

Deliverables:	*If this deliverable is a milestone, fill out this section.*				
	Type	Start MS	Finish MS	MS Ctrl. No.	Comp. Date
1. Issue Feed Staging Feasibility Study (L1W02742A)	5		X	T32-96-020	11/1/95
2. Issue Draft Preliminary Feed Staging Plan (L1W02744A)	6		X	T32-96-021	1/15/96
3. Issue Preliminary Feed Staging Plan (L1W02746A)	5		X	T32-96-022	2/15/96
4. Confirmation of Preliminary Feed Staging Plan (L1W02748A)	5		X	T32-96-023	8/15/96
5.					
6.					
7.					

Milestone Types: 1=TPA Major, 2=TPA Interim, 3=TPA Target, 4=DOE-HQ, 5=DOE-RL, 6=WHC Key, 7=WHC Other

Assumptions/Key Predecessors:

Impacts/Risks:

54-3000-101 (9/59) GEF014

Kruger 1996

Author: Albert A Kruger at ~WHC55
Date: 1/8/96 2:49 PM
Priority: Normal

TO: Paul J Certa at ~WHC53

CC: Susan J Eberlein at ~WHC352

Subject: Verify Assumptions for Preliminary LLW Feed Staging Plan
------------------------------ Message Contents ------------------------------

Susan,

I've assembled a bunch of assumptions talking with different people (you included) that concern characterization. Would you look over the assumptions below and let me know if you agree with them. If not, would you provide better assumptions. If you have a referenceable basis for these assumptions (or your changes) would you let me know. Otherwise, I will cite your response (assuming you respond by ccMail). Could you respond by close-of-business this Wed?

These are some of the assumptions I'm using to compare several different feed staging alternatives. Rather than using point-values for all variables, I am using ranges from some of them to account for uncertainty. To establish the range, I need a Minimum, Maximum, and Median value. The Median is the value which half of the time you are above and half of the time you are below. Its a nominal value.

No comments or corrections. In speaking with DWH, such activities are covered by existing Tank Farms Operations Permits and so there is no "treatment" protocol that applies.

1) The time needed to mix a DST containing supernate (such as DSSF, DSS, CC or NCAW) and pH adusted dilution water prior to taking grab samples. A small fraction of the time, no dilution water will be needed. Most of the time the waste:water ratio will be 1:1.
   Minimum: 0 day
   Median: 7 days
   Maximum: 14 days.

2) The number and type of samples that need to be taken from a DST containing mostly supernate to verify the composition prior to transfer to the Private LLW Contractors (planning basis):

   6 grap samples at random heights and risers.

CC:Mail Message
From Albert A Kruger
Page 2

Be aware that for BY-110 we are at 70 days and we are not done. Otherwise your numbers are reasonable for a less "involved" tank 3) The time needed for the lab (once custody is transfered) to analyse and report the results of the above samples. Expect to have to run g/l on: Al, Ba, Ca, Cd, Cl, Cr, F, Fe, Hg, K, La, Na, Ni, NO2, NO3, OH, Pb, PO4, SO4, TIC, TOC and U and Bq/L on: TRU, Cs137, Sr89/90 and Tc99. Also will need: supernate density, bulk density, pH, volume % settled solids, wt % settled solids, and %water. The sample should normally be less than 5 volume % settled solids.

Minimum: 14 days
Median: 60 days
Maximum: 60 days

We'd feel better taking the median out to 3 days.

3) The time needed to evaluate the above results. By this I mean to compair all of the results against a set of specifications (upper and lower limits and some other constraints), get clarification of weird results (perphaps rerunning an analysis), and determining the bulk and supernate composition of the waste in the tank.

Minimum: 1 days
Median: 1 days
Maximum: 5 days

Thank-you for your help. Contact me if you need additional background information. You will be on review and distribution of the final report so you'll get another chance to review the assumptions and how I use them.

Paul Certa
376-5429

Wiemers 1995

Author: Karyn D Wiemers at ~PNL95
Date: 9/29/95 6:52 AM
Priority: Normal

TO: Paul J Certa at ~WHC53

CC: Thomas W Wood at ~PNL2, Dewey A Jr Burbank at ~WHC53, Karyn D Wiemers, William G Richmond at ~PNL88, Jeffry A Voogd at ~WHC347, Bruce A Reynolds at ~PNL24

Subject: Re: Feed Envelopes - Solids Questions
------------------------------ Message Contents ------------------------------

Karyn,

Two related questions concerning the draft feed envelopes:

1) Are the concentrations (g/l) of various constituents for the supernate only or supernate togehter with entrained and/or bulk solids? The envelope boundaries are expected to be conservative enough to include entrained solids.

2) What are allowable amounts and/or composition of entrained or bulk solids permitted to be transferred from the DST system to the vendor feed DSTs? maximum: 5 vol%

Paul

APPENDIX H

TRANSFER SYSTEM ALTERNATIVES

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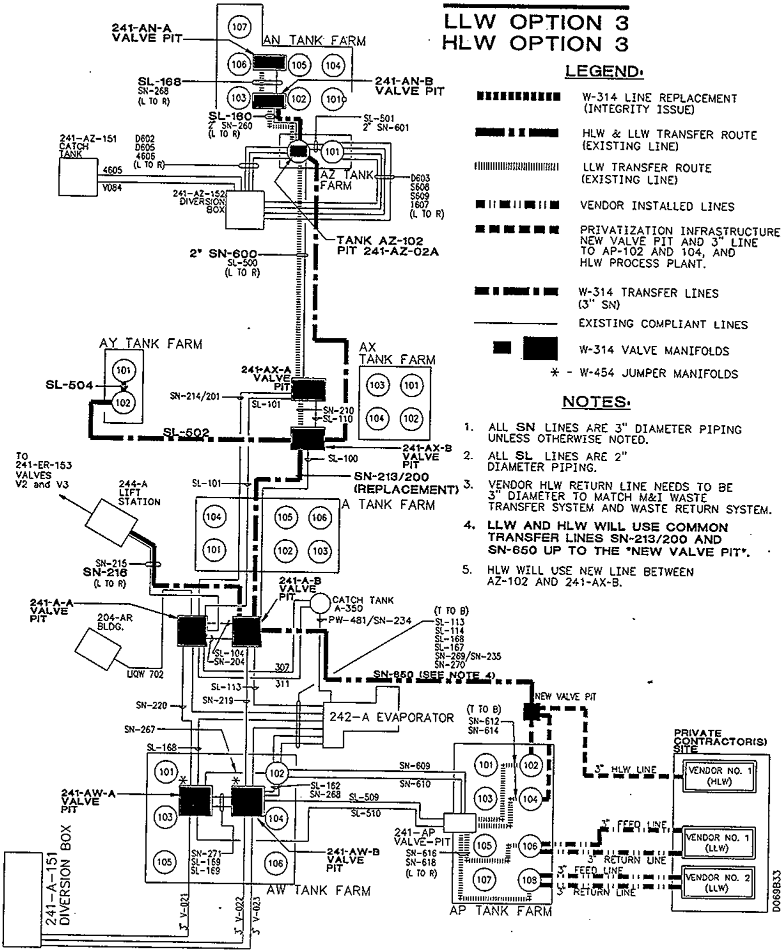
ALTERNATIVE B node 2B

LLW OPTION 3
HLW OPTION 3

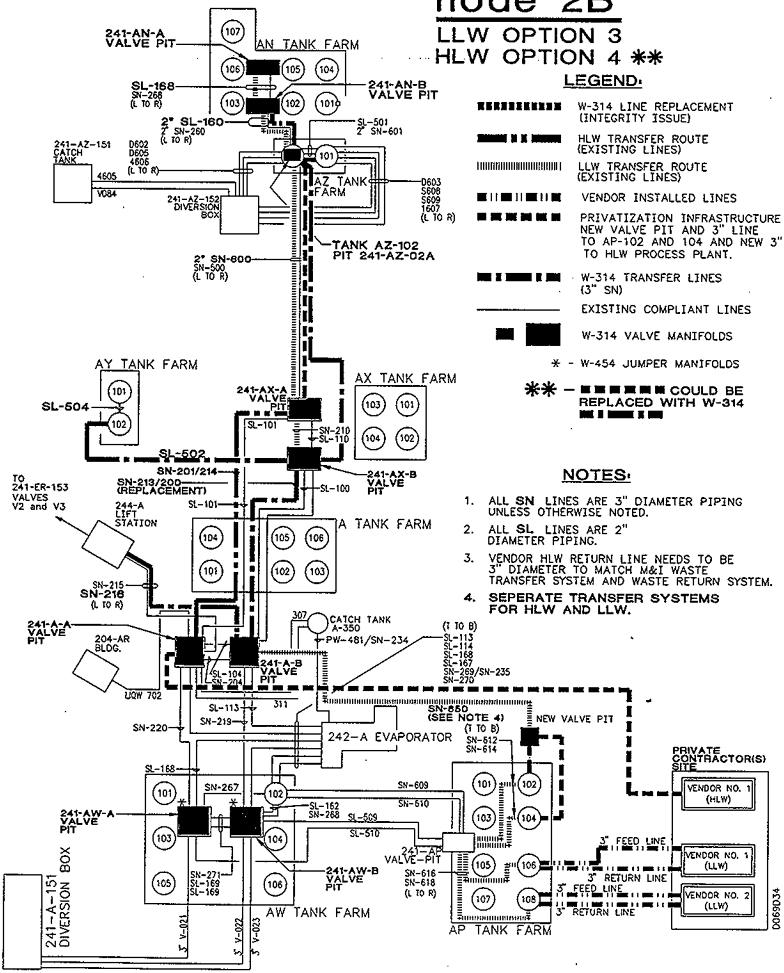


NOTES:

1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. **LLW AND HLW WILL USE COMMON TRANSFER LINES SN-213/200 AND SN-650 UP TO THE "NEW VALVE PIT".**
5. HLW WILL USE NEW LINE BETWEEN AZ-102 AND 241-AX-B.

ALTERNATIVE D node 2B

LLW OPTION 3
HLW OPTION 4 **



LEGEND:

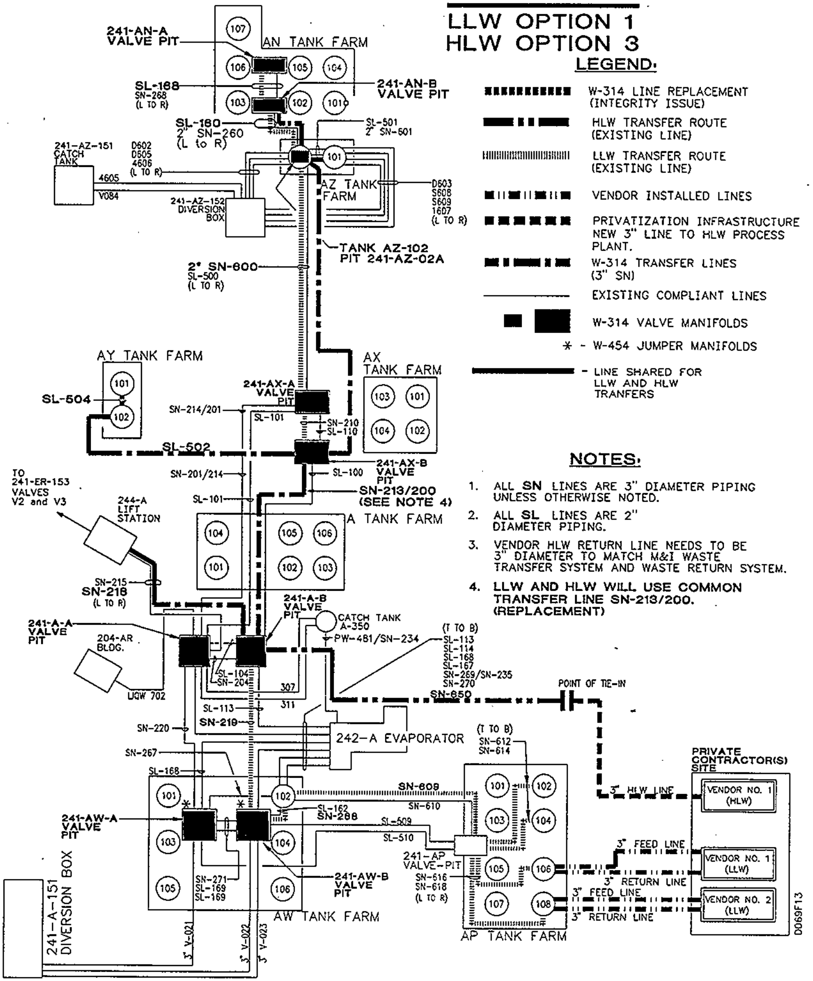
- W-314 LINE REPLACEMENT (INTEGRITY ISSUE)
- HLW TRANSFER ROUTE (EXISTING LINES)
- LLW TRANSFER ROUTE (EXISTING LINES)
- VENDOR INSTALLED LINES
- PRIVATIZATION INFRASTRUCTURE NEW VALVE PIT AND 3" LINE TO AP-102 AND 104 AND NEW 3" TO HLW PROCESS PLANT.
- W-314 TRANSFER LINES (3" SN)
- EXISTING COMPLIANT LINES
- W-314 VALVE MANIFOLDS
- * - W-454 JUMPER MANIFOLDS
- ** - COULD BE REPLACED WITH W-314

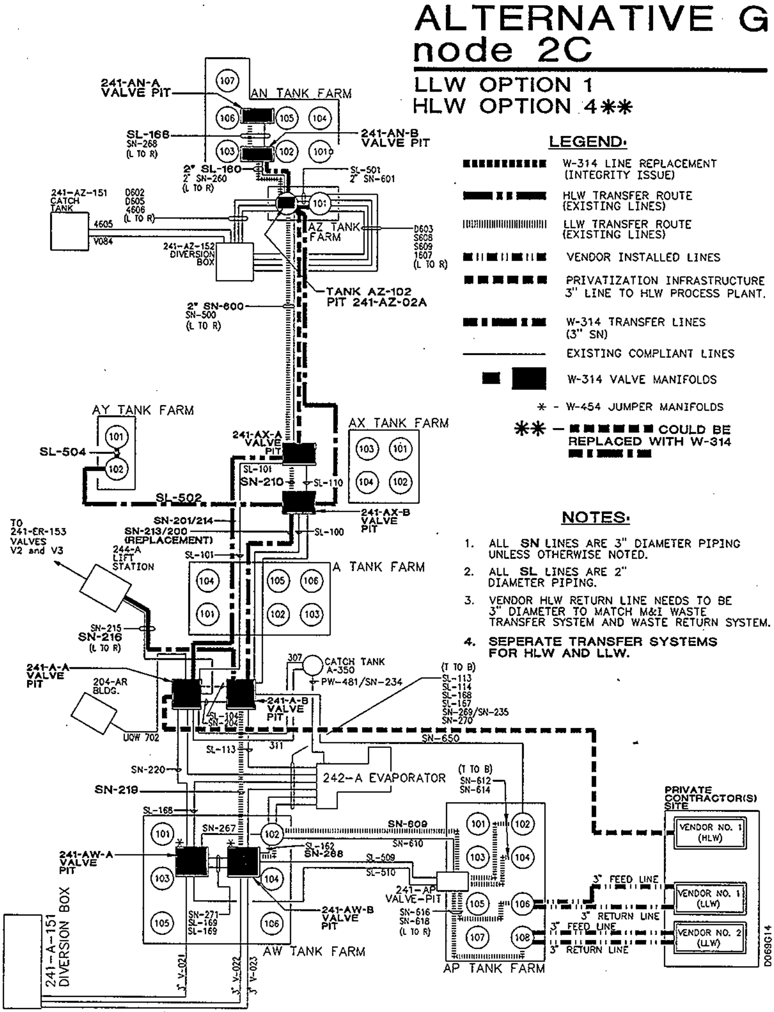
NOTES:

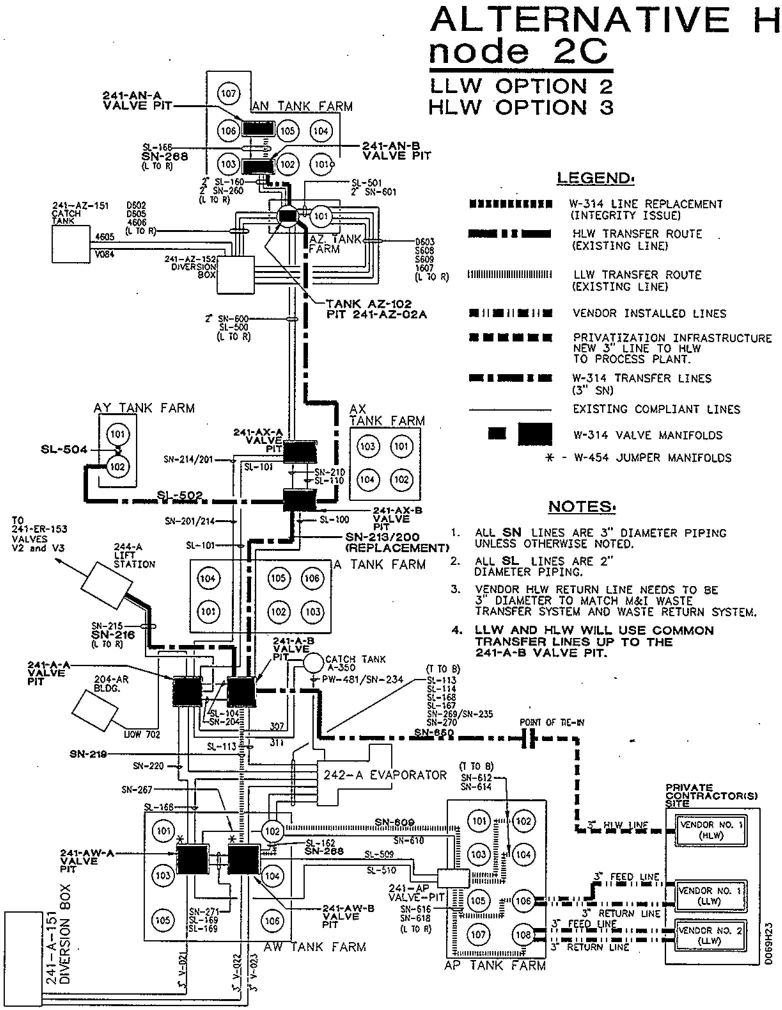
1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. **SEPERATE TRANSFER SYSTEMS FOR HLW AND LLW.**

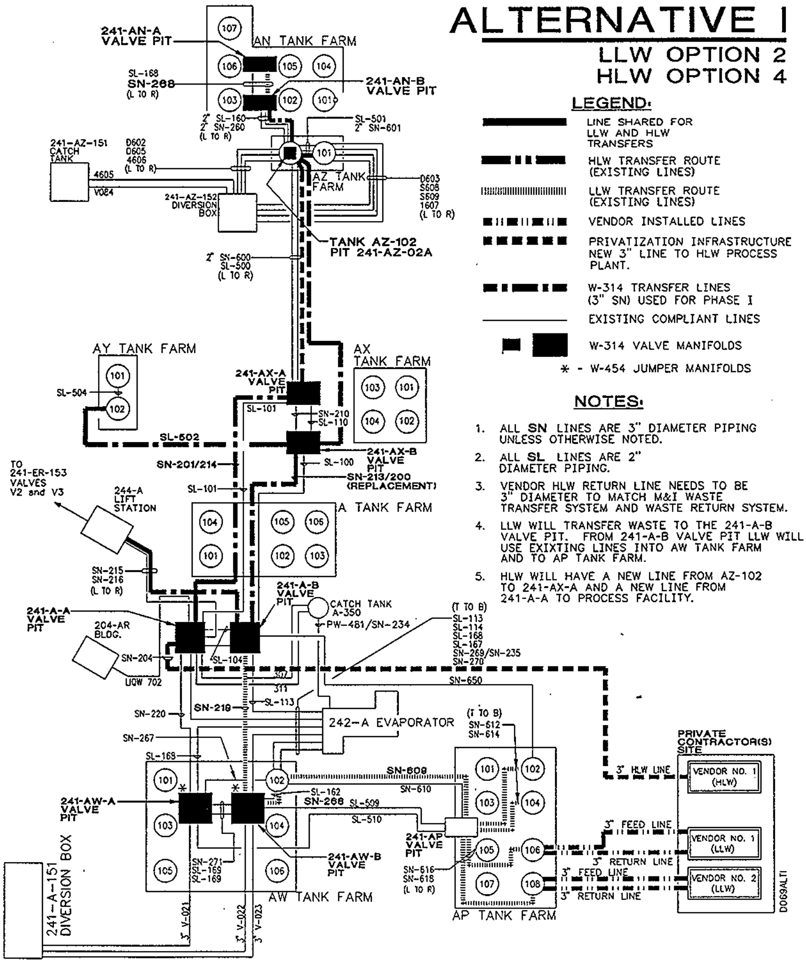
ALTERNATIVE F node 2C

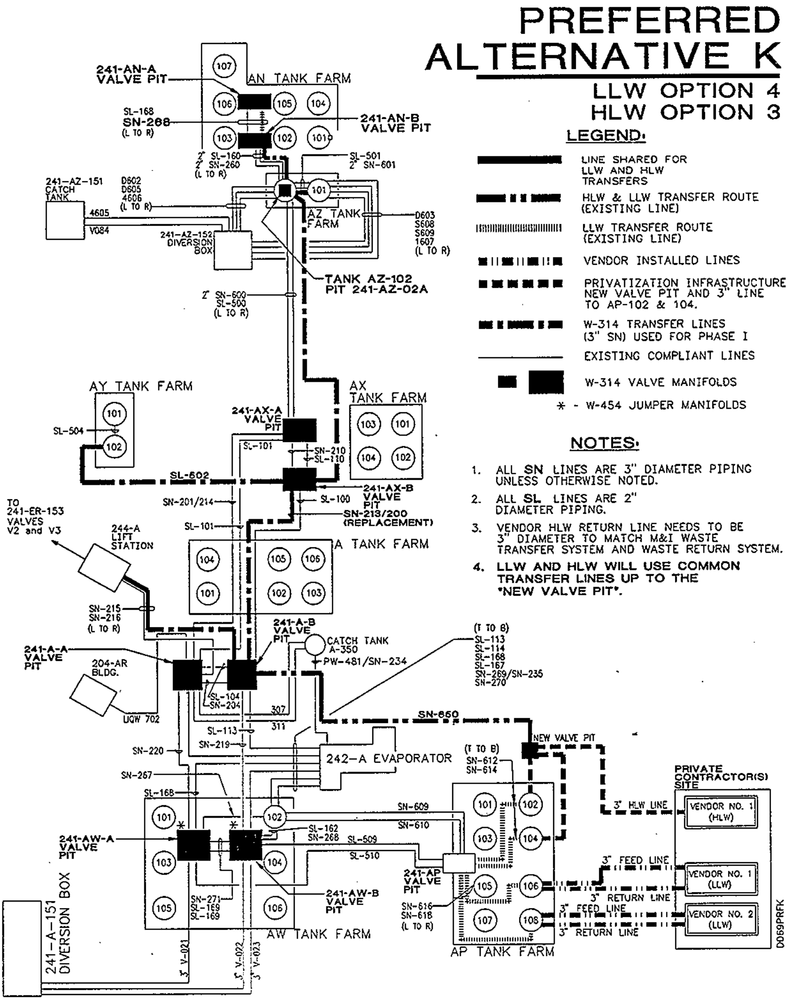
LLW OPTION 1
HLW OPTION 3

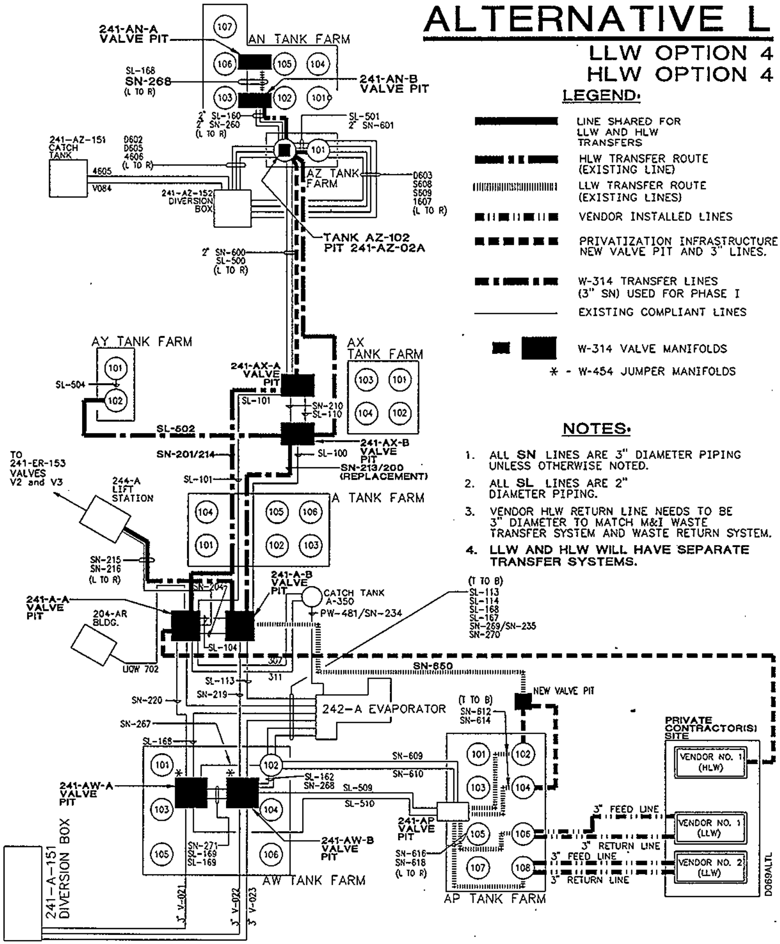



ALTERNATIVE G
node 2C
LLW OPTION 1
HLW OPTION 4**
LEGEND:
W-314 LINE REPLACEMENT (INTEGRITY ISSUE)
HLW TRANSFER ROUTE (EXISTING LINES)
LLW TRANSFER ROUTE (EXISTING LINES)
VENDOR INSTALLED LINES
PRIVATIZATION INFRASTRUCTURE 3" LINE TO HLW PROCESS PLANT.
W-314 TRANSFER LINES (3" SN)
EXISTING COMPLIANT LINES
W-314 VALVE MANIFOLDS
* - W-454 JUMPER MANIFOLDS
** - COULD BE REPLACED WITH W-314
NOTES:
1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. SEPERATE TRANSFER SYSTEMS FOR HLW AND LLW.
241-AN-A VALVE PIT
AN TANK FARM
241-AN-B VALVE PIT
SL-168
SN-268
(L TO R)
2" SL-160
2" SN-260
(L TO R)
SL-501
2" SN-601
241-AZ-151 CATCH TANK
D602
D505
4606
(L TO R)
4605
V084
241-AZ-152 DIVERSION BOX
AZ TANK FARM
D603
S608
S609
1607
(L TO R)
TANK AZ-102
PIT 241-AZ-02A
2" SN-600
SN-500
(L TO R)
AY TANK FARM
SL-504
SL-502
AX TANK FARM
241-AX-A VALVE PIT
SL-101
SN-210
SL-110
241-AX-B VALVE PIT
SL-100
SN-201/214
SN-213/200 (REPLACEMENT)
TO 241-ER-153 VALVES V2 and V3
244-A LIFT STATION
SL-101
A TANK FARM
SN-215
SN-216
(L TO R)
241-A-A VALVE PIT
204-AR BLDG.
UOW 702
241-A-B VALVE PIT
SL-104
SN-204
307
CATCH TANK A-350
PW-481/SN-234
(T TO B)
SL-113
SL-114
SL-168
SL-167
SN-269/SN-235
SN-270
SN-650
SL-113
311
SN-220
242-A EVAPORATOR
SN-219
(T TO B)
SN-612
SN-614
SL-168
SN-267
SN-609
SN-610
SL-162
SN-268
SL-509
SL-510
241-AW-A VALVE PIT
241-AP VALVE-PIT
SN-616
SN-618
(L TO R)
241-AW-B VALVE PIT
SN-271
SL-169
SL-169
AW TANK FARM
AP TANK FARM
241-A-151 DIVERSION BOX
3" V-021
3" V-022
3" V-023
PRIVATE CONTRACTOR(S) SITE
VENDOR NO. 1 (HLW)
3" FEED LINE
VENDOR NO. 1 (LLW)
3" RETURN LINE
3" FEED LINE
VENDOR NO. 2 (LLW)
3" RETURN LINE
D069G14


ALTERNATIVE H
node 2C
LLW OPTION 2
HLW OPTION 3
LEGEND:
W-314 LINE REPLACEMENT (INTEGRITY ISSUE)
HLW TRANSFER ROUTE (EXISTING LINE)
LLW TRANSFER ROUTE (EXISTING LINE)
VENDOR INSTALLED LINES
PRIVATIZATION INFRASTRUCTURE NEW 3" LINE TO HLW TO PROCESS PLANT.
W-314 TRANSFER LINES (3" SN)
EXISTING COMPLIANT LINES
W-314 VALVE MANIFOLDS
* - W-454 JUMPER MANIFOLDS
NOTES:
1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. LLW AND HLW WILL USE COMMON TRANSFER LINES UP TO THE 241-A-B VALVE PIT.
AN TANK FARM
241-AN-A VALVE PIT
241-AN-B VALVE PIT
SL-166
SN-268
(L TO R)
2" SL-160
2" SN-260
SL-501
2" SN-601
241-AZ-151 CATCH TANK
AZ. TANK FARM
241-AZ-152 DIVERSION BOX
TANK AZ-102
PIT 241-AZ-02A
2" SN-600
SL-500
AY TANK FARM
SL-504
SL-502
AX TANK FARM
241-AX-A VALVE PIT
241-AX-B VALVE PIT
SN-214/201
SN-201/214
SL-101
SN-210
SL-110
SL-100
SN-213/200 (REPLACEMENT)
TO 241-ER-153 VALVES V2 and V3
244-A LIFT STATION
A TANK FARM
SN-215
SN-216
241-A-A VALVE PIT
241-A-B VALVE PIT
CATCH TANK A-350
PW-481/SN-234
204-AR BLDG.
SL-104
SN-204
SL-113
SL-114
SL-168
SL-167
SN-269/SN-235
SN-270
SN-650
POINT OF TIE-IN
SN-219
SN-220
SN-267
242-A EVAPORATOR
SN-612
SN-614
241-AW-A VALVE PIT
241-AW-B VALVE PIT
SN-609
SN-610
SL-162
SN-268
SL-509
SL-510
241-AP VALVE-PIT
SN-616
SN-618
SN-271
SL-169
AW TANK FARM
AP TANK FARM
241-A-151 DIVERSION BOX
3" V-021
3" V-022
3" V-023
PRIVATE CONTRACTOR(S) SITE
3" HLW LINE
VENDOR NO. 1 (HLW)
3" FEED LINE
3" RETURN LINE
VENDOR NO. 1 (LLW)
VENDOR NO. 2 (LLW)
D069H23


ALTERNATIVE I
LLW OPTION 2
HLW OPTION 4
LEGEND:
LINE SHARED FOR LLW AND HLW TRANSFERS
HLW TRANSFER ROUTE (EXISTING LINES)
LLW TRANSFER ROUTE (EXISTING LINES)
VENDOR INSTALLED LINES
PRIVATIZATION INFRASTRUCTURE NEW 3" LINE TO HLW PROCESS PLANT.
W-314 TRANSFER LINES (3" SN) USED FOR PHASE I
EXISTING COMPLIANT LINES
W-314 VALVE MANIFOLDS
* - W-454 JUMPER MANIFOLDS
NOTES:
1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. LLW WILL TRANSFER WASTE TO THE 241-A-B VALVE PIT. FROM 241-A-B VALVE PIT LLW WILL USE EXIXTING LINES INTO AW TANK FARM AND TO AP TANK FARM.
5. HLW WILL HAVE A NEW LINE FROM AZ-102 TO 241-AX-A AND A NEW LINE FROM 241-A-A TO PROCESS FACILITY.
AN TANK FARM
241-AN-A VALVE PIT
241-AN-B VALVE PIT
SL-168
SN-268
(L TO R)
2" SL-160
2" SN-260
(L TO R)
SL-501
2" SN-601
241-AZ-151 CATCH TANK
D602
0605
4606
(L TO R)
4605
V024
241-AZ-152 DIVERSION BOX
AZ TANK FARM
D603
S608
S609
1607
(L TO R)
TANK AZ-102
PIT 241-AZ-02A
2" SN-600
SL-500
(L TO R)
AY TANK FARM
SL-504
AX TANK FARM
241-AX-A VALVE PIT
SL-101
SN-210
SL-110
SL-502
241-AX-B VALVE PIT
SN-201/214
SL-100
SN-213/200 (REPLACEMENT)
TO 241-ER-153 VALVES V2 and V3
244-A LIFT STATION
SL-101
A TANK FARM
SN-215
SN-216
(L TO R)
241-A-A VALVE PIT
241-A-B VALVE PIT
CATCH TANK A-350
PW-481/SN-234
(T TO B)
SL-113
SL-114
SL-168
SL-167
SN-269/SN-235
SN-270
204-AR BLDG.
SN-204
UGW 702
SL-104
307
311
SN-650
SN-219
SL-113
SN-220
242-A EVAPORATOR
(T TO B)
SN-612
SN-614
SN-267
SL-168
SN-609
SN-610
SL-162
SN-268
SL-509
SL-510
241-AW-A VALVE PIT
241-AW-B VALVE PIT
241-AP VALVE PIT
SN-271
SL-169
SL-169
SN-616
SN-618
(L TO R)
AW TANK FARM
AP TANK FARM
241-A-151 DIVERSION BOX
3" V-021
3" V-022
3" V-023
PRIVATE CONTRACTOR(S) SITE
3" HLW LINE
VENDOR NO. 1 (HLW)
3" FEED LINE
VENDOR NO. 1 (LLW)
3" RETURN LINE
3" FEED LINE
VENDOR NO. 2 (LLW)
3" RETURN LINE
D069ALT1


PREFERRED
ALTERNATIVE K
LLW OPTION 4
HLW OPTION 3
LEGEND:
LINE SHARED FOR LLW AND HLW TRANSFERS
HLW & LLW TRANSFER ROUTE (EXISTING LINE)
LLW TRANSFER ROUTE (EXISTING LINE)
VENDOR INSTALLED LINES
PRIVATIZATION INFRASTRUCTURE NEW VALVE PIT AND 3" LINE TO AP-102 & 104.
W-314 TRANSFER LINES (3" SN) USED FOR PHASE I
EXISTING COMPLIANT LINES
W-314 VALVE MANIFOLDS
* - W-454 JUMPER MANIFOLDS
NOTES:
1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. LLW AND HLW WILL USE COMMON TRANSFER LINES UP TO THE "NEW VALVE PIT".
AN TANK FARM
241-AN-A VALVE PIT
241-AN-B VALVE PIT
SL-168
SN-268
(L TO R)
2" SL-160
2" SN-260
(L TO R)
SL-501
2" SN-601
241-AZ-151 CATCH TANK
D602
D605
4606
(L TO R)
4605
V084
241-AZ-152 DIVERSION BOX
AZ TANK FARM
D603
S608
S609
1607
(L TO R)
TANK AZ-102
PIT 241-AZ-02A
2" SN-609
SL-509
(L TO R)
AY TANK FARM
SL-504
AX TANK FARM
241-AX-A VALVE PIT
SL-101
SN-210
SL-110
SL-602
241-AX-B VALVE PIT
SN-201/214
SL-100
SN-213/200 (REPLACEMENT)
TO 241-ER-153 VALVES V2 and V3
244-A LIFT STATION
SL-101
A TANK FARM
SN-215
SN-216
(L TO R)
241-A-B VALVE PIT
CATCH TANK A-350
PW-481/SN-234
241-A-A VALVE PIT
204-AR BLDG.
SL-104
SN-204
UGW 702
307
311
(T TO B)
SL-113
SL-114
SL-168
SL-167
SN-269/SN-235
SN-270
SN-650
SL-113
SN-219
SN-220
242-A EVAPORATOR
NEW VALVE PIT
(T TO B)
SN-612
SN-614
SN-267
SL-168
PRIVATE CONTRACTOR(S) SITE
3" HLW LINE
VENDOR NO. 1 (HLW)
SN-609
SN-610
SL-162
SN-268
SL-509
SL-510
241-AW-A VALVE PIT
3" FEED LINE
VENDOR NO. 1 (LLW)
3" RETURN LINE
241-AP VALVE PIT
SN-271
SL-169
SL-169
241-AW-B VALVE PIT
SN-616
SN-618
(L TO R)
3" FEED LINE
VENDOR NO. 2 (LLW)
3" RETURN LINE
AW TANK FARM
AP TANK FARM
241-A-151 DIVERSION BOX
3" V-021
3" V-022
3" V-023
D059PRFK


ALTERNATIVE L
LLW OPTION 4
HLW OPTION 4
LEGEND:
LINE SHARED FOR LLW AND HLW TRANSFERS
HLW TRANSFER ROUTE (EXISTING LINE)
LLW TRANSFER ROUTE (EXISTING LINES)
VENDOR INSTALLED LINES
PRIVATIZATION INFRASTRUCTURE NEW VALVE PIT AND 3" LINES.
W-314 TRANSFER LINES (3" SN) USED FOR PHASE I
EXISTING COMPLIANT LINES
W-314 VALVE MANIFOLDS
* - W-454 JUMPER MANIFOLDS
NOTES:
1. ALL SN LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL SL LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. LLW AND HLW WILL HAVE SEPARATE TRANSFER SYSTEMS.
AN TANK FARM
241-AN-A VALVE PIT
241-AN-B VALVE PIT
SL-168
SN-268
(L TO R)
2" SL-160
2" SN-260
(L TO R)
SL-501
2" SN-601
241-AZ-151 CATCH TANK
D602
D505
4606
(L TO R)
4605
V084
241-AZ-152 DIVERSION BOX
AZ TANK FARM
D603
S608
S509
1607
(L TO R)
TANK AZ-102
PIT 241-AZ-02A
2" SN-600
SL-500
(L TO R)
AY TANK FARM
SL-504
AX TANK FARM
241-AX-A VALVE PIT
SL-101
SN-210
SL-110
SL-502
241-AX-B VALVE PIT
SN-201/214
SL-100
SN-213/200 (REPLACEMENT)
TO 241-ER-153 VALVES V2 and V3
244-A LIFT STATION
SL-101
A TANK FARM
SN-215
SN-216
(L TO R)
241-A-A VALVE PIT
204-AR BLDG.
SN-204
241-A-B VALVE PIT
CATCH TANK A-350
PW-481/SN-234
(T TO B)
SL-113
SL-114
SL-168
SL-167
SN-269/SN-235
SN-270
SL-104
UOW 702
307
311
SN-650
SL-113
SN-219
SN-220
NEW VALVE PIT
242-A EVAPORATOR
(T TO B)
SN-612
SN-614
SN-267
SL-168
PRIVATE CONTRACTOR(S) SITE
VENDOR NO. 1 (HLW)
SN-609
SN-610
SL-162
SN-268
SL-509
SL-510
241-AW-A VALVE PIT
241-AP VALVE PIT
3" FEED LINE
VENDOR NO. 1 (LLW)
3" RETURN LINE
3" FEED LINE
VENDOR NO. 2 (LLW)
3" RETURN LINE
SN-271
SL-169
SL-169
241-AW-B VALVE PIT
SN-616
SN-618
(L TO R)
241-A-151 DIVERSION BOX
3" V-021
3" V-022
3" V-023
AW TANK FARM
AP TANK FARM
D069ALTL