**Tank Waste Processing Analysis:
Database Development, Tank-by-Tank Processing
Requirements, and Examples of Pretreatment
Sequences and Schedules as Applied to Hanford
Double-shell Tank Supernatant Waste - FY 1993**

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Summary

This report gives the results of work conducted in FY 1993 by the Tank Waste Processing Analysis Task for the Underground Storage Tank Integrated Demonstration. The main purpose of this task, led by Pacific Northwest Laboratory, is to demonstrate a methodology to identify processing sequences, i.e., the order in which a tank should be processed. In turn, these sequences may be used to assist in the development of time-phased deployment schedules. Time-phased deployment is implementation of pretreatment technologies over a period of time as technologies are required and/or developed.

The work discussed here illustrates how tank-by-tank databases and processing requirements have been used to generate processing sequences and time-phased deployment schedules. The processing sequences take into account requirements such as the amount and types of data available for the tanks, tank waste form and composition, required decontamination factors, and types of compact processing units (CPUs) required and technology availability. These sequences were developed from processing requirements for the tanks, which were determined from spreadsheet analyses. The spreadsheet analysis program was generated by this task in FY 1993.

Efforts conducted for this task have focused on the processing requirements for Hanford double-shell tank (DST) supernatant wastes (pumpable liquid) because this waste type is easier to retrieve than the other types (saltcake and sludge), and more tank space would become available for future processing needs. The processing requirements were based on Class A criteria set by the U.S. Nuclear Regulatory Commission and Clean Option goals provided by Pacific Northwest Laboratory.

Based on the processing sequences developed under this task, several interesting observations have been made:

- The processing sequence for DST supernatant is influenced slightly by changing disposal requirements from NRC Class A criteria to Clean Option goals. Tank AW-101, the first tank listed in the processing sequence based on NRC Class A criteria drops in the processing sequence based on Clean Option goals because of the presence of ^{99}Tc and ^{129}I . These constituents represent about 2% of the total approximate site inventory for each contaminant.
- Tanks that require ^{137}Cs removal also require either organic destruction and/or ^{90}Sr removal to satisfy total organic carbon grout feed acceptance criterion and both NRC Class A criteria and Clean Option goals.
- ^{99}Tc removal technology is required fairly early in the pretreatment sequence to satisfy Clean Option goals, and ^{129}I removal is required later. Even without these technologies immediately available, a case may be made for proceeding with pretreatment of several DSTs if future processing of all remaining tanks includes increased ^{99}Tc and ^{129}I removal.

A simulation study was performed to couple processing sequences with processing rates to generate time-phased deployment schedules. Based on this study and the resulting deployment schedules, the following observations have been made:

- In addition to allowing tanks low in technetium and iodine to be treated first, the Clean Option schedule frees more tank space early in the pretreatment time frame.

- Minimal glass production rates are required to keep up with tank waste processing at 5 gpm. The overall glass production requirement, based on heat loading limits, for treating supernatant from the 20 DSTs is approximately 98 logs.
- Assuming 5M Na in the feed to grout, a total of 7.6×10^4 m³ feed to grout results from pretreating the supernatant from the 20 DSTs. Continual operation of the grout facility, corresponding to at least the same flowrate as the pretreatment processing, would be required for efficient pretreatment.
- Assuming a 5-gpm flowrate and 100% on-stream efficiency, the time required to treat the supernatant in the 20 DSTs is approximately 9 years. This is an idealistic time frame for this flowrate; however, these results can be used as a basis for estimating the total processing time required for different flowrates or multiple CPUs operating in parallel.
- Although tank location was not used as a primary criterion in developing the tank pretreatment sequences or time-phased deployment schedules, the logistics from this standpoint are favorable for early treatment of tanks via both the Clean Option and Class A tank processing schedules that were developed. Seven of the first eight tanks in the Class A sequence and the first seven tanks in the Clean Option sequence are all located in two adjacent tank farms (AW and AP farms).

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Contents

Summary	iii
Acknowledgments	v
1.0 Introduction	1.1
2.0 Processing Analysis Logic Structure	2.1
2.1 Decision-Tree Logic	2.1
2.2 Criteria/Goals for Treatment	2.4
2.3 Tank Waste Composition Databases	2.4
3.0 Processing Analysis for DST Supernatant	3.1
3.1 Definition of DFs	3.1
3.2 Considerations and Assumptions for Processing Requirements	3.2
3.3 Processing Requirements for DST Supernatant	3.3
4.0 Processing Sequences for DST Supernatant	4.1
4.1 Processing Sequence Development	4.1
4.2 Processing Sequence Using Class A Disposal Criteria	4.2
4.3 Processing Sequence Using Clean Option Goals	4.7
5.0 Deployment Schedules for Distributed Processing of DST Supernatant	5.1
5.1 Deployment Schedule Development	5.1
5.1.1 Description of the Simulation Model	5.1
5.1.2 Simulation Study Assumptions	5.2
5.1.3 Simulation Study Results	5.4
5.2 Examples of Time-phased Deployment Schedules	5.9
5.3 Discussion of Results	5.9
6.0 Conclusions	6.1

7.0 References	7.1
Appendix A Example Calculations	A.1
Appendix B DST Supernatant Database	B.1

Figures

2.1	Decision Analysis: Database	2.2
2.2	Decision Analysis: Processing Requirements	2.3
5.1	Example Deployment Schedule: NRC Class A and TOC Grout Feed Acceptance Criteria	5.10
5.2	Example Deployment Schedule: Clean Option Goals and TOC Grout Feed Acceptance Criterion	5.11

Tables

3.1	Comparison of Selected Processing Requirements and Data from Analytical and Inventory Supernatant Databases	3.4
3.2	Processing Requirements to Target: NRC Class A and TOC Grout Feed Acceptance Criteria	3.6
3.3	Processing Requirements: Clean Option Goals and TOC Grout Feed Acceptance Criterion	3.7
4.1	Example of DST Supernatant Processing Sequence and Rationale to Meet: NRC Class A and TOC Grout Feed Acceptance Criteria	4.4
4.2	Processing Requirements Listed in Order of Processing Sequence: NRC Class A and TOC Grout Feed Acceptance Criteria	4.5
4.3	Example of DST Supernatant Processing Sequence and Rationale to Meet: Clean Option Goals and TOC Grout Feed Acceptance Criterion	4.9
4.4	Processing Requirements Listed in Order of Processing Sequence: Clean Option Goals and TOC Grout Feed Acceptance Criterion	4.10
5.1	Simulation Results: NRC Class A and TOC Grout Feed Acceptance Criteria	5.6
5.2	Simulation Results: Clean Option Goals and TOC Grout Feed Acceptance Criterion ...	5.8

1.0 Introduction

Work conducted for the Underground Storage Tank Integrated Demonstration (USTID) supports technology demonstration for tank remediation operations at the U.S. Department of Energy's (DOE) Hanford Site and other DOE sites. An important element of these remediation efforts at Hanford is pretreatment of tank wastes. During pretreatment, radioactive components are separated and concentrated for disposal in a high-level waste (HLW) form; reactive and hazardous constituents are destroyed; and residuals are prepared for near-surface disposal in a low-level waste (LLW) form.

Extensive pretreatment operations offer substantial reductions in the quantity of high-level waste and in the toxicity of the low-level waste. Options being considered for deploying pretreatment technology include a new, large, centralized pretreatment facility; an initial pretreatment module/s (IPM); and compact processing units (CPU) for "distributed processing" (small-scale deployment of multiple process units on a tank-by-tank basis).

The USTID Tank Waste Processing Analysis Task^(a), discussed here, assists strategic planning for implementing pretreatment processing of Hanford tank wastes. This task demonstrates a methodology to identify processing sequences, i.e., the order in which a tank should be processed. In turn, these sequences may be used to assist in development of time-phased deployment schedules. Time-phased deployment is implementation of pretreatment technologies over a period of time as technologies are required and/or developed.

Specific objectives within this task for FY 1993 are to define processing requirements, e.g., required decontamination factors (DFs) for radionuclides and total organic carbon (TOC), for supernatant-type wastes on a tank-specific basis; and to use these requirements to illustrate processing sequences and time-phased deployment schedules for the distributed processing approach. Efforts to date have focused on identifying processing requirements for double-shell tank (DST) supernatant-type wastes because this waste type is easier to retrieve than saltcake and sludge, and treating this waste provides tank space for future processing needs.

This paper reports the results from these efforts and presents examples of tank-by-tank processing sequences and deployment schedules. In addition, the methodologies that were used to determine processing requirements and time-phased deployment schedules are described. Sample calculations are included in Appendix A, and tank waste databases are included in Appendix B. Although the emphasis to date has been on Hanford tank waste processing, the tank waste analysis methodology developed here may be used across the DOE complex where multiple waste types, contained in multiple storage facilities, exist.

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2.0 Processing Analysis Logic Structure

A logic structure, using a spreadsheet format for analysis of the data, was developed by this task during FY 1993 and was used to select the required pretreatment processes for Hanford DST supernatant. The logic structure was developed to accomplish two primary objectives:

- Identify processing requirements to meet pretreatment criteria on a tank-by-tank basis. These requirements were then used to develop a time-phased deployment schedule for distributed processing.
- Rapidly evaluate the effect of changes in pretreatment criteria and/or database on processing requirements.

The spreadsheet format uses decision-trees that represent the processing logic of specific chemical approaches to pretreatment, quantitative criteria that represent the target waste component concentrations for any disposal/pretreatment scenario, and tank waste characterization data to identify process needs and required DFs for pretreating waste in each tank.

2.1 Decision-Tree Logic

A series of decision-trees, built into a spreadsheet format, are used to identify pretreatment processes required to meet various criteria for both LLW and HLW forms as well as for operational safety. The decision-trees are composed of activities, decisions, and criteria sets (refer to Figures 2.1 and 2.2). The decision-tree logic for processing supernatant is illustrated in Figure 2.2, and a simplified hand calculation is provided in Example 1, Appendix A, to illustrate how the spreadsheet format operates.

The spreadsheet analysis begins with identification of a specific tank(s). Identification implies knowledge of the mass/es, volume/s, and constituents, i.e., the database for that tank; and waste type, e.g., liquid, saltcake, or sludge. Each waste type requires a transport activity such as pumping for liquid and mining for saltcake and sludge (refer to Figure 2.1). These activities may be carried out simultaneously; however, the decision-tree treats them as independent activities. Existing characterization data for each tank are allocated to the three waste types, and the processing requirements for each waste type, on a tank-by-tank basis, are determined through a series of decisions that are based on comparison of the characterization data with criteria sets.

The first decision made in the spreadsheet analysis is whether to accept the tank contents as appropriate LLW. The decision is based on Criteria Set A. This criteria set identifies allowed concentrations of key constituents that are potential hazards for near-surface burial. The allowed concentrations are based on radionuclide disposal criteria, e.g., Class A disposal criteria or Clean Option disposal goals; TOC levels in feed to grout; and/or safety issues such as organic/ferrocyanide concentrations. If the waste immediately satisfies Criteria Set A, it is considered suitable for LLW disposal. If the waste does not satisfy the given criteria, outlier analytes are identified, and a decision is made whether reactions must be carried out to satisfy safety considerations (e.g., organic destruction). Criteria Set B, shown in Figure 2.2, is used to determine the extent of reaction, e.g., the DF required.

For Each Box:

- Identify chemicals and radionuclides
- Determine concentration and volumes
- Tally inventories for subsequent processing requirements analysis
- Determine processing requirements for each lower box

Figure 2.1. Decision Analysis: Database

Figure 2.2. Decision Analysis: Processing Requirements

Next, a decision is made to determine if the DF, established by Criteria Set C, is sufficient to render the outlier constituents, i.e., the constituents that did not meet Criteria Set A, suitable for LLW disposal. If the DF is sufficient, the waste streams can be split into HLW (radionuclides), LLW (bulk constituents, trace radionuclides), and a uranium stream for re-use. If the DF is not sufficient, new outlier constituents are identified, and the whole stream is sent to HLW. At this point, a decision is made whether constituents that are detrimental to glass production require removal. This decision is based on Criteria Set D, which contains concentration thresholds for glass production. The decision cycle may be repeated, while increasing DFs established by Criteria Set C, until disposal criteria are satisfied.

Note that any or all decision points in the decision analysis shown in Figure 2.2 can be enabled in the spreadsheet. Also note, all criteria values included in the spreadsheet can easily be changed so that influences of changing criteria on processing requirements can readily be determined.

2.2 Criteria/Goals for Treatment

Criteria/goals for treatment arise from the following considerations:

- acceptance of radionuclide and hazardous material contents for LLW disposal
- acceptance of operational safety for tanks containing organic and ferrocyanide constituents
- acceptance of TOC limits in LLW
- acceptance of constituents detrimental to conversion to glass for HLW disposal.

The analyses that are discussed in Sections 3 and 4 focus primarily on processing requirements to remove radionuclides and organics from the waste to meet LLW disposal criteria.

2.3 Tank Waste Composition Databases

Developing accurate tank waste composition databases is important because inaccuracies in the databases translate into uncertainties in the processing requirements defined for each tank. Data from analytical characterization reports and process and transfer history records provided tank-specific compositions for one database used in the tank waste processing analysis for DST supernatant wastes. This database will be updated as new data become available. Because the contents of some tanks have not been characterized, estimated inventories of chemical constituents and principal radionuclides also were used to provide waste-type compositions for DSTs in a second database. Both databases are included in Appendix B along with corresponding reference information. Similar databases will be established for the sludge and saltcake fractions of the DSTs and for all waste types contained in SSTs.

3.0 Processing Analysis for DST Supernatant

This section discusses the spreadsheet processing analysis for Hanford DST supernatant waste using two acceptance scenarios: 1) U.S. Nuclear Regulatory Commission (NRC) Class A criteria (10 CFR 61) and 2) Clean Option goals (Straalsund et al. 1992; Swanson 1993). NRC Class A criteria are given below for the radionuclides considered in this report. The values are given in terms of μCi radionuclide/gram of waste form:

Radionuclide	Class A near-surface disposal criteria ($\mu\text{Ci/g}$ waste form) ^(a)
⁹⁰ Sr	0.022
¹³⁷ Cs	0.56
TRU	0.01
⁹⁹ Tc	0.167
¹²⁹ I	0.0044

(a) Assumes a waste form density of approximately 1.8 g/mL.

Clean Option goals coincide with the Class A criteria, with the exception of technetium and iodine. The Clean Option goals include removal of these two radionuclides on an ALARA basis because of their high mobility in the environment. The tentative specific goal is to send < 1% of the total technetium inventory to near-surface burial, i.e., an overall DF of 100; and < 10% of the total iodine inventory to near-surface burial, i.e., an overall DF of 10 (Straalsund et al. 1992; Swanson 1993). The total technetium inventory is estimated to be 3×10^4 Ci, and the total iodine inventory is estimated to be 50 Ci (DOE 1987).

3.1 Definition of DFs

The radionuclide DFs used in the following sections are defined below:

$$DF_{\text{radionuclides}} = \frac{(\mu\text{Ci Radionuclide/g waste form})_u}{(\mu\text{Ci Radionuclide/g waste form})_t}$$

where

$(\mu\text{Ci Radionuclide/g waste form})_u =$ untreated radionuclide concentration after being concentrated to 5M Na and being sent to grout.

$(\mu\text{Ci Radionuclide/g waste form})_t =$ radionuclide target concentration based on Class A criteria or Clean Option goals.

This definition is fixed relative to the final waste form product rather than the feed stream concentration. Thus, if a required DF of 100 is given, this same DF value may be used to define a processing DF based on, for example, the volumetric flow to the pretreatment step, e.g., cesium ion exchange, assuming the volumetric (and sodium) flow into and out of this processing step remains unchanged. Example calculations are provided in Example 2, Appendix A, for further illustration.

DFs for radionuclides are presented in conservative decade units; e.g., if a DF of 50 is required, then a minimum required DF of 100 is reported; if a DF of 3 is required, then a minimum required DF of 10 is reported, etc. While the spreadsheet allows more "precise" DFs to be determined, radionuclide DFs are reported in decade units for the following reasons: 1) Many times the data used are not accurate enough to predict a DF with much more precision; 2) from a processing point of view, representation of DFs in decade units is sufficient for technology development; and 3) some cushion is built into the required DF, e.g., to take the sum-of-fractions portion of the NRC Class A regulations into account.

In addition, the effects of incrementally increasing the DFs (Criteria Set C) on glass production and grout production can be investigated. For example, a tank may be extremely difficult to treat because the DF for a given radionuclide is greater than any practical one-cycle processing DF. Thus, a decision would have to be made whether to send the contents of this tank to glass without pretreatment, whether to blend the tank waste with other wastes, or whether to process the waste in multiple cycles. This approach allows rapid identification of such a tank and may be used to determine the impact of sending the contents of the tank to glass on the total glass production.

Required DFs for TOC also were calculated. The DF definition is slightly different in this case because the allowable limits are based on feed to grout:

$$DF_{TOC} = \frac{(\text{mg TOC/liter 5M Na feed to grout})_u}{(\text{mg TOC/liter 5M Na feed to grout})_t}$$

where

$(\text{mg TOC/liter 5M Na feed to grout})_u$ = untreated TOC concentration after being concentrated to 5M Na.

$(\text{mg TOC/liter 5M Na feed to grout})_t$ = TOC target concentration based on 5M Na feed to grout.

The required organic destruction DFs are reported as actual minimum DFs based on the current TOC concentration, 1556 mg/L, allowed in feed to grout (Hendrickson 1991).

3.2 Considerations and Assumptions for Processing Requirements

The following considerations and assumptions were used to identify the processing requirements for DST supernatant:

- Target radionuclide waste component concentrations for the spreadsheet program were based on NRC Class A criteria and Clean Option goals. TOC levels were based on 1556 mg/L TOC grout feed acceptance criterion (Hendrickson 1991).

- Twenty-seven of the 28 DSTs were considered for supernatant processing. DST AN-103 contains very little pumpable liquid (approximately 1.5% by volume) and was not evaluated for supernatant processing requirements.
- Processing requirements were based on current information in the databases. The analytical/historical database was used to determine all processing requirements for nine DSTs. Data based on estimated volumes and inventories of chemical constituents and principal radionuclides of waste stored in DSTs ("inventory data") were used to determine processing requirements for an additional four DSTs. Three of the four DSTs, AN-102, AN-107, and AY-101, contained complexant concentrate (CC)-type waste. The inventory data for this waste type did not partition the radioactive constituents between liquid and solid phases. Analytical data for two other CC wastes, SY-101 and SY-103, showed that the TRU concentration in the liquid phase was minimal. Therefore, for this exercise, TRUs are assumed to be primarily in the sludge fraction in these three tanks. If in fact the TRUs exist predominantly in the liquid phase in these tanks, a TRU DF of approximately 10 would be required.

Partial analytical/historical data were available for an additional seven DSTs and were used along with inventory data for these tanks. No/insufficient data were available for seven DSTs containing dilute noncomplexed (DN) wastes. These databases will be updated periodically as further data are located or new data become available.

- Processing requirements were based on the pumpable liquid volumes listed in the Tank Farm Surveillance and Waste Status Summary Report for September 1992. Some tank volumes may have changed since that time. Tank volumes, like the databases, will be updated periodically.
- Processing requirements were determined on a tank-by-tank basis. Blending of various wastes was not considered because blending studies are being performed by EM-30 tasks.
- Volume of grout for each supernatant tank waste was based on adjusting the sodium concentration in each tank to meet the grout feed acceptance criterion of 5M Na. No other nonradioactive analytes were evaluated during the processing analysis to determine whether they met the grout feed acceptance criteria; however, the spreadsheet program is capable of identifying other analyte "outliers."
- The NRC sum-of-fractions rule was assumed to be covered by defining decontamination factors in conservative decade units.

3.3 Processing Requirements for DST Supernatant

Tank waste processing analyses were performed using both analytical data and data based on chemical constituent and radionuclide inventories for seven DSTs to determine how well the inventory-based compositions represented actual tank compositions. A comparison of processing requirements from these analyses and selected data from the two databases is provided in Table 3.1. Some

Table 3.1. Comparison of Selected Processing Requirements and Data from Analytical and Inventory Supernatant Databases

Tank ID	Waste Type	DF Sr 90		DF Cs 137		DF TRU		Ci Tc 99		Ci I 129	
		Analytical	Inventory	Analytical	Inventory	Analytical	Inventory	Analytical	Inventory	Analytical	Inventory
AN-106	DSS	100	100	1000	1000	NONE	NONE	357	965	0.111	3.11
AW-101	DSS	10	100	1000	1000	NONE	NONE	609	1010	1.21	3.25
AY-102	DNCW	10000	10000	1000	1000	NONE	NONE	NR	6.43	NR	0.01
AZ-101	NCAW	1000	1000000	10000	10000	10	NONE	907	1120	NR	2.55
AZ-102	NCAW	1000	1000000	10000	10000	NONE	NONE	318	1080	NR	2.45
SY-101	CC	100	10000	1000	1000	NONE	NONE	NR	385	NR	0.54
SY-103	CC	NONE	10000	NONE	1000	NONE	NONE	NR	262	NR	0.37
No Change		2	6	6	6				0		0
Less DF		0	0	0	1				0		0
More DF		5	1	1	0				4		2
NR		0	0	0	0				3		5

NR Not Reported

NOTE: Changes are listed for Inventory vs Analytical

variability in DFs exists, especially for strontium, iodine, and technetium. With the exception of the inventory value for TRU in Tank AZ-101, the inventory DF values are more conservative than (when not equal to) the analytical values for DST supernatant.

Analyses were then performed to identify processing requirements for 20 DSTs containing supernatant. Results of the analyses are summarized in Tables 3.2 and 3.3. Table 3.2 contains estimated minimum DFs that are needed to meet Class A disposal criteria and the 1556 mg/L TOC grout feed acceptance criterion. Table 3.3 contains estimated minimum DFs that are needed to meet Clean Option goals and the 1556 mg/L TOC grout feed acceptance criterion. In these analyses, inventory concentrations were assumed for analytes in supernatant only when no analytical or historical concentrations were available. No data were obtained for seven DSTs: Tank AN-101, AP-101, AP-102, AP-104, AP-107, AP-108, and AW-104; therefore no DFs were calculated for the components of interest for these tanks.

Tables 3.2 and 3.3 indicate that supernatant wastes, for which data are available, require some kind of pretreatment to satisfy both Class A criteria and Clean Option goals. Since Clean Option goals coincide with Class A criteria with the exception of technetium and iodine, the only differences in DFs are for these two radionuclides. Note that technetium removal is indicated to be required for only one tank (AY-102) to satisfy Class A disposal requirements. In this case, the removal requirement is based on inventory data, which may not be as reliable as analytical data. As previously noted, data based on chemical and radionuclide inventories are generally more conservative than the analytical or historical data. Iodine removal is not indicated to be required to satisfy Class A disposal criteria for any of the tanks for which data are available. The last columns in Tables 3.2 and 3.3 reflect the percent radionuclide activity for technetium and iodine in the waste. Technetium and iodine quantities become an important issue when developing pretreatment processing sequences and time-phased deployment schedules (see Sections 4 and 5).

Table 3.2. Processing Requirements to Target: NRC Class A and TOC Grout Feed Acceptance Criteria

DF REQUIREMENTS							TANK WASTE					TREATED WASTE	
NONE	10	100	1000	10000	100000	1000000	Tank ID	Data Source	Waste Type	Volume Kgal	Na (M)	% total Ci to grout	% total I to grout
(Cs, Sr, TRU, Tc, I, Org)							AN-101		DN	638	NR	NR	NR
TRU, Tc, I	Org=8		Cs	Sr			AN-102	Inv	CC	1018	16	5.2	4.11
Tc*, I*		Sr, Org=15	TRU, Cs				AN-104	H, Inv*	DSSF	799	12	2.59	4.74
Tc*, I*		Sr, Org=13	TRU, Cs				AN-105	H, Inv*	DSSF	1128	12	3.63	6.64
TRU, Tc, I	Org=3	Sr	Cs				AN-106	A	CP	980	3.9	1.19	0.21
TRU, Tc, I	Org=8		Cs	Sr			AN-107	Inv	CC	937	16	4.87	3.85
(Cs, Sr, TRU, Tc, I, Org)							AP-101		DN	1062	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-102		DN	150	NR	NR	NR
Sr, TRU, Tc, I	Org=2	Cs					AP-103	A	DN	1134	0.23	0.0155	0.259
(Cs, Sr, TRU, Tc, I, Org)							AP-104		DN	20	NR	NR	NR
TRU, Tc, I	Sr, Org=2		Cs				AP-105	H	DSSF	824	6.4	0.183	0.245
TRU, Tc, I	Org=2		Sr, Cs				AP-106	H	DN	1131	1.1	0.213	0.242
(Cs, Sr, TRU, Tc, I, Org)							AP-107		DN	1121	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-108		DN	903	NR	NR	NR
TRU, Tc, I, Org	Sr		Cs				AW-101	A	DSSF	1046	10	2.03	2.29
TRU, (Tc, I)	Sr, Org=3	Cs					AW-102	A, Inv	DN	730	0.73	NR	NR
Sr, TRU, Tc, I	Org=3		Cs				AW-103	A	DN-PD	300	0.97	0.0529	0.02
(Cs, Sr, TRU, Tc, I, Org)							AW-104		DN	861	NR	NR	NR
Sr, TRU, Tc, (I)	Org=2		Cs				AW-105	A, Inv	DN-PD	645	1	0.0903	NR
TRU, Tc, I	Sr, Org=2		Cs				AW-106	A	DN	657	1.7	0.14	0.201
TRU, Tc, I	Org=8		Cs	Sr			AY-101	Inv	DC	844	16	4.43	3.53
TRU, I*	Tc*, Org=10		Cs	Sr			AY-102	A, Inv*	DN	549	0.09	0.00214	0.0194
Tc, I, Org	TRU		Sr	Cs			AZ-101	A	NCAW	894	2.5	3.03	<0.005
TRU, Tc, I, Org			Sr	Cs			AZ-102	A	NCAW	843	2.2	1.06	<0.01
TRU, Tc*, I*	Org=7	Sr	Cs				SY-101	A, Inv*	CC	249	12.7	1.28	1.02
TRU, Tc, (I), Org					Cs	Sr	SY-102	Inv	PFP	603	0.08	<DL	NR
Cs, Sr, TRU, Tc*, I*	Org=10						SY-103	A, Inv*	CC	174	0.014	0.873	0.692
							Total			20240		30.8798	28.0684

() Analyte not reported

* Inventory value assumed as no analytical/historical value reported

Waste Type

DN: Dilute non-complexed waste
 CC: Complexant concentrate waste
 DSSF: Double-shell slurry feed
 CP: Concentrated phosphate waste
 DN-PD: Dilute non-complexed/PUREX TRU solids
 DC: Dilute complexed waste
 NCAW: Neutralized current acid waste
 PFP: Plutonium finishing plant waste

NR: Not Reported

DL: Detection Limit

Data Source

Inv: WHC Inventory Data Base 6/92
 A: Analytical Chemical Characterization Data (refer Appendix B)
 H: Historical Data (Hendrickson and Conner, 1993)

Table 3.3. Processing Requirements: Clean Option Goals and TOC Grout Feed Acceptance Criterion

DF REQUIREMENTS							TANK WASTE						
NONE	10	100	1000	10000	100000	1000000	Tank ID	Data Source	Waste Type	Volume Kgal	Na (M)	% total Tc Inv	% total I Inv
TRU	Org=8, I	Tc	Cs	Sr			AN-102	Inv	CC	1018	16	5.2	4.11
	I*	Sr, Org=15, Tc*	TRU, Cs				AN-104	H, Inv*	DSSF	799	12	2.59	4.74
	I*	Sr, Org=13, Tc*	TRU, Cs				AN-105	H, Inv*	DSSF	1128	12	3.63	6.64
TRU	Org=3, I	Sr, Tc	Cs				AN-106	A	CP	980	3.9	1.19	0.21
TRU	Org=8, I	Tc	Cs	Sr			AN-107	Inv	CC	937	16	4.87	3.85
Sr, TRU	Org=2, I	Cs, Tc					AP-103	A	DN	1134	0.23	0.0155	0.259
TRU	Sr, Org=2, I	Tc	Cs				AP-105	H	DSSF	824	6.4	0.183	0.245
TRU	Org=2, I	Tc	Sr, Cs				AP-106	H	DN	1131	1.1	0.213	0.242
TRU, Org	Sr, I	Tc	Cs				AW-101	A	DSSF	1046	10	2.03	2.29
TRU, (Tc, I)	Sr, Org=3	Cs					AW-102	A, Inv	DN	730	0.73	NR	NR
Sr, TRU	Org=3, I	Tc	Cs				AW-103	A	DN-PD	300	0.97	0.0529	0.02
Sr, TRU, (I)	Org=2	Tc	Cs				AW-105	A, Inv	DN-PD	645	1	0.0903	NR
TRU	Sr, Org=2, I	Tc	Cs				AW-106	A	DN	657	1.7	0.14	0.201
TRU	Org=8, I	Tc	Cs	Sr			AY-101	Inv	DC	844	16	4.43	3.53
TRU	Org=10, I*	Tc*	Cs	Sr			AY-102	A, Inv*	DN	549	0.09	0.00214	0.0194
I, Org	TRU	Tc	Sr	Cs			AZ-101	A	NCAW	894	2.5	3.03	<0.005
TRU, I, Org		Tc	Sr	Cs			AZ-102	A	NCAW	843	2.2	1.06	<0.01
TRU	Org=7, I*	Sr, Tc*	Cs				SY-101	A, Inv*	CC	249	12.7	1.28	1.02
TRU, Tc, (I), Org					Cs	Sr	SY-102	Inv	PFP	603	0.08	<DL	NR
Cs, TRU	Org=10, I*	Tc*		Sr*			SY-103	A, Inv*	CC	174	13.8	0.873	0.692
Tanks that require analysis:							AN-101		DN	638	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-101		DN	1062	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-102		DN	150	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-104		DN	20	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-107		DN	1121	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-108		DN	903	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AW-104		DN	861	NR	NR	NR

() Analyte not reported

* Inventory value assumed as no analytical/historical value reported

NR: Not Reported

DL: Detection Limit

Waste Type

DN: Dilute non-complexed waste
 CC: Complexant concentrate waste
 DSSF: Double-shell slurry feed
 CP: Concentrated phosphate waste
 DN-PD: Dilute non-complexed/PUREX TRU solids
 DC: Dilute complexed waste
 NCAW: Neutralized current acid waste
 PFP: Plutonium finishing plant waste

Data Source

Inv: WHC Inventory Data Base 6/92
 A: Analytical Chemical Characterization Data (refer Appendix B)
 H: Historical Data (Hendrickson and Conner, 1993)

4.0 Processing Sequences for DST Supernatant

Processing sequences provide an order in which each tank should be processed and serve as a basis for development of time-phased deployment schedules. In this section, the logic incorporated into development of these sequences is discussed and then illustrated with two processing sequences. In one case, Class A disposal criteria are used, and in the other Clean Option goals are used. These sequences were generated using processing requirements from Tables 3.2 and 3.3; therefore, all considerations and assumptions listed in Section 3.2 apply to these sequences as well.

4.1 Processing Sequence Development

The main items included in the development of processing sequences are listed below:

Item

- (1) tank-by-tank database
- (2) tank-by-tank required DFs for a given set of criteria
- (3) technology availability
- (4) tank volume freed up
- (5) operational safety for tanks containing organic and ferrocyanide constituents
- (6) tank location.

The database (Item 1) and the DFs (Item 2) that were calculated using spreadsheet logic are used as the basis for developing preliminary processing sequences. In addition, judgments must be made as to what technologies will initially be available for deployment (Item 3). One of the main goals for pretreating the tank waste is to free tank space (Item 4) to allow for surge capacity during the pretreatment process and to allow for transfer of waste from single-shell to double-shell tanks, if necessary. Item (5), early pretreatment of tanks posing safety concerns, may also be taken into account in developing the deployment schedule. The location of tanks (Item 6) should be investigated so that, if processing requirements allow, tanks close to one another will be treated in the same time frame.

Some overriding issues were addressed prior to developing the processing sequences. Due to greater reliability of the tank-specific analytical data, tanks for which analytical data were available were given priority in the pretreatment sequence over tanks for which inventory data were available. It was assumed that prior to the pretreatment of any tank, analytical data will be obtained for that particular tank. The tank sequencing for a given treatment criterion described in the following text was automatically prioritized in the following manner:

Priority

- (1) tank-specific analytical data^(a) available
- (2) tank-specific analytical + historical data^(b) available

(a) Tank-specific analytical data: data obtained by sampling and analyses at the specific tank under consideration.

(b) Historical data: data obtained from historical processing and tank records.

- (3) tank-specific historical data available
- (4) tank-specific analytical + waste-specific inventory data^(c) available
- (5) tank-specific historical + waste-specific inventory data available
- (6) waste-specific inventory data available.

(c) Waste-specific inventory data: data obtained by sampling and analyses of one or more tanks containing a specific waste type and applied to other tanks containing that waste type.

In some cases, data were not available for all of the constituents of interest. The deployment sequence is expected to change significantly as the database is updated and as new processing requirements (i.e., DFs) are calculated.

4.2 Processing Sequence Using Class A Disposal Criteria

Table 3.2 shows that all tanks for which characterization data exist need some pretreatment to satisfy Class A disposal criteria. To get started with sequencing, an assumption must be made as to what CPU pretreatment process(es) will be deployed first. Thus for this sequence, cesium removal is assumed to be the first deployable CPU pretreatment technology.

Investigation of the pretreatment requirements presented in Table 3.2 reveals that DSTs, for which data are available, require more than just cesium removal for supernatant processing. However, some tanks require cesium removal with minimal strontium removal (i.e., $DF < 10$), and/or minimal organic destruction. Since some cesium separation technologies also may be capable of removing minimal amounts of strontium, a major assumption in this processing sequence is that a given cesium separation technology will also be capable of separating minor amounts of strontium (i.e., $DF < 10$). For development of this processing sequence, pretreatment Criterion 1 and its important assumptions are stated as:

Criterion 1: Cesium removal technology: capable of achieving a ^{137}Cs $DF=10^4$ and a ^{90}Sr $DF=10$.

Assumption: Cs technology can also remove adequate amount of ^{90}Sr to satisfy Class A disposal criteria.

Tank-by-tank processing requirements targeting Class A disposal criteria (Table 3.2) show that only one tank, AW-101, falls under Criterion 1. Tank AW-101 does not require organic destruction to satisfy TOC grout feed acceptance criterion; it does require cesium and minimal strontium removal. Results in Table 3.2 also show that Tank AW-101 only requires a cesium DF of 10^3 as compared with a cesium DF of 10^4 stated in Criterion 1 above. When defining criteria for developing processing sequences, pretreatment of all DST supernatant tanks to Class A disposal criteria by a given pretreatment technology (i.e., in this case cesium removal) is taken into account.

As mentioned previously, the spreadsheet logic that was used to calculate the required DF s does not directly include calculations for the sum-of-fractions rule. In many cases, since the required DF s are increased in multiples of 10, the sum-of-fractions criterion is adequately satisfied. However, it is

uncertain at this point to what extent a cesium removal process can remove strontium; therefore, it is important to determine as best as possible the extent that strontium must be removed. Sum-of-fractions is further defined in Appendix A.

The sum-of-fractions for each tank for which a full set of analytical/historical data were available was calculated, and the required strontium DFs were calculated so that the sum-of-fractions rule was satisfied according to Criterion 1 (above) and Criterion 2 (below). For example, for Tank AW-101, a strontium DF of 10 was calculated from the spreadsheet program. When sum-of-fractions was taken into account it was determined that a minimum strontium DF of 13 was required to satisfy Criterion 1. Note that this value is slightly higher than the strontium DF stated in Criterion 1 above, although Criterion 1 is presented only as a means of defining the order of magnitude of the DFs required, not absolute DFs required.

The tank sequence for pretreatment processing is summarized in Table 4.1 along with pretreatment criterion, rationale behind the tank ordering, and minimum DFs required to satisfy the sum-of-fractions portion of Class A disposal criteria. These tanks are also listed in pretreatment order in Table 4.2 along with the processing requirements determined from the spreadsheet logic.

Investigation of Table 3.2 reveals several additional tanks that require cesium removal along with minimal or no removal of strontium and organic destruction. Organic destruction technology is currently being developed and appears to be a logical candidate for deployment shortly after cesium technology has been developed and deployed. In order to pretreat all of the DSTs to the 1556 mg/L TOC feed to grout target, an organic destruction technology capable of achieving a processing DF of 20 is required. Thus, Criterion 2 is stated as:

Criterion 2: Cesium removal technology: capable of achieving ^{137}Cs DF=10⁴ and ^{90}Sr DF=10.

Organic destruction technology: capable of achieving a processing DF of 20.

Seven tanks fall under Criterion 2. Tables 4.1 and 4.2 show that analytical or historical data exist for all components of interest for the first four tanks listed. Thus, the minimum strontium DFs required to satisfy the sum-of-fractions portion of Class A regulations were calculated for these four tanks and are included in Table 4.1.

Listed first is Tank AP-103, primarily because it requires the smallest DF for cesium to meet Class A disposal criteria. Tank AW-103 is a good candidate as well; although it requires a higher cesium DF, no strontium removal is required to satisfy the sum-of-fractions portion of Class A. Tank AW-106 is also a good candidate for pretreatment under Criterion 2. Note that the strontium removal requirements to satisfy the sum-of-fractions portion of the Class A disposal criteria are lower for each of these three tanks than the strontium removal requirements for AW-101. Furthermore, the sodium concentration of these three tanks is lower than 5M. It is conceivable that, if the contents of the tanks were not concentrated to 5M before grouting, no organic destruction or strontium removal would be required; however, this would increase the volume of the LLW form. Therefore, if during the development of cesium removal technology it is found that strontium DFs on the order of 10 are not attainable, Tanks AP-103, AW-103, and AW-106 may be more appropriate candidate tanks for cesium-only removal than Tank AW-101.

Table 4.1. Example of DST Supernatant Processing Sequence and Rationale to Meet: NRC Class A and TOC Grout Feed Acceptance Criteria

Rank Tank ID Rationale			Minimum Sr DF req'd to satisfy Class A sum-of-fractions (a)
Criterion 1: Cs DF=10⁴; Sr DF=10. No organic destruction required based on TOC Grout Feed Acceptance Criterion			
1	AW-101	Analytical data for all, Cs removal required, minimal Sr removal required, no organic destruction required.	13
Criterion 2: Cs DF=10⁴; Sr DF=10; organic destruction=20			
2	AP-103	Analytical data for all, minimal Cs DF, minimal or no organic DF required if not concentrated to 5M Na.	3
3	AW-103	Analytical data for all, Cs removal required, minimal or no organic DF required if not concentrated to 5M Na.	none
4	AW-106	Analytical data for all, Cs removal required, minimal or no organic DF required if not concentrated to 5M Na.	2
5	AP-105	Historical data for all, Cs removal required, minimal Sr DF required, organic destruction required.	3
6	SY-103	Inventory data for Tc and I, no Cs removal required, organic destruction required.	
7	AW-105	No data for I, analytical data for others, Cs removal required, no Sr removal required, minimal or no organic DF required if not concentrated to 5M Na.	
8	AW-102	No data for I and Tc, analytical data for others, minimal Cs DF, minimal or no organic or Sr DF required if not concentrated to 5M Na.	
Criterion 3: Cs DF =10⁴; Sr DF =10⁴; organic destruction DF=20			
9	AN-106	Analytical data for all, moderate Cs and Sr DF's, minimal organic destruction required.	
10	AZ-102	Analytical data for all, moderate to high Cs and Sr DF's, no organic destruction required.	
11	AP-106	Historical data for all, moderate to high Cs and Sr DF's, minimal or no organic DF required if not concentrated to 5M Na.	
12	SY-101	Inventory data for I and Tc, moderate Cs and Sr DF's, organic destruction required.	
13	AY-102	Inventory data for I and Tc, moderate to high Cs and Sr DF's, organic destruction required.	
14	AN-102	Inventory data for all, moderate to high Cs and Sr DF's, organic destruction required.	
15	AN-107	Inventory data for all, moderate to high Cs and Sr DF's, organic destruction required.	
16	AY-101	Inventory data for all, moderate to high Cs and Sr DF's, organic destruction required.	
17	SY-102	No data for I, inventory data for others, extremely high Cs and Sr DF's, no organic destruction required.	
Criterion 4: Class A, based on Cs DF =10⁴; Sr DF =10⁴; organic destruction DF =20; TRU DF =10³			
18	AZ-101	Analytical data for all, moderate to high Cs and Sr DF's, no organic destruction required, TRU removal required.	
19	AN-104	Inventory data for Tc and I, historical data for others, moderate to high Cs and Sr DF's, organic destruction required, TRU removal required.	
20	AN-105	Inventory data for Tc and I, historical data for others, moderate to high Cs and Sr DF's, organic destruction required, TRU removal required.	
Tanks that require analysis:			
	AN-101	Analysis required.	
	AP-101	Analysis required.	
	AP-102	Analysis required.	
	AP-104	Analysis required.	
	AP-107	Analysis required.	
	AP-108	Analysis required.	
	AW-104	Analysis required.	

(a): Only calculated for tanks with full analytical or historical data for which Cs technology is assumed to also remove minor amounts of Sr (i.e., Criteria 1 and 2).

Table 4.2. Processing Requirements Listed in Order of Processing Sequence: NRC Class A and TOC Grout Feed Acceptance Criteria

DF REQUIREMENTS							TANK WASTE					TREATED WASTE	
NONE	10	100	1000	10000	100000	1000000	Tank ID	Data Source	Waste Type	Volume Kgal	Na (M)	Cum % Ci Tc to grout	Cum % Ci I to grout
TRU, Tc, I, Org	Sr		Cs				AW-101	A	DSSF	1046	10	2.03	2.29
Sr, TRU, Tc, I	Org=2	Cs					AP-103	A	DN	1134	0.23	2.05	2.55
Sr, TRU, Tc, I	Org=3		Cs				AW-103	A	DN-PD	300	0.97	2.1	2.57
TRU, Tc, I	Sr, Org=2		Cs				AW-106	A	DN	657	1.7	2.24	2.77
TRU, Tc, I	Sr, Org=2		Cs				AP-105	H	DSSF	824	6.4	2.42	3.02
Cs, Sr, TRU, Tc*, I*	Org=10						SY-103	A, Inv*	CC	174	13.8	3.29	3.71
Sr, TRU, Tc, (I)	Org=2		Cs				AW-105	A, Inv	DN-PD	645	1	3.39	NR
TRU, (Tc, I)	Sr, Org=3	Cs					AW-102	A, Inv	DN	730	0.73	NR	NR
TRU, Tc, I	Org=3	Sr	Cs				AN-106	A	CP	980	3.9	4.58	3.92
TRU, Tc, I, Org			Sr	Cs			AZ-102	A	NCAW	843	2.2	5.85	3.92
TRU, Tc, I	Org=2		Sr, Cs				AP-106	H	DN	1131	1.1	5.84	4.16
TRU, Tc*, I*	Org=7	Sr	Cs				SY-101	A, Inv*	CC	249	12.7	7.13	5.18
TRU, I*	Tc*, Org=10		Cs	Sr			AY-102	A, Inv*	DN	549	0.09	7.15	5.2
TRU, Tc, I	Org=8		Cs	Sr			AN-102	Inv	CC	1018	16	12.35	9.31
TRU, Tc, I	Org=8		Cs	Sr			AN-107	Inv	CC	937	16	17.22	13.16
TRU, Tc, I	Org=8		Cs	Sr			AY-101	Inv	DC	844	16	21.65	16.69
TRU, Tc, (I), Org					Cs	Sr	SY-102	Inv	PFP	603	0.08	21.65	NR
Tc, I, Org	TRU		Sr	Cs			AZ-101	A	NCAW	894	2.5	24.68	16.69
Tc*, I*		Sr, Org=15	TRU, Cs				AN-104	H, Inv*	DSSF	799	12	27.27	21.42
Tc*, I*		Sr, Org=13	TRU, Cs				AN-105	H, Inv*	DSSF	1128	12	30.9	28.07
Tanks that require analysis:													
(Cs, Sr, TRU, Tc, I, Org)							AN-101		DN	638	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-101		DN	1062	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-102		DN	150	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-104		DN	20	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-107		DN	1121	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AP-108		DN	903	NR	NR	NR
(Cs, Sr, TRU, Tc, I, Org)							AW-104		DN	861	NR	NR	NR

() Analyte not reported

* Inventory value assumed as no analytical/historical value reported

NR: Not Reported

Waste Type

DN: Dilute non-complexed waste
 CC: Complexant concentrate waste
 DSSF: Double-shell slurry feed
 CP: Concentrated phosphate waste
 DN-PD: Dilute non-complexed/PUREX TRU solids
 DC: Dilute complexed waste
 NCAW: Neutralized current acid waste
 PFP: Plutonium finishing plant waste

Data Source

Inv: WHC Inventory Data Base 6/92
 A: Analytical Chemical Characterization Data (refer Appendix B)
 H: Historical Data (Hendrickson and Conner, 1993)

Tanks AP-105, SY-103, AW-105, and AW-102 are additional candidate tanks under Criterion 2; however, these tanks were ranked lower because analytical data were not available for all of the components of interest. Note that Tank SY-103 only requires organic destruction, although analytical data were not available for technetium and iodine for this tank.

The organic destruction criteria are based on grout specifications. It may also be necessary to destroy chelating organics to enable the removal of strontium and TRUs in future processing. The destruction of organics may also lead to the precipitation of strontium and TRUs, thus decreasing the required DFs for these components. Additional experimental investigation is required to determine 1) what organic destruction level is required to enable separation of strontium and TRUs and 2) what impact will this have on required DFs for strontium and TRUs.

The remaining tanks require substantial strontium removal, and some also require TRU removal. In order to pretreat the supernatant in the remaining DSTs to Class A strontium limits, a strontium technology capable of achieving a processing DF of approximately 10^4 is required. Thus, Criterion 3 is stated as:

Criterion 3: Cesium removal technology: capable of achieving a ^{137}Cs DF= 10^4 .

Organic destruction technology: capable of achieving a processing DF of 20.

Strontium removal technology: capable of achieving a ^{90}Sr DF= 10^4 .

Note that destruction of organics (DF=20) might result in precipitation of strontium from solution.

Nine additional tanks can be pretreated by deploying a strontium removal technology. Only two of the nine tanks, however, contain complete analytical data. One tank, SY-102, for which only inventory data were obtained, shows that a strontium DF of 10^5 is required. Analytical data have recently been located for this tank and will be used to check this requirement. In addition, inventory data for Tank AY-102 indicate that technetium removal is required to meet Class A disposal criteria. If this is truly the case, Tank AY-102 will either have to be blended with another tank or technetium removal technology will be required for this tank. For this illustration it has been assumed that either 1) Tank AY-102 could be pretreated along with another tank that is lower in technetium or 2) the inventory data overestimate the technetium content of Tank AY-102.

The remaining three tanks for which data were available require TRU removal to meet Class A disposal requirements. Thus, Criterion 4 is stated as:

Criterion 4: Cesium removal technology: capable of achieving a ^{137}Cs DF= 10^4 .

Organic destruction technology: capable of achieving a processing DF of 20.

Strontium removal technology: capable of achieving a ^{90}Sr DF= 10^4 .

TRU removal technology: capable of achieving a TRU DF= 10^3 .

Note that destruction of organics ($DF = 20$) might result in precipitating TRUs from solution, and, as a result, in achieving the required DF for TRUs. Tanks AZ-101, AN-104, and AN-105 all fall under Criterion 4. Only Tank AZ-101 has complete analytical data for all of the components of interest.

4.3 Processing Sequence Using Clean Option Goals

As previously discussed, Clean Option goals include Class A disposal criteria for strontium, cesium, and TRU. However, due to the long-term health effects of iodine and technetium, the Clean Option targets more stringent concentrations of technetium and iodine in LLW. To satisfy Clean Option goals with respect to technetium and iodine, two options are possible:

1. Deploy technetium ($DF=100$) and iodine ($DF=10$) removal technology immediately.
2. Begin pretreatment of selected tanks, low in technetium and iodine, before technetium and iodine technologies have been developed.

From a practical standpoint, Option 2 is by far the most viable. At this point, development and deployment of technetium and iodine removal technology are well behind development and deployment of cesium and organic destruction technologies. Therefore, in developing a processing sequence based on Clean Option goals, tanks low in technetium and iodine were targeted for early pretreatment. In determining when technetium or iodine removal technology was required, upper limits of 0.5% of the technetium Ci inventory and 5% of the iodine Ci inventory to grout were set for this exercise. After these limits were reached, removal technologies capable of processing DFs twice those defined by the Clean Option would be required to maintain Clean Option goals.

Table 3.3 shows that Tank AW-101, which was the first tank targeted for pretreatment in the Class A scenario, exceeds the Clean Option goals for technetium to grout. In addition, this tank has a fairly high iodine content. However, some of the tanks that satisfied Class A Criterion 2 have relatively low iodine and technetium contents. In addition, three tanks for which analytical data are available (AP-103, AW-103, and AW-106) may not require organic destruction or even strontium removal if the feed to grout is not concentrated to 5M Na (although more grout would be required). Thus, Clean Option Criterion 1 is stated as:

Criterion 1: Cesium removal technology: capable of achieving a ^{137}Cs $DF=10^4$ and Sr $DF=10$.

Organic destruction technology: capable of achieving a processing DF of 20.

Tanks having low ^{99}Tc and ^{129}I contents will be targeted for pretreatment: technetium removal technology will be required when ^{99}Tc levels to grout reach 0.5% inventory ^{99}Tc , and iodine removal technology will be required when ^{129}I levels to grout reach 5% inventory ^{129}I .

The tank sequence for pretreatment processing and the pretreatment criterion, rationale behind the tank ordering, and minimum DFs required to satisfy the sum-of-fractions portion of Class A disposal criteria are summarized in Table 4.3. These tanks are also listed in order of pretreatment in Table 4.4 along with the processing requirements that were determined from the spreadsheet logic. The order of the tanks under Clean Option Criterion 1 is the same as it was for the Class A Criterion 2, with the exception of Tank SY-103. This tank has been moved down the list, primarily because of its high technetium and iodine content. Note that no iodine data were available for Tanks AW-105 and AW-102, and no technetium data were available for AW-102. The sequencing of these two tanks could change dramatically depending on the iodine and technetium contents.

A technetium removal technology is required to continue pretreating the DST supernatant waste. If the same technetium to grout Clean Option goals are maintained, then a technetium removal technology capable of achieving an overall processing DF of 200 would be required for the remaining tanks. Thus, Criterion 2 for Clean Option processing is stated as:

Criterion 2: Cesium removal technology: capable of achieving a ^{137}Cs DF = 10^4 and ^{90}Sr DF = 10.

Organic destruction technology: capable of achieving a processing DF of 20.

Technetium removal technology: capable of achieving a ^{99}Tc DF = 200.

Tanks having low ^{129}I contents will be targeted for pretreatment: iodine removal technology will be required when ^{129}I levels to grout reach 5% inventory ^{129}I .

Given this criterion, two additional tanks can be pretreated: AW-101 and SY-103. Tank AW-101 is listed first because analytical data were available for all of the components of interest, whereas, for SY-103, only inventory data were available for technetium and iodine.

After pretreatment of these two tanks, strontium removal technology will be required. Criterion 3 for Clean Option processing is stated as:

Criterion 3: Cesium removal technology: capable of achieving a ^{137}Cs DF = 10^4 .

Organic destruction technology: capable of achieving a processing DF of 20.

Technetium removal technology: capable of achieving a ^{99}Tc DF = 200.

Table 4.3. Example of DST Supernatant Processing Sequence and Rationale to Meet: Clean Option Goals and TOC Grout Feed Acceptance Criterion

Rank Tank ID Rationale			Minimum Sr DF req'd to satisfy Class A sum-of-fractions (a)
Criterion 1: Cs DF=10⁴; Sr DF=10; organic destruction DF=20			
1	AP-103	Analytical data for all, minimal Cs DF, minimal or no organic DF required if not concentrated to 5M Na, low Tc and I contents.	3
2	AW-103	Analytical data for all, Cs removal required, minimal or no organic DF required if not concentrated to 5M Na, low Tc and I contents.	none
3	AW-106	Analytical data for all, Cs removal required, minimal or no organic or Sr DF required if not concentrated to 5M Na, low Tc and I contents.	2
4	AP-105	Historical data for all, Cs removal required, minimal Sr DF, organic destruction required, low Tc and I contents.	3
5	AW-105	No data for I, analytical data for others, Cs removal required, no Sr removal required, minimal or no organic DF required if not concentrated to 5M Na, low Tc contents.	
6	AW-102	No data for I and Tc, analytical data for others, minimal Cs DF, minimal or no organic or Sr DF required if not concentrated to 5M Na, low Tc contents.	
Criterion 2: Cs DF=10⁴; Sr DF=10; organic destruction DF=20; Tc DF=200			
7	AW-101	Analytical data for all, Cs removal required, no organic destruction required, minimal Sr DF, Tc removal required, high I content.	11
8	SY-103	Inventory data for Tc and I, no Cs removal required, organic destruction required, Tc removal required, relatively high I content.	
Criterion 3: Cs DF=10⁴; organic destruction DF=20; Tc DF=200; Sr DF=10⁴			
9	AN-106	Analytical data for all, moderate Cs and Sr DFs, minimal organic destruction required, Tc removal required, low I content.	
10	AZ-102	Analytical data for all, moderate to high Cs and Sr DFs, no organic destruction required, Tc removal required, low I content.	
11	AP-106	Historical data for all, moderate to high Cs and Sr DFs, minimal or no organic DF required if not concentrated to 5M Na, Tc removal required, low I content.	
12	AY-102	Inventory data for I and Tc, moderate to high Cs and Sr DFs, organic destruction required, Tc removal required, low I content.	
13	SY-101	Inventory data for I and Tc, moderate Cs and Sr DFs, organic destruction required, Tc removal required, relatively high I content.	
Criterion 4: Cs DF=10⁴; organic destruction DF=20; Tc DF=200; Sr DF=10⁴; I DF=20			
14	AN-102	Inventory data for all, moderate to high Cs and Sr DFs, organic destruction required, Tc and I removal required.	
15	AN-107	Inventory data for all, moderate to high Cs and Sr DFs, organic destruction required, Tc and I removal required.	
16	AY-101	Inventory data for all, moderate to high Cs and Sr DFs, organic destruction required, Tc and I removal required.	
17	SY-102	No data for I, Inventory data for others, extremely high Cs and Sr DFs, no organic destruction required, Tc and (I) removal required.	
Criterion 5: Cs DF=10⁴; organic destruction DF=20; Tc DF=200; Sr DF=10⁴; I DF=20; TRU DF=10³			
18	AZ-101	Analytical data for all, moderate to high Cs and Sr DFs, no organic destruction required, Tc, I and TRU removal required.	
19	AN-104	Inventory data for Tc and I, historical data for others, moderate to high Cs and Sr DFs, organic destruction required, Tc, I, TRU removal required.	
20	AN-105	Inventory data for Tc and I, historical data for others, moderate to high Cs and Sr DFs, organic destruction required, Tc, I, TRU removal required.	
Tanks that require analysis:			
	AN-101	Analysis required.	
	AP-101	Analysis required.	
	AP-102	Analysis required.	
	AP-104	Analysis required.	
	AP-107	Analysis required.	
	AP-108	Analysis required.	
	AW-104	Analysis required.	

(a): Only calculated for tanks with full analytical or historical data for which Cs technology is assumed to remove minor amounts of Sr (i.e., Criteria 1 and 2).

Table 4.4. Processing Requirements Listed in Order of Processing Sequence: Clean Option Goals and TOC Grout Feed Acceptance Criterion

DF REQUIREMENTS							TANK WASTE					TREATED WASTE			
NONE	10	100	1000	10000	100000	1000000	Tank ID	Data Source	Waste Type	Volume Kgal	Na (M)	Cum % Cl to grout	Tc DF Req'd for Remain	Cum % Cl to grout	IDF Req'd for Remain
Sr, TRU, Tc, I	Org=2	Cs					AP-103	A	DN	1134	0.23	0.016	102	0.26	6
Sr, TRU, Tc, I	Org=3		Cs				AW-103	A	DN-PD	300	0.97	0.069	107	0.3	10.3
TRU, Tc, I	Sr, Org=2		Cs				AW-106	A	DN	657	1.7	0.209	126	0.51	10.5
TRU, Tc, I	Sr, Org=2		Cs				AP-105	H	DSSF	824	6.4	0.392	164	0.75	10.7
Sr, TRU, Tc, (I)	Org=2		Cs				AW-105	A, Inv	DN-PD	645	1	0.482	192	NR	
TRU, (Tc, I)	Sr, Org=3	Cs					AW-102	A, Inv	DN	730	0.73	NR		NR	
TRU, I, Org	Sr		Cs, Tc=200				AW-101	A	DSSF	1046	10			2.9	13.7
Cs, Sr, TRU, I*	Org=10		Tc*=200				SY-103	A, Inv*	CC	174	13.8			3.6	15.1
TRU, I	Org=3	Sr	Cs, Tc=200				AN-106	A	CP	980	3.9			3.8	15.5
TRU, I, Org			Sr, Tc=200	Cs			AZ-102	A	NCAW	843	2.2			3.8	15.5
TRU, I	Org=2		Sr, Cs, Tc=200				AP-106	H	DN	1131	1.1			4.1	16.3
TRU, I*	Org=10		Cs, Tc*=200	Sr			AY-102	A, Inv*	DN	549	0.09			4.1	16.3
TRU, I*	Org=7	Sr	Cs, Tc*=200				SY-101	A, Inv*	CC	249	12.7			5.1	19.4
TRU	Org=8	I=20	Cs, Tc=200	Sr			AN-102	Inv	CC	1018	16				
TRU	Org=8	I=20	Cs, Tc=200	Sr			AN-107	Inv	CC	937	16				
TRU	Org=8	I=20	Cs, Tc=200	Sr			AY-101	Inv	DC	844	16				
TRU, Org		(I)=20	Tc=200		Cs	Sr	SY-102	Inv	PFP	603	0.08				
Org	TRU	I=20	Sr, Tc=200	Cs			AZ-101	A	NCAW	894	2.5				
		Sr, Org=15, I*=20	TRU, Cs, Tc*=200				AN-104	H, Inv	DSSF	799	12				
		Sr, Org=13, I*=20	TRU, Cs, Tc*=200				AN-105	H, Inv	DSSF	1128	12				
Tanks that require analysis:							AN-101		DN	638	NR				
(Cs, Sr, TRU, Tc, I, Org)							AP-101		DN	1062	NR				
(Cs, Sr, TRU, Tc, I, Org)							AP-102		DN	150	NR				
(Cs, Sr, TRU, Tc, I, Org)							AP-104		DN	20	NR				
(Cs, Sr, TRU, Tc, I, Org)							AP-107		DN	1121	NR				
(Cs, Sr, TRU, Tc, I, Org)							AP-108		DN	903	NR				
(Cs, Sr, TRU, Tc, I, Org)							AW-104		DN	861	NR				

() Analyte not reported

* Inventory value assumed as no analytical/historical value reported

NR: Not Reported

Waste Type

DN: Dilute non-complexed waste
 CC: Complexant concentrate waste
 DSSF: Double-shell slurry feed
 CP: Concentrated phosphate waste
 DN-PD: Dilute non-complexed/PUREX TRU solids
 DC: Dilute complexed waste
 NCAW: Neutralized current acid waste
 PFP: Plutonium finishing plant waste

Data Source

Inv: WHC Inventory Data Base 6/92
 A: Analytical Chemical Characterization Data (refer Appendix B)
 H: Historical Data (Hendrickson and Conner, 1993)

Strontium removal technology: capable of achieving a ^{90}Sr $\text{DF}=10^4$.

Tanks having low ^{129}I contents will be targeted for pretreatment: iodine removal technology will be required when ^{129}I levels to grout reach 5 % inventory ^{129}I .

Tanks that can be pretreated based on this criterion are AN-106, AZ-102, AP-106, AY-102, and SY-101. After pretreatment of these tanks, iodine removal technology will be required. If the same Clean Option goals for iodine to grout are to be maintained, an iodine removal technology capable of achieving an overall processing DF of 20 would be required for the remaining tanks. Thus, Criterion 4 for Clean Option processing is stated as:

Criterion 4: Cesium removal technology: capable of achieving a ^{137}Cs $\text{DF}=10^4$.

Organic destruction technology: capable of achieving a processing DF of 20.

Technetium removal technology: capable of achieving a ^{99}Tc $\text{DF}=200$.

Strontium removal technology: capable of achieving a ^{90}Sr $\text{DF}=10^4$.

Iodine removal technology: capable of achieving an ^{129}I $\text{DF}=20$.

Based on this criterion, an additional four tanks can be pretreated: AN-102, AN-107, AY-101, and SY-102. The remaining DSTs for which data were available, AZ-101, AN-104, and AN-105, require TRU removal from the supernatant to achieve Clean Option goals. Thus, Clean Option processing Criterion 5 is stated as:

Criterion 5: Cesium removal technology: capable of achieving a ^{137}Cs $\text{DF}=10^4$.

Organic destruction technology: capable of achieving a processing DF of 20.

Technetium removal technology: capable of achieving a ^{99}Tc $\text{DF}=200$.

Strontium removal technology: capable of achieving a ^{90}Sr $\text{DF}=10^4$.

Iodine removal technology: capable of achieving an ^{129}I $\text{DF}=20$.

TRU removal technology: capable of achieving a TRU $\text{DF}=10^3$.

Note that destruction of organics ($\text{DF} = 20$) might result in precipitating TRUs from solution and, consequently, in achieving the required DF for TRUs.

The processing sequences illustrated in this report will change as more data become available and as more criteria are built into the sequencing logic; however, the sequences for the two disposal scenarios, illustrated in Tables 4.1 and 4.3, serve as 1) a basis for developing a deployment schedule and 2) preliminary assessments of potential early pretreatment tanks, technology requirements, and analytical requirements.

5.0 Deployment Schedules for Distributed Processing of DST Supernatant

Incorporating a time factor into processing sequences results in time-phased deployment schedules. These schedules provide a means to evaluate the number and types of CPUs required; required technology development and deployment time frames; potential bottlenecks to distributed processing; and compatibility of pretreatment schedules with final waste form schedules. This section discusses the methodology that was used to develop the deployment schedules and presents examples of deployment schedules for the Class A and Clean Option tank sequences presented in Sections 4.2 and 4.3.

5.1 Deployment Schedule Development

A simulation study was performed to aid in the development of deployment schedules. The study used a simulation software package to couple processing sequences with processing rates to produce deployment schedules. The objectives of this study were to:

- develop time-phased deployment schedules
- determine when new pretreatment technologies are needed
- gain an understanding of the interplay between pretreatment operation processing rates and the grout and Hanford Waste Vitrification Plant (HWVP) operating schedules
- determine tank space availability over time.

5.1.1 Description of the Simulation Model

Cesium removal is anticipated to be the first pretreatment technology to be tested; a cesium CPU is currently under development. Therefore, the CPU system consisting of cesium removal, grout, and HWVP operations was simulated. Other technologies for removal of strontium, TRU, technetium, and iodine and destruction of organic constituents also were included in the simulation. However, these pretreatment technologies were left in generic terms; i.e., unlike the cesium system, no specific processing steps were incorporated into the simulation.

The steps assumed in cesium removal include: evaporation/dilution, filtration, ferric hydroxide scavenging, and cesium removal by ion exchange (Straalsund et al. 1992; Swanson 1993). In the simulation, these steps were handled in the following manner:

1. Pump supernatant to a holding unit to set the sodium concentration to a predefined value. This operation is treated as a batch continuous process in the simulation. Water is added to dilute the supernatant, or water is evaporated from the supernatant depending on the sodium content in the tank being pumped.

2. Filter the supernatant to remove most of the solids. This operation is treated as a batch continuous process. The filter units are interrupted for backwashing and regenerating after a predetermined amount of flow-through. The batch size represents the amount of supernatant flowing through filter units between interruptions.
3. Scavenge the residual colloids in the supernatant with ferric hydroxide. This operation is treated as a batch continuous process.
4. Remove cesium by ion exchange (IX) and elute the absorbed cesium in a separate feed stream to HWVP. This is a continuous process where one column, of a four-column bank, is being eluted at a time.

Additional steps in the simulation include:

5. Remove other radionuclides, when required, using generic pretreatment processes.
6. Accumulate the separated solids and radionuclides in separate holding tanks for drawdown to HWVP. The volumes of solid from the filtering and scavenging steps are combined.
7. Accumulate the volume of liquid passing through the pretreatment steps to a holding tank for grout preparation. This step is accomplished by assigning a global variable to the volume of grout feed and tracking it.

In the simulation, the HWVP operation processes a preset amount of slurry defined by a limited curie level (heat control) or a limited solid content (composition control) and produces a glass log in the HWVP facility. The grout operation processes a preset amount of pretreated feed to produce grout; the frequency depends on the throughput rate in the grout facility.

The tank contents are loaded into the simulation on a tank-by-tank basis in the order it appears in the processing sequences (refer to Sections 4.2 and 4.3). The simulation treats the contents of each tank as a separate entity that requires several input values for processing instructions. The required input values are:

- volume of supernatant (m^3)
- volume of solids (m^3)
- mass of Na (kg)
- activity of ^{137}Cs (kCi)
- activity of ^{90}Sr (kCi)
- activity of TRU (kCi)
- activity of Tc (kCi).

5.1.2 Simulation Study Assumptions

The following assumptions and considerations were made in the simulation study:

- **Process efficiency:** 365 day/year, 24 hr/day operation, 100% on-stream efficiency, and no delay times due to relocation of CPUs and related equipment are assumed. These are idealized operating conditions; as a result, time frames generated by this study will be underestimated. These time frames may, however, be used to estimate more realistic schedules. A flow rate of 5 gpm (after sodium adjustment to 5M) through the CPUs was used in the simulations.
- **Management of solids:** The simulation model assumes all solids in the tanks are pumped with the supernatant in a uniform manner. The tanks are assumed to contain no residue after pumping since they are considered candidates for potential storage of liquids and/or solids. The system flow keeps track of the solids in order to successfully manage the solids distribution while the supernatant is being processed.
- **Scavenging:** After filtration, some colloidal solids are expected to remain. For the simulation, 99.9% of the solids are assumed to be removed during filtration. Scavenging material is used to remove the remaining solids. The required scavenging material is assumed be 200 times greater than the remaining colloids, which increases the total solids to about 120% of the original volume of tank solids.
- **Sodium Content:** In this version of the simulation, the sodium content is used only to determine the amount of water to be added or evaporated/condensed. In turn, the addition or evaporation of water affects the total volume to be fed through the pretreatment process and to the grout operation.

The sodium fraction that passes with the cesium in the eluent stream from the IX unit to the HWVP is not determined.

- **Radioactive constituents:** The DFs required to produce acceptable feed solutions for grout are assumed to be achievable as needed. One of the objectives of the simulation study is to determine when additional pretreatment technologies for removal of strontium, TRU, technetium, and iodine are required; therefore, these components are tracked in the simulation.

In addition, strontium is tracked along with cesium to determine the heat load in glass. The other radionuclides are not tracked for this purpose since their contributions to the heat load are minimal compared with strontium and cesium.

- **Nonradioactive constituents:** Nonradioactive constituents detrimental to glass performance, e.g., chromium and phosphate, were not addressed in this study.
- **Glass and grout disposition:** The grout and HWVP operations draw down feed only when the conditions are appropriate for production of at least one unit of grout or one log of glass. After a specified time interval, the accumulated solids, curies, and grout volumes are evaluated to decide whether the volumes are sufficient for production.

The glass and grout outputs are tracked and recorded on a quarterly basis. The maximum production rate is assumed to be 100 units/year (25 units/quarter) for the HWVP and grout operations. A grout unit is assumed to be 100 m³, and a glass log to be 1650 kg. Each log, however, must contain less than 371,200 Ci or 223 L of dry slurry feed, i.e., solids removed by filtration and scavenging (Mitchell and Nelson 1988).

The limit of 223 L arises from the requirement that no more than 25 wt% of the log may consist of waste solids. A dry solids density of 1.85 g/cm^3 was assumed in the conversion of weight percent to the volume limit of 223 L. Since the simulation recovers all the solids in the tank, disposing of these solids in glass logs leads to an impractical number of logs. Consequently, the simulation currently uses only the heat load criterion for determining glass log production. Some small fraction of filtered/scavenged solids could be disposed of by sending them to glass, and provisions to do so have been incorporated into the simulation model for future efforts.

- **Water management:** Water consumption and evaporation/condensation is tracked over the simulation period. Tank wastes containing no sodium pass through pretreatment without a change in the volume. Evaporation/condensation is assumed not to cause precipitation of radionuclides or other constituents.

Tank wastes with low sodium concentrations require extensive evaporation of the original feed and produce a smaller number of batches for treatment. Conversely, high sodium concentrations require a larger number of batches. To balance the flow of batches to pretreatment in the simulation, delay times to prepare a batch for sodium adjustment are assumed shorter for evaporation/condensation and longer for addition of water.

5.1.3 Simulation Study Results

Results from the simulation study using processing sequences, based on Class A disposal criteria and Clean Option goals, are presented in this section. A sodium content adjusted to 5M and a throughput rate of 5 gpm after sodium adjustment were used in the simulation to generate the results. The 5M Na concentration represents the current sodium limit in feed to grout. The 5 gpm throughput rate is based on the throughput rate for the cesium CPU under development.

Results generated from the 5-gpm case may be used as a basis for determining the effect of the throughput rate on tank processing time, technology implementation schedule, HLW and LLW processing schedules, and accumulation of solids. The impact of different throughput rates on the time required to process a tank can be estimated by assuming the processing time is inversely proportional to flowrate. The impact of different throughput rates on other variables, e.g., glass production/quarter, LLW generation/quarter, and accumulated solids/quarter, can be estimated by assuming these variables are directly proportional to flowrate.

5.1.3.1 Results Using Processing Sequence Based on Class A Disposal Criteria

Pretreatment of supernatant from the 20 DSTs for which data are available was simulated. The tanks were processed in the order they appear in the processing sequence based on Class A disposal criteria. The 20 tanks were divided into three groups to stay within the capacity of the software program. The first group consisted of the eight tanks that met Class A Criteria Sets 1 and 2 (refer Section to 4.2). The second group consisted of the first eight (out of nine) tanks that met Class A Criteria Set 3. The third group of four tanks consisted of the last tank in Class A Criteria Set 3 and the three remaining tanks that met Class A Criteria Set 4.

Simulations were conducted for each group, and run results were tallied automatically by the software. The total simulation period for pretreatment was obtained by manually linking the three separate run periods. Note that a short period of idle time exists at the startup of each simulation run while the first tank is being emptied for processing. When a run is manually linked to another run, this idle time roughly translates into an additional quarter period in the time frame.

The results based on the Class A disposal criteria processing sequence are presented in Table 5.1. The time period to process supernatant from all 20 tanks is 35 quarters (8.75 years). The HWVP operation is well below its assigned capacity of 25 logs/quarter. The maximum demand of 16 logs/quarter does not occur until the 27th quarter. In addition, a minimal number of logs are generated in the first 2 years of operation. This situation indicates that startup of the HWVP could be delayed for several years after startup of the cesium pretreatment module; however, a holding tank capable of storing highly radioactive waste would be required for the extracted cesium and strontium.

The 5M Na constraint results in the addition of approximately 18,000 m³ of process water. As a result, a total of 76,400 m³ of supernatant is processed and becomes feed to grout. The grout demand is almost always near its assigned operating capacity of 25 grout units/quarter. This would be expected, since uninterrupted operation at 5 gpm is equivalent to 24.9 grout units/quarter. The lower LLW production rates shown in Table 5.1 correspond to shutdown and startup times among groups of tanks when the system is not operating at full capacity.

Approximately 15,000 m³ of solids accumulate during pretreatment of the 20 supernatant tanks. Approximately six 1-million-gal storage tanks (approximately 70% full) would be required to store all this material until further pretreatment of the solids. During the first year of operation when tank space is limited, four tanks are processed; however, the first tank is not completely processed until the 4th quarter. During the first year of operation, approximately 3300 m³ of solids are accumulated; this volume of solids corresponds to approximately one 1-million-gal storage tank. Note that the bulk of these solids is not generated until the 4th quarter.

Results from the simulation study based on the Class A disposal criteria processing sequence indicate that additional pretreatment technologies will be required as follows:

<u>Pretreatment Technology</u>	<u>Years After Initiating Cesium Pretreatment</u>
Organic destruction	0.75
Strontium removal	2.0
TRU removal	6.75

Table 5.1. Simulation Results: NRC Class A and TOC Grout Feed Acceptance Criteria

Processing Time ^(a) (annual quarters)	Cumulative # Tanks Processed ^(b)	Required HLW Production (logs/annual quarter)	LLW Feed Generation (m ³ x100/annual quarter)	Solids Accumulation (m ³)
1	0	1	19	128
2	0	2	25	273
3	0	1	24	378
4	4	2	24	3297
5	4	1	23	3297
6	5	1	21	4187
7	7	0	22	7368
8	8	0	1	7368
9	8	2	21	7426
10	10	7	24	7869
11	11	2	23	11446
12	13	2	22	12088
13	13	3	25	12178
14	13	3	24	12250
15	13	3	25	12319
16	13	3	25	12395
17	14	3	24	12521
18	14	3	24	12653
19	14	3	25	12783
20	14	3	25	12914
21	15	4	25	13019
22	15	3	24	13093
23	15	3	25	13166
24	15	3	25	13240
25	15	3	25	13284
26	16	0	3	13284
27	17	16	9	13640
28	18	10	22	14042
29	18	2	25	14567
30	18	2	25	14898
31	19	2	25	14912
32	19	1	24	14912
33	19	1	25	14912
34	19	2	25	14912
35	20	1	11	14912
	20 (total)	98 (total)	764 (total)	

(a): Uninterrupted pretreatment processing rate of 5 gpm is assumed.
(b): Time that pretreatment of the tank is completed; tank is assumed to be empty and available for storage at this time.

5.1.3.2 Results Using Processing Sequence Based on Clean Option Goals

Pretreatment of supernatant from the 20 DSTs for which data are available was again simulated. This time, the tanks were processed in the order they appear in the processing sequence based on Clean Option goals. The tanks were divided into three groups. The first group consisted of the eight tanks that met Clean Option Criteria Sets 1 and 2 (refer to Section 4.3). The second consisted of the five tanks that met Clean Option Criteria Set 3, and three (of the four) tanks under Criteria Set 4. The third group of four tanks consisted of the 4th tank in Clean Option Set 4 and the three remaining tanks that met Clean Option Criteria Set 5. Simulations were conducted for each group, and run results were tallied automatically by the software. The total simulation period for pretreatment was obtained by manually linking the three separate run periods.

The results based on the Clean Option goals processing sequence are presented in Table 5.2. As might be expected, the overall results are similar to those obtained using the Class A disposal criteria processing sequence. The time period to process the supernatant from all 20 tanks is 35 quarters (8.75 years).

The HWVP operation is well below its assigned capacity of 25 logs per quarter. The maximum demand of 16 logs/quarter does not occur until the 28th quarter. The log production in the first 2 years of operation is again minimal, and indicates startup of HWVP could be delayed; however, holding tanks would be required to store highly radioactive wastes.

The grout demand is almost always near its assigned operating capacity of 25 grout units/quarter. Again, the dips in the LLW production rates shown in Table 5.2 correspond to shutdown and startup times among groups of tanks processed when the system is not operating at full capacity.

In the first year of operation, when tank space is limited, five tanks are processed. During this same time period, approximately 4300 m³ solids are processed. This volume of solids corresponds to approximately two 1-million-gal tanks for storage.

Results from the simulation study based on the Clean Option goals processing sequence indicate that additional pretreatment technologies will be required as follows:

<u>Pretreatment Technology</u>	<u>Years After Initiating Cesium Pretreatment</u>
Organic destruction	immediately
Technetium removal	1.25
Strontium removal	2.25
Iodine removal	3.0
TRU removal	6.75

Table 5.2. Simulation Results: Clean Option Goals and TOC Grout Feed Acceptance Criterion

Processing Time ^(a) (annual quarters)	Cumulative # Tanks Processed ^(b)	Required HLW Production (logs/annual quarter)	LLW Feed Generation (m ³ x100/annual quarter)	Solids Accumulation (m ³)
1	1	0	2	1054
2	3	0	16	2913
3	3	2	23	2913
4	5	0	17	4263
5	6	1	14	4343
6	6	2	25	4494
7	6	2	24	4618
8	7	1	25	7147
9	8	0	13	7369
10	10	2	21	7426
11	12	7	24	7869
12	13	1	13	9202
13	13	2	24	12080
14	13	3	25	12161
15	13	3	25	12229
16	13	3	25	12298
17	14	3	24	12366
18	14	3	24	12482
19	14	3	25	12613
20	14	3	25	12745
21	14	4	24	12874
22	15	3	25	12994
23	15	3	25	13071
24	15	3	25	13144
25	15	3	24	13218
26	16	3	25	13284
27	17	1	11	13284
28	18	16	9	13640
29	18	10	22	14042
30	18	2	25	14567
31	19	2	25	14898
32	19	2	25	14912
33	19	1	24	14912
34	19	1	25	14912
35	20	2	25	14912
36		1	11	14912
	20 (total)	98 (total)	764 (total)	
(a): Uninterrupted pretreatment processing rate of 5 gpm is assumed.				
(b): Time that pretreatment of the tank is completed; tank is assumed to be empty and available for storage at this time.				

5.2 Examples of Time-phased Deployment Schedules

The time-phased deployment schedules based on the simulation results discussed above and processing sequences for the Class A and Clean Option scenarios are summarized in Figures 5.1 and 5.2, respectively. These figures include the specific tanks processed, the pretreatment technologies required, and the time frames in which pretreatment is accomplished. As previously mentioned, the simulation model used to develop these time-phased deployment schedules assumes 365 days/year operation and 100% operating efficiency, and does not take into account down time or time required to move the CPU or switch to processing another tank; thus, the time frames given for pretreatment are underestimated. However, these schedules may be used to estimate more realistic schedules based on more realistic on-stream efficiencies, e.g., 50% on-stream efficiency.

5.3 Discussion of Results

The differences between the Clean Option and Class A deployment schedules are mainly a result of the different sequencing of the initial eight tanks to be pretreated. These differences are reflected in the early time periods of the simulation results (refer to Tables 5.1 and 5.2) and time-phased deployment schedules (refer to Figures 5.1 and 5.2). For example, in the Clean Option case (Table 5.2 and Figure 5.2), more tanks are available for storage in the initial quarters of processing than in the Class A case (Table 5.1 and Figure 5.1) because tanks containing smaller quantities of supernatant (after adjustment to 5M Na) are being processed initially in the Clean Option case.

During the initial quarters of processing, fewer solids are accumulated in the Class A case than in the Clean Option case; however, after 1 year of processing, the accumulated solids in both cases are comparable. Glass log production in the first quarters of operation in both cases are comparable. As previously mentioned, the minimal log production in the first few years of operation indicates that startup of HWVP could be delayed if HLW storage facilities are available.

Although location of tanks is not incorporated in the simulation, the logistics from this standpoint are favorable for both tank processing sequences. Seven of the first eight tanks in the Class A case (refer to Figure 5.1) and the first seven tanks in the Clean Option case (refer to Figure 5.2) are all located in two tank farms, AP and AW. These tank farms are close to one another. In addition, only cesium and organic destruction technologies are required to treat these tanks in the Class A case and six of the seven tanks in the Clean Option case. Based on these observations, it would make sense to locate the first cesium removal/organic destruction CPUs within these tank farms.

Figure 5.1. Example Deployment Schedule: NRC Class A and TOC Grout Feed Acceptance Criteria

Figure 5.2. Example Deployment Schedule: Clean Option Goals and TOC Grout Feed Acceptance Criterion

6.0 Conclusions

While the emphasis here has been on Hanford tank waste processing, the methodology can be used for other sites with multiple waste types contained in multiple storage facilities. Results for the task activities described in this report are given below:

1. The methodology developed within this task can effectively be used to determine processing requirements on a tank-by-tank basis and can effectively be used as a basis to develop deployment sequences and schedules for pretreating tank wastes.
2. The nature of the spreadsheet provides a way to rapidly determine the effects of changing disposal criteria or changing databases on tank-by-tank processing requirements.
3. Target goals or requirements can influence which tanks should be processed first, what technology requirements are warranted, and in what order technologies are warranted in the future. The following observations are made.
 - Tank AW-101, the first tank listed in the processing sequence based on NRC Class A criteria drops in the processing sequence based on Clean Option goals because of the presence of ^{99}Tc and ^{129}I . These constituents represent about 2% of the total approximate inventory for each contaminant.
 - Tanks that require ^{137}Cs removal also require either organic destruction and/or ^{90}Sr removal to satisfy TOC grout feed acceptance criterion and both NRC Class A criteria and Clean Option goals.
 - To satisfy Clean Option goals, ^{99}Tc removal technology is required fairly early in the pretreatment sequence (Table 4.3), and ^{129}I removal is required later. Even without these technologies immediately available, a case may be made for proceeding with treatment of several DSTs if future processing of all remaining tanks includes increased ^{99}Tc and ^{129}I removal.
4. Development of the deployment schedules led to several observations.
 - In addition to allowing tanks low in technetium and iodine to be treated first, the Clean Option schedule frees more tank space early in the pretreatment time frame.
 - Minimal glass production rates are required to keep up with tank waste processing at 5 gpm. The overall glass production requirements, based on heat loading limits, for treating supernatant from the 20 DSTs is approximately 98 logs.
 - Assuming 5M Na in the feed to grout, a total of $7.6 \times 10^4 \text{ m}^3$ feed to grout results from pretreating the supernatant from the 20 DSTs. Continual operation of the grout facility, corresponding to at least the same flowrate as the pretreatment processing, would be required for efficient pretreatment.

- Assuming a 5-gpm flowrate and 100% on-stream efficiency, the time required to treat the supernatant in the 20 DSTs is approximately 9 years. This is an idealistic time frame for this flowrate; however, these results can be used as a basis for estimating the total processing time required for different flowrates or multiple CPUs operating in parallel.
- Although tank location was not used as a primary criterion in developing the tank pretreatment sequences or time-phased deployment schedules, the logistics from this standpoint are favorable for early treatment of tanks via both the Clean Option and Class A tank processing schedules that were developed. Seven of the first eight tanks in the Class A sequence and the first seven tanks in the Clean Option sequence are all located in two adjacent tank farms (AW and AP farms).

7.0 References

Hendrickson, D. W. 1991. *Treatment Facility Waste Feed Acceptance Criteria*. WHC-SD-WM-RD-019, Rev 1, Westinghouse Hanford Company, Richland, Washington.

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Straalsund, J. L., J. L. Swanson, E. G. Baker, J. J. Holmes, E. O. Jones, and W. L. Kuhn. 1993. *Clean Option: An Alternative Strategy for Hanford Tank Waste Remediation, Volume 1. Overview*. PNL-8388 Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

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Appendix A

Example Calculations

Appendix A

Example Calculations

The following example is a sample calculation used in the spreadsheet format. These repetitive calculations were performed using macros in the spreadsheet format to ensure consistency and efficiency.

Example 1: Spreadsheet Logic For Calculating Radionuclide DFs

Tank AW-101

Components of interest (Database):

	<u>Curies</u>	<u>g</u>
Sr	4.35×10^3	Na 9.23×10^8
Tc	6.09×10^2	
I	1.21	
Cs	2.08×10^6	
TRU	9.22	

Class A Limits (e.g., Criteria A in Section 3)

	<u>$\mu\text{Ci/g waste form}$</u>
Sr	0.022
Tc	0.167
I	0.0044
Cs	0.56
TRU	0.01

Convert Tank Contents to Same Units as Class A Limits

Step 1: Calculate volume required to give 5M Na

$$\frac{9.23 \times 10^8 \text{ g Na} \mid \text{mole Na} \mid \text{liter}}{\mid 23 \text{ g Na} \mid 5 \text{ moles Na}} = 8.03 \times 10^6 \text{ liters feed to waste form}$$

Step 2: Convert from feed-to-waste form to waste form

- Assume 1.4 liters waste form/liter feed to waste form (Lokken et al. 1993)
- Assume waste form density = 1800 g/l

$$\frac{8.03 \times 10^6 \text{ l fd to wstfrm} \mid 1.4 \text{ l wstfrm} \mid 1800 \text{ wstfrm}}{\mid 1 \text{ fd to wstfrm} \mid 1 \text{ wstfrm}} = 2.02 \times 10^{10} \text{ g wstfrm}$$

Step 3: Normalize contents of tank to g waste form

$$Sr = \frac{4.35 \times 10^3 \text{ Ci}}{2.02 \times 10^{10} \text{ g wstfrm}} \left| \frac{10^6 \mu\text{Ci}}{\text{Ci}} \right| = 0.215 \mu\text{Ci/g waste form}$$

$$Tc = \frac{6.09 \times 10^2 \text{ Ci}}{2.02 \times 10^{10} \text{ g wstfrm}} \left| \frac{10^6 \mu\text{Ci}}{\text{Ci}} \right| = 0.030 \mu\text{Ci/g waste form}$$

$$I = \frac{1.21 \text{ Ci}}{2.02 \times 10^{10} \text{ g wstfrm}} \left| \frac{10^6 \mu\text{Ci}}{\text{Ci}} \right| = 0.030 \mu\text{Ci/g waste form}$$

$$Cs = \frac{2.08 \times 10^6 \text{ Ci}}{2.02 \times 10^{10} \text{ g wstfrm}} \left| \frac{10^6 \mu\text{Ci}}{\text{Ci}} \right| = 1.03 \times 10^2 \mu\text{Ci/g waste form}$$

$$\text{TRU} = \frac{9.22 \text{ Ci}}{2.02 \times 10^{10} \text{ g wstfrm}} \left| \frac{10^6 \mu\text{Ci}}{\text{Ci}} \right| = 4.56 \times 10^{-4} \mu\text{Ci/g waste form}$$

Step 4: Compare Untreated Waste with Class A Criteria (e.g., Criterion A, Section 3.1) and determine outliers; if no outliers go to LLW.

$$Sr: \frac{0.215 \mu\text{Ci}}{\text{g wstfrm}} \left| \frac{\text{g wstfrm}}{0.022 \mu\text{Ci}} \right| = 9.77 > 1 : Sr = \text{outlier}$$

$$Tc: \frac{0.03 \mu\text{Ci}}{\text{g wstfrm}} \left| \frac{\text{g wstfrm}}{0.167 \mu\text{Ci}} \right| = 0.180 < 1 : Tc = \text{not outlier}$$

$$I: \frac{5.99 \times 10^{-5} \mu\text{Ci}}{\text{g wstfrm}} \left| \frac{\text{g wstfrm}}{0.0044 \mu\text{Ci}} \right| = 0.014 < 1 : I = \text{not outlier}$$

$$Cs: \frac{1.03 \times 10^2 \mu\text{Ci}}{\text{g wstfrm}} \left| \frac{\text{g wstfrm}}{0.56 \mu\text{Ci}} \right| = 184 > 1 : Cs = \text{outlier}$$

$$\text{TRU}: \frac{4.56 \times 10^{-4} \mu\text{Ci}}{\text{g wstfrm}} \left| \frac{\text{g wstfrm}}{0.01 \mu\text{Ci}} \right| = 0.0456 < 1 : \text{TRU} = \text{not outlier}$$

Outliers: Sr, Cs

Multiply Class A criteria by 10 (e.g., results in Criterion C, Section 3.1), and determine outliers; if no outliers go to LLW.

$$Sr: \frac{0.215 \mu\text{Ci}}{\text{g}} \left| \frac{\text{g}}{0.022 (10) \mu\text{Ci}} \right| = 0.977 < 1 : Sr = \text{not outlier}$$

$$Cs: \frac{1.03 \times 10^2 \mu\text{Ci}}{\text{g}} \left| \frac{\text{g}}{0.56 (10) \mu\text{Ci}} \right| = 18.4 > 1 : Cs = \text{outlier}$$

Outliers: Cs

Multiply Class A criteria by 100 (e.g., results in Criterion C, Section 3.1), and determine outliers; if no outliers go to LLW.

$$\text{Cs: } \frac{1.03 \times 10^2 \mu\text{Ci}}{\text{g}} \bigg| \frac{\text{g}}{0.56 (100) \mu\text{Ci}} = 1.84 > 1 : \text{Cs} = \text{outlier}$$

Outliers: Cs

Multiply Class A criteria by 100 (e.g., results in Criterion C, Section 3.1), and determine outliers; if no outliers go to LLW.

$$\text{Cs: } \frac{1.03 \times 10^2 \mu\text{Ci}}{\text{g}} \bigg| \frac{\text{g}}{0.56 (1000) \mu\text{Ci}} = 0.184 < 1 : \text{Cs} = \text{not outlier}$$

Outliers: None

Therefore, waste can be sent to grout.

Results:

	<u>Required DF</u>
Sr	10
Tc	< 1 (no pretreatment required)
I	< 1 (no pretreatment required)
Cs	1000
TRU	< 1 (no pretreatment required)

The above example illustrates how the spreadsheet logic operates in calculating required DFs. For most cases it is assumed that because the DFs are calculated in decade increments, sum-of-fractions should be satisfied. At present the spreadsheet does not check this assumption; however, it may be included at a later date. The sum-of-fractions criterion is checked below for the Tank AW-101 required DFs that were calculated above.

	<u>DF</u>	<u>initial conc. $\mu\text{Ci/g}$</u>	<u>Class A limit $\mu\text{Ci/g}$</u>	<u>Final Sr conc. Class A limit</u>
Sr	10	0.215	0.022	0.977
Tc	none	0.03	0.167	0.180
I	none	5.99×10^{-5}	0.0044	0.014
Cs	1000	1.03×10^2	0.56	0.184
TRU	none	4.56×10^{-4}	0.01	<u>0.046</u>
				1.4 > 1 (sof exceeded)

In this case, the sum-of-fractions has been exceeded, assuming the data are accurate. The component primarily responsible is strontium. In this particular case, the final strontium concentration was very close to the limits for a DF of 10. To satisfy the sum-of-fractions rule, the minimum strontium DF would have to be 18 rather than 10. Therefore, although the DFs are of the same magnitudes, a slightly higher strontium DF is required to satisfy the sum-of-fractions. In Tables 4.1 and 4.3 in Section 4, slightly lower minimum strontium DFs were calculated because the criterion in the Tables used a higher cesium DF (Table 4.1) and higher cesium and technetium DFs (Table 4.3).

Example 2:DF Calculation, Definition, And Applicability

Tank AW-101

Values of interest (Database)

Sr: 4.35×10^3 Ci

Na: 9.23×10^8 g

Supernatant volume: 4.01×10^6 L

Sr concentration in AW-101: 1085 $\mu\text{Ci/L}$

Class A Sr Limit: 0.022 $\mu\text{Ci/g}$ waste form

DF definition given in Section 3.0:

$$\text{DF}_{\text{radionuclides}} = \frac{(\mu\text{Ci Radionuclide/g waste form})_u}{(\mu\text{Ci Radionuclide/g waste form})_t}$$

where:

$(\mu\text{Ci Radionuclide/g waste form})_u$ = untreated radionuclide concentration after being concentrated to 5M Na and being sent to grout.

$(\mu\text{Ci Radionuclide/g waste form})_t$ = radionuclide target concentration based on Class A criteria or Clean Option goals.

Convert Sr Tank Content to Same Units as Class A Limits

Step 1: Calculate volume required to give 5M Na

$$\frac{9.23 \times 10^8 \text{ g Na} \mid \text{mole Na} \mid \text{liter}}{\mid 23 \text{ g Na} \mid 5 \text{ moles Na}} = 8.03 \times 10^6 \text{ liters feed to waste form}$$

Step 2: Convert from feed-to-waste form to waste form

- Assume 1.4 liters waste form/liter feed to waste form (Lokken et al. 1993)
- Assume waste form density = 1800 g/l

$$\frac{8.03 \times 10^6 \text{ l fd to wstfrm} \mid 1.4 \text{ l wstfrm} \mid 1800 \text{ wstfrm}}{\mid 1 \text{ l fd to wstfrm} \mid 1 \text{ wstfrm}} = 2.02 \times 10^{10} \text{ g wstfrm}$$

Step 3: Normalize Sr content of tank to g waste form

$$\text{Sr} = \frac{4.35 \times 10^3 \text{Ci}}{2.02 \times 10^{10} \text{g wstfrm}} \left| \frac{10^6 \mu\text{Ci}}{\text{Ci}} \right| = 0.215 \mu\text{Ci/g waste form}$$

$$\text{therefore, DF} = \frac{0.215 \mu\text{Ci Sr/g waste form}_u}{0.022 \mu\text{Ci Sr/g waste form}_t} = 9.8$$

Now suppose one decides to process the strontium prior to concentrating or diluting to 5M Na. Since the DF given above has been normalized to g waste form for both the untreated and target concentrations (i.e., the denominator for the untreated and target concentrations cancel one another), the same DF value of 9.8 can be used below, assuming that during processing, little or no volume change takes place, and the sodium content is not changed significantly:

$$\begin{array}{c} \text{pretreat to DF=9.8 dilute to 5M Na} \\ 1085 \mu\text{Ci Sr/L} \longrightarrow 111 \mu\text{Ci Sr/L} \longrightarrow \end{array}$$

$$\begin{array}{c} \text{convert to g waste form} \\ 56 \mu\text{Ci Sr/L} \longrightarrow 0.022 \mu\text{Ci Sr/g waste form} \end{array}$$

As can be seen, the strontium concentration in the waste form agrees with the Class A targets, as would be expected. The same ending value is obtained if the waste is diluted prior to pretreatment:

$$\begin{array}{c} \text{dilute to 5M Na pretreat to DF=9.8} \\ 1085 \mu\text{Ci Sr/L} \longrightarrow 543 \mu\text{Ci Sr/L} \longrightarrow \end{array}$$

$$\begin{array}{c} \text{convert to g waste form} \\ 56 \mu\text{Ci Sr/L} \longrightarrow 0.022 \mu\text{Ci Sr/g waste form} \end{array}$$

From the above example, it can be seen that by normalizing the DF to a common denominator for both the untreated and treated (or target) concentrations, the value of the DF defined above, can be used in determining a processing DF, wherever in the sequence of events that processing takes place, assuming constant volume and sodium content during that pretreatment process.

A.1 Reference

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Appendix B

DST Supernatant Database

Table B.1. Double Shell Tank Supernatant Analytical/Historical Data

Tank	Liters Total	Liters Liquid	Curies C14	Curies Ni63	Curies Sr90	Curies Y90	Curies Zr93	Curies Nb93	Curies Tc99	Curies I129	Curies Cs137	Curies Ba137
AN-103	3.60E+06	4.92E+04	9.84E-02	NR	5.17E+02	NR	NR	NR	8.37E+00	2.56E-02	3.02E+04	NR
AN-104	4.02E+06	3.03E+06	NR	NR	2.98E+04	NR	NR	NR	NR	NR	2.29E+06	NR
AN-105	4.27E+06	4.27E+06	NR	NR	1.38E+04	NR	NR	NR	NR	NR	2.15E+06	NR
AN-106	3.77E+06	3.71E+06	1.24E+00	NR	7.46E+03	NR	NR	NR	2.57E+02	2.78E-01	6.86E+05	NR
AN-106	3.77E+06	3.71E+06	2.41E+00	3.36E+02	1.54E+04	NR	NR	NR	3.57E+02	1.11E-01	9.16E+05	NR
AP-103	4.29E+06	4.29E+06	1.92E-02	NR	1.12E+01	NR	NR	NR	4.66E+00	1.37E-01	2.81E+04	NR
AP-105	3.12E+06	3.12E+06	7.36E-01	NR	5.93E+02	NR	NR	NR	5.58E+01	1.30E-01	7.98E+05	NR
AP-106	4.28E+06	4.28E+06	1.16E-01	NR	1.80E+04	NR	NR	NR	6.42E+01	1.28E-01	1.54E+05	NR
AW-101	4.33E+06	4.01E+06	1.48E+00	NR	4.35E+03	NR	NR	NR	6.09E+02	1.21E+00	2.08E+06	NR
AW-101	4.33E+06	4.01E+06	1.48E+00	NR	4.05E+03	NR	NR	NR	6.09E+02	1.21E+00	1.94E+06	NR
AW-102	2.76E+06	2.76E+06	NR	NR	1.25E+02	NR	NR	NR	NR	NR	4.19E+04	NR
AW-103	2.46E+06	1.14E+06	NR	NR	1.71E-01	NR	NR	NR	1.59E+01	1.06E-02	3.29E+04	NR
AW-105	3.41E+06	2.31E+06	NR	NR	7.94E+00	NR	NR	NR	2.71E+01		1.08E+05	NR
AW-106	3.55E+06	2.51E+06	1.88E-01	NR	7.40E+01	NR	NR	NR	4.22E+01	1.06E-01	1.27E+05	NR
AY-102	2.31E+06	2.18E+06	NR	NR	1.44E+04	NR	NR	NR	NR	0.00E+00	9.43E+03	NR
AZ-101	3.48E+06	3.35E+06	4.35E+00	NR	1.16E+04	NR	NR	NR	9.07E+02	<2.00E-03	8.50E+06	NR
AZ-102	3.54E+06	3.18E+06	3.37E+00	NR	1.89E+04	NR	NR	NR	3.18E+02	<3.00E-03	2.37E+06	NR
SY-101	4.22E+06	9.65E+05	NR	NR	4.65E+03	NR	NR	NR	NR	NR	5.68E+05	NR
SY-103	2.82E+06	6.59E+05	NR	NR	NR	NR	NR	NR	NR	NR	4.76E+02	NR
	NR: Not Reported											
	ND: Not Detected											

Table B.1. (contd)

Tank	Curies	Curies	Curies	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
	Sm151	U	TRU	Ag	Al	Ba	Bi	CO3	Ca	Ce	Cl	Cr
AN-103	NR	NR	2.05E-01	7.86E+02	2.83E+06	7.91E+02	2.41E+03	4.40E+05	4.25E+03	NR	4.71E+05	4.17E+04
AN-104	NR	NR	3.40E+04	NR	1.14E+08	NR	NR	8.59E+07	NR	NR	2.27E+06	2.05E+06
AN-105	NR	NR	4.79E+04	NR	2.01E+08	NR	NR	9.31E+07	NR	NR	3.62E+06	2.89E+06
AN-106	NR	NR	2.37E+00	1.35E+04	3.44E+07	4.12E+04	5.38E+05	7.28E+07	3.34E+05	NR	9.10E+05	2.08E+06
AN-106	NR	NR	3.65E+00	NR	4.01E+07	NR	NR	8.50E+07	2.60E+05	NR	9.04E+05	2.46E+06
AP-103	NR	NR	7.88E-02	1.72E+02	1.06E+06	2.79E+02	NR	NR	NR	NR	2.12E+05	3.12E+05
AP-105	NR	NR	4.28E+00	6.73E+04	1.35E+07	1.86E+04	2.41E+05	4.73E+07	1.35E+05	NR	8.02E+05	5.38E+05
AP-106	NR	NR	9.85E-01	1.45E+04	1.24E+07	4.10E+03	5.29E+04	6.68E+06	1.45E+04	NR	2.28E+05	3.36E+06
AW-101	NR	NR	9.22E+00	1.30E+05	1.12E+08	3.74E+04	NR	4.93E+07	1.32E+05	NR	2.07E+06	6.46E+05
AW-101	NR	NR	9.38E+00	1.34E+05	1.11E+08	3.74E+04	4.85E+05	4.93E+07	1.32E+05	NR	2.07E+06	6.44E+05
AW-102	NR	NR	1.71E+00	2.46E+03	1.35E+06	3.59E+03	NR	NR	NR	NR	1.28E+05	1.88E+06
AW-103	NR	NR	3.66E-01	NR	1.01E+05	6.10E+02	NR	5.86E+05	5.00E+03	9.76E+02	2.07E+05	5.37E+04
AW-105	NR	NR	2.73E-01	NR	1.51E+06	NR	NR	3.30E+05	8.95E+04	NR	3.96E+06	1.01E+05
AW-106	NR	NR	3.02E-01	1.21E+04	4.20E+06	4.34E+03	NR	NR	NR	NR	1.34E+05	1.97E+06
AY-102	NR	NR	5.11E-01	1.51E+04	3.48E+03	8.70E+02	NR	3.80E+06	9.61E+03	NR	1.23E+05	2.38E+04
AZ-101	NR	NR	4.35E+01	8.37E+03	8.99E+06	8.41E+03	NR	NR	3.20E+04	<4.00E+03	1.03E+06	1.76E+06
AZ-102	NR	NR	4.13E+00	2.34E+04	3.45E+05	2.66E+03	NR	1.36E+08	2.05E+04	4.02E+04	2.33E+05	3.40E+06
SY-101	NR	NR	9.86E-01	NR	4.33E+07	NR	NR	3.66E+06	6.48E+05	NR	1.25E+06	8.45E+04
SY-103	NR	NR	4.41E+00	NR	4.28E+07	4.81E+03	NR	1.58E+07	1.92E+05	NR	7.02E+05	2.88E+06
	NR: Not Reported											
	ND: Not Detected											

Table B.1. (contd)

Tank	Grams F	Grams Fe	Grams Fe(CN)6	Grams K	Grams La	Grams Mn	Grams NO2	Grams NO3	Grams Na	Grams Ni	Grams OH	Grams PO4
AN-103	3.61E+04	3.46E+03	1.65E+03	7.48E+05	NR	1.73E+00	6.77E+06	7.75E+06	1.65E+07	1.18E+03	4.80E+06	4.62E+04
AN-104	NR	3.39E+04	NR	2.17E+07	NR	NR	2.68E+08	5.83E+08	8.37E+08	NR	2.11E+08	8.56E+05
AN-105	NR	4.77E+04	NR	2.62E+07	NR	NR	5.13E+08	8.27E+08	1.18E+09	NR	2.64E+08	8.20E+05
AN-106	2.28E+05	2.57E+04	2.23E+04	4.00E+06	NR	2.51E+02	1.10E+08	2.51E+08	3.35E+08	NR	2.99E+07	6.91E+06
AN-106	5.56E+05	NR	NR	1.15E+05	NR	NR	1.42E+08	3.28E+08	3.48E+08	1.00E+05	8.53E+07	5.65E+06
AP-103	5.55E+05	3.57E+03	2.56E+03	NR	NR	1.36E-01	5.57E+06	1.71E+07	2.28E+07	NR	6.56E+06	5.97E+05
AP-105	7.70E+06	3.48E+04	5.39E+04	1.05E+08	NR	6.40E+01	1.56E+08	5.14E+08	4.56E+08	3.94E+05	2.45E+08	4.85E+05
AP-106	3.35E+04	1.94E+04	1.19E+04	1.86E+07	NR	1.40E+01	2.21E+07	4.11E+07	1.06E+08	4.40E+04	6.39E+07	9.37E+05
AW-101	3.05E+05	<1.75E+05	1.04E+05	1.67E+08	NR	1.05E+05	3.99E+08	8.59E+08	9.23E+08	NR	3.46E+08	8.54E+05
AW-101	3.06E+05	1.76E+05	1.07E+05	1.68E+08	NR	1.28E+02	4.04E+08	8.60E+08	9.22E+08	NR	3.45E+08	8.54E+05
AW-102	1.11E+07	8.71E+04	3.54E+03	NR	NR	3.27E+00	7.10E+06	3.90E+07	4.63E+07	NR	7.97E+06	4.87E+05
AW-103	1.95E+07	1.05E+04	NR	1.51E+07	1.83E+02	1.22E+02	1.22E+06	4.34E+06	2.55E+07	1.83E+03	NR	1.66E+06
AW-105	2.59E+07		NR	2.97E+07	NR		5.49E+06	3.91E+07	5.40E+07	NR	NR	5.42E+05
AW-106	1.64E+07	1.88E+05	4.98E+03	NR	NR	2.05E+01	2.40E+07	9.01E+07	9.99E+07	NR	2.51E+07	1.85E+05
AY-102	3.86E+05	8.78E+02	NR	9.39E+04	<1.21E+02	NR	2.51E+06	5.96E+05	4.57E+06	1.80E+02	NR	1.15E+05
AZ-101	2.38E+06	8.00E+04	NR	8.32E+06	1.30E+04	1.79E+02	6.01E+08	3.50E+08	1.90E+08	1.03E+04	NR	4.04E+05
AZ-102	2.86E+06	3.68E+04	NR	4.89E+06	5.92E+03	2.55E+03	1.09E+07	2.23E+06	1.63E+08	7.28E+03	NR	7.03E+04
SY-101	9.86E+05	4.23E+04	1.27E+05	5.09E+06	NR	NR	1.93E+08	2.27E+08	2.72E+08	5.64E+04	3.97E+07	7.47E+05
SY-103	1.44E+06	9.04E+05	NR	3.65E+06	1.92E+04	2.21E+05	8.03E+07	9.62E+07	2.09E+08	7.69E+04	2.35E+07	2.98E+05
	NR: Not Reported											
	ND: Not Detected											

Table B.1. (contd)

Tank	Grams Pb	Grams SiO3	Grams Sn	Grams SO4	Grams Sr	Grams U	Grams ZrO	Grams TOC
AN-103	3.54E+03	3.62E+04	NR	7.89E+04	NR	NR	1.38E+03	3.02E+04
AN-104	NR	NR	NR	1.98E+07	NR	NR	NR	1.68E+08
AN-105	NR	NR	NR	2.80E+07	NR	6.23E+01	NR	1.99E+08
AN-106	1.71E+06	NR	NR	7.98E+06	NR	NR	1.21E+05	1.21E+07
AN-106	NR	5.54E+05	NR	9.44E+08	NR	NR	NR	1.96E+09
AP-103	1.72E+03	NR	NR	1.50E+06	NR	NR	NR	4.80E+05
AP-105	6.03E+05	8.37E+05	NR	7.43E+06	NR	NR	1.20E+05	1.22E+07
AP-106	1.32E+05	1.43E+05	NR	4.73E+05	NR	9.72E+04	2.59E+04	2.18E+06
AW-101	1.21E+06	1.33E+06	NR	4.13E+06	NR	8.96E+05	NR	9.86E+06
AW-101	1.21E+06	1.33E+06	NR	4.12E+06	NR	8.96E+05	2.38E+05	9.86E+06
AW-102	2.21E+04	NR	NR	6.44E+06	NR	4.25E-02	NR	1.36E+06
AW-103	NR	4.37E+06	5.61E+04	NR	NR	NR	5.73E+03	9.88E+05
AW-105	NR	NR	NR	9.66E+06	NR	NR	NR	9.66E+05
AW-106	1.10E+05	NR	NR	8.58E+06	NR	NR	NR	2.63E+06
AY-102	NR	7.64E+05	NR	2.31E+05	4.97E+02	NR	1.29E+05	6.28E+05
AZ-101	1.61E+04	9.40E+05	NR	6.28E+07	7.15E+02	NR	4.11E+04	4.17E+05
AZ-102	2.00E+04	5.09E+06	NR	4.61E+07	6.79E+02	NR	3.90E+04	5.21E+06
SY-101	NR	NR	NR	1.83E+06	NR	NR	NR	3.14E+07
SY-103	NR	1.54E+05	NR	2.31E+06	ND	NR	2.14E+04	1.07E+07
	NR: Not Reported							
	ND: Not Detected							

Table B.2. Double Shell Tank Supernatant Inventory Data

Tank	Liters	Liters	Curies	Curies	Curies	Curies	Curies	Curies	Curies	Curies	Curies	Curies
	Total	Liquid	C14	Ni63	Sr90	Y90	Zr93	Nb93	Tc99	I129	Cs137	Ba137
AN-101	2.38E+06	2.38E+06	NR	NR	4.03E+03	NR	NR	NR	NR	NR	4.57E+05	NR
AN-102	4.14E+06	3.80E+06	3.12E+02	NR	1.18E+06	NR	NR	NR	1.56E+03	2.18E+00	4.43E+06	NR
AN-103	3.59E+06	4.54E+04	2.50E+00	NR	1.53E+02	NR	NR	NR	1.16E+01	3.74E-02	6.44E+04	NR
AN-104	4.02E+06	3.03E+06	1.67E+02	NR	1.02E+04	NR	NR	NR	7.77E+02	2.51E+00	4.31E+06	NR
AN-105	4.27E+06	4.27E+06	2.35E+02	NR	1.44E+04	NR	NR	NR	1.09E+03	3.52E+00	6.06E+06	NR
AN-106	3.77E+06	3.71E+06	2.08E+02	NR	1.27E+04	NR	NR	NR	9.65E+02	3.11E+00	5.36E+06	NR
AN-107	4.07E+06	3.56E+06	2.92E+02	NR	1.10E+06	NR	NR	NR	1.46E+03	2.04E+00	4.15E+06	NR
AP-101	4.02E+06	4.02E+06	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-102	5.03E+05	5.03E+05	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-103	4.29E+06	4.29E+06	NR	NR	4.60E+01	NR	NR	NR	NR	NR	2.48E+00	NR
AP-104	7.57E+04	7.57E+04	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-105	3.12E+06	3.12E+06	1.71E+02	NR	1.05E+04	NR	NR	NR	7.97E+02	2.57E+00	4.42E+06	NR
AP-106	4.28E+06	4.28E+06	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-107	4.25E+06	4.25E+06	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-108	3.38E+06	3.38E+06	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-101	4.33E+06	4.01E+06	2.17E+02	NR	1.33E+04	NR	NR	NR	1.01E+03	3.25E+00	5.59E+06	NR
AW-102	2.76E+06	2.76E+06	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-103	2.46E+06	1.14E+06	NR	NR	4.62E+04	NR	NR	NR	NR	NR	2.53E+05	NR
AW-104	4.26E+06	3.26E+06	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-105	3.41E+06	2.31E+06	NR	NR	9.38E+04	NR	NR	NR	NR	NR	5.13E+05	NR
AW-106	3.55E+06	2.51E+06	2.03E+01	NR	2.09E+05	2.16E+05	NR	4.76E+00	7.07E+00	1.08E-02	1.25E+04	2.31E+03
AY-101	3.56E+06	3.25E+06	2.66E+02	NR	1.01E+06	NR	NR	NR	1.33E+03	1.87E+00	3.78E+06	NR
AY-102	2.31E+06	2.18E+06	2.94E+00	NR	2.31E+03	2.38E+03	NR	3.52E-01	6.43E+00	1.03E-02	2.45E+03	2.29E+03
AZ-101	3.48E+06	3.35E+06	1.83E+02	NR	1.11E+07	NR	NR	NR	1.12E+03	2.55E+00	1.28E+07	NR
AZ-102	3.54E+06	3.18E+06	1.77E+02	NR	1.07E+07	NR	NR	NR	1.08E+03	2.45E+00	1.24E+07	NR
SY-101	4.22E+06	9.65E+05	7.70E+01	NR	2.91E+05	NR	NR	NR	3.85E+02	5.39E-01	1.09E+06	NR
SY-102	2.56E+06	2.29E+06	NR	NR	1.76E+05	NR	NR	NR	NR	NR	3.72E+05	NR
SY-103	2.82E+06	6.59E+05	5.25E+01	NR	1.98E+05	NR	NR	NR	2.62E+02	3.67E-01	7.45E+05	NR
	NR: Not Reported											
	ND: Not Detected											

Table B.2. (contd)

Tank	Curies	Curies	Curies	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
	Sm151	U	TRU	Ag	Al	Ba	Bi	C2H3O3	C6H5O7	CO3	C2O4	Ca
AN-101	NR	NR	2.14E+00	NR	NR	NR	NR	NR	NR	NR	NR	NR
AN-102	NR	6.38E-03	ND	NR	1.65E+08	1.52E+05	NR	NR	3.61E+08	2.36E+08	NR	2.17E+06
AN-103	NR	5.94E-03	ND	NR	1.72E+06	6.69E+01	NR	NR	8.08E+05	2.95E+05	NR	6.39E+02
AN-104	NR	3.97E-01	ND	NR	1.15E+08	4.48E+03	NR	NR	5.41E+07	1.97E+07	NR	4.28E+04
AN-105	NR	5.59E-01	ND	NR	1.62E+08	6.29E+03	NR	NR	7.60E+07	2.77E+07	NR	6.01E+04
AN-106	NR	4.94E-01	ND	NR	1.43E+08	5.56E+03	NR	NR	6.72E+07	2.45E+07	NR	5.31E+04
AN-107	NR	5.97E-03	ND	NR	1.54E+08	1.42E+05	NR	NR	3.38E+08	2.21E+08	NR	2.03E+06
AP-101	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-102	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-103	NR	NR	1.21E-01	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-104	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-105	NR	4.08E-01	ND	NR	1.18E+08	4.59E+03	NR	NR	5.55E+07	2.02E+07	NR	4.39E+04
AP-106	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-107	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-108	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-101	NR	5.16E-01	ND	NR	1.50E+08	5.81E+03	NR	NR	7.01E+07	2.56E+07	NR	5.55E+04
AW-102	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-103	NR	3.56E-04	ND	NR	1.73E+05	1.57E+01	NR	NR	NR	3.10E+05	NR	8.55E+03
AW-104	NR	NR	5.08E-13	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-105	NR	7.24E-04	ND	NR	3.51E+05	3.18E+01	NR	NR	NR	6.29E+05	NR	1.74E+04
AW-106	3.76E+03	4.14E-08	9.55E+01	5.10E-05	1.94E+06	5.01E-01	3.21E-12	8.39E+04	4.86E+05	3.08E+06	NR	1.14E-01
AY-101	NR	5.45E-03	ND	NR	1.41E+08	1.29E+05	NR	NR	3.08E+08	2.01E+08	NR	1.85E+06
AY-102	7.39E+01	NR	5.32E+01	4.93E-05	1.67E+05	1.26E+00	1.44E-13	2.42E+03	6.45E+05	7.74E+04	NR	9.38E-01
AZ-101	NR	9.05E-01	ND	1.49E+04	1.56E+07	5.00E+03	NR	NR	1.10E+07	1.75E+07	NR	2.14E+04
AZ-102	NR	8.71E-01	ND	1.44E+04	1.51E+07	4.82E+03	NR	NR	1.06E+07	1.69E+07	NR	2.07E+04
SY-101	NR	1.58E-03	ND	NR	4.07E+07	3.74E+04	NR	NR	8.92E+07	5.82E+07	NR	5.35E+05
SY-102	NR	NR	ND	NR	2.91E+05	NR	NR	NR	NR	6.47E+05	NR	NR
SY-103	NR	1.07E-03	ND	NR	2.77E+07	2.55E+04	NR	NR	6.08E+07	3.97E+07	NR	3.64E+05
	NR: Not Reported											
	ND: Not Detected											

Table B.2. (contd)

Tank	Grams Ce	Grams Cl	Grams Cr	Grams EDTA	Grams F	Grams Fe	Grams Fe(CN)6	Grams HEDTA	Grams K	Grams La	Grams Mn	Grams NO2
AN-101	NR	4.84E+08	8.77E+07	NR	NR	2.66E+08	7.53E+08	NR	NR	NR	NR	NR
AN-102	NR	3.43E+07	7.58E+06	NR	1.21E+07	8.55E+06	NR	NR	9.68E+06	1.25E+06	3.46E+06	2.58E+08
AN-103	NR	6.22E+05	4.94E+03	NR	2.61E+04	2.48E+02	3.07E+02	NR	2.17E+06	NR	1.79E+02	8.38E+06
AN-104	NR	4.16E+07	3.31E+05	NR	1.74E+06	1.66E+04	2.05E+04	NR	1.45E+08	NR	1.20E+04	5.61E+08
AN-105	NR	5.85E+07	4.65E+05	NR	2.45E+06	2.34E+04	2.89E+04	NR	2.04E+08	NR	1.68E+04	7.88E+08
AN-106	NR	5.17E+07	4.11E+05	NR	2.17E+06	2.07E+04	2.55E+04	NR	1.80E+08	NR	1.49E+04	6.97E+08
AN-107	NR	3.21E+07	7.09E+06	NR	1.13E+07	8.00E+06	NR	NR	9.05E+06	1.16E+06	3.24E+06	2.41E+08
AP-101	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-102	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-103	NR	1.15E+07	5.41E+06	NR	NR	1.26E+06	8.85E+07	NR	NR	NR	NR	NR
AP-104	NR	NR	NR	NR	NR	0.00E+00	NR	NR	NR	NR	NR	NR
AP-105	NR	4.27E+07	3.39E+05	NR	1.79E+06	1.71E+04	2.11E+04	NR	1.49E+08	NR	1.23E+04	5.75E+08
AP-106	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-107	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-108	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-101	NR	5.40E+07	4.29E+05	NR	2.26E+06	2.16E+04	2.67E+04	NR	1.88E+08	NR	1.55E+04	7.28E+08
AW-102	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-103	NR	7.03E+05	1.82E+04	NR	6.44E+05	6.96E+02	NR	NR	5.97E+06	1.58E+01	NR	5.97E+06
AW-104	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-105	NR	1.43E+06	3.70E+04	NR	1.31E+06	1.41E+03	NR	NR	1.21E+07	3.22E+01	NR	1.21E+07
AW-106	5.35E+02	4.28E-05	6.87E+03	7.64E+05	1.69E+04	6.90E+04	3.55E+01	1.39E+06	2.36E+04	NR	3.58E+04	7.70E+05
AY-101	NR	2.93E+07	6.47E+06	NR	1.03E+07	7.30E+06	NR	NR	8.26E+06	1.06E+06	2.96E+06	2.20E+08
AY-102	2.84E+01	2.27E-06	1.96E+02	2.21E+04	8.96E+02	3.31E+04	7.89E-02	4.03E+04	2.27E+03	NR	2.23E+03	4.09E+04
AZ-101	NR	3.78E+05	2.53E+06	NR	3.89E+06	4.35E+04	NR	NR	9.78E+06	3.10E+04	3.40E+03	6.47E+07
AZ-102	NR	3.63E+05	2.44E+06	NR	3.75E+06	4.18E+04	NR	NR	9.42E+06	2.99E+04	3.27E+03	6.23E+07
SY-101	NR	8.47E+06	1.87E+06	NR	2.99E+06	2.11E+06	NR	NR	2.39E+06	3.07E+05	8.55E+05	6.37E+07
SY-102	NR	1.53E+05	NR	NR	1.64E+05	NR	NR	NR	5.91E+05	NR	NR	4.96E+05
SY-103	NR	5.77E+06	1.28E+06	NR	2.04E+06	1.44E+06	NR	NR	1.63E+06	2.09E+05	5.83E+05	4.34E+07
	NR: Not Reported											
	ND: Not Detected											

Table B.2. (contd)

Tank	Grams NO3	Grams Na	Grams Ni	Grams OH	Grams PO4	Grams Pb	Grams SiO3	Grams Sn	Grams SO4	Grams Sr	Grams ZrO
AN-101	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AN-102	1.29E+09	1.39E+09	1.75E+06	7.27E+08	3.37E+07	NR	NR	NR	4.12E+07	NR	5.18E+05
AN-103	1.76E+07	2.25E+07	1.26E+02	1.54E+07	6.99E+04	5.97E+02	1.59E+03	NR	2.31E+05	NR	NR
AN-104	1.18E+09	1.50E+09	8.40E+03	1.03E+09	4.67E+06	3.99E+04	1.07E+05	NR	1.55E+07	NR	NR
AN-105	1.65E+09	2.11E+09	1.18E+04	1.45E+09	6.57E+06	5.61E+04	1.50E+05	NR	2.18E+07	NR	NR
AN-106	1.46E+09	1.87E+09	1.04E+04	1.28E+09	5.81E+06	4.96E+04	1.32E+05	NR	1.92E+07	NR	NR
AN-107	1.21E+09	1.30E+09	1.63E+06	6.80E+08	3.15E+07	NR	NR	NR	3.85E+07	NR	4.85E+05
AP-101	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-102	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-103	NR	2.24E+04	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-104	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-105	1.21E+09	1.54E+09	8.62E+03	1.06E+09	4.80E+06	4.10E+04	1.09E+05	NR	1.59E+07	NR	NR
AP-106	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-107	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AP-108	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-101	1.53E+09	1.95E+09	1.09E+04	1.34E+09	6.07E+06	5.18E+04	1.38E+05	NR	2.01E+07	NR	NR
AW-102	NR	2.62E+02	NR	1.94E+02	NR	NR	NR	NR	NR	NR	NR
AW-103	4.46E+06	3.63E+06	1.12E+02	1.14E+06	NR	NR	3.47E+04	NR	1.98E+05	NR	NR
AW-104	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
AW-105	9.04E+06	7.37E+06	2.28E+02	2.31E+06	NR	NR	7.03E+04	NR	4.03E+05	NR	NR
AW-106	7.28E+07	2.70E+07	5.61E+00	1.65E+03	4.60E+04	7.85E-01	7.16E+04	NR	2.89E+06	1.37E+02	NR
AY-101	1.10E+09	1.19E+09	1.49E+06	6.21E+08	2.88E+07	NR	NR	NR	3.52E+07	NR	4.42E+05
AY-102	3.11E+06	1.07E+06	2.40E+01	1.35E+03	4.70E+03	1.32E-01	3.81E+03	NR	2.50E+04	3.83E+00	NR
AZ-101	1.92E+08	3.21E+08	7.08E+03	1.20E+08	2.31E+07	1.74E+04	1.09E+06	NR	5.30E+07	NR	3.26E+04
AZ-102	1.84E+08	3.10E+08	6.82E+03	1.15E+08	2.23E+07	1.68E+04	1.05E+06	NR	5.10E+07	NR	3.13E+04
SY-101	3.19E+08	3.44E+08	4.31E+05	1.79E+08	8.32E+06	NR	NR	NR	1.02E+07	NR	1.28E+05
SY-102	5.36E+06	4.24E+06	NR	1.63E+06	1.02E+05	NR	2.42E+04	NR	1.66E+05	NR	NR
SY-103	2.17E+08	2.34E+08	2.94E+05	1.22E+08	5.67E+06	NR	NR	NR	6.93E+06	NR	8.71E+04
	NR: Not Reported										
	ND: Not Detected										

Table B.3. Hanford Double Shell Tank Data Sources

Double Shell Tank Identification	Inventory Data Source	Analytical/Historical Data Source
AN-101	None	None
AN-102	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	None
AN-103	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AN-104	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AN-105	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AN-106	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AN-107	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	None
AP-101	None	None
AP-102	None	None
AP-103	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AP-104	None	None
AP-105	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
Double Shell Tank Identification	Inventory Data Source	Analytical/Historical Data Source WHC Internal Memorandum 01120-92-020
AP-106	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AP-107	None	None
AP-108	None	None
AW-101	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993; Hendrickson, 1993.
AW-102	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993.
AW-103	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	J.M. Tingey et al., PNL; HWVP Internal Memorandum 85440-91-018
AW-104	None	None
AW-105	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	HWVP Internal Memorandum 85440-91-018

Table B.3. (contd)

Double Shell Tank Identification	Inventory Data Source	Analytical/Historical Data Source
AW-106	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Hendrickson and Conner, 1993
AY-101	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	None
AY-102	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	R.D. Scheele et al., PNL
AZ-101	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Peterson et al. 1989.
Double Shell Tank Identification	Inventory Data Source	Analytical/Historical Data Source WHC Internal Memorandum 01120-92-020
AZ-102	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Peterson et al. 1989.
SY-101	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Herting et al. 1992.
SY-102	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	None
SY-103	1992 TWRS Systems Engineering Study Double-Shell Tank Waste Inventories.	Bryan et al. 1991; C.L. Fow et al., PNL

B.1 References

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