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Tank Characterization Report for Single-Shell Tank 241-T-109

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Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-T-109. This report supports the requirements of Tri-Party Agreement Milestone M-44-09.

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Tank Characterization Report for Single-Shell Tank 241-T-109

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LIST OF TERMS

1C	first cycle decontamination waste
μCi/g	microcuries per gram
μCi/gal	microcuries per gallon
μg	microgram
μg/g	micrograms per gram
ASTM	American Society for Testing and Materials
BL	B Plant low-level waste
BNW	Battelle Northwest waste
Btu/hr	British thermal units per hour
Ci	curies
Ci/L	curies per liter
CI	confidence interval
cm	centimeter
DOE	U. S. Department of Energy
DQO	data quality objectives
DSC	differential scanning calorimetry
EB	evaporator bottoms
Ecology	Washington State Department of Ecology
FIC	Food Instrument Corporation
ft	feet
g	gram
g/L	grams per liter
g/mL	grams per milliliter
HDW	Hanford defined waste
HTCE	historical tank content estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
IX	ion exchange waste
J/g	joules per gram
kg	kilogram
kg/L	kilograms per liter
kgal	kilogallon
kL	kiloliter
kW	kilowatt
L	liter
LANL	Los Alamos National Laboratory
LEL	lower explosive limit
LL	lower limit
m	meter
M	moles per liter

LIST OF TERMS (Continued)

mm	millimeter
mrad/hr	millirads per hour
MT	metric ton
ppm	parts per million
SAP	sampling and analysis plan
SST	single-shell tank
T1SltCk	242-T Evaporator saltcake waste, 1951-55
TBP	tributyl phosphate
TCP	tank characterization plan
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TOC	total organic carbon
TWRS	Tank Waste Remediation System
UL	upper limit
UR	uranium recovery waste
W	watts
WSTRS	waste status and transaction record summary
wt%	weight percent

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1.0 INTRODUCTION

One of the major functions of the Tank Waste Remediation System (TWRS) is to characterize wastes in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis, along with other available information about a tank, are compiled and maintained in a tank characterization report (TCR). This report and its appendices serve as the TCR for single-shell tank 241-T-109. The objectives of this report are: 1) to use characterization data in response to technical issues associated with 241-T-109 waste; and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. The response to technical issues is summarized in Section 2.0, and the best-basis inventory estimate is presented in Section 3.0. Recommendations regarding safety status and additional sampling needs are provided in Section 4.0. Supporting data and information are contained in the appendices. This report also supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) milestone M-44-09.

1.1 SCOPE

Characterization information presented in this report originated from sample analyses and known existing (historical) sources. While only the results of recent sample events will be used to fulfill the requirements of the data quality objectives (DQOs), other information can be used to support (or question) conclusions derived from these results. Historical information for tank 241-T-109, provided in Appendix A, included surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model.

The recent sampling events listed in Table 1-1, as well as sample data obtained prior to 1989, are summarized in Appendix B along with the sampling results. The results of the 1995 sampling events, also reported in the laboratory data package (Conner 1995a), satisfied the data requirements specified in the tank characterization plan (TCP) for this tank (Conner 1995b). The statistical analysis and numerical manipulation of data used in issue resolution are reported in Appendix C. Appendix D contains the evaluation to establish the best basis for the inventory estimate and the statistical analysis performed for this evaluation. A bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-T-109 and its respective waste types is contained in Appendix E. The reports listed in Appendix E may be found in the Tank Characterization Resource Center.

Table 1-1. Summary of Recent Sampling.

Sample/date	Phase	Location	Segmentation	% Recovery	Mass (g)
Vapor sample (8/15/95)	Gas	Tank headspace, Riser 6, 6 m (20 ft) below top of riser	n/a	n/a	n/a
Auger 95-AUG-040 (8/18/95)	Solid	Riser 6	No segmentation	Unknown (probably only top of waste)	67.5
Auger 95-AUG-041 (8/21/95)	Solid	Riser 2	Divided sample in half (upper and lower)	Good recovery. Bottom 2.5 to 13 cm (1 to 5 in.) of the waste may not be represented.	232.5
Vapor sample (5/9/96)	Gas	Tank headspace, Riser 6, 6 m (20 ft) below top of riser	n/a	n/a	n/a

1.2 TANK BACKGROUND

Tank 241-T-109 is located in the 200 West Area T Tank Farm on the Hanford Site. It is the last tank in a three-tank cascade series. The tank went into service in 1945, receiving first cycle decontamination waste cascaded from tank 241-T-108. Supernate was transferred from the tank in 1951. During 1952 and 1953, uranium recovery waste was cascaded into tank 241-T-109. Supernate was transferred both into and out of the tank during 1953 and 1954, and in 1954, the tank received saltcake waste from the 242-T Evaporator. Additional supernate transfers into and out of the tank occurred from 1969 through 1976. The final transfer of waste occurred in 1983, when liquids were pumped from the tank in support of stabilization efforts.

A description of tank 241-T-109 is summarized in Table 1-2. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains an estimated 220 kL (58 kgal) of non-complexed waste (Hanlon 1996). The tank is not on the Watch List (Public Law 101-510).

Table 1-2. Description of Tank 241-T-109.

TANK DESCRIPTION	
Type	Single-Shell
Constructed	1943-1944
In-service	1945
Diameter	22.9 m (75.0 ft)
Operating depth	5.2 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom Shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Non-complexed
Total waste volume[1]	220 kL (58 kgal)
Supernatant volume	0 kL (0 kgal)
Saltcake volume[2]	0 kL (0 kgal)
Sludge volume[2]	220 kL (58 kgal)
Drainable interstitial liquid volume	0 kL (0 kgal)
Waste surface level (7/30/96)	76.2 cm (30.0 in.)
Temperature (2/11/76 to 7/30/96)	11.6 °C (52.9 °F) to 32 °C (90 °F)
Integrity	Assumed leaker
Watch List	None
SAMPLING DATE	
Auger samples	August 1995
SERVICE STATUS	
Declared inactive	1974
Interim stabilization	1984
Intrusion prevention	1982

Note:

[1]Waste volume is estimated from surface level measurements.

[2]Although Hanlon (1996) reports that the tank contains all sludge waste, it is evident from the transfer history (Agnew et al. 1996b) and the auger samples (Conner 1995a) that the majority of the waste is probably saltcake.

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2.0 RESPONSE TO TECHNICAL ISSUES

Two technical issues have been identified for tank 241-T-109 (Brown et al. 1995). They are:

- Does the waste pose or contribute to any recognized potential safety problems?
- Is the waste inventory generated by a model based on process knowledge and historical information (Agnew et al. 1996b) representative of the current tank waste inventory?

The TCP (Conner 1995b) provides the types of sampling and analysis used to address the above issues. Data from the recent analysis of two auger samples and tank vapor space flammability measurements, as well as available historical information, provided the means to respond to these two issues. This response is detailed in the following sections. See Appendix B for sample and analysis data for tank 241-T-109.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-T-109 for potential safety problems is documented in *Tank Safety Screening Data Quality Objective*, Rev. 2 (Dukelow et al. 1995). These potential safety problems are exothermic conditions in the waste; flammable gases in the waste and/or tank headspace; and criticality conditions in the waste. Each of these conditions is addressed separately below. Because tank 241-T-109 is not a Watch List tank, the safety screening DQO was the only safety-related DQO associated with the sampling effort.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO (Dukelow et al. 1995) is to ensure that there are not enough exothermic constituents (organic or ferrocyanide) in tank 241-T-109 to cause a safety hazard. Because of this requirement, energetics in the tank 241-T-109 waste were evaluated. The safety screening DQO required that the waste sample profile be tested for energetics every 24 cm (9.5 in.) to determine if the energetics exceed the safety threshold limit. The threshold limit for energetics is 480 J/g on a dry weight basis. Results obtained using differential scanning calorimetry indicated that no exotherms were apparent for any of the three samples (95-AUG-40, 95-AUG-41 upper, and 95-AUG-41 lower) (Conner 1995a). Note that auger sample 95-AUG-40 was not subdivided into an upper and lower sample because of the low recovery. Thus, the requirement of testing energetics for every 24 cm (9.5 in.) of the sample profile was met only for one of the two samples.

Historically, there is no evidence that any exothermic agent should exist in this waste. Waste transfer records indicate that the major waste type expected to be in the tank is T1 saltcake, with a small possibility that some first-concentration-cycle waste from the bismuth phosphate process may be in the bottom of the tank (Agnew et al. 1996a). Neither of these waste types is expected to have organic or ferrocyanide constituents. Analysis of a sample taken in 1974 (Sant 1974) also showed no evidence of exotherms (see Appendix B).

2.1.2 Flammable Gas

Vapor phase measurements, taken in the tank headspace prior to the auger samples in August 1995 and again in May 1996, indicated that no flammable gas was detected (0 percent of the lower flammability limit). Data from these vapor phase measurements are presented in Appendix B.

2.1.3 Criticality

The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu and assuming a density of 1.55 g/mL, 1 g/L of ^{239}Pu is equivalent to 40 μCi/g of alpha activity. The auger samples were analyzed in accordance with an earlier revision of the safety screening DQO (Babad et al. 1995) which did not require density measurements. Because density was not measured, the density estimated by Agnew et al. (1996b) was used. Waste samples were tested for total alpha activity for each auger sample. Concentrations in all samples were well below this limit. Additionally, as required by the DQO, the upper limit of the one-sided 95 percent confidence interval for these results was less than 1 g/L. The method used to calculate confidence limits is contained in Appendix C.

2.2 HISTORICAL EVALUATION

The purpose of the historical evaluation is to determine whether the model based on process knowledge and historical information (Brevick et al. 1995, Agnew et al. 1996b) predicts tank inventories that are in agreement with current tank inventories. If the historical model can be shown to accurately predict the waste characteristics as observed through sample characterization, then there is a possibility that the amount of total sampling and analysis needed may be reduced. Data requirements for this evaluation are documented in *Historical Model Evaluation Data Requirements*, Rev. 0-A (Simpson and McCain 1995).

A "gateway" analysis is a quick check to ensure that the data obtained from sampling support the remainder of the historical evaluation analysis. Failure of the gateway analysis indicates that the model waste composition estimate is not comparable to the sample data and that the tank is not a good tank on which to perform the historical DQO. If the gateway analysis fails, the remainder of the sampling and analysis for the historical DQO will not be applied to the tank. If the gateway analysis passes, then further analyses will be performed on the

waste samples as specified in the historical model evaluation DQO. Results of the historical model evaluation DQO will be used to quantify the errors associated with the historical tank content estimates (HTCE).

The gateway analysis was applied to each of the auger samples taken from tank 241-T-109 in August 1995. The gateway analytes for tank 241-T-109 are sodium, water, nitrate, phosphate, and fluoride. These analytes were chosen because the tank waste is predicted to be composed entirely of saltcake waste generated from the 242-T evaporator from 1951 through 1955 (T1SltCk). The gateway analysis required two tests be performed for each sample. The first test was to determine if the gateway analytes contributed to more than 85 percent (by mass) of the total waste. The second test was to determine if the concentration of each of the gateway analytes was over 10 percent of the predicted concentration (as specified in the DQO). The gateway analysis for tank 241-T-109 is shown in Appendix C.

The first test in the gateway analysis passed; water, sodium, and phosphate alone contributed to over 90 percent of the waste mass. The second test, however, failed for each segment. In sample 95-AUG-40, the fluoride was less than 10 percent of the predicted value. In the 95-AUG-41 upper and lower samples, the nitrate was less than 10 percent of the predicted value. Phosphate appeared to be the predominant anion in all samples. If the historical model evaluation DQO had used the average of the two auger samples, both fluoride and nitrate would have been greater than 10 percent of the predicted value and the samples would have passed the second test.

Because the gateway analysis for tank 241-T-109 failed, the remainder of the sample analyses specified in the historical model evaluation DQO will not be performed for the tank. The likely reason for the gateway analysis failure is that the model predicts the presence of just one waste type (T1SltCk) when other wastes were also received by the tank. Further evaluation will be performed later to determine the specific reason why the gateway analysis failed. See Section D1.4 in Appendix D for conclusions about the tank waste contents.

2.3 OTHER TECHNICAL ISSUES

A factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. An estimate of the tank heat load based on the 1995 sample event was not possible because radionuclide analyses were not required. However, the heat load estimate based on the tank process history was 44.7 W (153 Btu/hr) (Agnew et al. 1996b). The heat load estimate based on the tank headspace temperature was 518 W (1,770 Btu/hr) (Kummerer 1994). Both of these estimates are quite low, and are well below the limit of 11,700 W (40,000 Btu/hr) that separates high- and low-heat-load tanks (Bergmann 1991.)

2.4 SUMMARY

The results from all analyses performed to address potential safety issues showed that no primary analyte exceeded safety decision threshold limits. Some uncertainty exists as to whether or not the auger samples included waste from the bottom of the tank. There is, however, no indication that any waste type other than T1SltCk or first concentration cycle waste exists in the tank. Both these waste types have no exothermic constituents and do not represent a safety hazard. The gateway analysis for the historical evaluation DQO failed; thus, no further analyses from the historical DQO will be applied to this tank. The analyses results are summarized in Table 2-1.

Table 2-1. Summary of Safety Screening and Historical Evaluation Results.

Issue	Sub-issue	Result
Safety screening	Energetics	No exotherms observed in any sample.
	Flammable gas	Vapor measurement reported 0 percent of lower flammability limit. (Combustible gas meter).
	Criticality	All analyses well below 41 μCi/g total alpha (within 95 percent confidence limit on each sample).
Historical (gateway analysis)	Total mass of indicators	Passed - Indicator analytes contribute over 95 percent of total waste mass.
	Comparison of each indicator	Failed.

3.0 BEST-BASIS INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. Waste management activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing the wastes into a form that is suitable for long-term storage. Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The most recent model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1996b). Not surprisingly, information derived from these two different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as standard characterization information for the various waste management activities (Kupfer et al. 1995). As part of this effort, an evaluation of available chemical information for tank 241-T-109 was performed that included:

- Data from recent analyses of two auger samples collected in August 1995 (Conner 1995a)
- Data from the analysis of supernatant sample T-2289 collected in 1974
- The solids composite inventory estimate for this tank generated from the LANL model (Agnew et al. 1996b), also referred to as the historical tank content estimate (HTCE).

Results from this evaluation, detailed in Appendix D, support using the sampling data as the basis for the best estimate inventory for tank 241-T-109 for the following reasons:

1. The inventory estimate generated by the LANL model is based on a single defined salt waste stream (T1SltCk) and does not take into account any solids contributions and/or waste dilution effects from the 1,431 kL (378 kgal) of waste transferred from T-108 to T-109 in 1973. This 1,431 kL is not considered to be T1SltCk and would most likely alter the composition of the 515 kL (136 kgal) of salt waste in the tank at that time.

2. Phosphate concentration values, which appear consistent for all analyzed segments, suggest that phosphates formed the bulk of the precipitated solids. The predicted concentration value for this major component is less than half of

the lower limit of the two-sided 95 percent confidence interval on the mean. The LANL assumption that only 40 percent of the phosphate in the T1 waste stream precipitates appears to be conservative.

Best-basis inventory estimates for tank 241-T-109 are presented in Tables 3-1 and 3-2. While samples were analyzed for numerous analytes, only those detected in the waste are included in these tables. Table 3-1 provides an inventory estimate in terms of percent (expected) chemical species. Note that this waste is predominantly sodium phosphate and should not be mixed with waste types that could result in phosphate gels. Table 3-2 lists compound inventories along with the analytical concentrations that were used to calculate these inventories. A tank volume of 220 kL (58 kgal) (Hanlon 1996) and a density of 1.55 g/mL (Agnew et al. 1996b) were used to calculate these inventories.

Table 3-1. Best-Basis Inventory Estimate for Tank 241-T-109 (Percent Nonradioactive Chemical Species).

Compound		Percent total waste
Water		48
Sodium phosphate[1]		40 - 44
Sodium fluoride		2.9
Sodium nitrate		2.9
Sodium nitrite[2]		0.074 - 2.3
Sodium sulfate[2]		0.076 - 0.75
Sodium carbonate[3]		0.48 - 1.8
Minor compounds:		1.6
Iron hydroxide	0.87	
Aluminum hydroxide	0.36	
Silicon dioxide	0.19	
Manganese hydroxide	0.17	
Calcium carbonate	0.081	
Sodium chloride	0.047	
Zinc hydroxide	0.029	
Bismuth oxide	0.019	

Notes:

[1]Range accounts for range in sodium sulfate, sodium nitrite, and sodium carbonate inventories; refer to (2) and (3) below.

[2]Low value based on auger sample analysis; high value based on 1974 supernatant analysis. The 1974 data have not been validated and should be used with caution.

[3]Low value based on 0.542 percent CO_3 in supernatant sample, and high value based on 0.542 M CO_3.

Table 3-2. Best-Basis Inventory Estimates for 241-T-109. (2 Sheets)

Analyte (method/sample preparation)	Mean concentration µg/g	Lower limit 95% CI µg/g	Upper limit 95% CI µg/g	HTCE concentration within CI? (Y/N)	Bulk tank inventory (kg)
Al (ICP/Fusion)	1,250	0	3,300	Y	430
Bi[1] (ICP/Acid)	170	n/a	n/a	n/a	58
B (ICP/Acid)	217	n/a	n/a	n/a	74
Ca[1] (ICP/Acid)	324	n/a	n/a	n/a	110
Cl[1] (IC/Water)	341	n/a	n/a	n/a	120
Cr[1] (ICP/Acid)	40	n/a	n/a	n/a	14
F (IC/Water)	13,000	0	168,000	Y	4,500
Fe (ICP/Fusion)	5,490	0	26,800	Y	1,900
Pb (ICP/Acid)	303	n/a	n/a	n/a	100
Mg (ICP/Acid)	111	n/a	n/a	n/a	38
Mn (ICP/Fusion)	1,030	0	7,060	Y	350
Na (ICP/Fusion)	181,000	0	370,000	Y	62,000[2]
NO_2[7] (IC/Water)	492 - 15,000	n/a	n/a	n/a	170 - 5,100
NO_3 (IC/Water)	20,800	0	241,000	Y	7,100
P as PO_4 (ICP/Fusion, IC/Water)	269,000 - 246,000[3]	198,000	331,000	N	92,000 - 83,000[4]
Si (ICP/Fusion)	889	n/a	n/a	n/a	300
Ag (ICP/Acid)	18.6	n/a	n/a	n/a	6

Table 3-2. Best-Basis Inventory Estimates for 241-T-109. (2 Sheets)

Analyte (method/sample preparation)	Mean concentration $\mu g/g$	Lower limit 95% CI $\mu g/g$	Upper limit 95% CI $\mu g/g$	HTCE concentration within CI? (Y/N)	Bulk tank inventory (kg)
S as SO_4[1,7] (ICP/Acid)	516 - 5,050	n/a	n/a	n/a	180 - 1,700
TIC as CO_3[1,5]	2,710 - 10,400	n/a	n/a	n/a	920 - 3,600
Zn (ICP/Fusion)	276	47.3	505	Not Reported	95
Zr (ICP/Acid)	12.2	n/a	n/a	n/a	4
Total α (μCi/g)	0.0137	0	0.1	Y	4.7 Ci
H_2O (wt%)	47.7	38.1	57.3	Y	48 wt%
Density (g/mL)[6]	1.55	n/a	n/a	n/a	1.55

Key:

CI	Confidence level
IC	Ion chromatography
ICP	Inductively coupled plasma spectroscopy
TIC	Total organic carbon
Water	Approximately 1 g sample is contacted with 100 mL water; solution analyzed by IC.
Acid	Sample is digested with acid; solution analyzed by ICP.
Fusion	Sample is fused with KOH at high temperatures to form a "melt," which is subsequently dissolved with water; solution analyzed by ICP.
n/a	not applicable

Notes:

[1]Analyte detected in only one sample; insufficient data to calculate confidence intervals.

[2]Na inventory is based on 178,000 μg Na/g waste for ion balance purposes, assuming $Na_{2.5}H_{0.5}PO_4$.

[3]Range reflects mean analyte concentrations from ICP and IC analyses.

[4]PO_4 inventory of 92,000 kg is based on 269,000 μg PO_4/g waste; lower inventory value accounts for uncertainties in NO_2, SO_4, and TIC as CO_3 inventories.

[5]Auger samples not analyzed for CO_3; concentration has been estimated from supernatant data. Concentration in the supernatant sample was reported as "0.542" with no units. The lower concentration/inventory value is based on 0.542 percent CO_3 and the higher concentration/inventory value is based on 0.542 M CO_3.

[6]Density analyses not performed with auger samples. Density of 1.55 kg/L was generated by LANL and is consistent with a densities of 1.6 g/mL for $Na_3PO_4 \cdot 12H_2O$ and 1.5 g/mL for $Na_2HPO_4 \cdot 12H_2O$.

[7]Low value based on auger sample analysis; high value based on 1974 supernatant analysis. The 1974 data have not been validated and should be used with caution.

4.0 RECOMMENDATIONS

All analytical results for the safety screening DQO were well within the safety notification limits. However, the full depth of the waste was not sampled. Therefore, the tank cannot yet be classified as "safe." The gateway analysis for the historical DQO failed, indicating that no further sampling and analysis of tank 241-T-109 will be performed to support this DQO. Further evaluation of the available data will be performed at a later time to determine why the gateway analysis failed. The sampling and analysis activities performed for tank 241-T-109 have met all requirements for all of the applicable DQO documents. Furthermore, a characterization best-basis inventory was developed for the tank contents.

Table 4-1 summarizes the status of TWRS Program review and acceptance of the sampling and analysis results reported in this tank characterization report. All DQO issues required to be addressed by sampling and analysis are listed in column one of Table 4-1. The second column indicates whether the requirements of the DQO were met by the sampling and analysis activities performed and is answered with a "yes" or a "no." The third column indicates concurrence and acceptance by the program in TWRS that is responsible for the DQO that the sampling and analysis activities performed adequately meet the needs of the DQO. A "yes" or "no" in column three indicates acceptance or disapproval of the sampling and analysis information presented in the TCR. If the results/information have not yet been reviewed, "N/R" is shown in the column. If the results/information have been reviewed, but acceptance or disapproval has not been decided, "N/D" is shown in the column. Because the waste at the bottom of the tank was not sampled (see Section B3.1) the safety screening DQO has been only partially completed. The upper part of the waste was sampled and analyzed in accordance with the safety screening DQO and accepted by the responsible TWRS program.

Table 4-1. Acceptance of Tank 241-T-109 Sampling and Analysis.

Issue	Evaluation performed	TWRS Program acceptance
Safety Screening DQO	Partial	Partial
Historical Evaluation DQO	Yes	Yes

Note:
N/R = Not reviewed

Table 4-2 summarizes the status of TWRS Program review and acceptance of the evaluations and other characterization information contained in this report. The evaluations specifically outlined in this report are the best-basis inventory evaluation, the gateway analysis, and the evaluation to determine whether the tank is safe, conditionally safe, or unsafe. Column one lists the different evaluations performed in this report. Columns two and three are in the

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-T-109.

Issue	Evaluation performed	TWRS Program acceptance
Best basis inventory	Yes	N/R
Historical "gateway" analysis	Yes	Yes
Safety categorization (tank is safe)	Partial	Partial

Note:
N/R = Not reviewed

same format as Table 4-1. The manner in which concurrence and acceptance are summarized is also the same as that in Table 4-1. The safety categorization of the tank is listed as "partial" in Table 4-2 because the full depth of the waste was not sampled. However, none of the analyses performed on the auger samples indicate any safety problems.

Resampling of tank 241-T-109 using push-mode core sampling has been recommended in order to provide the two full depth profiles required by the safety screening DQO (Kirch 1995, Conner 1995c). Further evaluation of the information available on tank 241-T-109 is recommended to determine if additional samples are needed to categorize the tank as "safe."

One final comment regarding the safety screening DQO needs to be made. The one-sided confidence intervals that were used to determine whether or not ^{239}Pu is below the DQO stated threshold limit were performed solely on each individual sample as required by the DQO.

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-T-109 based on historical information. For this report, historical information includes any information about the fill history, waste types, surveillance, or modeling data about the tank. This information is necessary for providing a balanced assessment of the sampling and analytical results.

This appendix contains the following information:

- **Section A1**: Current status of the tank, including the current waste levels as well as the stabilization and isolation status of the tank.
- **Section A2**: Information about the design of the tank.
- **Section A3**: Process knowledge of the tank; i.e., the waste transfer history and the estimated contents of the tank based on modeling data.
- **Section A4**: Surveillance data for tank 241-T-109, including surface-level readings, temperatures, and a description of the waste surface based on photographs.
- **Section A5**: References for Appendix A.

Historical sampling results (results from samples obtained prior to 1989) are included in Appendix B.

A1.0 CURRENT TANK STATUS

As of April 30, 1996, tank 241-T-109 contained an estimated 220 kL (58 kgal) of non-complexed waste (Hanlon 1996). The waste volumes were estimated using a manual tape surface-level gauge. The volumes of the waste phases found in the tank are shown in Table A1-1.

In 1974, tank 241-T-109 was declared an assumed leaker and removed from service. It was interim stabilized in 1984; intrusion prevention (interim isolation) was completed in December 1982. The tank is passively ventilated and is not on the Watch List (Public Law 101-510).

Table A1-1. Tank Contents Status Summary (Hanlon 1996).

Waste type	kL (kgal)
Total waste	220 (58)
Supernatant	0 (0)
Sludge[1]	220 (58)
Saltcake[1]	0 (0)
Drainable interstitial liquid	0 (0)
Drainable liquid remaining	0 (0)
Pumpable liquid remaining	0 (0)

Note:

[1]Although the Waste Status Summary Report (Hanlon 1996) reports that the tank contents are all sludge waste, it is evident from the transfer history (Agnew et al. 1996a) and the appearance of the auger samples that the majority of the waste is probably saltcake.

A2.0 TANK DESIGN AND BACKGROUND

Tank 241-T-109 was constructed during 1943 and 1944. It is one of twelve 2,010-kL (530-kgal) tanks in T Farm. These tanks were designed for nonboiling waste with a maximum fluid temperature of 104 °C (220 °F). A typical T Farm tank contains 9 to 11 risers ranging in size from 10 cm (4 in.) to 1.1 m (42 in.) in diameter that provide surface-level access to the underground tank. Generally, there is one riser through the center of the tank dome and four or five each on opposite sides of the dome.

Tank 241-T-109 entered service in 1945 and is third in a three-tank cascading series. These tanks are connected by a 7.6-cm (3-in.) cascade line. The bottom center elevation of tank 241-T-107 is 193.2 m (634 ft) above sea level. The tank cascades to tank 241-T-108 at 193.0 m (633 ft), which then cascades to tank 241-T-109, which has a bottom center elevation at 192.3 m (631 ft). The cascade overflow height is approximately 4.78 m (188 in.) from the tank bottom and 60 cm (2 ft) below the top of the steel liner.

These single-shell tanks (SSTs) are constructed of 30-cm (1-ft)-thick reinforced concrete with a 6.4 mm (1/4 in.) mild carbon steel liner (ASTM A283 Grade C) on the bottom and sides and a 38-cm (1.25-ft)-thick domed concrete top. These tanks have a dished bottom with a 1.2-m (4-ft) radius knuckle and a 5.18-m (17-ft) operating depth. The tanks are set on a reinforced concrete foundation.

A three-ply cotton fabric waterproofing was applied over the foundation and the steel tank. Four coats of primer paint were sprayed on all exposed interior tank surfaces. Tank ceiling domes were covered with three applications of magnesium zincfluorosilicate wash. Lead flashing was used to protect the joint where the steel liner meets the concrete dome. Asbestos gaskets were used to seal the access holes in the tank dome. The tanks were waterproofed on the sides and top with tar and gunite. Each tank was covered with approximately 2.1 m (7 ft) of overburden.

The surface level is monitored through riser 1 with an ENRAF[1] gauge. A manual tape in riser 4 is no longer used to record waste level data, except when the other systems fail. Riser 8 contains a thermocouple tree. The interior tank photograph from 1993 shows a saltwell screen located in riser 13. Figure A2-1 is a plan view of the riser configuration. A list of tank 241-T-109 risers showing their sizes and general use is provided in Table A2-1.

A tank cross section showing the approximate waste level, along with a schematic of the tank equipment, is shown in Figure A2-2. Tank 241-T-109 has nine risers. Risers 2, 3, 4, 5, 6, and 7 are tentatively available for sampling (Lipnicki 1995). Risers 2, 3, 6, and 7, are all 30 cm (12 in.) in diameter. Risers 4 and 5 are 10-cm (4 in.) in diameter. If used as sampling ports, the risers would give access to two opposite sides of the tank. Risers 2 and 4 are approximately 40 degrees counterclockwise from the inlet, and risers 5, 6, and 7 are approximately 70 degrees clockwise from the inlet.

Tank 241-T-109 has four process inlet nozzles and one cascade overflow inlet located approximately 4.8 m (188 in.) from the tank bottom (as measured at the tank wall). Locations are shown on Figure A2-1.

[1]ENRAF is a trademark of the ENRAF Corporation, Houston, Texas.

Figure A2-1. Riser Configuration for Tank 241-T-109.

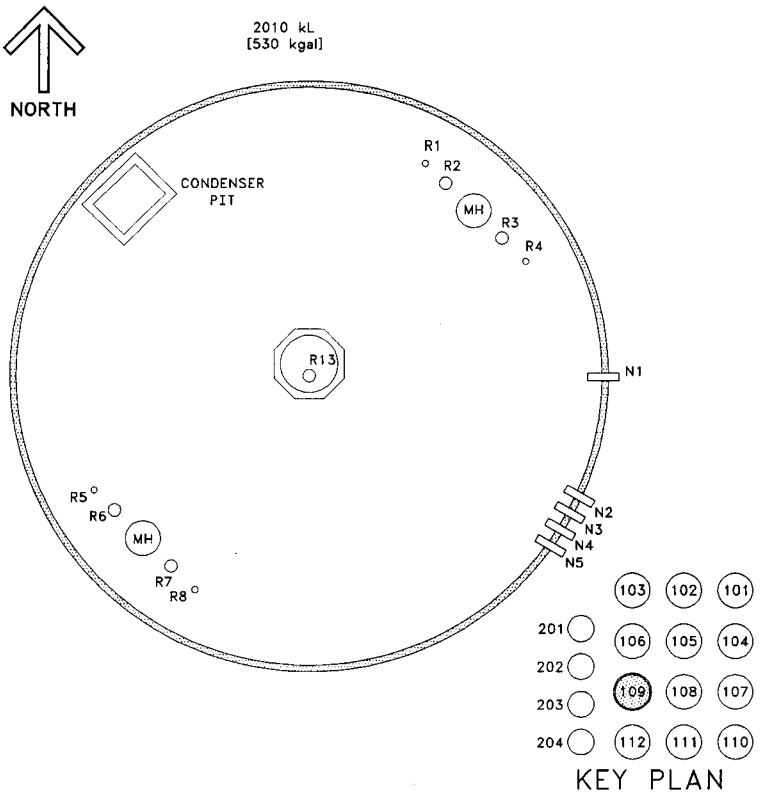
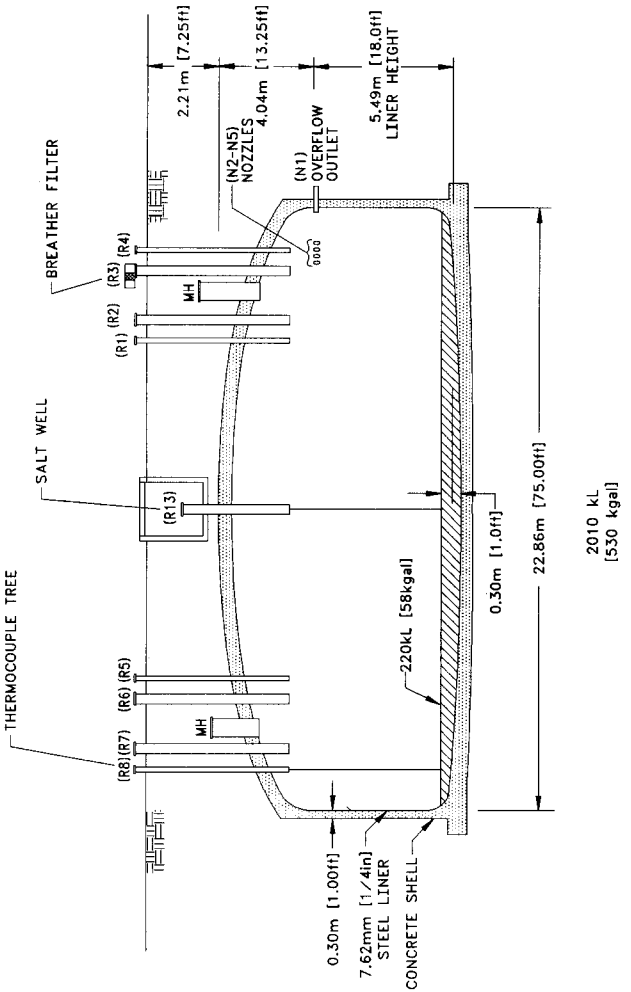


Table A2-1. Tank 241-T-109 Risers.[1]

Number	Diameter (inches)	Description and comments
R1	4 in.	FIC, (benchmarked 12-11-86), (ENRAF® 9-6-94)
R2	12 in.	Flange with bale
R3	12 in.	Breather filter
R4	4 in.	Blind flange
R5	4 in.	Blind flange
R6	12 in.	Flange
R7	12 in.	Flange
R8	4 in.	Thermocouple tree
R13	12 in.	Saltwell riser, (benchmarked 12-11-86)
N1	3 in.	Cascade inlet nozzle (from T-108)
N2	3 in.	Process inlet nozzle
N3	3 in.	Process inlet nozzle
N4	3 in.	Process inlet nozzle
N5	3 in.	Process inlet nozzle

Note:
[1]Alstad (1993)

Figure A2-2. Tank 241-T-109 Cross Section and Schematic.



A3.0 PROCESS KNOWLEDGE

The sections below: 1) provide information about the transfer history of tank 241-T-109; 2) describe the process wastes that made up the transfers; and 3) give an estimate of the current tank contents based on transfer history.

A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-T-109 (Agnew et al. 1996a). Waste was initially added to tank 241-T-109 in the fourth quarter of 1945 with the cascade of first cycle decontamination waste from the bismuth phosphate process (1C)) from tank 241-T-108. Because tank 241-T-109 was the third tank in the cascade, it is unlikely that it received any 1C waste solids. In March 1946, the entire cascade series (tanks 241-T-107, 241-T-108, and 241-T-109) was declared full.

Supernatant was pumped from tank 241-T-109 to tank 241-TX-118 during the second quarter of 1951. Uranium recovery waste (UR) was intermittently cascaded from tank 241-T-108 to tank 241-T-109 from the fourth quarter of 1952 to the first quarter of 1953. Again, it is likely that all of the waste cascaded to tank 241-T-109 was liquid. During the third quarter of 1953, supernatant was transferred from tank 241-T-109 to tank 241-TX-118. During the fourth quarter of 1953 and the first quarter of 1954, tank 241-T-109 received supernatant from tank 241-TX-117. Additionally, waste (T1SltCk) was pumped from the 242-T Evaporator to tank 241-T-109 during the first quarter of 1954. The addition of T1SltCk was probably a major solids contribution to the tank even though it was a relatively low-volume transfer. There were no transfers into or out of tank 241-T-109 from the second quarter of 1954 through the third quarter of 1969.

During the fourth quarter of 1969, supernatant was transferred from tank 241-T-109 to tank 241-TY-103. During the first and second quarters of 1973, supernatant was pumped to tank 241-T-109 from tank 241-T-108. Historical records suggest that the supernatant may have been B Plant low-level waste (BL), Battelle Northwest waste (BNW), and/or ion exchange (IX) waste. Supernatant was transferred to tank 241-T-109 from tank 241-T-111 during the second quarter of 1974. Also, during the same time period, supernatant was transferred from tank 241-T-109 to tank 241-S-110. Finally, the last major waste transfer for tank 241-T-109 involved the transfer of supernatant to tank 241-T-101 during the first quarter of 1975 and the second quarter of 1976. Saltwell liquid was pumped from tank 241-T-109 in support of tank stabilization in the third quarter of 1983.

Table A3-1. Tank 241-T-109 Major Transfers.[1,2]

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Waste Volume	
				kL	kgal
241-T-108		1C	1945-1946	1,991	526
	241-TX-118	SU	1951	-1,991	-526
241-T-108		UR	1952-1953	1,995	527
	241-TX-118	SU	1953	-1,687	-443
241-TX-117		SU	1953-1954	1,673	442
242-T		T1SltCk	1954	49	13
	241-TY-103	SU	1969	-1,571	-415
241-T-108		SU	1973	1,514	400
	241-S-110	SU	1974	-1,499	-396
241-T-111		SU	1974	53	14
	241-T-101	SU	1975-1976	-220	-58
	241-AN-101	SWLQW	1983	-337	-89

Notes:

1C — 1st-cycle decontamination waste from the $BiPO_4$ process (contains 10 percent of the fission products and 1 percent plutonium and often included in cladding waste).

SU — Supernatant (liquid considered free of contamination to the extent it could be pumped to a crib).

SWLQW — Saltwell liquid (dilute non-complexed liquid pumped from single-shell tanks to double-shell tanks).

T1SltCk — Saltcake waste generated from the 242-T evaporator-crystallizer from 1951 until 1955.

UR — Uranium recovery waste from uranium recovery operations (also called TBP [tri-butyl phosphate] waste).

[1]Agnew et al. 1996a

[2]Because only major transfers are listed, the sum of these transfers will not equal the current tank waste volume.

A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

This section provides an estimate of the contents of tank 241-T-109 based on historical transfer data. The historical data used for the estimate are the waste status and transaction record summary (WSTRS) (Agnew et al. 1996a), the Hanford defined waste (HDW) (Agnew et al. 1996b) list, and the tank layer model (TLM) (Agnew et al. 1996b) from the historical tank content estimate (HTCE) (Brevick et al. 1995b). The WSTRS is a compilation of available waste transfer and volume status data. The HDW provides the assumed typical

compositions for 50 separate wastes types. In some cases, the available data are incomplete, reducing the usability of the transfer data and the modeling results derived from it. The TLM takes the WSTRS data, models the waste deposition processes, and, using additional data from the HDW (which may introduce more error), generates an estimate of the tank contents. Thus, these model predictions can only be considered estimates that require further evaluation using analytical data.

Based on Agnew et al. (1996b), tank 241-T-109 contains only a layer of 220 kL (58 kgal) of T1SltCk waste. Figure A3-1 shows a graphical representation of the estimated waste type and volume for the tank layer. The historical tank content estimate model predicts tank 241-T-109 to contain very large amounts of sodium, nitrate, and phosphate. Hydroxide and carbonate are also expected to be present in significant quantities. Additionally, noticeable quantities of aluminum, iron, bismuth, sulfate, nitrite, and a trace quantity of plutonium will be found. The presence of cesium and strontium will give this waste layer an activity corresponding to their concentrations. Table A3-2 shows the historical estimate of the expected waste constituents and their concentrations.

Figure A3-1. Tank Layer Model.

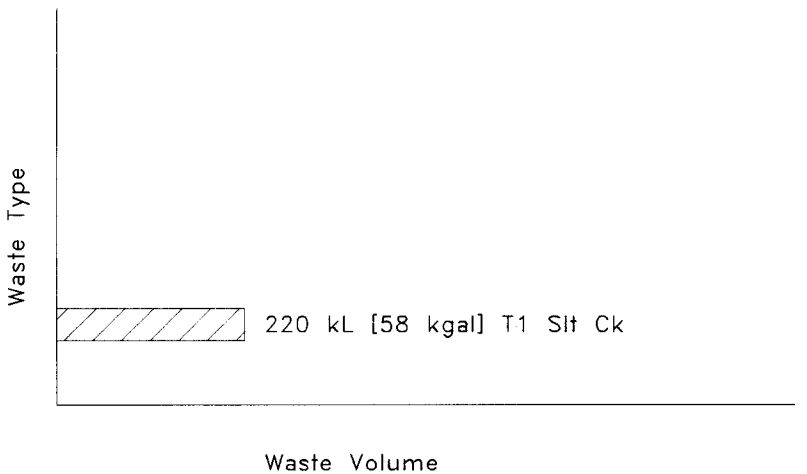


Table A3-2. Historical Tank Inventory Estimate.[1,2] (2 sheets)

Total Inventory Estimate			
Physical Properties			
Total solid waste	3.41E+05 kg (58 kgal)		
Heat load	4.47E-02 kW (153 Btu/hr)		
Bulk density	1.55 (g/mL)		
Void fraction	0.731		
Water wt%	57.2		
Total organic carbon wt% carbon (wet)	1.91E-04		
Chemical Constituents	M	ppm	kg[3]
Na^+	9.29	1.37E+05	4.69E+04
Al^{3+}	0.170	2.96E+03	1.01E+03
Fe^{3+} (total Fe)	0.222	7.99E+03	2.72E+03
Cr^{3+}	5.26E-03	176	60.0
Bi^{3+}	4.55E-02	6.12E+03	2.09E+03
La^{3+}	0	0	0
Hg^{2+}	3.90E-05	5.04	1.72
Zr (as $ZrO(OH)_2$)	3.34E-03	196	67.0
Pb^{2+}	0	0	0
Ni^{2+}	1.14E-02	431	147
Sr^{2+}	0	0	0
Mn^{4+}	0	0	0
Ca^{2+}	0.113	2.93E+03	998
K^+	1.43E-02	361	123
OH^-	1.45	1.59E+04	5.42E+03
NO_3^-	3.09	1.23E+05	4.20E+04
NO_2^-	0.290	8.58E+03	2.93E+03
CO_3^{2-}	0.248	9.58E+03	3.27E+03
PO_4^{3-}	1.69	1.03E+05	3.52E+04
SO_4^{2-}	0.138	8.56E+03	2.92E+03
Si (as SiO_3^{2-})	2.34E-02	424	145

Table A3-2. Historical Tank Inventory Estimate.[1,2] (2 sheets)

Total Inventory Estimate			
Chemical Constituents (Cont'd)	M	ppm	Kg[3]
F^-	0.146	1.79E+03	610
Cl^-	8.16E-02	1.86E+03	635
citrate	0	0	0
$EDTA^{4-}$	0	0	0
$HEDTA^{3-}$	0	0	0
glycolate	0	0	0
acetate	0	0	0
oxalate	0	0	0
DBP	2.06E-05	3.52	1.20
butanol	2.06E-05	0.981	0.335
NH_3	8.99E-04	9.83	3.35
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents			
Pu		1.10E-02 (μCi/g)	6.26 (kg)
U	7.60E-03 (M)	1.16E+03 (μg/g)	397 (kg)
Cs	1.89E-02 (Ci/L)	12.2 (μCi/g)	4.15+03 (Ci)
Sr	1.71E-03 (Ci/L)	11.0 (μCi/g)	3.76E+03 (Ci)

Notes:

[1]Agnew et al. (1996b)

[2]The HTCE predictions have not been validated and should be used with caution.

[3]Differences exist among the inventories in this column and the inventories calculated from the two sets of concentrations.

A4.0 SURVEILLANCE DATA

Tank 241-T-109 surveillance consists of surface-level measurements (liquid and solid), temperature monitoring inside the tank (waste and headspace), and leak detection well (drywell) monitoring for radioactivity outside the tank. Surveillance data provide the basis for determining tank integrity.

Liquid-level measurements can indicate if the tank has a major leak. Solid surface-level measurements provide an indication of physical changes in and consistencies of the solid layers of a tank. Drywells located around the tank perimeter may show increased radioactivity due to leaks.

A4.1 SURFACE-LEVEL READINGS

Tank 241-T-109 is categorized as an assumed leaker. An automatic Food Instrument Corporation (FIC) gauge set in intrusion mode is used to monitor the surface level through riser 1. An ENRAF® gauge has replaced the FIC gauge. Manual readings are required daily if the ENRAF® gauge fails or if the computer automated surveillance system readings are zero. A manual tape in riser 4 is used to record level data only if the other systems fail. The leak detection criteria for tank 241-T-109 are an increase of 5.1 cm (2.0 in) or a decrease of 2.5 cm (1.0 in.) in intrusion mode from the baseline value. The criterion for a decrease does not apply to this tank. The FIC readings range from 37.9 cm (14.9 in.) to 44.3 cm (17.45 in.) and the ENRAF® readings range from 46.6 cm (18.35 in.) to 46.9 cm (18.46 in.) The surface-level plot indicates a steady waste level from January 1991 to January 1994. A level history graph of the volume measurements is presented in Figure A4-1.

Tank 241-T-109 has no liquid observation well, and has six identified drywells.

A4.2 INTERNAL TANK TEMPERATURES

Tank 241-T-109 has a single thermocouple tree with 11 thermocouples to monitor the waste temperature through riser 8. Thermocouple 1 is 36.6 cm (1.2 ft) from the bottom of the tank. Thermocouples 2 though 9 are spaced at 61-cm (2-ft) intervals above thermocouple 1. Thermocouples 9 though 11 are at 1.22 m (4 ft) intervals. The condition of the thermocouple tree, and whether it was removed or replaced, is unclear.

Only two data points are available for each thermocouple after November 1982. There are temperature data for a twelfth thermocouple, but its location is unknown and the data are not considered in this report. Non-suspect temperature data for the first eleven thermocouples

recorded from February 1976 to February 1991 were available from the surveillance analysis computer system. Within this time span, two large breaks and several small breaks occurred in the temperature data sequence for all of the thermocouples.

The average tank temperature is 20 °C (68 °F), the minimum is 8 °C (47 °F), and the maximum is 33 °C (91 °F). Plots of the thermocouple readings can be found in the supporting document for the HTCE (Brevick et al. 1995a). Figure A4-2 shows a graph of the weekly high temperature.

A4.3 TANK 241-T-109 PHOTOGRAPHS

The waste in the photographs appears to have a crusted surface with varied colors ranging from tan to green, red, and dark brown. The waste in the near side of the photograph is light tan in color and appears to have a sand-like texture. The waste in the far side of the photograph is dark and appears to have a liquid surface in one small section. An old level measurement tape and other debris can be seen on the left side of the montage. An FIC probe, temperature probe, saltwell screen, manhole, and some inlet nozzles are also visible in the photographs. The photographs were taken in 1993. A photographic montage from February, 1993 may be found in *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 West Area* (Brevick et al. 1995b). The tank has been inactive since the mid 1980s, so the photographs should accurately represent the tank interior. The 220 kL (58 kgal) of waste would fill the tank to a depth between 30 cm (1 ft) and 60 cm (2 ft).

Figure A4-1. Tank 241-T-109 Level History.

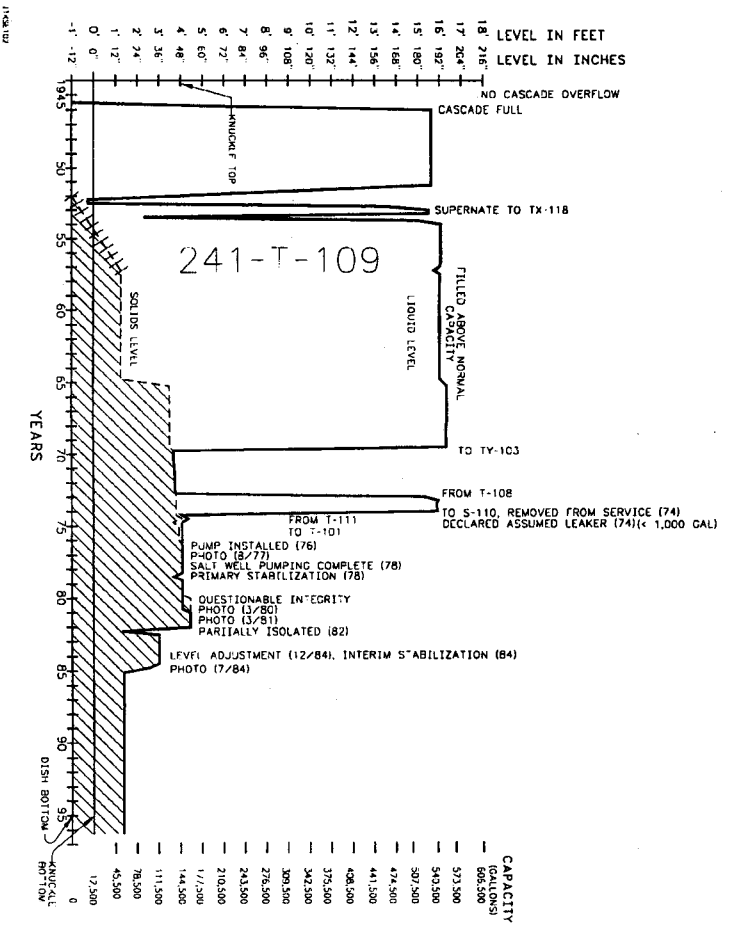
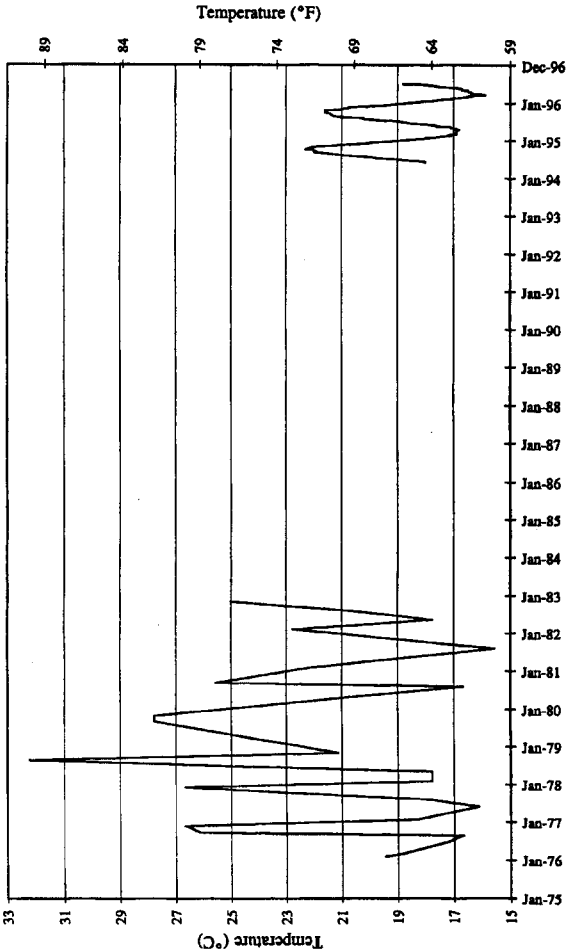


Figure A4-2. Tank 241-T-109 High Temperature Plot.



A5.0 APPENDIX A REFERENCES

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APPENDIX B

SAMPLING OF TANK 241-T-109

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APPENDIX B

SAMPLING OF TANK 241-T-109

Appendix B provides sampling and analysis information for each known sampling event for tank 241-T-109 and provides an assessment of the auger sample results.

- **Section B1**: Tank Sampling Overview
- **Section B2**: Analytical Results
- **Section B3**: Assessment of Characterization Results
- **Section B4**: References for Appendix B.

Future sampling of tank 241-T-109 will be appended to the above list.

B1.0 TANK SAMPLING OVERVIEW

This section describes the August 1995 sampling and analysis events for tank 241-T-109. Auger samples were taken to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Babad et al. 1995), and the *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995). The sampling and analyses were performed in accordance with the *Tank 241-T-109 Auger Sampling and Analysis Plan* (Conner 1995a). The sampling and analysis plan (SAP) also instructed that if enough sample were recovered, composite material would be retained for pretreatment studies as guided in the *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology* (Kupfer et al. 1995). Further discussions of the sampling and analysis procedures can be found in the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994). A liquid sample was also taken from this tank in February 1974; this sample event is discussed in Section B1.4.

B1.1 DESCRIPTION OF SAMPLING EVENT

Two auger samples were collected from tank 241-T-109. Auger 95-AUG-040 was obtained on August 18 and auger 95-AUG-041 was obtained on August 21, 1995. The first auger sample was collected from riser 6 on August 18, 1995 and extruded at the 222-S Laboratory on August 24, 1995. The second auger sample was obtained from riser 2 on August 21, 1995 and extruded by the 222-S Laboratory on August 25, 1995.

Auger sampling was used because of the depth of the waste and the expectation that a full vertical profile of the waste would be obtained. The auger samples, however, may not have recovered a full vertical profile of the waste. The waste depth was expected to be 16 to 18 in. However, because the waste sloped down from the sides to the middle, waste level readings indicated that the waste depth was 27 in. under riser 6 and 63 in. under riser 2. A memo was written stating that additional sampling may be recommended (Conner 1995b). A vertical profile is used to satisfy the safety screening data quality objective (DQO). Safety screening analyses include: total alpha to determine criticality, differential scanning calorimetry (DSC) to ascertain the fuel energy value, and thermogravimetric analysis (TGA) to obtain the total moisture content. In addition, combustible gas meter readings in the tank headspace were performed to measure flammability. The current revision of the safety screening DQO (Dukelow et al. 1995) also requires bulk density measurements. However, because the samples were taken under the previous revision of the safety screening DQO (Babad et al. 1995), bulk density was not required.

Tank 241-T-109 also was evaluated against the historical model requirements. The specified gateway analytes to evaluate the Tank Layer Model (TLM) for this tank are sodium, nitrate, fluoride, and phosphate. Historical model analyses include: DSC, TGA, inductively coupled plasma (ICP), and ion chromatography (IC). The full range of analytes is required for both ICP and IC analyses.

Sampling and analytical requirements from the safety screening and historical DQOs are summarized in Table B1-1.

Table B1-1. Integrated Data Quality Objective Requirements for Tank 241-T-109.[1]

Sampling event	Applicable DQOs	Sampling requirements	Analytical requirements
Auger Sampling	Safety Screening	Core samples from a minimum of two risers separated radially to the maximum extent possible.	▸Energetics ▸Moisture Content ▸Total Alpha
	Historical Model	A minimum of two cores. Efforts should be made to obtain thick, layered segments from widely separated areas of the tank.	▸Energetics ▸Moisture Content ▸Metals ▸Anions
Combustible Gas Meter Reading	Safety Screening	Measurement in a minimum of one location within tank vapor space.	▸Flammable Gas Concentration

Note:
[1]Conner 1995a

B1.2 SAMPLE HANDLING

The riser 6 auger sample, identified as sample 95-AUG-040, had a total weight of 67.5 grams of dirty-white, crystalline solids. Most of the sample fell onto the extrusion tray when extruded at the 222-S Laboratory on August 24, 1995. The bulk of the sample appeared to come from flutes 1 to 6 at the top of the auger, with only a thin coating on the remaining flutes. The sample was homogenized and subsampled for further laboratory analyses and archiving. Due to the relatively low recovery, the sample was not divided into subsegments, but was analyzed on a whole-segment basis.

The riser 2 auger sample, identified as sample 95-AUG-041, had a total weight of 232.5 grams of solids recovered. Most of the sample fell onto the auger tray when extruded on August 25, 1995. The sample was divided into upper and lower half-segments, the upper half appearing to be gray-black crystals and the lower half appearing to be dirty white crystals. The material was homogenized and subsampled for laboratory analyses and archiving. Subsamples of each half-segment were then recombined and subsampled for composite analyses and for shipment to Pacific Northwest National Laboratory for use in pretreatment studies. Table B1-2 gives the subsampling scheme and sample description.

Table B1-2. Tank 241-T-109 Subsampling Scheme and Sample Description.[1]

Riser	Sample identification	Weight (grams)	Sample recovery (%)[2]	Sample portion	Sample characteristics
6	95-AUG-040	67.5	16	Whole	Dirty-white crystalline solids
2	95-AUG-041	232.5	54	Upper half	Gray-black crystals
				Lower half	Dirty-white crystals

Note:

[1]Conner 1995c

[2]Sample recovery calculated using an expected sample length of 15 in. and an estimated density of 1.55 g/mL.

B1.3 SAMPLE ANALYSIS

The analyses performed on the auger samples were limited to those required by the safety screening DQO and the historical model evaluation DQO. The analyses required by the safety screening DQO included analyses for thermal properties by DSC, moisture content by TGA, and content of fissile material by total alpha activity analysis. The historical DQO required a full set of analytes to be analyzed by IC and ICP in order to determine the presence of selected "gateway" analytes in sufficient abundance to warrant further investigation.

Differential scanning calorimetry and TGA were performed on 8.665-mg to 45.550-mg samples. Quality control tests included performing the analyses in duplicate, and the use of standards. Moisture content was also measured by a gravimetric method.

Total alpha activity measurements were performed on samples that had been fused in a solution of potassium and then dissolved in acid. The resulting solution was then dried on a counting planchet and counted in an alpha proportional counter. Quality control tests included standards, spikes, blanks, and duplicate analyses.

Ion chromatography was performed on samples that had been prepared by water digestion. Quality control tests included standards, spikes, blanks, and duplicate analyses. The SAP required that the full suite of IC analytes be measured.

Inductively coupled plasma spectrometry was performed initially on samples that had been prepared by a fusion procedure, followed by dissolution in acid. Before the analyses could be completed, however, the DQO was revised to require that ICP samples be prepared by an acid digestion procedure. The reason for the change was the need to use high dilutions in the fusion procedure, resulting in higher detection limits. Quality control tests included standards, blanks, spikes, and duplicate analyses. The SAP required that the full suite of ICP elements be analyzed.

All reported analyses were performed in accordance with approved laboratory procedures. A list of the sample numbers and applicable analyses is presented in Table B1-3. The procedure numbers are presented in the discussion in Section B2.0

B1.4 DESCRIPTION OF HISTORICAL SAMPLING EVENT

Sampling data for tank 241-T-109 have been obtained for one sample obtained on February 9, 1974 and reported on March 13, 1974 (Sant 1974). The data are presented in Section B2.6. Pre-1989 analytical data have not been validated and should be used with caution.

No information was available regarding sample handling for this tank. The reason for the sampling was given as "242-Feed." The sample was reported as being a clear, amber color with no solids.

Table B1-3. Tank 241-T-109 Sample Analysis Summary.[1]

Riser	Sample identification	Sample portion	Sample number	Analyses
6	95-AUG-040	Whole	S95T001597[2]	Gravimetric, TGA
			S95T001600	Gravimetric, DSC, TGA
			S95T001612	Total Alpha, ICP
			S95T001613	IC
2	95AUG-041	Core composite	S95T002176	IC
			S95T002177	ICP
		Upper sample	S95T001626[2]	Gravimetric, TGA
			S95T001629	Gravimetric, DSC, TGA
			S95T001630	ICP
			S95T001631	IC
		Lower sample	S95T001616[2]	Gravimetric, TGA
			S95T001618	Gravimetric, DSC, TGA
			S95T001619	ICP
			S95T001620	IC

Note:
[1]Conner 1995c
[2]Sample portion not homogenized prior to subsampling.

B2.0 ANALYTICAL RESULTS

B2.1 OVERVIEW

This section summarizes the sampling and analytical results associated with the August 1995 sampling and analysis of tank 241-T-109. The total alpha activity, percent water, energetics, IC, and ICP analytical results associated with this tank are presented in Table B2-1. These results are documented in Conner (1995c).

Table B2-1. Analytical Presentation Tables.

Analysis	Table number
Total alpha activity	B2-2
Percent water	B2-3
Differential scanning calorimetry	B2-4
Summary data for metals by ICP	B2-5 through B2-41
Anions by IC	B2-42 through B2-49

The four QC parameters assessed in conjunction with the tank 241-T-109 samples were standard recoveries, spike recoveries, duplicate analyses (RPDs), and blanks. The QC criteria specified in the SAP (Conner 1995a) were 90 to 110 percent recovery for standards and spikes and ≤ 10 percent for RPDs. These criteria applied to all of the analytes. The only QC parameter for which limits are not specified in the SAP is blank contamination. The limits for blanks are set forth in guidelines followed by the laboratory, and all data results presented in this report have met those guidelines. Sample and duplicate pairs in which any of the QC parameters were outside of these limits are footnoted in the sample mean column of the following data summary tables with an a, b, c, d, or e as follows:

- "a" indicates that the standard recovery was below the QC limit.
- "b" indicates that the standard recovery was above the QC limit.
- "c" indicates that the spike recovery was below the QC limit.
- "d" indicates that the spike recovery was above the QC limit.
- "e" indicates that the RPD was above the QC limit.

B2.2 TOTAL ALPHA ACTIVITY

Analyses for total alpha activity were performed on the samples recovered from tank 241-T-109. The samples were prepared by fusion digestion per procedure LA-549-141, Rev. D-0 and analyzed according to procedure LA-508-101, Rev. D-2. Two fusions were prepared per sample (for duplicate results). Each fused dilution was analyzed twice, the results were averaged and reported as one value. The highest result returned was 0.00653 μCi/g. The sample results for total alpha are given in Table B2-2.

Table B2-2. Tank 241-T-109 Total Alpha Activity.[1]

Sample number	Segment portion	Result (μCi/g)	Duplicate (μCi/g)	Sample mean (μCi/g)
95-AUG-040				
S95T001612	Whole segment	0.0191	0.0219	0.0205[c,e]
95-AUG-041				
S95T001630	Upper half	0.00947	0.00516	0.00731[c,e]
S95T001619	Lower half	0.00623	0.00653	0.00638[c]

Note:
[1]Conner 1995c

B2.3 THERMODYNAMIC ANALYSES

As required by the safety screening and historical DQOs, TGA and DSC were performed on the solids. No other physical tests were required or performed.

B2.3.1 Thermogravimetric Analysis

Thermogravimetric analysis measures the mass of a sample while its temperature is increased at a constant rate. Nitrogen is passed over the sample during heating to remove any released gases. Any decrease in the weight of a sample during TGA represents a loss of gaseous matter from the sample, either through evaporation or through a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 degrees Celsius [°C]) is due to water evaporation. The temperature limit for moisture loss is chosen by the operator at an inflection point on the TGA plot. Other volatile matter fractions can often be differentiated by inflection points as well.

Tank 241-T-109 samples were analyzed by TGA using either procedure LA-514-114, Rev. C-0 on a Perkin-Elmer TGA 7 instrument, or procedure LA-560-112, Rev. B-0 on a Mettler TG 50 instrument. Auger sample AUG-95-040 (sample S95T001600) measured considerably less water than the remaining samples. However, inspection of the thermogram revealed that the weight loss curves for the sample were interpreted conservatively (first integration is only up to a slight inflection of the curves at about 105 °C). The second weight loss step is also integrated; if the two steps are added, the weight loss is similar to what is recorded for the other samples from this tank. Gravimetric analyses were performed for all the 241-T-109 subsamples from this tank to access the accuracy of the TGA results. Because some of the TGA results were conservatively interpreted, the gravimetric results provide a better estimate of the moisture content of the samples. Comparison of the TGA and gravimetric results is presented in Table B2-3.

Table B2-3. Percent Water by TGA and Gravimetric Analysis.[1]

Sample number	Segment level	Temperature range[2] (°C)	Result % H_2O	Duplicate % H_2O	Mean % H_2O
Thermogravimetric analysis					
S95T001600	Whole segment	ambient to 120 (ambient to 90)	12.70	12.21	12.46
S95T001597[3]		ambient to 90 (ambient to 100)	15.57	16.87	16.22
S95T001629	Upper half	ambient to 130 (ambient to 140)	48.87	49.30	49.08
S95T001626[3]		ambient to 180 (ambient to 200)	49.11	51.95	50.53
S95T001618	Lower half	ambient to 120 (ambient to 125)	39.37	45.76	42.56[e]
S95T001616[3]		ambient to 170 (ambient to 170)	44.35	46.50	45.42
Gravimetric analysis					
S95T001600	Whole segment	n/a	47.60	49.30	48.45
S95T001597[3]			50.70	50.40	50.55
S95T001629	Upper half	n/a	48.10	47.30	47.70
S95T001626[3]			48.90	49.20	49.05
S95T001618	Lower half	n/a	46.60	45.70	46.15
S95T001616[3]			45.60	45.50	45.55

Notes:

[1]Conner 1995c

[2]Temperature ranges in parentheses are for the duplicate.

[3]Unhomogenized sample

B2.3.2 Differential Scanning Calorimetry

In a DSC analysis, heat absorbed or emitted by a substance is measured while the temperature of the sample is heated at a constant rate. Nitrogen is passed over the sample material to remove any gases being released. The onset temperature for an endothermic or exothermic event is determined graphically.

The DSC analyses for tank 241-T-109 were performed using either procedure LA-514-113, Rev. C-0 on a Mettler DSC 20 instrument or procedure LA-514-114, Rev. C-0 on a Perkin-Elmer DSC 7 instrument. No exothermic reactions were noted. Therefore, an upper limit of a 95 percent confidence interval on the mean for each sample was not calculated. Transitions 1 and 2 represent endothermic events, both of which are caused by water evaporation. DSC results are presented in Table B2-4.

Table B2-4. Differential Scanning Calorimetry.[1]

Sample number	Segment level	Run	Transition 1		Transition 2	
			Temp. range (°C)	ΔH (J/g)	Temp. range (°C)	ΔH (J/g)
S95T001600	Whole segment	1	40-145	1,267	---	---
		2	38-140	1,372	---	---
S95T001618	Lower half	1	40-155	1,553	---	---
		2	40-158	1,146	190-320	50.0
S95T001629	Upper half	1	20-160	1,228	130-330	52.0
		2	40-145	1,141	220-340	45.2

Note:
[1]Conner 1995c

B2.4 INORGANIC ANALYSES

The last two analyses performed on the auger samples were ICP and IC for the anions and cations respectively. In the sections below, a table is provided for each analyte.

In each table, the "Mean" column is the average of the result and duplicate values. All values, including those below the detection level (denoted by the less-than symbol, "<"), were averaged. If both sample and duplicate values were non-detected, the mean is expressed as a non-detected value. If one value were detected while the other were not, the mean is expressed as a detected value. If both values were detected, the mean is expressed as a detected value.

B2.4.1 Inductively Coupled Plasma

Samples were prepared by either fusion or acid digests. The ICP analyses were performed per procedures LA-505-161, Rev. B-0, or LA-505-151, Rev. D-3, depending on the ICP instrument used. Although a full suite of analytes were reported, only sodium and phosphorus were specifically requested by the historical DQO. Phosphorus was analyzed as a cross-check for the phosphate results reported from IC analyses. Reports for silver, aluminum, boron, bismuth, calcium, chromium, iron manganese, lead sulfur, silicon, and zinc are above detection limits in some of the samples. The potassium and nickel results for the ICP fusion analyses (samples S95T001612, S95T001619, and S95T001630) should be disregarded, because the samples were prepared in a nickel crucible by fusion using potassium hydroxide.

The concentrations of metals in the samples are shown in Tables B2-5 through B2-41. The results from two preparation methods, fusion and acid, are presented for the metals. Composite samples shown in Tables B2-5 through B2-41 were prepared by acid digestion prior to analysis. Other samples were prepared by fusion with potassium hydroxide in a nickel crucible.

Table B2-5. Tank 241-T-109 Analytical Results: Aluminum.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	1,370	1,460	1,410
S95T002177	95-AUG-041	Composite	1,410	1,420	1,420
S95T001630		Upper half	1,430	833	1,130[c]
S95T001619		Lower half	1,090	1,010	1,050

Table B2-6. Tank 241-T-109 Analytical Results: Antimony.[1]

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 2,450	< 2,430	< 2,440
S95T002177	95-AUG-041	Composite	< 60.0	< 60.0	< 60.0[a]
S95T001630		Upper half	< 2,510	< 2,490	< 2,500[c]
S95T001619		Lower half			

Table B2-7. Tank 241-T-109 Analytical Results: Arsenic.

Sample Number	Auger	Auger Section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	< 100	< 100	< 100
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-8. Tank 241-T-109 Analytical Results: Barium.

Sample number	Auger	Auger Section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	< 50.0	< 50.0	< 50.0
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-9. Tank 241-T-109 Analytical Results: Beryllium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 61.3	< 60.8	< 61.0
S95T002177	95-AUG-041	Composite	< 5.00	< 5.00	< 5.00
S95T001630		Upper half	< 62.9	< 62.3	< 62.6
S95T001619		Lower half	< 56.5	< 57.3	< 56.9

Table B2-10. Tank 241-T-109 Analytical Results: Bismuth.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	181	158	170[e]
S95T001630		Upper half	< 1,260	< 1,250	< 1,250
S95T001619		Lower half	< 1,130	< 1,150	< 1,140

Table B2-11. Tank 241-T-109 Analytical Results: Boron.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	217	217	217
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-12. Tank 241-T-109 Analytical Results: Cadmium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122
S95T002177	95-AUG-041	Composite	< 5.00	< 5.00	< 5.00
S95T001630		Upper half	< 126	< 125	< 125
S95T001619		Lower half	< 113	< 115	< 114

Table B2-13. Tank 241-T-109 Analytical Results: Calcium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	1, 410	1,320	1,370
S95T002177	95-AUG-041	Composite	326	323	325
S95T001630		Upper half	< 1,260	< 1,250	< 1,250[c]
S95T001619		Lower half	< 1,130	< 1,150	< 1,140[c]

Table B2-14. Tank 241-T-109 Analytical Results: Cerium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	< 100	< 100	< 100
S95T001630		Upper half	< 1,260	< 1,250	< 1,250
S95T001619		Lower half	< 1,130	< 1,150	< 1,140

Table B2-15. Tank 241-T-109 Analytical Results: Chromium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122
S95T002177	95-AUG-041	Composite	39.7	39.5	39.6
S95T001630		Upper half	< 126	< 125	< 125
S95T001619		Lower half	< 113	< 115	< 114

Table B2-16. Tank 241-T-109 Analytical Results: Cobalt.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 245	< 243	< 244
S95T002177	95-AUG-041	Composite	< 20.0	< 20.0	< 20.0
S95T001630		Upper half	< 251	< 249	< 250
S95T001619		Lower half	< 226	< 229	< 228

Table B2-17. Tank 241-T-109 Analytical Results: Copper.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122
S95T002177	95-AUG-041	Composite	< 10.0	< 10.0	< 10.0
S95T001630		Upper half	< 126	<125	< 125
S95T001619		Lower half	< 113	< 115	< 114

Table B2-18. Tank 241-T-109 Analytical Results: Iron.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	3,400	4,340	3,870[c]
S95T002177	95-AUG-041	Composite	15,900	15,900	15,900
S95T001630		Upper half	14,300	3,900	9,090[d]
S95T001619		Lower half	5,450	4,800	5,130[e]

Table B2-19. Tank 241-T-109 Analytical Results: Lanthanum.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	< 50.0	< 50.0	< 50.0
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-20. Tank 241-T-109 Analytical Results: Lead.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	344	261	303[e]
S95T001630		Upper half	< 1,260	< 1,250	< 1,260
S95T001619		Lower half	< 1,130	< 1,150	< 1,140

Table B2-21. Tank 241-T-109 Analytical Results: Lithium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122[e]
S95T002177	95-AUG-041	Composite	< 10.0	< 10.0	< 10.0
S95T001630		Upper half	< 126	< 125	< 125
S95T001619		Lower half	< 113	< 115	< 114

Table B2-22. Tank 241-T-109 Analytical Results: Magnesium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	< 100	111.0	111.0
S95T001630		Upper half	< 1,260	< 1,250	< 1,250
S95T001619		Lower half	< 1,130	< 1,150	< 1,140

Table B2-23. Tank 241-T-109 Analytical Results: Manganese.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	1,380	1,630	1,500[e]
S95T002177	95-AUG-041	Composite	1,120	1,110	1,120
S95T001630		Upper half	754	493	624[e]
S95T001619		Lower half	555	423	489[e]

Table B2-24. Tank 241-T-109 Analytical Results: Molybdenum.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	< 50.0	< 50.0	< 50.0
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-25. Tank 241-T-109 Analytical Results: Neodymium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	< 100	< 100	< 100
S95T001630		Upper half	< 1,260	< 1,250	< 1250
S95T001619		Lower half	< 1,130	< 1,150	< 1,140[d]

Table B2-26. Tank 241-T-109 Analytical Results: Nickel.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	2,860	1,670	2,260[e]
S95T002177	95-AUG-041	Composite	< 20.0	< 20.0	< 20.0
S95T001630		Upper half	4,730	8,450	6,590[e]
S95T001619		Lower half	5,240	5,770	5,510

Table B2-27. Tank 241-T-109 Analytical Results: Phosphorus.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	83,800	82,800	83,300
S95T002177	95-AUG-041	Composite	81,000	81,000	81,000[c]
S95T001630		Upper half	80,200	82,000	81,100[d]
S95T001619		Lower half	81,400	79,400	80,400[c]

Table B2-28. Tank 241-T-109 Analytical Results: Potassium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	5.22E+06	n/a	5.22E+06
S95T002177	95-AUG-041	Composite	< 500	< 500	< 500[c]
S95T001630		Upper half	7.22E+06	n/a	7.22E+06
S95T001619		Lower half	7.20E+06	n/a	7.20E+06

Note:
n/a = Not analyzed

Table B2-29. Tank 241-T-109 Analytical Results: Samarium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	< 100	< 100	< 100
S95T001630		Upper half	< 1,260	< 1,250	< 1,250
S95T001619		Lower half	< 1,130	< 1,150	< 1,140

Table B2-30. Tank 241-T-109 Analytical Results: Selenium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 1,230	< 1,220	< 1,220
S95T002177	95-AUG-041	Composite	< 100	< 100	< 100
S95T001630		Upper half	< 1,260	< 1,250	< 1,250
S95T001619		Lower half	< 1,130	< 1,150	< 1,140

Table B2-31. Tank 241-T-109 Analytical Results: Silicon.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	1,050	1,240	1,150[e]
S95T002177	95-AUG-041	Composite	2,580	2,580	2,580[b]
S95T001630		Upper half	774	< 623	774
S95T001619		Lower half	< 565	< 573	< 569

Table B2-32. Tank 241-T-109 Analytical Results: Silver.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122[c]
S95T002177	95-AUG-041	Composite	18.7	18.4	18.6[a,d]
S95T001630		Upper half	< 126	< 125	< 125[c]
S95T001619		Lower half	< 113	< 115	< 114[c]

Table B2-33. Tank 241-T-109 Analytical Results: Sodium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	1.69E+05	1.64E+05	1.66E+05[c]
S95T002177	95-AUG-041	Composite	1.82E+05	1.84E+05	1.83E+05[d]
S95T001630		Upper half	1.84E+05	1.94E+05	1.89E+05[d]
S95T001619		Lower half	2.03E+05	2.04E+05	2.03E+05

Table B2-34. Tank 241-T-109 Analytical Results: Sulfur.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	173	172	173
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-35. Tank 241-T-109 Analytical Results: Strontium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122
S95T002177	95-AUG-041	Composite	< 10.0	< 10.0	< 10.0
S95T001630		Upper half	< 126	< 125	< 125
S95T001619		Lower half	< 113	< 115	< 114

Table B2-36. Tank 241-T-109 Analytical Results: Thallium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 2,450	< 2,430	< 2,440
S95T002177	95-AUG-041	Composite	< 200	< 200	< 200
S95T001630		Upper half	< 2,510	< 2,490	< 2,500
S95T001619		Lower half	< 2,260	< 2,290	< 2,280

Table B2-37. Tank 241-T-109 Analytical Results: Titanium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122
S95T002177	95-AUG-041	Composite	< 10.0	< 10.0	< 10.0
S95T001630		Upper half	< 126	< 125	< 125
S95T001619		Lower half	< 113	< 115	< 114

Table B2-38. Tank 241-T-109 Analytical Results: Uranium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 4,900	< 4,860	< 4,880
S95T002177	95-AUG-041	Composite	< 500	< 500	< 500
S95T001630		Upper half	< 5,030	< 4,980	< 5,010[c]
S95T001619		Lower half	< 4,520	< 4,580	< 4,550

Table B2-39. Tank 241-T-109 Analytical Results: Vanadium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 613	< 608	< 610
S95T002177	95-AUG-041	Composite	< 50.0	< 50.0	< 50.0
S95T001630		Upper half	< 629	< 623	< 626
S95T001619		Lower half	< 565	< 573	< 569

Table B2-40. Tank 241-T-109 Analytical Results: Zinc.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	295	293	294
S95T002177	95-AUG-041	Composite	48.1	55.9	52.0[e]
S95T001630		Upper half	271	266	269
S95T001619		Lower half	247	248	247

Table B2-41. Tank 241-T-109 Analytical Results: Zirconium.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001612	95-AUG-040	Whole	< 123	< 122	< 122
S95T002177	95-AUG-041	Composite	12.6	11.8	12.2
S95T001630		Upper half	< 126	< 125	< 125
S95T001619		Lower half	< 113	< 115	< 114

B2.4.2 Ion Chromatography

Samples for ion chromatography (IC) were prepared by water digestion and performed in duplicate per procedure LA-533-105, Rev. D-1. All analytes reported by the IC instrument were requested (except for oxalate). However, only the fluoride, nitrate, and phosphate results are discussed here, as these are the only anions requested by the historical DQO for this tank. If data for other anions are to be used, the quality control criteria and raw data should be evaluated. Of the remaining IC analytes reported, only the chloride results for auger 95-AUG-040 are above the detection limit. The concentrations of anions by IC are shown in Tables B2-42 through B2-49.

Table B2-42. Tank 241-T-109 Analytical Results: Bromide.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	< 1,300	< 1,300	< 1,300
S95T002176	95-AUG-041	Composite	< 563	< 563	< 563
S95T001631		Upper half	< 1,010	< 1,010	< 1,010
S95T001620		Lower half	< 1,100	< 1,100	< 1,100

Table B2-43. Tank 241-T-109 Analytical Results: Chloride.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	578	569	574
S95T002176	95-AUG-041	Composite	80.9	< 74.8	80.9
S95T001631		Upper half	< 132	< 132	< 132
S95T001620		Lower half	< 144	< 144	< 144

Table B2-44. Tank 241-T-109 Analytical Results: Fluoride.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	961	682	822[c,e]
S95T002176	95-AUG-041	Composite	23,500	24,500	24,000
S95T001631		Upper half	23,100	22,900	23,000
S95T001620		Lower half	27,200	27,900	27,600

Table B2-45. Tank 241-T-109 Analytical Results: Nitrate.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	38,800	37,300	38,000
S95T002176	95-AUG-041	Composite	3,210	2,460	2,840[e]
S95T001631		Upper half	3,780	2,970	3,380[e]
S95T001620		Lower half	3,640	3,420	3,530

Table B2-46. Tank 241-T-109 Analytical Results: Nitrite.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	< 113	< 1,130	< 622
S95T002176	95-AUG-041	Composite	< 493	< 493	< 493
S95T001631		Upper half	< 872	< 872	< 872
S95T001620		Lower half	< 952	< 952	< 952

Table B2-47. Tank 241-T-109 Analytical Results: Oxalate.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T002176	95-AUG-041	Composite	< 468	< 468	< 468
S95T001631		Upper half	< 791	< 791	< 791
S95T001620		Lower half	< 863	< 863	< 863

Table B2-48. Tank 241-T-109 Analytical Results: Phosphate.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	2.85E+05	2.50E+05	2.68E+05[c]
S95T002176	95-AUG-041	Composite	2.37E+05	2.38E+05	2.38E+05
S95T001631		Upper half	2.66E+05	2.71E+05	2.68E+05[b]
S95T001620		Lower half	2.71E+05	2.78E+05	2.74E+05

Table B2-49. Tank 241-T-109 Analytical Results: Sulfate.

Sample number	Auger	Auger section	Result	Duplicate	Mean
			µg/g	µg/g	µg/g
S95T001613	95-AUG-040	Whole	< 1,400	< 1,400	< 1,400
S95T002176	95-AUG-041	Composite	< 604	< 604	< 604
S95T001631		Upper half	< 1,080	< 1,080	< 1,080
S95T001620		Lower half	< 1,180	< 1,180	< 1,180

B2.5 VAPOR PHASE MEASUREMENT

Prior to the August 18-21 auger sampling of tank 241-T-109, a vapor phase measurement was taken. Additional measurements were made on May 9, 1996. These measurements supported the safety screening DQO (Dukelow et al. 1995). The vapor phase screening was taken for flammability issues. The vapor phase measurements were taken 20 ft below riser 6 in the dome space of the tank and results were obtained in the field (ie. no gas sample was sent to the laboratory for analysis). The results of the vapor phase measurements are provided in Table B2-50.

Table B2-50. Results of Vapor Phase Measurements of Tank 241-T-109.

Measurement	Result	
	August 15, 1995	May 9, 1996
Total organic carbon (TOC)	< 1 ppm	1.2 ppm
Lower explosive limit (LEL)	0.0% of LEL	0.0% of LEL
Oxygen	21.0%	20.8%
Ammonia	0 ppm	5 ppm

B2.6 HISTORICAL SAMPLE RESULTS

The results of the February 9, 1974 sample are shown in Table B2-51. It appears that the contents of this tank were scheduled to be used as feed to the 242-S Evaporator. Because the sample was liquid and the tank has since been pumped of liquids, the sample probably does not represent present tank contents. The sample was analyzed for specific constituents and the results showed high concentrations of sodium, nitrate, and nitrite. The radionuclides tested for were cesium, cobalt, and ruthenium/rhodium. These data have not been validated and should be used with caution.

Table B2-51. Supernatant Sample.[1]

Waste Tank 241-T-109 Analysis of Tank Farm Sample February 9, 1974		
Sample Number: T-2289		
COMPONENT	LAB VALUE	LAB UNIT
Physical Data		
Sample description	Clear, amber, no solids. 300 mrad/hr.	
pH	12.0	
Specific gravity	1.1982	
Water	77.57	%
Chemical Analysis		
OH	0.384	M
Al	3.14E-02	M
Na	3.74	M
NO_2	1.02	M
NO_3	0.977	M
Pu	4.70E-05	g/L
SO_4	0.164	M
PO_4	6.24E-02	M
F	4.89E-02	M
CO_3	0.542	M
Radiological Analysis		
^{60}Co	1.06E+03	μCi/gal
$^{106}RuRh$	1.10E+06	μCi/gal
^{134}Cs	8.36E+03	μCi/gal
^{137}Cs	6.02E+05	μCi/gal

NOTE:
[1]Pre-1989 analytical data have not been validated and should be used with caution.

B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

The purpose of this chapter is to discuss the overall quality and consistency of the current sampling results for tank 241-T-109, and to present the results of the calculation of an analytical-based inventory.

This section also evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in the use of the data.

B3.1 FIELD OBSERVATIONS

Sample recovery from 95-AUG-040 was quite poor as most of the waste appeared to come from the top six flutes, with just a thin coating on the remaining flutes. Recovery was much better from 95-AUG-041, but the bottom 13 cm (5 in.) of waste may not have been recovered. This raises questions about the representativeness of the samples. Due to the crystalline nature of much of the solids recovered, it was speculated that some of the analytical variability may be caused by homogenization difficulties.

The expected depth of the waste was 16 to 18 in. However, readings taken at the risers at the time of sampling indicated 27 in. of waste under riser 6 and 63 in. under riser 2 (Conner 1995b). In-tank photographs showed that the waste sloped down significantly from the side wall of the tank. Therefore, it appears that the full depth of the waste was not sampled and the SAP (Conner 1995a) requirement that vertical profiles of the waste be obtained from two risers was not met.

B3.2 QUALITY CONTROL ASSESSMENT

The usual quality control assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All the pertinent quality control tests were conducted on the 1995 auger samples, allowing a full assessment regarding the accuracy and precision of the data. The SAP (Conner 1995a) established the specific criteria for all analytes. Sample and duplicate pairs that had one or more QC results outside the specified criteria were identified by footnotes in the data summary tables.

The standard and spike recovery results provide an estimate of the accuracy of the analysis. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. The precision is estimated by the relative percent difference (RPD), which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred. A number of spike recoveries and RPDs were outside the target level for total alpha activity. This may

have been caused by a high dissolved solids content on the sample mount and subsequent self-shielding. Reruns were deemed unnecessary as the sample results were far below the action limit. Some of the high RPDs for the IC analytes may be attributable to sample homogeneity problems. The two high RPDs for nitrate can be explained by the fact that the phosphate peak interferes with the resolution of the much smaller nitrate peak. The high RPD and low spike recovery for fluoride can be attributed to the fact that the fluoride peak is very near the baseline and suffers interference from the slightly larger chloride peak (Conner 1995c). Many of the ICP analytes also had one or more QC parameters outside the specified limits. The poor spike recoveries for sodium may be due to the high concentration of sodium in the samples (samples cannot be spiked to levels much greater than already present). The high concentrations of sodium required high dilutions for all ICP samples. These high dilutions in turn can cause poor or meaningless spike recoveries and RPDs for those ICP elements that had either very high concentrations or were close to the detection limit. Finally, none of the samples exceeded the criterion for preparation blanks; thus, contamination was not a problem.

In summary, the vast majority of the QC results were within the boundaries specified in the SAPs. The discrepancies mentioned here and footnoted in the data summary tables should not impact either the validity or the use of the data.

B3.3 DATA CONSISTENCY CHECKS

Comparisons of different analytical methods can help to assess the consistency and quality of the data. Several correlations were possible with the data set provided by the two core samples. Including a comparison of phosphorous as analyzed by ICP with phosphate as analyzed by IC, and a comparison of weight percent water by TGA with the weight percent water by gravimetry. In addition, mass and charge balances were calculated to help assess the overall data consistency.

B3.3.1 Comparison of Results from Different Analytical Methods

The following data consistency checks compare the results from two different analytical methods. A close correlation between the two methods strengthens the credibility of both results, whereas a poor correlation brings the reliability of the data into question. All analytical mean results were taken from tables in Section B2.0.

The analytical phosphorous mean result as determined by ICP was 80,300 μg/g, which converts to 246,000 μg/g of phosphate. This compared well with the IC phosphate mean result of 269,000 μg/g. The RPD between these two phosphate results was 8.9 percent.

The mean weight percent water result, as determined by TGA, for auger 95-AUG-041 was 45.82 percent. This compared well with the gravimetric result of 46.92 percent. The RPD between these two weight percent water results was 2.4 percent. The mean TGA result for

auger 95-AUG-040 was 12.46 percent. This compared poorly with the gravimetric result of 48.45 percent. The RPD between these two weight percent water results was 118 percent. The large difference is attributable to the conservative manner in which the laboratory integrated the TGA raw data (Conner 1995c).

B3.3.2 Mass and Charge Balance

The principle objective in performing mass and charge balances is to determine if the measurements are self-consistent. In calculating the balances, only analytes listed in Section B2.0 detected at a concentration of 1,000 μg/g or greater were considered.

Except sodium, all cations listed in Table B3-1 were assumed to be in their most common hydroxide or oxide form, and the concentrations of the assumed species were calculated stoichiometrically. Because precipitates are neutral species, all positive charge was attributed to the sodium cation. The anions listed in Table B3-2 were assumed to be present as sodium salts and were expected to balance the positive charge exhibited by the cations. Phosphate, as determined by IC, is assumed to be completely water soluble and appears only in the anion mass and charge calculations. The concentrations of cationic species in Table B3-1, the anionic species in Table B3-2, and the percent water were ultimately used to calculate the mass balance.

The mass balance was calculated from the formula below. The factor 0.0001 is the conversion factor from μg/g to weight percent.

$$\text{Mass balance} = \%\ \text{Water} + 0.0001 \times \{\text{Total Analyte Concentration}\}$$

$$= \%\ \text{Water} + 0.0001 \times \{Al(OH)_3 + FeO(OH) + MnO(OH) + Na^+ + F^- + NO_3^- + PO_4^{-3}\}$$

The total analyte concentrations calculated from the above equation is 498,000 μg/g. The mean weight percent water (obtained from the gravimetric analyses reported in Table B2-3) is 47.7 percent, or 477,000 μg/g. The mass balance resulting from adding the percent water to the total analyte concentration is 97.5 percent (Table B3-3).

The following equations demonstrate the derivation of total cations and total anions; the charge balance is the ratio of these two values.

$$\underline{\text{Total cations}}\ (\mu\text{eq/g}) = [Na^+]/23.0 = 7{,}870\ \mu\text{eq/g}$$

$$\underline{\text{Total anions}}\ (\mu\text{eq/g}) = [F^-]/19.0 + [NO_3^-]/62.0 + [PO_4^{-3}]/31.7 = 9{,}510\ \mu\text{eq/g}$$

The charge balance obtained by dividing the sum of the positive charge by the sum of the negative charge was 0.83.

In summary, the above calculations yield reasonable mass and charge balance values (close to 1.00 for charge balance and 100 percent for mass balance), indicating that the analytical results are generally self-consistent.

Table B3-1. Cation Mass and Charge Data.

Analyte	Concentration (μg/g)	Assumed Species	Concentration of Assumed Species (μg/g)	Charge (μeq/g)
Aluminum	1,250	$Al(OH)_3$	3,610	0
Iron	5,490	FeO(OH)	8,730	0
Manganese	1,030	MnO(OH)	1,650	0
Sodium	181,000	Na^+	181,000	7,870
Total			195,000	7,870

Table B3-2. Anion Mass and Charge Data.

Analyte	Concentration (μg/g)	Assumed Species	Concentration of Assumed Species (μg/g)	Charge (μeq/g)
Fluoride	13,000	F^-	13,000	684
Nitrate	20,800	NO_3^-	20,800	335
Phosphate	269,000	PO_4^{3-}	269,000	8,490
Total			303,000	9,510

Table B3-3. Mass Balance Totals.

Totals	Concentrations (μg/g)
Total from Table B3-1	195,000
Total from Table B3-2	303,000
Water %	477,000
Grand Total	975,000

B3.4 CALCULATION OF ANALYTICAL BASED MEANS AND INVENTORY

The following evaluation was performed on the analytical data from the August 1995 auger samples for tank 241-T-109. These statistics and inventory development are used to support the characterization best-basis inventory that will be developed in Appendix D.

There were three major differences in the statistical analysis for the inventory development compared to safety screening: 1) instead of computing confidence intervals for each sub-segment mean inventory, only one confidence interval was obtained for the tank mean inventory; 2) only an inventory estimate was needed without comparing it to a threshold value; therefore, two-sided 95 percent confidence intervals on the mean inventory were computed; and 3) more analytes were analyzed for the inventory development.

The 95 percent confidence interval upper limit (UL) and lower limit (LL) on the mean for all the analytes detected are

$$\hat{\mu}_w \pm t_{(a-1,[(1+0.95)/2])} * \sqrt{\hat{\sigma}^2_{\hat{\mu}}}\,.$$

Where $\hat{\mu}_w$ is a weighted sample mean, a is the number of core samples, $\hat{\sigma}^2_{\hat{\mu}}$ is the variance of the sample mean and $t_{(a-1,[(1+0.95)/2])}$ is a quantile from Student's t distribution with a-1 degrees of freedom and 0.95 confidence.

The weighted sample mean $\hat{\mu}_w$ was computed weighting the cores equally (i.e. the arithmetic means for cores 40 and 41 were computed and then those means were averaged for the weighted sample mean). For the tank 241-T-109 data, a is two and $t_{(1,[(1+0.95)/2])}$ is 12.706. The variance, $\hat{\sigma}^2_{\hat{\mu}}$, was estimated using restricted maximum likelihood estimation (REML) methods.

Table B3-4 gives the upper and lower limits to the 95 percent confidence intervals for analytes detected in tank 241-T-109. Some analytes had a computed lower limit less than 0. Because an inventory estimate less than 0 is not possible, the lower limit is recorded as 0 in Table B3-4 whenever that occurred.

Table B3-4. 95% Two-Sided Confidence Interval Limits on the Mean Concentration. (2 sheets)

Analyte	$\hat{\mu}_w$	$\hat{\sigma}^2_{\hat{\mu}}$	LL	UL
Grav. (%)[2]	47.7	0.570	38.1	57.3
TGA (%)[2]	29.1	279	0.00	100
Alpha (μCi/g)	0.0137	4.66E-05	0.00	0.1
ICP.f.Al (μg/g)	1250	25900	0.00	3300
IC.F (μg/g)	13000	1.49E+08	0.00	168000

Table B3-4. 95% Two-Sided Confidence Interval Limits on the Mean Concentration. (2 sheets)

Analyte	$\hat{\mu}_w$	$\hat{\sigma}^2_b$	LL	UL
ICP.f.Fe (μg/g)	5490	2.82E+06	0.00	26800
ICP.f.Mn (μg/g)	1030	225000	0.00	7060
ICP.f.Ni[1] (μg/g)	4160	3.57E+06	0.00	28200
IC.NO3 (μg/g)	20800	2.99E+08	0.00	241000
IC.PO4 (μg/g)	269000	2.36E+07	208000	331000
ICP.f.P (μg/g)	82000	1.62E+06	65800	98200
ICP.f.Na (μg/g)	181000	2.21E+08	0.00	370000
ICP.f.Zn (μg/g)	276	323	47.3	505

Note:
[1]Nickel crucible used
[2]Unhomogenized sample results not used in calculations.

Confidence intervals could not be performed on the differential scanning calorimetry (DSC) data, because all of the results were zero.

After the weighted sample means are calculated for the tank for each analyte, the sampling based inventory may be calculated. Because the analyte concentrations above are presented in terms of a mass basis concentration, the total mass of waste in the tank is needed to estimate inventories. The total mass of waste is derived from the tank volume (from surveillance) and the estimated tank bulk density (from the HTCE model). The total tank volume is 58 kgal (or 220 m^3) (Hanlon 1996). The density used for this estimate is 1.55 g/mL (Agnew et al. 1996b). The total mass of waste is calculated to be 343 metric tons. Assuming that there are 343 metric tons of waste in the tank, the inventory of each of the analytes is presented in Table B3-5.

Table B3-5. Analytical-Based Inventory of Tank 241-T-109.[1] (2 sheets)

Analyte	Inventory (kg)	LL[2]	UL[2]
Water	47.7 wt%	38.1 wt%	57.3 wt%
Aluminum	430	0	1,100
Bismuth[3]	58	n/a	n/a
Boron[3]	74	n/a	n/a
Calcium[3]	110	n/a	n/a
Chloride[7]	120	n/a	n/a
Chromium[3]	14	n/a	n/a

Table B3-5. Analytical-Based Inventory of Tank 241-T-109.[1] (2 sheets)

Analyte	Inventory (kg)	LL[2]	UL[2]
Fluoride	4,500	0	57,000
Iron	1,900	0	9,100
Lead[3]	100	n/a	n/a
Magnesium[3]	38	n/a	n/a
Manganese	350	0	2,400
Nitrite[6]	170	n/a	n/a
Nitrate	7,100	0	82,000
Phosphate[4]	92,000	71,000	110,000
Silicon[7]	300	n/a	n/a
Silver[3]	6	n/a	n/a
Sodium	62,000	0	130,000
Sulfate[3,5]	180	n/a	n/a
Zinc	94	16	170
Zirconium[3]	4	n/a	n/a
Total Alpha	4.67 Ci	0	34.1

Notes:

n/a = Not applicable

[1]The bulk density used to calculate inventory was not measured; it is an estimate from Agnew et al. (1996b).

[2]95 percent two-sided confidence interval upper and lower limits.

[3]These analytes were measured using acid digestion on the composite of 95-AUG-041. Because only one sample was available, the mean and upper and lower limits were not calculated.

[4]Assume that all phosphorus is in the form of phosphate.

[5]Sulfate was not detected using IC, but sulfur was measured using ICP (acid digestion only). All sulphur is assumed to be sulfate.

[6]All nitrate results were below detection limits. Lowest detection limit value was used to estimate inventory.

[7]The concentration used to estimate the inventory was a weighted mean. The weighted mean was calculated using both measured concentrations and detection limits. Silicon calculations used fusion digest results only.

B4.0 APPENDIX B REFERENCES

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

In appendix C, the analyses required for the applicable data quality objective (DQO) reports for tank 241-T-109 are performed. Specifically, statistical and other numerical manipulations required in the DQO reports are performed and documented in this appendix. The two analyses required for tank 241-T-109 are documented in the following sections:

- **Section C1**: Statistical analysis supporting the Safety Screening DQO (Dukelow et al. 1995). Specifically, confidence intervals were needed to support the plutonium (criticality) threshold limit.
- **Section C2**: Gateway analysis supporting the *Historical Model Evaluation Data Requirements* DQO (Simpson and McCain 1995).
- **Section C3**: References for Appendix C.

C1.0 STATISTICS FOR SAFETY SCREENING DQO

The safety screening DQO (Dukelow et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals on the mean for each subsample. In this appendix, one sided confidence limits supporting the safety screening DQO are calculated for tank 241-T-109. All data considered in this section are taken from the final laboratory data package for the 1995 auger sampling event for tank 241-T-109 (Conner 1995).

Confidence intervals were computed for each sample number from tank 241-T-109 analytical data. The sample numbers and confidence intervals are provided in Table C1-1.

The upper limit (UL) of a one-sided 95 percent confidence interval for the mean is

$$\hat{\mu} + t_{(n-1,0.95)} * \sqrt{\frac{\hat{\sigma}^2}{n}} .$$

where $\hat{\mu}$ is the arithmetic mean of the data, n is the number of observations, $\hat{\sigma}^2$ is the estimate of the variance of the data, and $t_{(n-1,0.95)}$ is a quantile from Student's t distribution with $n-1$ degrees of freedom and 0.95 confidence.

For the tank 241-T-109 data (per sample number), n is two and $t_{(1,0.95)}$ is 6.314.

The upper limit of the 95 percent confidence interval for each sample number based on the total alpha data is listed in Table C1-1. Each confidence interval can be used to make the following statement. If the upper limit is less than 40 μCi/g, then one would reject the null hypothesis that the total alpha is greater than or equal to 40 μCi/g at the 0.05 level of significance. The upper limit of 40 μCi/g was calculated from the 1 g/L plutonium limit assuming a density of 1.55 g/mL (Agnew et al. 1996) and assuming that all the plutonium is ^{239}Pu.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Total Alpha for Tank 241-T-109.

Sample number	Auger	Auger section	$\bar{x}$ (μCi/g)	σ^2/n	UL (μCi/g)
95T001612	95-AUG-040	Whole	2.05E-02	1.96E-06	2.93E-02
95T001619	95-AUG-041	Lower half	7.32E-03	4.64E-06	2.09E-02
95T001630	95-AUG-041	Upper half	6.38E-03	2.25E-08	7.33E-03

Notes:
AUG = Auger
UL = Upper limit

Confidence intervals were not performed on the differential scanning calorimetry (DSC) data, because all of the results were zero.

C2.0 GATEWAY ANALYSIS FOR HISTORICAL MODEL DQO

The *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995) requires that a gateway analysis be performed on the analytical data obtained from tank 241-T-109. The purpose of the gateway analysis is to provide a quick screening check of the analytical data before a more thorough set of analyses are performed on the tank. If the gateway analysis fails, then the remainder of the analyses in the historical DQO will not be performed. The historical gateway analysis consists of two parts, both of which are described below. All data considered in this section are taken from the final laboratory data package for the 1995 auger sampling event for tank 241-T-109 (Conner 1995).

The first part of the gateway analysis is to check if the sum of the mass of a set group of analytes (indicator analytes) contributes over 85 percent of the total tank waste mass. The indicator analytes for tank 241-T-109 are water, sodium, nitrate, phosphate, and fluoride.

The gateway analysis will be performed for three samples: 95-AUG-040, 95-AUG-041 upper half, and 95-AUG-041 lower half. The results of this analysis are shown in Table C2-1. The first part of the gateway analysis passed for all samples.

Table C2-1. Part 1 of Gateway Analysis.

	95-AUG-040 (Whole sample)	95-AUG-041 (Upper half)	95-AUG-041 (Lower half)
Water %	48.5	47.7	46.2
Sodium %	16.6	18.9	20.4
Nitrate %	3.8	0.34	0.35
Phosphate %	26.8	26.9	27.5
Fluoride %	0.08	2.3	2.8
Sum (%)	95.7	96.1	97.06
Pass/fail	Pass	Pass	Pass

The second part of the gateway analysis requires that each of the indicator analytes (used above) be compared to the value predicted by the historical model. For the second part of the gateway analysis to pass, each of the indicator analytes measured from sampling has to be greater than 10 percent of the value predicted by the model. Table C2-2 summarizes the results of this analysis. The second part of the gateway analysis failed for every sample. However, it should be noted that averaging the results of the two auger samples gives results which would have passed this part of the gateway analysis.

Table C2-2. Part 2 of Gateway Analysis.

	Historical predicted value[1]	10 % of predicted value	95-AUG-040 (Whole sample)	95-AUG-041 (Upper half)	95-AUG-041 (Lower half)
Water %	36.1	3.61	48.5	47.7	46.2
Sodium %	14.4	1.44	16.6	18.9	20.4
Nitrate %	8.6	0.86	3.8	0.34	0.35
Phosphate %	9.6	0.96	26.8	26.9	27.5
Fluoride %	1.1	0.11	0.08	2.3	2.8
Pass/fail	n/a	n/a	Fail (Fluoride)	Fail (Nitrate)	Fail (Nitrate)

Note:
[1]Simpson and McCain (1995)

Because the gateway analysis passed part 1 but failed part 2, the analysis is considered to have failed for tank 241-T-109. This means that the remainder of the historical DQO analysis will not be applied to the tank.

C3.0 APPENDIX C REFERENCES

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-T-109

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-T-109

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Kupfer et al. 1995). As part of this effort, an evaluation of available chemical information for tank 241-T-109 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

Available chemical information for tank 241-T-109 included:

- Data from recent analyses of two auger samples that were collected in August, 1995 (Conner 1995). See Appendix B, Section B2.0 for data.
- Data from the analysis of supernatant sample T-2289 collected in 1974 (Sant 1974). See Appendix B, Section B2.0 for data. (These data were used for comparison purposes; these data have not been validated and should be used with caution.)
- The solids composite inventory estimate for this tank (Agnew et al. 1996) generated from the Los Alamos National Laboratory (LANL) model, also referred to as the Historical Tank Content Estimate (HTCE). See Appendix A, Section A3.2 for model estimate.

A list of references used in this evaluation is provided at the end of this Appendix (Section D4.0).

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sampling-based inventories (see Appendix B, Section B3.2), derived from the analytical concentration data from the two auger samples, and HTCE inventories, generated by the LANL model (See Appendix A, Section A3.2), are compared in Tables D2-1 and D2-2.

Table D2-1 compares nonradioactive components on a metric ton (MT) basis, and Table D2-2 compares the radioactive components on a curie basis.

Table D2-1. Sampling- and HTCE-based Inventory Estimates for Nonradioactive Components in Tank 241-T-109 Waste. (2 sheets)

Analyte	Sampling[1] inventory estimate (MT)	HTCE[2] (MT)	Analyte	Sampling[1] inventory estimate (MT)	HTCE[2] (MT)
Al	0.43	1.0	Ni	n/a	0.15
Ag	0.006	NR	NO_2	0.17	2.9
As	n/a	NR	NO_3	7.1	42
Ba	n/a	NR	OH_{total}	NR	5.4
Be	n/a	NR	oxalate	n/a	0
Bi	0.058	2.1	Pb	0.10	0
Ca	0.11	1.0	Pd	n/a	NR
Ce	n/a	NR	P as PO_4	84-92[3]	35
Cd	n/a	NR	Pt	NR	NR
Cl	0.099	0.64	Rh	NR	NR
Co	n/a	NR	Ru	NR	NR
Cr	0.014	0.06	Sb	n/a	NR
Cr^{+3}	NR	NR	Se	n/a	NR
Cr^{+6}	NR	NR	Si	0.30	0.15
Cs	NR	NR	S as SO_4	0.18	2.9
Cu	n/a	NR	Sr	n/a	0
F	4.5	0.61	Te	NR	NR
Fe	1.9	2.7	TIC as CO_3	NR	3.3
FeCN/CN	NR	0	Th	n/a	NR
formate	NR	NR	Tl	NR	NR
Hg	NR	0.0017	TOC	NR	NR
K	n/a	0.12	U_{total}	n/a	NR
La	n/a	0	V	n/a	NR
Mg	0.038	NR	W	NR	NR

Table D2-1. Sampling- and HTCE-based Inventory Estimates for Nonradioactive Components in Tank 241-T-109 Waste. (2 sheets)

Analyte	Sampling[1] inventory estimate (MT)	HTCE[2] (MT)	Analyte	Sampling[1] inventory estimate (MT)	HTCE[2] (MT)
Mn	0.35	0	Zn	0.094	NR
Mo	n/a	NR	Zr	0.004	0.067
Na	62	47	H_2O (wt%)	47.7	57.2
Nd	n/a	NR	density (g/mL)	NR	1.55
NH_4	NR	NR			

Notes:

MT = metric ton
n/a = Not applicable; i.e., concentration reported as less than value.
NR = Not reported.

[1]Conner (1995) - See Appendix B.
[2]Agnew et al. (1996) - See Appendix A.
[3]Range reflects two methods of analysis.

Table D2-2. Sampling and Predicted Inventory Estimates for Radioactive Components in Tank 241-T-109 Waste.

Analyte	Sampling[1] inventory estimate (Ci)	HTCE[2] (Ci)	Analyte	Sampling[1] inventory estimate (Ci)	HTCE[2] (Ci)
^{14}C	NR	NR	^{237}Np	NR	NR
^{90}Sr	NR	3,760	$^{239/240}Pu$	NR	2.35
^{99}Tc	NR	NR	^{241}Am	NR	NR
^{129}I	NR	NR	Total α	4.69	NR
^{137}Cs	NR	4,150	Total β	NR	NR
^{154}Eu	NR	NR			

Notes:

n/a = Not applicable; i.e., concentration reported as less than value.
NR = Not reported.

[1]Conner (1995) - See Appendix B.
[2]Agnew et al. (1996) - See Appendix A.

In addition to the auger sampling- and HTCE-based information, results from the analysis of tank 241-T-109 supernatant, performed in 1974 (Sant 1974), provided another source of information for component inventories. This supernatant sample appeared to have been obtained after the 1973 addition of 1,431 kL (378 kgal) of waste from tank 241-T-108 and prior to any major transfer of waste out of tank 241-T-109; therefore, analyte concentrations in the supernatant should be representative of analyte concentrations in the interstitial liquid. However, in some cases, e.g., nitrite, these concentrations provided a third inventory estimate that was not consistent with either the auger sampling- or the HTCE-based inventories (refer to Table D2-3). Note that the supernatant results were not validated and should be used with caution.

Table D2-3. Comparison of Selected Component Inventory Estimates for Tank 241-T-109 Waste.

Component	Auger samples (MT)	Supernatant samples (MT)[1]	HTCE (MT)
PO_4	84-92[2]	n/a	35
F	4.5	n/a	0.61
NO_3	7.1	6.6	42
NO_2	0.17	5.1	2.9
SO_4	0.18	1.7	2.9
CO_3	NR	0.92-3.6[3]	3.3
Na	62	n/a	47

Notes:

MT = metric ton
n/a = Not applicable
NR = Not reported

[1]Used to derive inventory estimates for components expected only in interstitial liquid (Sant 1974). These data are used for comparison purposes; they have not been validated and should be used with caution.

[2]Range reflects two methods of analysis.

[3]CO_3 concentration in the supernatant sample was reported as "0.542" with no units. The lower inventory value is based on 0.542 percent CO_3 and the higher inventory value is based on 0.542 M CO_3.

Sampling-based component inventories were calculated by multiplying the mean analyte concentration value by the current tank waste volume and by the density of the waste. A tank volume of 220 kL (58 kgal) (Hanlon 1996) and a density of 1.55 g/mL were used in these calculations. The density of 1.55 g/mL reflects the LANL model density (Agnew et al. 1996) because no density measurements were performed on the recent auger samples. This density is consistent with densities of 1.6 g/mL for $Na_3PO_4 \cdot 12H_2O$ and 1.5 for $Na_2HPO_4 \cdot 12H_2O$; phosphate appears to be a bulk constituent in this waste (refer to Table D2-1).

The following evaluation of tank contents was performed in order to identify potential errors and/or missing information that could influence the sampling- and/or the HTCE-based component inventories.

D3.0 COMPONENT INVENTORY EVALUATION

Tank 241-T-109, the third tank in a cascade group comprised of tanks 241-T-107, 241-T-108, and 241-T-109, received/transferred (Agnew et al. 1996):

through 1953	Received overflow 1C, UR wastes from tank 241-T-108
1951-1953	Supernatant sent to tank 241-TX-118
1953-1954	Received supernatant from tank 241-TX-117
1954	Evaporator waste received
1969	Supernatant sent to tank 241-TY-103 (515 kL [136 kgal] waste remains)
1973	Received 1,514 kL (400 kgal) supernatant from tank 241-T-108 (potentially B Plant wash/LL/IX waste)
1974	Supernatant sampled, 1,499 kL (396 kgal) transferred to tank 241-S-110; tank removed from service.

Notes:

1C	First decontamination cycle $BiPO_4$ waste
UR	Uranium recovery waste (tributyl phosphate waste)
LL	Low-level
IX	Ion-exchange

(Please refer to Appendix A, Section A3.1 for a more detailed summary of the waste transfer history.)

LANL sets the waste type in this tank as T1-saltcake (T1SltCk) beginning 1955 and does not take into account any solids contributions and/or waste dilution effects from the 1,514 kL (400 kgal) of supernatant waste transferred from tank 241-T-108 in 1973. This 1,514 kL would most likely alter the composition of the 515 kL (136 kgal) of salt waste in the tank at that time. The T1SltCk composition is compared with the auger sampling-based composition on a dry weight percent basis in Table D3-1.

Table D3-1. Comparison of Auger Sampling and HTCE Waste Compositions for Tank 241-T-109 on a Dry Weight Percent Basis.

Component	Auger Sample	HTCE
PO_4	52	25
F	2.7	0.43
Fe	1.2	1.9
Si	0.19	0.10
NO_3	4.4	30
NO_2	0.10	2.1
SO_4	0.11	2.1
Bi	0.036	1.5
Al	0.26	0.72
CO_3	NR	2.3
Na	38	33

The bulk of LANL's T1SltCk is comprised of Na, NO_3, and PO_4, while the bulk of the auger sample is comprised of Na and PO_4. Phosphate concentration values appeared consistent for all analyzed auger-sample segments, and the high concentration values suggested that all/nearly all of the PO_4 precipitated from the aqueous salt stream sent to the tank. LANL assumed that only 58 percent of the PO_4 precipitated.

The following observations are made for several of the individual components listed in Tables D2-3 and D3-1:

Phosphate: Phosphate concentration values appeared consistent for all analyzed auger-sample segments. The high inventory value derived from these concentrations also suggests that all/nearly all of the PO_4 precipitated from the aqueous salt waste. The LANL assumption that only 58 percent of the PO_4 precipitated is reflected in the significantly lower HTCE inventory value.

Fluoride: The mean concentration value that was used to generate the auger sampling-based inventory was based on two very different concentration values--800 μg F/g waste in one sample and 25,000 μg F/g waste in the other. These difference in concentration could be due to two distinct waste types in the tank and/or to inhomogeneous dilution effects. These sampling-based values suggest that some of the fluoride precipitated from solution, while the HTCE concentration and resulting inventory values are based on the assumption that fluoride remains dissolved in interstitial liquid.

Nitrate: The mean concentration value that was used to generate the auger sampling-based inventory was derived from two very different concentration values--38,000 μg NO_3/g waste in one sample (corresponding to the 800 μg F/g waste sample) and 3500 μg NO_3/g waste in the other (corresponding to 23,000 μg F/g waste sample). These different values could be due to two distinct waste types in the tank and/or to inhomogeneous dilution effects. The inventory value in Table D2-3, derived from the supernatant sample, compares favorably with the inventory based on the auger sample. This observation tends to support the assumption that analyte concentrations in the supernatant might be representative of present analyte concentrations in the interstitial liquid. The concentration in T1SltCk is considerably higher than the sampling-based concentration values; the HTCE concentration value does not account for any potential dilution effects from the addition of 1,462 kL (386 kgal) of aqueous waste in 1973.

Nitrite: The auger and supernatant-based inventories in Table D2-3 for NO_2 are very different (0.17 MT, auger versus 5.1 MT, supernatant). In contrast to NO_3, this observation does not support the assumption that the analyte concentration in the supernatant might be representative of present analyte concentrations in the interstitial liquid. While the HTCE inventory falls within the sampling-based inventory range, the HTCE value could be smaller due to potential dilution effects.

Sulfate: The auger and supernatant-based inventories in Table D2-3 for SO_4 vary by an order of magnitude. In contrast to NO_3, this observation does not support the assumption that the analyte concentration in the supernatant might be representative of present analyte concentrations in the interstitial liquid. The HTCE inventory falls outside the sampling-based inventory range; however, the HTCE value may be smaller due to potential dilution effects.

Bismuth: The HTCE inventory is larger than the auger sampling-based inventory. Tank 241-T-109 was the third tank in the cascade series, and as a result Bi, a heavy element, may have precipitated in the first two tanks.

Carbonate: Auger samples were not analyzed for CO_3. The range in Table D3-1 results from the concentration in the supernatant sample being reported as "0.542," with no units provided. Because carbonate analyses were reported in the past both in terms of percent mass or molarity, two inventory values were generated: the lower inventory value is based on 0.542 percent CO_3, and the upper inventory value is based on 0.542 $\underline{M}$ CO_3. The HTCE inventory falls within this range.

With two modifying assumptions, the HTCE component inventories begin to compare favorably with the sampling-based inventories. First, assume all the PO_4 in the LANL defined waste stream precipitates, and second, assume the components dissolved in the interstitial liquid are diluted by a factor of 7. The resulting HTCE composition is compared to the auger sample composition on a dry weight percent basis in Table D3-2.

Table D3-2. Comparison of Auger Sampling and Modified HTCE Component Inventories for Tank 241-T-109 Waste on a Dry Weight Percent Basis.

Component	Sampling inventory	Modified[1] HTCE inventory
PO_4	52	51
F	2.7	0.51
Fe	1.2	2.2
Si	0.19	0.12
NO_3	4.4	4.8
NO_2	0.10	0.34
SO_4	0.11	0.34
Bi	0.036	1.6
Al	0.26	0.12
CO_3	NR	2.6
Na	38	38

Note:

[1]All PO_4 in the LANL defined waste stream is assumed to precipitate, and the remaining salts dissolved in the interstitial liquid are assumed to have been diluted by a factor of 7.

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

The results from this evaluation support using the sampling data as the basis for the best estimate inventory for tank 241-T-109 for the following reasons:

1. The inventory estimate generated by the LANL model is based on a single defined salt waste stream (T1SltCk) and does not take into account any solids contributions and/or waste dilution effects from the 1,431 kL (378 kgal) of waste transferred from tank 241-T-108 to tank 241-T-109 in 1973. This 1,431 kL is not considered to be T1SltCk and most likely altered the composition of the 515 kL (136 kgal) of salt waste in the tank at that time.

2. Phosphate concentration values, which appear consistent for all analyzed segments, suggest that phosphates formed the bulk of the precipitated solids. The predicted concentration value for this major component is less than half the lower 95 percent confidence value. The LANL assumption that only 40 percent of the phosphate in the T1 waste stream precipitates appears to be conservative.

Best-basis inventory estimates for tank 241-T-109 are presented in Tables D4-1 and D4-2. While samples were analyzed for numerous analytes (refer to Table D2-1), only those detected in the waste are included in these tables. Table D4-1 provides an inventory estimate in terms of percent nonradioactive (expected) chemical species. Note that this waste is predominantly sodium phosphate and should not be mixed with waste types that could result in phosphate gels.

Best-basis component inventory estimates and the mean analytical concentrations that were used to calculate these component inventories are provided in Table D4-2. This table also includes 95 percent confidence intervals around the mean concentration value (refer to Appendix B for information regarding the statistical analysis of analytical data for tank 241-T-109). Note that inventory ranges are presented in Table D4-2 for NO_2, TIC as CO_3, and SO_4. These ranges result from the uncertainties associated with these components.

Table D4-1. Best-Basis Inventory Estimate for Tank 241-T-109 (Percent Nonradioactive Chemical Species).

Compound		Percent total waste
Water		48
Sodium phosphate[1]		40 - 44
Sodium fluoride		2.9
Sodium nitrate		2.9
Sodium nitrite[2]		0.074 - 2.3
Sodium sulfate[2]		0.076 - 0.75
Sodium carbonate[3]		0.48 - 1.8
Minor compounds:		1.6
Iron hydroxide	0.87	
Aluminum hydroxide	0.36	
Silicon dioxide	0.19	
Manganese hydroxide	0.17	
Calcium carbonate	0.081	
Sodium chloride	0.047	
Zinc hydroxide	0.029	
Bismuth oxide	0.019	

Notes:

[1]Range accounts for range in sodium sulfate, sodium nitrite, and sodium carbonate inventories; refer to (2) and (3) below.

[2]Low value based on auger sample analysis; high value based on 1974 supernatant analysis.

[3]Low value based on 0.542 percent CO_3 in supernatant sample, and high value based on 0.542 M CO_3.

Table D4-2. Best-Basis Inventory Estimates for Tank 241-T-109.
(2 Sheets)

Analyte (method/ sample preparation)	Mean concentration µg/g	Lower limit 95% CI µg/g	Upper limit 95% CI µg/g	HTCE concentration within CI? (Y/N)	Bulk tank inventory (MT)
Al (ICP/Fusion)	1250	0	3300	Y	0.43
Bi[1] (ICP/Acid)	170	n/a	n/a	n/a	0.058
B (ICP/Acid)	217	n/a	n/a	n/a	74
Ca[1] (ICP/Acid)	324	n/a	n/a	n/a	0.11
Cl[1] (IC/Water)	341	n/a	n/a	n/a	0.12
Cr[1] (ICP/Acid)	40	n/a	n/a	n/a	0.014
F (IC/Water)	13000	0	168000	Y	4.5
Fe (ICP/Fusion)	5490	0	26800	Y	1.9
Pb (ICP/Acid)	303	n/a	n/a	n/a	100
Mg (ICP/Acid)	111	n/a	n/a	n/a	38
Mn (ICP/Fusion)	1030	0	7060	Y	0.35
Na (ICP/Fusion)	181000	0	370000	Y	62[2]
NO_2[7] (IC/Water)	492 - 15000	n/a	n/a	n/a	0.17 - 5.1
NO_3 (IC/Water)	20800	0	241000	Y	7.1
P as PO_4 (ICP/Fusion, IC/Water)	269000 - 246000[3]	198000	331000	N	92 - 83[4]
Si (ICP/Fusion)	889	n/a	n/a	n/a	0.30
Ag (ICP/Acid)	18.6	n/a	n/a	n/a	6

Table D4-2. Best-Basis Inventory Estimates for Tank 241-T-109. (2 Sheets)

Analyte (method/ sample preparation)	Mean concentration µg/g	Lower limit 95% CI µg/g	Upper limit 95% CI µg/g	HTCE concentration within CI? (Y/N)	Bulk tank inventory (MT)
S as SO_4[1,7] (ICP/Acid)	516 - 5050	n/a	n/a	n/a	0.18 - 1.7
TIC as CO_3[1,5]	2710 - 10400	n/a	n/a	n/a	0.92 - 3.6
Zn (ICP/Fusion)	276	47.3	505	Not Reported	0.095
Zr (ICP/Acid)	12.2	n/a	n/a	n/a	4
Total α (µCi/g)	0.0137	0	0.1	Y	4.7 Ci
H_2O (wt%)	47.7	38.1	57.3	Y	48 wt%
Density (g/mL)[6]	1.56	n/a	n/a	n/a	1.56

Notes:

IC	Ion chromatography
ICP	Inductively coupled plasma spectroscopy
MT	metric ton
Water	Approximately 1 g sample is contacted with 100 mL water; solution analyzed by IC.
Acid	Sample is digested with acid; solution analyzed by ICP.
Fusion	Sample is fused with KOH at high temperatures to form a "melt," which is subsequently dissolved with water; solution analyzed by ICP.

[1]Analyte detected in only one sample; insufficient data to calculate confidence intervals.

[2]Na inventory is based on 178,000 µg Na/g waste for ion balance purposes, assuming $Na_{2.5}H_{0.5}PO_4$.

[3]Range reflects mean analyte concentrations from ICP and IC analyses.

[4]PO_4 inventory of 92 MT is based on 269,000 µg PO_4/g waste; lower inventory value accounts for uncertainties in NO_2, SO_4, and TIC as CO_3 inventories.

[5]Auger samples not analyzed for CO_3; concentration has been estimated from supernatant data. Concentration in the supernatant sample was reported as "0.542" with no units. The lower concentration/inventory value is based on 0.542 percent CO_3 and the higher concentration/inventory value is based on 0.542 M CO_3.

[6]Density analyses not performed with auger samples. Density of 1.55 kg/L was generated by LANL (Brevick 1995) and is consistent with a densities of 1.6 g/mL for $Na_3PO_4 \cdot 12H_2O$ and 1.5 g/mL for $Na_2HPO_4 \cdot 12H_2O$.

[7]Low value based on auger sample analysis; high value based on 1974 supernatant analysis. Pre-1989 data have not been validated and should be used with caution.

D5.0 APPENDIX D REFERENCES

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Hanford Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Los Alamos National Laboratory, Los Alamos, New Mexico.

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 East Areas*, WHC-SD-WM-ER-351, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Conner, J. M., 1995, *Final Report for Tank 241-T-109, Auger Samples 95-AUG-040 and 95-AUG-041*, WHC-SD-WM-DP-144, Rev. 1-A, Westinghouse Hanford Company, Richland, Washington.

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending April 30, 1996*, WHC-EP-0182-97, Westinghouse Hanford Company, Richland, Washington.

Kupfer, M. J., M. D. LeClair, W. W. Schulz, and L. W. Shelton, 1995, *Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Sant, W. H., 1974, *Analysis of Tank Farm Samples, Sample: T-2289, Tank 109-T*, (internal memorandum to R. L. Walser, March 13), Atlantic Richfield Hanford Company, Richland, Washington.

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-T-109

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-T-109

Appendix E provides a bibliography of information that supports the characterization of tank 241-T-109. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, and modeling information, as well as processing occurrences associated with tank 241-T-109 and its respective waste types.

The references in this bibliography are separated into three broad categories containing references broken down into subgroups. These categories and their subgroups are listed below.

I. NON-ANALYTICAL DATA

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

- IIa. Sampling of tank 241-T-109
- IIb. Sampling of 242-T Evaporator Streams
- IIc. Sampling of TBP-Salt Mixtures

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories using both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources

This bibliography is broken down into the appropriate sections of material to use, with an annotation at the end of each reference describing the information source. Where possible, a reference is provided for information sources. A majority of the information listed below may be found in the Westinghouse Hanford Company Tank Characterization Resource Center.

I. NON-ANALYTICAL DATA

Ia. Models/Waste Type Inventories/Campaign Information

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Document contains single-shell tank fill history and primary campaign/waste type information up to 1981.

Jungfleisch, F. M. and B. C. Simpson, 1993, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, WHC-SD-WM-TI-057 Rev. 0-A, Westinghouse Hanford Company, Richland, Washington.

- A model based on process knowledge and radioactive decay estimations using ORIGEN for different compositions of process waste streams assembled for total, solution, and solids compositions per tank. Assumptions about waste/waste types and solubility parameters/constraints are also given.

Schneider, K. J., 1951, *Flow Sheet and Flow Diagrams of Precipitation Separations Process*, HW-23043, General Electric Company, Richland, Washington.

- Document contains compositions of first concentration cycle waste before transfer to 200E waste tanks.

Ib. Fill History/Waste Transfer Records

Agnew, S. F., 1995, *Tank Layer Model (TLM), Rev 1 for Northeast, Southwest, and Northwest Quadrants*, LA-UR-94-4269, Rev. 1, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document predicts volumes of waste type layers in single-shell tanks.

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1994, *Waste Status and Transaction Record Summary for the Northwest Quadrant of the Hanford 200 East Area*, WHC-SD-WM-TI-669, Rev. 1, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document contains spreadsheets depicting all available data on tank additions/transfers.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Document contains single-shell tank fill history and primary campaign/waste type information up to 1981.

Ic. Surveillance/Tank Configuration

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-RE-TI-053, Rev. 9, Westinghouse Hanford Company, Richland, Washington.

- Document shows tank riser locations in relation to tank aerial view as well as a description of riser and its contents.

Lipnicki, J., 1995, *Waste Tank Risers Available for Sampling*, WHC-SD-WM-TI-710, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Document gives an assessment of riser locations for each tank, however not all tanks are included/completed. Also included is an estimate of what risers are available for sampling.

Id. Sample Planning/Tank Prioritization

Brown, T. M., S. J. Eberlein, and T. J. Kunthara, 1995, *Tank Waste Characterization Basis*, WHC-SD-WM-TA-164, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Document that summarizes the technical basis for characterizing the waste in the tanks and assigns a priority number to each tank.

Conner, J. M., 1995, *Tank 241-T-109 Tank Characterization Plan*, WHC-SD-WM-TP-368, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document discusses any and all relevant DQOs and how they will be met for tank 241-T-109.

Conner, J. M., 1995, *Tank 241-T-109 Auger Sampling and Analysis Plan*, WHC-SD-WM-TSAP-014, Rev. 0-A, Westinghouse Hanford Company, Richland, Washington.

- Document contains detailed sampling and analysis procedure information for tank 241-T-109 based on applicable DQOs.

Conner, J. M., 1995, *Need Identified to Resample Tank 241-T-109*, (internal memo #75310-95-098 to T. J. Kelley, October 24), Westinghouse Hanford Company, Richland, Washington.

- Memo summarizes 1995 decision to take additional samples from tank 241-T-109 to meet Safety Screening DQO needs.

Grimes, G. W., 1977, *Hanford Long-Term Defense High-Level Waste Management Program Waste Sampling and Characterization Plan*, RHO-CD-137, Rockwell Hanford Operations, Richland, Washington.

- Early characterization planning document.

Homi, C. S., 1995, *FY 1996 Tank Waste Analysis Plan*, WHC-SD-WM-PLN-101, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains Tri-Party Agreement (see Ecology et al. 1994 listing in Section 5.0) requirement-driven TWRS Characterization Program information and a list of tanks addressed in fiscal year 1996.

Winters, W. I., L. Jensen, L. M. Sasaki, R. L. Weiss, J. F. Keller, A. J. Schmidt, and M. G. Woodruff, 1989, *Waste Characterization Plan for the Hanford Site Single-Shell Tanks*, WHC-EP-0210, Westinghouse Hanford Company, Richland, Washington.

- Early version of characterization planning document.

Ie. Data Quality Objectives (DQO) and Customers of Characterization Data

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- DQO used to determine if tanks are under safe operating conditions.

Kupfer, M. J., W. W. Schultz, G. L. Borsheim, S. J. Eberlein, B. C. Simpson, and J. T. Slankas, 1994, *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology*, WHC-SD-WM-TA-154, Westinghouse Hanford Company, Richland, Washington.

- Document provides basis for selection of tanks for disposal needs.

Simpson, B. C., and D. J. McCain, 1995, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-018, Rev. 0-A, Westinghouse, Hanford Company, Richland, Washington.

- Document provides data needs for evaluating the LANL model for estimating tank waste compositions.

Slankas, T. J., M. J. Kupfer, and W. W. Schulz, 1995, *Data Needs and Attendant Data Quality Objectives for Tank Waste Pretreatment and Disposal*, WHC-SD-WM-DQO-022, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Documents the needs of the pretreatment function within TWRS.

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

IIa. Sampling of tank 241-T-109

Conner, J. M., 1995, *Final Report for Tank 241-T-109, Auger Samples 95-AUG-040 and 95-AUG-041*, WHC-SD-WM-DP-144, Rev. 1-A, Westinghouse Hanford Company, Richland, Washington.

- Document contains sample analyses from 1995 tank 241-T-109 auger sampling event.

Conner, J. M., 1995, *Immediate Notification: Violation of Limits for Moisture Content for Samples from Tank 241-T-109*, (internal memo #75310-95-078 to R. J. Cash, September 21), Westinghouse Hanford Company, Richland, Washington.

- Memo provides sample analysis results that fall outside of acceptable range (Notification limit: < 17 percent moisture) for tank 241-T-109.

Cromar, R. D., 1995, *95% Confidence Intervals for Tank T-109*, (internal memo #75764-PCS95-083 to J. M. Conner, September 27), Westinghouse Hanford Company, Richland, Washington.

- Memo provides one-sided confidence intervals on 1995 auger data to support the safety screening DQO.

Sant, W. H., 1974 *Analysis of Tank Farm Samples, Sample: T-2289, Tank 109-T*, (letter to R. L. Walser, March 13), Atlantic Richfield Hanford Company, Richland, Washington.

- Internal letter provides analyses of supernatant sample from February 9, 1974 sampling.

IIb. Sampling of 242-Evaporator Waste Streams

- All the information in this section is documented in Process Aids 1970 - 1993. Process Aids is a consecutive compilation of laboratory memos, letters, etc. indexed by year then by subject and/or tank. The following analyses may provide insight as to the composition of T1SltCk waste type expected to be in tank 241-T-109.

Buckingham, J. S., 1972, *Interim Report III: Nitric Acid Neutralization and Concentration of Caustic Waste Solutions - 242-T Evaporator Feed*, ARH-2529, Atlantic Richfield Hanford Company, Richland, Washington.

Buckingham, J. S., 1972, *Nitric Acid Neutralization and Concentration of 242-T Evaporator Recycle Feed*, (internal letter, Process Aids #00256, to W. P. Metz, May 12), Atlantic Richfield Hanford Company, Richland Washington.

Buckingham, J. S. and D. A. Dodd, 1972, *Nitric Acid Neutralization and Concentration of Synthetic Recycle Waste Solution*, (internal letter, Process Aids #00263, to D. J. Larkin, July 17), Atlantic Richfield Hanford Company, Richland, Washington.

Puryear, D. A., 1970, *Solubility of 242-T Evaporator Process Feed and Concentrate*, (internal letter, Process Aids #00088, to M. C. Fraser, December 9), Atlantic Richfield Hanford Company, Richland, Washington.

Puryear, D. A. and J. S. Buckingham, 1971, *Status Report on Waste Solidification Studies and Separations Chemistry Laboratory*, (internal letter, Process Aids #00362, to M. H. Campbell, July 23), Atlantic Richfield Hanford Company, Richland, Washington.

IIc. Sampling of TBP-Salt Mixtures

Barney, G. S, 1970, *Thermoanalysis of TBP-Salt Mixtures*, (internal letter, Process Aids #00209, to D. S. Thurman, December 10), Atlantic Richfield Hanford Company, Richland, Washington.

- This letter is documented in Process Aids 1970 - 1993.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories from Campaign and Analytical Information

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1995, *Hanford Tank Chemical and Radionuclide Inventories: HDW Rev. 3*, LA-UR-96-858, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document contains waste type summaries as well as primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids.

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Atlantic Richfield Hanford Company, Richland, Washington.

- Document contains major components for waste types, and some assumptions. Purchase record are used to estimate chemical inventories.

Allen, G. K., 1975, *Hanford Liquid Waste Inventory As Of September 30, 1974*, ARH-CD-229, Atlantic Richfield Hanford Company, Richland, Washington.

- Document contains major components for waste types, and some assumptions

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 Areas*, WHC-SD-MW-ER-351, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary information from the supporting document as well as in-tank photo collages and the solid composite inventory estimates Rev. 0 and Rev. 0A.

Brevick, C. H., L. A. Gaddis, and W. W. Pickett, 1995, *Supporting Document for the Historical Tank Content Estimate for T Tank Farm*, WHC-SD-WM-ER-320, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendices for the data. The appendices contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E -

Surface Level Graph; Appendix F, pg F-1 - Cascade/ Drywell Chart; Appendix G - Riser Configuration Drawing and Table; Appendix I - In-Tank Photos; and Appendix K - Tank Layer Model Bar Chart and Spreadsheet.

IIIb. Compendium of data from other sources physical and chemical

Agnew, S. F., and J. G. Watkin, 1994, *Estimation of Limiting Solubilities for Ionic Species in Hanford Waste Tank Supernates*, LAUR-94-3590, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document gives solubility ranges used for key chemical and radionuclide components based on supernatant sample analyses.

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Tank Waste Source Term Inventory Validation, Vol I & II.*, WHC-SD-WM-ER-400, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains a quick reference to sampling information in spreadsheet or graphical form for 23 chemicals and 11 radionuclides for all the tanks.

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending April 30, 1996*, WHC-EP-0182-97, Westinghouse Hanford Company, Richland, Washington.

- These documents contain a monthly summary of: fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information.

Husa, E. I., 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

- Document contains in-tank photos as well as summaries on the tank description, leak detection system, and tank status.

Husa, E. I., 1995, *Hanford Waste Tank Preliminary Dryness Evaluation*, WHC-SD-WM-TI-703, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document gives assessment of relative dryness between tanks.

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