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Tank 241-BX-110 Tank Characterization Report

Ruth D. Schreiber

Westinghouse Hanford Company, Richland, WA 99352
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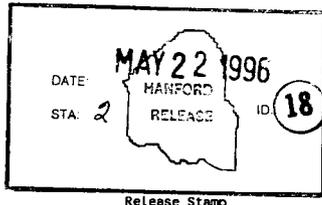
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Abstract: This document summarizes the information on the historical uses, present status and the sampling and analysis results of waste stored in Tank 241-BX-110. This report supports the requirements of Tri-Party Agreement Milestone M-44-09.

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Tank Characterization Report for Single-Shell Tank 241-BX-110

R. D. Schreiber
Westinghouse Hanford Company

T. Tran
Los Alamos Technical Associates

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Westinghouse
Hanford Company

P.O. Box 1970
Richland, Washington

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EXECUTIVE SUMMARY

This characterization report summarizes the available information on the historical uses and the current status of single-shell tank 241-BX-110, and it presents the analytical results of the 1990 grab sample and October 1995 auger sampling and analysis projects. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-09 (Ecology et al. 1994).

Tank 241-BX-110 is one of 12 tanks located in the Hanford 200 East Area BX Tank Farm. It is the first in a three-tank cascade which also includes tanks 241-BX-111 and 241-BX-112. Tank 241-BX-110 went into service in September 1949 and received first-cycle decontamination waste (1C) from the B Plant bismuth phosphate process. In 1954, the tank received supernatant concentrate evaporator bottoms (EB) waste from tank 241-B-105, and in 1957, much of this supernatant was transferred to tank 241-C-111 for the ferrocyanide scavenging campaign. In 1964, PUREX cladding waste from tank 241-C-102 was transferred into tank 241-BX-110, and in 1968, supernatant was removed to tank 241-BX-106. In 1969, the tank received cesium recovery supernatant (IX) waste from the B Plant cesium recovery process, some of which was transferred to tank 241-BX-104 in 1970. In 1972, the tank received in-tank solidification waste (EB waste) from tanks 241-BY-109 and 241-BY-112, and it continued receiving this waste until it completed active service. In 1976, the tank was found to be leaking, and in 1977, it was removed from service and declared inactive. Partial isolation (December 1982) and interim stabilization (August 1985) have since been completed.

Table ES-1 describes tank 241-BX-110. The tank has an operating capacity of 2,010 kL (530 kgal) and presently contains an estimated 783 kL (207 kgal) of waste. Of this total estimated volume, 738 kL (195 kgal) are sludge, 34 kL (9 kgal) are saltcake, and 11 kL (3 kgal) are supernatant (Hanlon 1996). The sludge contains 61 kL (16 kgal) of drainable interstitial liquid.

This report summarizes the results of two sampling and analysis events. The most recent event was the collection and analysis of the auger samples which were obtained in October 1995. Because the top layer of waste was to be sampled, auger sampling was chosen over core sampling. The sampling event was performed to partially satisfy the requirements listed in the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995) and the *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue* (Turner 1995). The sampling and analyses were performed in accordance with the *Tank 241-BX-110 Auger Sampling and Analysis Plan* (Schreiber 1995b). The sampling effort involved taking two auger samples of tank waste from widely spaced risers. Auger 95-AUG-045 was obtained from riser 6, and auger 95-AUG-046 was obtained from riser 3. The safety screening and organic data quality objectives (DQOs) require analyses for fuel content using differential scanning calorimetry (DSC), percent water by thermogravimetric analysis (TGA), total alpha activity through alpha proportional counting, bulk density measurement by centrifugation, and total organic carbon (TOC) by direct persulfate oxidation/coulometry. The safety screening DQO also requires a determination of the flammability of the tank headspace gases. To satisfy this requirement, vapor samples

Table ES-1. Description and Status of Tank 241-BX-110.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1946 to 1947
In service	September 1949
Diameter	22.9 m (75 ft)
Operating depth	5.18 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Noncomplexed
Total waste volume	783 kL (207 kgal)
Sludge volume	738 kL (195 kgal)
Saltcake volume	34 kL (9 kgal)
Drainable interstitial liquid volume	61 kL (16 kgal)
Supernatant volume	11 kL (3 kgal)
Waste surface level (November 1992 to November 1995)	1.7 m (67 in.) to 1.8 m (71 in.)
Temperature (November 1974 to January 1994)	13 °C (55 °F) to 52 °C (125 °F)
Integrity	Leaker 1976
Watch List	None
SAMPLING DATES	
Auger samples and tank headspace flammability	October 1995
Grab sampling	1990 and 1993
SERVICE STATUS	
Declared inactive	1977
Primary stabilization/partial isolation	December 1982
Interim stabilization	August 1985

were taken prior to auger sampling, and the flammability was measured as a percent of the lower flammability limit (LFL) using a combustible gas meter.

Percent water values by TGA were greater than the organic DQO decision threshold limit of 17 weight percent for both the 95-AUG-045 and 95-AUG-046 samples, with average values of 32.83 percent water and 44.45 percent water, respectively. The DSC results were within the DQO limit of -480 J/g (dry weight basis), with an average dry weight basis tank value of -22.88 J/g. All total alpha activity results were well below the safety screening DQO notification limit of 1 g/L, and all sample results for total organic carbon were below the notification limit of 30,000 $\mu\text{g C/g}$ (dry weight basis). The flammability of the tank 241-BX-110 headspace was measured at 0 percent of the LFL. Some relative percent differences and relative standard deviations between results for DSC and total alpha activity were outside the limits specified in Schreiber (1995b). The average tank values for all analyses performed during this event are provided in Table ES-2.

In 1990, a supernatant grab sample was obtained from tank 241-BX-110. General compatibility analyses were performed on the sample, presumably to prepare for supernatant pumping. Results of a compatibility assessment of these results with tank 241-AN-101 results indicated that no tank safety risks would be created as a result of the liquid waste transfer (Sutey 1993). However, no quality control data, such as duplicate analyses, were reported; therefore, these results should be used with caution.

A second grab sample was obtained in 1993. However, these results are not presented in this tank characterization report because they were not considered representative of the tank waste (Sutey 1993).

The heat load in the tank produced by radioactive decay was calculated to be 167 W (569 Btu/hr), well below the 40,000 Btu/hr criterion listed in Bergmann (1991) that separates high-heat from low-heat load tanks.

Based on the analytical results, the top 30.5 cm (12 in.) of the tank waste meets the applicable DQO criteria (Schreiber 1995a). Core sampling must be done to obtain a vertical profile and to characterize the bottom 149.8 cm (59 in.) of tank waste. A profile of tank 241-BX-110 is shown in Figure ES-1.

Table ES-2. Tank 241-BX-110 Analytical Averages.^{1,2}

Analyte	Average Result
Total alpha activity	0.00652 $\mu\text{Ci/g}$
Percent water	37.48%
Total organic carbon	5,330 $\mu\text{g C/g}$ (dry)
Energetics ³	-22.88 J/g (dry)
Density	1.635 g/mL
Tank headspace flammability	0% of the LFL

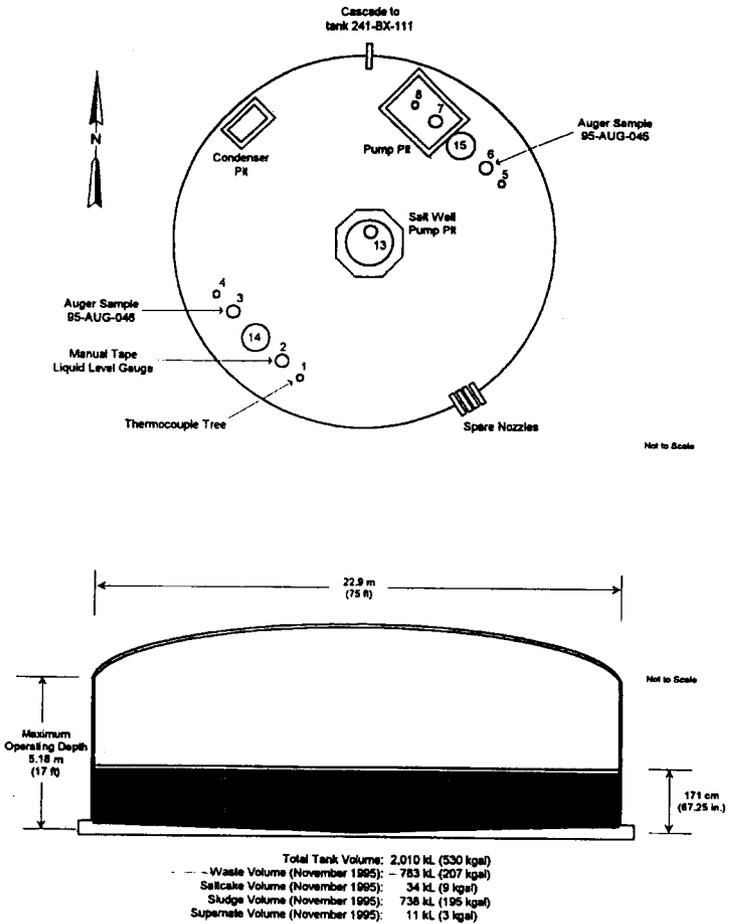
Notes:

¹Schreiber (1995a)

²WHC (1995b)

³A negative value denotes exothermic energy.

Figure ES-1. Profile of Tank 241-BX-110.



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LIST OF TERMS

1C	first-cycle decontamination
ANOVA	analysis of variance
BiPO ₄	bismuth phosphate
Btu/hr	British thermal units per hour
Ci	curies
Ci/g	curies per gram
Ci/L	curies per liter
cm	centimeter
DP	dibutyl phosphate
DQO	data quality objective
DSC	differential scanning calorimetry
EB	evaporator bottoms
EDTA	ethylenediaminetetraacetic acid
ft	feet
g	grams
g/cm ³	grams per cubic centimeter
g/L	grams per liter
g/mL	grams per milliliter
HDW	Hanford Defined Wastes
HEDTA	N (2 hydroxyethyl) ethylenediaminetriacetic acid
HTCE	Historical Tank Content Estimate
in.	inches
IX	cesium recovery supernatant waste
J/g	joules per gram
kg	kilograms
kgal	kilogallons
kL	kiloliters
LFL	lower flammability limit
m	meters
mg	milligrams
mol/L	moles per liter
mR/hr	milliroentgens per hour
NPH	normal paraffin hydrocarbon
NTA	nitritotriacetic acid
ppm	parts per million
RPD	relative percent difference
RSD	relative standard deviation
SAP	sampling and analysis plan
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	Tank Layer Model
TOC	total organic carbon

LIST OF TERMS (Continued)

W	watts
WSTRS	Waste Status and Transaction Record Summary
°C	degrees Celsius
°F	degrees Fahrenheit
μCi/g	microcuries per gram
μg/g	micrograms per gram
μg C/g	micrograms of carbon per gram

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1.0 INTRODUCTION

This tank characterization report provides an overview of single-shell tank 241-BX-110 and its waste components including estimated concentrations and inventories for the waste constituents based on the latest sampling and analysis activities, background tank information, and a brief description of the tank's material condition and process history.

Tank 241-BX-110 was auger sampled in October 1995 in accordance with the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995) and the *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue* (Turner 1995). The tank was grab sampled in 1990 and 1993, most likely for compatibility purposes.

Tank 241-BX-110 began operation in September 1949 and received waste until 1973. In 1977, the tank was declared inactive. Partial interim isolation was completed in December 1982, and interim stabilization was completed in August 1985. Therefore, the composition of the waste should not change significantly until pretreatment and retrieval activities commence. The analyte concentrations reported in this document reflect the best composition estimates of the waste based on available analytical data and historical models. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-09 (Ecology et al. 1994).

1.1 PURPOSE

This report summarizes information about the use and contents of tank 241-BX-110. When possible, this information will be used to assess issues associated with safety, operational, environmental, and process activities. This report also provides a reference point for more detailed information about tank 241-BX-110. Although tank 241-BX-110 is not on the Organic Watch List, it has been identified in the *Operation Specifications for Watch List Tanks* (WHC 1995a) as a possible Organic Watch List tank, and it has been treated as an Organic Watch List tank for the purposes of this report.

1.2 SCOPE

As required by Dukelow et al. (1995) and Turner (1995), the objective of the 1995 auger sampling event was to verify the non-Watch List status of tank 241-BX-110 and/or to identify any unknown safety issues associated with the tank. Because of the narrow focus of the sampling event, only five analyses were performed as directed in the *Tank 241-BX-110 Auger Sampling and Analysis Plan* (Schreiber 1995b). These analyses included the following: differential scanning calorimetry (to evaluate fuel level and energetics), thermogravimetric analysis (to determine moisture content), total alpha activity analysis (to evaluate criticality potential), bulk density measurements, and direct persulfate oxidation/coulometry (to measure the total organic carbon concentration). Dukelow et al. (1995) also required measurement of the tank headspace flammability. The goals of the 1990 and 1993 grab sampling events were

most likely to assess the compatability of the tank 241-BX-110 supernatant with double-shell tank waste to prepare for supernatant pumping. Analyses included major metals, anions, radionuclides, percent water, and total organic carbon (TOC).

2.0 HISTORICAL TANK INFORMATION

This section describes tank 241-BX-110 based on historical information. The first part details the current condition of the tank. This is followed by discussions of the tank's design, transfer history, and the process sources that contributed to the tank waste, including an estimate of the current contents based on process history. It also includes events that may relate to tank safety issues such as potentially hazardous tank contents or off-normal operating temperatures. The final subsection summarizes available surveillance data for the tank. Solid and liquid level data are used to determine tank integrity (leaks) and to provide clues to internal activity in the solid layers of the tank. Temperature data are used to evaluate the heat generating characteristics of the waste.

2.1 TANK STATUS

As of November 30, 1995, tank 241-BX-110 was estimated to contain 783 kL (207 kgal) of noncomplexed waste (Hanlon 1996). The liquid volume was determined by photographic evaluation and manual tape surface level gauge measurements, and the solids volume was determined using a manual tape surface level gauge. The volumes of the waste phases in the tank are shown in Table 2-1. This estimate of tank volume was changed from 749 kL (198 kgal) to 783 kL (207 kgal) in 1994 when a 60 cm-wide by 90 cm-high (2 ft-wide by 3 ft-wide) ledge on the perimeter of the tank was taken into account.

Table 2-1. Summary of Estimated Tank Contents.¹

Waste Form	Volume	
	kiloliters	kilogallons
Total waste	783	207
Supernatant liquid	11	3
Sludge	738	195
Saltcake	34	9
Drainable interstitial liquid	61	16
Drainable liquid remaining	72	19
Pumpable liquid remaining	49	13

Note:

¹Hanlon (1996)

In 1976, tank 241-BX-110 was declared an assumed leaker (with a leak volume of approximately 30 kL [8 kgal]). Partial interim isolation was completed in December 1982, and interim stabilization was completed in August 1985. This passively ventilated tank is not on any Watch Lists. All monitoring systems were in compliance with documented standards as of November 30, 1995 (Hanlon 1996).

2.2 TANK DESIGN AND BACKGROUND

The 241-BX Tank Farm was constructed from 1946 to 1947 in the 200 East Area of the Hanford Site; it contains twelve 100 series tanks. These tanks have an operating capacity of 2,010 kL (530 kgal) and are 22.9-m (75-ft)-diameter tanks with a 5.18-m (17-ft)-operating depth. Tank 241-BX-110 began operation in September 1949. Built as a first generation design tank farm, the 241-BX Tank Farm was designed for nonboiling waste with a maximum fluid temperature of 104 °C (220 °F). A 7.6 cm (3 in.) cascade overflow line connects three tanks together in a step series. Tank 241-BX-110 is first in the three-tank cascade which also includes tanks 241-BX-111 and 241-BX-112. The cascade overflow height is approximately 4.6 m (181 in.) from the tank bottom and 60 cm (2 ft) below the top of the steel liner.

Tank 241-BX-110 has a dished bottom with a 1.2 m (4 ft) radius knuckle. Similar to all other single-shell tank farms, the BX Tank Farm tanks are designed with a mild steel primary liner and a concrete dome with various risers. The tank is set on a reinforced concrete foundation, and is covered with approximately 2.4 m (8 ft) of overburden.

Tank 241-BX-110 is equipped with nine risers through the tank dome and two below grade manholes. The risers range in size from 10 cm (4 in.) to 30 cm (12 in.) in diameter. The belowgrade manholes are 1.1 m (42 in.) in diameter. Table 2-2 shows each riser number, size, and description. Figure 2-1 shows the riser configuration. Risers 3 and 6, each 30 cm (12 in.) in diameter, are available for use. Figure 2-2 shows the approximate waste level and a schematic of the tank equipment. Like all single-shell tanks, tank 241-BX-110 is out of service.

Table 2-2. Tank 241-BX-110 Risers.¹

Riser Number	Diameter (in.)	Description and Comments
R1	4	Thermocouple tree, benchmark
R2	12	Liquid level reel
R3	12	Flange/B-222 observation port
R4	4	Breather filter
R5	4	Sludge measurement port, benchmark
R6	12	Flange
R7	12	Pump, saltwell screen, weather covered
R8	4	Drain, weather covered
R13	12	Saltwell screen
R14	42	Manhole, below grade
R15	42	Manhole, below grade
Nozzle Number	Diameter (in.)	Description and Comments
N1	3	Nozzle
N2	3	Nozzle
N3	3	Nozzle
N4	3	Nozzle
N5	3	Overflow nozzle

Note:

¹Alstad (1993)

Figure 2-1. Riser Configuration for Tank 241-BX-110.

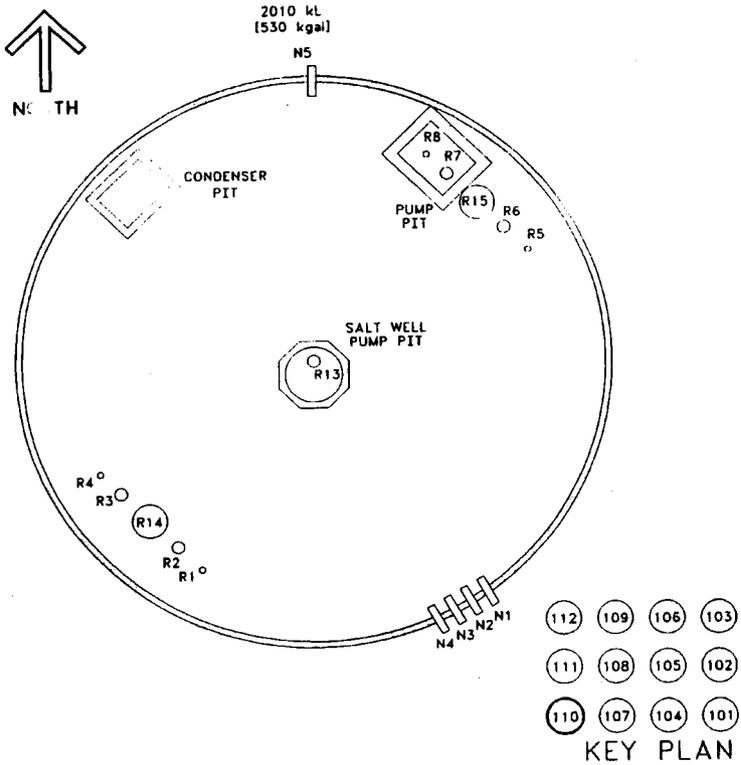
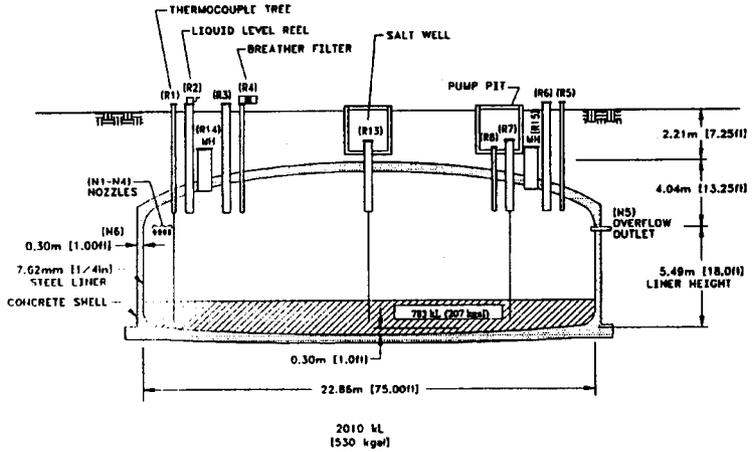


Figure 2-2. Tank 241-BX-110 Cross-Section.



2.3 PROCESS KNOWLEDGE

These sections provide the transfer history of tank 241-BX-110 and describe the process wastes that made up these transfers. This is followed by an estimate of current tank contents based on transfer history.

2.3.1 Waste Transfer History

During the third quarter of 1949, tank 241-BX-110 received 1C waste, from the B Plant bismuth phosphate (BiPO_4) process. Because tank 241-BX-110 is the first tank in a cascade series that includes tanks 241-BX-111 and 241-BX-112, a large percent of the suspended waste solids would have settled in this tank. In 1954, tank 241-BX-110 received supernatant concentrate evaporator bottoms (EB) waste from tank 241-B-105, and in 1957, much of this supernatant waste was transferred to tank 241-C-111 for the ferrocyanide scavenging campaign. In 1964, PUREX cladding waste was received from tank 241-C-102, and in 1968, supernatant was transferred to tank 241-BX-106.

In 1969, tank 241-BX-110 again received waste from B Plant. At this time, the cesium recovery process was being conducted in B Plant, and tank 241-BX-110 received cesium recovery supernatant waste (IX) waste. A transfer of EB waste, originating from tank 241-BY-109, occurred in 1972. Following the designation of tank 241-BX-110 as a receiver tank for in-tank solidification waste bottoms, frequent transfers of this waste type were sent to tank 241-BX-110 from tank 241-BY-112 until 1973. Approximately 749 kL (198 kgal) of waste were left in tank 241-BX-110 after the final transfer of saltwell liquid in 1988. This estimate was revised in October 1994 to 783 kL (207 kgal) to account for a solids ledge around the tank perimeter. Table 2-3 summarizes the waste transfer history of the tank.

After a leak of approximately 30 kL (8 kgal) was discovered in 1976, tank 241-BX-110 was declared inactive in the second quarter of 1977. The waste currently contained by tank 241-BX-110 has been classified as noncomplexed.

Table 2-3. Summary of Tank 241-BX-110 Waste Transfer History.^{1, 2, 3}

Transfer Source	Waste Type Received	Time Period	Estimated Waste Volume	
			Kiloliters	Kilogallons
B Plant	BiPO ₄ 1C waste	1949 - 1950	4,013	1,060
241-B-105	EB waste	1954	1,113	294
241-C-102	PUREX cladding waste	1964	583	154
B Plant	IX waste	1969	867	229
241-BY-109 241-BY-112	EB waste	1972 - 1973	3,267	863

Notes:

¹Agnew et al. (1996)²Anderson (1990)³Waste volumes and types are best estimates based on historical data.

2.3.2 Historical Estimation of Tank Contents

An estimate of the current contents of tank 241-BX-110 based on historical transfer data is available from the *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area* (Brevick 1995). The historical data used for the estimate is the *Waste Status and Transaction Record Summary for the Northeast Quadrant* (Agnew et al. 1996), the *Hanford Defined Wastes: Chemical and Radionuclide Compositions* list (Agnew 1995), and the *Tank Layer Model (TLM)* (Agnew et al. 1995). The Waste Status and Transaction Record Summary (WSTRS) is a compilation of available waste transfer and volume status data. The Hanford Defined Wastes (HDW) provides the assumed typical compositions for Hanford waste types. In some cases, the available data is incomplete, thereby reducing the usefulness 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 additional error), generates an estimate of the tank contents. Thus, these model predictions can only be considered an estimate that requires further evaluation using analytical data.

The Historical Tank Content Estimate (HTCE) states that tank 241-BX-110 contains 591 kL (156 kgal) of 1C waste, 160 kL (42 kgal) of BY saltcake waste, and 4 kL (1 kgal) of supernatant liquid. In comparison with the Hanlon (1996) waste volumes shown in Table 2-1, the HTCE predicts that more saltcake and less sludge is contained in the tank, although both sources identify the same waste types for tank 241-BX-110. The waste is

stratified: the bottom and largest layer is 1C waste; the middle layer is the BY saltcake waste layer, and the top layer is supernatant liquid.

The 1C waste should contain very large amounts of sodium, aluminum, nitrate, and phosphate, and large quantities of iron and bismuth. Nickel, mercury, zirconium, uranium, plutonium, cesium, and strontium should be present also. The presence of cesium and strontium will give this waste layer a modest activity.

The BY saltcake waste should contain extremely large quantities of sodium and nitrates and very large quantities of aluminum, nitrites, and carbonates. Iron, chromium, bismuth, lanthanum, mercury, zirconium, lead, uranium, plutonium, strontium, and cesium should be detected as well. The quantities of strontium and cesium are significantly higher than the concentrations found in the 1C waste layer; therefore, this waste layer will have more activity. The presence of lead and lanthanum in the BY saltcake layer distinguishes this waste layer from the 1C waste layer. Figure 2-3 presents the Tank Layer Model for tank 241-BX-110 and Table 2-4 shows an estimate of the expected waste constituents and their concentrations.

Figure 2-3. Tank Layer Model for Tank 241-BX-110.

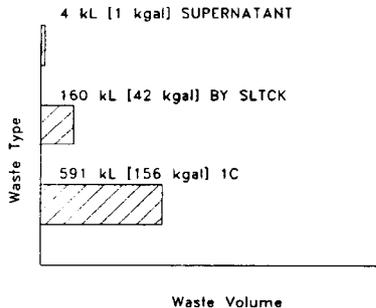


Table 2-4. Tank 241-BX-110 Inventory Estimate.^{1,2} (2 sheets)

Solids Composite Inventory Estimate			
Properties			
Total solid waste	1.06E+06 kg (198 kcal) ³		
Heat load	0.497 kW (1,700 Btu/hr)		
Bulk density	1.42 (g/cm ³)		
Void fraction	0.633		
Water wt%	62.1		
Total Organic Carbon wt% Carbon (wet)	0.025		
Chemical Constituents	mol/L	ppm⁴	kg
Na ⁺	6.85	1.11E+05	1.18E+05
Al ³⁺	1.31	25,000	26,500
Fe ³⁺ (total Fe)	0.397	15,600	16,600
Cr ³⁺	0.0217	794	844
Bi ³⁺	0.0732	10,800	11,500
La ³⁺	0	0	0
Ce ³⁺	0	0	0
Zr (as ZrO(OH) ₂)	0.00863	555	590
Pb ²⁺	3.43E-05	5.01	5.33
Ni ²⁺	0.00181	74.8	79.3
Sr ²⁺	0	0	0
Mn ⁴⁺	0	0	0
Ca ²⁺	0.0658	1,860	1,970
K ⁺	0.00730	201	214
OH ⁻	5.55	66,500	70,700
NO ₃ ⁻	2.05	89,600	95,200
NO ₂ ⁻	0.343	11,100	11,800
CO ₃ ²⁻	0.0968	4,100	4,350
PO ₄ ³⁻	1.13	75,800	80,500
SO ₄ ²⁻	0.153	10,400	11,100
Si (as SiO ₃ ²⁻)	0.143	2,830	3,000
F ⁻	0.345	4,630	4,920
Cl ⁻	0.0280	700	744

Table 2-4. Tank 241-BX-110 Inventory Estimate.^{1,2} (2 sheets)

Solids Composite Inventory Estimate			
Chemical Constituents (Cont'd)	mol/L	ppm	kg
citrate ³⁻	5.30E-04	70.7	75.1
EDTA ⁴⁻	0.00106	215	229
HEDTA ³⁻	0	0	0
NTA ³⁻	0	0	0
glycolate	0	0	0
acetate	0.00676	281	299
oxalate ²⁻	0	0	0
DBP	8.10E-04	152	161
NPH	0	0	0
CCl ₄	0	0	0
hexone	0	0	0
Fe(CN) ₆ ⁴⁻	0	0	0
Radiological Constituents	Ci/L	μCi/g	kg
Pu	---	0.0398	0.647
U	0.00766 (mol/L)	1,290 (μg/g)	1,370
Cs	0.132	92.8	98,700 (Ci)
Sr	0.00693	4.89	5,200 (Ci)

Notes:

¹Brevick (1995)

²Small differences appear to exist among the inventory above and the inventories calculated from the two sets of concentrations. These differences are being evaluated. The HTCE predictions have not been validated and should be used with caution.

³Revised to 783 kL (207 kgal) on October 1994 to account for a ledge of solids around the perimeter of the tank.

⁴Parts per million calculations are based on a weight basis, not a volume basis.

2.4 SURVEILLANCE DATA

Tank 241-BX-110 surveillance consists of surface level measurements (liquid and solid), temperature monitoring inside the tank (waste and vapor space), and leak detection well (drywell) monitoring for radioactivity outside the tank. The data provide the basis for determining tank integrity.

Liquid level measurement indicates whether there may be a major tank leak. Solid surface level measurements indicate physical changes and consistency of the solid layers of a tank. Drywells, located around the perimeter of the tank, may show increased radioactivity caused by a leak to the soil.

2.4.1 Surface Level Readings

The waste surface level in tank 241-BX-110 is monitored daily with a manual tape. The maximum allowable deviation from the baseline surface level is an increase or decrease of 5 cm (2 in.). The waste surface level, which has remained steady for the past three years, ranges between 1.7 and 1.8 m (67 and 71 in.). The surface level was 1.71 m (67.25 in.) on November 6, 1995.

Two occurrence reports were issued because of liquid level increases. The January 1980 report was attributed to rapid snow melt runoff though a pump pit under construction. The January 1981 report was attributed to precipitation through a riser in the pump pit.

Tank 241-BX-110 does not have a liquid observation well. A graph representing the surface level measurement history is presented in Figure 2-4.

2.4.2 Internal Tank Temperatures

Tank 241-BX-110 has a thermocouple tree in riser 1 which contains 14 thermocouples. Temperature data for six thermocouples are continuously monitored by the Temperature Monitoring and Control System and are recorded once a day. Thermocouple 1 is 40 cm (1.3 ft) from the bottom of the tank. Thermocouples 2 through 14 are at 60 cm (2 ft) intervals above thermocouple 1. Thermocouples 1 through 3 are in the waste. Thermocouples 4, 7, and 11, also recorded by the Temperature Monitoring and Control System, are in the vapor space.

The average temperature for the recorded data is 19 °C (66 °F), the minimum temperature is 13 °C (56 °F), and the maximum temperature is 40 °C (104 °F). The highest thermocouple reading was at thermocouple 1 on September 3, 1974. Figure 2-5 shows a plot of the temperatures recorded by the three thermocouples in the waste from 1974 to the present.

2.4.3 Drywells

Tank 241-BX-110 has five drywells. Drywells 21-10-01, 21-10-03, and 21-10-05 were active prior to 1990 and have readings greater than 200 counts/second. These readings are consistent with the classification of tank 241-BX-110 as an assumed leaker. To view data from the active drywells from January 1990 to the present, refer to Brevick et al. (1994).

Figure 2-4. Tank 241-BX-110 Level History.

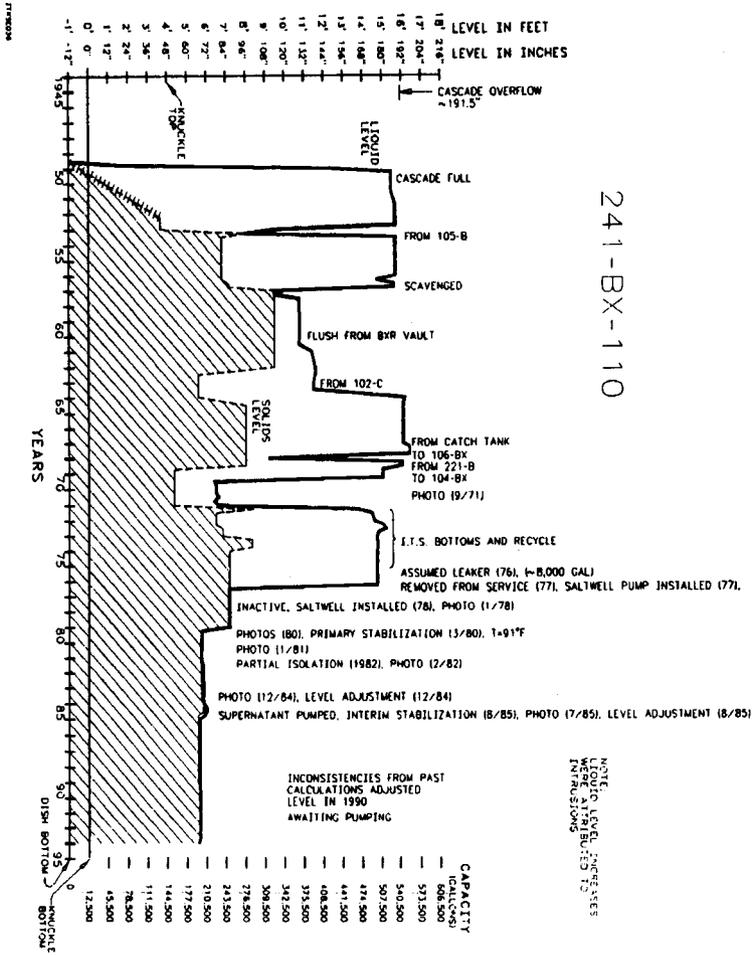
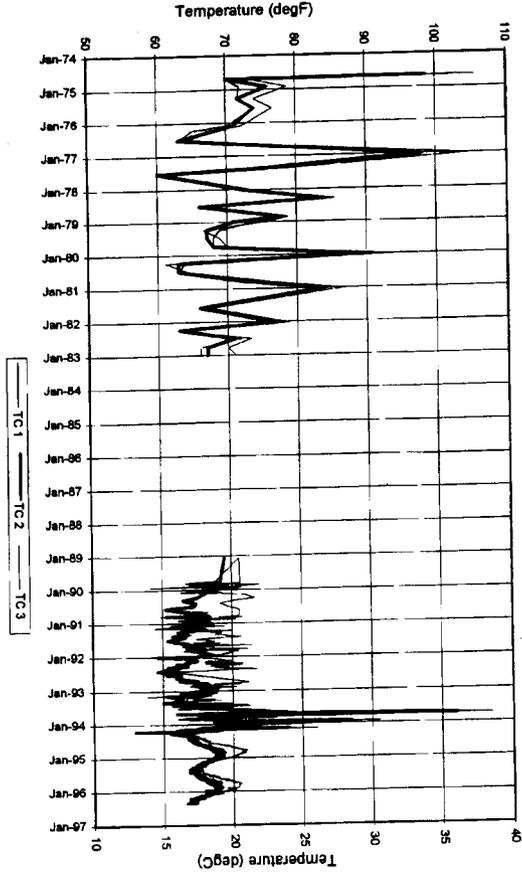


Figure 2-5. Tank 241-BX-110 Temperature Trend for In-Waste Thermocouples.



2.4.4 Tank 241-BX-110 Photographs

The July 1994 photographic montage of the interior of tank 241-BX-110 reveals translucent pools of liquid (mostly in the center) on an irregular solid surface of saltcake that appears to be on top of sludge (see Figure 2-6). A heavy coating of light-colored saltcake clings to the tank perimeter. Visible equipment and debris include a manual tape, a thermocouple tree, a saltwell screen, and some nozzles. Currently, tank 241-BX-110 contains 783 kL (207 kgal) of waste (Hanlon 1996). It is unclear whether additional supernate pumping has taken place since the photograph date. Considering the small amount of supernate in question, the photograph should accurately show the tank contents even if supernate was pumped from the tank after the photographs were taken. To account for the saltcake on the tank perimeter (estimated as 60 cm [1.97 ft] wide by 60 cm [1.97 ft] high), a volume adjustment was made in October 1994. An in-tank video was taken October 13, 1994.

241-BX-110

Photo Date: 7/11/94

Figure 2-6. July 1994 Photographic Montage of Tank 241-BX-110.



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3.0 TANK SAMPLING OVERVIEW

This section describes three sampling events: a 1995 auger event, a 1990 liquid grab event, and a 1993 liquid grab event. During the October 1995 sampling and analysis event for tank 241-BX-110, auger samples were obtained from two risers to partially satisfy the requirements of Dukelow et al. (1995). The sampling and analyses were performed in accordance with Schreiber (1995b). Although tank 241-BX-110 is not on the Organic Watch List, it has been identified in *Operation Specifications for Watch List Tanks* (WHC 1995a) as a possible Organic Watch List tank. Consequently, the analytical requirements of Turner (1995) were applied. During the 1990 and 1993 sampling and analysis events, one liquid grab sample each was obtained, most likely for compatibility purposes. This section also discusses the 1975 and 1978 historical sampling events. For additional information on the sampling and analysis procedures, refer to the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994).

3.1 DESCRIPTION OF THE 1995 AUGER SAMPLING EVENT

Auger samples from two risers were collected from tank 241-BX-110 on October 12, 1995. Sample 95-AUG-045 was collected from riser 6, and was extruded on October 18, 1995 at the 222-S Laboratory. Sample 95-AUG-046 was collected from riser 3, and was extruded on October 19, 1995 at the 222-S Laboratory. It should be noted that the samples represent only the top approximately 30 cm (12 in.) of waste in a tank which has an estimated waste depth of 180 cm (71 in.). Although the applicable data quality objectives (DQOs) would not be fully satisfied, the auger sampling of tank 241-BX-110 was done to determine whether any organics had permeated the saltcake waste material after the tank was stabilized. For this sampling event, the 50.8 cm (20-in.) auger was used. This auger has 20 flutes, each of which is 2.5 cm (1 in.) wide. Flute 1 is at the top of the auger, and flute 20 is near the bottom (the bit).

To address flammable vapor issues, Dukelow et al. (1995) requires sampling of the tank headspace. Prior to removing the tank 241-BX-110 auger samples, vapor samples were obtained from the tank headspace and analyzed using a combustible gas meter. Dukelow et al. (1995) specifies that the flammability, as a percent of the LFL, must not exceed 25 percent. The results of this analysis are provided in Section 4.5.

Sampling and analytical requirements from the safety screening and organic DQOs are given in Table 3-1.

Table 3-1. Integrated Data Quality Objective Requirements for Tank 241-BX-110.¹

Sampling Event	Sampling Requirements	Applicable References and Analytical Requirements
Auger Sampling	Samples from a minimum of two risers separated radially to the maximum extent possible	Safety Screening Data Quality Objective: Energetics, Total Alpha Activity, Bulk Density, Flammable Gas Concentration Organic Data Quality Objective: Moisture Content, TOC

Note:

¹Schreiber (1995b)

3.1.1 1995 Auger Sample Handling

Sample 95-AUG-045 had a total of 125.7 g of solid material recovered from the top half of the auger. The material was a grayish-blue crystalline solid, similar to crushed ice. An opaque, grayish-blue drainable liquid accompanied the solid material, but the liquid was not retained because of insufficient volume. Sample archiving of the solid material was performed in accordance with the sampling and analysis plan (SAP) (Schreiber 1995b).

Sample 95-AUG-046 had a total of 185.2 g of solid material recovered from the bottom half of the auger. Flutes 9 through 13 contained a grayish-blue granular material, and flutes 14 through 20 contained brown sludge. Because the waste types could not be separated from each other, all solids were subsampled into one jar. A cloudy, brown liquid accompanied the solid material, but the liquid was not retained because of insufficient volume. In addition to the solid and liquid material, a small piece of cloth, covered with brown sludge, was recovered from the auger. The solid samples were archived according to the SAP, and the cloth was archived as directed by the Safety Program.

Table 3-2 lists the sample numbers, sample locations (riser number), drill string dose rates, mass, and visual characteristics of the samples.

Table 3-2. Tank 241-BX-110 Subsampling Scheme and Sample Description.¹

Riser	Drill String Dose Rate (mR/hr)	Mass (g)	Flute(s)	Sample Characteristics
Sample 95-AUG-045				
6	45	125.7	1 through 8	grayish/blue crystalline solid
Sample 95-AUG-046				
3	140	185.2	9 through 13	grayish/blue granular solid
			14 through 20	brown sludge

Note:

¹Schreiber (1995a)

3.1.2 1995 Auger Sample Analysis

The analyses performed on the auger samples were limited to those required by the safety screening and organic DQOs. These include analyses for thermal properties by DSC, moisture content by TGA, fissile content by total alpha activity analysis, bulk density, and fuel content by TOC analysis. Although not required by either the safety screening or the organic DQOs, analytical results for total inorganic carbon (TIC) were obtained on an opportunistic basis in accordance with Kristofzski (1995). The TGA and DSC analyses were performed on 14 to 53 mg aliquots. Prior to analyzing for total alpha activity, the samples were prepared by a fusion procedure using potassium hydroxide. A liquid aliquot of the fused sample was then dried on a counting planchet and measured for alpha activity using an alpha proportional counter. Samples were analyzed for TOC by the direct persulfate oxidation/coulometry method.

The results of these analyses are discussed in Sections 4.0 and 5.0. All data were obtained from *45-Day Safety Screening Results and Final Report for Tank 241-BX-110, Auger Samples 95-AUG-045 and 95-AUG-046* (Schreiber 1995a).

Laboratory control standards, matrix spikes, blanks, and duplicate analysis quality control checks were applied to the TOC, TIC, and total alpha activity analyses. Laboratory control standards and duplicate analysis quality control checks were used for the DSC and TGA analyses. An assessment of the quality control procedures and data is provided in Section 5.1.2.

All reported analyses were performed in accordance with approved laboratory procedures. Table 3-3 shows a list of the sample numbers and applicable analyses; Table 3-4 shows the analytical procedures by title and number. No deviations or modifications were noted by the laboratory.

Table 3-3. Tank 241-BX-110 Sample Analysis Summary.¹

Riser	Sample Identification	Sample Number	Analyses
6	95-AUG-045	S95T002903	DSC, TGA, TOC, TIC
		S95T002905	Bulk density
		S95T002906	Total alpha activity
3	95-AUG-046	S95T002945	DSC, TGA, TOC, TIC
		S95T002946	Total alpha activity
		S95T002948	Bulk density
Flammable Gas Concentration ²		Not applicable	Combustible gas meter

Note:

¹Schreiber (1995a)

²WHC (1995b)

Table 3-4. Analytical Procedures.¹

Analysis	Instrument	Preparation Procedure	Analytical Procedure
Energetics by DSC	Mettler™	n/a	LA-514-113, Rev. C-0
Percent water by TGA	Mettler™	n/a	LA-560-112, Rev. B-0
Total alpha activity	Alpha proportional counter	LA-549-141, Rev. D-0	LA-508-101, Rev. D-2
TOC, TIC	Direct persulfate oxidation/coulometry	n/a	LA-342-100, Rev. A-0
Bulk density	Centrifuge	n/a	LO-160-103, Rev. A-7
Flammable Gas ₂	Combustible gas meter	n/a	TO-080-500, Rev. B-2

Notes:

n/a = not applicable

Mettler is a registered trademark of Mettler Electronics, Anaheim, California

¹Schreiber (1995a)

²WHC (1995b)

3.2 DESCRIPTION OF THE 1990 GRAB SAMPLING EVENT

In early 1990, laboratory results are reported for one liquid grab sample (it is hypothesized that this sample was obtained in late 1989). Although the reason for sampling is unknown, the analyses performed indicate that it was for compatibility purposes. Analyses included a number of metals, anions, and radionuclides, as well as TOC and some physical properties.

No information is available about the exact date, riser, or analytical procedures used during the project. However, the data are the best and most recent representative analyses of the supernate portion of the waste. Appendix Table A-1 provides the analytical results and inventory estimates for the listed analytes.

3.3 DESCRIPTION OF THE 1993 GRAB SAMPLING EVENT

A second grab sampling event occurred in 1993. During this sampling event, one sample was obtained while attempts to retrieve other samples were unsuccessful. The results are not considered representative of the waste because the constituent concentrations were much lower than the 1990 sample results. Further, the results were very different from those of the two tank 241-BX-111 grab samples taken during 1993. The tank 241-BX-111 sample results, however, were similar to the 1990 results from tank 241-BX-110, which was expected since the two tanks were used for similar purposes during their fill cycles (Sutey 1993). For these reasons, this data set has not been included in the tank characterization report.

3.4 DESCRIPTION OF HISTORICAL SAMPLING EVENTS

A sample was obtained from tank 241-BX-110 in 1975 to perform actinide analyses. The data are not used in this report because the tank was still active when the sample was taken, and the results do not represent the current waste. For additional information about the results, refer to Brevick (1994).

Tank 241-BX-110 was sampled using a split-tube core sampler in 1978. Three core segments were obtained, only one of which (#3) contained sufficient material to analyze. The sample was obtained near the bottom of the tank. It consisted of sludge with a small amount of supernate. Earlier attempts to obtain a sample were unsuccessful because the drill had difficulty penetrating a thick, hard layer of saltcake. Rotating the drill in a "whip" condition may have broken the crust and allowed drill penetration. The drill penetrated to the tank bottom and collected approximately 41 cm of sludge and 5 cm of supernate. For a discussion of the sampling event, refer to Jungfleisch (1980) where the author speculates about the nature and depth of the waste based on several attempts to sample the tank. His conclusion, which is the waste is composed of a layer of saltcake (top), a layer of supersaturated liquor (middle), and a layer of soft sludge (bottom), is somewhat corroborated

by the TLM (Agnew et al. 1995). The tank layering is further discussed in Section 5.3 of this document. The data from this sampling event are also compared to the 1995 analytical data in Section 5.2 (Horton 1979).

4.0 ANALYTICAL RESULTS

4.1 INTRODUCTION

This section summarizes the analytical results associated with the October 1995 sampling of tank 241-BX-110. The sampling and analyses were performed as directed in the *Tank BX-110 Auger Sampling and Analysis Plan* (Schreiber 1995b). This plan integrated all documents related to the tank 241-BX-110 sampling and analytical requirements including applicable DQOs. The SAP requirements for the two augers samples were taken from the safety screening DQO (Dukelow et al. 1995) and the organic DQO (Turner 1995). Sample extrusion and analyses were performed at the Westinghouse Hanford Company 222-S Laboratory. Table 4-1 identifies the tables which show the total alpha activity, total carbon, density, percent water, and energetics results associated with this tank. The solid samples, from which these results were derived, were collected on October 12, 1995 and were reported in Schreiber (1995a). Flammable gas data is provided in Section 4.5. Applications of the data to specific program requirements are provided in Section 5.5.

Table 4-1. Analytical Data Tables.

Analysis	Table Number
Total alpha activity	4-2
Total organic carbon	4-3
Total inorganic carbon	4-4
Density	4-5
Percent water	4-6
Differential scanning calorimetry	4-7

Overall means were calculated for total alpha activity, TOC, TIC, density, and weight percent water. These means were derived by averaging the primary/duplicate means from each auger. If a result was reported as less than the detection limit, the detection limit was used as the result in these calculations. A relative standard deviation (RSD) of the mean was also calculated for analytes with the exception of density. The RSD (mean) is defined as the standard deviation of the mean divided by the overall mean, multiplied by 100. The four quality control parameters assessed with the tank 241-BX-110 samples were spike recoveries, standard recoveries, duplicates, and blanks. The data table footnotes in Section 4 indicate quality control deviations for specific samples. Section 5.2 provides quality control test results and a discussion of implications for data quality and usefulness.

The introduction to Appendix A describes the method of calculating the projected inventories. Table A-1 shows the analytical results from the 1990 sampling event along with projected inventories (Weiss 1990).

4.2 TOTAL ALPHA ACTIVITY

Analyses for total alpha activity were performed on the auger samples recovered from tank 241-BX-110. The samples were prepared by fusion digestion and measured using an alpha proportional counter. Table 4-2 displays the total alpha activity analytical results from Schreiber (1995a). All the tank 241-BX-110 total alpha activity results were below or near the instrument detection limit.

Table 4-2. Tank 241-BX-110 Total Alpha Activity Results.¹

Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)
	μCi/g	μCi/g	μCi/g	μCi/g	%
S95T002906 ^{2,3}	< 0.00261	< 0.00165	< 0.00213	0.00652	67
S95T002946 ^{2,3,4}	0.0101	0.0118	0.0109		

Notes:

¹Schreiber (1995a)

²The standard recovery was outside the 90 to 100 percent recovery range defined in the SAP.

³The spike recovery was outside the 90 to 110 percent recovery range defined in the SAP.

⁴The relative percent difference between primary/duplicate samples was greater than the 10 percent criterion defined in the SAP.

4.3 TOTAL CARBON

Analyses for TOC and TIC were performed on the 1995 auger samples; TOC as required by Turner (1995), and TIC on an opportunistic basis in accordance with Kristofzski (1995).

4.3.1 Total Organic Carbon

Analyses for TOC were performed on auger samples S95T002903 and S95T002945. The direct persulfate oxidation/coulometry method was used for the analyses. Table 4-3 shows the results in μg (wet weight basis).

Table 4-3. Tank 241-BX-110 Total Organic Carbon Results.¹

Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)
	µg	µg	µg	µg	%
S95T002903	3,480	3,470	3,480	3,740	7
S95T002945	4,100	3,890	4,000		

Note:

¹Schreiber (1995a)

4.3.2 Total Inorganic Carbon

Analyses for TIC were performed on auger samples S95T002903 and S95T002945 for tank 241-BX-110. Table 4-4 show the results in µg (wet weight basis).

Table 4-4. Tank 241-BX-110 Total Inorganic Carbon Results.¹

Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)
	µg	µg	µg	µg	%
S95T002903	681.0	687.0	684.0	811.3	16
S95T002945	946.0	931.0	938.5		

Note:

¹Schreiber (1995a)

4.4 PHYSICAL ANALYSES

As requested by Dukelow et al. (1995), density, TGA, and DSC were performed on the solid samples. The auger sampling method did not recover enough liquid sample for analysis. No other physical tests were requested or performed.

4.4.1 Density

Analyses for density were performed on auger samples S95T002905 and S95T002948. Table 4-5 shows the results in g/mL. The overall mean was derived by averaging the two sample means.

Table 4-5. Tank 241-BX-110 Density Results.¹

Sample Number	Result	Overall Mean
	g/mL	g/mL
S95T002905	1.570	1.635
S95T002948	1.700	

Note:

¹Schreiber (1995a)

4.4.2 Thermogravimetric Analyses

During the TGA run, the mass of a sample is measured while its temperature is increased at a constant rate. A gas, such as nitrogen or air, is passed over the sample during heating to remove any gaseous matter. Any decrease in the weight of a sample represents a loss of gaseous matter from the sample through evaporation or 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 °C) is caused by water evaporation. The temperature limit for moisture loss is chosen by the responsible chemist at an inflection point on the TGA plot. Other volatile matter fractions often can be differentiated by inflection points as well. Weight percent water by TGA was performed by the 222-S Laboratory under a nitrogen purge using procedure LA-560-112, Rev B-0.

Table 4-6 shows reasonable agreement between the analytical results of the two auger samples. The mean TGA result for sample S95T002903 was 44.45 weight percent water; for sample S95T002945, the mean result was 32.83 weight percent.

Table 4-6. Thermogravimetric Analysis Results for Tank 241-BX-110.¹

Sample Number	Temp. Range	Result	Duplicate	Mean	Overall Mean	RSD (Mean)
	°C	% H ₂ O	% H ₂ O	% H ₂ O	% H ₂ O	%
S95T002903 ²	35-180	45.22	43.67	44.45	37.48	15.5
S95T002945 ²	35-180	31.89 35.68 ³	30.93	32.83		

Notes:

¹Schreiber (1995a)

²Percent water by thermogravimetric analysis using a Mettler instrument.

³Triplicate run

4.4.3 Differential Scanning Calorimetry

In a DSC analysis, heat absorbed or emitted by a substance is measured while the substance is exposed to a linear increase in temperature. While the substance is heated, a gas such as nitrogen is passed over the sample to remove any gasses being released. The onset temperature for an endothermic event (characterized by or causing the absorption of heat) or exothermic event (characterized by or causing the release of heat) is determined graphically. The DSC analyses for the tank 241-BX-110 auger samples were performed by the 222-S Laboratory using procedure LA-514-113, Rev. C-0 under a nitrogen atmosphere.

Table 4-7 shows the DSC results on a wet weight basis. The temperature range and the magnitude of the enthalpy change are provided for each transition. The first transition represents the endothermic reaction associated with the evaporation of free and interstitial water. The second transition probably represents the energy (heat) required to remove bound water from hydrated compounds such as aluminum hydroxide or to melt salts such as sodium nitrate. The third transition is generally exothermic and is probably caused by the fuel components of the sample reacting with nitrate salts. The results are reported in Table 4-7 on a wet weight basis.

Table 4-7. Differential Scanning Calorimetry Analysis Results for Tank 241-BX-110.¹

Sample Number	Run	Sample Weight mg	Transition 1		Transition 2		Transition 3	
			Temp. range (°C)	Δ H (J/g)	Temp. range (°C)	Δ H (J/g)	Temp. range (°C)	Δ H (J/g)
Auger Sample 95-AUG-045								
S95T002903 ^{2,3}	1	35.56	ambient 180	773.4	210-280	41.2	420-470	-7.6
S95T002903 ^{2,3}	2	17.34	ambient 190	1394.0	270-300	4.1	---	---
S95T002903 ^{2,3}	3	31.23	ambient 190	779.2	220-320	79.3	380-460	-24.8
Auger Sample 95-AUG-046								
S95T002945 ^{2,3}	1	26.59	ambient 170	808.5	190-300	74.2	---	---
S95T002945 ^{2,3}	2	29.75	ambient 190	695.6	210-320	117.0	390-440	-16.2
S95T002945 ^{2,3}	3	14.06	ambient 180	986.5	200-310	76.5	400-420	-6.1

Notes:

- = no transition
- Temp. = temperature
- Δ H = change in enthalpy (negative sign denotes exothermic reaction)

¹Schreiber (1995a)

²Energetics by differential scanning calorimetry using a Mettler instrument.

³The RSD among primary/duplicate/triplicate samples was greater than the 10 percent criterion defined in the SAP.

4.5 TANK HEADSPACE FLAMMABILITY

Vapor samples were taken from the tank 241-BX-110 headspace prior to auger sampling to satisfy the requirements of Dukelow et al. (1995). As specified in the DQO, the flammability of the headspace cannot exceed 25 percent of the LFL. During this sampling event, readings were 0 percent of the LFL (WHC 1995b), indicating no flammability concerns.

5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

This section discusses the overall quality and consistency of the 1995 auger sampling results for tank 241-BX-110 and assesses and compares the results with historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

This section evaluates sampling and analysis factors that may impact data interpretation. These factors are used to assess overall data quality and consistency and to identify limitations in data use. Most of the usual consistency checks were not possible given the limited scope of the analyses.

5.1.1 Field Observations

The Dukelow et al. (1995) requirement to sample at least two widely-spaced risers was fulfilled. The Dukelow et al. (1995) requirement for a vertical profile was not met because approximately 1.5 m (5 ft) of the tank waste was not sampled. Auger 95-AUG-045 collected 20.3 cm (8 in.) of an expected 30.5 cm (12 in.). Interestingly, the waste was present on the upper half of the auger (flutes 1 through 8) rather than the lower half. Auger 95-AUG-046 collected 30.5 cm (12 in.) of sample as expected on flutes 9 to 20. A horizontal comparison of the analytical results between the two auger samples shows the distribution of waste constituents in the top 30.5 cm (12 in.) of the waste. A vertical comparison was not possible because of the shallow depth of the auger samples in relation to the total depth of the waste.

5.1.2 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 pertinent quality control tests were conducted on the 1995 analyses, allowing a full assessment regarding the accuracy and precision of the data. The SAP (Schreiber 1995b) established the specific criteria for all quality control checks.

The standard and spike recovery results provide an estimate of the accuracy of the analysis, and they were within the defined-criterion for all analytes except total alpha activity. The single standard conducted for total alpha activity and both spike recoveries was slightly below the target level. This was most likely caused by the large sample size used for the analysis which resulted in a high amount of solids on the sample mount and subsequent self-shielding. In any case, these deviations were not substantial enough to affect the criticality evaluation.

The analytical 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. For the DSC results of each sample, an RSD value was calculated rather than an RPD because triplicate runs were performed. Both DSC RSD results were outside the limit, and total alpha activity had its only RPD outside the limit. The precision problems with DSC are probably attributable to the heterogeneous nature of the crystalline sample material, and the results found are the best achievable results. Also, the total alpha activity concentration estimate was less than three times the analytical detection limit. Good precision is difficult to achieve when analyte concentrations are low; therefore, the RPD result for total alpha activity was not meaningful. Finally, no sample exceeded the criterion for preparation blanks; therefore, contamination was not a problem.

In summary, most quality control results were within the SAP or laboratory boundaries (Schreiber 1995b). Although a few quality control results were outside their target levels, they were not found to substantially impact the validity or use of the data.

5.1.3 Data Consistency Checks

Comparing different analytical methods is useful in assessing data consistency and quality. Examples of data consistency checks include the calculation of mass and charge balances, the comparison of sulfur and phosphorus concentrations as measured by inductively coupled plasma spectroscopy to sulfate and phosphate results as evaluated by ion chromatography, and the comparison of total alpha and total beta activities to the sums of their individual emitters. Because of the lack of radionuclide data (other than total alpha activity) and cation or anion results, no data consistency checks were possible for this analysis event.

5.2 COMPARISON OF HISTORICAL WITH ANALYTICAL RESULTS

Based on the tank waste transfer history, the solid portion of the tank waste has not changed since 1976. Therefore, a comparison is possible between the 1995 auger sampling event and a historical sludge sampling event from 1978. However, the 1978 sample was taken from the sludge layer at the bottom of the tank (Jungfleisch 1980), and the 1995 sampling was from the upper portion of the tank. Because the TLM predicts two types of solid waste are present in the tank, an upper BY saltcake layer and a lower IC waste layer, the results of this comparison must be qualified.

Table 5-1 compares the two data sets. The differences in percent water and bulk density may be caused by the removal of most of the supernatant from the tank between the two sampling events. In attempting to make a comparison between the 1995 total alpha activity result and the 1978 data, only a ^{239}Pu value was available from the 1978 results. Therefore, the conversion factor of 0.0615 Ci/g was used to convert the 1978 analytical result of 1.28 $\mu\text{g/g}$ to 0.0787 $\mu\text{Ci/g}$.

Two of the four analytes listed do not compare well as measured by the RPDs. Because the 1995 samples probably consisted mostly or entirely of BY saltcake waste, and the 1978 results represent the lower portion of the tank waste (1C waste), the HDW (Agnew 1995) estimates of these two waste compositions were examined to see if they could account for the differences in Table 5-1. The supposition that the 1978 results consisted mostly of 1C waste appears to be substantiated by the HDW prediction that this waste type would have a higher percent water, much lower density, and no TOC. The one discrepancy was that much less plutonium was predicted in the 1C waste than in the BY saltcake. In any case, it appears that the two data sets may be based on different waste types; therefore, comparisons between the data sets are probably not valid.

Table 5-1. Comparisons of Sludge Data from 1995 and 1978.

Analyte	1978 Result ¹	1995 Result ²	Relative Percent Difference
Percent water	42.0%	37.48%	11.4%
Bulk density	1.44 g/mL	1.635 g/mL	12%
TOC (wet weight)	405 µg	3,740 µg	161%
²³⁹ Pu/total alpha	0.0787 µCi/g	0.00652 µCi/g	169%

Notes:

¹Horton (1979)²Schreiber (1995a)

5.3 TANK WASTE PROFILE

The objective of the 1995 auger sampling event was to obtain only a sample of the top portion of the waste (Schreiber 1995b). Although the applicable DQOs would not be fully satisfied, the auger sampling of tank 241-BX-110 was done to determine whether any organics had permeated into the saltcake waste material after the tank was stabilized. This objective was accomplished, allowing a statistical assessment of the horizontal distribution of the tank waste for several analytes (upper portion of the tank only). Information on the vertical disposition of the entire tank waste was available from the TLM (see Figure 2-3). According to the TLM, the waste is composed of three layers: the top layer is a small quantity of supernatant, the presence of which was confirmed by the sampling event; the middle layer was predicted to be BY saltcake; and the bottom portion was predicted to be 1C waste. These different layers imply that the tank contents were expected to be vertically heterogeneous. The visual descriptions of both auger samples indicated that, along with a small amount of supernatant, a grayish-blue crystalline material composed the upper portion

of the waste. Auger 95-AUG-046 also had several inches of sludge beneath the crystalline material. The crystalline material coincided with the BY saltcake, and the sludge coincided with 1C waste.

Because two risers were sampled, a statistical procedure known as the one-way analysis of variance (ANOVA) was conducted on the 1995 auger samples to determine whether there were horizontal variations in the analyte concentrations. The ANOVA generates a p-value which is compared with a standard significance level ($\alpha = 0.05$). If a p-value is below 0.05, there is enough evidence to conclude that the sample means are significantly different from each other. However, if a p-value is above 0.05, there is not enough evidence to conclude that the samples are significantly different from each other.

The results of the ANOVA indicated that all four analytes tested showed significant concentration differences between risers 3 and 6. The p-values were as follows: percent water (0.010), total alpha (0.012), TOC (0.004), and TIC (0.001).

In summary, it is reasonable to state that, based on the visual descriptions of the auger samples and the TLM predictions, the waste may be vertically heterogeneous. Horizontally, it can only be stated is that, based on the statistical analysis of the four analytes mentioned above, the upper several inches of waste is horizontally heterogeneous. Nothing can be stated about the horizontal disposition of the waste below the upper portion.

5.4 COMPARISON OF TRANSFER HISTORY WITH ANALYTICAL RESULTS

Table 5-2 compares the HTCE reference estimate of the tank contents to the analytical results from the 1995 sampling event. This comparison is for information purposes only. The HTCE values have not been validated and therefore should be used with caution. Because the 1995 sampling results consist mostly or entirely of BY saltcake waste and the HTCE estimates are based on the entire tank contents (which is mostly 1C waste), direct correlation between the two sets of numbers is poor and the comparisons are probably not valid. However, because the top waste layer is predicted to be BY saltcake and this was the only layer sampled, a comparison is made between the HDW concentration estimates (Agnew 1995) for BY saltcake and the 1995 analytical results in Table 5-3. The percent water, bulk density, and TOC are similar between the two data sets, indicating that the top layer may have correctly been predicted to be BY saltcake. However, the plutonium/total alpha activity comparison still did not agree. Again, total alpha activity was measured during 1995 analysis, and the HDW only provides a prediction for plutonium (without differentiating between individual isotopes).

Table 5-2. Comparison of Historical Estimates with the 1995 Analytical Results for Tank 241-BX-110.

Analyte	HTCE Estimate ¹	1995 Result ²	Relative Percent Difference
Percent water	62.1	37.48	49%
Bulk density	1.42 g/mL	1.635 g/mL	14%
TOC (wet weight)	250 µg	3,740 µg	175%
Pu/total alpha	0.0398 µCi/g	0.00652 µCi/g	144%

Notes:

¹Brevick (1995)

²Schreiber (1995a)

Table 5-3. Comparison of Waste Stream Composition Predictions with the 1995 Analytical Results for Tank 241-BX-110.

Analyte	BY Saltcake Composition Prediction ¹	1995 Result ²	Relative Percent Difference
Percent water	39.7	37.48%	5.8%
Bulk density	1.613 g/mL	1.635 g/mL	1.4%
TOC (wet weight)	4,490 µg	3,740 µg	18%
Pu/total alpha	0.139 µCi/g	0.00652 µCi/g	182%

Notes:

¹Agnew (1995)

²Schreiber (1995a)

5.5 EVALUATION OF PROGRAM REQUIREMENTS

The two auger samples obtained from tank 241-BX-110 in October 1995 were analyzed to partially meet the requirements of the safety screening-DQO (Dukelow et al. 1995) and the organic DQO (Turner 1995). This section discusses the specific requirements of these DQOs and compares the analytical data with DQO-defined concentration limits.

5.5.1 Safety Evaluation

Data criteria, identified in the safety screening and organic DQOs, are used to assess the safety of the waste in tank 241-BX-110. For a proper safety assessment, vertical profiles of the waste from at least two widely-spaced risers are required. However, during this sampling event, the vertical profile requirement was not met because only the top 30.5 cm (12 in.) of waste were sampled. The requirement that at least two widely-spaced risers be sampled was met because the risers sampled (risers 3 and 6) are on opposite sides of the tank. The set of primary analyses required by the two DQOs were similar: both dictated that DSC be performed to evaluate the fuel content and that TGA be conducted to determine the weight percent water. The safety screening DQO also required analysis for total alpha activity and a determination of the concentration of the gases in the tank headspace as a percent of the LFL. The organic DQO required a determination of the TOC content using the direct persulfate oxidation/coulometry method. For each required analysis, a notification or decision threshold was established by the DQOs which, if exceeded, may warrant further investigation to assure tank safety. Table 5-4 lists the applicable DQOs, the analytes and their notification or decision threshold limits, and the corresponding analytical results which are outside of these thresholds.

The potential for criticality can be assessed from the total alpha activity data. The safety screening notification limit is 1 g/L (Dukelow et al. 1995). Because the laboratory reports total alpha activity in units of $\mu\text{Ci/g}$, the 1 g/L threshold was converted using the density for a particular sample as specified in the safety screening DQO. It was assumed that all the total alpha activity originated from ^{239}Pu . With a density of 1.57 g/mL, auger 95-AUG-045 had a notification limit of 39.2 $\mu\text{Ci/g}$. With a density of 1.7 g/mL, auger 95-AUG-046 had a notification limit of 36.2 $\mu\text{Ci/g}$ (see footnote 2, Table 5-4). Total alpha activity was detected only in auger 95-AUG-046. This auger had a mean result of 0.0109 $\mu\text{Ci/g}$ and a one-sided 95 percent upper confidence limit of 0.0163 $\mu\text{Ci/g}$. All results were well below the safety screening DQO limits.

The safety screening DQO has established an enthalpy change notification limit of -480 J/g (dry weight basis) for the DSC analyses (Dukelow et al. 1995). Because all analytical results were reported on a wet weight basis, each was converted to a dry weight basis prior to comparing it with the DQO specified limits. This conversion was accomplished by dividing the wet weight DSC values by the solid fraction (1 minus the percent water value) for a given sample using corresponding TGA results. Two exothermic reactions were noted from each auger sample. The highest enthalpy change was -44.64 J/g (dry weight basis; negative sign denotes exothermic energy). The one-sided 95 percent lower confidence limits for auger samples 95-AUG-045 and 95-AUG-046 were -58.0 J/g and -31.6 J/g, respectively, and the overall one-sided 95 percent lower confidence limit was -41.6 J/g. All results were far less than the limit of -480 J/g.

Table 5-4. Decision Variables and Criteria for the Safety Screening and Organic Data Quality Objectives. (2 sheets)

Applicable DQO	Primary Decision Variable	Decision Criteria Threshold	Analytical Results Outside Threshold
Safety screening; Organic	Total fuel content	-480 J/g	None
Safety screening; Organic	Percent moisture	17 weight percent	None
Safety screening	Total alpha activity	1 g/L ¹ (39.2 μCi/g ²) (36.2 μCi/g ²)	None
Safety screening; Organic	Total organic carbon	30,000 μg	None
Safety screening	Flammable gas	25 % of the LFL	None

Notes:

¹Although the actual decision criterion listed in the DQO was 1 g/L, total alpha was measured in μCi/g rather than g/L. To convert the notification limit for total alpha into the same units as the laboratory, it was assumed that all alpha decay originated from ²³⁹Pu. Then, by using the density result of 1.57 g/mL for sample S95T002905 and 1.7 g/mL for sample S95T002948, and the specific activity of ²³⁹Pu (0.0615 Ci/g), the sludge decision criterion may be converted to μCi/g as shown:

$$\left(\frac{1 \text{ g}}{\text{L}}\right) \left(\frac{1 \text{ L}}{10^3 \text{ mL}}\right) \left(\frac{1 \text{ mL}}{\text{density g}}\right) \left(\frac{0.0615 \text{ Ci}}{1 \text{ g}}\right) \left(\frac{10^6 \mu\text{Ci}}{1 \text{ Ci}}\right) = \frac{61.5 \mu\text{Ci}}{\text{density g}}$$

²Limit for auger 95-AUG-045

³Limit for auger 95-AUG-046

The total organic carbon content of the tank was measured to satisfy the organic DQO. The established notification limit is 30,000 μg on a dry weight basis (Turner 1995). As with the DSC data, the TOC analytical results were reported on a wet weight basis. Therefore, all values were converted to a dry weight basis in the same manner as the DSC results before comparisons were made with the 30,000 μg limit. No individual sample result exceeded the notification limit; the highest value was 6,350 μg for the primary result from 95-AUG-045. The overall tank dry weight mean result was 5,330 μg with an upper 95 percent confidence limit of 11,200 μg. Because all results were well below the notification limit, they tend to substantiate the DSC results and confirm that the waste in the portion of the tank sampled is not capable of supporting an exothermic reaction.

The presence of sufficient moisture reduces the potential for propagating exothermic reactions in the waste. All percent water results for auger 95-AUG-045 were well above the 17 weight percent decision criterion established by the organic DQO (Turner 1995), producing a mean value of 44.45 weight percent and a 95 percent lower confidence limit of 39.6 weight percent. Similarly, the weight percent water results for auger 95-AUG-046 were above the 17 percent criterion, producing a mean value of 32.83 weight percent and a 95 percent lower confidence limit of 23.68 weight percent. The overall tank mean was 37.48 weight percent, and the corresponding 95 percent lower confidence limit was 0.8 weight percent.

The flammability of the gas in the tank headspace is an additional safety consideration. Analysis of the tank 241-BX-110 headspace flammability was performed prior to auger sampling, and the tank was found to be safe for sampling with a concentration of 0 percent of the LFL (WHC 1995b).

Another factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. The heat value, decay corrected to the first quarter of 1996, was calculated using data from the 1978 sampling effort (Bratzel 1980 and Anderson 1990) and was estimated to be 167 W (569 Btu/hr). The HTCE estimate of heat load was 1,700 Btu/hr, which compares favorably with the 2,300 Btu/hr estimated from the tank headspace temperature (Kummerer 1994). All these estimates are well below the limit of 40,000 Btu/hr which separates high- and low-heat load tanks (Bergmann 1991). Because an upper temperature limit has been exhibited (see Section 2.4.3), it may be concluded that any heat generated from radioactive sources throughout the year is dissipated.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The waste in tank 241-BX-110 was auger sampled in October 1995. The sampling and analyses were performed in accordance with the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995) and *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue* (Turner 1995).

No analyses for this tank 241-BX-110 auger analysis project violated the notification limits or decision thresholds identified in the applicable DQOs. Percent water analytical results for both augers were greater than the organic DQO decision threshold of 17 weight percent, and the energetics values for all samples, as measured by DSC, were within the DQO limit of -480 J/g on a dry weight basis. Total alpha activity results were all far below the notification limit as were those for TOC. The tank headspace flammability was measured to be 0 percent of the LFL.

All heat load estimates, including the 167 W (569 Btu/hr) estimate from historical sampling data, were well below the 40,000 Btu/hr limit which separates high- and low-heat load tanks.

Based on the analytical results performed in accordance with the safety screening and organic DQOs, the top 12 in. (of 71 in.) are considered "safe." Although the applicable DQOs would not be fully satisfied, the auger sampling of tank 241-BX-110 was done to determine whether any organics had permeated into the saltcake waste material after the tank was stabilized. Another sampling event for tank 241-BX-110 using the core sampling method (to obtain a full vertical profile) is planned for the future, and this report will be revised when that information becomes available.

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APPENDIX A

1990 CORE SAMPLING ANALYTICAL RESULTS

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APPENDIX A

1990 CORE SAMPLING ANALYTICAL RESULTS

Table A-1 shows the results obtained from the analysis of a first quarter 1990 sample of the supernate component of the waste in tank 241-BX-110. The projected inventories were calculated by converting the analytical results to kilograms or curies by multiplying the equivalent activity in $\mu\text{g/g}$ or $\mu\text{Ci/g}$ by the density of the supernate, 1.37 g/mL, the appropriate conversion factors, and the volume of the supernate in the tank, 3,800 L, according to Brevick (1994).

It should be noted that no information is available about the exact date of sampling, the riser sampled, or the analytical procedures used. Further, no quality control results are available for this sampling event. Therefore, although these results represent the best supernatant concentration estimates of the tank, these data should be used with caution.

Table A-1. 1990 Analytical Results and Projected Inventories.¹ (2 sheets)

Physical Properties		
Density	1.37 g/mL	
Percent water	56.6 wt %	
pH	12.5	
Metal	Concentration ($\mu\text{g/g}$)	Projected Inventory (kg)
Al	529	2.75
Ca	8.98	0.0468
Cr	972	5.06
K	2,920	15.2
Mo	66.9	0.348
Na	164,220	855
P	406	2.11
Si	43.8	0.228
U	1,020	5.32

Table A-1. 1990 Analytical Results and Projected Inventories.¹ (2 sheets)

Anion	Concentration ($\mu\text{g/g}$)	Projected Inventory (kg)
Cl ⁻	4,900	25.5
F ⁻	< 1,410	< 7.34
NO ₂ ⁻	36,500	190
NO ₃ ⁻	312,000	1,630
Anion	Concentration ($\mu\text{g/g}$)	Projected Inventory (kg)
SO ₄ ⁻	< 14,600	< 76.0
OH ⁻	23,500	122
CO ₃ ⁻	17,200	89.6
Radionuclide	Concentration ($\mu\text{Ci/g}$)	CI
Total alpha	< 4.24	< 0.0161
Total beta	1.67E+05	635
¹³⁷ Cs (water)	1.35E+05	513
¹³⁷ Cs (acid)	1.31E+05	498
^{89/90} Sr	15.0	0.057
^{239/240} Pu	< 0.0799	< 3.04E-04
²⁴¹ Am	< 0.260	< 9.88E-04
Total Carbon	Concentration (μg)	Projected Inventory kg C
Total Organic Carbon	40,900	213

Note:

¹Weiss (1990)

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Los Alamos Technical Associates

T. T. Tran B1-44 X

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R. J. Anema X

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W. C. Miller	R1-30	X			
C. T. Narquis	T6-16	X			
D. E. Place	H5-27	X			
D. A. Reynolds	R2-11	X			
L. M. Sasaki (2)	R2-12	X			
R. D. Schreiber	R2-12	X			
L. W. Shelton, Jr.	H5-49	X			
B. C. Simpson	R2-12	X			
G. L. Troyer	T6-50	X			
M. S. Waters	S6-30	X			
L. R. Webb	T6-06	X			
K. A. White	S5-13	X			
Central Files	A3-88	X			
EDMC	H6-08	X			
ERC (Environmental Resource Center)	R1-51	X			
OSTI (2)	A3-36	X			
TCRC (10)	R2-12	X			