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Tank Characterization Report for Single-Shell Tank 241-BX-106

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Abstract: This document summarizes the information on the historical uses, present status, and the samping and analysis results of waste stored in tank 241-BX-106. This report supports the requirements of Tri-Party Agreement Milestone M-44-09.

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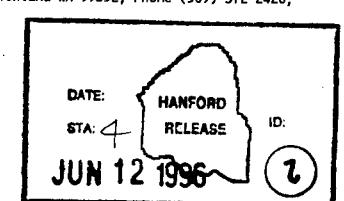

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Tank Characterization Report for Single-Shell Tank 241-BX-106

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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-106, and presents the analytical results from the December 1995 auger and March 1995 grab 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-106 is one of 12 single-shell underground waste storage tanks located in the 200 East Area BX Tank Farm on the Hanford Site. It is the last tank in a three-tank cascade series. The tank went into service in September 1949, receiving metal waste (MW) from B Plant through the cascade. This waste type continued to cascade into the tank through 1951. The tank was sluiced in May 1955 to provide feed for the uranium recovery process. An active process history followed, as the tank received waste from the tributyl phosphate (TBP) process, liquid B Plant low-level (BL) waste, cladding waste, evaporator bottoms (EB) waste, organic wash waste (OWW), ion exchange (IX) waste from cesium recovery operations and possibly first-cycle decontamination (1C) waste (from B Plant operations). Tank 241-BX-106 last received waste in 1977 and is out of service, as are all single-shell tanks. Interim stabilization efforts were completed in July 1995.

A description and status of tank 241-BX-106 are summarized in Table ES-1 and Figure ES-1. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains an estimated 144 kL (38 kgal) of sludge with no supernatant liquid remaining. Tank 241-BX-106 was removed from the Ferrocyanide Watch List in November 1994 and is not on any other Watch Lists (Hanlon 1996).

This report summarizes the collection and analysis of the auger samples acquired in December 1995. The collection and analysis of supernatant grab samples acquired in March 1995 are also presented. However, due to stabilization efforts in July 1995, no supernatant remains in the tank.

The December 1995 sampling and analyses were performed in accordance with *Tank 241-BX-106 Auger Sampling and Analysis Plan* (Sasaki 1995) to satisfy the requirements listed in *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). The sampling effort involved taking two auger samples of the tank waste from two widely spaced risers. Auger sample 95-AUG-49 was taken from riser 6, and auger sample 95-AUG-50 was obtained from riser 2. The safety screening data quality objective (DQO) required analyses for fuel content using differential scanning calorimetry (DSC), percent water by thermogravimetric analysis (TGA), total alpha activity by alpha proportional counting, and density by the bulk density method. The DQO also requires a determination of the flammability of the tank headspace gases. To meet this requirement, headspace flammability measurements were made using a combustible gas meter in risers 2 and 6 prior to auger sampling.

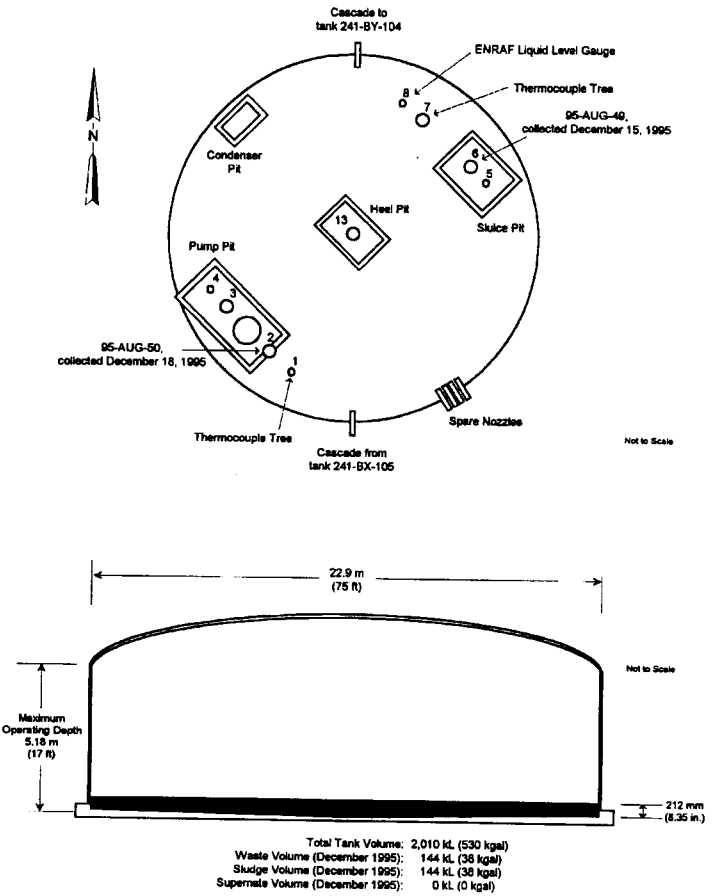
Table ES-1. Description and Status of Tank 241-BX-106.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1946-47
In-service	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	Non-complexed
Total waste volume[1]	144 kL (38 kgal)
Sludge volume[1]	144 kL (38 kgal)
Drainable interstitial liquid	0
Saltcake volume	0
Waste surface level (March 4, 1996)	21.2 cm (8.35 in.)
Temperature (1989 to 1996)	25.2 to 8.3 °C (77.3 to 46.9 °F)
Integrity	Sound
Watch List Status	Non-Watch List
SAMPLING DATES	
Auger sampling	December 1995
Grab sampling	March 1995
SERVICE STATUS	
Interim stabilized	July 1995

Notes:

[1]Estimated volume (Hanlon 1996)

Figure ES-1. Profile of Tank 241-BX-106.



No violations of the safety screening DQO notification limits were observed. No exothermic reactions were observed in the DSC analysis. Percent water values by TGA ranged from 36.20 for auger 95-AUG-49 to 41.48 percent for auger 95-AUG-50. The overall average was 38.7 percent. All total alpha activity results were far below the DQO notification limit of 36.6 μCi/g, as the highest detected result was 0.652 μCi/g. The one-sided 95 percent confidence interval upper limits were also well below the action limit. Combustible gas meter readings demonstrated that the flammability of the tank headspace gases was zero percent of the lower flammability limit. Table ES-2 presents the analytical means for all analytes.

Table ES-2. Tank 241-BX-106 Analytical Means.[1]

Analyte	Mean
Energetics	No exotherms observed
Percent water	38.7%
Total alpha activity	0.590 μCi/g
Bulk density	1.64 g/mL
Flammable gas	0% of the lower flammability limit

Note:
[1]Sasaki (1996)

The Historical Tank Content Estimate (HTCE) heat load was 200 watts (684 Btu/hr) (Brevick et al. 1994a). A second estimate of 735 watts (2,510 Btu/hr) was available based on tank temperatures (Kummerer 1994). For the 1995 sampling events, only the supernate samples were analyzed for ^{137}Cs and ^{90}Sr. These results were used to estimate a minimum heat generation rate of 92 watts (314 Btu/hr) for the tank. All estimates were far below the 11,700-watt (40,000-Btu/hr) limit separating high-heat and low-heat tanks (Bergmann 1991).

Surveillance data show that tank temperatures have remained constant between 25.2 °C (77.3 °F) and 8.3 °C (46.9 °F). Surface level readings before July 1995 are no longer applicable because the supernatant was removed during interim stabilization. Recent measurements have indicated a surface level height of 21.2 cm (8.35 in.).

The March 1995 sampling and analysis activities were performed in accordance with the *Tank 241-BX-106 Tank Characterization Plan* (Schreiber 1995) to satisfy the requirements listed in *Data Quality Objectives for the Waste Compatibility Program* (Carothers 1994). Two liquid grab samples were obtained from a single riser. The compatibility DQO required a number of analyses to support operational decisions (transuranic content, heat generation, and total organic carbon content) and safety evaluations (criticality, flammable gas accumulation, energetics, and corrosivity) regarding the transfer of the supernatant. All compatibility criteria were met and the tank was stabilized in July 1995.

The analytical results for the safety screening of the auger samples and compatibility analysis of the grab samples were all well below notification limits. Based on the results of the analyses and the decision criteria of the safety screening DQO, the waste in tank 241-BX-106 may be categorized as "safe."

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LIST OF TERMS

1C	first-cycle decontamination
ANOVA	analysis of variance
BL	B Plant low-level
Btu/hr	British thermal units per hour
Ci	curies
Ci/g	curies per gram
Ci/L	curies per liter
cm	centimeters
DQO	data quality objective
DSC	differential scanning calorimetry
EB	evaporator bottoms
ft	feet
GEA	gamma energy analysis
g/L	grams per liter
g/mL	grams per milliliter
HTCE	Historical Tank Content Estimate
IC	ion chromatography
ICP	inductively coupled plasma atomic emission spectroscopy
in.	inches
ITS	in-tank solidification
IX	ion exchange
J/g	joules per gram
kg	kilograms
kgal	kilogallons
kL	kiloliters
m	meters
mg	milligrams
mm	millimeters
mol/L	moles per liter
mR/hr	milliroentgens per hour
MW	metal waste
nCi/g	nanocuries per gram
OWW	organic wash waste
ppm	parts per million
QC	quality control
RPD	relative percent difference
RSD	relative standard deviation
SAP	sampling and analysis plan
SpG	specific gravity
TBP	tributyl phosphate
TGA	thermogravimetric analysis
TIC	total inorganic carbon

LIST OF TERMS (Continued)

TLM	tank layer model
TOC	total organic carbon
WSTRS	Waste Status and Transaction Record Summary
μCi/g	microcuries per gram
μg/g	micrograms per gram
μg/mL	micrograms per milliliter
μCi/mL	microcuries per milliliter
°C	degrees Celsius
°F	degrees Fahrenheit
ΔH	change in enthalpy

1.0 INTRODUCTION

This tank characterization report presents an overview of single-shell tank 241-BX-106 and its waste contents. It provides background information about the tank, and estimated concentrations and inventories for the waste components based on the latest sampling and analysis activities. This document presents the results of two sampling events: an auger sampling event in December 1995 and a liquid grab sampling event in March 1995. The supernatant was removed from the tank during stabilization efforts in July 1995, so only the auger results are relevant to the tank's current contents.

Tank 241-BX-106 began operation in 1949 and received waste until 1977. As stated previously, interim stabilization has been completed; therefore, with the exception of drying and radioactive decay, the composition of the waste should not change until pretreatment and retrieval activities commence. The analyte concentrations reported in this document reflect the best composition estimates of the waste based on the available analytical data and historical models. This report supports the requirements of *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-09 (Ecology et al. 1994).

1.1 PURPOSE

The purpose of this report is to summarize available information about the use and contents of tank 241-BX-106. Where possible, this information will be used to assess issues associated with safety, operations, environmental, and process development activities. This report also serves as a reference point for more detailed information concerning tank 241-BX-106.

1.2 SCOPE

The December 1995 auger sampling event for tank 241-BX-106 supported evaluation of the tank waste according to *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). Four analyses were performed on the recovered waste as directed in *Tank 241-BX-106 Auger Sampling and Analysis Plan* (Sasaki 1995). These analyses were DSC (to evaluate fuel level and energetics), TGA (to determine moisture content for calculating dry basis exotherm values), total alpha activity analysis (to evaluate criticality potential), and bulk density (needed to derive the total alpha activity notification limit). As also required by the safety screening DQO, the flammability of the tank headspace vapors was measured prior to removal of the augers. The number of analyses was small due to the narrow focus of the sampling event: to verify the non-Watch List status of the tank and/or identify any unknown safety issues associated with the tank.

The March 1995 liquid grab sampling event supported evaluation of the tank waste according to *Data Quality Objectives for the Waste Compatibility Program* (Carothers 1994). Analyses were performed on the samples as directed in *Tank 241-BX-106 Tank Characterization Plan* (Schreiber 1995) to support the stabilization of tank 241-BX-106.

2.0 HISTORICAL TANK INFORMATION

This section describes tank 241-BX-106 based on historical information. The first part details the current condition of the tank. The next part contains 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 the process history. Events that may be related to tank safety issues, such as potentially hazardous tank contents or off-normal operating temperatures, are included. The final part summarizes available surveillance data for the tank. Solid and liquid level data are used to determine tank integrity (leaks). Temperature data are provided to evaluate the heat generating characteristics of the waste.

2.1 TANK STATUS

As of February 29, 1996, tank 241-BX-106 contained an estimated 144 kL (38 kgal) of non-complexed waste (Hanlon 1996). The total waste volume was determined using a combination of photographic evaluation and automatic ENRAF[1] surface level gauge measurements. Solids volume was determined using a combination of photographic evaluation and a sludge level measurement device. The volumes of the various waste phases found in the tank are shown in Table 2-1.

Table 2-1. Summary Tank Contents Status.[1]

Waste Form	Volume	
	kL	kgal
Total waste	144	38
Supernatant liquid	0	0
Drainable interstitial liquid	0	0
Drainable liquid remaining	0	0
Pumpable liquid remaining	0	0
Sludge	144	38
Saltcake	0	0

Note:
[1]Hanlon (1996)

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

Tank 241-BX-106 is a sound tank that is partially interim isolated. Interim stabilization was completed in July 1995. This passively ventilated tank is not on any Watch Lists. In January 1991, tank 241-BX-106 was added to the Ferrocyanide Watch List; however, it was removed from the list in November 1994 (Sheridan 1994). All monitoring systems were in compliance with documented standards as of December 31, 1995.

2.2 TANK DESIGN AND BACKGROUND

The BX Tank Farm was constructed between 1946 and 1947 in the 200 East Area. The BX Tank Farm contains twelve 100-series tanks. These tanks have 2,010-kL (530-kgal) capacities, 22.9-m (75-ft) diameters, and 5.18-m (17-ft) operating depths. Tank 241-BX-106 first began receiving waste in the third quarter of 1949. The BX Tank Farm was designed for non-boiling waste with a maximum fluid temperature of 104 °C (220 °F). Tank 241-BX-106 is third in the three-tank cascade that includes tanks 241-BX-104 and 241-BX-105. A 7.6-cm (3-in.) cascade overflow line connects the three tanks. The bottom elevation of tank 241-BX-104 is 187.8 m (616 ft), cascading to 241-BX-105 with a bottom elevation of 187.5 m (615 ft,) cascading to tank 241-BX-106 with a bottom elevation of 187.2 m (614 ft). Tank 241-BX-106 cascades to tank 241-BY-104. The cascade overflow height is approximately 5.2 m (17 ft) from the tank bottom and 0.6 m (2 ft) below the top of the steel liner.

Tank 241-BX-106 has a dished bottom with a 1.2-m (4-ft) radius knuckle. Like all single-shell tanks, tank 241-BX-106 has a primary mild steel liner and a concrete dome with various risers. The typical BX tank is equipped with 11 risers through the tank dome: one through the center, one on each side of the tank, and the remainder scattered over the dome. The tank is on a reinforced concrete foundation, and is covered with approximately 2.5 m (8.1 ft) of overburden.

The surface level is monitored through riser 8 with an ENRAF™ gauge. Tank 241-BX-106 has 9 risers ranging from 10 cm (4 in.) to 30 cm (12 in.) in diameter. Table 2-2 shows riser numbers, sizes, and descriptions. A plan view that depicts the riser configuration is shown as Figure 2-1. Risers 2 and 6, which are 30 cm (12 in.) in diameter, are available for use. A tank cross-section showing the approximate waste level, along with a schematic of the tank equipment, is found in Figure 2-2. Tank 241-BX-106 last received waste in 1977 and is out of service, as are all single-shell tanks.

Figure 2-1. Riser Configuration for Tank 241-BX-106.

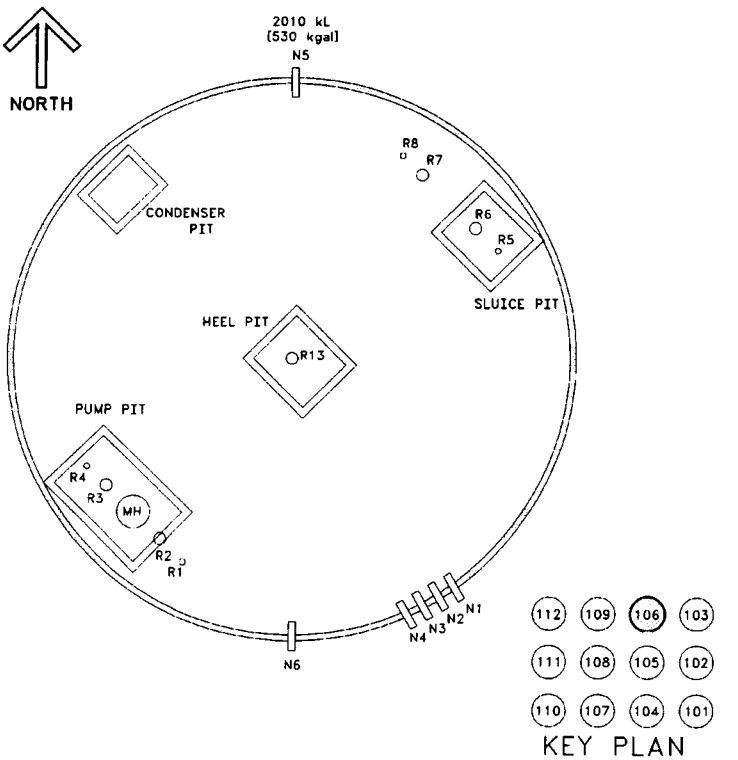


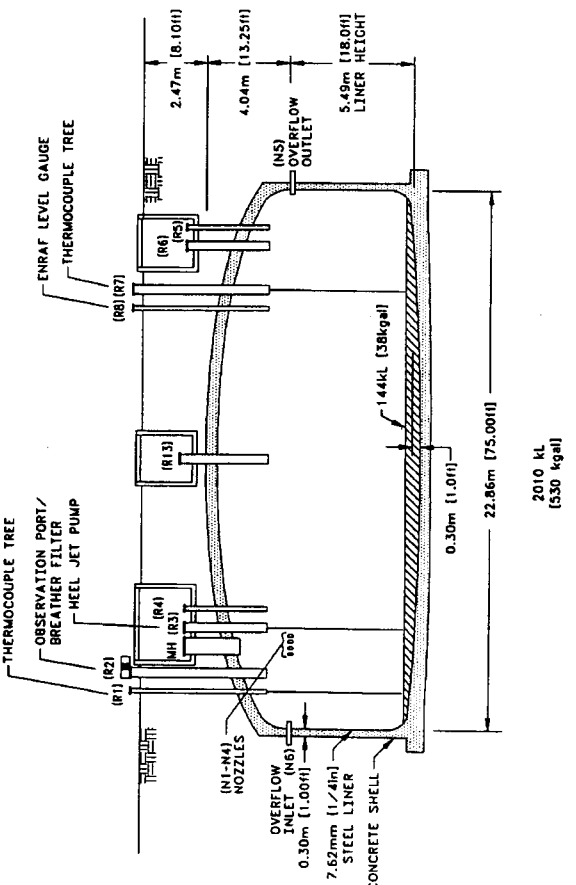
Table 2-2. Tank 241-BX-106 Risers.[1,2,3,4]

Riser Number	Diameter (inches)	Description and Comments
R1	4	Thermocouple tree
R2	12	B-222 observation port/air filter
R3	12	Heel jet pump, weather covered
R4	4	Process inlet, weather covered
R5	4	Flange, weather covered
R6	12	Flange
R7	12	Thermocouple tree
R8	4	ENRAF™ 854
R13	12	Heel pit, weather covered
Nozzle Number	**Diameter (inches)**	**Description and Comments**
N1	3	Spare
N2	3	Spare
N3	3	Spare
N4	3	Spare
N5	3	Cascade overflow outlet
N6	3	Cascade inlet

Notes:

[1]Alstad (1993)
[2]Lipniki (1995)
[3]Tran (1993)
[4]Vitro Engineering Corporation (1986)

Figure 2-2. Tank 241-BX-106 Cross-Section.



2.3 PROCESS KNOWLEDGE

The subsections below provide information about the transfer history of tank 241-BX-106, describe the process wastes that made up the transfers, and give an estimate of the current tank contents based on transfer history.

2.3.1 Waste Transfer History

Waste was first added to tank 241-BX-106 in September 1949 from the cascade of B Plant metal waste (MW) from tank 241-BX-105. The cascade of MW waste continued until the entire cascade was filled in January 1950.

Supernatant, presumably MW from B Plant, was pumped to tank 241-BX-106 from several tanks during the second quarter of 1954. The tanks transferring waste were 241-BX-104, 241-BX-105, 241-BY-104, 241-BY-105, and 241-BY-111. The waste was sluiced from the tank in May 1955 to provide feed for the uranium recovery process (Rodenhizer 1987). Additional supernatant was added in the second quarter of 1956 from tank 241-BY-108. This waste is assumed to be 1C waste from B Plant and TBP waste. In the third quarter of 1957, supernate was transferred from tank 241-BX-106 to tank 241-BY-102. In the first and second quarters of 1963, tank 241-BX-106 received liquid cladding waste from tank 241-C-102.

The tank did not receive waste again until the first quarter of 1968 when ion exchange (IX) waste from the cesium recovery operations and evaporator bottoms (EB) waste from the In-Tank Solidification (ITS) campaign were transferred from tank 241-BX-104 into tank 241-BX-106. Additional EB waste was added from several tanks during the fourth quarter of 1968. The tanks involved in this transfer of waste were 241-BX-103, 241-BX-107, 241-BX-108, 241-BX-109, 241-BX-110, 241-BX-111, and 241-BX-112. Tank 241-BX-106 received an additional amount of IX waste from tank 241-BX-104 in the first quarter of 1969. From the third quarter of 1957 to the third quarter of 1969, supernate transfers from tank 241-BX-106 were made to tanks 241-BY-103 and 241-BY-102. From the second quarter of 1970 through the second quarter of 1971, tank 241-BX-106 received liquid B Plant low-level (BL) waste from tank 241-BX-101. Tank 241-BX-104 received supernate from tank 241-BX-106 in the second quarter of 1970. From the fourth quarter of 1970 to the second quarter of 1971, supernate transfers went to tanks in TX and TY farms (tanks 241-TY-103, 241-TX-118, 241-TX-101, and 241-TX-105).

Waste from several tanks was transferred to tank 241-BX-106 from the fourth quarter of 1972 through the second quarter of 1976. The waste was comprised of organic wash waste (OWW) from the plutonium-uranium extraction (PUREX) process plant, and BL and IX liquid wastes. The tanks involved in the transfer were: 241-B-101, 241-BX-105, 241-BX-107, 241-BX-108, 241-BX-109, 241-BY-107, 241-BY-110, and 241-BY-112. Tank 241-BX-103 received supernate from tank 241-BX-106 from the second quarter of 1972 to

the first quarter of 1973. Between the second quarter of 1974 and the second quarter of 1977, tank 241-BX-106 supernate went to tanks 241-S-107, 241-SX-106, and 241-A-102.

Tank 241-BX-106 also received EB saltcake from ITS during the first quarter of 1976. The final waste addition was an unspecified waste from tank 241-A-102 during the first quarter of 1977. Historical records indicate that the waste appears to be 242-A EB waste.

A summary of waste received by tank 241-BX-106 is given in Table 2-3.

2.3.2 Historical Estimation of Tank Contents

An estimate of the current contents of tank 241-BX-106 based on historical transfer and predicted waste stream composition data are available from *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area* (HTCE) (Brevick et al. 1994a). The concentration estimates provided in the HTCE have not been validated and should be used with caution. The historical data used for the estimate are *Waste Status and Transaction Record Summary for the Northeast Quadrant* (WSTRS) (Agnew et al. 1996), *Hanford Defined Waste: Chemical and Radionuclide Compositions* (Agnew 1995), *Tank Layer Model for the Northeast, Southwest, and Northwest Quadrants* (TLM) (Agnew et al. 1995), and *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3* (Agnew 1996). The WSTRS is a compilation of available waste transfer and volume status data. The *Hanford Defined Wastes* document provides the assumed typical compositions for Hanford Site waste 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 *Hanford Defined Wastes* document, generates an estimate of the tank contents. Thus, these model predictions can only be considered estimates that require further evaluation using analytical data.

According to the TLM, tank 241-BX-106 contains 57 kL (15 kgal) of supernatant waste, 106 kL (28 kgal) of BY saltcake, and 11 kL (3 kgal) of MW. Since the TLM evaluation, the supernatant was removed during interim stabilization efforts (July 1995). Based on Hanlon (1996), tank 241-BX-106 now contains only sludge, with no supernatant. Therefore, it is expected that of the TLM predictions, only the supernatant layer will change, and the sludge will remain unaffected. A graphical representation of the estimated waste types and volumes for the TLM predictions can be seen in Figure 2-3. Note that since the figure was generated based on the TLM data, it still includes the supernatant layer.

The TLM predicts that the solids in the tank consist mostly of BY saltcake, which should contain large amounts of hydroxide, sodium, aluminum, nitrate, and nitrite. Other major constituents include carbonate, phosphate, sulfate, silicate, fluoride, chloride, and complexants. The MW should contain large amounts of sodium, iron, hydroxide, carbonate,

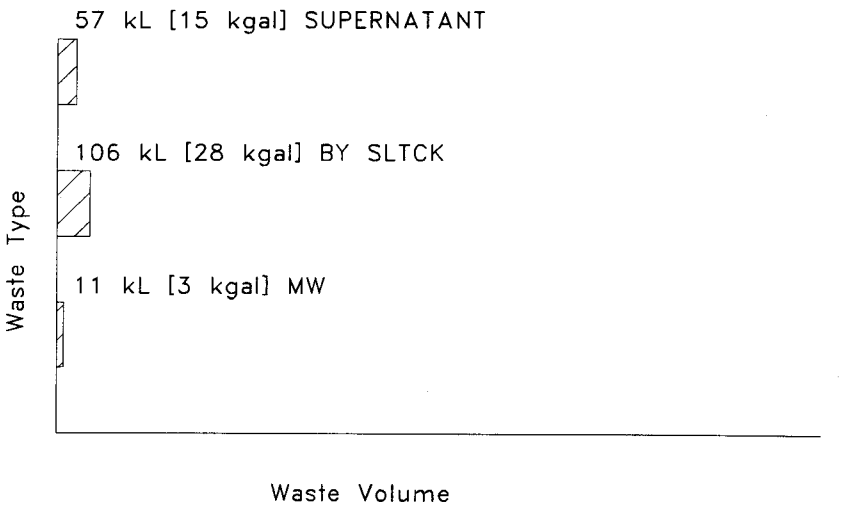
Table 2-3. Summary of Tank 241-BX-106 Waste Received History.[1]

Transfer Source	Waste Type Received	Time Period	Estimated Waste Volume kL	(kgal)
B Plant / cascade from tank 241-BX-105	MW from $BiPO_4$ process	1949-1950	6,807	(1,783)
241-BY-104, 241-BY-105, 241-BY-111, 241-BX-104, 241-BX-105	Transfer of supernatant MW from B Plant	1954	9,132	(2,392)
241-BY-108	Transfer of supernatant TBP waste and 1C	1956	1,985	(520)
241-C-102	Transfer of supernatant cladding waste	1963	1,677	(443)
241-BX-103, 241-BX-104, 241-BX-107, 241-BX-108, 241-BX-109, 241-BX-110, 241-BX-111, 241-BX-112	Transfer of supernatant EB waste from ITS and IX waste	1968	9,831	(2,597)
241-BX-104	Transfer of supernatant IX waste	1969	1,953	(516)
241-BX-101	Transfer of supernatant BL from B Plant operations	1970-1971	18,451	(4,874)
241-B-101, 241-BX-105, 241-BX-107, 241-BX-108, 241-BX-109, 241-BY-107, 241-BY-110, 241-BY-112	Transfer of supernatant BL, IX, OWW waste	1972-1976	4,092	(1,081)
241-BY-102 (ITS#1) and 241-BY-112 (ITS#2)	EB saltcake from ITS process	1976	1,019	(267)
241-A-102	Unknown waste transfer (possibly EB from 242-A Evaporator)	1977	504	(132)

Note:

[1]Agnew et al. (1996)

Figure 2-3. Tank Layer Model Estimates for Tank 241-BX-106.[1]



Note:

[1]The TLM waste layer predictions were generated before interim stabilization efforts and the removal of the supernate. Consequently, the upper supernatant layer no longer exists. It is believed that the volumes of the solids layers remained unchanged.

phosphate, nitrate, sulfate, nitrate, and uranium. Additionally, chromium, calcium, nickel, chloride, silicate, and a trace of plutonium will be found. Table 2-4 shows an estimate of the expected waste constituents and their concentrations for the tank solids.

2.4 SURVEILLANCE DATA

Tank 241-BX-106 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. The data provide the basis for determining tank integrity.

Liquid level measurements can indicate that there may be a major leak from the tank. Solid surface level measurements provide an indication of physical changes and consistency of the solid layers of waste. Drywells located in the soil around the perimeter of the tank may show increased radioactivity due to a leak.

2.4.1 Surface Level Readings

The tank 241-BX-106 waste surface level is monitored automatically with an ENRAF™ surface-level gauge. The maximum deviations allowed from the baseline are a 5-cm (2-in.) increase and a 2.5-cm (1-in.) decrease. Until interim stabilization in July 1995, the surface level of the waste had remained steady for the past 10 years, with the readings ranging between 31 and 33 cm (12.2 and 13 in.). A graph representing the level measurement history is presented in Figure 2-4. The surface level was 21.2 cm (8.35 in.) on March 4, 1996. Tank 241-BX-106 does not have a liquid observation well. The waste level history is shown in Figure 2-4.

2.4.2 Internal Tank Temperatures

As of March 1996, tank 241-BX-106 had 10 functioning thermocouples on two thermocouple trees to monitor internal tank temperatures. The thermocouple tree in riser 7 has 14 J-type thermocouples with four functioning, numbers 1, 2, 7, and 11. Thermocouple 1 is 40 cm (16 in.) from the centerline bottom of the tank. Thermocouples 2 through 14 are at 60-cm (24-in.) intervals above thermocouple 1. Historical data indicate that thermocouples 1 through 12 have similar temperature readings spanning from 1974 to the present. No data are available from 1982 to 1989, although it appears that there was a thermocouple tree in the tank in May 1988. A second thermocouple tree with six K-type thermocouples is in riser 1. Thermocouples 1 through 6 in riser 1 are 40 cm (16 in.), 51 cm (20 in.), 64 cm (25 in.), 76 cm (30 in.), 90 cm (35 in.), and 490 cm (193 in.) from the centerline bottom of the tank, respectively. The thermocouple tree was installed in June 1993 and the first manual readings were taken in April 1994. Daily automated readings began in May 1994.

Table 2-4. Tank 241-BX-106 Inventory Estimate.[1,2,3] (2 sheets)

Solids Composite Inventory Estimate			
Chemical Constituents	**mol/L**	**ppm**	**kg**
Na^+	11.7	1.65E+05	31,500
Al^{3+}	1.94	32,100	6,140
Fe^{3+} (total Fe)	0.0260	890	170
Cr^{3+}	0.0459	1,460	280
Bi^{3+}	8.12E-04	104	19.9
La^{3+}	2.96E-06	0.248	0.0475
Hg^{2+}	3.27E-05	4.03	0.770
Zr (as $ZrO(OH)_2$)	2.68E-04	15.0	2.87
Pb^{2+}	0.00512	651	125
Ni^{2+}	0.0122	441	84.4
Sr^{2+}	3.24E-06	0.174	0.0333
Mn^{4+}	0.00294	99.0	18.9
Ca^{2+}	0.0744	1,830	350
K^+	0.0341	817	156
OH^-	9.50	99,100	18,900
NO_3^-	5.80	2.21E+05	42,200
NO_2^-	1.57	44,400	8,500
CO_3^{2-}	0.636	23,400	4,470
PO_4^{3-}	0.101	5,860	1,120
SO_4^{2-}	0.181	10,600	2,040
Si (as SiO_3^{2-})	0.0709	1,220	234
F^-	0.0538	627	120
Cl^-	0.115	2,500	478
citrate	0.0217	2,510	481
$EDTA^{4-}$	0.00486	859	164
$HEDTA^{3-}$	6.57E-04	110	21.1
glycolate	0.0153	702	134
acetate	0.0289	1,050	200
oxalate	2.49E-06	0.135	0.0258

Table 2-4. Tank 241-BX-106 Inventory Estimate.[1,2,3] (2 sheets)

Solids Composite Inventory Estimate			
Chemical Constituents	**mol/L**	**ppm**	**kg**
DBP	0.0230	3,760	718
butanol	0.0230	1,050	200
NH_3	0.00929	96.9	18.5
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents	**Ci/L**	**μCi/g**	**Ci**
Pu	---	0.0963	0.307 (kg)
U	0.216 (mol/L)	31,500 (μg/g)	6,020 (kg)
Cs	0.195	119	22,900
Sr	0.118	72.4	13,800
Physical Properties			
Total solid waste	1.91E+05 kg (31 kgal)		
Heat load	200 watts (684 Btu/hr)		
Bulk density	1.63 (g/mL)		
Void fraction	0.738		
Water weight percent	38.1		
Total organic carbon weight percent carbon (wet)	0.405		

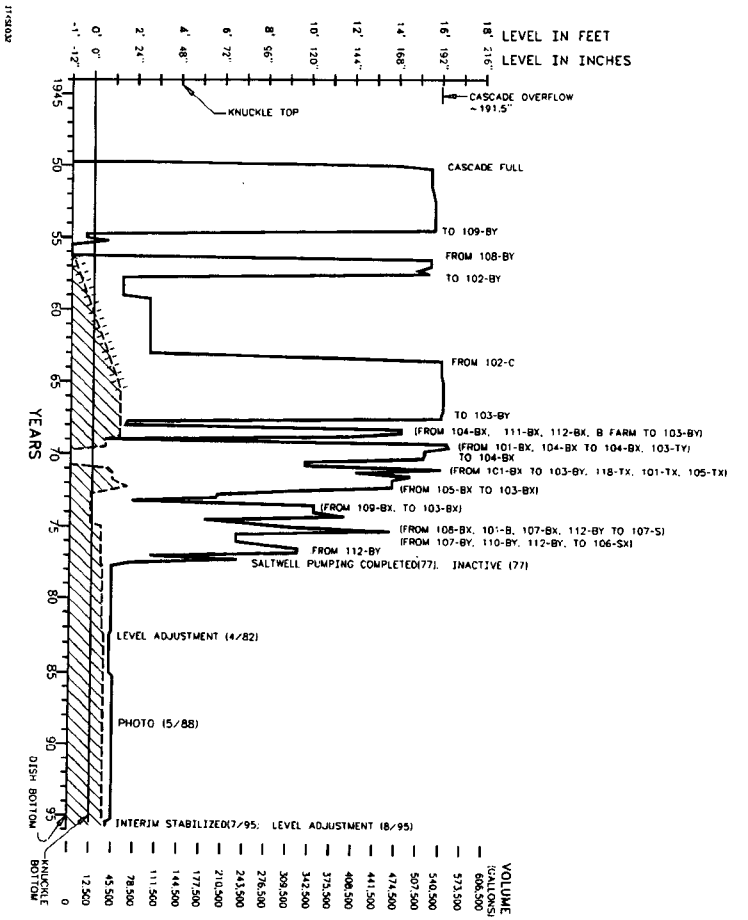
Notes:

[1]Agnew 1996

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

[3]Small differences (about 3 % or less) appear to exist among the inventory above and the inventories calculated from the two sets of concentrations. These differences are being evaluated.

Figure 2-4. Tank 241-BX-106 Level History.



The waste level of 21.2 cm (8.35 in.) at riser 8 is equivalent to about 51.7 cm (20.3 in.) above the centerline bottom of the tank. Based on this waste level, thermocouple 1 in risers 1 and 7 is in the waste. Thermocouple 2 in riser 1 may or may not be in the waste, depending on local sludge level variations.

This tank experiences seasonal temperature undulations. The mean temperature for data recorded between November 1989 and March 1996 is 19 °C (66 °F) with a minimum of 8.3 °C (46.9 °F) and a maximum of 25.2 °C (77.3 °F). The highest temperature recorded on March 4, 1996 was 18 °C (64 °F) recorded by thermocouple 1 in riser 7. The low temperature on this day was 17 °C (63 °F) recorded by thermocouples 7 and 11 in riser 7 and thermocouple 2 in riser 1.

Plots of the individual thermocouple readings for tank 241-BX-106 may be found in the supporting document for the HTCE (Brevick et al. 1994b). A graph of the weekly high temperatures is shown in Figure 2-5.

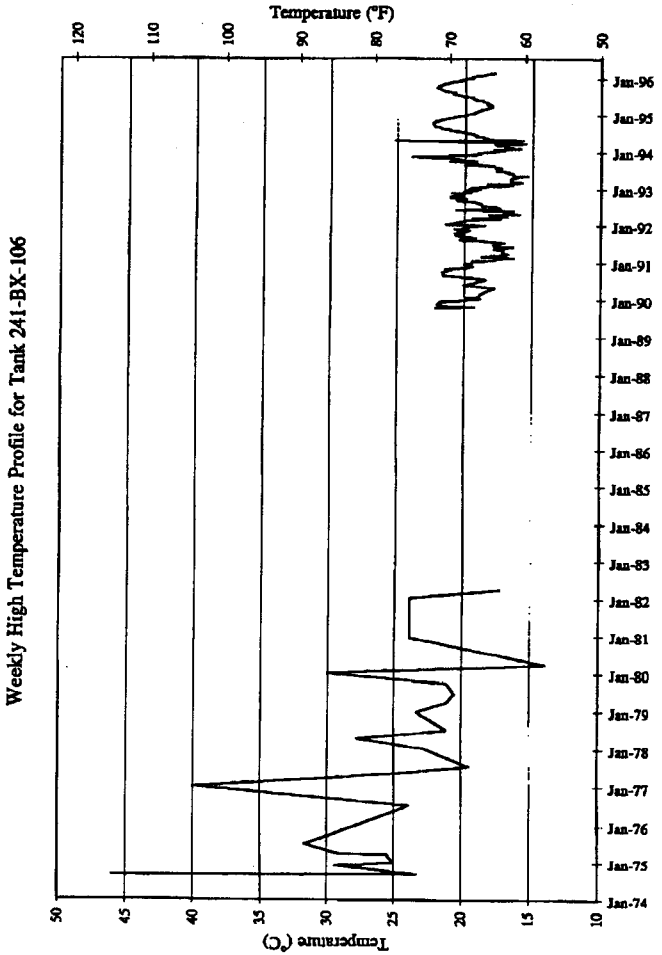
2.4.3 Drywells

Four drywells are associated with tank 241-BX-106. Graphs representing the data from active drywells are in Brevick et al. (1994b). The graphs include the peak counts per second, the depth at which the peak occurred, and the date of the reading.

2.4.4 Tank 241-BX-106 Photographs

The 1988 photographic montage of the tank 241-BX-106 interior shows a dark liquid surface with a ring of sludge at the perimeter. The quality of the photographs is poor and identifying tank contents and equipment is difficult; however, some equipment and tank features are visible and have been identified and labeled. At the time of the photograph, this tank contained approximately 57 kL (15 kgal) of supernatant. The supernatant has since been removed; therefore, the picture does not represent the current tank contents.

Figure 2-5. Tank 241-BX-106 Weekly High Temperature Plot.



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3.0 TANK SAMPLING OVERVIEW

This section describes the two 1995 sampling and analysis events for tank 241-BX-106. Auger samples were taken in December 1995 to satisfy the requirements of *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). The sampling and analyses were performed in accordance with *Tank 241-BX-106 Auger Sampling and Analysis Plan* (Sasaki 1995). Liquid grab samples were taken in March 1995 to satisfy the requirements of *Data Quality Objectives for the Waste Compatibility Program* (Carothers 1994). Further discussions of the sampling and analysis procedures can be found in *Tank Characterization Reference Guide* (DeLorenzo et al. 1994).

3.1 DESCRIPTION OF THE 1995 AUGER SAMPLING EVENT

Auger sample 95-AUG-49 was collected from riser 6 on December 15, 1995, and auger sample 95-AUG-50 was collected from riser 2 on December 18, 1995. Both samples were received by the Westinghouse Hanford Company 222-S Laboratory on December 22, and extruded on January 5, 1996.

Table 3-1 summarizes the applicable DQOs and their respective sampling and analytical requirements. Table 3-2 summarizes sample numbering and dose rate information for the 1995 auger sampling event.

Table 3-1. Sampling and Analytical Requirements for Tank 241-BX-106.[1]

Sampling Event	Sampling Requirements	Applicable References and Analytical Requirements
Auger sampling	Auger samples from a minimum of two risers separated radially to the maximum extent possible	*Tank Safety Screening Data Quality Objective*[2]: Moisture content, total alpha activity, energetics, bulk density, tank headspace flammability

Notes:

[1]Sasaki (1995)

[2]Dukelow et al. (1995)

Table 3-2. Auger Sample Information.[1]

Riser	Sample Identification	LABCORE Number	Dose Rate through Auger Sleeve (mR/hr)
6	95-AUG-49	S96T000110	150
		S96T000112	
		S96T000113	
2	95-AUG-50	S96T000114	400
		S96T000116	
		S96T000117	

Note:
[1]Sasaki (1996)

3.1.1 Sample Handling

3.1.1.1 Auger 95-AUG-49. A 20-inch auger bit with flutes 1 inch apart was used. The sample was contained on the bottom 8 flutes of the auger sampler, and a total of 63.1 grams of solids was recovered. The solids were black in color, and the texture was that of a soft, wet sludge. The sample also contained several small pieces of white material. No drainable liquids were found in the sample. The sample was homogenized prior to analysis.

3.1.1.2 Auger 95-AUG-50. A 20-inch auger bit with flutes one half inch apart was used. The sample was contained on the bottom 15 flutes of the sampler, and a total of 40.9 grams of solids was recovered. The solids were black in color, and no drainable liquids were present in the sample. The sample also contained an electrical cord that was wrapped around the auger and across several flutes. The cord was removed and set aside. The sample was homogenized prior to analysis.

Table 3-3 describes both auger samples in terms of riser number, recovered segments, color, texture, and mass.

Table 3-3. Auger Sample Description.[1]

Sample Identification	Sample Total Weight (g)	Recovery[2] (%)	Segment Description
95-AUG-49	63.1	76	The solids were black in color and the texture was that of a soft, wet sludge. No drainable liquids were present.
95-AUG-50	40.9	83	The solids were black in color and the texture was that of a soft, wet sludge. No drainable liquids were present.

Notes:

[1]Sasaki (1996)

[2]Recovery is calculated by dividing the actual recovered length of solid by the length of the expected recovery (26.7 cm [10.5 in.] for sample 95-AUG-49 and 23 cm [9 in.] for sample 95-AUG-50). Expected recoveries are based on waste level measurements at the riser and the distance the auger was lowered into the waste.

3.1.2 Sample Analysis

The analyses performed on the auger samples were limited to those required by the safety screening DQO. These included analyses for thermal properties by DSC, moisture by TGA, fissile content by total alpha activity analysis, and density. Prior to analyzing for total alpha activity, the samples were dissolved by fusing with potassium hydroxide in a nickel crucible and dissolving the flux in nitric and hydrochloric acids. A liquid aliquot of the fused sample was then dried on a counting planchet and measured for alpha activity using an alpha proportional counter. The results of the analyses are presented and discussed in Sections 4 and 5 of this report.

Laboratory control standards, matrix spikes, and duplicate analysis quality control (QC) checks were applied to the total alpha activity analysis. Laboratory control standards and duplicate analysis QC checks were used for the TGA and DSC analyses. No QC checks were applicable to the density determinations. An assessment of the QC procedures and data is presented in Section 5.1.2 of this report.

Because of the small amount of sample recovered, the augers were analyzed on a whole auger basis. All reported analyses were performed in accordance with approved laboratory procedures. A list of the sample numbers and applicable analyses is presented in Table 3-4. Table 3-5 displays the analytical procedures by title and number. No deviations or modifications were noted in the laboratory.

Table 3-4. Tank 241-BX-106 Sample Analysis Summary.[1]

Riser	Sample Identification	Sample Number	Analyses
6	95-AUG-49	S96T000110	Bulk density
		S96T000112	DSC, TGA
		S96T000113	Total alpha
2	95-AUG-50	S96T000114	Bulk density
		S96T000116	DSC, TGA
		S96T000117	Total alpha

Note:

[1]Sasaki (1996)

Table 3-5. Tank 241-BX-106 Auger Samples Analytical Procedures.[1]

Analysis	Instrument	Preparation Procedure	Analytical Procedure
Energetics by DSC	Perkin-Elmer DSC 7™ instrument	N/A	LA-514-114, Rev. C-1
Percent water by TGA	Mettler TG 50™ instrument	N/A	LA-560-112, Rev. B-1
Total alpha activity	Alpha proportional counter	LA-549-141, Rev. D-0	LA-508-101, Rev. D-2
Density	N/A	N/A	LO-160-103, Rev. A-7

Notes:

N/A = not applicable

Mettler TG 50™ is a registered trademark of Mettler Electronics, Anaheim, California.

Perkin-Elmer DSC 7™ is a registered trademark of Perkins Research and Manufacturing Company, Inc., Canoga Park, California.

[1]Sasaki (1996)

3.1.3 Tank Headspace Measurements

Prior to obtaining the auger samples from tank 241-BX-106, flammability measurements were made of the tank's headspace. Measurements were made in risers 2 and 6, 6 m (20 ft) below the top of the risers, using a combustible gas meter.

3.2 DESCRIPTION OF 1995 GRAB SAMPLING EVENT

Liquid grab samples 6BX-95-1 (LABCORE number S95T000355) and 6BX-95-2 (LABCORE number S95T000358) were collected from riser 2 on March 15 and 16, 1995, respectively. Both samples were received by the Westinghouse Hanford Company 222-S Laboratory on March 17, 1995 (Rollison 1995a). Table 3-6 summarizes the applicable DQOs and the sampling and analytical requirements for the sampling event.

Table 3-6. Sampling and Analytical Requirements for Tank 241-BX-106 Grab Samples.[1]

Sampling Event	Sampling Requirements	Applicable References and Analytical Requirements
Grab sampling	Two grab samples from a single riser. One sample to be taken from near the top and one from near the bottom of the supernatant.	*Data Quality Objectives for the Waste Compatibility Program*[2]: Moisture content, density, total organic carbon (TOC), carbonate, energetics, cesium, strontium, plutonium, americium, aluminum, sodium, iron, pH, hydroxide, nitrate, nitrite, phosphate, sulfate, fluoride, chloride, separable organics, and percent solids.

Notes:
[1]Schreiber (1995)
[2]Carothers (1994)

3.2.1 Sample Handling

Both samples were taken using 125-mL sample bottles. The samples consisted of 125 mL of clear green liquid with less than 1 percent solids and no visible separable organic layers. The dose measurement for each sample was 600 mR/hr.

3.2.2 Sample Analysis

The analyses performed on the grab samples consisted of those required by the waste compatibility DQO (Carothers 1994) and are listed in Table 3-6. Viscosity and cooling curve measurements listed in the DQO were not required for these samples because existing process information adequately addressed waste transfer issues (Schreiber 1995).

All analyses were run in duplicate. Laboratory control standards were applied to TOC, total inorganic carbon (TIC) (carbonate), TGA, DSC, specific gravity, pH, hydroxide, $^{239/240}Pu$, ion chromatography (IC), gamma energy analysis (GEA), and ^{241}Am. Matrix spikes were used for IC and iron analysis by inductively coupled plasma atomic emission spectroscopy (ICP). An assessment of the QC procedures is presented in Section 5.1.2 of this report.

3.3 HISTORICAL SAMPLING EVENTS

No previous sampling of the sludge was performed. Previous sampling and analysis of the supernatant had occurred in 1990, 1975, and 1974. The results of the historical sampling events are not discussed in this report as they are no longer applicable to the current tank waste.

4.0 ANALYTICAL RESULTS

Results of the analysis of the auger and grab samples are presented below. The results are presented in separate sections because the supernatant has been pumped from the tank and no longer represents the tank's contents.

4.1 ANALYTICAL RESULTS FOR THE 1995 AUGER SAMPLING EVENT

This section presents the analytical results associated with the December 1995 sampling of tank 241-BX-106. The sampling and analysis were performed as directed in *Tank 241-BX-106 Auger Sampling and Analysis Plan* (SAP) (Sasaki 1995) to satisfy the safety screening DQO (Dukelow et al. 1995). The total alpha activity, density, weight percent water, and energetics results associated with this tank are presented in Table 4-1.

Table 4-1. Analytical Data Presentation Tables.

Data Type	Tabulated Location
Total alpha activity	Table 4-2
Density	Table 4-3
Thermogravimetric analysis	Table 4-4
Differential scanning calorimetry	Table 4-5
Tank headspace flammability	Table 4-6

Overall tank means were calculated for total alpha activity, bulk density, and weight percent water. These means were derived by simply averaging the sample/duplicate means from each auger. A relative standard deviation (RSD) of the mean was also calculated for total alpha activity and weight percent water. The RSD (mean) is defined as 100 times the standard deviation of the mean divided by the tank mean. The four QC parameters assessed with the tank 241-BX-106 samples were spike recoveries, standard recoveries, duplicates, and blanks, the results of which are summarized in Section 5.1.2. More specific QC information is provided in each of the analyte data summary tables found in this section. Sample and duplicate pairs in which any of the QC parameters were outside their specified limits have been footnoted appropriately.

4.1.1 Total Alpha Activity

Total alpha activity was measured on the auger samples recovered from tank 241-BX-106. The samples were prepared by acid fusion digestion using procedure LA-549-141, Rev. D-0. Total alpha analyses were performed using procedure LA-508-101, Rev. D-2 and measured with an alpha proportional counter.

The total alpha activity results are presented in Table 4-2. The overall mean for total alpha was 0.590 μCi/g, with an RSD of 5.0 percent.

Table 4-2. Tank 241-BX-106 Total Alpha Activity Results.[1]

Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)
	μCi/g	μCi/g	μCi/g	μCi/g	%
S96T000113	0.652	0.586	0.619[2]	0.590	5.0
S96T000117	0.543	0.577	0.560[2]		

Note:

[1]Sasaki (1996)

[2]The spike recovery was lower than the 90-110 percent recovery range defined in the SAP.

4.1.2 Density

Bulk density measurements were performed on the auger samples using procedure LO-160-103, Rev. A-7. The bulk density results for tank 241-BX-106 are presented in Table 4-3. The overall mean was 1.64 g/mL, and was determined by averaging the two results. Due to insufficient sample, the laboratory was unable to perform duplicate measurements.

Table 4-3. Tank 241-BX-106 Bulk Density Results.[1]

Sample Number	Result	Duplicate	Overall Mean	RSD (Mean)
	g/mL	g/mL	g/mL	%
S96T000113	1.68	N/A	1.64	N/A
S96T000117	1.60	N/A		

Note:

[1]Sasaki (1996)

4.1.3 Thermogravimetric Analysis

In TGA, 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 the heating to remove any gaseous matter emitted from the sample either through evaporation or through a reaction that forms gas phase products.

Weight percent water by TGA was performed by the 222-S Laboratory under a nitrogen purge using procedures LA-560-112, Rev. B-1 on a Mettler TG 50™ instrument.

Table 4-4 shows the TGA percent water data for tank 241-BX-106. All TGA scans had two transitions; however, only data from the first transition was used to determine the weight percent water. (The second transition occurred in the temperature range of about 210 to 320 °C (410 to 608 °F), resulted in weight losses ranging from 7.06% to 13.99%, and may represent the loss of bound water.) The overall percent water value for the tank was 38.69 percent, with an RSD of 6.4 percent.

Table 4-4. Thermogravimetric Analysis Results for Tank 241-BX-106.[1]

Sample Number[2]	Auger	Temp. Range	Result	Duplicate	Mean	Overall Mean	RSD (Mean)
		°C	% H_2O	% H_2O	% H_2O	% H_2O	%
112	95-AUG-49	35-163	39.64	32.75	36.20[3]	38.69	6.4
116	95-AUG-50	30-140	38.90	43.46	41.18[3]		

Note:

Temp. = temperature

[1]Sasaki (1996)
[2]Sample numbers begin 'S96T000'
[3]The relative percent difference between primary and duplicate samples was greater than the 10 percent criterion defined in the SAP.

4.1.4 Differential Scanning Calorimetry

In a DSC analysis, heat absorbed or emitted by a sample is measured while the sample is heated so that its temperature increases at a constant rate. Nitrogen is passed over the sample to remove any gases that are released. The onset temperature for an endothermic event (characterized by or causing the absorption of heat) or an exothermic event (characterized by or causing the release of heat) is determined graphically. The DSC

analyses were performed by the 222-S Laboratory using procedure LA-514-114, Rev. C-1 on a Perkin-Elmer DSC 7™ instrument. No exotherms were observed in either auger sample.

The DSC results are shown on a wet weight basis in Table 4-5. The temperature range and magnitude of the enthalpy change (ΔH) are provided for each transition. A positive enthalpy change denotes an endotherm, and a negative enthalpy change denotes an exotherm. 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, observed in some tank wastes, is generally exothermic and is probably caused by the organic components of the sample reacting with nitrate salts. However, no exotherms were observed in the tank 241-BX-106 samples.

Table 4-5. Differential Scanning Calorimetry Results for Tank 241-BX-106.[1]

Sample Number	Run	Sample Weight	Transition 1		Transition 2		Transition 3	
		mg	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-49								
S96T000112	1	28.52	95.16 to 180	671.82	242.48 to 330	404.31	449 to 453	0.828
	2	50.96	109.29 to 160	728.96	231.0 to 325	255.72	---	---
Auger Sample 95-AUG-50								
S96T000116	1	42.740	108.01 to 190	811.57	234.73 to 340	270.67	---	---
	2	35.960	110.4 to 190	932.74	236.18 to 330	203.13	---	---

Notes:

ΔH = change in enthalpy (negative sign denotes exothermic reaction)
Temp. = temperature
--- = no transition observed
[1]Sasaki (1996)

4.1.5 Tank Headspace Flammability

To address flammable vapor issues, the safety screening DQO (Dukelow et al. 1995) requires sampling of the tank headspace. The tank headspace flammability was measured in risers 2 and 6 prior to auger sampling. The measurements were taken 6 m (20 ft) below the top of the risers using a combustible gas meter. Readings at both locations were zero percent of the

lower flammability limit (LFL), indicating no flammability concerns (Sasaki 1996). Other headspace measurements support the low flammability readings. Results are presented in Table 4-6.

Table 4-6. Tank Headspace Measurements.

Analyte	Riser 2	Riser 6
Flammability (% of LFL)	0	0
Oxygen (%)	---	19.8
Total organic vapors (ppm)	3.9	6.7
Ammonia (ppm)	50	50

Note:

--- = not measured

4.2 ANALYTICAL RESULTS FOR THE 1995 GRAB SAMPLING EVENT

This section presents the analytical results associated with the March 1995 sampling of tank 241-BX-106. The sampling and analysis were performed as directed in the *Tank 241-BX-106 Tank Characterization Plan* (Schreiber 1995) to satisfy the waste compatibility DQO (Carothers 1994). Analytical results are presented in Table 4-7. Sample S95T000355 was taken near the surface of the supernate, and sample S95T000358 was taken near the bottom of the supernate.

Table 4-7. Analytical Results for the 1995 Grab Sampling for Tank 241-BX-106. (3 sheets)[1]

Analyte	Sample Identification	Sample Result	Duplicate Result	Mean	RSD (Mean)
METALS		µg/mL	µg/mL	µg/mL	%
Aluminum	S95T000355	7.07E+03	7.07E+03	6.72E+03	5.21
	S95T000358	6.78E+03	5.96E+03		
Iron	S95T000355	<20	<20	NA	NA
	S95T000358	<20	<20		
Sodium	S95T000355	1.54E+05	1.65E+05	1.57E+05	2.06
	S95T000358	1.50E+05	1.59E+05		

Table 4-7. Analytical Results for the 1995 Grab Sampling for Tank 241-BX-106. (3 sheets)[1]

Analyte	Sample Identification	Sample Result	Duplicate Result	Mean	RSD (Mean)
IONS		µg/mL	µg/mL	µg/mL	%
Chloride	S95T000355	3.37E+03[2]	3.40E+03[2]	3.41E+03	0.83
	S95T000358	3.37E+03	3.49E+03		
Fluoride	S95T000355	359	356	336	6.56
	S95T000358	324	303		
Hydroxide	S95T000355	2.81E+04	2.68E+04	2.71E+04	1.75
	S95T000358	2.75E+04	2.59E+04		
Nitrate	S95T000355	1.08E+05	1.12E+05	1.11E+05	1.12
	S95T000358	1.12E+05	1.13E+05		
Nitrite	S95T000355	6.26E+04	6.28E+04	6.44E+04	2.56
	S95T000358	6.59E+04	6.61E+04		
Phosphate	S95T000355	<2.48E+03[2]	<2.48E+03[2]	NA	NA
	S95T000358	1.80E+03	1.72E+03		
Sulfate	S95T000355	<3.31E+03[2]	<3.31E+03[2]	NA	NA
	S95T000358	2.41E+03	2.41E+03		
RADIONUCLIDES		µCi/mL	µCi/mL	µCi/mL	%
^{137}Cs	S95T000355	163	160	166	2.56
	S95T000358	170	170		
^{90}Sr	S95T000355	0.274	0.284	0.277	1.49
	S95T000358	0.282	0.266		
^{238}Pu	S95T000355	<7.04E-03	<8.77E-03	NA	NA
	S95T000358	<1.23E-02	<9.49E-03		
$^{239/240}Pu$	S95T000355	<7.04E-03	<8.77E-03	NA	NA
	S95T000358	<1.23E-02	<9.49E-03		
^{241}Am	S95T000355	<0.0306	<0.0250	NA	NA
	S95T000358	<0.0264	<0.0220		

Table 4-7. Analytical Results for the 1995 Grab Sampling for Tank 241-BX-106. (3 sheets)[1]

Analyte	Sample Identification	Sample Result	Duplicate Result	Mean	RSD (Mean)
PHYSICAL PROPERTIES					%
Specific Gravity	S95T000355	1.28	1.27	1.27	0.33
	S95T000358	1.26	1.28		
pH	S95T000355	13.7	13.8	13.8	0.21
	S95T000358	13.7	13.8		
% Water	S95T000355	63.1	62.7	61.3	2.57
	S95T000358	62.7	56.8		
Exotherms	S95T000355	0	0	0	NA
	S95T000358	0	0		
CARBON		µg C/mL	µg C/mL	µg C/mL	%
TIC	S95T000355	1.23E+04	1.21E+04	1.23E+04	0.81
	S95T000358	1.24E+04	1.24E+04		
TOC	S95T000355	2.96E+03	3.20E+03	2.36E+03	30.37
	S95T000358	1.64E+03	1.62E+03		

Notes:

[1]Rollison (1995b)

[2]The spike recovery was lower than the 80 to 120 percent recovery range defined in Schreiber (1995).

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5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

Section 5.0 evaluates the overall quality and consistency of the available results for tank 241-BX-106 and assesses and compares these results against historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

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

5.1.1 Field Observations

The safety screening DQO (Dukelow et al. 1995) requirement that at least two widely spaced risers be sampled was fulfilled. 27 cm (10.5 in.) of sample was expected to be recovered from 95-AUG-49, and sludge was found on the bottom 20 cm (8 in.) of the auger, giving a sample recovery of 76 percent. For sample 95-AUG-50, 23 cm (9 in.) of sludge was expected to be recovered; 19 cm (7.5 in.) was actually obtained, giving a sample recovery of 83 percent. Although the material recovered from the augers may not be fully representative of the tank waste, the sample recoveries were quite good.

5.1.2 Quality Control Assessment

The usual QC assessment includes an evaluation of the appropriate blanks, duplicates, spike recoveries, and standard recoveries performed in conjunction with the chemical analyses. All of the pertinent QC tests were conducted on the 1995 auger sample results and are reported in Sasaki (1996). The SAP (Sasaki 1995) established the specific accuracy and precision criteria for the QC checks (none of the QC parameters applied to bulk density). Sample and duplicate pairs that had one or more QC result outside the SAP target levels were identified (by footnoting) in the Section 4.0 data presentation tables and are discussed below.

The standard recoveries were within the defined criterion for all analytes. Both spike recoveries for total alpha activity were slightly below the target level. This low recovery was most likely due to the large sample sizes used for the analysis, resulting 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 precision (estimated by the RPD, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred) between the two percent water duplicate samples were both slightly above the target level. However, reruns were not requested because the TGA results were only needed to convert any wet weight

exothermic reactions to a dry weight basis (Sasaki 1995), and no exotherms were observed. Finally, none of the samples exceeded the criterion for preparation blanks; thus, contamination was not a problem for any of the analyses.

All of the pertinent QC tests were conducted on the 1995 grab samples analyses and are reported in Rollison (1995b). Schreiber (1995) established the specific accuracy and precision requirements for the QC checks. Results that had QC results outside the target levels of Schreiber (1995) were identified (by footnoting) in Table 4-6.

Standard recoveries and RPDs were within the defined criteria for all analytes. Spike recoveries were below the target levels for sulfate, phosphate, and chloride. No reruns were required because the spike recoveries were only slightly below the criteria and did not affect the outcome of the compatibility assessment.

The majority of the QC results for the auger and grab samples were within the boundaries specified in the SAP and Schreiber (1995). Although a few results were outside their target levels, they were not found to substantially impact either the validity or the use of the data.

5.1.3 Data Consistency Checks

Comparisons of different analytical methods can help to assess the reliability and quality of the data. Examples would be the comparison of sulfur and phosphorus concentrations as obtained by inductively coupled plasma spectroscopy to the sulfate and phosphate results as determined by ion chromatography, and the comparison of total alpha and total beta to the sums of their emitters. In addition, calculations of mass and charge balances provide a measure of the overall consistency of the data. Because of the lack of data appropriate for consistency checks, no data consistency checks were performed.

5.2 COMPARISON OF HISTORICAL AND ANALYTICAL RESULTS

The solids in tank 241-BX-106 had not been previously sampled and analyzed. Therefore, no comparisons were made between the auger sample and historical sample events. However, the December 1995 auger sample results were compared with the March 1995 supernate sample results and checked for consistency. Because limited analyses were performed on the auger samples, only a few comparisons can be made. Table 5-1 presents auger and supernate sample results.

Table 5-1. Comparison of Analytical Results for Solids and Supernate Samples

Analyte	Supernate Result	Solids Results
RADIONUCLIDES		
Total alpha	<0.03 μCi/mL[1]	0.590 μCi/g
PHYSICAL PROPERTIES		
Exotherms	none	none
Density	1.27 g/mL	1.64 g/mL
Weight percent water	63.3%	38.69%

Note:

[1]Sum of the highest "less-than" values for $^{239/240}$Pu, ^{241}Am, and ^{238}Pu analyses (all results were below detection limits).

The supernate and solids results are consistent with each other. No exotherms were observed in either set of samples. The lower total alpha result for the supernate is consistent with the fact that the alpha emitters are generally not soluble in non-complexed wastes. The lower density and higher water content of the supernate is also consistent with expectations.

5.3 TANK WASTE PROFILE

Two objectives of the 1995 auger sampling event were to obtain two vertical profiles of the tank waste and to obtain them from widely spaced risers (Dukelow et al. 1995). The second objective was met, allowing a statistical assessment of the horizontal distribution of the tank waste for the safety screening analytes. Because of the shallow waste depth, however, the individual auger samples were not vertically split into subsegments. The visual descriptions of both auger samples were the same except that auger 95-AUG-49 contained three pieces of white material.

The fact that two risers were sampled allowed a statistical procedure known as the one-way analysis of variance (ANOVA) to be conducted on the 1995 auger samples in order to determine whether there were horizontal variations in the analyte concentrations. The ANOVA generates a p-value that is compared with a standard significance level ($\alpha = 0.05$). If a p-value is below 0.05, there is sufficient 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 sufficient evidence to conclude that the samples are significantly different from each other. A two-tailed statistical test was used in all cases.

The quantity of data available allowed the statistical assessment of only two analytes: percent water and total alpha activity. The results of the ANOVA indicated that neither

percent water (p-value = 0.351) nor total alpha activity (p-value = 0.253) showed any significant concentration differences between risers 2 and 6.

In summary, both the visual descriptions of the two auger samples and the results of the statistical analysis indicate that the waste appears to be horizontally homogeneous. Vertically, the visual descriptions of the samples also indicate homogeneity. Because the samples were not split into subsegments, this could not be confirmed statistically.

5.4 COMPARISON OF TRANSFER HISTORY WITH ANALYTICAL RESULTS

Given the very limited number of analyses from the auger sampling, only a few comparisons were possible between the HTCE estimates and the results from the analysis of the solids in tank 241-BX-106. Table 5-2 compares the HTCE estimates with the 1995 auger sample analytical results for density, percent water, and total alpha. Because total alpha was not listed in the HTCE, the comparison was made between the 1995 total alpha activity result and the HTCE value for total plutonium. Because the HTCE value does not include any other alpha emitters, the high RPD (144%) is not unexpected. The other two analytes agreed quite well.

Table 5-2. Comparison of Historical Estimates with December 1995 Auger Sample Analytical Results for Tank 241-BX-106.

Analyte	December 1995 Analytical Result	HTCE Estimate	Relative Percent Difference
RADIONUCLIDES	**μCi/g**	**μCi/g**	**%**
Total Alpha	0.590	0.0963 (as Pu)	144
PHYSICAL PROPERTIES			
Bulk Density	1.64 g/mL	1.63 g/mL	1.8
Weight Percent Water	38.69%	38.1%	1.5

If one assumes that the water in the sludge is from interstitial liquid and that the composition of the interstitial liquid is the same as the supernate, the analytical data can be used to estimate a lower bound for concentrations in the tank. Table 5-3 lists these minimum estimated concentrations calculated from the March 1995 grab sampling results and compares them with the HTCE estimate. If the two sets of concentrations are consistent, the HTCE estimates should be higher than the calculated minimum estimated concentrations. The two estimates are generally consistent with each other. Only the HTCE TIC estimate is lower than the minimum expected from the grab sample analysis. For components that are generally insoluble, the HTCE concentration estimates should be much higher than the estimated minimum concentrations, while for soluble components the numbers should be closer. The values for iron and strontium appear to be consistent with this expectation. The

HTCE estimates for aluminum, sodium, and the anions are considerably higher; this may be due to the presence of precipitated salts expected in the BY saltcake.

Table 5-3. Comparison of Historical Estimates with Estimated Minimum Concentrations Calculated from March 1995 Analytical Results

Analyte	Estimated Minimum Concentration[1]	HTCE Estimate
METALS	**μg/g**	**μg/g**
Aluminum	3,340	32,100
Iron	< 10	890
Sodium	78,000	1.65E+05
IONS	**μg/g**	**μg/g**
Chloride	1,700	2,500
Fluoride	167	627
Hydroxide	13,500	99,100
Nitrate	55,200	2.21E+05
Nitrite	32,000	44,400
Phosphate	< 1,230	5,860
Sulfate	< 1660	10,600
RADIONUCLIDES	**μCi/g**	**μCi/g**
^{137}Cs	82.5	119
^{90}Sr	0.138	72.4
$^{239/240}Pu$	< 0.00622	0.0963[2]
CARBON	**μg C/g**	**μg C/g**
TIC	6,110	4,680[3]
TOC	1,170	4,050

Notes:

[1]Calculated from supernate grab sample analysis assuming that all the water in the solids is from interstitial liquid and the composition of interstitial liquid is the same as the concentration of the supernate.
[2]Total plutonium estimate.
[3]Calculated from carbonate estimate.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

The two auger samples retrieved from tank 241-BX-106 and analyzed at the 222-S Laboratory were acquired to meet the requirements of the safety screening DQO (Dukelow et al. 1995). The two liquid grab samples were sampled and analyzed to meet the requirements of the waste compatibility DQO (Carothers 1994). A discussion of the specific requirements of the DQOs and a comparison of the analytical data to defined concentration limits is presented in this section.

5.5.1 Safety Evaluation

Data criteria identified in the safety screening DQO (Dukelow et al.1995) are used to assess the safety of the waste in tank 241-BX-106. For a proper safety assessment, the DQO requires a vertical profile of the tank waste and sampling from two widely spaced risers. As stated in Section 5.3, sampling was performed through two widely spaced risers, and a vertical profile was not required because the depth of the waste was so shallow. The augers were therefore analyzed on a whole auger basis. Four primary analyses are required by the safety screening DQO to be performed on the tank waste. These include: DSC for evaluation of energetics, TGA for measurement of weight percent water, a determination of total alpha activity, and density. For two of the required analyses, DSC and total alpha activity, a notification limit was established by the DQO which, if exceeded, warrants further investigation and analyses to evaluate tank safety. A final requirement of the safety screening DQO is to determine the flammability of the tank headspace vapors (Sasaki 1995).

The safety screening DQO has established a notification limit of 480 J/g, dry weight basis (i.e., a ΔH of -480 J/g, dry weight basis) for exothermic reactions detected during the DSC analysis. No exothermic reactions were found in any of the tank 241-BX-106 samples. The presence of moisture reduces the potential for propagating exothermic reactions in the waste. The safety screening DQO no longer specifies a notification limit for weight percent water. However, TGA is still required by the DQO because it is needed to convert exothermic energy values to a dry weight basis. The weight percent water means for augers 95-AUG-49 and 95-AUG-50 were 36.20 and 41.18 percent, respectively. The overall tank mean was 38.69 percent.

The criticality safety issue can be assessed through the total alpha activity results. The safety screening DQO stipulates a notification limit of 1 g/L. Using the highest measured density of 1.68 g/mL (to provide the most stringent limit), this limit was converted to 36.6 μCi/g. All total alpha activity results were well below this limit, as none of the samples contained total alpha activity greater than 0.652 μCi/g. The one-sided 95 percent confidence interval upper limits were also far below the notification limit.

The final safety screening requirement, determination of the flammability of the tank headspace gases, was satisfied by taking combustible gas meter readings of tank headspace

samples. A result of zero percent of the lower flammability limit was obtained, more than satisfying the DQO requirement.

In summary, all safety screening requirements were satisfied and no issues were identified. Table 5-4 provides a comparison of the safety screening criteria to the 1995 analytical results.

Table 5-4. Safety Screening Data Quality Objective Criteria.[1]

Safety Issue	Primary Decision Threshold	Decision Criteria Threshold	Analytical Results
Ferrocyanide/ Organics	Total fuel content	480 J/g	no exotherms
Criticality	Total alpha	1 g/L[1] (36.6 μCi/g)	Highest value = 0.652 μCi/g
Flammable Gas	Flammable Gas	25% of the lower flammability limit	0%

Note:

[1]Although the actual decision criterion listed in the DQO is 1 g/L, total alpha is measured in μCi/g rather than g/L. To convert the notification limit for total alpha into a number more readily usable by the laboratory, it was assumed that all alpha decay originates from ^{239}Pu. Using the highest sample density of 1.68 g/mL and the specific activity of ^{239}Pu (0.0615 Ci/g), the notification limit becomes 36.6 μCi/g. The following equation displays the derivation method of the notification limit:

$$\left[\frac{1\ g}{L}\right]\left[\frac{1\ L}{10^3\ mL}\right]\left[\frac{1\ \ mL}{density\ g}\right]\left[\frac{0.0615\ Ci}{1\ g}\right]\left[\frac{10^6\ \mu Ci}{1\ Ci}\right] = \frac{61.5\ \mu Ci}{density\ g}.$$

Another factor in assessing the safety of the tank waste is the heat generation and waste temperature. Heat is generated in the waste from radioactive decay. An estimate of 200 watts (684 Btu/hr) was provided in the HTCE (Brevick et al. 1994a). A second estimate of 735 watts (2,510 Btu/hr), based on tank temperatures, was obtained from Kummerer (1994). For the 1995 sampling events, only the supernate samples were analyzed for ^{137}Cs and ^{90}Sr; these analyses were not required for the auger sampling event. If one assumes that the water in the sludge is from interstitial liquid and that the composition of the interstitial liquid is the same as the supernate, the analytical data can be used to estimate a lower bound for the tank's heat generation rate. Using these assumptions, a minimum heat generation rate of 92 watts (314 Btu/hr) is estimated. All estimates are well under the 40,000 Btu/hr limit differentiating high-heat from low-heat tanks (Bergmann 1991). Because an upper temperature limit is exhibited (see Section 2.4.2), it may be concluded that any heat generated from radioactive sources throughout the year is dissipated.

5.5.2 Waste Compatibility Evaluation

The 1995 grab samples were analyzed in accordance with the requirements of *Data Quality Objectives for the Waste Compatibility Program* (Carothers 1994). After the analyses were completed, the waste compatibility DQO was revised. The sampling results were evaluated against the revised DQO (Fowler 1995). The waste compatibility DQO (Fowler 1995) identifies criteria to ensure (1) continued operability during waste transfer and waste concentration and (2) safety problems are not created as a result of commingling wastes under interim storage. The grab samples were analyzed to ensure that the supernatant in tank 241-BX-106 could be transferred to interim storage in a double-shell tank. The waste compatibility assessment was performed and documented in Jones (1995).

Analytical results that can be compared directly to waste compatibility criteria are listed in Table 5-5. The results presented in Table 5-3 differ slightly from the results presented in Jones (1995) because the table uses the revised analytical results in Rollison (1995b) and a more conservative estimate of waste compositions. However, these differences do not affect the assessment of the data. In addition to comparing the compatibility criteria to the tank 241-BX-106 sample results, the compositions of all the wastes to be mixed together were examined to ensure that the final waste mixture will also be in compliance with the criteria (Jones 1995).

Other compatibility issues evaluated in Jones (1995) included: (1) determination that the heat generation rate of the waste mixture would not exceed the 20,700-watt (70,000-Btu/hr) limit for the receiver tank; (2) determination that the waste mixture would not exceed a TOC concentration of 10 g C/L when concentrated to double-shell slurry feed; and (3) ensuring that the waste could be successfully pumped without transfer line plugging. The wastes were found to be in compliance with the compatibility requirements and the tank was stabilized by the removal of supernatant in July 1995.

Table 5-5. Waste Compatibility Data Quality Objective Criteria.[1]

Issue	Program Requirement	Analytical Result
Criticality	Pu $\leq$ 0.013 g/L	< 2.00E-04[2]
Flammable gas accumulation	SpG < 1.3	1.27
Energetics	Exotherm/endotherm ratio < 1	0
	No separable organics	no separable organics
Corrosivity	If NO_3^- < 1.0 mol/L then 0.01 mol/L < OH^- $\leq$ 8 mol/L and 0.011 mol/L $\leq$ NO_2^- $\leq$ 5.5 mol/L. If 1.0 mol/L < NO_3^- $\leq$ 3.0 mol/L then 0.1 x NO_3^- $\leq$ OH^- < 10 mol/L and OH^- + NO_2^- $\geq$ 0.4 x NO_3^-	NO_3^- = 1.79 mol/L OH^- = 1.59 mol/L NO_2^- = 1.40 mol/L
TRU segregation	$^{239/240}Pu$ + ^{241}Am < 100 nCi/g	< 33.8 nCi/g
Phosphate waste	If PO_4^{-3} > 0.1 mol/L, then waste is not to be mixed with high salt (Na^+ > 8.0 mol/L) waste	< 0.0258 mol/L

Note:

[1]Results are from Rollison (1995b). Average results are used except where less than results were reported; the highest result or less than value was used in these cases.
[2]Assumes all $^{239/240}Pu$ is ^{239}Pu and uses an activity of 0.0615 Ci/g to convert from Ci to g.

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6.0 CONCLUSIONS AND RECOMMENDATIONS

The waste in tank 241-BX-106 has been sampled and analyzed for the purposes of safety screening according to the requirements listed in the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). The tank was auger sampled in December 1995. Because of the shallow depth of the waste and the resulting small amount of sample recovered, the analyses were performed on a whole-auger basis. The safety screening DQO required analyses for percent water, energetics, total alpha activity, density, and flammable gas concentration to assess tank safety. All samples were analyzed at the Westinghouse Hanford Company 222-S Laboratory.

All analyses met the requirements of the safety screening DQO. No exothermic reactions were observed in the DSC analysis. The average percent water value by TGA was 38.7 percent. The highest total alpha activity measured was 0.652 μCi/g, well below the DQO notification limit of 36.6 μCi/g. Finally, the flammability of the tank headspace gases was zero percent of the lower flammability limit.

A minimum tank heat load of 92 watts (314 Btu/hr) was estimated from ^{137}Cs and ^{90}Sr analyses of the supernate; ^{137}Cs and ^{90}Sr analyses of the auger samples was not required. Estimated tank heat load values of 200 watts (684 Btu/hr) and 735 watts (2,510 Btu/hr) are listed in the HTCE (Brevick et al. 1994a) and Kummerer (1994), respectively. All estimates are well below the 11,700-watt (40,000-Btu/hr) limit separating high-heat and low-heat load tanks (Bergmann 1991).

The results of the March 1995 grab samples were evaluated by Westinghouse Hanford Company East Systems Engineering. The evaluation determined that the waste met all compatibility criteria, and recommended that supernatants from tank 241-BX-106, along with liquids from tanks 241-BY-103, 241-BY-105, and 241-BY-106, be pumped to tank 241-AN-101 (Jones 1995). Stabilization of tank 241-BX-106 was completed in July 1995.

The analytical results for the safety screening of the auger samples and compatibility analysis of the grab samples were all well below notification limits. Based on the results of the analyses and the decision criteria of the safety screening DQO, the waste in tank 241-BX-106 may be categorized as "safe."

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