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

Jim G. Field
Westinghouse Hanford Company, Richland, WA 99352
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Abstract: This document summarizes information on historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-BX-109. Sampling and analyses meet Safety Screening and Historical Data Quality Objectives. This report supports requirements of Tri-Party Agreement Milestone M-44-09.

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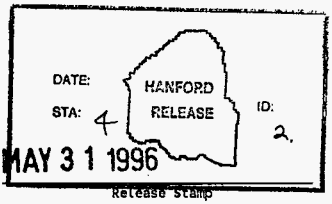

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Tank Characterization Report for Single-Shell Tank 241-BX-109

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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-109, and presents the analytical results of the April 1995 sampling and analysis effort. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-09 (Ecology et al. 1996).

Tank 241-BX-109 is a single-shell underground waste storage tank located in the 200 East Area BX Tank Farm on the Hanford Site. It is the third tank in a three-tank cascade series that includes tanks 241-BX-107 and 241-BX-108. Unknown waste (probably first-cycle decontamination waste supernatant) was initially added in November 1950 from tank 241-BX-108. Tank 241-BX-109 received uranium recovery (UR) waste from U Plant during this same period. During 1964, tank 241-BX-109 received supernatant (UR or PUREX cladding waste, based on the historical record) from tanks 241-BX-105 and 241-C-102. Between 1964 and 1969, tank 241-BX-109 received cesium recovery waste from B Plant. Finally, the tank received water from an unknown source in 1973. Several transfers from tank 241-BX-109 to other tanks occurred between 1953 and 1968 (see Section 2.3.1). Tank 241-BX-109 was declared inactive in 1978.

Table ES-1. Description and Status of Tank 241-BX-109.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1946-1947
In-service	1950
Diameter	23 m (75 ft)
Maximum operating depth	5.2 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom Shape	Dish
Ventilation	Passive
TANK STATUS	
Total waste volume	730 kL (193 kgal)
Supernatant volume	0 kL (0 kgal)
Saltcake volume	0 kL (0 kgal)
Sludge volume	730 kL (193 kgal)
Drainable interstitial liquid volume	49 kL (13 kgal)
Waste surface level	1.66 m (65.4 in.)
Median temperature (April 1995 - April 1996)	22 °C (71 °F)
Integrity	Sound
Watch List	None
SAMPLING DATES	
Push-mode core samples	April 1995
SERVICE STATUS	
Partial isolation	June 1985
Interim stabilized	September 1990

A description and the status of tank 241-BX-109 are given in Table ES-1 and Figure ES-1. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains 730 kL (193 kgal) of waste. The total amount is composed of 49 kL (13 kgal) of drainable interstitial liquid, and 730 kL (193 kgal) of sludge (Hanlon 1996). Current surveillance data and observations appear to support these amounts.

This report summarizes the collection and analysis of a set of samples that were obtained in April 1995. The sampling event was performed to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994), *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995), and *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology* (Kupfer et al. 1995).

The sampling effort consisted of the acquisition of two core samples of four segments each by the push-mode core sampling method. Core 85 was taken from riser 2, and core 84 from riser 7. Hydrostatic head fluid was used in the sampling process.

The analytical results showed no violations of the safety screening data quality objective limits. The overall tank mean weight percent water was 50.3. Out of 32 samples none yielded percent water results below 17 percent. The lowest weight percent water result (43.7 percent) came from the upper half of segment 2 core 85 (sample number S95T000789). The highest detected total alpha activity (0.138 μCi/g) came from the lower half of segment 2 core 85 (sample number S95T000787). The upper limit to a one-sided 95 percent confidence interval on the mean alpha activity for segment 2 core 85 was 0.424 μCi/g, much

less than the 41.0-μCi/g limit. No exothermic reactions were noted in the differential scanning calorimetric analyses (Schreiber 1996), and the flammability in the tank head space was measured at 0 percent of the lower flammability limit (LFL). The historical gateway analysis passed for all analytes.

Based on current analyses of cesium and strontium, the tank heat load produced by radioactive decay is calculated to be 1.35 kW (4,600 Btu/hr), which is less than the limit of 11.7 kW (39,960 Btu/hr), the boundary between high- and low-heat tanks (Bergmann 1991). Surveillance data show that the average temperature of the tank between May 1994 and April 1996 was 21.8 °C (71.3 °F), with a maximum temperature of 25.7 °C (78.5 °F) during the same time period. Since August 1995, the tank surface level has remained steady at 1.66 m (65.4 in.).

Table ES-2. Summary of Analytical Results and Projected Inventories.[1]

Analyte	Mean Concentration	RSD (Mean)	Projected Inventory[2]
Safety Screening Analytes			
Water content	50.3 weight percent (solids portion of sample)	3.9 %	5.43E+05 kg
	60.1 weight percent (drainable liquid portion of sample)	N/A	N/A
Total alpha activity	< 0.045 μCi/g	N/A	< 48 Ci
Fuel content	No exothermic reactions		
Flammable gas	0 %		
Anions	**μg/g**	**%**	**kg**
Chloride	1.32E+03	2.9	1.46E+03
Fluoride	<5.28E+02	NA	<5.73E+02
Nitrate	1.93E+05	2.8	2.10E+05
Nitrite	1.81E+04	11.8	1.96E+04
Phosphate	2.52E+04	4.2	2.72E+04
Sulfate	1.76E+04	2.9	1.90E+04
Metals	**μg/g**	**%**	**kg**
Aluminum	2.48E+03	26.8	2.68E+03
Calcium	3.03E+03	17.2	3.27E+03
Chromium	1.37E+02	6.6	1.47E+02
Iron	2.19E+04	5.6	2.38E+04
Phosphorous	2.08E+04	4.6	2.25E+04
Silicon	7.39E+02	7.9	7.99E+02
Sodium	1.05E+05	1.5	1.13E+05
Sulfur	6.28E+03	1.6	6.78E+03
Uranium	1.42E+04	12.8	1.53E+04

Table ES-2. Summary of Analytical Results and Projected Inventories.[1]

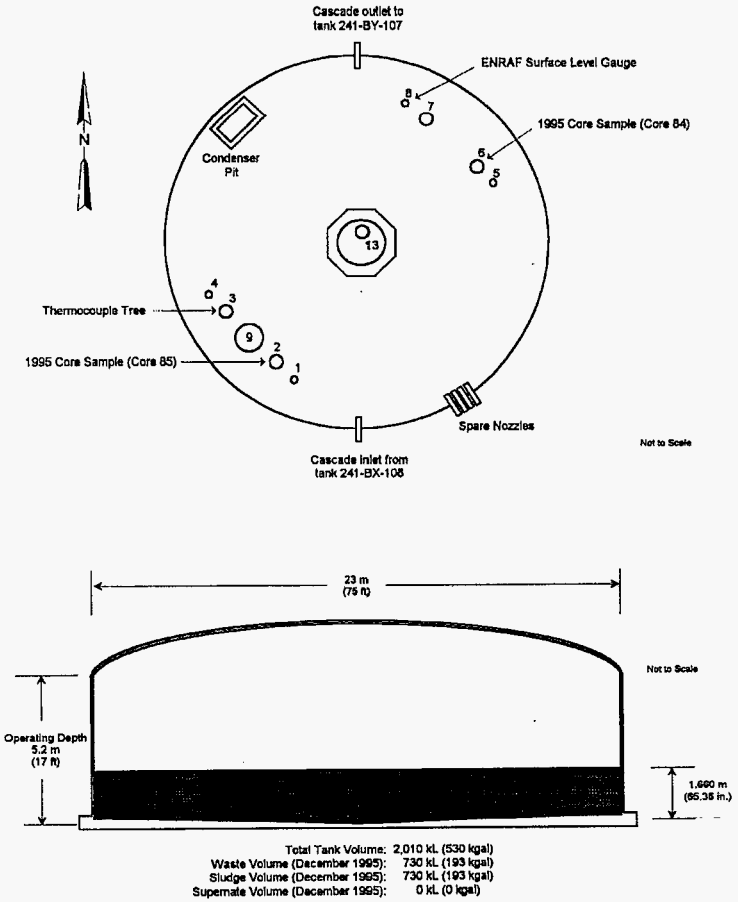
Analyte	Mean Concentration	RSD (Mean)	Projected Inventory[2]
Radionuclides	**μCi/g**	**%**	**Ci**
Cesium-137	1.29E+01	12.8	1.39E+04
Strontium-89/90	1.78E+02	1.5	1.92E+05
Physical Properties			
Density[3]	1.48	N/A	N/A
Carbon	**μg C/g**	**%**	**kg C**
Total Organic Carbon	4.10E+02	7.3	4.42E+02

Notes:

N/A = Not applicable
RSD (Mean) = Relative standard deviation of the mean

[1]Schreiber (1996) and Appendix A
[2]Calculation based on 1.48 g/mL sludge density and 730 kL sludge.
[3]Average of Core Composite Analyses (Table A-53).

Figure ES-1. Profile of Tank 241-BX-109.



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LIST OF TERMS

1C	first-cycle decontamination waste
2C	second-cycle decontamination waste
ANOVA	analysis of variance
Bsltck	242-B Evaporator saltcake
Btu/hr	British thermal units per hour
C	Celsius
Ci	curies
Ci/L	curies per liter
CSR	cesium recovery waste
CW	PUREX cladding waste
DL	drainable liquid
DQO	data quality objective
DSC	differential scanning calorimetry
EDTA	ethylenediaminetetraacetic acid
F	Fahrenheit
ft	feet
g	grams
g/cc	grams per cubic centimeter
g/L	grams per liter
g/mL	grams per milliliter
gal	gallons
GEA	gamma energy analysis
HDW	Hanford Defined Wastes
HEDTA	N-(hydroxylethyl)-ethylenediaminetriacetic acid
HHF	hydrostatic head fluid
HTCE	Hanford Tank Content Estimate
IC	ion chromatography
ICP/AES	inductively coupled plasma atomic emission spectrometry
in.	inches
J/g	joules per gram
kg	kilograms
kgal	kilogallons
kL	kiloliters
kW	kilowatts
L	liters
LFL	lower flammability limit
m	meters
M	molar
mg	milligrams
mL	milliliters
mm	millimeters

LIST OF TERMS (Continued)

mol/L	moles per liter
NTA	nitrilotriacetic acid
ppm	parts per million
PUREX	Plutonium-Uranium Extraction Plant
QC	quality control
Rev.	Revision
RPD	relative percent difference
RSD	relative standard deviation
TBP	tributyl phosphate
TGA	thermogravimetric analysis
TLM	Tank Layer Model
TOC	total organic carbon
UR	uranium recovery waste
WSTRS	Waste Status and Transaction Record Summary
wt%	weight percent
μCi/g	microcuries per gram
μg/g	micrograms per gram
μg/mL	micrograms per milliliter
μmol/g	micromoles per gram
ΔH	change in enthalpy

1.0 INTRODUCTION

This characterization report presents an overview of single-shell tank 241-BX-109 and its waste components. It provides estimated concentrations and inventories for the waste constituents based on the latest sampling and analysis activities and background tank information. Tank 241-BX-109 was sampled in April 1995 to satisfy the requirements of *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994), *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995), and *Strategy for Sampling Hanford Site Tank Wastes for Developmental Disposal Technology* (Kupfer et al. 1995).

Tank 241-BX-109 was declared inactive in 1978. Interim stabilization and intrusion prevention have been completed; therefore, the composition of the waste should not change substantially until pretreatment and retrieval activities commence. The analyte concentrations reported in this document reflect the best estimates of the waste composition based on available analytical data and historical models. This report supports the requirements of *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) Milestone M-44-09.

1.1 PURPOSE

The purpose of this report is to summarize the information about the use and contents of tank 241-BX-109. 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-109.

1.2 SCOPE

The April 1995 core sampling event for tank 241-BX-109 supported the evaluation of the tank waste according to the safety screening and historical data quality objectives (DQOs). From the two core samples, four primary analyses were performed as directed in the *Tank 241-BX-109 Sample and Analysis Plan* (Schreiber 1995). These analyses were differential scanning calorimetry (DSC) (to evaluate fuel level and energetics), thermogravimetric analysis (TGA) (to determine moisture content), total alpha activity (to evaluate criticality potential), and flammable gas. Selected sub-segment and composite samples were analyzed as directed for historical analyses. From these samples, principal anions, cations, water content, and radionuclides were measured to evaluate past process history data and a prediction model developed from it.

Lithium analysis was conducted by inductively coupled plasma atomic emission spectrometry (ICP/AES) to check for sample contamination by the hydrostatic head fluid used during the push-mode core sampling process. Bromide was also analyzed as a secondary check for hydrostatic head fluid infiltration.

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2.0 HISTORICAL TANK INFORMATION

This four-part section describes tank 241-BX-109 based on historical information. The first part of this section details the current condition of the tank. The next part discusses the tank's design, transfer history, and the process sources that contributed to the tank waste, and includes 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 constitute the third part. The final part 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 provided to evaluate the heat-generating characteristics of the waste.

2.1 TANK STATUS

As of December 31, 1995, tank 241-BX-109 contained an estimated 730 kL (193 kgal) of waste classified as non-complexed (Hanlon 1996). Liquid waste volume was estimated using a combination of a surface level gauge and photographic evaluation. Solid waste volume was estimated using a photographic evaluation method on September 17, 1990. The amounts of various waste phases existing in the tank are presented in Table 2-1.

Table 2-1. Estimated Tank Contents. (Hanlon 1996)

Waste Form	Estimated Volume[1]	
	kL	(kgal)
Supernatant liquid	0	(0)
Drainable interstitial liquid	49	(13)
Drainable liquid remaining	49	(13)
Pumpable liquid remaining	30	(8)
Sludge	730	(193)
Saltcake	0	(0)

Note:

[1]For definitions and calculation methods refer to (Hanlon 1996, Appendix C).

Tank 241-BX-109 was declared inactive in 1978. Tank 241-BX-109 is a sound tank that is interim stabilized with intrusion prevention (interim isolation) completed. This passively ventilated tank is not on any Watch Lists. All monitoring systems were in compliance with documented standards as of December 31, 1995 (Hanlon 1996).

2.2 TANK DESIGN AND BACKGROUND

Information for this section is taken from Anderson (1990), Alstad (1993), Leach and Stahl (1993), and tank construction drawings.

The BX Tank Farm was constructed between 1946 and 1947 in the 200 East Area and contains twelve 100-series tanks. These tanks have 2,010-kL (530-kgal) capacities, 23-m (75-ft) diameters, and 5.2-m (17-ft) operating depths. The BX Tank Farm was designed for non-boiling waste with a maximum fluid temperature of 104 °C (220 °F).

Tank 241-BX-109 is third in a three-tank cascade series that includes tanks 241-BX-107 and 241-BX-108. A 7.6-cm (3-in.) cascade overflow line connects these three tanks. The bottom center elevation of tank 241-BX-107 is 187.45 m (615 ft), cascading to tank 241-BX-108 with a bottom elevation of 187.15 m (614 ft), cascading to tank 241-BX-109 with a bottom elevation of 186.84 m (613 ft). Tank 241-BX-109 then cascades to tank 241-BY-107. The height of the cascade overflow is approximately 4.6 m (15 ft) from the tank bottom and 61 cm (2 ft) below the top of the steel liner.

The tank has a dished bottom with a 1.2 m (4 ft) radius knuckle. The tank was constructed with a primary mild steel liner and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. A three-ply asphalt waterproofing was applied over the foundation and steel tank. The tank ceiling dome was covered with three applications of magnesium zincfluorosilicate wash. Lead flashing was used to protect the joint where the steel liner meets the concrete dome. Asbestos gaskets were used to seal the manholes in the tank dome. The tank was waterproofed on the sides and top with tar and welded wire reinforced gunite. This tank was covered with approximately 2.64 m (8.65 ft) of overburden.

Tank 241-BX-109 has 10 risers ranging in diameter from 10 cm (4 in.) to 1.1 m (42 in.). Table 2-2 shows riser numbers, sizes, and descriptions. Figure 2-1 shows a plan view of the riser configuration. The surface level of the waste is monitored through riser 8 with a manual ENRAF[1] surface level gauge. Risers 2, 6, and 7 are tentatively available for intrusive tank activities (Lipnicki 1996). Three risers are 30 cm (12 in.) in diameter. A tank cross-section showing the approximate waste level, along with a schematic of the tank equipment, is found in Figure 2-2.

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

Figure 2-1. Riser Configuration for Tank 241-BX-109.

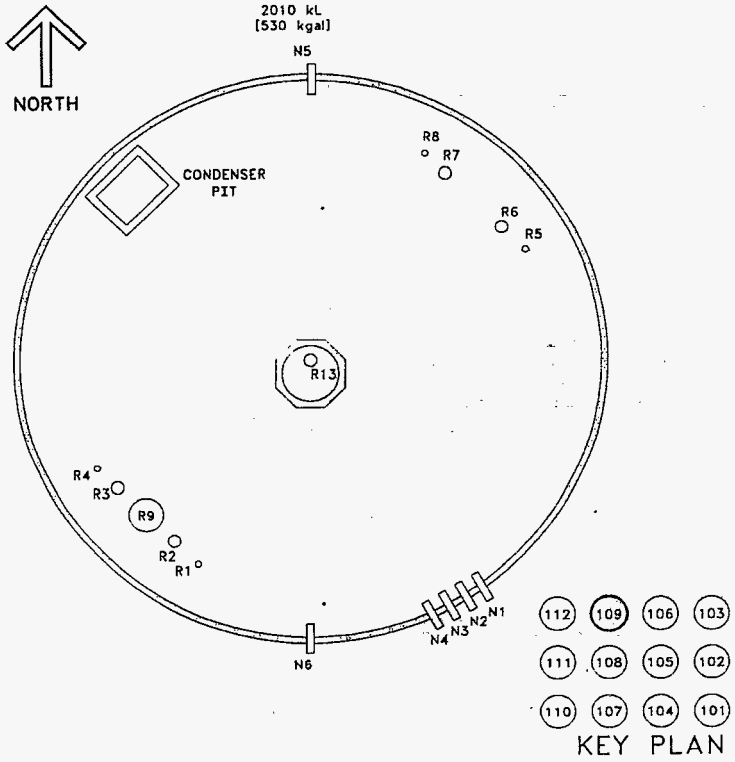


Table 2-2. Tank 241-BX-109 Risers. (Alstad 1993)

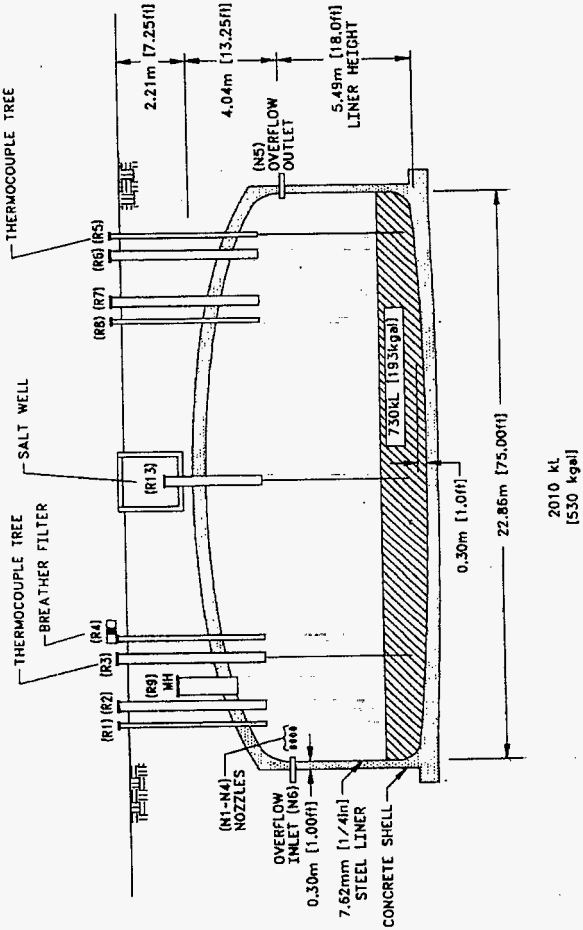
Riser Number	Diameter (inches)	Description and Comments
R1	4	Flange, benchmark
R2	12	Flange
R3	12	Thermocouple tree
R4	4	Breather filter, G1 housing
R5	4	Thermocouple Tree
R6	12	Flange
R7	12	Flange/B-222 observation port
R8	4	ENRAF® 854 surface level gage, benchmark
R9	42	Manhole, below grade
R13	12	Saltwell screen and pump
Nozzle Number	**Diameter (inches)**	**Description and Comments**
N1	3	Spare nozzle
N2	3	Spare nozzle
N3	3	Spare nozzle
N4	3	Line V-345
N5	3	Cascade outlet nozzle
N6	3	Cascade inlet nozzle

Other source:

Hanford Drawing:

Vitro, 1988, *Piping Waste Tank Isolation 241-BX-109*, Drawing H-2-73319, Rev. 3, Vitro Engineering Corporation.

Figure 2-2. Tank 241-BX-109 Configuration.



2.3 PROCESS KNOWLEDGE

These sections present the history of waste transfer for tank 241-BX-109. Section 2.3.1 and Table 2-3 present the major transfers that involved tank 241-BX-109.

2.3.1 Waste Transfer History

Waste was initially added to tank 241-BX-109 in November 1950 via the cascade of first-cycle decontamination (1C) supernatant waste from tank 241-BX-108. From the first quarter of 1953 until the third quarter of 1954, supernatant waste was transferred from tank 241-BX-109 to tank 241-B-106. During the same period, tank 241-BX-109 received waste consisting of 1C and uranium recovery (UR) waste, consisting of primarily tributyl phosphate (TBP) waste, from U Plant. Tank 241-BX-109 supernate also cascaded to tank 241-BY-107 during this time period. According to historical records, the supernate was most likely UR waste. During the fourth quarter of 1957, supernatant was pumped to tank 241-C-101, scavenged with ferrocyanide, then pumped to tank 241-C-108 for in-tank settling of co-precipitated cesium (scavenging transfer T29).

During the second quarter of 1964, tank 241-BX-109 was sluiced to tank 241-A-102, removing 204 kL (54 kgal) of solid waste. Tank 241-BX-109 received supernatant PUREX cladding waste (CW) from tank 241-BX-105 during the second quarter of 1964. During the fourth quarter of 1964, tank 241-BX-109 received supernatant PUREX cladding waste (CW) from tank 241-C-102. During the fourth quarter of 1967 and the first quarter of 1969, tank 241-BX-109 received cesium recovery waste from B Plant. From the fourth quarter of 1968 until the fourth quarter of 1973, supernate (CSR and/or IX waste) was transferred from tank 241-BX-109 to tank 241-BX-106. The final transfer occurred during the second quarter of 1973, when tank 241-BX-109 received water from an unknown source. Tank 241-BX-109 was removed from service in 1977 and declared inactive in 1978 (Agnew et al. 1995, and Anderson 1990).

Table 2-3. Summary of tank 241-BX-109 Waste Received History.[1] (Agnew et al. 1995)

Transfer Source	Waste Type Received	Time Period	Estimated Waste Volume	
			kL	(kgal)
B Plant / Cascade from 241-BX-108	First-cycle decontamination waste from $BiPO_4$ operations	1950	2,006	(530)
221-U	Uranium recovery waste in the form of TBP waste	1953 - 1954	23,762	(6,277)
241-BX-105	Supernatant CW from PUREX operations	1964	401	(106)
241-C-102	Supernatant CW from PUREX operations	1964	909	(240)
B Plant	Supernatant waste from cesium recovery operations	1967 & 1969	943	(249)

Note:

[1]Waste volumes and types are best estimates based on historical data.

2.3.2 Historical Estimation of Tank Contents

The following is an estimate of the contents in tank 241-BX-109 based on historical transfer data. The historical data used for the estimate are *Waste Status and Transaction Record Summary (WSTRS) for the Northeast Quadrant* (Agnew et al. 1995), *Hanford Defined Wastes* (HDW) (Agnew 1996), and the *Tank Layer Model* (TLM) (Agnew et al. 1996). As of May 1996 the *Historical Tank Content Estimate* (HTCE) and support documents (Brevick et al. 1995a and 1995b) are being revised to reflect Agnew et al. (1996). The WSTRS is a compilation of available waste transfer and volume status data. The HDW provides the assumed typical compositions for all the separate wastes types. In most cases, the available data are incomplete, which reduces the reliability of the transfer data and the modeling results derived from it. These sources of data are used to model the waste deposition process and generate an estimate of the tank contents. The errors introduced in each step of the process make these model predictions only estimates that require further evaluation using analytical data.

Based on the HTCE and the TLM, tank 241-BX-109 contains 603 kL (159 kgal) of UR waste and 130 kL (34 kgal) of 1C waste. Figure 2-3 shows a graph representing the estimated waste type and volumes for the tank layers. The 1C waste, predicted as the bottom layer, should contain primarily sodium, aluminum, hydroxide, nitrate, nitrite, iron, bismuth, and phosphate. The 1C layer will also contain trace amounts of calcium, fluoride, carbonate, sulfate, silicate, and chloride. Also, minute quantities of plutonium, strontium and cesium will produce a small activity. The predicted top layer of UR waste should contain significant concentrations of uranium, sodium, iron, sulfate, nitrate, nitrite, carbonate, phosphate, and hydroxide. Traceable amounts of potassium, chloride, cesium, plutonium, and strontium will also be present in this layer. The cesium and strontium will produce a modest amount of radiological activity. Aluminum and bismuth should largely be absent from the UR waste. Table 2-4 shows waste constituents and concentrations predicted by Agnew et al. (1995). Because transfers of 1C waste to tank 241-BX-109 were from cascading, it is likely that most 1C solids settled out in tank 241-BX-107 and were not transferred to tank 241-BX-109. Further, two of the primary transfers of UR waste directly from U Plant occurred before the first solids measurements were taken. Consequently, the bottom layer of waste in tank 241-BX-109 is likely UR not 1C waste.

Figure 2-3. Tank Layer Model for tank 241-BX-109 (Agnew et al. 1995).

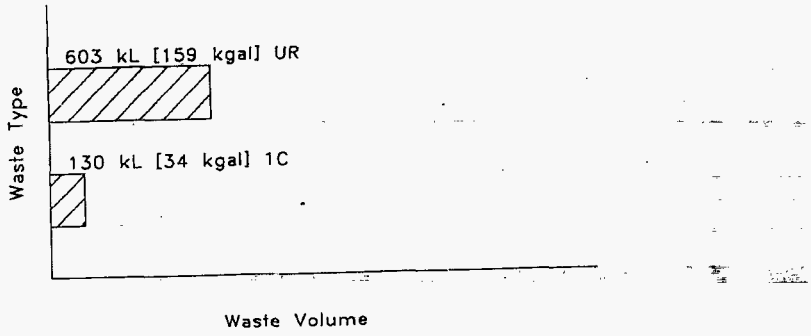


Table 2-4. Tank 241-BX-109 Inventory Estimate (Agnew et al. 1996) (2 sheets).

Solids Composite Inventory Estimate			
Physical Properties			
Total solid waste	9.49E+05 kg (193 kgal)		
Heat load	0.111 kW (379 Btu/hr)		
Bulk density[1]	1.30 (g/cc)		
Water wt%	62.4		
Total organic carbon wt% carbon (wet)	2.54E-04		
Chemical Constituents	**mol/L**	**ppm**	**kg**
Na^{1+}	3.57	6.32E+04	5.99E+04
Al^{3+}	0.15	3.15E+03	2.99E+03
Fe^{3+} (total Fe)	1.33	5.71E+04	5.42E+04
Cr^{3+}	3.18E-03	127	121
Bi^{3+}	7.78E-03	1.25E+03	1.19E+03
La^{3+}	0	0	0
Hg^{2+}	1.02E-05	1.58	1.5
Zr (as $ZrO(OH)_2$)	1.24E-03	86.8	82.4
Pb^{2+}	0	0	0
Ni^{2+}	1.44E-03	65.2	61.9
Sr^{2+}	0	0	0
Mn^{4+}	0	0	0
Ca^{2+}	0.29	9.02	8.56E+03
K^{1+}	1.35E-02	407	386
OH^-	5.14	6.72E+04	6.38E+04
NO_3^-	1.87	8.94E+04	8.48E+04
NO_2^-	0.35	1.23E-04	1.17E+04
CO_3^{2-}	0.43	1.98E+04	1.88E+04
PO_4^{3-}	0.25	1.85E+04	1.76E+04

Table 2-4. Tank 241-BX-109 Inventory Estimate (Agnew et al. 1996) (2 sheets).

Chemical Constituents	mol/L	ppm	kg
SO_4^{2-}	0.12	8.57E+03	2.68E+05
Si (as SiO_3^{2-})	8.82E-03	191	2.58E+03
F^-	3.38E-02	494	4.65E+03
Cl^-	7.96E-02	2.17E+03	7.75E+03
$C_6H_5O_7^{3-}$	0	0	0
$EDTA^{4-}$	0	0	0
$HEDTA^{3-}$	0	0	0
$glycolate^-$	0	0	0
$acetate^-$	0	0	0
$oxalate^{2-}$	0	0	0
DBP	2.29E-05	4.69	0
Butanol	0	1.31	0
NH_3	8.12E-04	10.6	0
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents			
Pu		5.57E-03 (μCi/g)	8.81E-02 (kg)
U	0.115 (M)	2.11E+04 (μg/g)	2.00E+04 (kg)
Cs	6.26E-03 (Ci/L)	4.82 (μCi/g)	4.57E+03 (Ci)
Sr	1.82E-02 (Ci/L)	14.0 (μCi/g)	1.33E+04 (Ci)

Notes:

These estimates have not been validated and should be used with caution.

2.4 SURVEILLANCE DATA

Tank 241-BX-109 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 are significant because they provide the basis for determining tank integrity.

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

2.4.1 Surface Level Readings

Since August 1995, the surface level of the waste in tank 241-BX-109 is monitored with a manual ENRAF® surface level gauge through riser 8. Prior to this, surface level was monitored with a Food Instrument Corporation gauge through riser 8. The maximum allowed deviations from the 1.66-m (65.3-in.) baseline are an increase or decrease of 5 cm (2 in.).

The ENRAF® surface level readings from August 1995 to April 1996 have remained steady with the readings ranging between 165.8 cm (65.3 in.) and 166.4 cm (65.5 in.). A graph representing the level measurement history is presented in Figure 2-4. The surface level on April 8, 1996 was 166.1 cm (65.4 in.). Tank 241-BX-109 has four drywells but no liquid observation well.

2.4.2 Internal Tank Temperatures

Eleven thermocouples are available for recording temperature data in tank 241-BX-109. No elevations are known for the thermocouples. Two thermocouple trees were present in the tank in September 1990. The thermocouples were out of service in January 1991 due to the absence of a relay box. Prior to May 1994, only one temperature reading was recorded per thermocouple in July 1993.

Temperature data are available from May 1994 to April 1996. Currently, temperature data are recorded automatically on a daily basis. The average temperature for this period was 21.8 °C (71.3 °F), the minimum temperature was 16.7 °C (62.1 °F), and the maximum temperature was 25.7 °C (78.3 °F). The average temperature for the past year (April 95 through April 96) was 21.6 °C (70.9 °F), with a minimum temperature of 16.7 °C (62.1 °F) and a maximum temperature of 25.5 °C (77.9 °F). The maximum temperature for April 9, 1996 was 22.7 °C (72.9 °F) recorded by thermocouple 2, and the minimum temperature was 16.8 °C (62.2 °F) recorded by thermocouple 11. A graph of the weekly high temperatures between March 1994 and May 1996 is provided as Figure 2-5.

Figure 2-4. Tank 241-BX-109 Level History.

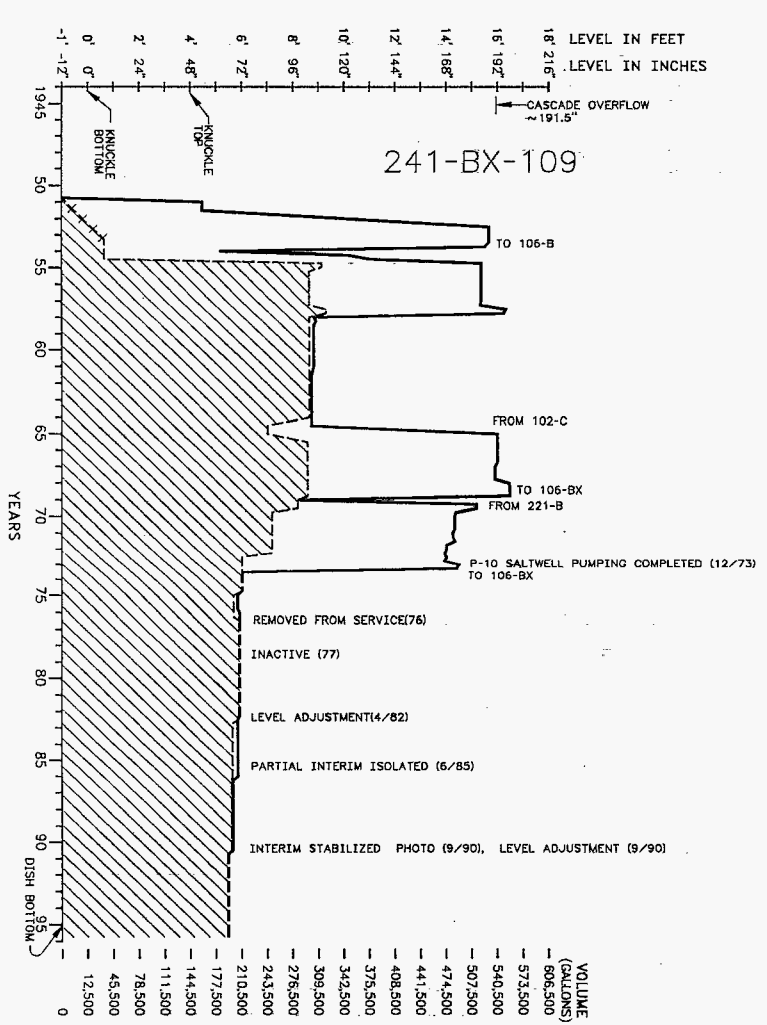
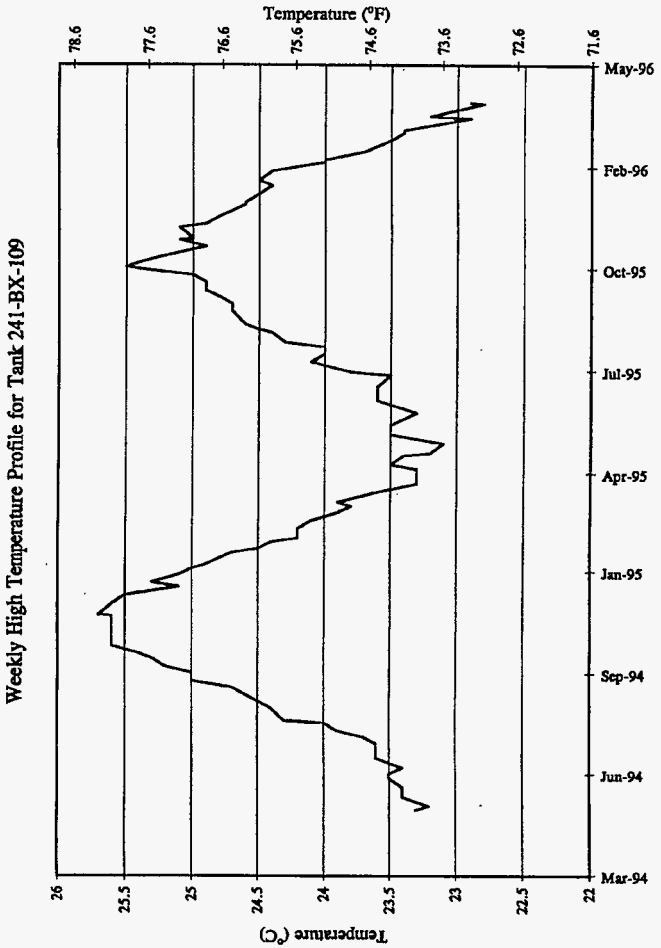


Figure 2-5. Tank 241-BX-109 Weekly High Temperature Plot.



2.4.3 Tank 241-BX-109 Photographs

The 1982 photographic montage of the tank 241-BX-109 interior indicates a dark, pockmarked sludge surface with pools of clear brown liquid. Equipment visible in the photograph includes a saltwell screen, a temperature probe, a flange gasket, a pump, a Food Instrument Corporation probe, and an old level measurement tape. Since the photographs were taken, 15 kgal of saltwell liquid were pumped to tank 241-AN-101; as a result, the tank appearance may have changed.

3.0 TANK SAMPLING OVERVIEW

This section describes sampling and analysis events for tank 241-BX-109. Historically, waste samples from single-shell tanks have been analyzed to characterize the supernate, sludge, and/or saltcake in each tank. Data were compiled for samples obtained from the late 1950s to the present. Data have been located for two samples from tank 241-BX-109 prior to the 1995 push-mode core sample. The samples were reported on May 20, 1975 and March 16, 1990. Analytical results for 1995 core samples are presented in Appendix A. Data tables for 1975 and 1990 sample analyses are presented in Appendix B.

3.1 DESCRIPTION OF THE 1975 SAMPLING EVENT (Buckingham 1975)

A description of the technique used to extract the sample from tank 241-BX-109 was not available. The sample was a liquid with approximately 20 percent insoluble solids. Because this sample was taken before 1989, it should not be assumed to be representative of the present waste composition within the tank.

3.1.1 Sample Handling

The procedure described for this sample was obtained from an Atlantic Richfield Hanford Company internal memo from J. S. Buckingham to W. P. Metz (Buckingham 1975). The sample was heated to redissolve the solids. However, 20 percent remained undissolved, so the sample was slurried and aliquots of the slurry were taken. 50 mL of the slurried solution was diluted with 50 mL of water. The diluted sample was then filtered through an 0.25-micron filter. Analyses were made on the final filtered solution. The filter was washed with four 25-mL portions of 0.05 M NaOH.

3.1.2 Sample Analysis

The reported sample was used for determining actinide concentrations in the alkaline waste solutions of the tanks. The samples revealed the presence of sodium compounds of aluminate, nitrite, nitrate, hydroxide, carbonate, phosphate, fluoride, and silicate. The primary radionuclides were cesium, americium, and plutonium. Results and comparisons with other liquid analyses are included in Appendix B.

3.2 DESCRIPTION OF THE 1990 SAMPLING EVENT (Weiss 1990)

The 1990 sample was a process grab sample taken for tank transfer information. The sample was a liquid with a small amount of solids (less than one percent). No further information regarding sampled riser, sampling depth, or type of sample was available from the historical records.

No procedure was available on how the sample was handled by the laboratory. The reported OH^- for the sample was a result of a measured neutralization titration at approximately pH 7.5. The reported value is low for normal OH^- concentrations in the tanks. The sample contained primarily sodium, nitrate, nitrite, and cesium, with smaller concentrations of phosphate, sulfate, carbonate, and strontium. Summary analytical information and comparisons with other liquid sample analyses are included in Appendix B. Additional comparisons are not warranted because there is currently no supernate in the tank and interstitial liquids constitute less than 7% of the tank volume (Hanlon 1996).

3.3 DESCRIPTION OF 1995 SAMPLING EVENT

Two push-mode core samples were collected from tank 241-BX-109 in April 1995. Cores 84 and 85 were collected from risers 6 and 2, respectively. Both cores were sent to the 222-S Laboratory for analysis. Hydrostatic head fluid (HHF) was used during the sampling process. In addition to the cores, a field blank and an HHF blank were sent to the 222-S Laboratory. Chain-of-custody forms were generated for each sample and can be located in Schreiber (1996).

The push-mode core sampling method was chosen as the most appropriate method to obtain a vertical profile of the tank waste, as required by the safety screening DQO (Babad and Redus 1994). Primary safety screening analyses are: total alpha activity to determine criticality; DSC to ascertain the fuel energy value; TGA to obtain the total moisture content; and dome vapor surveys to determine flammable gas percent. In addition, comprehensive ICP/AES, GEA and ion chromatography (IC) analyses were required for selected sub-segment and composite samples to assess data for compliance with historical requirements, and as a check for HHF contamination. Sampling and analytical requirements from the applicable DQOs are summarized in Table 3-1.

3.3.1 Sample Handling

The riser 6 core sample, identified as core 84, was extruded by the 222-S Laboratory April 10 and 11, 1995. The sample was composed of four separate segments that were labeled with distinct identification numbers. Segments one through four were identified as samples 95-073 through 95-076, respectively (with one segment as the top segment in the tank). No liner liquid or free-standing (drainable) liquid was observed in these segments, and no extrusion difficulties were encountered.

Table 3-1. Integrated Data Quality Objective Requirements for Tank 241-BX-109.[1]

Sampling Event	Applicable DQOs	Sampling Requirements	Applicable References
Push-mode core sampling	SAFETY SCREENING ▸Energetics ▸Moisture Content ▸Total Alpha ▸Flammable Gas HISTORICAL PRETREATMENT	Core samples from a minimum of two risers separated radially to the maximum extent possible.	Babad and Redus (1994) Simpson and McCain (1995) Kupfer et al. (1995)

Note:
[1]Schreiber (1995)

The riser 2 core sample, identified as core 85, was extruded by the 222-S Laboratory April 11, 17 and 18, 1995. The sample was composed of four separate segments that were labeled with distinct identification numbers. Segments 1 through 4 were identified as samples 95-077 through 95-080, respectively. All segments had less than 5 mL of liner liquid. Drainable liquid was observed in segments 1 and 4.

Table 3-2 describes cores 84 and 85, including segment numbers, phase (solid or liquid), color, texture, and amount of material recovered. Photos of extruded samples are included in Appendix C.

Table 3-2. Cores 84 and 85 Push-Mode Core Sample Description (2 sheets).[1]

Segment	Sample ID	Sample Total Weight (grams)	Segment Description
Core 84, Riser 6			
1	95-073	177.04	Recovered 177 g of dark brown solids and no drainable liquid. Solids were 21.6 cm (8.5 in.) in length, were soft and maintained shape. Upon subsampling, cream-colored material was discovered on the inside of the sample.
2	95-074	402.23	Recovered 48 cm (19 in.) of solids and no drainable liquid. Lower half solids were dark to medium brown. Upper half solids were light to medium brown. All solids were wet, and maintained shape.
3	95-075	414.68	Recovered 48 cm (19 in.) of solids and no drainable liquid. Lower half solids were light brown (tan). Upper half solids were medium brown with some tan material on the surface. All solids were soft, wet, and creamy.
4	95-076	402.49	Recovered 48 cm (19 in.) of solids and no drainable liquid. Lower half solids were medium brown. Upper half solids were tan. All solids were soft, wet, and creamy.

Table 3-2. Cores 84 and 85 Push-Mode Core Sample Description (2 sheets).[1]

Segment	Sample ID	Sample Total Weight (grams)	Segment Description
Core 85, Riser 2			
1	95-092	184.82	Recovered 148 g of medium to dark brown solids and 36 g of drainable liquid. Solids were 20.3 cm (8 in.) in length, were soft, wet and did not maintain shape. Drainable liquid was medium brown.
2	95-093	394.48	Recovered 48 cm (19 in.) of solids and no drainable liquid. The first 10 to 13 cm (4 to 5 in.) of solids were light brown, followed by 15 to 18 cm (6 to 7 in.) of medium brown material. The remaining solids were medium to dark brown. All solids were soft, wet, and maintained shape. Consistency and texture were uniform.
3	95-094	425.88	Recovered 48 cm (19 in.) of solids and no drainable liquid. Solids were light brown, soft, wet, and maintained shape. Consistency and texture were uniform.
4	95-095	392.31	Recovered 317 g and 40.6 to 43.2 cm (16 to 17 in.) of solids and 74.77 g of drainable liquid. Solids had a creamy consistency and were soft, wet and maintained shape.

Note:
[1]Schreiber (1996.)

The field blank was collected on April 17, 1995 and received at the 222-S Laboratory the next day. A total of 275.69 grams of a clear, colorless drainable liquid was recovered. There was no liner liquid and no problems were noted during extrusion.

All archiving requirements listed in the tank characterization plan were performed, including those prescribed to satisfy the pretreatment DQO.

3.3.2 Sample Analysis

For a safety evaluation, the safety screening DQO requires determination of the total alpha activity, energetics, water content, and flammable gas. Because HHF was used during the sampling process, some of the percent water results may be biased high. To determine the extent of possible HHF contamination, the samples were analyzed for lithium by ICP/AES and for bromide by IC. Lithium bromide is used as a tracer in the HHF; the HHF should be the only source of lithium or bromide in the waste.

All segments were split into half-segments for analysis. Each half segment was homogenized and analyzed separately. The first segments from cores 84 and 85 were not split because only 21.5 and 20 cm (8.5 and 8 in.) of solids were retrieved. Drainable liquid (free-standing liquid in the sample matrix) samples from the first and fourth segments of core 85 were also analyzed.

Composite analyses and ICP acid digestion analyses for core 84 and core 85 segment 3 (lower half) were conducted to meet historical data quality requirements.

Appendix A lists the samples and the analyses performed. Sample procedures are given in Table 3-3.

Table 3-3. Analytical Procedures.[1]

Analysis	Instrument	Preparation Procedure	Procedure Number
Energetics by DSC	Mettler™ Perkin-Elmer™	Direct	LA-514-113, Rev. B-1 LA-514-114, Rev. B-0
Percent water by TGA	Mettler™ Perkin-Elmer™	Direct	LA-560-112, Rev. A-2 LA-514-114, Rev. B-0
Total alpha activity	Alpha proportional counter	LA-549-141, Rev. D-0	LA-508-101, Rev. D-2
Flammable gas	Combustible gas analyzer	Direct	WHC-IP-0030 IH 1.4 and IH-2.1[2]
Total organic carbon	Coulometer	Persulfate oxidation	LA-342-100, Rev. C-0
Metals by ICP/AES	Inductively coupled plasma spectrometer	LA-549-141, Rev. D-0	LA-505-151, Rev. D-2 LA-505-161, Rev. A-1
Anions by IC	Ion chromatograph	LA-504-101, Rev. D-0	LA-533-105, Rev. C-2 LA-533-105, Rev. D-1

Notes:

N/A = Not applicable
Rev. = Revision

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

[1]Schreiber (1995)
[2]Safety Department Administrative Manuals;
IH 1.4, Industrial Hygiene Direct Reading Instrument Survey
IH 2.1, Standard Operating Procedure, MSA Model 260 Combustible Gas and Oxygen Analyzer.

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4.0 ANALYTICAL RESULTS

4.1 OVERVIEW

This section presents the analytical results associated with the sampling of tank 241-BX-109. The required analyses are based on the DQO process. The DQOs that govern the sampling and subsequent sample analysis for tank 241-BX-109 are *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994), *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995), and *Interim Data Quality Objectives for Waste Pretreatment and Vitrification* (Kupfer et al. 1995).

Analyses were performed on the half-segment level, with the exception of the first segment from cores 84 and 85, which were not subdivided and considered whole segments. Table 4-1 details the tabulated location of data within this document.

Table 4-1. Data Locations.

Analyte	Tabulated Location
Percent moisture	Tables 4-2 and 4-3
Energetics	Table 4-4
Flammable gas	Table 4-10
Anions/IC	Table 4-5
Cations/ICP	Tank 4-6
1995 analytical data set	Appendix A
Hydrostatic head fluid contamination check data	Table 4-7 through 4-9 and Appendix B

An overall mean was calculated for all analytes by averaging concentration values for the core samples obtained from risers 6 and 2. The results for each sample and duplicate pair were averaged, giving a half-segment mean. The half-segment means were then averaged to obtain a segment mean, and the segment means were averaged to obtain a core mean. The two core means were then averaged to obtain an overall tank mean. Individual sample results and their respective duplicate results are reported in Appendix A of this report, while only a mean value and a relative standard deviation (RSD) for each sample are reported in this section.

In addition to the overall mean, a projected tank inventory was calculated. The projected inventory is the product of the concentration of the analyte, the amount of waste in the tank (730 kL) (Hanlon 1996), and the average core composite bulk density (1.48 g/mL) (Table A-53).

4.2 RADIONUCLIDES/TOTAL ALPHA

The total alpha analyses were performed on a fusion digested sample with an alpha proportional counter according to procedure LA-508-101, Rev. D-2. All total alpha results were well below the DQO notification limit of 41.0 μCi/g. The overall tank average for total alpha was < 4.46E-02 μCi/g. The highest observed value of any sample or duplicate was 0.138 μCi/g for sample number S95T000787 (core 85, lower half of segment 2). The upper limit to a one-sided 95 percent confidence on the mean was 0.424 μCi/g. Appendix A presents the data for total alpha from tank 241-BX-109. The table identifies the sample by number, core, segment, and segment portion. Quality control problems were noted in Schreiber (1996). However, corrective actions were not requested for any of these analyses because of the low alpha activities compared to the notification limit. Further discussion of quality control tests and results can be found in Section 5.1.2.

Gamma isotopic analyses and Strontium -89/90 analyses were also conducted. Cesium-137 was detected at an average concentration of 12.9 μCi/g and the strontium-89/90 concentration was 178 μCi/g. All other radionuclides were below analytical detection limits.

4.3 THERMODYNAMIC ANALYSES

Physical analyses required by the tank characterization plan (Schreiber 1996) included TGA and DSC. Bulk density was performed on core composites. Percent solids, particle size, and rheology were neither requested nor performed.

4.3.1 Thermogravimetric Analysis

In TGA, the mass of a sample is measured while its temperature is increased at a constant rate. Any decrease in the weight of a sample represents a loss of gaseous matter from the sample either through evaporation or through a reaction that forms gas phase products.

Weight percent (wt%) water by TGA was performed under a nitrogen purge using procedure LA-560-112, Rev. A-2, and LA-514-114, Rev. B-0. Analytical results satisfied the safety screening DQO requirement of greater than 17 percent moisture for all samples. The overall average for the tank solids was 50.3 wt% water, with an overall RSD of the mean of 3.8 percent. Although no calculations of the 95 percent confidence interval lower limit have

been performed, out of 32 samples none yielded percent water results below the notification limit. The lowest percent water result was 43.7 percent, from sample number S95T000789 (core 85, upper half of segment 2). Results for the solids TGA are presented in Table 4-2.

Table 4-2. Solids Thermogravimetric Analysis Results for Tank 241-BX-109 (2 sheets).[1]

Sample Number	Sample Location Segment (Portion)	Temperature Range °C	Result % H_2O	Duplicate % H_2O	Mean % H_2O
Core 84, Riser 6					
1325	Core Composite	30-180	51.23	50.64	50.94
0759	1 (Whole)	30-160	48.07	49.92	49.00
0762	2 (Lower half)	30-240	51.17	50.89	51.03
0765	2 (Upper half)	25-218	50.78	50.03	50.41
0768	3 (Lower half)	28-220	49.52	48.67	49.09
0771	3 (Upper half)	30-210	48.91	49.02	48.97
0774	4 (Lower half)	23-228	47.98	48.87	48.42
0777	4 (Upper half)	30-185	52.78	52.92	52.85
Core 85, Riser 2					
1468	Core Composite	30-180	51.03	50.55	50.79
0780	Whole Segment	30-180	52.56	52.78	52.67
0786	2 (Lower half)	30-180	51.36	49.58	50.47
0789	2 (Upper half)	30-220	50.65	43.72	47.19
0836	3 (Lower half)	30-180	51.23	50.86	51.05
0839	3 (Upper half)	30-180	50.98	51.70	51.34
0847	4 (Lower half)	30-190	51.29	51.39	51.34
0850	4 (Upper half)	30-180	53.46	54.63	54.05 (49.00)[3]
Mean wt% water = 50.3%[2]					
Relative standard deviation of the mean = 3.8 %					

Notes:

[1]Schreiber (1996)

[2]Average does not include core composites

[3]HHF correction made using bromide concentrations (Schreiber 1996).

Drainable liquid was found in segments 1 and 4 of core 85. However, the liquid in segment 4 was determined to be entirely due to HHF intrusion (see Section 5.1.2). As a result, these values are not included in Table 4-3 or in average water content values for drainable liquids. The average for the drainable liquid (free-standing liquid in the sample matrix) in segment 1 samples was 60.1 wt% water. Drainable liquid results are provided in Table 4-3 and Appendix A.

Table 4-3. Drainable Liquid Thermogravimetric Analysis Results for Tank 241-BX-109.[1]

Sample Number	Core	Segment	Temperature Range °C	Result % H_2O	Duplicate % H_2O	Mean % H_2O
0783	85	1		67.45	57.73	62.59
Mean wt% water = 62.59%						

Note:

[1]Schreiber (1996)

4.3.2 Differential Scanning Calorimetry

In DSC analysis, heat absorbed or emitted by a substance is measured while the substance is exposed to a linear increase in temperature. The onset temperature for an endothermic (characterized by or causing the absorption of heat) or exothermic (characterized by or causing the release of heat) event is determined graphically.

Analyses by DSC were performed under a nitrogen atmosphere using procedure LA-514-113, Rev. B-1, using a Mettler™ Model 20 differential scanning calorimeter, and procedure LA-514-114, Rev. B-0, using Perkin-Elmer™ equipment. No exothermic reactions were observed. No problems with quality control were noted.

The DSC results are presented in Table 4-4. The sample weight, temperature at maximum enthalpy change, and the magnitude of the enthalpy change are provided for each transition. The first transition represents the reaction associated with the evaporation of free and interstitial water. Positive enthalpy changes in Table 4-4 represent endothermic processes. 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.

Table 4-4. Differential Scanning Calorimetry Results for Tank 241-BX-109[1,2]. (3 Sheets)

Sample Number	Sample Location Segment (Portion)	Run	Sample Weight (mg)	Transition 1 Peak (°C)	Transition 1 ΔH (J/g)	Transition 2 Peak °C	Transition 2 ΔH (J/g)	Transition 3 Peak °C	Transition 3 ΔH (J/g)
Core 84, Riser 6									
1325	Core Composite	1	12.08	119.1	1237.4	289.1	31.1		
		2	14.41	114.9	1074.4	289.0	28.9		
0759	1 (Whole)	1	16.06	119.8	1300.5	284.9	44.3		
		2	27.94	117.3	1090.3	284.6	83		
0765	2 (Upper half)	1	13.97	118.1	887.6	289.7	13.7		
		2	14.32	118.1	978.6	287.1	26.5		
0762	2 (Lower half)	1	18.77	121.6	1324.3	288.7	43		
		2	15.64	120.0	1267.2	288.9	31		
0771	3 (Upper half)	1	9.46	102.8	845.5	290.1	21.9	379.2	139.2
		2	22.6	121.2	1076.9	290.5	23.9		
0768	3 (Lower half)	1	10.68	101.6	815.8	290.4	36.4	386.2	40.5
		2	10.07	107.7	825.9	277.2	35.9		
0777	4 (Upper half)	1	10.16	105.4	1183.7	291.0	52.5		
		2	9.01	103.7	1195.9	291.1	53.0		
0774	4 (Lower half)	1	10.55	108.2	994.9	292.9	24.7		
		2	10.74	114.3	1018.1	292.1	31.0		

Table 4-4. Differential Scanning Calorimetry Results for Tank 241-BX-109[1,2]. (3 Sheets)

Sample Number	Sample Location Segment (Portion)	Run	Sample Weight (mg)	Transition 1 Peak (°C)	Transition 1 ΔH (J/g)	Transition 2 Peak °C	Transition 2 ΔH (J/g)	Transition 3 Peak °C	Transition 3 ΔH (J/g)
Core 85, Riser 2									
1468	Core Composite	1	12.12	105.1	1291.3	284.9	47.9		
		2	20.35	121.5	1143.9	284.7	48.6		
0780	Whole Segment	1	8.97	115.4	1285.1	283.1	59.3		
		2	9.43	113.3	1212.1	283.1	51.6		
0789	2 (Upper half)	1	9.17	115.6	1335.3	285.1	57.0		
		2	10.27	132.8	1139.8	285.1	46.1		
0786	2 (Lower half)	1	8.36	137.5	870.4	285.0	48.7		
		2	12.57	115.0	1270.9	285.0	45.5		
0839	3 (Upper half)	1	21.39	119.3	1137.9	284.8	32.3		
		2	15.25	117.8	1232.3	284.8	32.4		
0836	3 (Lower half)	1	14.97	120.5	1166.8	287.0	32.1		
		2	18.60	121.7	1206.8	286.8	34.0		
0850	4 (Upper half)	1	29.96	119.3	1156.6	284.7	31.5		
		2	33.51	109.3	1113.1	284.5	28.1		

Table 4-4. Differential Scanning Calorimetry Results for Tank 241-BX-109[1,2]. (3 Sheets)

Sample Number	Sample Location	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3	
	Segment (Portion)			Peak (°C)	ΔH (J/g)	Peak °C	ΔH (J/g)	Peak °C	ΔH (J/g)
Core 85, Riser 2									
0847	4 (Lower half)	1	17.98	115.9	1049.9	285.0	34.5		
		2	20.35	117.3	1235.0	284.8	30.6		
0783	1 (Drainable liquid)	1	14.56	118.4	1292.7	284.2	27.7		
		2	13.78	116.8	1224.6	282.5	24.6		

Note:

[1]Schreiber (1996)

[2]Positive enthalpy changes represent endothermic processes.

4.3.3 Bulk Density/Specific Gravity

Measurements of bulk density were performed on composite samples from core 84 and core 85. For core 84, the bulk density was 1.46 g/ml. A value of 1.5 g/ml was found for core 85. The average specific gravity results of the two drainable liquid samples from core 85 were 1.035 and 1.268.

4.4 ION CHROMATOGRAPHY ANALYSIS

A summary of the results for this analysis is provided in Table 4-5. The full data set can be found in Appendix A.

The overall means, RSDs, and projected inventories given in Table 4-4 were taken from Appendix A. The overall means were derived by weighting each segment and core equally. The projected inventories were calculated using the composite density of 1.48 g/mL and a solid waste volume of 730 kL (193 gal) (Hanlon 1995). As expected, high concentrations of nitrate, nitrite, phosphate and sulfate were found (> 10,000 μg/g). Nitrate appears to make up about 20 wt% of the waste. The nitrate/nitrite ratio is about 10:1.

Table 4-5. Ion Chromatography Analytical Results.[1]

Analyte	Overall Mean μg/g	RSD (Mean) %	Projected Inventory kg
Chloride	1.32E+03	6.2	1.46E+03
Fluoride	<5.28E+02	N/A	<5.73E+02
Nitrate	1.93E+05	6.4	2.10E+05
Nitrite	1.81E+04	12.7	1.96E+04
Phosphate	2.52E+04	11.0	2.72E+04
Sulfate	1.76E+04	6.5	1.90E+04

Note:
[1]Schreiber (1996)

4.5 INDUCTIVELY COUPLED PLASMA (ICP) ANALYSIS

Metals/cations were detected using ICP analyses. Results for cations required by historical requirements or critical to mass balance calculations are provided in Table 4-6. Nickel was also detected at significant concentrations, but was not included because a nickel crucible was used for ICP fusion tests. The full suite of ICP analytes and results is included in Appendix A.

The overall means, RSDs and projected inventories given in Table 4-6 and Appendix A were derived as specified in Section 4.4.

Table 4-6. ICP Analytical Results[1]

Analyte	Overall Mean	RSD (Mean)	Projected Inventory
METALS	µg/g	%	kg
Aluminum	2.48E+03	47.8	2.68E+03
Calcium	3.03E+03	32.3	3.14E+03
Chromium	1.37E+02	11.8	1.47E+02
Iron	2.19E+04	8.9	2.38E+04
Phosphorous	2.08E+04	7.9	2.25E+04
Sodium	1.05E+05	2.6	1.13E+05
Sulfur	6.28E+03	1.2	6.78E+03
Uranium	1.42E+04	24.0	1.53E+04

Note:

Schreiber (1996).

4.6 ANALYSIS FOR HYDROSTATIC HEAD FLUID CONTAMINATION

Water was used as a hydrostatic head fluid (HHF) in the acquisition of core 84 and 85. Lithium bromide was added to the HHF to act as a tracer. Composite and segment analyses for lithium were performed in accordance with the sampling and analysis plan (Schreiber 1995) to detect contamination of the waste samples with HHF. Analytical data are shown in Appendix D.

4.6.1 Lithium

Lithium was analyzed by ICP using procedures LA-505-151, Rev. D-2, and LA-505-161, Rev. A-1. Samples were prepared in accordance with procedure LA-505-151. Four of the tank 241-BX-109 lithium samples shown in Table 4-7 have lithium results or detection limits that exceeded the notification limit of 100 μg/g specified in the sampling analysis plan (Schreiber 1995, Appendix A). The analytical results for lithium are presented in Appendix B. Note that no projected inventory was calculated for lithium. This is because lithium is not a constituent of the waste, but is an artifact of sampling operations.

Due to the potential incursion of HHF into these samples, bromide was requested as a secondary analysis.

Table 4-7. Tank 241-BX-109 Li Samples That Exceeded Notification Limits.

Sample Number	Core/Segment	Average Li (μg/g)
S95T000851	C85 S4 Upper Half	166.8
S95T000854	C85 S4 Drainable Liquid	1,550
S95T001329	C84 Composite	<228
S95T001471	C85 Composite	<390

4.6.2 Bromide

Bromide was analyzed by IC using procedure LA-533-105. Bromide analyses are required when lithium results exceed the notification limit listed in Schreiber (1995). Composite sample analyses and segment analyses are included in Appendix A. Bromium results for samples where Li notification levels were exceeded are shown in Table 4-8. Both core composites produced results that were below the detection limit. However, because of dilution factors used during these analyses, the bromium detection limits were higher than the bromide notification limit of 1,200 μg/g. To determine whether HHF intrusion occurred with these samples, a bromide concentration for the core composites was extrapolated from the IC calibration curve (Schreiber 1996). Results are included in Table 4-8.

As can be seen by the results in Table 4-8, segment 4 of core 85 was contaminated by the HHF used during the push-mode core sampling process. In fact, the drainable liquid sample from core 85, segment 4 is mostly HHF (the concentration of Br in the HHF blank was 23,600 μg/ml), indicating that the results from this subsegment are highly suspicious. Because the HHF added water to these samples, corrections to the TGA results were made for lithium and bromide results, and are reported in Table 4-9. It should be noted that lithium may precipitate out of solution, giving a biased low result.

Table 4-8. Tank 241-BX-109 Br Samples That May Have HHF Contamination.

Sample Number	Core/Segment	Average Br (μg/g)	Extrapolated Br (μg/g)
S95T001000	C85 S4 Upper Half	2,420	2,420
S95T001001	C85 S4 Drainable Liquid	22,000	22,000
S95T001326	C84 Composite	<6,600	0
S95T001469	C85 Composite	<2,710	1,035

Table 4-9. Correction to TGA Results Due to HHF Contamination.

Sample Number	Core/Segment	Original TGA Result	Corrected TGA Result Based on Li Results	Corrected TGA Result Based on Br Results
S95T000850	C85 S4 UH	54.05%	49.8%	49.0%
S95T000853	C85 S4 DL	87.63%	48.6%	0%

4.7 HEADSPACE VAPOR SAMPLING

A vapor survey was conducted in April 1996 to analyze headspace vapors below the riser. Results from the survey are shown in Table 4-6. The results show that gas concentration was at 0 percent of the lower flammability limit.

Table 4-10. Headspace Vapor Survey Results

Flammability	Results
LFL headspace	0%
Vapor	**Results**
TOC (headspace)	1.7 ppm
NH_3 (headspace)	20 ppm

Notes:
LFL = lower flammability limit
TOC = total organic carbon

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5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

The purpose of this chapter is to evaluate the overall quality and consistency of the available characterization results for tank 241-BX-109 and to assess and compare these results against historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

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

5.1.1 Field Observations

The safety screening DQO (Babad and Redus 1994) requirement that at least two widely spaced risers be sampled was fulfilled. Sample recovery was good for all segments from both risers. HHF intrusions above notification limits are identified in Section 4.6. It was determined that all of the drainable liquid in core 85, segment 4 was due to HHF intrusion (see Section 4.6).

5.1.2 Quality Control Assessment

The quality control assessment includes an evaluation of the four quality control checks (blanks, duplicates, spikes, and standards) performed in conjunction with the chemical analyses. This section provides only a general evaluation and summary of some key safety areas. The original data report (Schreiber 1996) should be consulted for more detailed quality control information. The Sampling and Analysis Plan (Appendix A of Schreiber 1995) establishes the specific accuracy and precision criteria for the four quality control checks. Samples that had one or more quality control results outside of the criteria have been flagged in Appendix A.

Several quality control results for the total alpha activity standard and spike recoveries were outside the quality control criteria. However, because the average of the results for all of these samples were orders of magnitude lower than the notification limits, no reruns were requested, and alpha activity was determined to be well below criticality notification levels (Schreiber 1996).

The precision (estimated by the relative percent difference [RPD], defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred) for the safety screening analytes also exceeded the limits for a few samples. There were no RPDs for DSC because there were no exothermic reactions.

Percent water had 3 results exceeding the RPD criterion, and total alpha activity had 2 results outside the limits. No reruns were performed on these samples because they were below the notification limits and no exotherms were detected. The total alpha activity violations were attributed to analyte concentrations near the detection limits (Appendix A). High precision is difficult to achieve when analyte concentrations are low, and thus RPD results are not meaningful.

Preparation blanks are used to identify any sample contamination that was introduced in the laboratory during the process of sample breakdown, digestion, and dilution. High bromium concentrations were detected, indicating HHF intrusion. Other than this, blank results indicated that contamination was not a problem.

Quality control results for IC and ICP analyses are included in Appendix A. Although some violations for standard recovery, spike recovery and RPD limits occurred (see Appendix A), all standards conducted were within the defined criterion. As with the safety screening analytes, several of the violations were attributable to the analytical results being near the detection limit.

Additional information is included in Schreiber (1996).

5.1.3 Data Consistency Checks

Comparisons of different analytical methods were conducted to assess the consistency and quality of the data. Data consistency checks included: radionuclide checks, comparing sulfur and phosphorous concentrations as determined by ICP/AES with sulfate and phosphate as measured by IC, and calculation of a mass and charge balance.

5.1.3.1 Comparison of Radionuclide Analyses. Gross beta composite analyses were compared with the sum of ^{137}Cs and twice $^{89/90}Sr$ composite analyses. As shown, the gross beta results for core 84 were within 1 percent of the sum of ^{137}Cs and twice $^{89/90}Sr$ results. Average core results were within 13 percent because a larger discrepancy was noted for core 85.

	Core 84	Core 85
^{137}Cs	14.25	13.55
$^{89/90}Sr$ x 2	362	350
^{137}Cs + $^{89/90}Sr$ x 2	376	364
Gross beta	373	320

Total alpha/plutonium-americium checks were not possible because plutonium was not analyzed separately. However, GEA results suggest alpha activity can be attributed solely to plutonium (i.e., no ^{241}Am was detected).

5.1.3.2 Comparison of ICP Sulfur and IC Sulfate Analyses. When the ICP sulfur results were converted to sulfate and compared to the ion chromatographic sulfate result shown below, the results differed by only 7 percent. This indicates that the sulfur is likely 100 percent soluble as the SO_4 ion.

$$SO_{4\,ICP} = 6,280\ (S_{ICP}) \times 3.0\ (SO_4{:}S \text{ atomic mass ratio}) = 18,840\ \mu g/g$$

$$SO_{4\,IC} = 17,600\ \mu g/g.$$

5.1.3.3 Comparison of ICP Phosphorus and IC Phosphate Analyses. When the ICP phosphorus results were converted to phosphate and compared to the ion chromatographic phosphate result, the results differed by 60 percent. This indicates that the phosphate is 40 percent soluble. For purposes of the mass and charge balance, the other 60 percent of the phosphorous was assumed to be in the form of calcium phosphate and iron phosphate.

$$PO_{4\,ICP} = 20,800\ (P_{ICP}) \times 3.06\ (PO_4{:}P \text{ atomic mass ratio}) = 63,650$$

$$PO_{4\,IC} = 25,200.$$

5.1.3.4 Comparison of ICP Uranium and Uranium by Phosphorescence. No discrepancies between these methods were observed within the uncertainty of these methods. The ICP value for uranium will be used in the mass balance and summary tables to be consistent with other analyte-based calculations.

5.1.3.5 Mass and Charge Balance. The principal objective in performing a mass and charge balance is to determine if the measurements are consistent. In calculating the balances, only sludge phase analytes listed in Tables 5-1 and 5-2 were considered because these analytes were all present at concentrations $>$ 1,000 $\mu g/g$. Nickel was also found at $>$ 1,000 $\mu g/g$, but was not included because a nickel crucible was used for analyses.

The normal assumption, that all cations except sodium are present in their most common hydroxide or oxide forms, resulted in calculating a low anion-to-cation ratio and did not appear to adequately account for non-soluble phosphates. As a result, it was assumed that calcium and iron are present as calcium phosphate and iron phosphate. Other analytes identified in Table 5-1 were assumed to be present in their most common hydroxide or oxide form. Concentrations of the assumed species were calculated stoichiometrically. There may be some argument whether or not certain species are hydroxides or oxides, but the difference in molecular weight has a minimal effect on the overall mass balance. Although smaller concentrations of other forms of the species are also present in the waste, they are not included in order to keep the mass-charge balance calculations simple and consistent.

Because precipitates are neutral species, all positive charge was attributed to the sodium cation. The anionic analytes listed in Table 5-2 were assumed to be present as sodium or potassium salts and were expected to balance the positive charge. Estimated acetate concentrations were derived from the total organic carbon analyses. The concentrations of the assumed species in Table 5-3, of the anionic species in Table 5-2, and the percent water were used to calculate the mass balance, shown in Table 5-3.

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

$$\text{Mass balance} = \%\ \text{Water} + 0.0001 \times \{\text{Total Analyte Concentration}\}$$
$$= \%\ \text{Water} + 0.0001 \times \{Al(OH)_3 + Ca_3(PO_4)_2 + Fe_3(PO_4)_2 + U_3O_8 + Na^+ + Cl^- + NO_3^- + NO_2^- + PO_4^{3-} + SiO^{2-}{}_3 + SO^{2-}{}_4 + C_2H_3O_2\}.$$

The analyte concentrations from the preceding equation totaled 442,650 μg/g. The mean weight percent water in the sludge was determined to be 50.3 percent. The mass balance resulting from adding the percent water to the total analyte concentration is 94.4 percent.

Table 5-1. Cation Mass and Charge Data.[1]

Analyte	Concentration[1] (μg/g)	Assumed Species	Concentration of Assumed Species (μg/g)	Charge (μmol/g)
Aluminum	2,150	$Al(OH)_3$	6,213	0
Calcium	2910	$Ca_3(PO_4)_2$	22,553	0
Iron	22,000	$Fe_3(PO_4)_2$	134,200	0
Sodium	105,000	Na^+	105,000	4,565
Uranium	14,200	U_3O_8	32,319	0
Totals			300,286	4,565

Note:

[1]Schreiber (1996)

Table 5-2. Anion Mass and Charge Data.[1]

Analyte	Concentration (μg/g)	Charge (μmol/g)
Chloride	1,320	37
Nitrate	194,000	3,129
Nitrite	18,100	393
Phosphate	25,200	796
Silicate[2]	2,001	53
Sulfate	17,600	366
TOC	1,001	17
Totals	259,233	4,791

Notes:
[1]Schreiber (1996)
[2]Calculated from ICP data

Table 5-3. Mass Balance Totals.

	Concentrations (μg/g)
Total from Table 5-1	300,286
Total from Table 5-2	259,233
Water	503,000
Grand Total	1,062,519

The charge balance is the ratio of total cations (microequivalents) to total anions (micro equivalents) with respect to the species listed below, which were assumed to be water soluble.

Total cations (microequivalents) = $Na^+/23.0$

The total cation charge, 4,565 μmol/g, is calculated in Table 5-1.

Total anions (microequivalents)
= $Cl^-/35.5+NO_3^-/62.0+NO_2^-/46.0+PO_4^{3-}/31.7+SiO_3^{2-}/38.0+SO_4^{2-}/48.0$

The total anion charge, 4,791 μmol/g, is calculated in Table 5-2.

The ratio of microequivalents of total cations to microequivalents of total anions was 0.95; a perfect charge balance would yield a ratio equivalent to 1.00. The slightly lower cation charge may be due to neglecting K^+.

The charge and mass balance results (95 and 1.06 percent recovery respectively) demonstrate good agreement among analyses when considering the uncertainty in the assumptions and numerous measurements that are used to arrive at the values. These results indicate that no large data inconsistencies or errors are present, and all major components have been analyzed and evaluated.

5.2 COMPARISON OF ANALYTICAL RESULTS FROM DIFFERENT SAMPLING EVENTS

Due to the lack of any historical sampling data, no comparisons between current and historical analytical results were possible.

5.3 TANK WASTE PROFILE

In April 1995, core samples were obtained from two widely spaced risers to obtain a vertical profile of the waste (Schreiber 1995). No problems were encountered during the sampling and extrusion, and sample recovery was good. Homogenization difficulties are often a cause of data variability; however, no homogenization problems were noted. A vertical profile was obtained from both risers, satisfying the sampling objective and allowing a statistical assessment of the vertical (and horizontal) distribution of the tank waste for several analytes. Information on the vertical disposition of the waste was also available from the TLM (Agnew et al. 1996) (Figure 2-3). According to the TLM, the waste is composed mostly of UR/TBP waste.

A statistical analysis of variance (ANOVA) was conducted on the core sample results in order to determine whether there were vertical variations in the analyte concentrations. The ANOVA model used was a random effects nested model, and only those analytes that had at least half of their individual measurements above the detection limit were analyzed. The ANOVA generates a p-value that is compared with a standard significance level ($\alpha = 0.01$). If a p-value is below 0.01, there is sufficient evidence to conclude that the sample means are

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Figure 5-1. Clustering Results for the BX-109 Cores.
(Refer to color figure in Appendix E, Figure E-3)

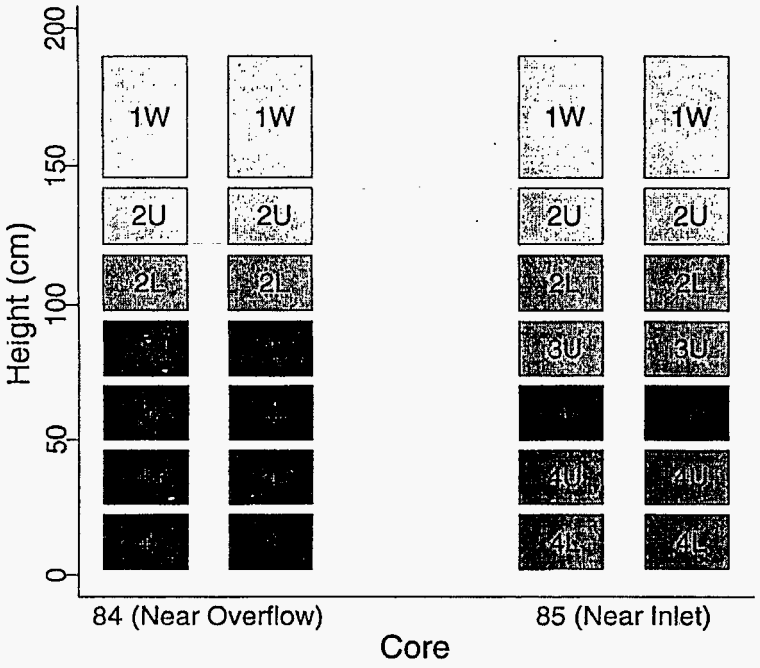

Table 5-4. Comparison of UR/TBP Waste Type with 1995, Segment 3, Upper Half Analytical Results for Tank 241-BX-109. (2 Sheets)

Analyte	Type UR/TBP Waste[1]	Threshold (10%)	Segment 3 Core 84	Segment 3 Core 85
IONS	µg/g	µg/g	µg/g	µg/g
Carbonate	23,332	2,333	--	--
Chloride	2,526	256	1,410	1,400
Fluoride	--	--	--	--
Nitrate	103,244	10,324	208,000	202,000
Nitrite	12,915	1,292	17,100	20,500
Phosphate	8,601	860	68,850	66,708
Sulfate	9,476	948	18,900	18,500
Silicate	--	--	--	--
METALS	µg/g	µg/g	µg/g	µg/g
Aluminum	--	--	885	693
Bismuth	--	--	--	--
Calcium	10,513	1,051	4,770	1,980
Chromium	115	11.5	169	112
Iron	66,801	6,680	27,900	24,100
Lanthanum	--	--	--	--
Lead	--	--	--	--
Manganese	--	--	--	--
Mercury	--	--	--	--
Nickel	65	6.5	4,860	5,150
Potassium	470	47	--	--
Sodium	62,431	6,243	110,000	128,000
Strontium	--	--	--	--
Uranium	25,287	2,529	21,700	16,600

Table 5-4. Comparison of UR/TBP Waste Type with 1995, Segment 3, Upper Half Analytical Results for Tank 241-BX-109. (2 Sheets)

Analyte	Type UR/TBP Waste[1]	Threshold (10%)	Segment 3 Core 84	Segment 3 Core 85
PHYSICAL PROPERTIES	%	%	%	%
Percent Water	63.84	6.38	48.97	51.34

Notes:

-- = Analyte was below detection limits, not analyzed for, or assumed negligible.

[1]Agnew et al. (1995). UR waste is tributyl phosphate waste from the solvent based uranium recovery operations in the 1950s.

particularly low for phosphate and nickel. Some of the nickel found in the 1995 analyses may be due to the use of a nickel crucible during ICP fusion analyses. Calcium and iron HDW estimates were higher than the analyses. These differences suggest a source term discrepancy between the flow sheets and the actual plant process.

Comparisons of core composite concentrations with TLM estimates were especially low (> 50%) for nitrate, phosphate, sulfate, and nickel (Table 5-5). TLM estimates were more than 50% higher than core composite concentrations for calcium and iron.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

Tank 241-BX-109 is classified as a non-Watch List tank. This section details the data needs as defined in *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994), *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995), and *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology* (Kupfer et al. 1995), and determines whether tank 241-BX-109 has been appropriately categorized concerning safety issues. The safety screening DQO establishes decision criteria or notification limits for concentrations of analytes of concern. The decision criteria are used to assess tank safety and determine if further investigation is warranted. If results from one of the primary analyses exceed any of the decision criteria, further analyses are conducted to assure the safety of the tank (Babad and Redus 1994).

Table 5-5. Comparison of TLM Estimates with Core Composite Results for Tank 241-BX-109. (2 Sheets)

Analyte	TLM Estimates[1]	Core 84 Composite	Core 85 Composite
IONS	µg/g	µg/g	µg/g
Carbonate	19,800	--	--
Chloride	2,170	1,260	1,220
Fluoride	494	--	--
Nitrate	89,400	222,000	203,000
Nitrite	12,300	18,000	20,200
Phosphate	18,500	67,932	66,708
Sulfate	8,570	19,300	18,300
Silicate	191	--	--
METALS	µg/g	µg/g	µg/g
Aluminum	3,150	1,550	2,260
Bismuth	1,250	--	--
Calcium	9,020	2,460	5,610
Chromium	127	--	--
Iron	57,100	20,400	22,500
Lanthanum	--	--	--
Lead	--	--	--
Manganese	--	--	--
Mercury	1.58	--	--
Nickel	65.2	4,860	5,150
Potassium	407	--	--
Sodium	63,200	113,000	115,000
Strontium	--	570	670
Zirconium	86.8	--	--
Uranium	21,100	17,400	18,600

Table 5-5. Comparison of TLM Estimates with Core Composite Results for Tank 241-BX-109. (2 Sheets)

Analyte	TLM Estimates[1]	Core 84 Composite	Core 85 Composite
PHYSICAL PROPERTIES	%	%	%
Percent water	57.9	50.94	50.79

Notes:

-- = Analyte was below detection limits, not analyzed for, or assumed negligible.

[1]Agnew (1996)

Table 5-6. Safety Screening DQO Decision Variables and Criteria.

Safety Issue	Primary Decision Variable	Decision Criteria Threshold	Analytical Result
Ferrocyanide/ Organics	Total fuel content	-481 J/g (115 calories/gram)	No exotherms
Organics	Percent moisture	17 wt%	Mean = 51.1 Lowest value = 43.7
Criticality	Total alpha	1 g/L (41.0 μCi/g)[1]	Mean = 0.045 μCi/g Highest value = 0.138 μCi/g
Flammable Gas	Flammable gas	< 25% of LFL	0%

Note:

[1]To convert g/L to μCi/g for total alpha, it was assumed that all alpha decay alpha decay originated from ^{239}Pu. Assuming a density of 1.5 g/ml and specific activity of ^{239}Pu (0.0615 Ci/g) the conversion is as follows:

$$\left(\frac{1\ g}{L}\right)\left(\frac{1\ L}{10^3\ ml}\right)\left(\frac{1\ ml}{1.5\ g}\right)\left(\frac{0.0615\ Ci}{1\ g}\right)\left(\frac{10^6\ \mu Ci}{1\ Ci}\right) = \frac{41.0\ \mu Ci}{density\ g}$$

5.5.1 Safety Evaluation

The primary analytical requirements identified in the safety screening DQO for a safety evaluation were energetics, total alpha activity, moisture content, and flammable gas concentration. The 1995 core sampling event and 1996 vapor survey are expected to meet all the requirements of this DQO. The requirement that a vertical profile of the tank be obtained from at least two widely spaced risers was also met. Table 5-6 lists the safety issue, the applicable analytes, their notification limits, and their analytical results.

The waste fuel energy value was determined by DSC. No exothermic reactions were observed in any of the 1995 safety screening samples.

Large amounts of moisture reduce the potential for propagating exothermic reactions in the waste. All of the primary and duplicate samples for percent water were above the 17 percent criterion as determined by TGA, with a mean concentration of 50.3 percent.

The potential for criticality can be assessed from the total alpha activity. None of the individual samples from the 1995 data contained total alpha activity greater than 0.138 μCi/g, and the mean result was 0.045 μCi/g. The highest upper limit to a one-sided 95 percent confidence interval on the mean was 0.424 μCi/g. This is well below the safety limit of 41.0 μCi/g or 1 g/L, as specified in the safety screening DQO (see footnote 1 of Table 5-6).

The flammability of the gas in the headspace of the tank was assessed based on a vapor survey. Only 1.7 ppm total organic carbon was detected and ammonia concentrations were 20 ppm. The concentration of gases was determined to be at 0 percent of the lower flammability limit.

Another factor in assessing the safety of the tank waste is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. Based on current analyses of cesium and strontium, the tank heat load produced by radioactive decay is calculated to be 1.35 kW (4,600 Btu/hr). This is below the criterion of $<$ 11.7 kW (39,960 Btu/hr) that separates a high- from a low-heat load tank (Bergmann 1991). Because an upper temperature limit was exhibited (Section 2.4.2), it may be concluded that any heat generated from radioactive sources throughout the year is dissipated.

5.5.2 Historical Evaluation

This DQO was met by collecting and analyzing core samples as specified in the Sampling and Analysis Plan for fingerprint analytes identified in Simpson and McCain (1995). The fingerprint analytes for tank 241-BX-109 were sodium, iron, H_2O, sulfate, and uranium. All of these analytes were found at threshold levels exceeding 10 percent of the HDW and passed the historical "Gateway" analysis. The lower half of segment 3, core 85 was re-analyzed in compliance with historical requirements. Analyses included total beta and strontium 89/90,

bulk density, total inorganic carbon, total organic carbon and ICP acid digestion analyses of water soluble analytes. Results for these analyses are included in Appendix A. In general, the historical evaluation showed acceptable comparison with most analytes in the UR waste type but not the tank model estimates. Substantial source term discrepancies were noted in several cases for the TLM comparison that were not as pronounced in the HDW. This behavior suggests an internal model flaw occurring when the tank estimates are generated. Variations and statistical comparisons are discussed in Section 5.4 and Appendix E.

5.5.3 Pretreatment Evaluation

This requirement was met by sending samples to Los Alamos National Laboratory for future analysis to characterize for pretreatment and/or disposal.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The waste in tank 241-BX-109 has been sampled and analyzed for the purposes of safety screening in accordance with the requirements listed in the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994), *Historical Model Evaluation Data Requirements* (Simpson and McCain 1995), and *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology* (Kupfer et al. 1995). The tank was sampled in April 1995 using the push-mode core sampling method. The safety screening DQO required analyses for percent water, energetics, total alpha activity, and flammable gas. The historical DQO required that subsegment and composite samples be analyzed for principal anions, cations, radionuclides, and water content. Analyses for lithium and bromide were also performed in order to detect any contamination by the hydrostatic head fluid.

All total alpha, DSC percent water and flammable gas results satisfied safety DQOs.

Sampling showed that the concentrations of flammable gases in the tank headspace was 0 percent. This meets the requirement for flammable gases to be less than 25 percent of the LFL.

Hydrostatic head fluid marked with a lithium bromide tracer was used to obtain the core samples. The results of lithium and bromide analyses, performed to detect intrusion into the samples by the hydrostatic head fluid, showed that drainable liquid in segment 4 of core 85 was entirely due to HHF intrusion. Consequently, these drainable liquid results were disregarded in assessing the data. Corrections for core 85, segment 4 soils are shown in Table 4-9.

An estimated value of 1.35 kW (4,600 Btu/hr) was derived from the sample data (^{137}Cs and $^{89/90}Sr$), which is well below the 11.7-kW (39,960-Btu/hr) limit separating high- and low-heat load tanks (Bergmann 1991).

Statistical (Appendix E) analyses of the ICP and IC data suggest that two definable layers are present in the tank. Both layers appear to be UR type waste, but soluble analyte concentrations are higher and uranium concentration lower in the upper layer. No first cycle waste was detected either visually or analytically.

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APPENDIX A

ANALYTICAL RESULTS FROM 1995 CORE SAMPLING

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APPENDIX A

ANALYTICAL RESULTS FROM 1995 CORE SAMPLING

A.1 INTRODUCTION

Appendix A reports the chemical, radiochemical, and physical characteristics of tank 241-BX-109 in table form and in terms of the specific concentrations of metals, ions, radionuclides, and physical properties.

Each data table lists the following: laboratory sample identification, sample origin (core/segment/subsegment), an original and duplicate result for each sample, a sample mean, a mean for the tank in which all cores, segments, and subsegments are weighted equally, a relative standard deviation of the mean (RSD [mean]), and a projected tank inventory for the particular analyte using the weighted mean and the appropriate conversion factors. The data are listed in standard notation for values greater than 0.001 and less than 100,000. Values outside these limits are listed in scientific notation.

The tables are numbered A-1 through A-53. A description of the units and symbols used in the analyte tables and the references used in compiling the analytical data (Schreiber 1996) are found in the list of terms and Section 7.0, respectively. For information on sampling rationale, locations, and descriptions of sampling events, see Section 3.0.

A.2 ANALYTE TABLE DESCRIPTION

The "Sample Number" column lists the laboratory sample for which the analyte was measured.

Column two describes the core and segment from which each sample was derived. The first number listed is the core number. It is followed by a colon and the segment number.

Column three contains the name of the segment portion from which the sample was taken. This can be the entire segment (whole), the drainable liquid portion (DL), or the upper or lower half segment portions.

The result and duplicate columns are self-explanatory. The "Mean" column is the average of the result and duplicate values. All values, including those below the detection level (indicated by the less-than symbol, <), were averaged in calculating the sample means. If the result and duplicate values were both nondetected, the mean is expressed as a nondetected value. On the other hand, if one of the two values is nondetected and one is detected, or if both are detected, then the sample mean is reported as a detected value. The result and duplicate values, as well as the result/duplicate means, are reported in the tables exactly as found in the original laboratory data package. The means may appear to have been rounded

up in some cases and rounded down in others. This is because the analytical results given in the tables may have fewer significant figures than originally reported, not because the means were incorrectly calculated. N/A indicates not applicable.

The overall (or analyte concentration) means for the waste in tank 241-BX-109 were calculated as follows:

- The overall drainable liquid means were calculated by averaging the two sample/duplicate pair means.
- The overall sludge means estimated from the composite sample results were obtained by averaging the means of the two composite sample/duplicate pairs.
- To obtain the estimated overall sludge mean, the sample/duplicate results within a subsegment were first averaged. The subsegment means were then averaged to obtain a segment mean, the segment means were averaged to obtain a core mean, and finally the two core means were averaged to obtain the overall mean.
- The RSD (mean) (in percent) is 100 times the standard deviation of the mean divided by the overall tank mean. Relative standard deviations of the mean were not computed for analytes that had greater than 50 percent nondetected values. The standard deviation of the mean was estimated using standard analysis of variance statistical techniques.
- The projected inventory is the product of the tank (or analyte concentration) mean, the volume of tank waste (730 kL [193 kgal]), the bulk density of the sludge (1.48), and the appropriate conversion factors.

The four quality control (QC) parameters assessed on the tank 241-BX-109 samples were standard recoveries, spike recoveries, duplicate analyses (RPDs), and blanks. These were summarized in Section 5.1.2, and more detailed information is provided with each of the following appendix tables. The QC criteria specified in the SAP (Schreiber 1995) and DOE 1995 were 90 to 110 percent recovery for standards and spikes, $\pm$ 10 percent for RPDs, and $\leq$ 5 percent of the analyte concentration for blanks. These criteria applied to all analytes. Sample and duplicate pairs in which any of the QC parameters were outside their specified limits are footnoted in column 6 of the tables with an a, b, c, d, e, or f as follows:

- "a" indicates that the standard recovery was below the QC limit
- "b" indicates that the standard recovery was above the QC limit
- "c" indicates that the spike recovery was below the QC limit
- "d" indicates that the spike recovery was above the QC limit
- "e" indicates that the RPD was outside the QC limits
- "f" indicates that there was some blank contamination.

Table A-1. Tank 241-BX-109 Analytical Results: Aluminum (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	4,310	4,380	4,350	2,480	26.8	2,680
S95T000766	84:2	Upper ½	2,750	2,980	2,860			
S95T000763		Lower ½	1,230	1,230	1,230			
S95T000772	84:3	Upper ½	946.0	824.7	885.3[e]			
S95T000769		Lower ½	490.0	486.9	488.4			
S95T000778	84:4	Upper ½	465	660.6	562.7[e]			
S95T000775		Lower ½	2,480	2,340	2,410			
S95T000781	85:1	Whole	7,400	7,360	7,380			
S95T000790	85:2	Upper ½	3,540	3,620	3,580			
S95T000787		Lower ½	1,830	1,720	1,770			
S95T000840	85:3	Upper ½	702	683.2	692.5			
S95T000837		Lower ½	612	598.4	605.4			
S95T000851	85:4	Upper ½	604	515.8	559.9[e]			
S95T000848		Lower ½	553	523.5	538.5			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-1. Tank 241-BX-109 Analytical Results: Aluminum (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.05	< 5.05	< 5.05			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	1,600	1,510	1,550	1,910	18.4	3,440
S95T001471	85:N/A	N/A	2,120	2,390	2,260[e]			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	293	309.8	301.5	259	16.7	N/A
S95T001470	85:N/A	N/A	221	209.4	215.4			

Table A-2. Tank 241-BX-109 Analytical Results: Antimony (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 974	< 975.4	< 975	< 988	N/A	N/A
S95T000766	84:2	Upper ½	< 1,080	< 1,001.2	< 1,040			
S95T000763		Lower ½	< 920	< 946.6	< 933			
S95T000772	84:3	Upper ½	< 999	< 998.4	< 999			
S95T000769		Lower ½	< 999	< 1,014.4	< 1,010			
S95T000778	84:4	Upper ½	< 1,070	< 1,025	< 1,050			
S95T000775		Lower ½	< 1,010	< 1,011.4	< 1,010			
S95T000781	85:1	Whole	< 974	< 955.8	< 965			
S95T000790	85:2	Upper ½	< 995	< 1,005	< 1,000			
S95T000787		Lower ½	< 869	< 862	< 866			
S95T000840	85:3	Upper ½	< 1,060	< 1,056.2	< 1,060			
S95T000837		Lower ½	< 953	< 952.8	< 953			
S95T000851	85:4	Upper ½	< 960	< 962.2	< 961			
S95T000848		Lower ½	< 1,040	< 1,056.8	< 1,050			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-2. Tank 241-BX-109 Analytical Results: Antimony (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 80.20	< 80.20	< 80.20	< 50.2	N/A	N/A
S95T000854	85:4	N/A	< 20.20	< 20.20	< 20.20			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 4,610	< 4,498	< 4,550	< 6,180	N/A	N/A
S95T001471	85:N/A	N/A	< 7,860	< 7,730	< 7,800			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 103	< 104.08	< 104	< 94.7	N/A	N/A
S95T001470	85:N/A	N/A	< 84.12	< 86.54	< 85.3			

Table A-3. Tank 241-BX-109 Analytical Results: Arsenic (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 243	< 243.9	< 243	< 247	N/A	N/A
S95T000766	84:2	Upper ½	< 270	< 250.3	< 260			
S95T000763		Lower ½	< 230	< 236.7	< 234			
S95T000772	84:3	Upper ½	< 250	< 249.6	< 250			
S95T000769		Lower ½	< 250	< 253.6	< 252			
S95T000778	84:4	Upper ½	< 268	< 256.3	< 262			
S95T000775		Lower ½	< 253	< 252.9	< 253			
S95T000781	85:1	Whole	< 243	< 239.0	< 241			
S95T000790	85:2	Upper ½	< 249	< 251.3	< 250			
S95T000787		Lower ½	< 217	< 215.5	< 217			
S95T000840	85:3	Upper ½	< 265	< 264.1	< 265			
S95T000837		Lower ½	< 238	< 238.2	< 238			
S95T000851	85:4	Upper ½	< 240	< 240.6	< 241			
S95T000848		Lower ½	< 259	< 264.2	< 262			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-3. Tank 241-BX-109 Analytical Results: Arsenic (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.05	< 5.05	< 5.05[c]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 1,150	< 1,125	< 1,140	< 1,550	N/A	N/A
S95T001471	85:N/A	N/A	< 1,960	< 1,933	< 1,950			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 25.05	< 26.02	< 25.5	< 23.4	N/A	N/A
S95T001470	85:N/A	N/A	< 21.03	< 21.64	< 21.3			

Table A-4. Tank 241-BX-109 Analytical Results: Barium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 243	< 243.9	< 244[c]	< 247	N/A	N/A
S95T000766	84:2	Upper ½	< 270	< 250.3	< 260			
S95T000763		Lower ½	< 230	< 236.7	< 234			
S95T000772	84:3	Upper ½	< 250	< 249.6	< 250			
S95T000769		Lower ½	< 250	< 253.6	< 252			
S95T000778	84:4	Upper ½	< 268	< 256.3	< 262			
S95T000775		Lower ½	< 253	< 252.9	< 253			
S95T000781	85:1	Whole	< 243	< 239.0	< 242			
S95T000790	85:2	Upper ½	< 249	< 251.3	< 250			
S95T000787		Lower ½	< 217	< 215.5	< 217			
S95T000840	85:3	Upper ½	< 265	< 264.1	< 265[c]			
S95T000837		Lower ½	< 238	< 238.2	< 238[c]			
S95T000851	85:4	Upper ½	< 240	< 240.6	< 241			
S95T000848		Lower ½	< 259	< 264.2	< 262			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-4. Tank 241-BX-109 Analytical Results: Barium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.05	< 5.05	< 5.05			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 1,150	< 1,124.5	< 1,140	< 1,550	N/A	N/A
S95T001471	85:N/A	N/A	< 1,960	< 1,933	< 1,950			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 25.65	< 26.02	< 25.8	< 23.6	N/A	N/A
S95T001470	85:N/A	N/A	< 21.03	< 21.64	< 21.3			

Table A-5. Tank 241-BX-109 Analytical Results: Beryllium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 24.34	< 24.39	< 24.37	< 24.7	N/A	N/A
S95T000766	84:2	Upper ½	< 27.00	< 25.03	< 26.02			
S95T000763		Lower ½	< 23.00	< 23.67	< 23.34			
S95T000772	84:3	Upper ½	< 25.00	< 24.96	< 24.98			
S95T000769		Lower ½	< 25.00	< 25.36	< 25.18			
S95T000778	84:4	Upper ½	< 26.84	< 25.63	< 26.24			
S95T000775		Lower ½	< 25.30	< 25.29	< 25.30			
S95T000781	85:1	Whole	< 24.34	< 23.90	< 24.12			
S95T000790	85:2	Upper ½	< 24.90	< 25.13	< 25.02			
S95T000787		Lower ½	< 21.72	< 21.55	< 21.64			
S95T000840	85:3	Upper ½	< 26.50	< 26.41	< 26.46			
S95T000837		Lower ½	< 23.82	< 23.82	< 23.82			
S95T000851	85:4	Upper ½	< 24.00	< 24.06	< 24.03			
S95T000848		Lower ½	< 25.94	< 26.42	< 26.18			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-5. Tank 241-BX-109 Analytical Results: Beryllium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 2.005	< 2.005	< 2.005	< 1.26	N/A	N/A
S95T000854	85:4	N/A	< 0.505	< 0.505	< 0.505			
Composite: fusion			µg/g	µg/g	µg/g	µ/g	%	kg
S95T001329	84:N/A	N/A	< 115	< 112.5	< 114	< 155	N/A	N/A
S95T001471	85:N/A	N/A	< 196	< 193.3	< 195			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 2.565	< 2.602	< 2.58	< 7.23	N/A	N/A
S95T001470	85:N/A	N/A	< 2.103	< 21.64	< 11.9			

Table A-6. Tank 241-BX-109 Analytical Results: Bismuth (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 487	< 487.7	< 488[c]	< 494	N/A	N/A
S95T000766	84:2	Upper ½	< 539	< 500.6	< 520[c]			
S95T000763		Lower ½	< 460	< 473.3	< 467[c]			
S95T000772	84:3	Upper ½	< 500	< 499.2	< 500[c]			
S95T000769		Lower ½	< 500	< 507.2	< 504[c]			
S95T000778	84:4	Upper ½	< 537	< 512.5	< 525[c]			
S95T000775		Lower ½	< 506	< 505.7	< 506[c]			
S95T000781	85:1	Whole	< 487	< 477.9	< 483[c]			
S95T000790	85:2	Upper ½	< 498	< 502.5	< 501[c]			
S95T000787		Lower ½	< 434	< 431.0	< 433[c]			
S95T000840	85:3	Upper ½	< 530	< 528.1	< 529[c]			
S95T000837		Lower ½	< 476	< 476.4	< 476[c]			
S95T000851	85:4	Upper ½	< 480	< 481.1	< 481[c]			
S95T000848		Lower ½	< 519	< 528.4	< 524			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-6. Tank 241-BX-109 Analytical Results: Bismuth (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,280	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,900			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.30	< 53.10	< 52.2	63.4	17.7	N/A
S95T001470	85:N/A	N/A	69.99	79.29	74.64[c]			

Table A-7. Tank 241-BX-109 Analytical Results: Boron (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 243	< 243.9	< 244	< 247	N/A	N/A
S95T000766	84:2	Upper ½	< 270	< 250.3	< 260			
S95T000763		Lower ½	< 230	< 236.7	< 234			
S95T000772	84:3	Upper ½	< 250	< 249.6	< 250			
S95T000769		Lower ½	< 250	< 254.6	< 252			
S95T000778	84:4	Upper ½	< 268	< 256.3	< 262			
S95T000775		Lower ½	< 253	< 252.9	< 253			
S95T000781	85:1	Whole	< 243	< 239.0	< 241			
S95T000790	85:2	Upper ½	< 249	< 251.3	< 250			
S95T000787		Lower ½	< 217	< 215.5	< 217			
S95T000840	85:3	Upper ½	< 265	< 264.1	< 265			
S95T000837		Lower ½	< 238	< 238.2	< 238			
S95T000851	85:4	Upper ½	< 240	< 240.6	< 241			
S95T000848		Lower ½	< 259	< 264.2	< 262			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	39.8	41.0	40.4	40.4	N/A	N/A

Table A-7. Tank 241-BX-109 Analytical Results: Boron (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	30.98	32.61	31.80	21.6	46.9	N/A
S95T000854	85:4	N/A	11.77	11.21	11.49[d]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 1,150	< 1,125	< 1,140	< 1,550	N/A	N/A
S95T001471	85:N/A	N/A	< 1,960	< 1,933	< 1,950			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	29.30	30.29	29.83	29.7	0.6	N/A
S95T001470	85:N/A	N/A	29.69	29.67	29.68			

Table A-8. Tank 241-BX-109 Analytical Results: Cadmium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 48.70	< 48.77	< 48.7	< 49.4	N/A	N/A
S95T000766	84:2	Upper ½	< 53.94	< 50.06	< 52.0			
S95T000763		Lower ½	< 46.01	< 47.33	< 46.7			
S95T000772	84:3	Upper ½	< 50.00	< 49.92	< 50.0			
S95T000769		Lower ½	< 50.00	< 50.72	< 50.4			
S95T000778	84:4	Upper ½	< 53.69	< 51.25	< 52.5			
S95T000775		Lower ½	< 50.61	< 50.57	< 50.6			
S95T000781	85:1	Whole	< 48.68	< 47.79	< 48.2			
S95T000790	85:2	Upper ½	< 49.80	< 50.25	< 50.0			
S95T000787		Lower ½	< 43.44	< 43.10	< 43.3			
S95T000840	85:3	Upper ½	< 53.00	< 52.81	< 52.9			
S95T000837		Lower ½	< 47.63	< 47.64	< 47.6			
S95T000851	85:4	Upper ½	< 48.00	< 48.11	< 48.1			
S95T000848		Lower ½	< 51.90	< 52.84	< 52.4			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 1.26	< 1.21	< 1.24	< 1.24	N/A	N/A

Table A-8. Tank 241-BX-109 Analytical Results: Cadmium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.01	< 4.01	< 4.01	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.01	< 1.01	< 1.01			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 228	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 386.5	< 390			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 5.13	< 5.204	< 5.17	< 4.72	N/A	N/A
S95T001470	85:N/A	N/A	< 4.206	< 4.327	< 4.27			

Table A-9. Tank 241-BX-109 Analytical Results: Calcium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	5,740	5,630	5,680	3,030	17.2	3,270
S95T000766	84:2	Upper ½	4,670	4,870	4,770			
S95T000763		Lower ½	2,520	2,550	2,530			
S95T000772	84:3	Upper ½	2,180	2,300	2,300[e]			
S95T000769		Lower ½	1,160	1,130	1,140			
S95T000778	84:4	Upper ½	1,170	1,050	1,110[e]			
S95T000775		Lower ½	1,040	991	1,020			
S95T000781	85:1	Whole	4,700	4,920	4,810			
S95T000790	85:2	Upper ½	4,780	5,060	4,920			
S95T000787		Lower ½	4,010	4,110	4,060			
S95T000840	85:3	Upper ½	2,020	1,930	1,980			
S95T000837		Lower ½	1,530	1,590	1,560			
S95T000851	85:4	Upper ½	813	860	837			
S95T000848		Lower ½	1,220	1,410	1,320			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	170	262	216[e]	216	N/A	N/A

Table A-9. Tank 241-BX-109 Analytical Results: Calcium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.10	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	2,650	2,270	2,460[c]	4,035	39.0	4,360
S95T001471	85:N/A	N/A	5,900	5,310	5,610[c]			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	67.88	75.09	71.48[c]	77.6	7.9	N/A
S95T001470	85:N/A	N/A	90.30	77.06	83.68[c]			

Table A-10. Tank 241-BX-109 Analytical Results: Cerium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 487	< 487.7	< 487	< 494	N/A	N/A
S95T000766	84:2	Upper ½	< 539	< 500.6	< 520			
S95T000763		Lower ½	< 460	< 473.3	< 467			
S95T000772	84:3	Upper ½	< 500	< 499.2	< 500			
S95T000769		Lower ½	< 500	< 507.2	< 504			
S95T000778	84:4	Upper ½	< 537	< 512.5	< 525			
S95T000775		Lower ½	< 506	< 505.7	< 506			
S95T000781	85:1	Whole	< 487	< 477.9	< 499			
S95T000790	85:2	Upper ½	< 498	< 502.9	< 483			
S95T000787		Lower ½	< 434	< 431	< 433			
S95T000840	85:3	Upper ½	< 530	< 528.1	< 529			
S95T000837		Lower ½	< 476	< 476.4	< 476			
S95T000851	85:4	Upper ½	< 480	< 481.1	< 481			
S95T000848		Lower ½	< 519	< 528.4	< 524			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-10. Tank 241-BX-109 Analytical Results: Cerium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,275	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,900			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.30	< 52.04	< 51.67	< 47.2	N/A	N/A
S95T001470	85:N/A	N/A	< 42.06	< 43.27	< 42.7			

Table A-11. Tank 241-BX-109 Analytical Results: Chromium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	106	94.41	100.2[e]	137	6.6	148
S95T000766	84:2	Upper ½	121	126.5	123.7			
S95T000763		Lower ½	112	119.0	115.7			
S95T000772	84:3	Upper ½	187	168.8	177.7[e]			
S95T000769		Lower ½	143	137.5	140.0			
S95T000778	84:4	Upper ½	126	128.0	126.8			
S95T000775		Lower ½	168	160.5	164.2			
S95T000781	85:1	Whole	86.22	87.38	86.80			
S95T000790	85:2	Upper ½	134	142.2	137.9			
S95T000787		Lower ½	147	144.1	145.4			
S95T000840	85:3	Upper ½	131	93.67	112.2[e]			
S95T000837		Lower ½	187	171.9	179.3			
S95T000851	85:4	Upper ½	179	171.7	175.3			
S95T000848		Lower ½	216	211.4	213.9			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	55.1	57.1	56.1	56.1	N/A	N/A

Table A-11. Tank 241-BX-109 Analytical Results: Chromium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	110	107.7	108.7[d]	62.6	73.7	N/A
S95T000854	85:4	N/A	16.40	16.60	16.50[d]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 228	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 386.5	< 390			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	65.07	68.85	66.96	74.9	10.6	N/A
S95T001470	85:N/A	N/A	83.47	82.19	82.83			

Table A-12. Tank 241-BX-109 Analytical Results: Cobalt (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 97.40	< 97.54	< 97.47	< 98.8	N/A	N/A
S95T000766	84:2	Upper ½	< 108	< 100.1	< 104			
S95T000763		Lower ½	< 92.02	< 94.66	< 93.34			
S95T000772	84:3	Upper ½	< 99.90	< 99.84	< 99.87			
S95T000769		Lower ½	< 99.94	< 101.4	< 100.7			
S95T000778	84:4	Upper ½	< 107	< 102.5	< 105			
S95T000775		Lower ½	< 101	< 101.1	< 101			
S95T000781	85:1	Whole	< 97.36	< 95.58	< 96.47			
S95T000790	85:2	Upper ½	< 99.50	< 100.5	< 100			
S95T000787		Lower ½	< 86.90	< 86.20	< 86.55			
S95T000840	85:3	Upper ½	< 106	< 105.6	< 106			
S95T000837		Lower ½	< 95.30	< 95.28	< 95.29			
S95T000851	85:4	Upper ½	< 96.00	< 96.22	< 96.11			
S95T000848		Lower ½	< 104	< 105.7	< 105			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 5.04	< 4.84	< 4.94	< 4.94	N/A	N/A

Table A-12. Tank 241-BX-109 Analytical Results: Cobalt (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 8.02	< 8.02	< 8.02	< 5.02	N/A	N/A
S95T000854	85:4	N/A	< 2.02	< 2.02	< 2.02			
Composite			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 461	< 449.8	< 455	< 618	N/A	N/A
S95T001471	85:N/A	N/A	< 786	< 773.0	< 780			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 10.26	< 10.4	< 10.3	< 9.43	N/A	N/A
S95T001470	85:N/A	N/A	< 8.412	< 8.654	< 8.5			

Table A-13. Tank 241-BX-109 Analytical Results: Copper (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 48.70	< 48.77	< 48.74	< 50.7	N/A	N/A
S95T000766	84:2	Upper ½	< 53.94	< 50.06	< 52.00			
S95T000763		Lower ½	< 46.01	< 47.33	< 46.67			
S95T000772	84:3	Upper ½	55.66	86.46	71.06[e]			
S95T000769		Lower ½	< 50.00	< 50.72	< 50.36			
S95T000778	84:4	Upper ½	< 53.69	< 51.25	< 52.47			
S95T000775		Lower ½	< 50.61	< 50.57	< 50.59			
S95T000781	85:1	Whole	< 48.68	< 47.79	< 48.24			
S95T000790	85:2	Upper ½	< 49.80	< 50.25	< 50.03			
S95T000787		Lower ½	< 43.44	< 43.10	< 43.27			
S95T000840	85:3	Upper ½	< 53.00	< 52.81	< 52.91			
S95T000837		Lower ½	< 47.63	< 47.64	< 47.64			
S95T000851	85:4	Upper ½	< 48.00	< 48.11	< 48.06			
S95T000848		Lower ½	< 51.90	< 52.84	< 52.37			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 2.52	< 2.42	< 2.47	< 2.47	N/A	N/A

Table A-13. Tank 241-BX-109 Analytical Results: Copper (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.01	< 4.01	< 4.01	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.01	< 1.01	< 1.01			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 227	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 386.5	< 390			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 5.130	< 5.204	< 5.167	< 4.72	N/A	N/A
S95T001470	85:N/A	N/A	< 4.206	< 4.327	< 4.267			

Table A-14. Tank 241-BX-109 Analytical Results: Iron (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	25,100	33,900	29,500	21,900	5.6	23,800
S95T000766	84:2	Upper ½	18,500	19,500	19,000			
S95T000763		Lower ½	19,700	19,800	19,700			
S95T000772	84:3	Upper ½	30,000	27,900	29,000[c]			
S95T000769		Lower ½	21,200	21,000	21,100			
S95T000778	84:4	Upper ½	13,000	13,400	13,200			
S95T000775		Lower ½	19,800	18,600	19,200			
S95T000781	85:1	Whole	22,400	24,000	23,200			
S95T000790	85:2	Upper ½	18,200	18,800	18,500[d]			
S95T000787		Lower ½	16,200	16,800	16,500			
S95T000840	85:3	Upper ½	24,400	23,700	24,100			
S95T000837		Lower ½	22,300	23,000	22,600			
S95T000851	85:4	Upper ½	19,600	19,200	19,400			
S95T000848		Lower ½	23,500	23,000	23,300			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-14. Tank 241-BX-109 Analytical Results: Iron (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.05	< 5.05	< 5.05			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	20,000	20,700	20,400	21,500	5.1	23,200
S95T001471	85:N/A	N/A	22,600	22,500	22,500			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	1,860	2,480	2,170[c]	2,715	20.1	N/A
S95T001470	85:N/A	N/A	3,290	3,240	3,260[c]			

Table A-15. Tank 241-BX-109 Analytical Results: Lanthanum (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 243	< 243.4	< 243.2	< 247	N/A	N/A
S95T000766	84:2	Upper ½	< 270	< 250.3	< 260			
S95T000763		Lower ½	< 230	< 236.5	< 233			
S95T000772	84:3	Upper ½	< 250	< 249.6	< 250			
S95T000769		Lower ½	< 250	< 253.6	< 252			
S95T000778	84:4	Upper ½	< 268	< 256.3	< 262			
S95T000775		Lower ½	< 253	< 252.9	< 253			
S95T000781	85:1	Whole	< 243	< 239.0	< 241			
S95T000790	85:2	Upper ½	< 249	< 251.3	< 250			
S95T000787		Lower ½	< 217	< 215.5	< 216			
S95T000840	85:3	Upper ½	< 265	< 264.1	< 265			
S95T000837		Lower ½	< 238	< 238.2	< 238			
S95T000851	85:4	Upper ½	< 240	< 240.5	< 240			
S95T000848		Lower ½	< 259	< 264.2	< 262			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-15. Tank 241-BX-109 Analytical Results: Lanthanum (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.05	< 5.05	< 5.05			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 1,150	< 1,125	< 1,140	< 1,550	N/A	N/A
S95T001471	85:N/A	N/A	< 1,960	< 1,933	< 1,950			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 25.65	< 26.02	< 25.8	< 23.6	N/A	N/A
S95T001470	85:N/A	N/A	< 21.03	< 21.64	< 21.3			

Table A-16. Tank 241-BX-109 Analytical Results: Lead (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	770	817.1	793.7	668	7.3	721
S95T000766	84:2	Upper ½	583	626.9	604.7			
S95T000763		Lower ½	< 460	< 473.3	< 467			
S95T000772	84:3	Upper ½	937	684.0	810.4[e]			
S95T000769		Lower ½	< 500	< 507.2	< 504			
S95T000778	84:4	Upper ½	843	820.4	831.9			
S95T000775		Lower ½	688	745.5	716.8			
S95T000781	85:1	Whole	500	584.1	541.9[e]			
S95T000790	85:2	Upper ½	527	615.2	571.2[e]			
S95T000787		Lower ½	440	533.7	487.1[e]			
S95T000840	85:3	Upper ½	560	540.6	550.4			
S95T000837		Lower ½	959	900.0	929.7			
S95T000851	85:4	Upper ½	< 480	539.8	510			
S95T000848		Lower ½	971	1,080	1,030			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-16. Tank 241-BX-109 Analytical Results: Lead (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,270	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,900			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.30	< 55.16	< 53.23[d]	60.9	12.6	N/A
S95T001470	85:N/A	N/A	68.59	68.52	68.55			

Table A-17. Tank 241-BX-109 Analytical Results: Magnesium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	1,130	1,080	1,100[c]	748	9.5	808
S95T000766	84:2	Upper ½	992	968.9	980.3			
S95T000763		Lower ½	546	624.6	585.4[c]			
S95T000772	84:3	Upper ½	613	549.6	581.1[c]			
S95T000769		Lower ½	< 500	< 507.2	< 504			
S95T000778	84:4	Upper ½	< 537	< 512.5	< 525			
S95T000775		Lower ½	< 506	< 505.7	< 506			
S95T000781	85:1	Whole	1,050	1,040	1,040			
S95T000790	85:2	Upper ½	1,100	1,100	1,100			
S95T000787		Lower ½	901	799.4	850.0[c]			
S95T000840	85:3	Upper ½	545	< 528.1	537[c]			
S95T000837		Lower ½	555	< 476.4	516[c]			
S95T000851	85:4	Upper ½	< 480	< 481.1	< 481			
S95T000848		Lower ½	< 519	< 528.4	< 524			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	46.0	76.8	61.4[c]	61.4	N/A	N/A

Table A-17. Tank 241-BX-109 Analytical Results: Magnesium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.1	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.1	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,270	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,900			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.30	< 52.04	< 51.7	< 55.1	6.5	N/A
S95T001470	85:N/A	N/A	57.95	58.95	58.45			

Table A-18. Tank 241-BX-109 Analytical Results: Manganese (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	215	259.9	237.5[c]	149	8.0	161
S95T000766	84:2	Upper ½	180	183.8	181.7			
S95T000763		Lower ½	129	136.0	132.6			
S95T000772	84:3	Upper ½	144	131.0	137.7			
S95T000769		Lower ½	109	100.0	104.5			
S95T000778	84:4	Upper ½	83.23	80.01	81.62			
S95T000775		Lower ½	101	97.03	98.79			
S95T000781	85:1	Whole	180	191.6	185.7			
S95T000790	85:2	Upper ½	156	169.2	162.8			
S95T000787		Lower ½	129	123.5	126.3			
S95T000840	85:3	Upper ½	117	113.9	115.4			
S95T000837		Lower ½	110	109.4	109.6[c]			
S95T000851	85:4	Upper ½	132	121.7	127.0			
S95T000848		Lower ½	158	165.2	161.5			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 2.52	< 2.42	< 2.47	< 2.47	N/A	N/A

Table A-18. Tank 241-BX-109 Analytical Results: Manganese (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.010	< 4.010	< 4.010	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.010	< 1.010	< 1.010			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 227	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 386.5	< 390			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	9.697	12.82	11.26[e]	14.1	20.1	N/A
S95T001470	85:N/A	N/A	17.06	16.81	16.93			

Table A-19. Tank 241-BX-109 Analytical Results: Molybdenum (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 243	< 243.85	< 243	< 247	N/A	N/A
S95T000766	84:2	Upper ½	< 270	< 250.3	< 260			
S95T000763		Lower ½	< 230	< 236.65	< 233			
S95T000772	84:3	Upper ½	< 250	< 249.6	< 250			
S95T000769		Lower ½	< 250	< 253.6	< 252			
S95T000778	84:4	Upper ½	< 268	< 256.25	< 262			
S95T000775		Lower ½	< 253	< 252.85	< 253			
S95T000781	85:1	Whole	< 243	< 238.95	< 241			
S95T000790	85:2	Upper ½	< 249	< 251.25	< 250			
S95T000787		Lower ½	< 217	< 215.5	< 216			
S95T000840	85:3	Upper ½	< 265	< 264.05	< 265			
S95T000837		Lower ½	< 238	< 238.2	< 238			
S95T000851	85:4	Upper ½	< 240	< 240.55	< 240			
S95T000848		Lower ½	< 259	< 264.2	< 262			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-19. Tank 241-BX-109 Analytical Results: Molybdenum (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			**µg/mL**	**µg/mL**	**µg/mL**	**µg/mL**	**%**	**kg**
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.05	< 5.05	< 5.05			
Composite: fusion			**µg/g**	**µg/g**	**µg/g**	**µg/g**	**%**	**kg**
S95T001329	84:N/A	N/A	< 1,150	< 1,124.5	< 1,140	< 1,550	N/A	N/A
S95T001471	85:N/A	N/A	< 1,960	< 1,932.5	< 1,950			
Composite: H_2O dig./acid			**µg/g**	**µg/g**	**µg/g**	**µg/g**	**%**	**kg**
S95T001445	84:N/A	N/A	< 25.65	< 26.02	< 25.8[e]	< 23.6	N/A	N/A
S95T001470	85:N/A	N/A	< 21.03	< 21.635	< 21.3			

Table A-20. Tank 241-BX-109 Analytical Results: Neodymium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 487	< 487.7	< 487	< 494	N/A	N/A
S95T000766	84:2	Upper ½	< 539	< 500.6	< 520			
S95T000763		Lower ½	< 460	< 473.3	< 467			
S95T000772	84:3	Upper ½	< 500	< 499.2	< 500			
S95T000769		Lower ½	< 500	< 507.2	< 504			
S95T000778	84:4	Upper ½	< 537	< 512.5	< 525			
S95T000775		Lower ½	< 506	< 505.7	< 506			
S95T000781	85:1	Whole	< 487	< 477.9	< 482			
S95T000790	85:2	Upper ½	< 498	< 502.5	< 500			
S95T000787		Lower ½	< 434	< 431	< 433			
S95T000840	85:3	Upper ½	< 530	< 528.1	< 530			
S95T000837		Lower ½	< 476	< 476.4	< 476			
S95T000851	85:4	Upper ½	< 480	< 481.1	< 481			
S95T000848		Lower ½	< 519	< 528.4	< 524			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-20. Tank 241-BX-109 Analytical Results: Neodymium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,275	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,898			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.3	< 52.04	< 51.7	< 47.2	N/A	N/A
S95T001470	85:N/A	N/A	< 42.06	< 43.27	< 42.7			

Table A-21. Tank 241-BX-109 Analytical Results: Nickel (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	6,010	6,260	6,140	5,150	18.0	5,570
S95T000766	84:2	Upper ½	8,790	8,810	8,800			
S95T000763		Lower ½	4,590	5,830	5,210[c]			
S95T000772	84:3	Upper ½	3,580	4,860	4,220[c]			
S95T000769		Lower ½	7,790	4,970	6,380[c,e]			
S95T000778	84:4	Upper ½	6,570	5,250	5,910[c]			
S95T000775		Lower ½	5,230	4,900	5,070			
S95T000781	85:1	Whole	5,350	5,820	5,590			
S95T000790	85:2	Upper ½	5,210	7,620	6,420[c]			
S95T000787		Lower ½	8,550	3,160	5,850[c]			
S95T000840	85:3	Upper ½	4,870	5,420	5,150[c]			
S95T000837		Lower ½	4,490	3,530	4,010[c]			
S95T000851	85:4	Upper ½	1,130	1,200	1,170			
S95T000848		Lower ½	896	753.8	825.1[c]			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	5.04	< 4.84	< 4.94	< 4.94	N/A	N/A

Table A-21. Tank 241-BX-109 Analytical Results: Nickel (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 8.02	< 8.02	< 8.02	6.05	N/A	N/A
S95T000854	85:4	N/A	3.978	4.167	4.072			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	3,930	3,060	3,490[d,e]	5,895	40.7	6,370
S95T001471	85:N/A	N/A	7,560	9,030	8,300[e]			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 10.26	< 10.408	< 10.3	12.8	19.6	N/A
S95T001470	85:N/A	N/A	15.96	14.68	15.32			

Table A-22. Tank 241-BX-109 Analytical Results: Phosphorus (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	23,400	21,900	22,600	20,800	4.6	22,460
S95T000766	84:2	Upper ½	26,500	27,900	27,200[d]			
S95T000763		Lower ½	23,000	22,900	23,000			
S95T000772	84:3	Upper ½	23,500	22,500	23,000			
S95T000769		Lower ½	20,200	19,600	19,900			
S95T000778	84:4	Upper ½	17,200	17,400	17,300[d]			
S95T000775		Lower ½	16,700	15,700	16,200			
S95T000781	85:1	Whole	15,400	15,700	15,600			
S95T000790	85:2	Upper ½	25,600	26,600	26,100[d]			
S95T000787		Lower ½	24,000	24,400	24,200[e]			
S95T000840	85:3	Upper ½	22,300	21,400	21,800			
S95T000837		Lower ½	20,100	20,800	20,400			
S95T000851	85:4	Upper ½	17,300	17,700	17,500[e]			
S95T000848		Lower ½	19,800	19,300	19,600[e]			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	8,470	8,620	8,550[e]	8,550	N/A	93.4

Table A-22. Tank 241-BX-109 Analytical Results: Phosphorus (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	7,730	7,620	7,680[c]	4,270	79.9	N/A
S95T000854	85:4	N/A	859	859.8	859.6[d]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	22,000	22,500	22,200	22,000	1.1	23,760
S95T001471	85:N/A	N/A	21,400	22,300	21,800			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	8,470	8,750	8,610[d]	8,040	7.0	N/A
S95T001470	85:N/A	N/A	7,490	7,470	7,480			

Table A-23. Tank 241-BX-109 Analytical Results: Samarium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 487	< 487.7	< 487	< 494	N/A	N/A
S95T000766	84:2	Upper ½	< 539	< 500.6	< 520			
S95T000763		Lower ½	< 460	< 473.3	< 467			
S95T000772	84:3	Upper ½	< 500	< 499.2	< 500			
S95T000769		Lower ½	< 500	< 507.2	< 504			
S95T000778	84:4	Upper ½	< 537	< 512.5	< 525			
S95T000775		Lower ½	< 506	< 505.7	< 506			
S95T000781	85:1	Whole	< 487	< 477.9	< 482			
S95T000790	85:2	Upper ½	< 498	< 502.5	< 500			
S95T000787		Lower ½	< 434	< 431.0	< 433			
S95T000840	85:3	Upper ½	< 530	< 528.1	< 529			
S95T000837		Lower ½	< 476	< 476.4	< 476			
S95T000851	85:4	Upper ½	< 480	< 481.1	< 481			
S95T000848		Lower ½	< 519	< 528.4	< 524			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-23. Tank 241-BX-109 Analytical Results: Samarium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.1			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,275	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,897			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.30	< 52.04	< 51.7	< 47.2	N/A	N/A
S95T001470	85:N/A	N/A	< 42.06	< 43.27	< 42.7			

Table A-24. Tank 241-BX-109 Analytical Results: Selenium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 487	< 487.7	< 487[c]	< 494	N/A	N/A
S95T000766	84:2	Upper ½	< 539	< 500.6	< 520[c]			
S95T000763		Lower ½	< 460	< 473.3	< 467[c]			
S95T000772	84:3	Upper ½	< 500	< 499.2	< 500[c]			
S95T000769		Lower ½	< 500	< 507.2	< 504[c]			
S95T000778	84:4	Upper ½	< 537	< 512.5	< 525[c]			
S95T000775		Lower ½	< 506	< 505.7	< 506[c]			
S95T000781	85:1	Whole	< 487	< 477.9	< 482[c]			
S95T000790	85:2	Upper ½	< 498	< 502.5	< 500[c]			
S95T000787		Lower ½	< 434	< 431	< 433[c]			
S95T000840	85:3	Upper ½	< 530	< 528.1	< 529[c]			
S95T000837		Lower ½	< 476	< 476.4	< 476[c]			
S95T000851	85:4	Upper ½	< 480	< 481.1	< 481[c]			
S95T000848		Lower ½	< 519	< 528.4	< 524[c]			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 25.2	< 24.2	< 24.7	< 24.7	N/A	N/A

Table A-24. Tank 241-BX-109 Analytical Results: Selenium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 40.10	< 40.10	< 40.10	< 25.1	N/A	N/A
S95T000854	85:4	N/A	< 10.10	< 10.10	< 10.10			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 2,300	< 2,249	< 2,270	< 3,090	N/A	N/A
S95T001471	85:N/A	N/A	< 3,930	< 3,865	< 3,900			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 51.3	< 52.04	< 51.7[a]	< 47.2	N/A	N/A
S95T001470	85:N/A	N/A	< 42.06	< 43.27	< 42.7[a]			

Table A-25. Tank 241-BX-109 Analytical Results: Silicon (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	1,050	1,070	1,060	739	7.9	798
S95T000766	84:2	Upper ½	662	679.6	670.6			
S95T000763		Lower ½	466	579.1	522.3[c]			
S95T000772	84:3	Upper ½	928	841.5	884.9			
S95T000769		Lower ½	771	736	753.6			
S95T000778	84:4	Upper ½	568	527.4	547.8			
S95T000775*		Lower ½	42,200	40,300	41,300[d]			
S95T000781	85:1	Whole	829	879.6	854.4			
S95T000790	85:2	Upper ½	432	515.4	473.5[c]			
S95T000787		Lower ½	370	313.7	342.0[c]			
S95T000840	85:3	Upper ½	690	649.2	669.6			
S95T000837		Lower ½	882	762.2	822.3[c]			
S95T000851	85:4	Upper ½	743	784.2	763.6			
S95T000848		Lower ½	932	976.2	954.1			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	630	1,510	1,070[c]	1,070	N/A	N/A

Table A-25. Tank 241-BX-109 Analytical Results: Silicon (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.05	15.0	33.4	N/A
S95T000854	85:4	N/A	9.974	10.05	10.01[d]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	1,850	< 1,124.5	1,490	1,720	13.3	1,860
S95T001471	85:N/A	N/A	< 1,960	< 1,932.5	< 1,950			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	78.49	91.20	84.84[e]	87.9	3.6	N/A
S95T001470	85:N/A	N/A	91.04	90.80	90.92			

*Suspect values excluded from overall mean and mean RSD.

Table A-26. Tank 241-BX-109 Analytical Results: Sodium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	1.04E+05	98,000	1.01E+05[c]	1.05E+05	1.5	1.13E+05
S95T000766	84:2	Upper ½	1.09E+05	1.11E+05	1.10E+05[c]			
S95T000763		Lower ½	1.14E+05	1.12E+05	1.13E+05[c]			
S95T000772	84:3	Upper ½	1.07E+05	1.10E+05	1.09E+05[c]			
S95T000769		Lower ½	1.13E+05	1.12E+05	1.13E+05[c]			
S95T000778	84:4	Upper ½	1.02E+05	1.04E+05	1.03E+05[c]			
S95T000775		Lower ½	94,100	88,000	91,000[c]			
S95T000781	85:1	Whole	1.01E+05	1.04E+05	1.02E+05[c]			
S95T000790	85:2	Upper ½	1.10E+05	1.11E+05	1.10E+05[c]			
S95T000787		Lower ½	1.09E+05	1.13E+05	1.11E+05[c]			
S95T000840	85:3	Upper ½	1.08E+05	1.09E+05	1.08E+05[c]			
S95T000837		Lower ½	1.03E+05	1.05E+05	1.04E+05[c]			
S95T000851	85:4	Upper ½	1.03E+05	1.00E+05	1.02E+05[c]			
S95T000848		Lower ½	1.06E+05	1.01E+05	1.03E+05[c]			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	1.10E+05	1.15E+05	1.13E+05	1.13E+05	N/A	N/A

Table A-26. Tank 241-BX-109 Analytical Results: Sodium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	1.49E+05	1.48E+05	1.48E+05[c]	87,700	68.9	N/A
S95T000854	85:4	N/A	27,300	27,400	27,400[c]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	1.13E+05	1.13E+05	1.13E+05[c]	1.14E+05	0.7	1.23E+05
S95T001471	85:N/A	N/A	1.14E+05	1.15E+05	1.15E+05			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	1.02E+05	1.03E+05	1.03E+05	1.00E+05	2.7	N/A
S95T001470	85:N/A	N/A	98,400	96,000	97,200[d]			

Table A-27. Tank 241-BX-109 Analytical Results: Strontium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	571	568.9	569.8[c]	592	6.5	639
S95T000766	84:2	Upper ½	499	516.8	507.8			
S95T000763		Lower ½	473	471.6	472.4			
S95T000772	84:3	Upper ½	917	872.9	895.1			
S95T000769		Lower ½	673	659.7	666.5			
S95T000778	84:4	Upper ½	396	409.5	402.5			
S95T000775		Lower ½	680	639.4	659.6			
S95T000781	85:1	Whole	577	612.1	594.4			
S95T000790	85:2	Upper ½	434	445.9	440.0			
S95T000787		Lower ½	372	384.9	378.6			
S95T000840	85:3	Upper ½	638	627.2	632.4			
S95T000837		Lower ½	637	665.0	650.9			
S95T000851	85:4	Upper ½	680	660.9	670.4			
S95T000848		Lower ½	766	759.5	762.7			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	4.89	5.85	5.37[e]	5.37	N/A	N/A

Table A-27. Tank 241-BX-109 Analytical Results: Strontium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.010	< 4.010	< 4.010	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.010	< 1.010	< 1.010			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	569	570.3	569.5	590	3.4	637
S95T001471	85:N/A	N/A	608	611.9	609.9			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	21.7	28.40	25.05[c]	34.2	267	N/A
S95T001470	85:N/A	N/A	43.87	42.75	43.31			

Table A-28. Tank 241-BX-109 Analytical Results: Sulfur (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	6,180	6,000	6,090	6,280	1.6	6,780
S95T000766	84:2	Upper ½	6,130	6,340	6,240			
S95T000763		Lower ½	6,630	6,510	6,570			
S95T000772	84:3	Upper ½	6,180	6,370	6,280			
S95T000769		Lower ½	6,580	6,510	6,540			
S95T000778	84:4	Upper ½	6,910	7,010	6,960			
S95T000775		Lower ½	5,570	5,250	5,410			
S95T000781	85:1	Whole	5,920	6,030	5,980			
S95T000790	85:2	Upper ½	6,070	6,200	6,140			
S95T000787		Lower ½	6,410	6,530	6,470			
S95T000840	85:3	Upper ½	6,410	6,450	6,430			
S95T000837		Lower ½	6,530	6,490	6,510			
S95T000851	85:4	Upper ½	5,970	5,980	5,980			
S95T000848		Lower ½	6,590	6,390	6,490			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	7,080	7,390	7,240[c]	7,240	N/A	N/A

Table A-28. Tank 241-BX-109 Analytical Results: Sulfur (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	10,000	9,920	9,960[d]	5,810	71.4	N/A
S95T000854	85:4	N/A	1,670	1,660	1,660[d]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	6,480	6,780	6,630	6,840	3.0	7,390
S95T001471	85:N/A	N/A	6,980	7,110	7,040			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	6,760	6,840	6,800[d]	6,670	1.9	N/A
S95T001470	85:N/A	N/A	6,590	6,490	6,540[c]			

Table A-29. Tank 241-BX-109 Analytical Results: Thallium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 974	< 975.4	< 975	< 988	N/A	N/A
S95T000766	84:2	Upper ½	< 1,080	< 1,001.2	< 1,040			
S95T000763		Lower ½	< 920	< 946.6	< 933			
S95T000772	84:3	Upper ½	< 999	< 998.4	< 999			
S95T000769		Lower ½	< 999	< 1,014.4	< 1,010			
S95T000778	84:4	Upper ½	< 1,070	< 1,025.0	< 1,050			
S95T000775		Lower ½	< 1,010	< 1,011.4	< 1,010			
S95T000781	85:1	Whole	< 974	< 955.8	< 965			
S95T000790	85:2	Upper ½	< 995	< 1,005	< 1,000			
S95T000787		Lower ½	< 869	< 862.0	< 866			
S95T000840	85:3	Upper ½	< 1,060	< 1,056.2	< 1,060			
S95T000837		Lower ½	< 953	< 952.8	< 953			
S95T000851	85:4	Upper ½	< 960	< 962.2	< 961			
S95T000848		Lower ½	< 1,040	< 1,056.8	< 1,050			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 50.4	< 48.4	< 49.4	< 49.4	N/A	N/A

Table A-29. Tank 241-BX-109 Analytical Results: Thallium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 80.20	< 80.20	< 80.20	< 50.20	N/A	N/A
S95T000854	85:4	N/A	< 20.20	< 20.20	< 20.20[c]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 4,610	< 4,498	< 4,550	< 6,170	N/A	N/A
S95T001471	85:N/A	N/A	< 7,860	< 7,730	< 7,800			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 103	< 104.08	< 103.5	< 94.4	N/A	N/A
S95T001470	85:N/A	N/A	< 84.12	< 86.54	< 85.3			

Table A-30. Tank 241-BX-109 Analytical Results: Titanium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	136	130.9	133.4	88.5	N/A	95.6
S95T000766	84:2	Upper ½	106	117.1	111.8			
S95T000763		Lower ½	61.00	64.88	62.94[d]			
S95T000772	84:3	Upper ½	< 50.00	< 49.92	< 49.96			
S95T000769		Lower ½	< 50.00	< 50.72	< 50.36			
S95T000778	84:4	Upper ½	< 53.69	< 51.25	< 52.47			
S95T000775		Lower ½	< 50.61	< 50.57	< 50.59			
S95T000781	85:1	Whole	123	126.1	124.7			
S95T000790	85:2	Upper ½	137	126.9	132.1			
S95T000787		Lower ½	100	98.67	99.53			
S95T000840	85:3	Upper ½	< 53.00	< 52.81	< 52.91			
S95T000837		Lower ½	< 47.63	< 47.64	< 47.64			
S95T000851	85:4	Upper ½	130	< 48.11	89.1			
S95T000848		Lower ½	< 51.90	147.7	99.80			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 2.52	< 2.42	< 2.47	< 2.47	N/A	N/A

Table A-30. Tank 241-BX-109 Analytical Results: Titanium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.010	< 4.010	< 4.010	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.010	< 1.010	< 1.010			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 227.4	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 386.5	< 389.8			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 5.130	< 5.204	< 5.167	< 4.72	N/A	N/A
S95T001470	85:N/A	N/A	< 4.206	< 4.327	< 4.266			

Table A-31. Tank 241-BX-109 Analytical Results: Uranium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	11,900	11,200	11,600[c]	14,200	12.8	15,300
S95T000766	84:2	Upper ½	6,230	7,060	6,650[c]			
S95T000763		Lower ½	10,300	9,970	10,100			
S95T000772	84:3	Upper ½	16,300	16,400	16,300			
S95T000769		Lower ½	26,400	26,300	26,300			
S95T000778	84:4	Upper ½	13,900	14,400	14,200			
S95T000775		Lower ½	22,800	21,400	22,100			
S95T000781	85:1	Whole	6,760	5,930	6,340[c]			
S95T000790	85:2	Upper ½	5,260	6,200	5,730[c]			
S95T000787		Lower ½	7,720	8,140	7,930			
S95T000840	85:3	Upper ½	14,300	14,000	14,200			
S95T000837		Lower ½	21,200	21,700	21,500			
S95T000851	85:4	Upper ½	21,900	22,400	22,200			
S95T000848		Lower ½	23,700	22,700	23,200[c]			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 126	< 121	< 124	< 124	N/A	N/A

Table A-31. Tank 241-BX-109 Analytical Results: Uranium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	234	237.5	235.9[d]	156	51.6	N/A
S95T000854	85:4	N/A	75.19	75.40	75.30[d]			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	15,400	17,200	16,300[c]	16,200	2.4	17,500
S95T001471	85:N/A	N/A	16,400	15,800	16,100			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	447	567.6	507.1[e]	488	5.6	N/A
S95T001470	85:N/A	N/A	475	462.4	468.8			

Table A-32. Tank 241-BX-109 Analytical Results: Vanadium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 243	< 243.85	< 243.4	< 247	N/A	N/A
S95T000766	84:2	Upper ½	< 270	< 250.3	< 260.2			
S95T000763		Lower ½	< 230	< 236.65	< 233.3			
S95T000772	84:3	Upper ½	< 250	< 249.6	< 249.8			
S95T000769		Lower ½	< 250	< 253.6	< 251.8			
S95T000778	84:4	Upper ½	< 268	< 256.25	< 262.1			
S95T000775		Lower ½	< 253	< 252.85	< 252.9			
S95T000781	85:1	Whole	< 243	< 238.95	< 241.0			
S95T000790	85:2	Upper ½	< 249	< 251.25	< 250.1			
S95T000787		Lower ½	< 217	< 215.5	< 216.3			
S95T000840	85:3	Upper ½	< 265	< 264.05	< 264.5			
S95T000837		Lower ½	< 238	< 238.2	< 238.1			
S95T000851	85:4	Upper ½	< 240	< 240.55	< 240.3			
S95T000848		Lower ½	< 259	< 264.2	< 261.6			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 12.6	< 12.1	< 12.4	< 12.4	N/A	N/A

Table A-32. Tank 241-BX-109 Analytical Results: Vanadium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 20.05	< 20.05	< 20.1	< 12.6	N/A	N/A
S95T000854	85:4	N/A	< 5.050	< 5.050	< 5.050			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 1,150	< 1,124.5	< 1,140	< 1,540	N/A	N/A
S95T001471	85:N/A	N/A	< 1,960	< 1,932.5	< 1,950			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 25.65	< 26.02	< 25.84	< 23.6	N/A	N/A
S95T001470	85:N/A	N/A	< 21.03	< 21.635	< 21.33			

Table A-33. Tank 241-BX-109 Analytical Results: Zinc (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	108	148.6	128.2[e]	150	6.5	162
S95T000766	84:2	Upper ½	168	122.5	145.0[e]			
S95T000763		Lower ½	110	102.4	106.4			
S95T000772	84:3	Upper ½	214	193.9	203.8			
S95T000769		Lower ½	127	186.0	156.7[e]			
S95T000778	84:4	Upper ½	154	100.9	127.4[e]			
S95T000775		Lower ½	242	160.0	200.8[e]			
S95T000781	85:1	Whole	144	125.0	134.5[e]			
S95T000790	85:2	Upper ½	128	107.6	117.6[e]			
S95T000787		Lower ½	169	89.75	129.6[e]			
S95T000840	85:3	Upper ½	107	116.8	111.9			
S95T000837		Lower ½	173	186.0	179.3			
S95T000851	85:4	Upper ½	174	169.6	171.6			
S95T000848		Lower ½	230	210.2	220.3			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	4.77	4.44	4.61	4.61	N/A	N/A

Table A-33. Tank 241-BX-109 Analytical Results: Zinc (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.010	< 4.010	< 4.010	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.010	< 1.010	< 1.010			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 227	624	63.1	N/A
S95T001471	85:N/A	N/A	1,020	1,010	1,020			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	22.55	26.32	24.43[e]	28.4	14.0	N/A
S95T001470	85:N/A	N/A	33.42	31.36	32.39			

Table A-34. Tank 241-BX-109 Analytical Results: Zirconium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	54.96	< 48.77	51.9	< 49.8	N/A	N/A
S95T000766	84:2	Upper ½	< 53.94	< 50.06	< 52.0			
S95T000763		Lower ½	< 46.01	< 47.33	< 46.7			
S95T000772	84:3	Upper ½	< 50.00	< 49.92	< 50.0			
S95T000769		Lower ½	< 50.00	< 50.72	< 50.4			
S95T000778	84:4	Upper ½	< 53.69	< 51.25	< 52.5			
S95T000775		Lower ½	< 50.61	< 50.57	<50.6			
S95T000781	85:1	Whole	< 48.68	< 47.79	< 48.3			
S95T000790	85:2	Upper ½	< 49.80	< 50.25	< 50.0			
S95T000787		Lower ½	< 43.44	< 43.1	< 43.3			
S95T000840	85:3	Upper ½	< 53.00	< 52.81	< 52.9			
S95T000837		Lower ½	< 47.63	< 47.64	< 47.6			
S95T000851	85:4	Upper ½	< 48.00	< 48.11	< 48.1			
S95T000848		Lower ½	< 51.90	< 52.84	< 52.4			
Solids: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	< 2.52	< 2.42	< 2.47	< 2.47	N/A	N/A

Table A-34. Tank 241-BX-109 Analytical Results: Zirconium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	< 4.010	< 4.010	< 4.010	< 2.51	N/A	N/A
S95T000854	85:4	N/A	< 1.010	< 1.010	< 1.010			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 224.9	< 227	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 386.5	< 390			
Composite: H_2O dig./acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	< 5.130	< 5.204	< 5.167	< 4.72	N/A	N/A
S95T001470	85:N/A	N/A	< 4.206	< 4.327	< 4.267			

Table A-35. Tank 241-BX-109 Analytical Results: Uranium (Phosphorescence). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	14,000	13,200	13,600	16,400	11.5	17,700
S95T000766	84:2	Upper ½	8,470	8,960	8,720			
S95T000763		Lower ½	11,700	12,500	12,100			
S95T000772	84:3	Upper ½	21,000	22,400	21,700			
S95T000769		Lower ½	27,900	28,300	28,100			
S95T000778	84:4	Upper ½	17,600	17,700	17,600			
S95T000775		Lower ½	27,900	27,000	27,400			
S95T000781	85:1	Whole	9,640	8,320	8,980			
S95T000790	85:2	Upper ½	7,450	8,120	7,780			
S95T000787		Lower ½	9,990	9,660	9,820			
S95T000840	85:3	Upper ½	17,000	16,600	16,800			
S95T000837		Lower ½	24,200	24,700	24,400			
S95T000851	85:4	Upper ½	15,800	16,300	16,000			
S95T000848		Lower ½	25,700	28,000	26,800			

Table A-35. Tank 241-BX-109 Analytical Results: Uranium (Phosphorescence). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	1,110	1,070	1,090	1,090	N/A	N/A
S95T000854	85:4	N/A	0.116	0.152	0.134			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	17,300	17,400	17,400	18,000	3.5	19,400
S95T001471	85:N/A	N/A	18,500	18,700	18,600			

Table A-36. Tank 241-BX-109 Analytical Results: Chloride (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000976	84:1	Whole	1,300	804	1,050[c]	1,320	2.9	1,420
S95T000980	84:2	Upper ½	1,330	1,060	1,200[c]			
S95T000977		Lower ½	1,220	1,060	1,140[c]			
S95T000982	84:3	Upper ½	1,430	1,390	1,410			
S95T000981		Lower ½	1,510	1,660	1,580			
S95T000984	84:4	Upper ½	1,430	1,430	1,430			
S95T000983		Lower ½	1,510	1,420	1,460			
S95T000994	85:1	Whole	1,380	1,410	1,400			
S95T000996	85:2	Upper ½	1,260	1,360	1,310			
S95T000995		Lower ½	1,450	1,370	1,410			
S95T000998	85:3	Upper ½	1,470	1,340	1,400			
S95T000997		Lower ½	1,290	1,310	1,300			
S95T001000	85:4	Upper ½	1,170	1,180	1,180			
S95T000999		Lower ½	1,390	1,250	1,320			

Table A-36. Tank 241-BX-109 Analytical Results: Chloride (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: H_2O dilution			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	2,260	2,080	2,170	1,500	N/A	N/A
S95T001001	85:4	N/A	< 838	< 838	< 838			
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	1,100	1,260	1,180[c]	1,200	3.0	1,296
S95T001469	85:N/A	N/A	1,250	1,200	1,220[c]			

Table A-37. Tank 241-BX-109 Analytical Results: Fluoride (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000976	84:1	Whole	< 251	< 243	< 247	< 528	N/A	N/A
S95T000980	84:2	Upper ½	< 505	< 503	< 504			
S95T000977		Lower ½	< 421	< 414	< 418			
S95T000982	84:3	Upper ½	< 581	< 575	< 578			
S95T000981		Lower ½	< 611	< 587	< 599			
S95T000984	84:4	Upper ½	< 589	< 581	< 585[c]			
S95T000983		Lower ½	1,040	1,060	1,050			
S95T000994	85:1	Whole	< 604	< 580	< 592			
S95T000996	85:2	Upper ½	< 600	< 569	< 585			
S95T000995		Lower ½	< 594	< 595	< 595			
S95T000998	85:3	Upper ½	< 574	< 568	< 571			
S95T000997		Lower ½	< 590	< 569	< 580			
S95T001000	85:4	Upper ½	< 136	< 134	< 135			
S95T000999		Lower ½	< 588	< 567	< 578			

Table A-37. Tank 241-BX-109 Analytical Results: Fluoride (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: H_2O dilution			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	< 626	< 626	< 626	< 626	N/A	N/A
S95T001001	85:4	N/A	< 626	< 626	< 626			
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	< 642	< 652	< 647	< 458	N/A	N/A
S95T001469	85:N/A	N/A	< 266	< 273	< 270[c]			

Table A-38. Tank 241-BX-109 Analytical Results: Nitrite (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000976	84:1	Whole	19,000	11,400	15,200[c]	18,100	11.8	19,550
S95T000980	84:2	Upper ½	18,200	14,700	16,400[c]			
S95T000977		Lower ½	15,900	14,000	15,000[c]			
S95T000982	84:3	Upper ½	17,300	17,100	17,200			
S95T000981		Lower ½	16,200	17,300	16,800			
S95T000984	84:4	Upper ½	15,900	15,700	15,800			
S95T000983		Lower ½	14,900	15,000	15,000			
S95T000994	85:1	Whole	21,200	21,500	21,400			
S95T000996	85:2	Upper ½	21,000	21,000	21,000			
S95T000995		Lower ½	22,000	21,800	21,900			
S95T000998	85:3	Upper ½	20,900	20,100	20,500			
S95T000997		Lower ½	18,900	19,600	19,200			
S95T001000	85:4	Upper ½	17,300	17,200	17,200			
S95T000999		Lower ½	20,100	19,400	19,800			

Table A-38. Tank 241-BX-109 Analytical Results: Nitrite (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: H_2O dilution			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	31,900	29,600	30,800	19,400	N/A	N/A
S95T001001	85:4	N/A	7,920	8,060	7,990			
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	18,100	18,000	18,000	19,100	5.5	20,620
S95T001469	85:N/A	N/A	20,200	20,100	20,200			

Table A-39. Tank 241-BX-109 Analytical Results: Nitrate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000976	84:1	Whole	1.93E+05	1.14E+05	1.54E+05[c,e]	1.93E+05	2.8	2.08E+05
S95T000980	84:2	Upper ½	1.88E+05	1.49E+05	1.68E+05[e]			
S95T000977		Lower ½	1.79E+05	1.56E+05	1.68E+05[d,e]			
S95T000982	84:3	Upper ½	2.11E+05	2.08E+05	2.10E+05			
S95T000981		Lower ½	2.14E+05	2.28E+05	2.21E+05			
S95T000984	84:4	Upper ½	2.22E+05	2.20E+05	2.21E+05			
S95T000983		Lower ½	2.11E+05	2.17E+05	2.16E+05			
S95T000994	85:1	Whole	2.01E+05	1.98E+05	2.00E+05			
S95T000996	85:2	Upper ½	1.94E+05	1.88E+05	1.91E+05			
S95T000995		Lower ½	2.05E+05	2.06E+05	2.06E+05			
S95T000998	85:3	Upper ½	2.01E+05	2.04E+05	2.02E+05			
S95T000997		Lower ½	1.98E+05	1.99E+05	1.98E+05			
S95T001000	85:4	Upper ½	1.85E+05	1.85E+05	1.85E+05			
S95T000999		Lower ½	2.03E+05	1.99E+05	2.01E+05			

Table A-39. Tank 241-BX-109 Analytical Results: Nitrate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: H_2O dilution			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	5.16E+05	2.91E+05	3.04E+05	1.83E+05	N/A	N/A
S95T001001	85:4	N/A	62,400	62,100	62,200			
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	2.25E+05	2.18E+05	2.22E+05	2.13E+05	4.4	2.30E+05
S95T001469	85:N/A	N/A	2.03E+05	2.03E+05	2.03E+05[c]			

Table A-40. Tank 241-BX-109 Analytical Results: Phosphate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000976	84:1	Whole	37,300	22,900	30,100[c]	25,200	4.2	27,200
S95T000980	84:2	Upper ½	33,900	27,900	30,900[c]			
S95T000977		Lower ½	23,400	20,400	21,900[c]			
S95T000982	84:3	Upper ½	26,900	26,700	26,800			
S95T000981		Lower ½	24,200	25,200	24,700[c]			
S95T000984	84:4	Upper ½	22,400	22,000	22,200			
S95T000983		Lower ½	21,800	21,800	21,800			
S95T000994	84:1	Whole	28,800	28,300	28,600			
S95T000996	85:2	Upper ½	27,600	26,600	27,100			
S95T000995		Lower ½	26,300	26,400	26,400			
S95T000998	85:3	Upper ½	23,500	22,500	23,000			
S95T000997		Lower ½	21,000	21,100	21,000			
S95T001000	85:4	Upper ½	17,600	17,500	17,600			
S95T000999		Lower ½	21,900	22,000	22,000[c]			

Table A-40. Tank 241-BX-109 Analytical Results: Phosphate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: H_2O dilution			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	22,600	21,800	22,200	14,700	N/A	N/A
S95T001001	85:4	N/A	< 7,100	< 7,100	< 7,100			
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	26,600	26,500	26,600	24,500	8.6	26,500
S95T001469	85:N/A	N/A	22,400	22,300	22,400[c]			

Table A-41. Tank 241-BX-109 Analytical Results: Sulfate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000976	84:1	Whole	16,700	10,100	13,400[c]	17,600	2.9	19,000
S95T000980	84:2	Upper ½	17,000	13,900	15,400[c]			
S95T000977		Lower ½	15,800	14,000	14,900[c]			
S95T000982	84:3	Upper ½	19,100	18,700	18,900			
S95T000981		Lower ½	19,500	20,300	19,900			
S95T000984	84:4	Upper ½	19,600	19,400	19,500			
S95T000983		Lower ½	19,200	19,200	19,200			
S95T000994	85:1	Whole	18,800	18,500	18,600			
S95T000996	85:2	Upper ½	18,200	18,000	18,100			
S95T000995		Lower ½	19,100	19,200	19,200			
S95T000998	85:3	Upper ½	18,700	18,300	18,500			
S95T000997		Lower ½	18,200	18,600	18,400			
S95T001000	85:4	Upper ½	16,700	16,200	16,400			
S95T000999		Lower ½	18,600	18,100	18,400			

Table A-41. Tank 241-BX-109 Analytical Results: Sulfate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: H_2O dilution			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	27,600	26,100	26,800	16,600	N/A	N/A
S95T001001	85:4	N/A	6,370	6,450	6,410			
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	19,500	19,100	19,300	18,800	2.7	20,300
S95T001469	85:N/A	N/A	18,400	18,200	18,300[c]			

Table A-42. Tank 241-BX-109 Analytical Results: Oxalate (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Composite: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001469	85:N/A	N/A	< 2,130	< 2,189	< 2,170[c]	< 2,170	N/A	N/A

Table A-43. Tank 241-BX-109 Analytical Results: Americium-241 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000760	84:1	Whole	< 0.156	< 0.153	< 0.155	< 0.284	N/A	N/A
S95T000766	84:2	Upper ½	< 0.371	< 0.355	< 0.363			
S95T000763		Lower ½	< 0.170	< 0.174	< 0.172			
S95T000772	84:3	Upper ½	< 0.349	< 0.354	< 0.352			
S95T000769		Lower ½	< 0.298	< 0.304	< 0.301			
S95T000778	84:4	Upper ½	< 0.335	< 0.316	< 0.326			
S95T000775		Lower ½	< 0.319	< 0.318	< 0.319			
S95T000781	85:1	Whole	< 0.367	< 0.368	< 0.368			
S95T000790	85:2	Upper ½	< 0.139	< 0.140	< 0.140			
S95T000787		Lower ½	< 0.121	< 0.123	< 0.122			
S95T000840	85:3	Upper ½	< 0.451	< 0.443	< 0.447			
S95T000837		Lower ½	< 0.317	< 0.316	< 0.317			
S95T000851	85:4	Upper ½	< 0.312	< 0.294	< 0.303			
S95T000848		Lower ½	< 0.337	< 0.334	< 0.336			

Table A-43. Tank 241-BX-109 Analytical Results: Americium-241 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
S95T000784	85:1	N/A	< 0.107	< 0.106	< 0.107	< 0.0615	N/A	N/A
S95T000854	85:4	N/A	< 0.0170	< 0.0159	< 0.0165			
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	< 0.329	< 0.334	< 0.332	< 1.26	N/A	N/A
S95T001471	85:N/A	N/A	< 2.13	< 2.24	< 2.185			

Table A-44. Tank 241-BX-109 Analytical Results: Cobalt-60 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000760	84:1	Whole	< 0.00563	< 0.00556	< 0.00558	< 0.0133	N/A	N/A
S95T000766	84:2	Upper ½	< 0.0209	< 0.0197	< 0.0203			
S95T000763		Lower ½	< 0.00454	< 0.00540	< 0.00497			
S95T000772	84:3	Upper ½	< 0.0177	< 0.0197	< 0.0187			
S95T000769		Lower ½	< 0.0135	< 0.0154	< 0.0145			
S95T000778	84:4	Upper ½	< 0.0181	< 0.0108	< 0.0145			
S95T000775		Lower ½	< 0.0164	< 0.0157	< 0.0161			
S95T000781	85:1	Whole	< 0.0204	< 0.0190	< 0.0125			
S95T000790	85:2	Upper ½	< 0.00909	< 0.00938	< 0.0197			
S95T000787		Lower ½	< 0.00828	< 0.00855	< 0.00924			
S95T000840	85:3	Upper ½	< 0.0232	< 0.0170	< 0.0084			
S95T000837		Lower ½	< 0.0167	< 0.0139	< 0.0201			
S95T000851	85:4	Upper ½	< 0.0133	< 0.0154	< 0.0153			
S95T000848		Lower ½	< 0.0211	< 0.0135	< 0.01435			

Table A-44. Tank 241-BX-109 Analytical Results: Cobalt-60 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
S95T000784	85:1	N/A	< 0.00375	< 0.00417	< 0.00396	< 0.00340	N/A	N/A
S95T000854	85:4	N/A	< 0.00275	< 0.00293	< 0.00284			
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	< 0.0130	< 0.0137	< 0.0134	< 0.130	N/A	N/A
S95T001471	85:N/A	N/A	< 0.221	< 0.272	< 0.247			

Table A-45. Tank 241-BX-109 Analytical Results: Cesium-137 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000760	84:1	Whole	9.450	9.190	9.320	12.6	12.8	13,600
S95T000766	84:2	Upper ½	10.30	10.50	10.40			
S95T000763		Lower ½	24.90	25.00	24.95			
S95T000772	84:3	Upper ½	14.20	15.20	14.70			
S95T000769		Lower ½	8.690	8.650	8.670			
S95T000778	84:4	Upper ½	14.90	13.50	14.20			
S95T000775		Lower ½	7.700	7.250	7.475			
S95T000781	85:1	Whole	9.440	9.360	9.400			
S95T000790	85:2	Upper ½	10.00	10.20	10.10			
S95T000787		Lower ½	11.70	12.00	11.85			
S95T000840	85:3	Upper ½	28.40	28.50	28.45			
S95T000837		Lower ½	14.40	15.00	14.70			
S95T000851	85:4	Upper ½	10.70	10.70	10.70			
S95T000848		Lower ½	8.460	8.330	8.395			

Table A-45. Tank 241-BX-109 Analytical Results: Cesium-137 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid			**µCi/mL**	**µCi/mL**	**µCi/mL**	**µCi/mL**	**%**	**Ci**
S95T000784	85:1	N/A	12.70	12.60	12.65	6.33	N/A	N/A
S95T000854	85:4	N/A	< 0.00668	< 0.00680	< 0.00674			
Composite			**µCi/g**	**µCi/g**	**µCi/g**	**µCi/g**	**%**	**Ci**
S95T001329	84:N/A	N/A	14.10	14.40	14.25	13.9	2.5	15,000
S95T001471	85:N/A	N/A	13.90	13.20	13.55			

Table A-46. Tank 241-BX-109 Analytical Results: Europium-154 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000760	84:1	Whole	< 0.0235	< 0.0509	< 0.0372	< 0.0494	N/A	N/A
S95T000766	84:2	Upper ½	< 0.0671	< 0.0666	< 0.0669			
S95T000763		Lower ½	0.0473	< 0.0210	< 0.0342			
S95T000772	84:3	Upper ½	< 0.0522	< 0.0465	< 0.0494			
S95T000769		Lower ½	< 0.0549	< 0.0631	< 0.0590			
S95T000778	84:4	Upper ½	< 0.0505	< 0.0488	< 0.0497			
S95T000775		Lower ½	< 0.0491	< 0.0440	< 0.0466			
S95T000781	85:1	Whole	< 0.0706	< 0.0730	< 0.0718			
S95T000790	85:2	Upper ½	< 0.0324	< 0.0344	< 0.0334			
S95T000787		Lower ½	< 0.0294	< 0.0277	< 0.0286			
S95T000840	85:3	Upper ½	< 0.0657	< 0.0618	< 0.0638			
S95T000837		Lower ½	< 0.0442	< 0.0419	< 0.0431			
S95T000851	85:4	Upper ½	< 0.0381	< 0.0531	< 0.0456			
S95T000848		Lower ½	< 0.0562	< 0.0492	< 0.0527			

Table A-46. Tank 241-BX-109 Analytical Results: Europium-154 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
S95T000784	85:1	N/A	< 0.00993	< 0.0107	< 0.0103	< 0.0759	N/A	N/A
S95T000854	85:4	N/A	< 0.00710	< 0.00801	< 0.00756			
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	< 0.0505	< 0.0448	< 0.0477	< 0.157	N/A	N/A
S95T001471	85:N/A	N/A	< 0.618	< 0.667	< 0.643			

Table A-47. Tank 241-BX-109 Analytical Results: Europium-155 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000760	84:1	Whole	< 0.0567	< 0.0567	< 0.0567	< 0.113	N/A	N/A
S95T000766	84:2	Upper ½	< 0.164	< 0.160	< 0.162			
S95T000763		Lower ½	< 0.0600	< 0.0602	< 0.0601			
S95T000772	84:3	Upper ½	< 0.126	< 0.124	< 0.125			
S95T000769		Lower ½	< 0.134	< 0.136	< 0.135			
S95T000778	84:4	Upper ½	< 0.146	< 0.136	< 0.141			
S95T000775		Lower ½	< 0.118	< 0.115	< 0.117			
S95T000781	85:1	Whole	< 0.166	< 0.169	< 0.168			
S95T000790	85:2	Upper ½	< 0.0593	< 0.0603	< 0.0598			
S95T000787		Lower ½	< 0.0510	< 0.0519	< 0.0515			
S95T000840	85:3	Upper ½	< 0.160	< 0.158	< 0.159			
S95T000837		Lower ½	< 0.110	< 0.114	< 0.112			
S95T000851	85:4	Upper ½	< 0.109	< 0.109	< 0.109			
S95T000848		Lower ½	< 0.124	< 0.124	< 0.124			

Table A-47. Tank 241-BX-109 Analytical Results: Europium-155 (GEA).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
S95T000784	85:1	N/A	< 0.0443	< 0.0437	< 0.0440	< 0.0258	N/A	N/A
S95T000854	85:4	N/A	< 0.00757	< 0.00770	< 0.00764			
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	< 0.118	< 0.117	< 0.118	< 0.417	N/A	N/A
S95T001471	85:N/A	N/A	< 0.757	< 0.675	< 0.716			

Table A-48. Tank 241-BX-109 Analytical Results: $^{89/90}Sr$ (High Level Beta Counting).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000769	84:3	Lower ½	131	131	131	131	N/A	N/A
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	180	181	181	178	1.5	1.92E+05
S95T001471	85:N/A	N/A	177	173	175			

Table A-49. Tank 241-BX-109 Analytical Results: Total Alpha (Alpha Proportional Counting).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T000760	84:1	Whole	< 0.0546	< 0.0547	< 0.0547	< 0.0446	N/A	48.1
S95T000766	84:2	Upper ½	< 0.0385	< 0.0357	< 0.0371			
S95T000763		Lower ½	< 0.0328	< 0.0338	< 0.0333			
S95T000772	84:3	Upper ½	< 0.0454	< 0.0529	< 0.0492[c]			
S95T000769		Lower ½	< 0.0540	< 0.0528	< 0.0534			
S95T000778	84:4	Upper ½	< 0.0350	< 0.0334	< 0.0342[c]			
S95T000775		Lower ½	< 0.0305	< 0.0489	< 0.0397[a]			
S95T000781	85:1	Whole	< 0.0638	< 0.0508	< 0.0573[c]			
S95T000790	85:2	Upper ½	< 0.0341	< 0.0345	< 0.0343			
S95T000787		Lower ½	0.138	0.0304	0.0842[c]			
S95T000840	85:3	Upper ½	< 0.0389	< 0.0344	< 0.0367[a,c]			
S95T000837		Lower ½	< 0.0335	0.0286	0.0311[a,c]			
S95T000851	85:4	Upper ½	< 0.0200	< 0.0200	< 0.0200[c]			
S95T000848		Lower ½	< 0.0398	< 0.0320	< 0.0359[c]			

Table A-49. Tank 241-BX-109 Analytical Results: Total Alpha (Alpha Proportional Counting).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
S95T000784	85:1	N/A	8.09E-04	4.27E-04	6.18E-04[a,c]	3.48E-04	75.8	N/A
S95T000853	85:4	N/A	< 6.95E-05	8.54E-05	7.74E-05[a,c]			
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	< 0.0360	< 0.0276	< 0.0318	0.0292	90.4	N/A
S95T001471	85:N/A	N/A	0.0258	0.0274	0.0266			

Table A-50. Tank 241-BX-109 Analytical Results: Total Beta (Beta Proportional Counting).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Composite			µCi/g	µCi/g	µCi/g	µCi/g	%	Ci
S95T001329	84:N/A	N/A	380	365	373	347	N/A	
S95T001471	85:N/A	N/A	324	316	320		N/A	37,400

Table A-51. Tank 241-BX-109 Analytical Results: Total Organic Carbon (Persulfate/Coulometry).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000759	84:1	Whole	1,070	921	995.5	995.5	N/A	N/A
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001325	84:N/A	N/A	427	332	380	410	7.3	239
S95T002283	85:N/A	N/A	426	454	440			

Table A-52. Tank 241-BX-109 Analytical Results: Percent Water (TGA). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)
Solids			wt %	wt %	wt %	wt %	%
S95T000759	84:1	Whole	48.07	49.92	49.85	50.3	3.9
S95T000765	84:2	Upper ½	50.78	50.03	50.41		
S95T000762		Lower ½	51.17	50.89	51.03		
S95T000771	84:3	Upper ½	48.91	49.02	48.97		
S95T000768		Lower ½	49.52	48.67	49.09		
S95T000777	84:4	Upper ½	52.78	52.92	52.85		
S95T000774		Lower ½	47.98	48.87	48.42		
S95T000780	85:1	Whole	52.56	52.78	52.67		
S95T000789	85:2	Upper ½	50.65	43.72	47.19		
S95T000786		Lower ½	51.36	49.58	50.47		
S95T000839	85:3	Upper ½	50.98	51.70	51.34		
S95T000836		Lower ½	51.23	50.86	51.05		
S95T000850	85:4	Upper ½	53.46	54.63	49.00[1] (54.05)		
S95T000847		Lower ½	51.29	51.39	51.34		

Table A-52. Tank 241-BX-109 Analytical Results: Percent Water (TGA). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)
Drainable liquid			wt %	wt %	wt %	wt %	%
S95T000783[4]	85:1	N/A	67.45[2]	57.73	62.59	60.1	N/A
S95T000783[5]	85:1	N/A	57.53	---	57.53		
S95T000853	85:4	N/A	87.66	87.61	0[1,3] (87.63)		
Composite			wt %	wt %	wt %	wt %	%
S95T001325	84:N/A	N/A	51.23	50.64	50.94	50.9	0.6
S95T001468	85:N/A	N/A	51.03	50.55	50.79		

Notes:

[1]HHF corrections made using bromide concentrations.
[2]Analytical value disregarded as per Final Data Package for 241-BX-109.
[3]This drainable liquid sample was all HHF fluid. Its percent water value was not used.
[4]TGA using Mettler™.
[5]TGA using Perkin Elmer™.

Table A-53. Tank 241-BX-109 Analytical Results: Density and Specific Gravity.

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)
Core composite: bulk density			**g/mL**	**g/mL**	**g/mL**	**g/mL**	**%**
S95T001325	84:N/A	N/A	1.460	N/A	N/A	1.48	N/A
S95T001468	85:N/A	N/A	1.500	N/A	N/A		
Solids: bulk density			**g/mL**	**g/mL**	**g/mL**	**g/mL**	**%**
S95T000772	84:3	Lower ½	1.52	N/A	N/A	1.52	N/A
Drainable liquids: specific gravity			**g/mL**	**g/mL**	**g/mL**	**g/mL**	**%**
S95T000783	85:1	N/A	1.265	1.727	1.496	1.27	N/A
S95T000753	85:4	N/A	1.039	1.032	1.036		

APPENDIX B

ANALYTICAL RESULTS FROM 1975 AND 1990 SAMPLING

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Table B-1. Analysis of Alkaline Waste Solutions for Tank 241-BX-109, May 20, 1975.

Component	Lab Value		Lab Unit
	Concentration	Weight %	
Physical Data			
Density at 85°C	1.311	---	g/mL
Chemical Analysis			
$NaAlO_2$	0.005	< 0.1	M
$NaNO_2$	1.33	7.0	M
$NaNO_3$	4.50	29.2	M
NaOH	< 0.01	< 0.1	M
Na_2CO_3	0.29	2.3	M
Na_3PO_4	0.29	2.2	M
Na_2SiO_3	0.005	< 0.1	M
NaF	< 0.001	< 0.1	M
Radiological Analysis			
^{137}Cs	4.32E+04	---	μCi/L
^{134}Cs	- -	---	- -
^{125}Sb	- -		- -
$^{239/240}Pu$	4.14		μCi/L
^{238}Pu	0.17		μCi/L
^{237}Pu	0.01		μCi/L
^{241}Am	0.01		μCi/L

Note:

Reference: Buckingham (1975)

Table B-2. Analysis of Supernatant Liquid for Tank 241-BX-109, March 16, 1990.

Sample #R6039			
Component	**Concentration**	**Units**	**Wt%**
Physical Data			
Density	1.34	g/mL	---
$\%H_2O$	---	---	59.8
pH	11.43	---	---
Chemical Analysis			
B	2.97E-03	M	0.00
Ca	2.61E-04	M	0.00
Cr	1.99E-03	M	0.01
Hg	1.23E-06	M	0.00
Mg	2.87E-04	M	0.00
Na	6.11E+00	M	10.52
P	2.09E-01	M	0.49
U	2.55E-01	g/L	0.02
Cl	7.64E-02	M	0.20
F	<7.86E-02	M	---
NO_2	5.24E-01	M	1.80
NO_3	4.95E+00	M	22.97
PO_4	2.10E-01	M	1.49
SO_4	2.46E-01	M	1.77
OH	1.09E-01	M	---
CO_3	3.54E-01	M	1.59
TOC	3.0	g/L Carbon	---

Table B-2. Analysis of Supernatant Liquid for Tank 241-BX-109, March 16, 1990.

Sample #R6039			
Component	**Concentration**	**Units**	**Wt%**
Physical Data			
Density	1.34	g/mL	---
$\%H_2O$	---	---	59.8
Radiological Analysis			
Supernate			
AT	9.03E-01	μCi/L	---
TB	2.03E+04	μCi/L	---
^{137}Cs (water)	1.61E+04	μCi/L	---
^{137}Cs (acid)	1.60E+04	μCi/L	---
$^{89/90}Sr$	3.24E+02	μCi/L	---
$^{239/240}Pu$	9.72E-01	μCi/L	---
^{241}Am	<3.39E+00	μCi/L	---
Slurry			
^{137}Cs	1.55E+04	μCi/L	---
$^{89/90}Sr$	6.47E+02	μCi/L	---
$^{239/240}Pu$	9.95E-01	μCi/L	---
^{241}Am	1.77E-01	μCi/L	---

Note:

Reference: Weiss (1990)

Table B-3. Comparison of Tank 241-BX-109 Liquid Sample Results.

Analyte	Drainable Liquid 1995 Core 85 Seg. 1	Drainable Liquid 1995 Core 85 Seg. 4	Supernate 1990 Sample	Supernate 1975 Sample
	µg/mL	µg/mL	µg/mL	µg/mL
Sp Gr	1.265	1.039	1.34	1.311
Al	<20.05	<5.05	--	135
PO4	22,600	<7,100	19,740	27,500
SO4	27,600	6,370	23,600	--
NO3	516,000	62,000	307,000	279,000
NO2	31,900	7,920	24,100	61,200
	µCi/mL	µCi/mL	µCi/mL	µCi/mL
Cs-137	12.7	<0.00668	16.1	43.2
Total Alpha	0.000809	--	0.000903	0.0041

APPENDIX C

1995 SAMPLE EXTRUSION PHOTOS

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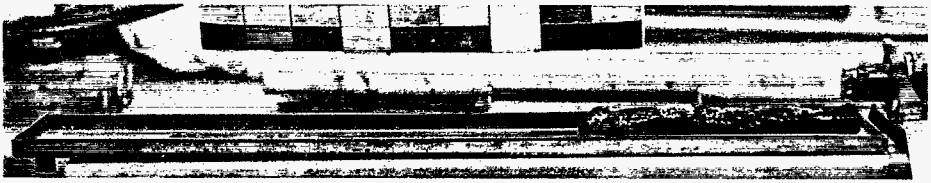
Figure C-1. Tank 241-BX-109 Core 84 Extrusion Photographs.

BX 109 Core 84 Segment #1 (riser 6)



BX 109 Core 84 Segment #2 (riser 6)

BX 109 Core 84 Segment #3 (riser 6)

BX 109 Core 84 Segment #4 (riser 6)

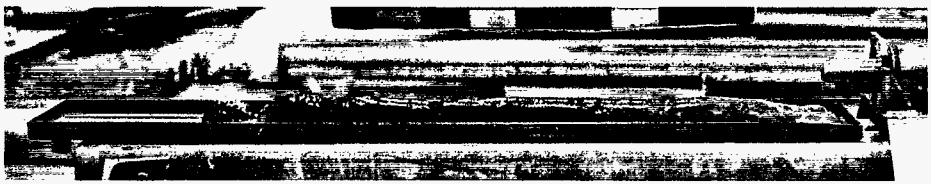


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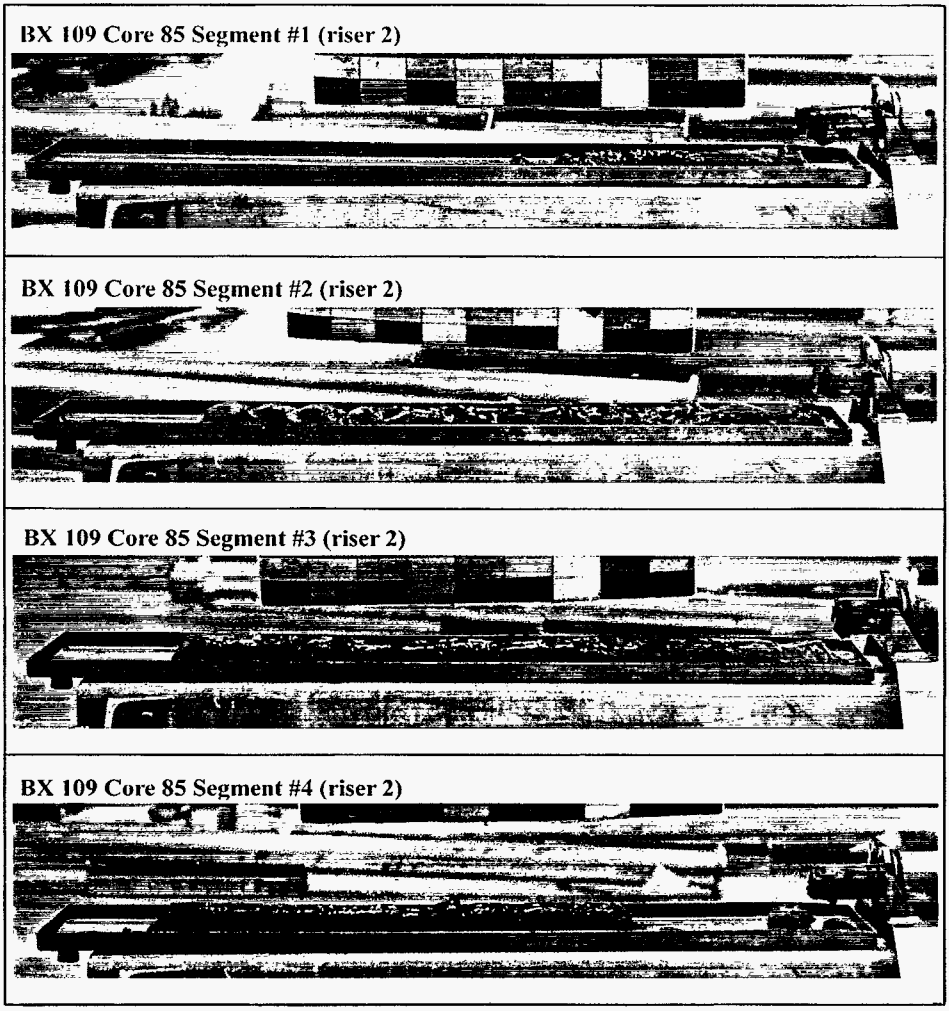
Figure C-2. Tank 241-BX-109 Core 85 Extrusion Photographs.



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APPENDIX D

HYDROSTATIC HEAD FLUID ANALYTICAL RESULTS

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Table D-1. Tank 241-BX-109 Hydrostatic Head Fluid Analytical Results: Bromide (IC).

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: H_2O dig.			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001000	85:4	Upper ½	2,440	2,400	2,420	4,030	N/A	N/A
S95T000999		Lower ½	< 5,740	< 5,530	< 5,640			
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000993	85:1	N/A	< 7,040	< 7,040	< 7,040	15,000	N/A	N/A
S95T001001	85:4	N/A	21,700	22,200	22,000			
Composite: H_2O			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001326	84:N/A	N/A	< 6,550	< 6,600	< 6,580	< 4,650	N/A	NA
S95T001469	85:N/A	N/A	< 2,710	< 2,710	< 2,710			

Table D-2. Tank 241-BX-109 Hydrostatic Head Fluid Analytical Results: Lithium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Solids: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T000760	84:1	Whole	< 48.70	< 48.77	< 48.7	< 56.8	N/A	N/A
S95T000766	84:2	Upper ½	< 53.94	< 50.06	< 52.0			
S95T000763		Lower ½	< 46.01	< 47.33	< 46.7			
S95T000772	84:3	Upper ½	< 50.00	< 49.92	< 50.0			
S95T000769		Lower ½	< 50.00	< 50.72	< 50.4			
S95T000778	84:4	Upper ½	< 53.69	< 51.25	< 52.5			
S95T000775		Lower ½	< 50.61	< 50.57	< 50.6			
S95T000781	85:1	Whole	< 48.68	< 47.79	< 48.2			
S95T000790	85:2	Upper ½	< 49.80	< 50.25	< 50.0			
S95T000787		Lower ½	< 43.44	< 43.10	< 43.3			
S95T000840	85:3	Upper ½	< 53.00	< 52.81	< 52.9			
S95T000837		Lower ½	< 47.63	< 47.64	< 47.6			
S95T000851	85:4	Upper ½	165	168.4	166.8			
S95T000848		Lower ½	< 51.90	< 52.84	< 52.4			
Solids: H_2O dig/acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001568	84:3	Lower ½	0.0611	0.0768	0.0689	0.0689	N/A	N/A

Table D-2. Tank 241-BX-109 Hydrostatic Head Fluid Analytical Results: Lithium (ICP). (2 sheets)

Sample Number	Core: Segment	Sub-Segment	Result	Dup.	Mean	Overall Mean	RSD (mean)	Projected Inventory
Drainable liquid: direct			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
S95T000784	85:1	N/A	7.735	7.698	7.716	781.4	99.0	N/A
S95T000854	85:4	N/A	1,550	1,560	1,550			
Composite: fusion			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001329	84:N/A	N/A	< 230	< 225	< 228	< 309	N/A	N/A
S95T001471	85:N/A	N/A	< 393	< 387	< 390			
Composite: H_2O dig/acid			µg/g	µg/g	µg/g	µg/g	%	kg
S95T001445	84:N/A	N/A	9.645	9.987	9.816	18.2	46.0	N/A
S95T001470	85:N/A	N/A	26.77	26.35	26.56			

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APPENDIX E

STATISTICAL ANALYSIS

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E.1 INTRODUCTION

Appendix E describes the statistical analyses performed on the sampled data from tank 241-BX-109 (referred to as BX-109). The appendix is divided into four sections, including: 1) an analysis of variance (ANOVA) for each analyte for both core composite and segment-level data; 2) cluster analysis on the segment-level data; 3) comparison of sampled data to historical analysis; and 4) plots of each analyte for the segment-level data (profiles).

E.2 ANALYSIS OF VARIANCE

The analysis of variance (ANOVA) is a statistical method used to assess data variability and to obtain uncertainly estimates for the mean concentration of various constituents.

This section is broken into two parts: core composites and segment-level analysis. Each subsection will briefly describe the analyses and present the results in tabular form. Detailed description of the ANOVA techniques as applied to the tank characterization problem has been presented elsewhere (Hartley et al. 1995).

E.2.1 CORE COMPOSITES

An ANOVA on the core composite data for tank BX-109 has been completed. Each analyte/analytical method was analyzed using a nested random effects model. The model used to analyze the core composite data is:

$$Y_{ij} = \mu + C_i + E_{ij} \qquad \text{(E.1)}$$

where

Y_{ij} = measured value of concentration in the i^{th} core and j^{th} sample
μ = mean concentration of the particular analyte for the tank
C_i = deviation of concentration from the mean in the i^{th} core
E_{ij} = analytical (lab) error in the measurement (primary and duplicate).

The results of the analysis are shown in Table E-1, where $\hat{\mu}$ is the estimated mean for the overall tank concentration for each analyte, RSD($\hat{\mu}$) is the relative standard deviation in percent units about the mean (calculated as the standard deviation for the mean divided by $\hat{\mu}$), σ_C is the variation (RSD) about the mean due to the different cores, σ_E is the variation due to the analytical measurements, <DL is the number of samples below the detection

Table E-1. Tank Concentrations and Variability for Core Samples. (2 Sheets)

Analyte	Method	Mean ($\hat{\mu}$)	Units	RSD ($\hat{\mu}$)	σ_C	σ_E	<DL	Obs.
Chloride	IC-Dionex	1.20E+03	µg/g	3	0	6.1	0	4
Nitrate	IC-Dionex	2.12E+05	µg/g	4.4	6.1	1.6	0	4
Nitrite	IC-Dionex	1.91E+04	µg/g	5.5	7.8	0.4	0	4
Phosphate	IC-Dionex	2.44E+04	µg/g	8.6	12.1	0.3	0	4
Sulfate	IC-Dionex	1.88E+04	µg/g	2.7	3.7	1.2	0	4
Bismuth	ICP:W Dig/Acid	6.34E+01	µg/g	17.7	24.5	7.5	0	4
Boron	ICP:W Dig/Acid	2.98E+01	µg/g	0.6	0	1.3	0	4
Calcium	ICP:F	4.03E+03	µg/g	39	54.8	8.7	0	4
Calcium	ICP:W Dig/Acid	7.76E+01	µg/g	7.9	8.7	9.7	0	4
Chromium	ICP:W Dig/Acid	7.49E+01	µg/g	10.6	14.9	2.7	0	4
Iron	ICP:F	2.15E+04	µg/g	5.1	7.2	1.6	0	4
Iron	ICP:W Dig/Acid	2.72E+03	µg/g	20.1	27.3	11.4	0	4
Lead	ICP:W Dig/Acid	6.09E+01	µg/g	12.6	17.7	3.2	0	4
Lithium	ICP:W Dig/Acid	1.82E+01	µg/g	46	65.1	1.5	0	4
Magnesium	ICP:W Dig/Acid	5.49E+01	µg/g	6.5	9.2	0.9	0	4
Manganese	ICP:W Dig/Acid	1.41E+01	µg/g	20.1	27.4	11.1	0	4
Nickel	ICP:F	5.89E+03	µg/g	40.7	56.7	14.5	0	4
Nickel	ICP:W Dig/Acid	1.28E+01	µg/g	19.6	27.5	5	0	4
Phosphorus	ICP:F	2.20E+04	µg/g	1.1	0	2.2	0	4
Phosphorus	ICP:W Dig/Acid	8.04E+03	µg/g	7	9.9	1.7	0	4
Silicon	ICP:F	1.73E+03	µg/g	13.3	12.2	20.2	0	4
Silicon	ICP:W Dig/Acid	8.79E+01	µg/g	3.6	0	7.1	0	4
Sodium	ICP:F	1.14E+05	µg/g	0.7	0.9	0.4	0	4
Sodium	ICP:W Dig/Acid	9.99E+04	µg/g	2.7	3.6	1.3	0	4
Strontium	ICP:F	5.90E+02	µg/g	3.4	4.8	0.4	0	4
Strontium	ICP:W Dig/Acid	3.42E+01	µg/g	26.7	37.1	9.9	0	4
Uranium	ICP:F	1.62E+04	µg/g	2.4	0	4.8	0	4
Uranium	ICP:W Dig/Acid	4.88E+02	µg/g	5.6	0	11.1	0	4
Uranium	Phosphorescence	1.80E+04	µg/g	3.5	4.9	0.6	0	4
Zinc	ICP:F	6.23E+02	µg/g	63.1	89.2	0.8	0	4
Zinc	ICP:W Dig/Acid	2.84E+01	µg/g	14	19.1	7.6	0	4

Table E-1. Tank Concentrations and Variability for Core Samples. (2 Sheets)

Analyte	Method	Mean ($\hat{\mu}$)	Units	RSD ($\hat{\mu}$)	σ_C	σ_E	<DL	Obs.
Cesium-137	GEA	1.39E+01	μCi/g	2.5	3	2.7	0	4
% Water	TGA	5.09E+01	%	0.3	0.0	0.6	0	4
Alpha	Digested Solid	2.78e-01	μCi/g	90.4	127.9	0.3	0	4
Aluminum	ICP:F	1.90E+03	μg/g	18.4	25.4	7.5	0	4
Aluminum	ICP:W Dig/Acid	2.58E+02	μg/g	16.7	23.4	4	0	4
Beta	Solid Sample	3.46E+02	μCi/g	7.6	10.6	2.5	0	4
Strontium	High Level	1.78E+02	μCi/g	1.5	2	1.2	0	4
Sulfur	ICP:F	6.84E+03	μg/g	3	3.9	2.4	0	4
Sulfur	ICP:W Dig/Acid	6.67E+03	μg/g	1.9	2.7	1	0	4
TOC	Persulfate/Coulom	409	μg/g	7.3	5.8	12	0	4

limit, and Obs. is the number of samples for each analyte. Only the analytes in which at least half of the observations were greater than the detection limit were analyzed. In all cases, four observations above the detection limit were available.

E.2.2 Segment-Level Estimates

The analysis of segment-level data from tank BX-109 is presented in this section. Because each segment is represented by a lower and upper portion, it was possible to analyze the data using half-segment resolution. Each analyte/analytical method combination was analyzed using a nested random effects model. The model used for the analysis is:

$$Y_{ijk} = \mu + C_i + V_{ij} + E_{ijk} \qquad \text{(E.2)}$$

where

Y_{ijk} = measured value of concentration in the i^{th} core, j^{th} segment, and k^{th} sample
μ = mean concentration of the particular analyte for the tank
C_i = deviation of concentration from the mean in the i^{th} core
V_{ij} = deviation of concentration from the mean in the i^{th} core and j^{th} segment-portion
E_{ijk} = analytical (lab) error in the measurement.

The results of the analysis are shown in Table E-2, where $\hat{\mu}$ is the estimated overall tank mean concentration, RSD($\hat{\mu}$) is the variation in terms of the overall tank mean (in percent units), the σ values represent the relative standard deviation for each factor (cores, segments, and replicate samples, respectively), and the V-pval is the significance level used to test for vertical variability. Only analytes in which more than half of the observations were greater than the detection limit were analyzed.

The results shown in Table E-2 indicate that there is a strong probability of a vertical heterogeneity effect, indicated by the low p-values (V-pval < 0.01) for most of the analytes and all of the ICP samples. P-values indicated less variability for the anions. Defining the vertical structure of this heterogeneity (i.e., layers) is not an easy task using the ANOVA analysis; the ANOVA analysis is performed on one analyte at a time (univariate). Thus, a clustering analysis has been performed to identify the layering structure. The next section describes this analysis.

Table E-2. Tank Concentrations and Variability for Segment-Level Samples.

Analyte	Method	Mean ($\hat{\mu}$)	Unit	RSD ($\hat{\mu}$)	σ_c	σ_v	σ_e	<DL	Obs	P-Val(V)
Chloride	IC-Dionex	1.33E+03	µg/g	2.9	0.0	8.7	9.3	2	28	0.0284
Nitrate	IC-Dionex	1.96E+05	µg/g	2.8	0.0	8.4	8.9	0	28	0.0278
Nitrite	IC-Dionex	1.80E+04	µg/g	11.8	16.4	2.9	9.2	0	28	0.3673
Phosphate	IC-Dionex	2.46E+04	µg/g	4.2	0.0	13.0	12.3	0	28	0.0183
Sulfate	IC-Dionex	1.78E+04	µg/g	2.9	0.0	9.3	8.1	0	28	0.0109
Aluminum	ICP:F	1.99E+03	µg/g	26.8	0.0	100.2	3.8	0	28	0.0000
Boron	ICP-Acid Dil.	2.16E+01	µg/mL	46.9	NA	NA	4.0	0	4	NA
Calcium	ICP:F	2.72E+03	µg/g	17.2	0.0	64.2	3.9	0	28	0.0000
Chromium	ICP-Acid Dil.	6.27E+01	µg/mL	73.7	NA	NA	1.6	0	4	NA
Chromium	ICP:F	1.43E+02	µg/g	6.6	0.0	24.4	6.5	0	28	0.0000
Iron	ICP:F	2.13E+04	µg/g	5.6	0.0	19.9	8.4	0	28	0.0000
Lead	ICP:F	6.67E+02	µg/g	7.3	0.0	26.5	9.6	5	28	0.0000
Magnesium	ICP:F	7.03E+02	µg/g	9.5	0.0	35.5	4.7	12	28	0.0000
Manganese	ICP:F	1.40E+02	µg/g	8.0	0.0	29.3	7.2	0	28	0.0000
Nickel	ICP:F	5.05E+03	µg/g	18.0	21.0	32.9	26.3	0	28	0.0069
Phosphorus	ICP:F	2.10E+04	µg/g	4.6	0.0	17.0	2.8	0	28	0.0000
Silicon	ICP:F	7.17E+02	µg/g	7.9	0.0	28.3	6.5	0	26	0.0000
Sodium	ICP:F	1.06E+05	µg/g	1.5	0.0	5.4	2.3	0	28	0.0000

Table E-2. Tank Concentrations and Variability for Segment-Level Samples.

Analyte	Method	Mean ($\bar{\mu}$)	Unit	RSD ($\bar{\mu}$)	σ_C	σ_V	σ_E	<DL	Obs	P-Val(V)
Strontium	ICP:F	5.93E+02	µg/g	6.5	0.0	24.2	2.7	0	28	0.0000
Titanium	ICP:F	8.27E+01	µg/g	11.5	5.5	34.9	29.1	14	28	0.0093
Uranium	ICP:F	1.49E+04	µg/g	12.8	0.0	47.8	3.3	0	28	0.0000
Uranium	Phosphorescence	1.72E+04	µg/g	11.5	0.0	43.1	3.9	0	28	0.0000
Zinc	ICP:F	1.52E+02	µg/g	6.5	0.0	19.9	19.6	0	28	0.0175
Cesium-137	GEA	1.31E+01	µCi/g	12.8	0.0	47.7	2.8	0	28	0.0000
% Water	TGA on Perkin Elmer	6.18E+01	%	20.9	28.3	14.0	4.6	0	12	0.0014
% Water	TGA using Mettler	5.13E+01	%	1.4	0.0	3.3	3.9	0	21	0.0560
Alpha	Digested Solid	6.79e-02	µCi/g	12.0	14.5	8.7	30.6	27	28	0.3890
Sulfur	ICP:F	6.29E+03	µg/g	1.6	0.0	5.7	1.7	0	28	0.0000

E.3 CLUSTER ANALYSIS

The tank BX-109 core sample dataset contains 28 multivariate observations. The observations may be cross-classified by core number (84 -- near the overflow, 85 -- near the inlet), sample size (whole or half segment), and sample replicate (primary or duplicate).

A multivariate observation describing one tank BX-109 analytical sample may include concentration measurements determined by IC (BO, Cl, F, NO2, NO3, Oxa, PO4, SO4), ICP:F (AG, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, La, Li, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, S, Sb, Se, Si, Sm, Sr, Ti, Tl, U, V, Zn, Zr) and GEA (Am, Co, Cs, Eu, Sr). Measurements for many of these analytes, however, were not made, or were below detection limits. Therefore, the analytes available for clustering were reduced to Cl, NO2, NO3, PO4, SO4, Al, Ca, Fe, Mg, Na, Ni, P, S, and U.

The objectives of the multivariate statistical analysis of the reduced BX-109 dataset were:

- Describe qualitatively potential spatial structure within the BX-109 wastes by identifying groups (clusters) of similar observations
- Describe quantitatively each layer based on the numerical characteristics of the associated cluster of observations.

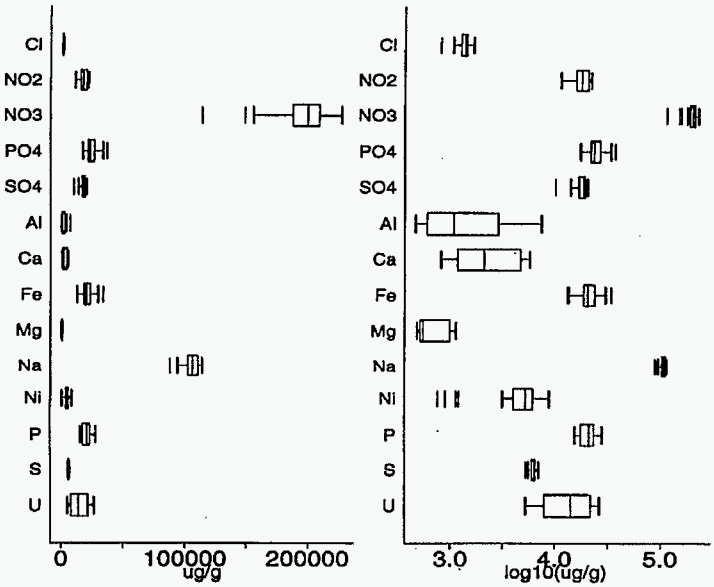
The application of multivariate methods to the BX-109 dataset proceeded through several steps: data screening, data transformation, sample clustering, analysis of the correlation structure, and summarization of the results. Several iterations through the steps were necessary to uncover anomalies and reveal consistencies. The results reported here are a composite of the results of several iterations.

E.3.1 DATA SCREENING

The BX-109 dataset was screened prior to clustering to identify variables and measurements that may have significant influence in the multivariate analysis and to identify possible corrective actions (variable transformations or exclusions). Screening was also used to gain a better understanding of the variables and measurements that drive the clustering.

The reduction of the set of analytes because of missing values and below detection limit measurements was described in the previous section. Screening also revealed a few measurements that eluded quality control efforts. For example, measurements in excess of a millon parts per million, and measurements reported below detection limit values in excess of the reported detection limit, were identified and addressed.

Figure E-1. Boxplots of Original and Log_{10} Transformed Data.



Disparities in the spread of measurement distributions significantly influence clustering results. Boxplots, which display the measurement distributions, show the disparities in the spread of measurement distributions across analytes (Figure E-1). Because of the large spread of measurement distribution, it is possible to say that NO3, U and Na would dominate the clustering analysis if performed on the original measuring scale (while, perhaps, important analytes based on physical principles would have minimal influence on the analysis). A $\log_{10}$ transformation reduced the influence of NO3 and increased the effect of Al, Ca and Mg on clustering results. With respect to the new differences in spread of analyte measurements, this transformation may be extreme. An rth root transformation may provide a better balance between the extremes of the original and $\log_{10}$ scales. Assessment of tank data is needed to identify appropriate transformations for individual tanks.

E.3.2 MULTIVARIATE CLUSTERING

A multivariate observation on one sample can be thought of as defining the coordinates of a point in multi-dimensional space. In this analysis, the 28 samples in the analyte-reduced dataset identify 28 points in a 14-dimensional space (one dimension for each analyte in the analysis dataset). A group of similar BX-109 samples was identified by finding a cluster of points that were, in some sense, close together in the 14-dimension space. A quantitative summary of the cluster (number of samples, 10th percentile, median, and 90th percentile) was then calculated from measurements on the cluster members.

Groups of similar BX-109 samples were identified by comparing the results of several clustering runs. Runs were performed on both the original-scaled and $\log_{10}$ transformed data. For both datasets, two cluster joining rules were used (''average'' and ''complete'' linkage). Two major clusters emerged, and one of these contained 3 distinct, but minor, sample subsets. Sample membership in the major clusters remained stable across all data transformation and linkage combinations. Membership in the minor groups varied slightly. Figure E-2 presents a dendogram (cluster tree) showing the linkages among samples and clusters, and the relative distances among them.

The two major groups consist of samples from the top and bottom of tank BX-109, respectively. The minor groups partition the samples in the bottom group into spatially-coherent subsets. The separation among samples in these subgroups, however, may not be physically significant. A useful visualization of the clustering results that suggests spatial structure for the BX-109 waste is shown in Figure E-3. Here, the different colors denote the clusters; the colors correspond to those featured on the BX-109 dendogram (Figure E-2).

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Figure E-2. Dendogram of Compact Linkage Clustering on Log_{10} Transformed Data using Cl, NO2, NO3, PO4, SO4, Al, Ca, Fe, Mg, Na, Ni, P, S.

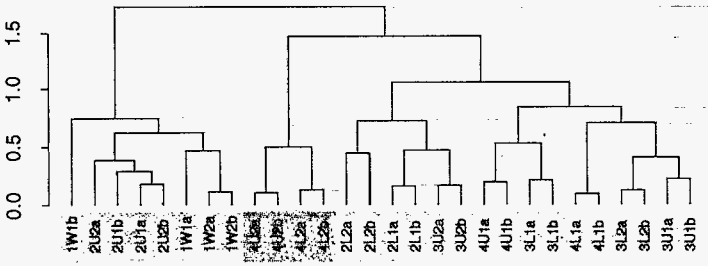

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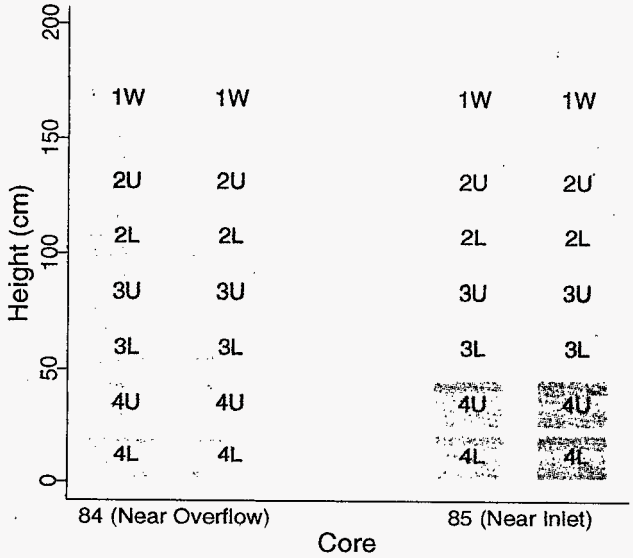
Figure E-3. Overlay of Clustering Results onto the Two Cores, Colors Denote Groupings Identified from the Clustering Dendogram.



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A quantitative summary of the 4 clusters can be found in Table E-3. The clusters are identified by 'color' in reference to the colors featured in the dendogram and core plot. For each analyte and cluster, three values labeled 'low', 'mid' and 'hi' are listed. These values correspond to the 10th percentile, median and 90th percentile of the sample distribution for the cluster members, and provide a sense of the distribution of measurements within a cluster. From visual comparisons of these summaries across clusters, distinct differences are found in U, Al, Ca and Ni, particularly between the 'green' major cluster and the subgroups in the other major clusters. Less distinct differences between clusters for each analyte can also be observed.

Table E-3. Quantitative Summary of BX-109 Clusters. ("Low", "mid", and "hi" denote the 10th percentile, median, and 90th percentile, respectively. Colors correspond to the clusters in Figure E-3. All Values are in $\mu g/g$)

	Green n = 8			Brown n = 4			Gold n = 6			Tan n = 10		
Analyte	low	mid	hi	low	mid	hi	low	mid	hi	low	mid	hi
Cl	983	1315	1389	1173	1215	1348	1140	1355	1460	1308	1430	1525
NO2	13710	20000	21290	17230	18350	19890	14950	20500	21900	14990	16650	18970
NO3	138500	190500	198900	185000	192000	201800	167500	202500	205500	198900	214000	222600
PO4	25490	28100	34920	17530	19750	21970	21450	23450	26350	21090	22200	26720
SO4	12760	17500	18590	16350	17400	18450	14900	18500	19150	18560	19200	19670
Al	2911	3965	7372	518	538	589	692	1230	1775	485	636	2354
Ca	4691	4895	5663	827	1040	1353	1975	2535	4060	1035	1165	2203
Fe	18410	20950	27740	19320	21300	23350	16500	19750	24050	13360	21100	28110
Mg	985	1065	1109	480	500	519	538	586	850	498	522	561
Na	100100	106500	111000	100300	102000	105100	108500	110500	113500	93490	104500	112100
Ni	5308	6135	8796	797	1013	1179	3875	5145	7190	3575	4935	6692
P	15610	24500	26990	17420	18500	19650	21850	22950	24200	16600	19850	22600
S	5976	6100	6242	5973	6185	6530	6410	6480	6580	5538	6500	6920
U	5729	6495	11410	22050	22550	23400	7930	10135	14150	14350	21300	26310

E.4 REFERENCES

Hartley, S. A., K. M. Remund, B. C. Simpson, R. D. Cromar, and C. M. Anderson, 1995, *Statistical Supplement to the Tank Characterization Reference Guide*, WHC-SD-WM-TI-648, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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