SEP 07 1994

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 608062

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Characterization Support	4. Related EDT No.:
5. Proj./Prog./Dept./Div.: WM/Characterization	6. Cog. Engr.: B. C. Simpson	7. Purchase Order No.: NA
8. Originator Remarks: Tank Characterization Report for Single-Shell Tank 241-C-110. This report contributes to the fulfillment of TPA Milestone M-44-05		9. Equip./Component No.: NA
		10. System/Bldg./Facility: Tank Farms
11. Receiver Remarks:	RECEIVED OCT 03 1994 OSTI	12. Major Assm. Dwg. No.: NA
		13. Permit/Permit Application No.: NA
		14. Required Response Date: Sept. 6, 1994

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-WM-ER-367		0	Tank Characterization Report for Single Shell Tank 241-C-110	NA	2	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature (M) MSIN	(L) Date	(J) Name	(K) Signature (M) MSIN	(L) Date	(G) Reason	(H) Disp.
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		Safety NA							
		Env. NA							
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18.	19.	20.	21. DOE APPROVAL (if required)
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BD-7400-172-2 (04/94) GEF097

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Document Number:	WHC-SD-WM-ER-367 Revision 0
Document Title:	Tank Characterization Report for Single-Shell Tank 241-C-110
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A-6001-400 (07/94) WEF256

SUPPORTING DOCUMENT

1. Total Pages 136

2. Title	3. Number	4. Rev No.
Tank Characterization Report for Single-Shell Tank 241-C-110	WHC-SD-WM-ER-367	0

5. Key Words

Waste Characterization; Single-Shell Tank; C-110; Tank Characterization Report; Waste Inventory; C Farm; TPA Milestone M-10; TPA Milestone M-44

APPROVED FOR PUBLIC RELEASE

KMB 9/7/94

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Organization/Charge Code 7E720/N4D2F

7. Abstract

This document provides the characterization information and interprets the data for Single-Shell Tank C-110

9. Impact Level NA

10. RELEASE STAMP

OFFICIAL RELEASE 5

BY WHC

DATE SEP 07 1994

Sta. 4

A-6400-073 (11/91) (EF) WEF124

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

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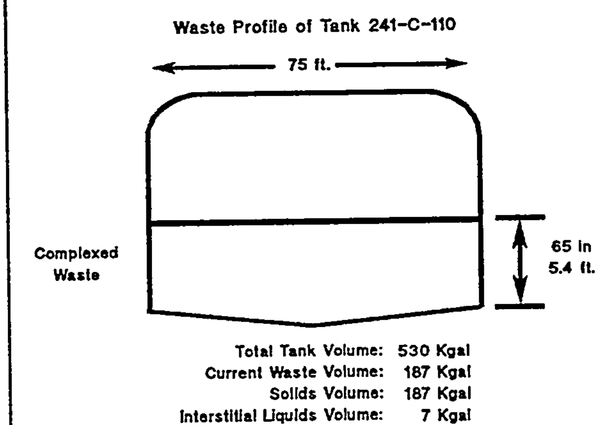
EXECUTIVE SUMMARY

Single-Shell Tank 241-C-110 is an underground storage tank containing radioactive waste most recently sampled in April of 1992. Sampling and characterization of the waste in Tank 241-C-110 contributes toward the fulfillment of Milestone M-44-05 of the *Hanford Federal Facility Agreement and Consent Order.*

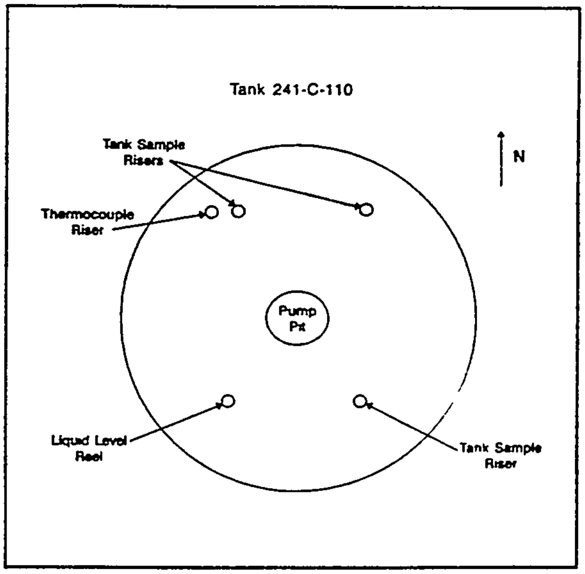


Tank 241-C-110, located in the 200 East Area C Tank Farm, was constructed in 1944 and 1945 and went into service in 1946, receiving first cycle decontamination waste from the B and T Plants. Later sources of waste included U Plant, PUREX Plant, Tank 241-BY-104, and Tank 241-BX-103. Tank 241-C-110 is the first tank in a cascade with Tanks 241-C-111 and 241-C-112. The final disposal of the waste in Tank 241-C-110 eventually will be as high- and low-level glass fractions. The tank has an operational capacity of 530,000 gallons, and currently contains 187,000 gallons of dilute complexed waste, existing primarily as sludge. Approximately 7,000 gallons of drainable interstitial liquid remain. The waste is believed to be heterogeneous, although distinct layers were unable to be discerned. The tank is not classified as a Watch List tank; however, it is an Assumed Leaker, with a leak estimate of 2,000 gallons of waste. The tank was interim stabilized in 1979 and partially interim isolated in 1982. There are no Unreviewed Safety Questions associated with Tank 241-C-110 at this time.

The waste in Tank 241-C-110 is composed of precipitated salts. The most prevalent analytes include aluminum, bismuth, sodium, iron, nitrate, nitrite, phosphate, and sulfate. The waste has a very low activity level. The major radionuclide constituents are ^{137}Cs and ^{90}Sr. Comparisons to established limits of concern for selected analytes can be made by referring to the *Tank Characterization Reference Guide* (De Lorenzo et al., 1994).

The results of the analyses have been compared to the dangerous waste codes in the *Washington Dangerous Waste Regulations* (WAC 173-303). This assessment was conducted by comparing tank analyses against dangerous waste characteristics ("D" waste codes) and against state waste codes. It did not include checking tank analyses against "U", "P", "F", or "K" waste codes since application of these codes is dependent on the source of the waste and not on particular constituent concentrations. The results indicate that the waste in this tank is adequately described in the Dangerous Waste Permit Application for the Single-Shell Tank System; this permit is discussed in the *Tank Characterization Reference Guide* (De Lorenzo et al., 1994).

Single-Shell Tank 241-C-110 Concentrations and Inventories for Critical List Analytes (as of April 1992)				
Physical Properties				
Specific Gravity	Solid: 1.45	Liquid: 1.09		
H_2O (Sludge)	59.8 wt%	616,000 kg		
pH	Solid: 11.0	Liquid: 10.4		
Heat Load	~ 136 kW			
Chemical Constituents	**Average Solid Concentration**	**Solid Bulk Inventory**	**Average Liquid Concentration**	**Liquid Bulk Inventory**
Al (Aluminum)	1.4 wt%	14,900 kg	0.00806 wt%	2.33 kg
Bi (Bismuth)	1.7 wt%	17,200 kg	0.00581 wt%	1.68 kg
Fe (Iron)	1.1 wt%	11,300 kg	0.00433 wt%	1.25 kg
Si (Silicon)	0.71 wt%	7,350 kg	0.00602 wt%	1.74 kg
Na (Sodium)	8.2 wt%	84,800 kg	4.12 wt%	1,190 kg
F^- (Fluoride)	0.76 wt%	7,830 kg	0.00474 wt%	13.7 kg
NO_3^- (Nitrate)	11.1 wt%	114,000 kg	8.34 wt%	2,410 kg
NO_2^- (Nitrite)	0.69 wt%	7,070 kg	0.720 wt%	208 kg
PO_4^{3-} (Phosphate)	2.8 wt%	28,800 kg	0.509 wt%	147 kg
SO_4^{2-} (Sulfate)	1.5 wt%	15,200 kg	1.02 wt%	294 kg
Total Organic Carbon	0.080 wt%	823 kg	0.0543 wt%	15.7 kg
Total Inorganic Carbon	0.14 wt%	1,440 kg	0.186 wt%	< 53.8 kg
Radionuclides				
$^{239/240}Pu$	116 μCi/L	82.4 Ci	1.76 μCi/L	0.0466 Ci
Total Uranium	0.15 μCi/L	1,520 kg	0.0295 wt%	8.53 kg
^{137}Cs	28,200 μCi/L	20,000 Ci	7,300 μCi/L	211 Ci
^{90}Sr	7,250 μCi/L	5,140 Ci	25.5 μCi/L	0.737 Ci
^{99}Tc	47.5 μCi/L	33.7 Ci	14.8 μCi/L	0.429 Ci
Total Alpha	180 μCi/L	128 Ci	6.44 μCi/L	0.186 Ci
Total Beta	61,300 μCi/L	43,500 Ci	3,350 μCi/L	99.6 Ci



TANK 241-C-110	
Tank Description	
Type:	Single-Shell
Constructed:	1944 and 1945
In-Service:	May 1946
Out of Service:	1976
Diameter:	75 feet
Usable Depth:	16 Feet
Operating Capacity:	530,000 gallons (2,000,000 L)
Bottom Shape:	Dish
Hanford Coordinates:	42.932° North 48.540° West
Total Risers	9
Usable Risers	4
Ventilation:	Passive
Tank Status (as of June 1994)	
Contents:	Dilute Complexed Waste
Total Waste:	187,000 gallons (708,000 L)
Supernate Volume:	-0- gallons
Drainable Interstitial Liquid:	7,000 gallons (26,500 L)
Sludge:	187,000 gallons (708,000 L)
Manual Tape Surface Level:	65.5 inches (2 94)
Temperature:	66° F (05/19 94)
Integrity Category:	Assumed Leaker
Date Declared Leaker:	1984
Leak Volume Estimate:	2,000 gallons (1989) (7,570 L)
Isolation Status	
Interim Stabilized:	09 79
Partially Interim Isolated:	12 15 82

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LIST OF TERMS

ANOVA	analysis of variance
CASS	Computer Automated Surveillance System
CW	coating waste
DL	detection limit
DNFSB	Defense Nuclear Facilities Safety Board
DOE	United States Department of Energy
DSC	differential scanning calorimetry
EB	evaporator bottoms
EOX	extractable organic halides
EPA	U. S. Environmental Protection Agency
HTCE	*Historical Tank Content Estimates*
IC	ion chromatography
ICP	inductively coupled plasma
IX	ion exchange
MDL	method detection limit
ND	not detected
NPH	normal paraffin hydrocarbons
OWW	organic solvent wash waste
PNL	Pacific Northwest Laboratory
PUREX	Plutonium-Uranium Extraction Plant
RPD	relative percent difference
RSD	relative standard deviation
SACS	Surveillance Analysis Computer System
SVOA	semivolatile organics analysis
TBP	tributyl phosphate
TCLP	toxicity characteristic leach procedure
TGA	thermogravimetric analysis
TMACS	Temperature Monitoring and Control System
TOX	total organic halides
TRAC	Track Radioactive Components
TWRS	Tank Waste Remediation System
VOA	volatile organics analysis
WHC	Westinghouse Hanford Company
1C	first-cycle decontamination waste

1.0 INTRODUCTION

In April of 1992, Single-Shell Tank 241-C-110 was sampled in order to comply with requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology, EPA & DOE, 1993) and the *Washington Administrative Code* (Ecology, 1991). The analyses also provided information to the Tank Waste Remediation System in terms of tank safety, waste retrieval, and waste disposal. This Tank Characterization Report presents an overview of that tank sampling and analysis effort, and contains observations regarding waste characteristics. It also addresses expected concentration and inventory data for the waste contents based on this latest sampling data and background tank information.

1.1 PURPOSE

The purpose of this report is to describe and characterize the waste in Single-Shell Tank 241-C-110 (hereafter known as Tank 241-C-110) based on information gathered from various sources. This report summarizes the available information regarding the waste in Tank 241-C-110, and arranges it in a useful format for making management and technical decisions concerning this particular waste tank.

Specific objectives reached by the sampling and characterization of the waste in Tank 241-C-110 are:

- Contribute toward the fulfillment of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-44-05 concerning the characterization of Hanford Site high-level radioactive waste tanks (Ecology, EPA & DOE, 1993).

- Complete safety screening of the contents of Tank 241-C-110 to meet the characterization requirements of the *Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 93-5* (Conway, 1993).

- Provide tank waste characterization to the Tank Waste Remediation System (TWRS) Program Elements in accordance with the *TWRS Tank Waste Analysis Plan* (Bell, 1994).

1.2 SCOPE

This report begins with a broad description and historical background of the tank. This allows a detailed estimation of the contents of Tank 241-C-110 based on historical process information and detailed transaction records. Next, the results of the sampling and analysis effort are summarized and interpreted both qualitatively and statistically. The information obtained from historical sources is then compared with the actual waste measurements to arrive at final waste inventory and concentration estimates. Finally, recommendations are given based on the current waste inventory and tank status.

1.3 ASSUMPTIONS

The concentration and inventory estimates derived for this report are considered by the authors and by the Westinghouse Hanford Company Characterization Program to be the most accurate, defensible, technically valid, and contemporary data concerning Tank 241-C-110. This Tank Characterization Report incorporates all available previous sampling, characterization, and transfer data concerning Tank 241-C-110. In addition, estimates of the current tank contents based on process knowledge, surveillance data, and waste transaction records provide important cross-checks and corroboration to the inventory estimates derived from recent analytical data. Given that the analytical data is valid and defensible, this report is therefore the definitive characterization of the contents of Tank 241-C-110, at this time. Since Tank 241-C-110 was removed from service in 1976 (Anderson, 1990) and partially interim isolated in 1982 (Husa et al., 1993), the contents of the tank will likely remain unchanged.

The term "analytical results" is used in this report to denote sample results from the most recent sampling event. Characterization data from these samples are used as the basis for the analytical section of this report, Section 5.0. The historical assessment of these tank contents presented in Section 2.0 is based on process knowledge and the available "historical results" prior to the 1992 sampling. The characterization of Tank 241-C-110 is considered accurate and representative of the tank contents as of the date of preparation of this report: August, 1994.

2.0 HISTORICAL TANK INFORMATION

The purpose of this section is to describe Tank 241-C-110 based on historical information. It is divided into five parts. A brief description and historical background of the tank comprise the first part, followed by the current tank status, a summary of the process sources that contributed to the tank waste, and an estimation of the contents of Tank 241-C-110 based on historical information. The final part details the surveillance data taken on the tank.

2.1 TANK HISTORY

Single-Shell Tank 241-C-110 consists of a carbon steel tank within a reinforced concrete shell and dome. It has a diameter of 75 ft., an operating depth of 16 ft., and a capacity of 530,000 gallons (Husa et al., 1993). The basic design of Tank 241-C-110 is shown in Figure 2-1. Instruments access Tank 241-C-110 through risers and monitor the temperature, sludge level, and other bulk tank characteristics (Fulton, 1994). The position of these risers is found in Figure 2-2.

The 241-C Tank Farm, built in 1943 and 1944, is one of the initial four tank farms to be used at the Hanford Site. It is located on the eastern side of the 200 East Area. Figure 2-3 details the Hanford Site's 200 East Area and the location of the 241-C Tank Farm. As shown in Figure 2-2, Tank 241-C-110 is found in the far left corner of the 241-C Tank Farm.

Tank 241-C-110 is the first tank in a "cascade" connecting it to Tanks C-111 and C-112. A cascade was a system in which a number of tanks were connected in series by pipes. These pipes were located at the top of the tanks' working depths. Once the first tank in a cascade was full, additional waste would spill over into the next tank, thereby preventing over filling of the first tank. Also, by using a cascade, fewer connections needed to be made during waste handling operations. This method reduced waste handling requirements, personnel exposure, and the chance of a loss of tank integrity from waste overflow. Another advantage of using the cascades was to clarify the waste. Entrained solids would settle and insoluble constituents would precipitate in the first tank (in this case Tank 241-C-110), and the clarified liquids would flow through the cascade on to the other tanks (241-C-111 and 241-C-112). This practice led to rapid filling of the first tank with solids, and allowed the clarified liquid from the other tanks in the cascade to be discharged to cribs. The cascade connections in the 241-C Tank Farm are illustrated in Figure 2-2.

Tank 241-C-110 went into service in 1946, receiving first cycle decontamination (1C) waste (Anderson, 1990). The cascade outlet to Tank 241-C-111 was blocked in 1952. The history of Tank 241-C-110 can be summarized as a series of waste transfers into the tank, settling and precipitation of the tank contents, and then partial pumping of the supernate.

Figure 2-1. Basic Design of Tank 241-C-110.

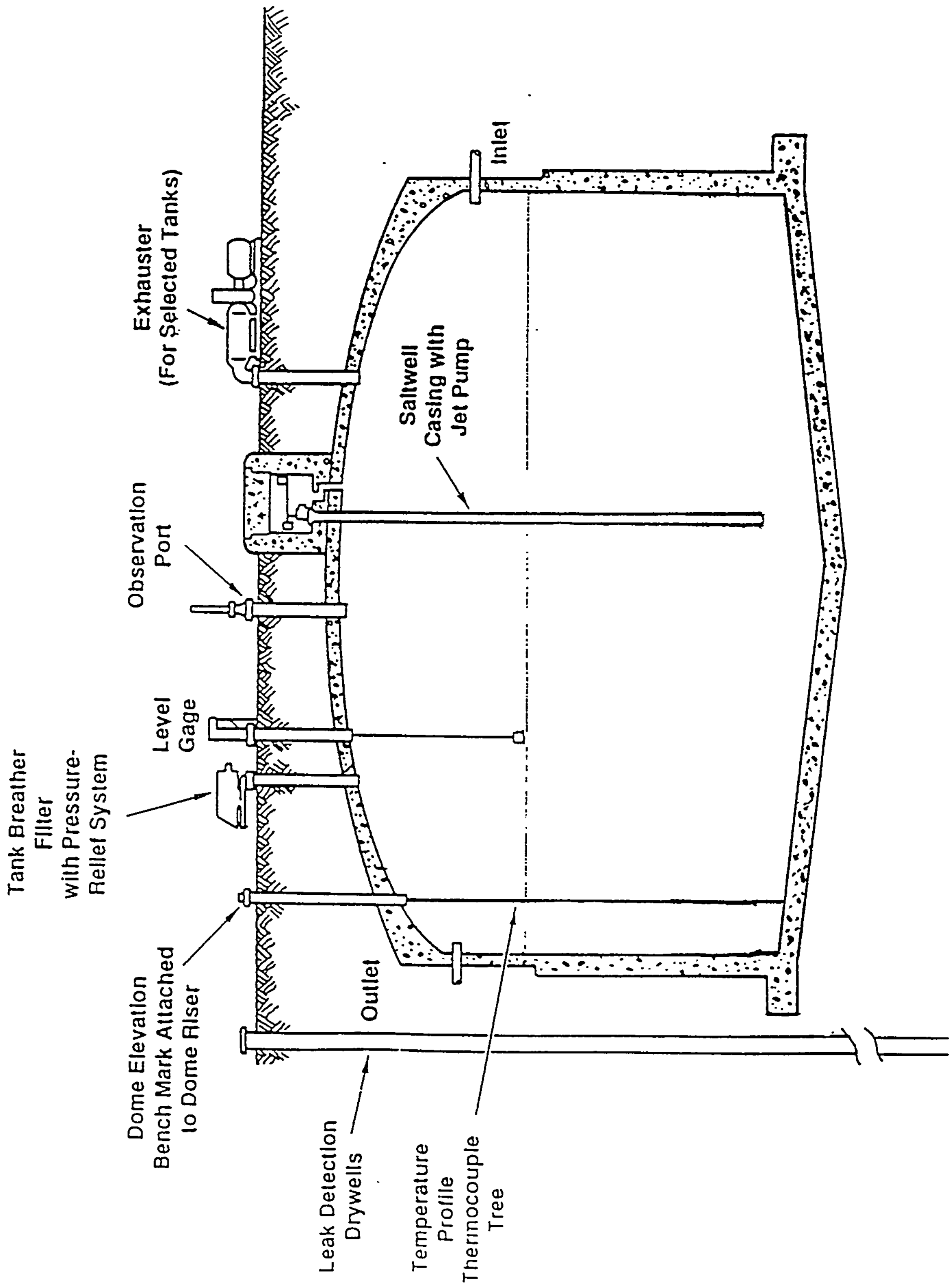


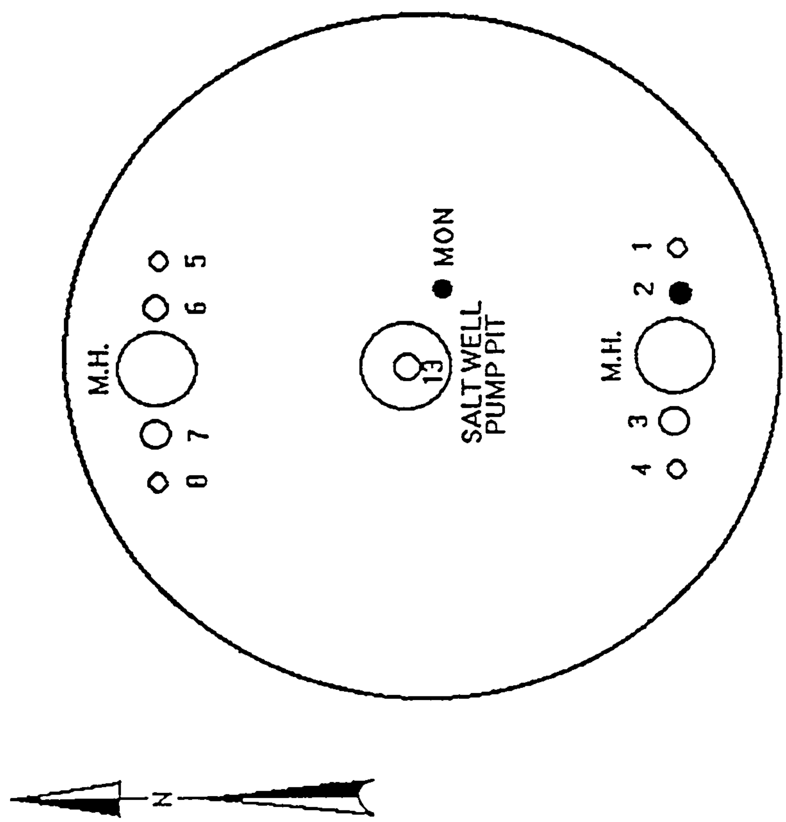
Figure 2-2. Riser Configuration for Tank 241-C-110.

241-C-110

NO.	DIA.	ELEV.	DESCRIPTION AND COMMENTS
1	4"	648.17	SMP
2	12"	648.17	FLANGE, BH
3	12"	648.19	BREATHER FILTER
4	4"	648.21	LIQUID LEVEL REEL
5	4"	647.72	FLANGE
6	12"	647.73	FLANGE WITH BALE
7	12"	647.72	FLANGE WITH LEAD/B-222 OBSV PORT
8	4"	647.70	TEMPERATURE PROBE
13	12"	644.08	SALTWELL SCREEN

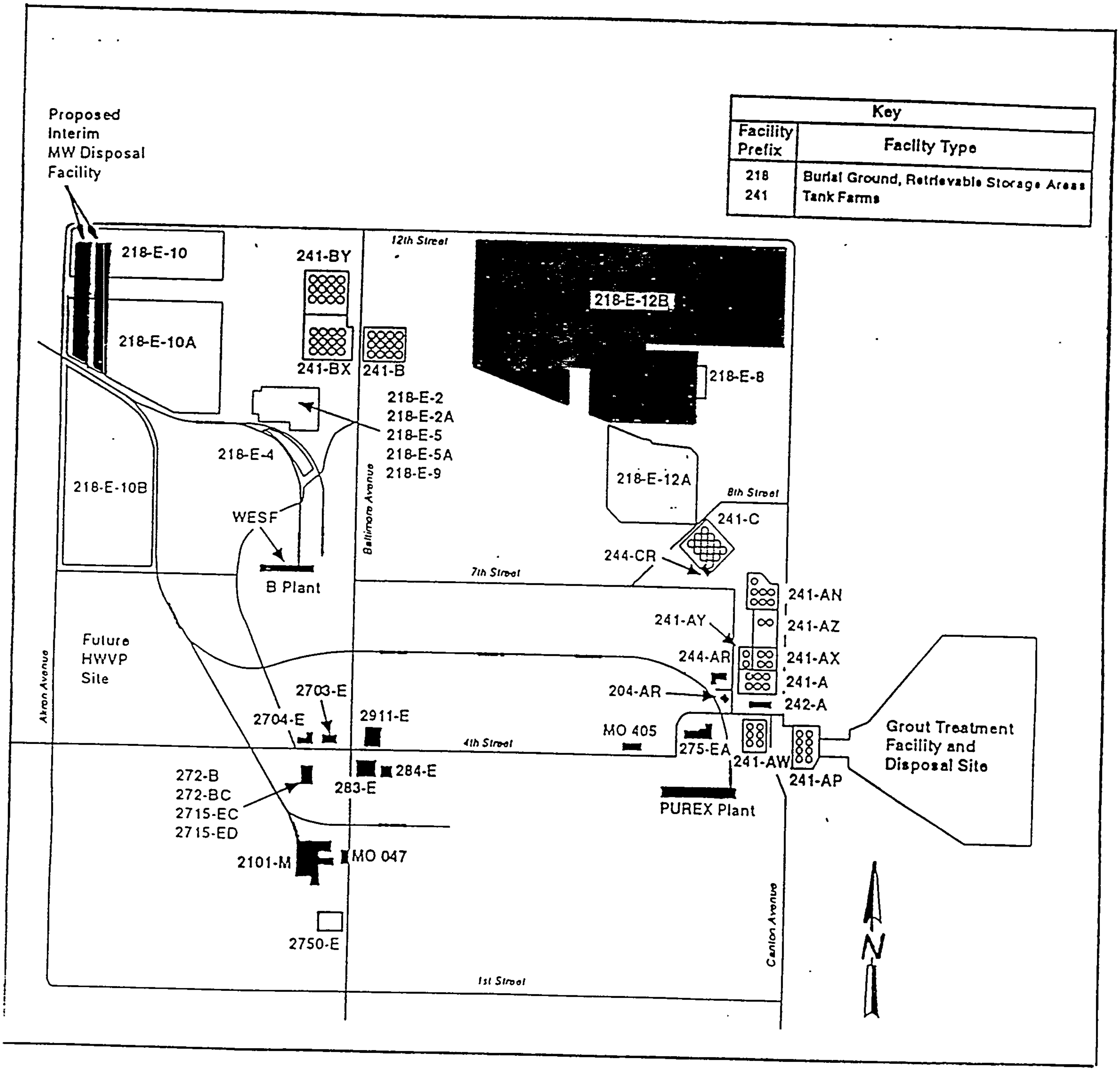
C_L INSIDE TANK BOTTOM = 610.00

REF DWGS DOME PLAN/AS BLT H-2-37010
RISER ELEV H-2-1744, H-2-37912, H-2-72743
ISOLATION H-2-73350
VERIFIED 6/30/88



M.H. Manhole in riser dome, no riser to surface

Figure 2-3. Location of the 241-C Tank Farm.



Four dry wells were drilled around Tank 241-C-110 in 1974 and 1975. Supernate was removed in 1975, and in 1976 the tank was salt well pumped to remove the remaining pumpable liquid. Tank 241-C-110 was officially removed from service in 1976. In 1977, Tank 241-C-110 was categorized as Questionable Integrity. It received this listing because of elevated radiation levels in dry well #30-10-09. Tanks with this label were suspected of leaking, although surveillance data did not provide conclusive evidence of leakage (Baumhardt, 1989). In fact, according to Welty (1988), intrusions occurred from 1977 to 1986, as the waste level actually increased without any waste being added. Primary stabilization of the tank took place in 1979.

In 1984, the Questionable Integrity designation was combined with the Confirmed Leaker category to create the current Assumed Leaker classification. Thus, Tank 241-C-110 was declared an Assumed Leaker in 1984. Since no detectable liquid level decrease had occurred, a leak estimate could not be derived from surveillance data. Instead, 2,000 gallons was chosen as the leak estimate, for it was decided that surface levels would have reflected the leak if it had been more that 2,000 gallons (Baumhardt, 1989). This leak estimate was updated in 1989. Finally, from December 1991 to January 1992, Tank 241-C-110 was again salt well pumped, removing any remaining pumpable liquid.

2.2 TANK STATUS

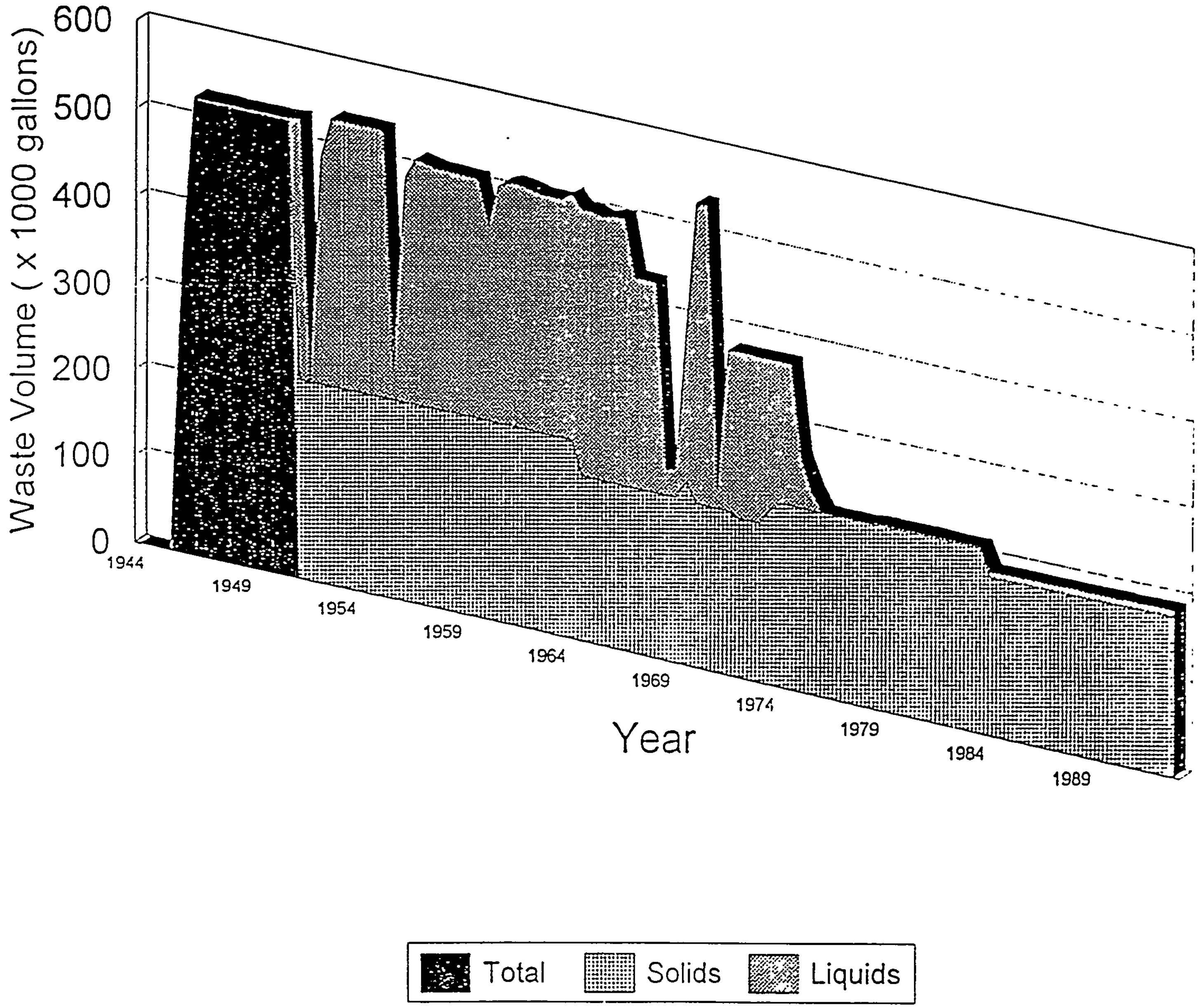
Tank 241-C-110 currently contains 187,000 gallons of sludge, with an estimated 7,000 gallons of the waste existing as drainable interstitial liquid (Hanlon, 1994). Current monitoring information indicates that the waste level extends approximately 65 inches from the baseline of the tank. (A baseline level measurement is taken near the side of the tank, and does not take the 12" dished bottom into consideration). Thermocouple data indicates that the waste temperature is 66°F and supports the conclusion that there are no significant heat-generation processes within the tank wastes. Liquid levels and tank temperatures are further discussed in Section 2.5. Ventilation for Tank 241-C-110 is passive (i.e., there are no forced-air exhausters). All monitoring systems are currently in compliance with established standards (Hanlon, 1994).

The current designation of the tank contents is dilute complexed waste. Tank 241-C-110 is not a Watch List tank, nor does it have Unreviewed Safety Questions associated with it. Tank 241-C-110 has been labeled an Assumed Leaker, and has been partially interim isolated. Partial interim isolation is the administrative designation reflecting the completion of physical modifications to tank piping systems to preclude the inadvertent addition of waste, with the exception of isolation of risers and piping necessary for jet pumping or other methods of stabilization.

2.3 PROCESS KNOWLEDGE

As mentioned in Section 2.1, the operating history of Tank 241-C-110 can be simplified to consist of 3 processes: a series of waste transfers into the tank (from separation plants or other tanks), settling and precipitation of the tank contents, and then partial pumping of the supernate. Figure 2-4 summarizes Tank 241-C-110 historic waste volume measurements.

Figure 2-4. Waste Volume History of Tank 241-C-110.



The first waste type to be introduced into Tank 241-C-110 was first cycle decontamination (1C) waste in 1946. Produced in the $BiPO_4$ process at the B and T plants, 1C waste consisted of byproducts co-precipitated from a plutonium-containing solution. Coating waste from the removal of aluminum fuel element cladding was added to the tank, and comprised about 24% of the total waste stream. The 1C waste completely filled the tank, and then cascaded on to Tanks C-111 and C-112. This waste then settled for a number of years, and the supernate was pumped off to make room for further waste additions (Anderson, 1990).

Tank 241-C-110 began receiving waste from the TBP uranium-extraction process at U Plant in 1952 and was filled by early 1953. The TBP waste was composed of concentrated, neutralized aqueous effluent from the primary extraction column and from the solvent wash. Several years elapsed, during which time settling of the TBP wastes occurred. It is possible that during this time settled 1C solids were partially re-dissolved by the TBP liquids, since the TBP was used as an extractant for 1C discharges. Tank 241-C-110 supernate was again drawn off, this time to the 001-CR crib. Since the waste was discharged to a crib, it likely contained primarily clarified liquids.

The next addition to the tank in the second quarter of 1956 was organic solvent wash waste (OWW), containing carbonate, permanganate, and nitrate, from the Plutonium-Uranium Extraction (PUREX) Plant. The waste was then allowed to settle for a full 10 years before further tank operations were conducted. During this time, the solids volume as measured by in-tank electrodes (instruments utilizing metal plates which sink until they contact the sludge layer) decreased markedly (Anderson, 1990). The likely causes for this were further settling of the sludges, and the re-dissolution of previously solidified wastes. Following the transfer of the majority of the supernate from Tank 241-C-110 in 1969, the tank received ion exchange (IX) waste supernate from Tank 241-BY-104 in 1970. Subsequent to this, large volumes of evaporator bottoms (EB) and IX waste were transferred into Tank 241-C-110, from Tank 241-BX-104, and then out again to other tanks. This left the tank completely full, primarily with the previously settled solids and the newly transferred liquids. Generated from the cesium recovery process at the B Plant, IX waste included column waste, column wash waste, and cesium purification waste. Evaporator bottoms were a slurry product from the evaporators, and would precipitate as a solid salt cake which was then stored in the single-shell tanks.

Following pumping of most of the supernatant, Tank 241-C-110 received its last waste when supernate from coating waste (CW) and OWW were transferred from Tank 241-BX-103 in 1972. Coating waste was produced at the PUREX Plant from the dissolution of zircaloy fuel cladding (after 1964) in an ammonium fluoride-ammonium nitrate solution. The tank was allowed to settle for several years, and then further pumping of the supernate began; salt well pumping further reduced the waste volume to approximately 211,000 gallons in the late 1970s. The waste volume has since decreased to the present waste volume of 187,000 gallons. Since the tank is an Assumed Leaker, it is possible that tank leakage accounts for some of the volume change and gravitational settling accounts for the rest. A salt well pumping campaign in 1991 accounts for almost 10,000 gallons of volume change.

2.4 HISTORICAL ESTIMATION OF THE CONTENTS OF TANK 241-C-110

By examining the approximate chemical composition of each waste stream introduced to Tank 241-C-110, and the inflows, outflows and transfers between tanks, estimated concentrations for selected elements, compounds, and isotopes can be developed. It is important to consider, however, that historical records are incomplete and were kept intermittently.

The following waste types have been transferred to Tank 241-C-110 throughout its operational lifetime: 1C, TBP, OWW, IX, EB, and CW (Anderson, 1990). It should be noted that Tank 241-C-110 was the first member of a cascade, which meant that it probably received more solid waste than the other two tanks when the cascade was operable. It is also important to note the quantity and chronology of the waste received. These guiding parameters indicate that Tank 241-C-110 received a large amount of solid 1C waste before any other waste type was introduced in the tank. For this reason, it is very likely that 1C waste will be the predominant waste type in Tank 241-C-110, and that it will chiefly occupy the lower portions of the tank. Estimates of the total amount of each waste type received by Tank 241-C-110, including waste volumes that have cascaded through the tank, are summarized in Table 2-1.

Table 2-1. Estimated Total Volume of Each Waste Type Received by Single-Shell Tank 241-C-110 (Anderson, 1990).

Waste Type	Estimated Volume*
1C**	1,584,000
TBP	307,000
OWW	328,000
IX	151,000
EB	84,000
CW	80,000

* Total volume can be greater than 530,000 since wastes were routinely pumped from Tank 241-C-110.
** Waste was cascaded to Tanks 241-C-111 and 241-C-112.
1C first-cycle decontamination waste
TBP tributyl phosphate waste
OWW organic solvent wash waste
IX ion exchange waste
EB evaporator bottoms
CW coating waste

A preliminary estimate of the waste constituents in Tank 241-C-110 can be generated by reviewing the historical characterization data for the tank. This estimate is compared with the most recent analytical data in Section 5.0. The Tank 241-C-110 historical tank inventory estimates reported in this Tank Characterization Report were produced using a model developed by Los Alamos National Laboratories, and reported and explained in the *Historical Tank Content Estimates* (HTCE) (ICF Kaiser Hanford, 1994). These inventory numbers were generated based on the assumption that the waste is 100% 1C sludge. Table 2-2 contains the estimated inventories from the HTCE. These values also appear in Table 5-5 as the Historic Tank Content Estimate for the solid material in Tank 241-C-110.

Table 2-2. Historical Tank Inventory Estimate of Tank 241-C-110 (ICF Kaiser Hanford, 1994).

Physical Properties		
Bulk Density	1.34	
Void Fraction	0.58	
Water wt%	68.4	
Chemical Constituents		
Analyte	**µg/g**	**Kg**
Na	1.00E+05	9.47E+04
Al	6.06E+03	5.73E+03
Fe	9.15E+03	8.66E+03
Cr	5.68E+02	5.37E+02
Bi	1.60E+04	1.51E+04
$ZrO(OH)_2$	1.99E+03	1.89E+03
OH^-	1.97E+04	1.87E+04
NO_3^{-1}	4.86E+03	4.59E+03
NO_2^{-1}	3.71E+03	3.51E+03
SO_4^{-2}	2.67E+03	2.53E+03
PO_4^{-3}	1.26E+05	1.19E+05
SiO_3^{-2}	5.83E+03	5.51E+03
F^{-1}	2.01E+ +03	1.90E+03
Radiological Constituents		
Radionuclide	**µCi/g**	
$^{239/240}Pu$	4.45E-02	0.70 Kg
^{137}Cs	0.65	6.12E+02 Ci
^{90}Sr	7.03	6.65E+03 Ci

Other estimates of historic constituent concentrations exist, and two have been included in Appendix B for comparison. The TRAC Model (Jungfleisch, 1984) and the results of previous sampling efforts comprise these additional historic estimates. The historic inventory numbers reported in this Tank Characterization Report for the liquid in Tank 241-C-110 are based on previous sampling results. These values are included in Table 5-6 as the Historic Tank Content Estimate for the liquid material.

2.5 SURVEILLANCE DATA

2.5.1 Surface Level Readings

Tank 241-C-110 is equipped with a manual tape gauge to determine the surface level of the waste. The manual tape uses a conductivity probe which is lowered by a hand crank until electrical contact is made with the waste surface and an electric circuit completed, providing the measurement. The operator records the manual tape's measurement and enters it into the Computer Automated Surveillance System (CASS).

The most recent manual tape reading for Tank 241-C-110 was 65 inches in February 1994 (Rios, 1994). Figure 2-5 illustrates the surface level readings from 1981 to the present. The readings are fairly consistent except for a significant drop in the last quarter of 1991 when Tank 241-C-110 was salt well pumped. Readings before 1981 are not included because the data has been archived and is not readily available on CASS.

2.5.2 Internal Tank Temperatures

Temperatures are taken in Tank 241-C-110 by a probe which enters the tank through riser 8. The probe has 11 thermocouples which are arranged at different heights in the tank. Due to the waste level in the tank, six of the thermocouples are currently being used. The most recent temperature reading available was 66°F taken on May 19, 1994. This measurement is consistent with historical measurements of Tank 241-C-110. Plotted temperature readings of Tank 241-C-110 since 1988 can be found in Figure 2-6.

Tank 241-C-110 is classified as a semiannual tank, meaning that temperatures are collected in January and July. However, as shown on the temperature plot in Figure 2-6, there was a period between 1988 and 1991 when temperatures were not taken. It is not known why temperatures were not taken during this period. It is possible that temperatures were taken, but the data sheets were misplaced. Also, since being hooked up to the Temperature Monitoring and Control System (TMACS) on April 4, 1994, Tank 241-C-110 has been monitored continually. Temperature data from TMACS is currently downloaded to the Surveillance Analysis Computer System (SACS) once a day, but it is planned to reduce this downloading frequency to once a week.

As can be seen in Figure 2-6, the temperature reading for January 1994 is far below any other temperature readings for Tank 241-C-110. Because the reading is below 50°F, its accuracy is immediately considered "suspect" by SACS. A re-check of the temperature was done a few days later which resulted in a measurement more consistent with historical data. Considering that the temperature of Tank 241-C-110 has historically been stable and that the re-check yielded a temperature in the expected range, it is reasonable to assume that the low measurement from January 1994 is a bad datum point, and can be discarded.

Figure 2-5. Tank 241-C-110 Surface Level Readings.

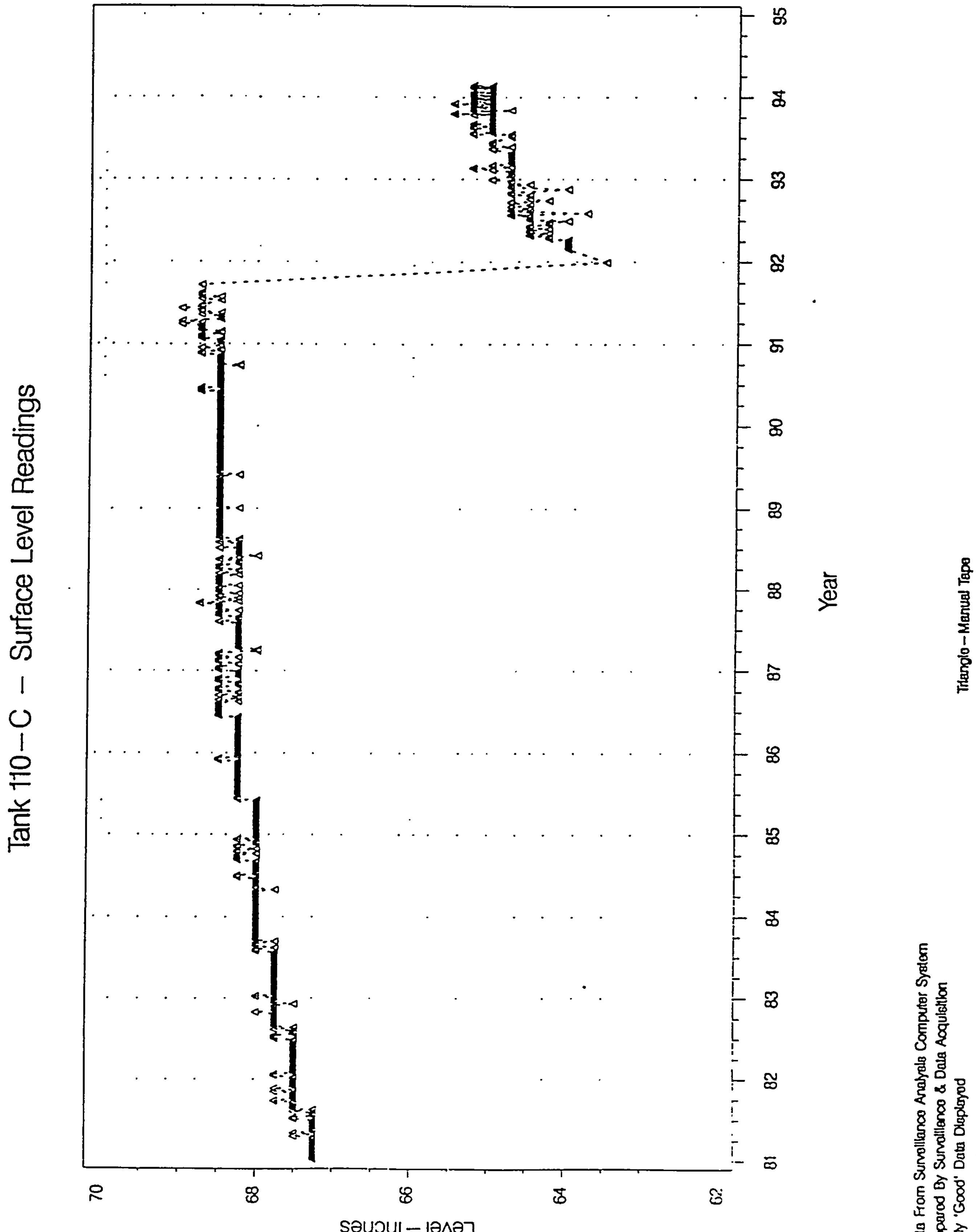
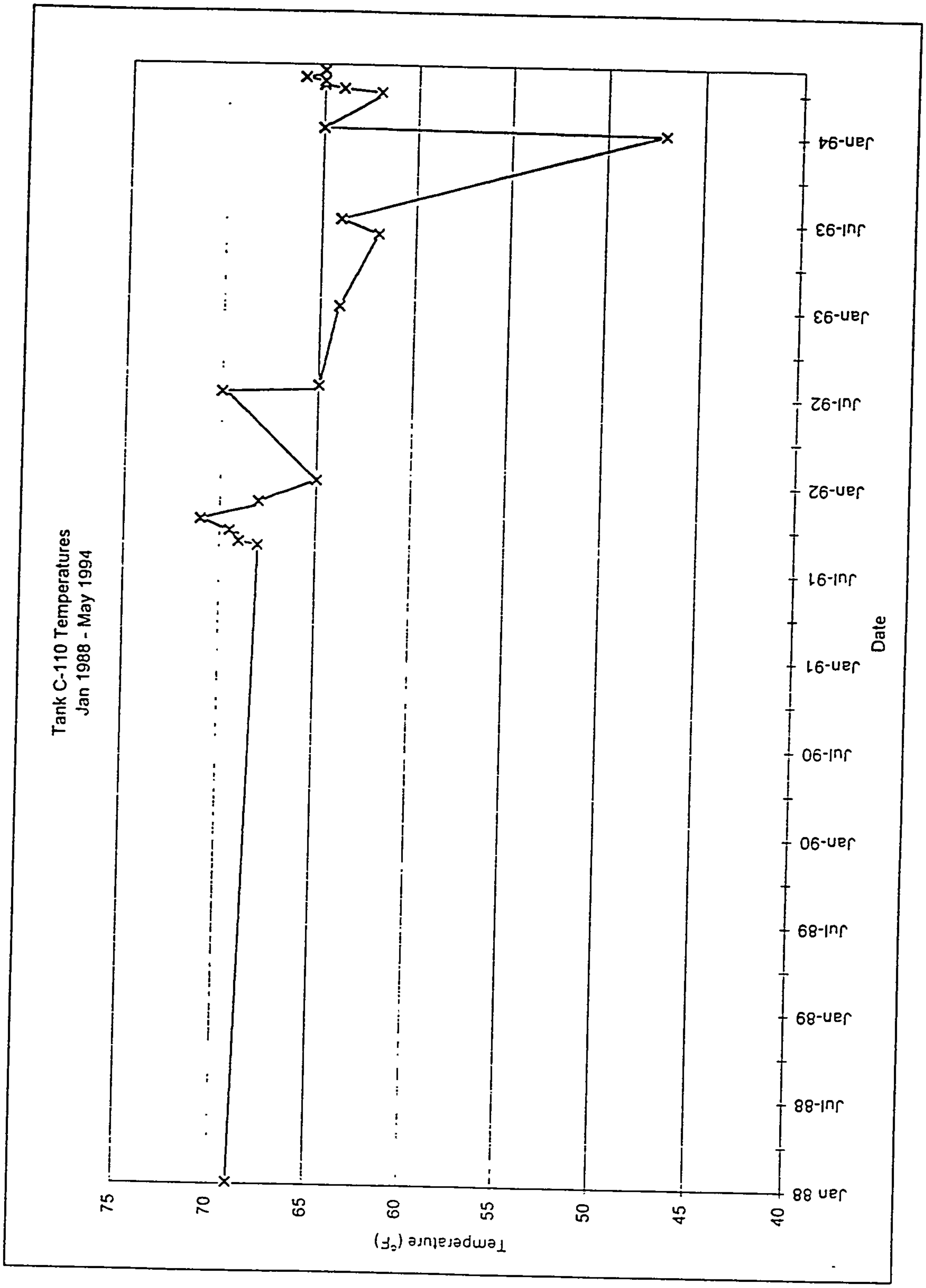


Figure 2-6. Tank 241-C-110 Temperatures Since 1988.



3.0 TANK SAMPLING OVERVIEW

The purpose of this section is to discuss the April 1992 sampling effort of Tank 241-C-110. The sampling event is described first, followed by a discussion of the distribution of samples among analytical laboratories. The analyses requested from each laboratory and sample are included in detail.

3.1 DESCRIPTION OF SAMPLING EVENT

In 1992, Tank 241-C-110 was push mode core sampled from April 14 through April 23. A total of three core samples were taken, each consisting of four segments. Core 37 was taken through riser #5, core 38 through riser #7, and core 39 through riser #2 (WHC, 1992). For a diagram of riser location, refer to Figure 2-2 in the previous chapter.

The core samples from Tank 241-C-110 were obtained using a specially designed core sampling truck (CST) that has sampling equipment mounted on a rotating platform. The core sampling truck used a drill string to push through the waste. The sampler was located inside this drill string. When the drill string was pushed into the waste, the sampler was filled. Once the sampler had passed 19 in. through the waste, a spring-activated rotary valve trapped the segment of waste within the sampler. Each segment has a length of 19 in., a diameter of 7/8 in., and a maximum volume of 187 milliliters. After the sampler was filled, it was extracted from the drill string and another sampler inserted. During sampler change out, kerosene range normal paraffin hydrocarbons were added to the drill string as a hydrostatic fluid to prevent the waste from backing up into the drill string. Because of the limitations of the core sampling equipment, the bottom three inches of waste in the tank were not sampled (Winters et al., 1990). For additional information concerning core sampling, see the *Tank Characterization Reference Guide* (De Lorenzo, et al., 1994).

Each segment-containing sampler was remotely removed from the drill string and sealed within a stainless steel liner, which was then placed inside a lead shielded shipping cask. The casks were then transported to the WHC 222-S Process and Analytical Laboratory. All segments were received by the laboratory on May 9, 1992. A chain-of-custody form was filled out for each segment.

3.2 SAMPLE CUSTODY DATA

A total of twelve segments from Tank 241-C-110 were received by the 222-S Laboratory. These segments were then divided into sub-samples and composites. Table 3-1 shows the sample distribution and custody data for the 222-S Laboratory.

Table 3-1. WHC 222-S Laboratory Sample Custody Data. (2 pages)

Core	Sample	Tank Farm Sample Number[1]	Date Received at 222-S[1]	Laboratory ID Number
37	Segment 1	92-007	5/9/92	No Recovery
37	Segment 2	92-008	5/9/92	J582, J583, J589, J738[2]
37	Segment 3	92-009	5/9/92	No Recovery
37	Segment 4	92-010	5/9/92	J586, J587, J591, J739[2]
38	Segment 1	92-011	5/9/92	J592, J593, J612, J613, J614, J742[2],
38	Segment 2	92-012	5/9/92	No Recovery
38	Segment 3	92-013	5/9/92	No Recovery
38	Segment 4	92-014	5/9/92	J596, J619, J620, J745[2]
39	Segment 1	92-015	5/9/92	No Recovery
39	Segment 2	92-016	5/9/92	J599, J624, J625, J747[2]
39	Segment 3	92-017	5/9/92	J600, J626, J627, J748[2]
39	Segment 4	92-018	5/9/92	J601, J628, J629, J749[2]
38	Segment 4 Homog.			J644, J645, J647, J649
39	Segment 3 Homog.			J650, J652, J656, J658
	Composite Homog.			J759, J760, J761, J762
37	Drainable Liquid			J779, J781, J782, J783
38	Drainable Liquid			J777, J778, J802, J803
39	Drainable Liquid			J772, J773, J774, J775
	Drainable Liquid Composite			J795, J796, J797, J798, J799, J800
37	Composite 1			J633, J634, J646, J651, J664, J665, J666, J670, J671, J674, J689, J690, J691, J692, J693, J694, J713, J714, J715, J726[2] J732[2], J753, J979, J980, J981, J982, J983
37	Composite 2			J635, J653, J667, J678, J695, J704, J716, J727[2], J733[2], J754
38	Composite 1			J636, J654, J655, J657, J668, J669, J672, J675, J679, J681, J682, J696, J697, J698, J705, J706, J707, J717, J718, J719, J728[2], J734[2], J755, J784, J785, J786

Table 3-1. WHC 222-S Laboratory Sample Custody Data. (2 pages)

Core	Sample	Tank Farm Sample Number[1]	Date Received at 222-S[1]	Laboratory ID Number
39	Composite 1			J639, J660, J661, J662, J676, J677, J680, J685, J686, J687, J700, J701, J702, J708, J710, J711, J721, J722, J723, J730[2], J736[2], J757, J788, J789, J972, J973, J974, J975, J976, J977
39	Composite 2			J640, J663, J683, J688, J703, J712, J724, J731[2], J737[2], J758, J790, J791

[1]The only samples taken directly from the tank were the segments. All the other samples were created at 222-S from the original segments. Thus, only the segments have sample numbers and receipt dates.

[2]Indicates that this particular vial was shipped to PNL for analysis.

Some of the samples were sent to Battelle's Pacific Northwest Laboratory (PNL) for organic, isotopic Pu and U, rheology, and physical analyses. Table 3-2 presents the custody data concerning the samples transferred from the 222-S Laboratory to PNL.

A list of the analytes requested from the samples at the 222-S Laboratory is found in Table 3-3. Table 3-4 lists the analyses requested for the samples sent to PNL.

3.3 PROBLEMS WITH THE SAMPLES

The waste recovery for Tank 241-C-110 was relatively poor. As described in Table 3-5, five of the 12 segments were recovered with 100% recovery, four segments were empty, one segment had an 80% recovery, and two segments contained less than 50% recovery. Each core had at least one empty segment, and core 38 contained only segments 1 and 4. There were very few liquid recoveries in any of the samples. Only one segment from each core contained drainable liquids exceeding 15%. Because of the poor recovery of the sampling effort and the poor mechanical performance of the sampling equipment for Tank 241-C-110, both from incomplete segments as well as unresolved segments, the results given later may be biased. The magnitude of this bias cannot be determined.

Table 3-2. PNL Sample Custody Data.

Core	Sample	ID Number	PNL Sample Number	Date Received
37	Segment 2	J738	92-11291	9/24/92
37	Segment 4	J739	92-11292	9/24/92
37	Composite 1	J726	92-08302	6/24/92
37	Composite 1	J732	92-08303	6/24/92
37	Composite 2	J727	92-08304	6/24/92
37	Composite 2	J733	92-08305	6/24/92
38	Segment 1	J742	92-08297	6/24/92
38	Segment 4	J745	92-08298	6/24/92
38	Composite 1	J728	92-08306	6/24/92
38	Composite 1	J734	92-08307	6/24/92
39	Segment 2	J747	92-08299	6/24/92
39	Segment 3	J748	92-08300	6/24/92
39	Segment 4	J749	92-08301	6/24/92
39	Composite 1	J730	92-08308	6/24/92
39	Composite 1	J736	92-08309	6/24/92
39	Composite 2	J731	92-08310	6/24/92
39	Composite 2	J737	92-08311	6/24/92
---	Hot Cell Blank	J762	92-08312	6/24/92
38	Drainable Liquid	J795	92-09437	---

Table 3-3. Samples and Requested Analytes for the 222-S Laboratory (McKinley, 1992 and Hill et al., 1991).

Identification Numbers	Requested Analytes
J666, J667, J672, J680, J683, J691, J704, J707, J711, J712, J715, J716, J719, J723, J724, J775, J778, J783, J800, J974	Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Sn, Tl, V, Zn, Si, The, U, Zr, NH_3
J694, J695, J698, J702, J703, J775, J783, J800, J7778, J635	NO_3^-, NO_2^-, F^-, Cl^-, SO_4^{-2}, PO_4^{-3}, NO_2^-, CO_3^{-2}, pH, ^{14}C, ^{3}H, specific gravity
J674, J678, J682, J687, J688, J799	CN^-
J715, J716, J719, J723, J724, J775, J778, J783, J800	U, $^{238,239,240}Pu$, ^{241}Am, ^{244}Cm, ^{237}Np, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, ^{79}Se, Total Alpha, Total Beta
J583, J587, J614, J620, J625, J627, J629, J786, J789, J791	$\%H_2O$
J589, J591, J593, J596, J599, J600, J601, J634, J635, J636, J639, J640	DSC, TGA
J651, J653, J657, J663, J761	Hg

Table 3-4. Samples and Requested Analyses For PNL (McKinley 1992).

PNL Sample Number	Identification Number	Analyses Requested
92-11291 92-11292	J738 J739	Rheology and Physical
92-08302 92-08304 92-08306 92-08308 92-08310 92-09437	J726 J727 J728 J730 J731 J795	Pu and U Isotopic
92-08297 92-08298 92-08299 92-08300 92-08301	J742 J745 J747 J748 J749	VOA
92-08303 92-08305 92-08307 92-08309 92-08311 92-09437 92-08312	J732 J733 J734 J736 J737 J795 J762	SVOA, EOX

Table 3-5. Tank 241-C-110 Core Sample % Recovery and Liquid/Solid Fraction.

Core	Segment	% Recovery	Liquid/Solid Fraction
37	1	0	NA
	2	100	All Solids
	3	100	All Drainable Liquid
	4	100	85% Solids, 15% Liquids
38	1	35	25% Solids, 10% Liquid
	2	0	N/A
	3	0	N/A
	4	100	50% Solids, 50% Liquid
39	1	0	N/A
	2	80	65% Solids, 15% Liquid
	3	25	All Solids
	4	100	All Solids

Four segments were recovered with the rotary valve left open: Core 38, segments 1, 2, and 3, and core 39, segment 1. None of these segments contained waste sample except for core 38, segment 1, which contained 25% recovery (solid sludge). Mechanical failure of the core sampler is suspected as the cause of the segment recovery problems.

Core 37, segment 1 was also recovered without sample; however, the valve on the sampler was closed. It is possible, although unlikely, that the sampler had not yet reached the top of the waste. It is more probable that the lack of sample recovery was due to obstruction or mechanical failure of the sampler.

In some segments, the consistency of the waste was softer than in many of the other segments. A likely reason for this change in consistency is that the sample was saturated by the NPH. Core 37, segment 3; core 38, segment 4; and core 39, segments 2 and 3 all had excessively soft consistencies and are suspected of being subject to contamination. It is possible that this low recovery was a result of mechanical failure and subsequent NPH contamination.

4.0 SAMPLE HANDLING AND ANALYSIS SCHEME

The object of these waste analyses is primarily to evaluate the waste in meeting requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology, EPA & DOE, 1993). However, there are other benefits. First, this information will help to evaluate whether constituent concentrations are within safe operating limits. Second, constituent concentrations relevant to functional limits can be determined.

4.1 WASTE DESCRIPTION

The solids in the waste collected from Tank 241-C-110 were reddish brown and very homogenous. For the most part, the appearance and consistency of the solids were like "melting chocolate ice cream" (WHC, 1992); however, some of the solids were significantly softer and more fluid. The hot cell chemist hypothesized that the softer solids were caused by NPH saturation (WHC, 1992). The liquids in the samples were also reddish brown and opaque. From an in-tank photograph, other miscellaneous debris such as black tubing and discarded level measurement tapes could be seen on the tank waste surface (ICF Kaiser Hanford, 1994).

4.2 HOLD TIME CONSIDERATIONS

For information concerning hold times, see the *Tank Characterization Reference Guide* (De Lorenzo et al., 1994)

4.3 SAMPLE PREPARATION

Sample preparation procedures are conducted in order to optimize the recovery of each analyte of interest from the tank waste. Water, acid, and KOH Fusion digestions are commonly used to extract metals and several radioisotopes from solid samples, and in some cases digestions are performed on liquid samples to improve analytical matrices. Many separations are specific to a particular analysis and are described within the corresponding analytical methods referenced in Tables 4-2 and 4-3. In order to verify analyte recoveries resulting from separation techniques, laboratory control samples, carriers, tracers, and surrogates are routinely analyzed concurrently with the samples. For further discussion of sample preparation procedures, refer to the *Tank Characterization Reference Guide* (De Lorenzo et al., 1994).

4.4 ANALYTICAL METHODS

This section briefly describes the analyses used to characterize the waste in Tank 241-C-110. The analyses were split between the Westinghouse 222-S Laboratory and Battelle's Pacific Northwest Laboratory (PNL).

4.4.1 Physical and Rheological Tests

Physical tests completed at the 222-S laboratory included: thermogravimetric analyses (TGA), differential scanning calorimetry (DSC), specific gravity, and %water analyses. Duplicate assays were performed for the %water analyses. The physical properties measured at PNL included wt% solids, settling behavior, and wt% dissolved solids. Rheological testing was performed at PNL and included shear strength and shear stress as a function of shear rate. Rheological properties were measured in duplicate. Table 4-1 lists the analytical methods used for physical and rheological testing.

Table 4-1. Analytical Methods for Physical and Rheological Testing.

Analyte	Procedure
TGA	LA-560-112
DSC	LA-514-113
Specific Gravity	LA-510-112
% Water	LA-564-101
Rheology	PNL-ALO-501, PNL-ALO-502
Physical Properties	N/A

4.4.2 Chemical and Radionuclide Constituent Analysis

Most of the chemical and radionuclide analyses were performed at the 222-S Laboratory. The uranium and plutonium isotopic analyses, however, were performed at PNL. Duplicate analyses were performed on every tank sample. Table 4-2 lists the analytical methods used (Winters et al., 1993).

4.4.3 Organic Constituent Analyses

All organic analyses of the samples from Tank 241-C-110 were performed at PNL. The organic analyses performed were Volatile Organic Analyses (VOA), Semivolatile Organic Analyses (SVOA), Total Organic Halides (TOX), and Extractable Organic Halides (EOX). Duplicates were performed for all of these analyses. Table 4-3 lists the analyses and procedure numbers.

4.5 MODULE SPECIFIC ANALYSES

The characterization program for Tank 241-C-110 was intended to satisfy criteria set by the Tank Waste Remediation System (TWRS). The TWRS sample characterization objectives are to provide adequate description of physical, chemical, and radiological properties of Hanford Site tank wastes to support the resolution of Unreviewed Safety Questions, other safety issues surrounding the Watch List tanks, and the design of retrieval, pretreatment, and final disposal systems (Bell, 1994). For this specific tank, analyses to provide sufficient information to confidently determine whether constituent concentrations are within safe operating limits were performed.

Table 4-2. Analytical Methods for Chemical and Radionuclide Analyses.

Analyte	Method	Procedure Number
Hg	Cold Vapor Atomic Absorption	LA-325-102
F^-, Cl^-, NO_3^-, NO_2^-, PO_4^{3-}, SO_4^{2-}	Ion Chromatography	LA-533-105
CN^-	Distillation/Spectrometric Analysis	LA-695-101 LA-695-102
U	Laser Fluorimetry	LA-925-106
Total Alpha, Total Beta	Proportional Counting	LA-508-101
^{238}Pu, $^{239,240}Pu$, ^{241}Am	Alpha Spectrometry	LA-503-156
^{237}Np	Alpha Proportional Counting	LA-933-141
Total Metals	Inductively Coupled Plasma	LA-505-151
^{90}Sr	Beta Proportional Counting	LA-220-101
^{99}Tc ^{79}Se	Liquid Scintillation	LA-438-101 LA-365-132
^{129}I	Low Energy Gamma Analysis	LA-378-104
^{14}C ^{3}H	Liquid Scintillation	LA-348-104 LA-218-114
^{154}Eu, ^{155}Eu, ^{241}Am, ^{137}Cs, ^{60}Co	Gamma Energy Analysis	LA-548-121
NO_2-	Spectrophotometry	LA-645-001
pH	Electrode	LA-212-103
As Se	Hydride Atomic Absorption	LA-355-131 LA-365-131
Pu Isotopic	Fusion Mass Spectrometry	PNL-ALO-423 PNL-MA-597
U Isotopic U Total	Mass Spectrometry Uranium Laser	PNL-MA-597 PNL-ALO-445
TOC	Total Organic Carbon	LA-344-105
CO_3/C	Total Inorganic Carbon	LA-622-102

Table 4-3. Analytical Methods For Organic Analyses.

Analysis	Method	Procedure Number
VOA	Gas Chromatography/Mass Spectrometry	PNL-ALO-335
SVOA	Gas Chromatography/Mass Spectrometry	PNL-ALO-345
EOX	Microcoulometric Titration	PNL-ALO-320.2
TOX	Microcoulometric Titration	PNL-ALO-321

5.0 ANALYTICAL RESULTS AND WASTE INVENTORY

The chemical, radiochemical, physical and organic results associated with Tank 241-C-110 are presented within this document as indicated in Table 5-1. The samples from which these results were derived were collected between April 14 and April 23, 1992. This sampling event was the most recent regarding Tank 241-C-110 and the results reflected the most accurate characterization of the tank waste available at the present time.

Table 5-1. Analytical Data Presentation Tables.

Analysis	Tabulated Results
Tank Characterization Report Results for Total Solid Material in Tank 241-C-110	Table 5-5
Tank Characterization Report Results for Liquid in Tank 241-C-110	Table 5-6
Metals	Table A-1
Ions	Table A-2
Radionuclides	Table A-3
Physical Properties and Misc. Chemical Data	Table A-4
Volatile Organics	Table A-5
Semivolatile Organics	Table A-6

The sample data presented in the Appendix A tables were obtained by calculating an average concentration value from the initial and duplicate analyses associated with each sample. If an analyte was detected during the original analysis but not the duplicate, or vice-versa, only the detected result was recorded. When both sample runs failed to detect an analyte, the detection limit preceded by a less than (<) sign was recorded as the sample result. Results which were determined to be estimated with respect to the data validation report were enclosed in parentheses, and a line was drawn through rejected results.

The Appendix A tables divide the laboratory data according to matrix, method of preparation, and method of analysis. The range of sample results is listed for each category. Statistically weighted means were either obtained from Remund and Jensen (1994), or calculated accordingly for all detected analytes obtained from core composite samples; these values were reported under the corresponding heading in the Appendix A tables. The weighted means were derived from a statistical model which allowed the results from each core to be weighted equally even though the analysis scheme involved the evaluation of two composite samples from cores 37 and 39 but only one composite sample from core 38. A complete discussion regarding the methodology is presented in Remund and Jensen (1994). Non-weighted averages pertaining to the liquid sample data are reported in the "Evaluated Data Result" columns. When a set of samples failed to detect an analyte, the highest reported detection limit was recorded as the "Evaluated Data Result".

The projected tank inventory value for drainable liquid in Tank 241-C-110 was calculated by multiplying the "Evaluated Data Result" by the volume of liquid in the tank at the time of sampling, 26,500 liters. With respect to the solid phase, the projected tank inventory was conservatively determined from the preferred analysis; that is, the digestion or analytical technique yielding the highest analyte concentration. The weighted mean of the preferred analysis was multiplied by 1,030,000 kilograms, the mass of solid waste in the tank. The appropriate conversion factors were included in the calculations to obtain the reported units.

5.1 CHEMICAL ANALYSES

5.1.1 Elemental Constituents

According to the validation report, the results associated with Bi, Ce, La, P, Sr, S, Sn, and Zr were rejected since the calibration verification standard solution utilized during the Inductively Coupled Plasma (ICP) runs did not include these analytes. However, sufficient spike and Laboratory Measurement Control System standard data were provided; therefore, the data was considered to be estimated as opposed to rejected for the purposes of this document.

The ICP analyses demonstrated that only phosphorous, sodium, and sulfur were present in the drainable liquid samples at concentrations above 1000 μg/ml; sodium exhibited a value of 44,700 μg/ml and was, by far, the most abundant. As shown in Table 5-2, the levels of chromium, lead, and selenium found in the drainable liquid samples were considered to be high since their reported concentrations exceeded regulatory limits as defined by the *Code of Federal Regulations* (EPA, 1990). Furthermore, the results acquired from the analysis of solid samples by the Toxicity Characteristics Leaching Procedure (TCLP) were consistent with those obtained from drainable liquid samples as indicated in Table 5-2.

Table 5-2. Comparison of Drainable Liquid and TCLP Data.

Analyte	Drainable Liquid Result (μg/ml)	TCLP Result from ICP (μg/ml)	Regulatory Level (μg/ml)
Chromium	173	13.3	5.0
Selenium	32.4	5.35	1.0
Lead	5.37	1.23	5.0

Inspection of Table 5-2 demonstrates that the ratios among chromium, selenium, and lead derived from the drainable liquid and TCLP analyses are somewhat similar.

The major constituents identified by ICP analysis with respect to the solid phase of the waste in Tank 241-C-110 were Al, Bi, Ca, Fe, P, Si, Na, S, and U; all were present in concentrations exceeding 100 μg/g. The historical estimates for Al, Bi, Cr, Fe, Si, Na, and Zr (ICF Kaiser Hanford, 1994) were available for comparison with the analytical data derived from core composite samples. The relative percent differences between the historical and analytical data associated with Bi, Cr, Fe, and Na were less than 20% RPD; aluminum, zirconium, and silicon displayed relative percent differences of 82%, 153%, and 160%, respectively. Historical comparisons regarding phosphorus and sulfur are discussed in the following sections.

5.1.2 Anions

The most abundant anion in both the liquid and solid phases of the waste in Tank 241-C-110 was nitrate. Fluoride and phosphate were detected in greater concentrations in the solid samples as opposed to the liquid samples. On the other hand, the solid and liquid concentrations of chloride, nitrate, nitrite, and sulfate agreed to within $\pm$ 25%. Cyanide was not detected in the solid portion of the waste, and its reported concentration from liquid samples was only 2.62 μg/ml.

After converting the phosphorous and sulfur values derived from the ICP analyses into corresponding phosphate and sulfate data, the results were compared, as displayed in Table 5-3, to the phosphate and sulfate data obtained by ion chromatography (IC). Inspection of the table reveals a large difference between the solid phase phosphate data; therefore, it is surmised that precipitated phosphate salts account for the majority (approximately 92%) of phosphorus in Tank 241-C-110. Furthermore, the concentration of phosphate contained within the solid phase of Tank 241-C-110 appears to be most accurately represented by the value calculated from the ICP data, and the historical data supports this claim.

Table 5-3. Comparison of ICP and IC Phosphate and Sulfate Results.

Analyte	Liquid Phase		Solid Phase	
	IC Result (μg/g)	ICP Result (μg/g)	IC Result (μg/g)	ICP Result (μg/g)
Phosphate	5070	5760	28100	62200
Sulfate	11100	8120	14800	12200

The historical estimates for nitrate, nitrite, phosphate, sulfate, and fluoride (ICF Kaiser Hanford, 1994) were available for comparison with the analytical data derived from core composite samples. The relative percent differences between the historical and analytical data associated with nitrate, sulfate, and fluoride ranged between 117 and 182%; nitrite and phosphate displayed relative percent differences of approximately 60 and 68%, respectively. The ICP derived phosphate value of 62200 μg/g was utilized for comparison since it offered the best correlation. The variations between analytical and historical data, although notable are not unexpected. The mobility and solubility properties of the ions in the waste, possible chemical changes in the waste over time, and incomplete and inconsistent recordkeeping contribute to the observed differences between analytical and historical data.

5.2 RADIOLOGICAL DETERMINATIONS

The following radionuclides demonstrated activities above their corresponding detection limits when the drainable liquid samples from Tank 241-C-110 were analyzed: ^{14}C, ^{137}Cs, $^{239/240}$Pu, ^{79}Se, ^{90}Sr, ^{99}Tc, ^{3}H, and ^{238}U. With the exception of ^{79}Se, the previously cited isotopes demonstrated detectable activities in the core composite samples as well. As a note, ^{238}U activity was calculated from the laser fluorimetry data, as opposed the isotopic analysis.

The major radioactive constituents in both matrices were ^{137}Cs and ^{90}Sr. The solid phase of the waste was predicted to yield a ^{90}Sr activity of 7.03 μCi/g according to historical records, and the analytically determined value was 5.00 μCi/g. The historical estimate of ^{137}Cs activity, however, was not nearly as accurate; 0.65 μCi/g compared to the laboratory value of 19.5 μCi/g.

5.3 ORGANIC CONSTITUENTS

None of the target analytes associated with the volatile and semivolatile organic analyses were detected, as indicated by Tables A-5 and A-6, during the evaluation of samples from Tank 241-C-110. Because of their volatile nature and relatively small contribution to the waste as indicated by the historical records, the appearance of these compounds was not expected. However, tributylphosphate was detected as a tentatively identified compound in the waste samples, and its presence is consistent with the fill history of the tank. Contamination resulting from the sampling process caused several normal paraffin hydrocarbons to appear as tentatively identified compounds during the sample analyses, and a reaction between the waste matrix and the organic surrogate compounds lead to the detection of nitration reaction products. These compounds, however, were not indigenous to the tank, and do not contribute substantially to the overall inventory of the tank. The reported concentration of tributyl phosphate cannot account for the total organic carbon in Tank 241-C-110; therefore, the bulk of organic carbon is assumed to be due to the presence of complexants.

Since inorganic carbon was detected in the core composite samples but not the drainable liquid, the data indicates that the carbonate in Tank 241-C-110 exists in the form of precipitated salt. The average amount of total inorganic carbon in the tank, 2030 μg/g, translates into an average carbonate concentration of 10200 μg/g.

5.4 PHYSICAL MEASUREMENTS

The physical properties of segments 2 and 4 of core 37 were extensively analyzed by PNL, and a summary of the results are presented in Table 5-4 (McKinley et al., 1992). Physical property data resulting from analyses conducted by the 222-S Laboratory are listed in Appendix A.

5.4.1 Specific Gravity

The specific gravity of the drainable liquid in Tank 241-C-110 was determined to be 1.09 as revealed by the data in Table A-4, and this value compares reasonably well with the density of centrifuged supernate data in Table 5-4. Density of the solid phase of the waste is also presented in Table 5-4.

Table 5-4. Physical Properties Obtained from Core 37.

Property	Segment 2	Segment 4
Centrifuged Solids (vol%) (wt%)	75.5 80.0	76.2 81.6
Density (g/ml) Sample Cent. Supernate Cent. Solid	1.41 1.15 1.49	1.48 1.13 1.59
Wt% Solids	40.3	28.4
Wt% Undissolved Solids	35.3	20.3
Viscosity	$\leq$ 5 cP	$\leq$ 5 cP
Shear Strength	5,000 $\pm$ 2,000 dynes/cm^2	5,000 $\pm$ 2,000 dynes/cm^2

5.4.2 Percent Water

All core and segment data pertaining to Tank 241-C-110 show that the waste is approximately 60% water. The only discrepancy with this claim arises from the weight percent solids result derived by the PNL laboratory for segment 4 of core 37, 81.6% (Table 5-4); the 222-S Laboratory found this segment to be 58.6% water.

5.4.3 Rheology

The Pacific Northwest Laboratory reported the shear strength of the segment samples from core 37 to be 5000 $\pm$ 2200 dynes/cm^2. The analyses of shear stress as a function of shear rate conducted on non-diluted segment samples did not yield valid data due to drying of samples. At ambient temperature, shear stress peaks were observed at low shear rates, but shear stress decreased as shear rates continued to increase. At 95°C the samples dried before the measurement could be completed, and the shear stress increased as sample moisture was lost.

Rheological properties were evaluated in duplicate on 1:1 and 3:1 water/segment dilutions of segment samples 2 and 4 of core 37 at both ambient temperature and at 95°C. At shear rates ranging between 200 and 500 hz, all of the diluted samples exhibited viscosities of 5 centipoise or less; the detection limit was 2 centipoise. The viscosity of the samples decreased as a function of rising temperatures.

5.4.4 Energetics

Exotherms were not observed in any of the tank waste samples during the differential scanning calorimetry analyses.

5.5 DATA PRESENTATION

The Tank Characterization Report Results recorded in Tables 5-5 and 5-6 are the final constituent inventory estimates for this document. The values are equal to either the "Weighted Mean" or "Evaluated Data Result" values presented in the Appendix A tables, whichever is greater. Exceptions have either been previously or are subsequently discussed in this text. If laboratory results were not available for an analyte, the Tank Characterization Result was, if possible, derived from historical data.

Table 5-5. Tank Characterization Report Data for Total Solid Material in Single-Shell Tank 241-C-110. (3 pages)

Analyte	Historic Tank Content Estimate	Tank Characterization Report Result	Total Tank Inventory
Metals	(μg/g)	(μg/g)	(kg)
Aluminum (Al)	6,060	**14,500**	14,900
Antimony (Sb)	---	**301**	309
Arsenic (As)	---	**4.11**	4.22
Barium (Ba)	---	**8.52**	8.75
Beryllium (Be)	---	**0.287**	0.295
Bismuth (Bi)	16,000	**16,800**	17,200
Boron (B)	---	**25.0**	25.7
Cadmium (Cd)	---	**5.36**	5.50
Calcium (Ca)	---	**1,150**	1,180
Cerium (Ce)	---	**210**	216
Chromium (Cr)	568	**470**	483
Cobalt (Co)	---	**6.59**	6.77
Copper (Cu)	---	**98.9**	102
Iron (Fe)	9,150	**11,000**	11,300
Lanthanum (La)	---	**2.00**	2.05
Lead (Pb)	---	**258**	265
Magnesium (Mg)	---	**153**	157
Manganese (Mn)	---	**56.3**	57.8
Mercury (Hg)	---	**0.450**	0.462
Molybdenum (Mo)	---	---	---
Neptunium (Np)	---	---	---
Nickel (Ni)	---	**23.9**	24.5

Table 5-5. Tank Characterization Report Data for Total Solid Material in Single-Shell Tank 241-C-110. (3 pages)

Analyte	Historic Tank Content Estimate	Tank Characterization Report Result	Total Tank Inventory
Metals (continued)	(μg/g)	(μg/g)	(kg)
Phosphorus (P)	---	**20,300**	20,800
Plutonium (Pu)	---	---	---
Potassium (K)	---	**557**	572
Selenium (Se)	---	**107**	110
Silicon (Si)	804	**7,160**	7,350
Silver (Ag)	---	**1.05**	1.08
Sodium (Na)	100,000	**82,600**	84,800
Strontium (Sr)	---	**131**	134
Sulfur (S)	---	**4,080**	4,190
Tin (Sn)	---	**12.8**	13.1
Titanium (Ti)	---	**10.5**	10.8
Uranium (U)	---	**1,480**	1,520
Vanadium (V)	---	**6.17**	6.33
Zinc (Zn)	---	**224**	230
Zirconium (Zr)	1,290	**172**	177
Ions	(μg/g)	(μg/g)	(kg)
Ammonia (NH_3)	---	< 4,500	< 4,620
Chloride (Cl^-)	---	**1,060**	1,090
Cyanide (CN^-)	---	< 5.00	< 5.13
Fluoride (F^-)	2,010	**7,630**	7,830
Hydroxide (OH^-)	19,700	---	---
Nitrate (NO_3^-)	4,860	**110,000**	114,000
Nitrite (NO_2^-)	3,710	**6,890**	7,070
Phosphate (PO_4^{3-})	126,000	**28,100**	28,800
Sulfate (SO_4^{2-})	2,670	**14,800**	15,200
Radionuclides	(μCi/g)	(μCi/g)	(Ci)
^{241}Am	---	< 0.280	< 287
^{14}C	---	**4.59E-04**	0.471
^{137}Cs	0.65	**19.5**	20,000

Table 5-5. Tank Characterization Report Data for Total Solid Material in Single-Shell Tank 241-C-110. (3 pages)

Analyte	Historic Tank Content Estimate	Tank Characterization Report Result	Total Tank Inventory
Radionuclides (continued)	(μCi/g)	(μCi/g)	(Ci)
^{60}Co	---	**< 0.0433**	< 44.5
^{154}Eu	---	**< 0.120**	< 123
^{155}Eu	---	**< 0.122**	< 125
^{129}I	---	**< 0.0250**	< 25.7
^{237}Np	---	**< 0.0541**	< 55.6
^{238}Pu	---	**< 0.0498**	< 51.1
$^{239/240}Pu$	0.0445	**0.0802**	82.4
^{79}Se	---	**0.00130**	1.34
^{90}Sr	7.03	**5.00**	5,140
^{99}Tc	---	0.0328	33.7
^{3}H	---	0.00118	1.21
^{238}U	---	4.95E-04	0.508
Total Alpha	---	**0.125**	128
Total Beta	---	**42.4**	43,500
Physical Properties			kg
Water	68.4	**59.8%**	---
pH	---	**11.0**	---
Specific Gravity	1.34	**1.45**	---
Thermogravimetric Analysis	---	**57.5%**	---
TIC	---	**2,030 μg/mL**	1,440
TOC	---	**802 μg/g**	823

Table 5-6. Tank Characterization Report Data for Liquid in Single-Shell Tank 241-C-110. (3 pages)

Analyte	Tank Characterization Report Result	Total Tank Inventory
Metals	(µg/ml)	(kg)
Aluminum (Al)	87.9	2.33
Antimony (Sb)	23.2	0.615
Arsenic (As)	1.94	0.0514
Barium (Ba)	< 0.303	< 0.00803
Beryllium (Be)	0.190	0.00504
Bismuth (Bi)	63.5	1.68
Boron (B)	15.7	0.416
Cadmium (Cd)	0.443	0.0117
Calcium (Ca)	17.2	0.456
Cerium (Ce)	6.20	0.164
Chromium (Cr)	173	4.58
Cobalt (Co)	0.649	0.0172
Copper (Cu)	1.76	0.0466
Iron (Fe)	47.3	1.25
Lanthanum (La)	1.01	0.0268
Lead (Pb)	5.37	0.142
Magnesium (Mg)	1.39	0.0368
Manganese (Mn)	0.287	0.00761
Mercury (Hg)	0.111	0.00281
Molybdenum (Mo)	---	---
Neptunium	---	---
Nickel (Ni)	1.16	0.0307
Phosphorus (P)	2,050	54.3
Plutonium (Pu)	---	---
Potassium (K)	436	11.6
Selenium (Se)	32.4	0.859
Silicon (Si)	65.5	1.74
Silver (Ag)	0.798	0.0211
Sodium (Na)	44,700	1,190
Strontium (Sr)	0.807	0.0214

Table 5-6. Tank Characterization Report Data for Liquid in Single-Shell Tank 241-C-110. (3 pages)

Analyte	Tank Characterization Report Result	Total Tank Inventory
Metals (cont.)	**(μg/ml)**	(kg)
Sulfur (S)	**2,950**	78.2
Tin (Sn)	**1.45**	0.0384
Titanium (Ti)	**0.253**	0.00670
Uranium (U)	**322**	8.53
Vanadium (V)	**1.61**	0.0427
Zinc (Zn)	**1.58**	0.0419
Zirconium (Zr)	**0.575**	0.0152
Ions	**(μg/ml)**	(kg)
Ammonia (NH_3)	**86.4**	2.29
Chloride (Cl^-)	**996**	26.4
Cyanide (CN^-)	**2.62**	0.0694
Fluoride (F^-)	**516**	13.7
Nitrate (NO_3^-)	**90,800**	2,410
Nitrite (NO_2^-)	**7,850**	208
Phosphate (PO_4^{3-})	**5,530**	147
Sulfate (SO_4^{2-})	**11,100**	294
Radionuclides	**(μCi/ml)**	(Ci)
^{241}Am	**< 0.0516**	< 1.37
^{14}C	**1.99E-04**	0.00527
^{137}Cs	**7.98**	211
^{60}Co	**< 0.00720**	< 0.191
^{154}Eu	**< 0.0192**	< 0.509
^{155}Eu	**< 0.0216**	< 0.572
^{129}I	**< 2.38E-05**	< 0.0211
^{237}Np	**< 6.49E-05**	< 0.0574
^{238}Pu	**< 9.00E-06**	< 1.59E-04
$^{239/240}$Pu	**0.00176**	0.0466
^{79}Se	**6.17E-05**	0.00163
^{90}Sr	**0.0278**	0.737
^{99}Tc	**0.0162**	0.429

Table 5-6. Tank Characterization Report Data for Liquid in Single-Shell Tank 241-C-110. (3 pages)

Analyte	Tank Characterization Report Result	Total Tank Inventory
Radionuclides (continued)	**(μCi/ml)**	**(Ci)**
^{3}H	**7.18E-04**	0.0190
^{238}U	**2.59E-06**	6.86E-05
Total Alpha	**7.02E-04**	0.186
Total Beta	**3.76**	99.6
Physical Properties		kg
Water	---	---
pH	**10.4**	---
Specific Gravity	**1.09**	---
Thermogravimetric Analysis	---	---
TIC	< 543 μg/mL	< 53.8
TOC	592 μg/ml	15.7

6.0 ANALYTICAL RESULTS INTERPRETATION

6.1 TANK WASTE PROFILE

Examination of the analytical results reveals that the waste in Tank 241-C-110 is 96% solids and 4% drainable liquids by mass. The sludge is composed of approximately 40% solids and 60% water. Sodium and nitrate ions were the major constituents present in the liquid phase of the tank. With respect to the solid phase of the waste, water was the single most significant compound with the following elements and anions demonstrating abundance: Al, Bi, Ca, Fe, Na, U, NO_3^-, and PO_4^{-3}. The major radioactive constituents in both matrices were ^{137}Cs and ^{90}Sr. The only organic constituent found in the tank was tributylphosphate.

An inventory of the composition of neutralized first cycle waste is presented in Table 6-1. Upon evaluation of the analytical data and inspection of Table 6-1, precipitated phosphate salts, such as bismuth phosphate, are expected to contribute to the solid phase of the waste in 241-C-110. Furthermore, the high ionic contents of the liquid in Tank 241-C-110 would also allow the precipitation of sulfate, hexafluorosilicate, and nitrate salts originating from first cycle waste as well.

Table 6-1. Neutralized First Cycle Waste Composition (Schneider, 1951).

Chemical	Percent (wt)
Bi^{+3}	0.24
Ce^{+4}	0.003
Zr^{+4}	0.003
Fe^{+3}	0.13
Cr^{+3}	0.02
$(NH_4)^+$	0.18
Na^+	4.3
SiF_6^{-2}	0.40
PO_4^{-3}	2.4
NO_3^-	8.5
SO_4^{-2}	0.44
H_2O	83.4

6.2 WASTE SUMMARY AND CONDITIONS

6.2.1 Spatial Variability Description

Two mechanisms are proposed to account for the spatial variability present in the waste in Tank 241-C-110. One is the relation between the flow of liquid waste in the tank to the settling and precipitation rates of solids. The other relates to the varying types of waste added to Tank 241-C-110 over its fill history.

It is possible that the spatial variability of the waste in Tank 241-C-110 is caused by the relation between the fill lines for incoming waste and the cascade overflow line to Tank 241-C-111. Fill lines are located approximately 150° counterclockwise from the location of the cascade outlet (refer to Figure 2-2). As wastes were introduced into Tank 241-C-110, solids settled and precipitated from the liquid, which would finally overflow into Tank 241-C-111. Based upon the rates at which the different waste solids formed and/or settled, constituent concentrations could be expected to vary between the inlet location and the waste outlet. A larger number of core samples, analyzed along very narrow horizons would be required to quantitatively determine this variability. However, some of the observed heterogeneity could possibly be attributed to the manner in which the tank was filled, and the restricted access and proximity of sampling locations to tank inlets and outlets.

Another potential mechanism to account for the variation between core samples is related to the fill history of Tank 241-C-110. The majority of solids in the tank resulted from 1C waste additions prior to 1950 (see Section 2.0). However, later additions of waste, including tributyl phosphate, organic wash waste, and coating waste, may have either left solids behind, or re-dissolved portions of the existing 1C solids. In either case, this would alter the constituent concentrations in the upper portions of the solids in Tank 241-C-110. The thickness of the effected region, or the amount of new deposits, could possibly vary over the surface of the waste (based on the first proposed mechanism). During core sampling, the uppermost segment from each core would contain this more recent or altered waste. Since core composites are made from all segment samples, this upper sample could bias the core sample analyte concentrations. This heterogeneity of the upper segments, however, is not supported by the Hot Cell Chemist's observations. If more rigorous analyses were performed of this portion of the waste, this mechanism could be possibly be verified or refuted.

6.2.2 Comparisons Between Historical Data and Recent Analytical Data

Comparisons have been made in this report between the most recent core sample results, the Historic Tank Content Estimate (ICF Kaiser Hanford, 1994), the TRAC model results (Jungfleisch, 1984), and past waste sampling activities (Sections 2.0 and 5.0 and Appendices A and B). Based on these comparisons, several preliminary conclusions regarding the non-core sampling data can be made.

- The TRAC model estimates (Jungfleisch, 1984) seem to bear little correspondence to the estimates derived from the analytical data, with the exception of Bi, Cr, Fe, and some of the radionuclides (Section 5.0 and Appendix B). For all other waste constituents modeled by TRAC, the TRAC estimate and the analytically derived Tank Characterization Report result differ by at least an order of magnitude. For example, Tank 241-C-110 has a tank inventory for Cs-137 of 17,300 Ci. Because of the manner in which the TRAC model accounts for cesium in solution, this radionuclide is not predicted to be part of the tank inventory. Similar model limitations exist for other waste constituents and properties (refer to Jungfleisch, 1984). Therefore, for the purposes of Tank 241-C-110, the TRAC model is generally inadequate as a predictive tool on an individual tank basis. It does seem likely, based on its initial inventory assumptions and the decay model used, that the TRAC model may be able to predict total Hanford Site radionuclide inventories, although not specific locations. As more Tank Characterization Reports are prepared for Hanford Site single-shell tanks, the ability of the TRAC model to predict waste inventories can be more fully assessed.

- Sample results from previous sampling and analysis activities show poor correlation to the current core sample analytical data (Section 5.0 and Appendices A and B). Prior to the mid-1980's, when characterization became a central mission at the Hanford Site (Winters et al., 1990), the on-site laboratories analyzed samples primarily for process control purposes. Rapid turnaround times, critical analyte screening, and high laboratory throughput were the dominant analytical needs. Analytes considered at the time to be ancillary to the critical analyses were still frequently quantitated, but then reported for informational purposes only. For these reasons, sample data generated prior to the current core sampling should be viewed in context, and then used accordingly.

Estimates derived for the Historical Tank Content Estimate report (ICF Kaiser Hanford, 1994) show reasonably good agreement to the estimates obtained from the analytical data for the major metallic constituents of Tank 241-C-110 waste (Sections 2.0 and 5.0). However, the HTCE estimate misrepresents some major metals (Al and Zr) and all of the anions, neglects many of the trace constituents of the waste, and provides inconsistent agreement with the major radionuclides (good for ^{90}Sr, poor for ^{137}Cs and uranium). This comparison is only valid for Tank 241-C-110; more tanks will require characterization before more definitive conclusions can be reached. It is possible that the HTCE estimate will prove to be an adequate predictive model for the major metallic waste constituents. As more comparisons between the HTCE results and Tank Characterization Report estimates are made, further conclusions about the utility and defensibility of the characterization information contained in the HTCE can be made.

6.2.3 Leak Inventory Estimate

As discussed in detail in Section 2.1, in 1984, Tank 241-C-110 was designated an Assumed Leaker with a leak estimate of 2,000 gallons of waste. An estimated inventory for this lost waste has been generated based on the 2,000 gallon leak volume, and is presented in Table 6-2. This inventory is useful to estimate possible contamination to the surrounding environment.

Table 6-2. Inventory Assumed Leaked From Tank 241-C-110.

Analyte	Amount Assumed Leaked	Analyte	Amount Assumed Leaked
Metal	**(kg)**	**Metal**	**(kg)**
Aluminum (Al)	0.665	Manganese (Mn)	0.00217
Antimony (Sb)	0.176	Mercury (Hg)	8.40E-04
Arsenic (As)	0.0147	Nickel (Ni)	0.00878
Barium (Ba)	< 0.00229	Phosphorus (P)	15.5
Beryllium (Be)	0.00144	Potassium (K)	3.30
Bismuth (Bi)	0.481	Selenium (Se)	0.245
Boron (B)	0.119	Silicon (Si)	0.496
Cadmium (Cd)	0.00335	Silver (Ag)	0.00604
Calcium (Ca)	0.130	Sodium (Na)	338
Cerium (Ce)	0.0469	Strontium (Sr)	0.00611
Chromium (Cr)	1.31	Sulfur (S)	22.3
Cobalt (Co)	0.00491	Tin (Sn)	0.0110
Copper (Cu)	0.0133	Titanium (Ti)	0.00192
Iron (Fe)	0.358	Uranium (U)	2.44
Lanthanum (La)	0.00765	Vanadium (V)	0.0122
Lead (Pb)	0.0407	Zinc (Zn)	0.0120
Magnesium (Mg)	0.0105	Zirconium (Zr)	0.00435
Ion	**(kg)**	**Ion**	**(kg)**
Ammonia (NH_3)	0.654	Nitrate (NO_3^-)	687
Chloride (Cl^-)	7.54	Nitrite NO_2^-)	59.4
Cyanide (CN^-)	0.0198	Phosphate (PO_4^{3-})	41.9
Fluoride (F^-)	3.91	Sulfate (SO_4^{2-})	84.0
Radionuclide	**(Ci)**	**Radionuclide**	**(Ci)**
Americium-241 (^{241}Am)	< 3.91	Plutonium-239/240 ($^{239/240}Pu$)	0.0133
Carbon-14 (^{14}C)	0.00151	Selenium-79 (^{79}Se)	4.67E-04
Cesium-137 (^{137}Cs)	60.4	Strontium-90 (^{90}Sr)	0.210
Cobalt-60 (^{60}Co)	< 0.0545	Technetium-99 (^{99}Tc)	0.123
Europium-154 (^{154}Eu)	< 0.145	Tritium (^{3}H)	0.00544
Europium-155 (^{155}Eu)	< 0.164	Uranium-238 (^{238}U)	1.96E-05
Iodine-129 (^{129}I)	< 1.80E-04	Total Alpha	0.00531
Neptunium-237 (^{237}Np)	< 4.91E-04	Total Beta	28.5
Plutonium-238 (^{238}Pu)	< 6.81E-05		

6.2.4 Projected Tank Heat Load

The low relative level of radionuclides in Tank 241-C-110 is reflected in the low heat load (Table 6-3). Only five of the elements tested for were detected by the analytical methods used.

Table 6-3. Tank 241-C-110 Heat Load.

Radionuclide	Ci	Watts
^{241}Am	< 287	< 0.220
^{137}Cs	20,000	95.8
^{60}Co	< 44.5	< 0.688
^{154}Eu	< 123	< 1.12
^{155}Eu	< 125	< 0.0919
^{129}I	< 25.7	< 0.0119
^{237}Np	< 55.6	< 1.01
^{238}Pu	< 51.1	< 0.167
$^{239/240}Pu$	82.4	2.52
^{90}Sr	5,140	34.5
^{99}Tc	33.7	0.0171
^{238}U	0.508	0.0126
Total Watts		~ 136

6.3 PROGRAM ELEMENT SPECIFIC ANALYSES

The sampling and analysis of Hanford Site waste tanks is driven by the need to satisfy the characterization requirements of the various Tank Waste Remediation System (TWRS) program elements. These characterization needs are implemented and documented through the Data Quality Objective process, and expressed in a series of program specific Data Quality Objective documents. The data needs are summarized in the *TWRS Tank Waste Analysis Plan* (Bell, 1994).

This Tank Characterization Report is the final step in the characterization of Tank 241-C-110. According to the process and issue based data requirements, the inventory estimates and waste properties contained in this report can be applied to the data requirements of the various program elements. Contained in Table 6-4 is a summary of which program data needs are fulfilled through this characterization of the waste in Tank 241-C-110, based on a review of the stated sampling and analysis requirements. In the future, the applicability of Tank Characterization Report results to each TWRS program element will be documented in tank specific Tank Characterization Plans, prior to the tank sampling.

Table 6-4. Applicability of Characterization Information to the Data Needs of the TWRS Program Elements.

Data Quality Objective	Applicability to Characterization of Tank 241-C-110
Tank Safety Screening	applies[1]
Ferrocyanide Safety Issues	does not apply
Flammable Gas Tanks Crust Burn Issue	does not apply
Generic Tank Vapor Issue Resolution	not addressed
Flammable Gas Tank	not completed
Waste Compatibility	does not apply
Organic Fuel Rich Tank	does not apply
Rotary Core Vapor Sampling	does not apply
Evaporator Operations	not completed
Process Control	not completed
Waste Tank Retrieval	not completed
Waste Tank Pretreatment	not completed
High-Level Immobilization	not completed
Low-Level Immobilization	not completed
Solid, Low-Level Waste Disposal	not completed
RCRA Part B Permit Application	not completed
Tank C-106 High-Heat Safety Issue	does not apply
Organic Layer Sampling of Tank C-103	does not apply
Tank C-103 Vapor and Gas Sampling	does not apply

[1]The sampling requirement for the Safety Screening Data Quality Objective (Babad, 1994) calls for both vertical waste samples and a vapor space sample. The sampling and analysis of Tank 241-C-110 supports full characterization of the waste in the tank; vapor space sampling or characterization was not conducted as part of this activity.

applies - The data needs expressed in this Data Quality Objectives document are fulfilled through this characterization report.

does not apply - The data needs expressed in this Data Quality Objectives document do not apply to the waste in Tank 241-C-110.

not addressed - The data needs expressed in this Data Quality Objectives document were not addressed by this characterization report.

not complete - At the date of preparation of this report, this Data Quality Objectives document has not yet been completed.

7.0 STATISTICAL INTERPRETATION

7.1 MASS AND CHARGE BALANCE

The principle objective in performing a mass and charge balance is to determine if the measurements are self-consistent. The mass and charge balance calculations also provide a method for estimating the weight percent of water. In calculating the balances, only analytes detected at a concentration of 1 ppm or greater were considered.

Mass and charge balance results are reported in Table 7-1. This represents data for the solid portion of the tank contents only (96%). The charge balance agrees, assuming that hydroxide ions account for part of the missing negative charge. The mass concentration, µg/g, resulting from the sum of the cations and anions, was subtracted from a million in order to obtain an estimated value for the weight percent of water. In other words, mass not accountable to the analyte concentrations is attributed to water. Inspection of the table indicates that the predicted weight percent of water is 62.7%. This agrees fairly closely with the evaluated data result of 59.8%.

Table 7-1. Tank 241-C-110 Mass and Charge Balance (2 pages).

	Mass µg/g	Charge µmol/g
Cations		
[1]ICP.a.Al^{+3}	14,500	1,611
[1]ICP.f.Sb^{+5}	301	12.3
[2]ICP.a.As^{+5}	4.1	0.27
ICP.a.Ba^{+2}	7.68	0.11
ICP.a.Bi^{+3}	16,800	241
ICP.f.Cd^{+2}	5.36	0.10
ICP.f.Ca^{+2}	1,150	57.4
ICP.a.Ce^{+3}	210	4.50
ICP.f.Co^{+2}	6.59	0.22
ICP.a.Cr^{+6}	470	54.2
ICP.f.Cu^{+2}	98.9	3.11
ICP.a.Fe^{+3}	11,000	591
[3]ICP.w.La^{+3}	2.00	0.04
ICP.f.Pb^{+2}	258	2.49
ICP.f.Mg^{+2}	153	12.6
ICP.f.Mn^{+2}	56.3	2.05
ICP.a.Ni^{+2}	23.9	0.81
ICP.a.K^{+}	557	14.2

Table 7-1. Tank 241-C-110 Mass and Charge Balance (2 pages).

	Mass µg/g	Charge µmol/g
Cations (continued)		
ICP.w.Ag^{+}	1.05	0.01
ICP.f.Na^{+}	82,600	3,590
ICP.f.Sr^{+2}	131	3.00
ICP.f.Sn^{+2}	12.8	0.22
ICP.a.Ti^{+2}	5.09	0.21
[4]LF.U^{+6}	1,480	37.3
ICP.a.V^{+5}	6.17	0.60
ICP.f.Zn^{+2}	224	6.85
ICP.f.Zr^{+4}	172	7.56
Anions		
Metasilicate ICP.f.SiO_3^{-2}	19,400	510
Selenite ICP.a.SeO_3^{-2}	113	1.77
Tetraborate ICP.w.$B_4O_7^{-2}$	89.8	1.16
[5]IC.w.F^{-}	7,520	396
IC.w.Cl^{-}	1,100	31.0
IC.w.NO_3^{-}	110,000	1,770
IC.w.PO_4^{-3}	62,200	1,904
IC.w.SO_4^{-2}	15,200	317
Spec.w.NO_2^{-}	7,260	158
Totals		
Cations	131,000	6,226
Anions	223,000	5,150
Hydroxide	18,800	1,103
Water (est.)	627,000	
Tank Characterization Report Results		
Water (TCR)	598,000	

1: ICP.a = Inductively Coupled Plasma, acid digestion
2: ICP.f = Inductively Coupled Plasma, KOH/Nickel fusion dissolution
3: ICP.w = Inductively Coupled Plasma, water digestion
4: LF = Laser Fluorimetry
5: IC = Ion Chromatography, water digestion

7.2 STATISTICAL ANALYSIS

7.2.1 Introduction

This section contains the results of a statistical analysis of data from the three core samples obtained from Tank 241-C-110 (Remund and Jensen, 1994). This statistical analysis was conducted on the solid segment material only (180,000 gallons, or 96%). No statistics were run on the drainable liquid portion of the tank (7,000 gallons, or 4%). Two topics are addressed here: the ability of the WHC 222-S Process and Analytical Laboratory to homogenize solid core segments, and estimates of the tank spatial and compositing variability.

Three core samples (cores 37, 38 and 39) were taken from Tank 241-C-110. The segment recoveries for each core are given in Table 3-5. Core 37 contained solid core sample material from segments 2, 3, and 4. Core 38 contained solid core sample material from segments 1 and 4. Core 39 contained solid core sample material from segments 2, 3, and 4. As mentioned in Chapter 3.3, the statistical results are biased due to the overall marginal core recoveries. The magnitude of this bias cannot be assessed with this data set.

Two core composite samples were made for each core (excluding core 38) from homogenized solid segment waste. Core 38 had only one core composite sample due to lack of solid segment material. Two samples were taken from each core composite. For the homogenization test, additional samples and duplicate samples were taken from two different locations.

In general, statistics were calculated for analytes with concentrations greater than 10 times their detection limits (DL). Analytical Evaluation and Reporting personnel, within the TWRS Information Management Systems, identified a list of critical analytes that have exception to this rule. Table 7-2 contains this critical list of analytes. Statistics were calculated for the analytes from this special list if the concentrations were greater than 3 times their DL. Analyte sample results with concentrations less than the DL were not used in any case. For a number of analytes, the concentrations of some samples were greater than a particular limit (3 or 10 times the DL) and the other samples were less than the limit. In these cases, the statistics were calculated using all of the data whether it was above or below the particular limit (3 or 10 DL).

Table 7-2. Special Analyte List.

Aluminum	Nitrate
Bismuth	Nitrite
Calcium	Phosphate
Chromium	Carbonate
Iron	Fluoride
Silicon	Chloride
Sodium	Total Organic Carbon
Zirconium	Cyanide

7.2.2 Sample Homogenization Test

A statistical test was conducted to determine the ability of the 222-S Laboratory to homogenize solid core segments. Segment 4 from core 38 and segment 3 from core 39 were homogenized and arbitrarily divided into two parts. One subsample was obtained from each part and two aliquots were taken from each subsample and prepared for chemical analysis. An ANOVA (Analysis of Variance) was then computed for 25 major analytes. For 21 out of 25 analytes, the variability between subsamples taken from different locations could not be distinguished from zero, indicating they were equivalent. Based on the results of this statistical test, it is generally concluded that the 222-S Laboratory can satisfactorily homogenize core segments (Remund and Jensen, 1994).

7.2.3 Comparison of Variance Component Estimates

The between core spatial variability, the compositing variability, and the analytical measurement variability can be separated from each other using the hierarchical structure of the core composite data. The spatial variance $\sigma^2(S)$ is a measure of the variability between cores. The compositing variance $\hat{\sigma}^2(C)$ measures the variability between composite samples within the same core. The analytical measurement variance includes, among other things, the segment homogenization error, the sample handling error, and the chemical analysis error. This variance is an estimate of the analytical error between the sample and duplicate samples, and a discussion of it is included in Section 7.3.

An ANOVA was computed for a hierarchical statistical model (Remund and Jensen, 1994). Appendix C contains a description of the model. An F-test, from the ANOVA, was used to test the hypothesis that $\sigma^2(S)$ is equal to zero (i.e., the tank is homogeneous). Another F-test, from the ANOVA, was used to test the hypothesis that there is not a significant difference between composite samples within the same core ($\hat{\sigma}^2(C) = 0$). The p-values (the attained level of significance) from the F-tests and the estimates of each components of variability are given in Table 7-3. If the p-value is smaller than 0.05, then $\sigma^2(S)$ or $\sigma^2(C)$ are significantly different from zero.

Only those analytes with concentrations greater than 1 ppm or 1 uCi/g were included. The analytical method that gave the highest concentration for a given analyte was the one listed in Table 7-4. Column 1 of Table 7-4 gives the analysis method used, digestion, and analyte.

Table 7-3. Variance Components Test Results. (2 pages)

Analyte	$\sigma^2(S)$	Spatial Variability $\sigma^2(S)$ p-value	$\sigma_2(C)$	Compositing Variability $\sigma^2(C)$ p-value	$\sigma_2(A)$
[1]ICP.a.Al	4.45E+05	0.003	6.94E-29	0.811	1.15E+05
ICP.a.Ba	3.02E+00	0.000	1.40E-30	0.609	5.91E-02
[2]ICP.f.Ca*#	6.38E-31	0.843	1.35E-14	0.329	1.71E+06
ICP.a.Cr	1.16E+03	0.000	1.48E-36	0.983	1.25E+02
ICP.f.Cu	4.12E+03	0.035	1.38E-12	0.941	2.28E+03

Table 7-3. Variance Components Test Results. (2 pages)

Analyte	σ^2(S)	Spatial Variability σ^2(S) p-value	σ_2(C)	Compositing Variability σ^2(C) p-value	σ_2(A)
ICP.a.Fe	1.84E+06	0.000	6.53E-25	0.622	1.05E+05
ICP.f.Pb*#	2.72E+04	0.000	4.45E+01	0.250	1.05E+02
ICP.f.Mg	6.65E-26	0.831	3.54E-19	0.447	1.28E+03
ICP.f.Mn	3.84E-13	0.350	1.51E+01	0.451	4.23E+02
ICP.a.Ni#	2.29E-23	0.977	1.36E-13	0.328	2.21E+02
ICP.a.K	2.11E+03	0.001	4.38E+02	0.011	7.33E+01
ICP.a.Se*#	3.60E+03	0.000	5.04E-25	0.710	2.37E+01
ICP.f.Na	2.13E+07	0.008	4.02E+06	0.172	4.95E+06
ICP.a.V#	4.68E+00	0.000	6.72E-36	0.621	2.99E-01
ICP.f.Zn	1.36E+06	0.160	9.91E-06	0.422	3.10E+03
ICP.a.Bi	4.14E+06	0.000	2.09E-36	0.849	6.65E+04
[3]ICP.w.B	8.48E-20	0.675	3.54E+01	0.000	4.09E-01
ICP.a.Ce	5.19E+02	0.000	5.35E-11	0.451	5.12E+01
ICP.f.P	2.33E+06	0.026	1.36E+06	0.098	9.58E+05
ICP.f.Si	5.31E+05	0.000	1.66E-09	0.458	1.80E+04
ICP.a.S	3.45E+05	0.000	8.89E+02	0.318	3.92E+03
ICP.a.Ti#	2.15E-01	0.051	1.00E-01	0.202	1.70E-01
ICP.f.Zr	6.67E+02	0.087	9.88E+01	0.003	8.89E+00
[4]IC.w.F	2.26E+06	0.208	1.29E+06	0.002	1.11E+05
IC.w.Cl	1.08E+05	0.369	1.92E+05	0.000	9.74E+02
IC.w.NO3	1.65E+08	0.000	1.70E-32	0.682	1.51E+07
IC.w.PO4	1.44E+08	0.001	5.86E+06	0.306	2.39E+07
IC.w.SO4	2.52E+07	0.000	1.54E+06	0.170	1.99E+06
Spec.w.NO2	1.97E+07	0.000	5.52E+04	0.142	5.65E+04
pH	8.32E-03	0.384	3.45E-02	0.004	3.38E-03
[5]GEA.^{137}Cs	1.90E+01	0.000	6.65E-02	0.342	3.97E-01
^{90}Sr	3.33E+00	0.000	1.65E-02	0.380	1.87E-01

1: ICP.a = Inductively Coupled Plasma, acid digestion
2: ICP.f = Inductively Coupled Plasma, KOH/Nickel fusion dissolution
3: ICP.w = Inductively Coupled Plasma, water digestion
4: IC = Ion Chromatography, water digestion
5: GEA = Gamma Energy Analysis
*: Analytes with a portion of the data below 3 times the DL.
#: Analytes with all or a portion of the data below 10 times the DL.

Table 7-4. Measurement Error Estimates. (2 pages)

Analyte	Analytical Error Estimate - 1 RSD (%)		Systematic Error Estimate - 1 RSD (%)	
	From Sample Results	From Standard Results	From Standard Results	From Spike Analyses
[1]ICP.a.Al	3.7	2.7	17	1176
ICP.a.Ba	4.9	2.7	4.7	7.9
[2]ICP.f.Ca*#	53	3.2	2.4	1.4
ICP.a.Cr	4.0	2.9	2.7	58
ICP.f.Cu	95	2.0	2.5	0.7
ICP.a.Fe	4.5	2.5	39	1289
ICP.f.Pb*#	5.5	3.5	3.5	1.9
ICP.f.Mg	37	3.0	3.4	2.8
ICP.f.Mn	55	2.4	5.2	4.3
ICP.a.Ni#	93	2.6	1.4	9.6
ICP.a.K	2.1	3.8	21	26
ICP.a.Se*#	16	4.5	16	7.3
ICP.f.Na	3.7	2.9	5.2	12
ICP.a.V#	13	2.5	3.6	7.1
ICP.f.Zn	36	2.5	1.1	1.2
ICP.a.Bi	2.5	2.6	24	2014
[3]ICP.w.B	3.4	4.4	6.0	5.4
ICP.a.Ce	4.8	2.8	17.6	28
ICP.f.P	6.8	5.0	2.9	7.9
ICP.f.Si	2.7	2.6	4.0	4.6
ICP.a.S	2.2	3.9	246	286
ICP.a.Ti#	12	3.6	3.4	8.4
ICP.f.Zr	2.6	4.6	3.2	2.8
[4]IC.w.F	6.3	4.7	2.0	13
IC.w.Cl	4.0	3.3	4.2	6.2
IC.w.NO3	5.5	4.3	2.9	7.3
IC.w.PO4	24	3.9	2.0	8.0
IC.w.SO4	13	2.7	1.3	12

Table 7-4. Measurement Error Estimates. (2 pages)

Analyte	Analytical Error Estimate - 1 RSD (%)		Systematic Error Estimate - 1 RSD (%)	
	From Sample Results	From Standard Results	From Standard Results	From Spike Analyses
Spec.w.NO2	3.3	3.1	2.7	4.7
pH	0.7	0.2	0.6	NA
[5]GEA.^{137}Cs	4.6	2.2	0.2	32
^{90}Sr	12	5.4	7.1	4.2

1: ICP.a = Inductively Coupled Plasma, acid digestion
2: ICP.f = Inductively Coupled Plasma, KOH/Nickel fusion dissolution
3: ICP.w = Inductively Coupled Plasma, water digestion
4: IC = Ion Chromatography, water digestion
5: GEA = Gamma Energy Analysis
*: Analytes with a portion of the data below 3 times the DL.
#: Analytes with all or a portion of the data below 10 times the DL.
&: Calculated from the Laboratory Measurement Control System standards analyzed in conjunction with the samples.

In 21 out of 32 cases tested, the p-values from the tests on $\sigma^2(S)$ are less than 0.05. For these 21 cases, the spatial variability is significantly greater than zero, a strong indication that the solid portion (96%) of the tank is heterogeneous. This is in addition to the heterogeneity created by the drainable liquid portion of the tank (4%).

In 26 out of 32 cases tested, the p-values from the tests on $\sigma^2(C)$ are greater than 0.05. For these 26 cases, there is no significant difference between the composite samples from core 37. Based on the core composite data from Tank 241-C-110, the 222-S Laboratories can adequately create reproducible core composites.

7.3 ANALYTICAL ERROR ESTIMATION

Analytical error is composed of two parts, random and systematic. Table 7-4 gives both the analytical and systematic error estimates, organized by analyte.

7.3.1 Random Analytical Error

The random analytical error is determined from the analytical results of the duplicate samples. It can also be estimated from the analysis of standards. The estimates for all analytes are taken from actual data only (no estimated data).

Although the value for V appeared low, it had one duplicate sample with an RPD or RSD over the criterion of 3 times the random analytical error from sample results. Despite high RSD values for Ca, Cu, Mg, Mn, Ni, and PO_4^{-3}, none of the sample duplicates for these analytes had any RPD's over the criterion. The high values for Ca and Ni can be explained in part by some of their sample results being close to the detection limit, and the presence of a few outliers. In general, standard deviations for all analytes were not unusually high.

7.3.2 Systematic Analytical Error

The systematic error estimate was determined from the analysis of standards or spike recoveries. For most of the analytes the differences between the two estimates are not large (Table 7-4). For a number of the metals, S, and ^{37}Cs, the estimates for spikes were outside the 100 ± 25% limits. The high Fe value was partially due to contamination of the blank and sample during preparation. Spike failures for major elements in general are frequently caused by a high element concentration in the sample. When the added spike concentration is insignificant compared to the concentration present in the sample, a failure usually occurs.

8.0 CONCLUSION AND RECOMMENDATIONS

8.1 SAFETY ISSUES

Characterization of Tank 241-C-110 supports the classification of the tank as non-Watch List. Given the current tank inventory of fissionable radionuclides and organic or exothermic waste constituents, no credible potential exists for further loss of tank integrity or release of radioactivity due to in-tank processes. Tank 241-C-110 is an Assumed Leaker; however, the liquid volume and waste level in the tank have remained relatively constant since 1984 (Anderson, 1990; Hanlon, 1994). Tank 241-C-110 is within established operating safety requirements, as defined by applicable Data Quality Objectives.

Thermocouple data support the conclusion that there are no significant heat-generating processes within the tank waste; there is no credible risk of self-boiling or excessive heating of the current tank contents. Given the generally stable waste properties, and taking into account the still questionable tank integrity, continued storage of the waste in Tank 241-C-110 poses no unreasonable risk to personnel, the public, or the environment.

8.2 FURTHER CHARACTERIZATION NEEDS

Characterization of the solid and liquid contents of Tank 241-C-110 has been performed in this report. While the current characterization is quite extensive, further sampling and analysis of the contents of Tank 241-C-110 is suggested for the following waste properties:

- If determination of vertical layering in the wastes and variations in analyte concentrations with waste depth are important for safety, retrieval, or other program elements, then additional analyses of segment and sub-segment samples are required.

- An analysis of the tank vapor space would allow final resolution of any safety concerns regarding the presence of flammable or noxious gases.

8.3 CONCLUSIONS

This Tank Characterization Report contains comparisons made between core sampling analytical data and on-going efforts to historically predict the waste contents of Tank 241-C-110 (Section 6.2.2). A more detailed and systematic review of these data sources will be possible as additional Hanford Site waste tanks are characterized. Hypotheses to be tested during this comparison include whether it will be possible to perform a preliminary Safety Screening of a waste tank prior to core sampling, and whether process design decisions can be made based on extremes in expected tank contents. One function of this report is to initiate this effort.

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APPENDIX A

ANALYTICAL DATA

A.1 INTRODUCTION

A.1.1 Appendix A presents the chemical and radiological characteristics of Tank 241-C-110 in a tabular form, in terms of the specific concentrations of anions, metals, physical properties, and radionuclides.

The data table for each analyte lists laboratory sample identification, an analytical data result for each sample, weighted (statistical) mean, standard deviation, an evaluated data result, and a projected tank inventory for the particular analyte. The projected tank inventory column is not applicable for the specific gravity, ph, or percent water data. The data are listed in standard notation for values >.001 and <100,000. Values outside these limits are listed in scientific notation.

A.2 TABLE DESCRIPTION

A.2.1 Abbreviations

Standard abbreviations are used to describe analytical methods.

Metals:	ICP - Inductively Coupled Plasma (generic for all metals unless otherwise known)
	GFAA - Graphite Furnace Atomic Absorption
	GHAA - Gaseous Hydride Atomic Absorption
	CVAA - Cold Vapor Atomic Absorption
	FAA - Flame Atomic Absorption
Anions:	IC - Ion Chromatography
Radionuclides:	GEA - Gamma Energy Analysis
	AEA - Alpha Energy Analysis
	APC - Alpha Proportional Counting
	BPC - Beta Proportional Counting
	LSC - Liquid Scintillation Counting
Physical Properties:	PT - Physical Testing
	DM - Direct Measurement
	DSC - Differential Scanning Calorimetry
	TGA - Thermogravimetric Analysis

A.3 Column Headings

A.3.1 The "Analyte" column contains, in addition to the name of the analyte or physical characteristic, information about the method of measurement, and in the case of the metals, information about the method of digestion. The method of digestion is listed for the metals, because unlike the other analytes, different digestion procedures are typically used for the same metal.

Possible digestion methods are: d - direct; a - acid digestion; w - water leach; and f - potassium hydroxide fusion.

The analyte and method are presented as follows: "method.analyte," or, (in the case of a metal) "method.digestion.analyte." For example, the specific concentration of ^{90}Sr was measured with a beta proportional counter and is listed "BPC.^{90}Sr." A specific concentration of Pb was determined by the inductively coupled plasma method which was preceded by acid digestion, and is listed as "ICP.a.Pb."

A.3.2 The "Laboratory Sample Identification" column lists the samples for which the analyte was measured; this identification number is different from the number assigned to the samples at the tank farm. Sampling rationale, locations, and descriptions of sampling events are contained in Section 3.0.

A.3.3 "Analytical Data Result" is the specific concentration of the analyte determined at different sampling points. No quality control data such as matrix spikes, serial dilutions, or duplicate analyses are listed. This information may be obtained from the 241-C-110 data package (WHC-SD-WM-DP-027). Data which was qualified as estimated (denoted by "J" or "UJ" in the data package) will be enclosed in parentheses, i.e., (395) μg/ml. Unusable data (denoted by "R" in the data package) will be entered with a strikeout, i.e., ~~395~~ μg/ml. Unqualified data will be entered in standard form.

A.3.4 The "Range of Values" column lists the highest and the lowest values for a particular analyte. If a measurement method has a constant method detection limit (MDL), and all results are less than the MDL, no range is given. However, if the MDL changes, (i.e., due to radiation background variations in radiochemistry) a range of detection limit values is given.

A.3.5 "Weighted Mean/*Standard Error*" is computed statistically for those solid sample results greater than the detection limit, with the exception of the results obtained from segment analysis.

A.3.6 Column 6 "Evaluated Data Result" is the average of all the listed sample results.

A.3.7 Column 7, "Projected Inventory," is the product of the concentration of the analyte (See Section 5 for description of selection process) and the volume of the waste in the tank. (187,000 gallons or 708,000L).

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Table A-1. Tank 241-C-110 Analytical Data: Aluminum

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Al	Sample J783	(51.6)	14.5 to 208	---	**87.9**	2.33
	Sample J778	(77.4)				
	Sample J775	(14.5)				
	Sample J800	(208)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Al	Sample J691	(2,710)	< 94.8 to 2,710	1,150 *452*		14,900
	Sample J704	< 94.8				
	Sample J707	(824)				
	Sample J711	(1,110)				
	Sample J712	(1,330)				
ICP.a.Al Segment Sample	Sample J647	(15,800)	12,100 to 15,800			
	Sample J649	(15,300)				
	Sample J658	(12,400)				
	Sample J656	(12,100)				
ICP.a.Al Core Sample	Sample J666	(14,100)	14,000 to 15,400	14,500 *406*		
	Sample J667	(14,000)				
	Sample J672	(14,100)				
	Sample J680	(15,400)				
	Sample J683	(15,200)				
ICP.f.Al	Sample J715	(13,700)	13,700 to 15,100	14,300 *284*		
	Sample J716	(14,300)				
	Sample J719	(14,000)				
	Sample J723	(15,100)				
	Sample J724	(14,600)				

Table A-1. Tank 241-C-110 Analytical Data: Antimony

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Sb	Sample J783	(18.3)	18.3 to 37.0	---	**23.2**	0.615
	Sample J778	(18.7)				
	Sample J775	(18.7)				
	Sample J800	(37.0)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Sb	Sample J691	(37.3)	18.0 to 71.7	36.6 *18.3*	---	309
	Sample J704	(71.7)				
	Sample J707	(18.0)				
	Sample J711	(37.2)				
	Sample J712	(37.2)				
ICP.a.Sb Segment Sample	Sample J647	29.0	29.0 to < 36.6	---	---	
	Sample J649	32.3				
	Sample J658	< 36.6				
	Sample J656	< 36.6				
ICP.a.Sb Core Sample	Sample J666	(< 17.7)	< 17.7 to 38.6	33.0 *7.88*	---	
	Sample J667	(< 17.7)				
	Sample J672	(38.6)				
	Sample J680	25.7				
	Sample J683	29.2				
ICP.f.Sb	Sample J715	(219)	183 to 383	301 *116*	---	
	Sample J716	(383)				
	Sample J719	< 183				
	Sample J723	< 183				
	Sample J724	< 183				

Table A-1. Tank 241-C-110 Analytical Data: Arsenic

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.As	Sample J783	(1.67)	1.53 to 3.03	---	**1.94**	0.0514
	Sample J778	(1.53)				
	Sample J775	(1.53)				
	Sample J800	(3.03)				
TCLP.ICP.As	Sample J723	(< 0.151)	N/A		**(< 0.151)**	
GHAA.As	Sample J800	(0.00735)	N/A		**(0.00735)**	
TCLP.GHAA.As	Sample J723	0.0453	N/A		**0.0453**	
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.As	Sample J691	(3.05)	3.05 to 6.73	3.66	---	4.22
	Sample J704	(6.73)				
	Sample J707	(3.05)		*1.06*		
	Sample J711	(3.05)				
	Sample J712	(3.05)				
ICP.a.As	Sample J647	(3.08)	< 3.00 to 3.13	---	---	
	Sample J649	< 3.00				
Segment Sample	Sample J658	(3.13)				
	Sample J656	< 3.00				
ICP.a.As	Sample J666	(4.50)	< 2.95 to 4.50	4.11	---	
	Sample J667	< 3.00				
Core Sample	Sample J672	< 3.95 *		*0.55*		
	Sample J680	(3.97)				
	Sample J683	(3.47)				
ICP.f.As	Sample J715	(< 15.0)	N/A	---	**< 15.0**	
	Sample J716	< 15.0)				
	Sample J719	(< 15.0)				
	Sample J723	< 15.0				
	Sample J724	< 15.0)				

* Blank Contamination

Table A-1. Tank 241-C-110 Analytical Data: Arsenic (cont.)

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
GHAA.As	Sample J666	(0.340)	< 0.250 to 0.677	0.503 *1.69*	---	---
	Sample J667	< 0.250				
	Sample J672	0.677				
	Sample J680	(0.446)				
	Sample J683	(0.535)				

Table A-1. Tank 241-C-110 Analytical Data: Barium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Ba	Sample J783	(< 0.150)	< 0.150 to < 0.303	---	**< 0.303**	< 0.00803
	Sample J778	(< 0.153)				
	Sample J775	(< 0.153)				
	Sample J800	(< 0.303)				
TCLP.ICP.Ba	Sample J723	< 0.0966	N/A		**< 0.0966**	
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Ba	Sample J691	(2.68)	< 0.305 to 2.68	1.59	---	8.75
	Sample J704	(< 0.604)				
	Sample J707	(0.505)		*1.54*		
	Sample J711	(< 0.305)				
	Sample J712	(< 0.305)				
ICP.a.Ba	Sample J647	(8.89)	4.35 to 8.95	---	---	
Segment Sample	Sample J649	(8.95)				
	Sample J658	(4.78)				
	Sample J656	(4.35)				
ICP.a.Ba	Sample J666	(8.91)	5.57 to 9.00	7.68	---	
Core Sample	Sample J667	(9.00)				
	Sample J672	(8.39)		*1.74*		
	Sample J680	(5.57)				
	Sample J683	(5.82)				
ICP.f.Ba	Sample J715	(8.11)	6.49 to 9.46	8.52	---	
	Sample J716	(8.89)				
	Sample J719	(9.46)		*0.930*		
	Sample J723	(6.49)				
	Sample J724	(8.41)				

Table A-1. Tank 241-C-110 Analytical Data: Beryllium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Be	Sample J783	(0.150)	0.150 to 0.303	---	**0.190**	0.00504
	Sample J778	(0.153)				
	Sample J775	(0.153)				
	Sample J800	(0.303)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Be	Sample J691	(0.305)	0.102 to 0.604	0.287	---	0.295
	Sample J704	(0.604)				
	Sample J707	(0.102)		*0.177*		
	Sample J711	(0.305)				
	Sample J712	(0.305)				
ICP.a.Be Segment Sample	Sample J647	< 0.100	N/A	---	---	
	Sample J649	< 0.100)				
	Sample J658	< 0.300				
	Sample J656	< 0.300)				
ICP.a.Be Core Sample	Sample J666	(< 0.100)	N/A	---	**< 0.300**	
	Sample J667	< 0.100				
	Sample J672	< 0.300				
	Sample J680	< 0.100				
	Sample J683	< 0.100				
ICP.f.Be	Sample J715	(< 1.50)	N/A	---	**< 1.50**	
	Sample J716	< 1.50				
	Sample J719	(< 1.50)				
	Sample J723	< 1.50				
	Sample J724	< 1.50				

Table A-1. Tank 241-C-110 Analytical Data: Bismuth

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Bi	Sample J783	(3.86)	3.86 to 192	---	**63.5**	1.68
	Sample J778	(38.5)				
	Sample J775	(19.7)				
	Sample J800	(192)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Bi	Sample J691	(102)	39.1 to 102	68.3 *11.4*	---	17,200
	Sample J704	(39.1)				
	Sample J707	(56.6)				
	Sample J711	(82.8)				
	Sample J712	(72.9)				
ICP.a.Bi Segment Sample	Sample J647	(16,900)	12,000 to 18,100	---	---	
	Sample J649	(16,800)				
	Sample J658	(12,800)				
	Sample J656	(12,000)				
ICP.a.Bi Core Sample	Sample J666	(17,700)	14,400 to 18,100	16,800 *1,180*	---	
	Sample J667	(17,900)				
	Sample J672	(18,100)				
	Sample J680	(14,400)				
	Sample J683	(14,400)				
ICP.f.Bi	Sample J715	(12,700)	11,800 to 15,400	13,700 *692*	---	
	Sample J716	(13,100)				
	Sample J719	(15,400)				
	Sample J723	(14,000)				
	Sample J724	(11,800)				

Table A-1. Tank 241-C-110 Analytical Data: Boron

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.B	Sample J783	(5.65)	5.65 to 23.6	---	**15.7**	0.416
	Sample J778	(23.6)				
	Sample J775	(22.8)				
	Sample J800	(10.9)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.B	Sample J691	28.2	14.4 to 28.6	25.0	---	25.7
	Sample J704	14.4				
	Sample J707	(25.6)		*2.81*		
	Sample J711	28.6				
	Sample J712	27.5				
ICP.a.B Segment Sample	Sample J647	28.2	< 28.2 to 29.8	---	---	
	Sample J649	29.8				
	Sample J658	< 28.5				
	Sample J656	< 28.2				
ICP.a.B Core Sample	Sample J666	23.9	17.3 to 25.2	21.2	---	
	Sample J667	25.2				
	Sample J672	17.3		*2.07*		
	Sample J680	20.8				
	Sample J683	22.7				
ICP.f.B	Sample J715	(7.49)	7.31 to 22.3	11.9	---	
	Sample J716	(7.31)				
	Sample J719	(16.4)		*6.36*		
	Sample J723	< 16.8				
	Sample J724	< 22.3				

Table A-1. Tank 241-C-110 Analytical Data: Cadmium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Cd	Sample J783	(0.350)	0.350 to 0.707	---	**0.443**	0.0117
	Sample J778	(0.357)				
	Sample J775	(0.357)				
	Sample J800	(0.707)				
TCLP.ICP.Cd	Sample J723	(< 0.0353)	N/A		**< 0.0353**	
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Cd	Sample J691	(0.750)	0.711 to 1.41	0.756 *0.304*	---	5.50
	Sample J704	(1.41)				
	Sample J707	(0.478)				
	Sample J711	(0.711)				
	Sample J712	(0.711)				
ICP.a.Cd Segment Sample	Sample J647	(3.59)	1.56 to 3.68	---	---	
	Sample J649	(3.68)				
	Sample J658	(1.88)				
	Sample J656	(1.56)				
ICP.a.Cd Core Sample	Sample J666	(2.66)	1.98 to 4.76	3.23 *1.35*	---	
	Sample J667	(2.78)				
	Sample J672	(4.76)				
	Sample J680	(1.98)				
	Sample J683	(2.46)				
ICP.f.Cd	Sample J715	(4.69)	3.79 to 6.16	5.36 *0.693*	---	
	Sample J716	(5.22)				
	Sample J719	(6.16)				
	Sample J723	(3.79)				
	Sample J724	(6.13)				

Table A-1. Tank 241-C-110 Analytical Data: Calcium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Ca	Sample J783	(13.6)	13.6 to 27.5	---	**17.2**	0.456
	Sample J778	(13.9)				
	Sample J775	(13.9)				
	Sample J800	(27.5)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Ca	Sample J691	119	< 35.0 to 299	154 *59.7*	---	1,180
	Sample J704	299				
	Sample J707	(211)				
	Sample J711	(< 51.2)				
	Sample J712	(< 35.0)				
ICP.a.Ca Segment Sample	Sample J647	< 429	N/A*	---	---	
	Sample J649	< 1,190				
	Sample J658	< 1,910				
	Sample J656	243				
ICP.a.Ca Core Sample	Sample J666	833	183 to 833	381 *171*	---	
	Sample J667	598				
	Sample J672	243				
	Sample J680	186				
	Sample J683	183				
ICP.f.Ca	Sample J715	1,250	< 403 to 2,600	1,150 *436*	---	
	Sample J716	585				
	Sample J719	1,020				
	Sample J723	< 403				
	Sample J724	2,600				

* Blank Contamination

Table A-1. Tank 241-C-110 Analytical Data: Cerium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	µg/mL	kg
ICP.d.Ce	Sample J783	(4.90)	4.90 to 9.90	---	**6.20**	0.164
	Sample J778	(5.00)				
	Sample J775	(5.00)				
	Sample J800	(9.90)				
Metal (Solid)		µg/g	µg/g	µg/g	µg/g	kg
ICP.w.Ce	Sample J691	(41.5)	9.95 to 41.5	16.6	---	216
	Sample J704	(17.3)				
	Sample J707	(10.3)		*11.1*		
	Sample J711	(9.95)				
	Sample J712	(9.96)				
ICP.a.Ce	Sample J647	(215)	141 to 215	---	---	
Segment Sample	Sample J649	(213)				
	Sample J658	(156)				
	Sample J656	(141)				
ICP.a.Ce	Sample J666	(219)	178 to 226	210	---	
Core Sample	Sample J667	(220)				
	Sample J672	(226)		*13.4*		
	Sample J680	(178)				
	Sample J683	(188)				
ICP.f.Ce	Sample J715	(184)	150 to 214	175	---	
	Sample J716	(150)				
	Sample J719	(170)		*11.4*		
	Sample J723	(214)				
	Sample J724	(162)				

Table A-1. Tank 241-C-110 Analytical Data: Chromium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Cr	Sample J783	(31.4)	31.4 to 393	---	**173**	4.58
	Sample J778	(150)				
	Sample J775	(393)				
	Sample J800	(119)				
TCLP.ICP.Cr	Sample J723	(13.3)	N/A		**13.3**	
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Cr	Sample J691	(294)	27.5 to 294	206 *52.1*	---	483
	Sample J704	(27.5)				
	Sample J707	(185)				
	Sample J711	(275)				
	Sample J712	(269)				
ICP.a.Cr Segment Sample	Sample J647	(555)	312 to 559	---	---	
	Sample J649	(559)				
	Sample J658	(321)				
	Sample J656	(312)				
ICP.a.Cr Core Sample	Sample J666	(492)	429 to 493	470 *20.0*	---	
	Sample J667	(493)				
	Sample J672	(488)				
	Sample J680	(431)				
	Sample J683	(429)				
ICP.f.Cr	Sample J715	(478)	417 to 496	464 *21.2*	---	
	Sample J716	(469)				
	Sample J719	(496)				
	Sample J723	(431)				
	Sample J724	(417)				

Table A-1. Tank 241-C-110 Analytical Data: Cobalt

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	µg/mL	kg
ICP.d.Co	Sample J783	(0.500)	0.500 to 1.01	---	**0.649**	0.0172
	Sample J778	(0.510)				
	Sample J775	(0.576)				
	Sample J800	(1.01)				
Metal (Solid)		µg/g	µg/g	µg/g	µg/g	kg
ICP.w.Co	Sample J691	(1.02)	0.814 to 2.42	1.18 *0.475*	---	6.77
	Sample J704	(2.42)				
	Sample J707	(0.814)				
	Sample J711	(1.02)				
	Sample J712	(1.02)				
ICP.a.Co Segment Sample	Sample J647	(1.86)	1.59 to 1.92	---	---	
	Sample J649	(1.59)				
	Sample J658	(1.92)				
	Sample J656	(1.02)				
ICP.a.Co Core Sample	Sample J666	(2.51)	2.25 to 2.97	2.69 *0.264*	---	
	Sample J667	(2.80)				
	Sample J672	2.97				
	Sample J680	2.25				
	Sample J683	2.64				
ICP.f.Co	Sample J715	(5.08)	5.00 to 8.93	6.59 *2.05*	---	
	Sample J716	(5.07)				
	Sample J719	(8.93)				
	Sample J723	(5.00)				
	Sample J724	(6.52)				

Table A-1. Tank 241-C-110 Analytical Data: Copper

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Cu	Sample J783	(0.266)	0.266 to 4.18	---	**1.76**	0.0466
	Sample J778	(4.18)				
	Sample J775	(1.42)				
	Sample J800	(1.10)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Cu	Sample J691	(8.35)	0.548 to 8.35	2.11	---	102
	Sample J704	(1.21)				
	Sample J707	(0.954)		*1.61*		
	Sample J711	(0.626)				
	Sample J712	(0.548)				
ICP.a.Cu Segment Sample	Sample J647	(27.4)	20.6 to 27.4	---	---	
	Sample J649	(24.7)				
	Sample J658	(21.3)				
	Sample J656	(20.6)				
ICP.a.Cu Core Sample	Sample J666	(43.4)	19.2 to 43.4	30.0	---	
	Sample J667	(43.0)				
	Sample J672	(26.3)		*6.83*		
	Sample J680	(19.2)				
	Sample J683	(21.7)				
ICP.f.Cu	Sample J715	55.2	< 47.1 to 182	98.9	---	
	Sample J716	73.9				
	Sample J719	182		*40.4*		
	Sample J723	52.7				
	Sample J724	< 47.1*				

* Blank Contamination

Table A-1. Tank 241-C-110 Analytical Data: Iron

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Fe	Sample J783	(< 0.750)	< 0.750 to 140	---	**47.3**	1.25
	Sample J778	(31.4)				
	Sample J775	(17.1)				
	Sample J800	(140)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Fe	Sample J691	(2,100)	39.5 to 2,100	584 *396*	---	11,300
	Sample J704	(39.5)				
	Sample J707	(420)				
	Sample J711	(251)				
	Sample J712	(275)				
ICP.a.Fe Segment Sample	Sample J647	(10,100)	8,990 to 10,100	---	---	
	Sample J649	(10,100)				
	Sample J658	(9,160)				
	Sample J656	(8,990)				
ICP.a.Fe Core Sample	Sample J666	(12,000)	9,400 to 12,300	11,000 *791*	---	
	Sample J667	(12,300)				
	Sample J672	(11,400)				
	Sample J680	(9,400)				
	Sample J683	(9,660)				
ICP.f.Fe	Sample J715	(11,600)	9,100 to 11,600	10,700 *710*	---	
	Sample J716	(11,600)				
	Sample J719	(11,300)				
	Sample J723	(9,540)				
	Sample J724	(9,100)				

Table A-1. Tank 241-C-110 Analytical Data: Lanthanum

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.La	Sample J783	(0.800)	0.800 to 1.62	---	**1.01**	0.0268
	Sample J778	(0.816)				
	Sample J775	(0.816)				
	Sample J800	(1.62)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.La	Sample J691	(1.63)	1.43 to 4.23	2.00	---	2.05
	Sample J704	(4.23)				
	Sample J707	(1.43)		*0.814*		
	Sample J711	(1.63)				
	Sample J712	(1.63)				
ICP.a.La Segment Sample	Sample J647	< 1.40	N/A	---	---	
	Sample J649	< 1.40				
	Sample J658	< 1.60				
	Sample J656	< 1.60				
ICP.a.La Core Sample	Sample J666	< 1.40	N/A	---	**< 1.60**	
	Sample J667	< 1.40				
	Sample J672	< 1.60				
	Sample J680	< 1.40				
	Sample J683	< 1.40				
ICP.f.La	Sample J715	< 8.00	N/A	---	**< 8.00**	
	Sample J716	< 8.00				
	Sample J719	< 8.00				
	Sample J723	< 8.00				
	Sample J724	< 8.00				

Table A-1. Tank 241-C-110 Analytical Data: Lead

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Pb	Sample J783	(3.55)	3.55 to 7.17	---	**5.37**	0.142
	Sample J778	(7.14)				
	Sample J775	(3.62)				
	Sample J800	(7.17)				
TCLP.ICP.Pb	Sample J723	(1.23)	N/A		**1.23**	
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Pb	Sample J691	(61.3)	6.31 to 61.3	17.6	---	265
	Sample J704	(17.1)				
	Sample J707	(6.31)		18.7		
	Sample J711	(7.21)				
	Sample J712	(7.22)				
ICP.a.Pb Segment Sample	Sample J647	(134)	68.0 to 134	---	---	
	Sample J649	(132)				
	Sample J658	(77.2)				
	Sample J656	(68.0)				
ICP.a.Pb Core Sample	Sample J666	(424)	103 to 426	232	---	
	Sample J667	(426)				
	Sample J672	(167)		*98.0*		
	Sample J680	(103)				
	Sample J683	(107)				
ICP.f.Pb	Sample J715	(449)	114 to 449	258	---	
	Sample J716	(434)				
	Sample J719	(212)		*95.3*		
	Sample J723	(114)				
	Sample J724	(127)				

Table A-1. Tank 241-C-110 Analytical Data: Magnesium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	μg/mL	kg
ICP.d.Mg	Sample J783	(0.427)	0.427 to 3.02	---	**1.39**	0.0368
	Sample J778	(1.22)				
	Sample J775	(0.903)				
	Sample J800	(3.02)				
Metal (Solid)		μg/g	μg/g	μg/g	μg/g	kg
ICP.w.Mg	Sample J691	(19.4)	5.49 to 28.2	16.5 *6.17*	---	157
	Sample J704	12.0				
	Sample J707	(28.2)				
	Sample J711	5.74				
	Sample J712	5.49				
ICP.a.Mg Segment Sample	Sample J647	150	121 to < 256	---	---	
	Sample J649	243				
	Sample J658	< 256*				
	Sample J656	(121)				
ICP.a.Mg Core Sample	Sample J666	(198)	114 to 198	149 *20.5*	---	
	Sample J667	(170)				
	Sample J672	(148)				
	Sample J680	(114)				
	Sample J683	(115)				
ICP.f.Mg	Sample J715	(166)	117 to 167	153 *11.9*	---	
	Sample J716	(145)				
	Sample J719	(161)				
	Sample J723	(117)				
	Sample J724	(167)				

* Blank Contamination

Table A-1. Tank 241-C-110 Analytical Data: Manganese

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Mn	Sample J783	(0.150)	0.150 to 0.533	---	**0.287**	0.00761
	Sample J778	(0.228)				
	Sample J775	(0.238)				
	Sample J800	(0.533)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Mn	Sample J691	(6.93)	0.604 to 6.93	1.99	---	57.8
	Sample J704	(0.604)				
	Sample J707	(1.52)		*1.29*		
	Sample J711	(0.675)				
	Sample J712	(0.661)				
ICP.a.Mn Segment Sample	Sample J647	(32.7)	29.5 to 33.9	---	---	
	Sample J649	(33.9)				
	Sample J658	32.8				
	Sample J656	(29.5)				
ICP.a.Mn Core Sample	Sample J666	(41.1)	28.3 to 41.6	35.8	---	
	Sample J667	(41.6)				
	Sample J672	(37.0)		*3.63*		
	Sample J680	(28.3)				
	Sample J683	(29.6)				
ICP.f.Mn	Sample J715	52.1	31.9 to 72.8	56.3	---	
	Sample J716	48.3				
	Sample J719	(72.8)		*7.10*		
	Sample J723	(31.9)				
	Sample J724	(59.8)				

Table A-1. Tank 241-C-110 Analytical Data: Mercury

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
CVAA.Hg	Sample J800	0.106	N/A	---	**0.106**	0.00281
TCLP.CVAA.Hg	Sample J723	0.111	N/A		**0.111**	
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
CVAA.Hg	Sample J651	0.449	0.327 to 0.619	0.450	---	0.462
	Sample J653	(0.619)				
	Sample J657	0.482		*0.104*		
	Sample J662	0.327				
	Sample J663	0.338				

Table A-1. Tank 241-C-110 Analytical Data: Nickel

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Ni	Sample J783	(0.700)	0.700 to 1.80	---	**1.16**	0.0307
	Sample J778	(1.80)				
	Sample J775	(0.714)				
	Sample J800	(1.41)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Ni	Sample J691	(6.21)	1.42 to 6.21	2.76	---	24.5
	Sample J704	(3.63)				
	Sample J707	(1.95)		*1.89*		
	Sample J711	(1.42)				
	Sample J712	(1.42)				
ICP.a.Ni Segment Sample	Sample J647	(21.8)	16.0 to 21.8	---	---	
	Sample J649	(18.8)				
	Sample J658	16.0				
	Sample J656	(16.1)				
ICP.a.Ni Core Sample	Sample J666	(25.9)	10.2 to 25.9	23.9	---	
	Sample J667	(25.2)				
	Sample J672	(22.8)		*4.95*		
	Sample J680	10.2				
	Sample J683	36.8				

Table A-1. Tank 241-C-110 Analytical Data: Phosphorus

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.P	Sample J783	(661)	661 to 3,110	---	**2,050**	54.3
	Sample J778	(2,750)				
	Sample J775	(3,110)				
	Sample J800	(1,660)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.P	Sample J691	(17,800)	549 to 17,800	7,660	---	20,800
	Sample J704	(549)				
	Sample J707	(6,190)		*3,000*		
	Sample J711	(5,720)				
	Sample J712	(9,510)				
ICP.a.P Segment Sample	Sample J647	(18,000)	18,000 to 36,000	---	---	
	Sample J649	(18,400)				
	Sample J658	(31,400)				
	Sample J656	(36,000)				
ICP.a.P Core Sample	Sample J666	(21,400)	16,100 to 21,400	18,500	---	
	Sample J667	(21,300)				
	Sample J672	(16,100)		*1,520*		
	Sample J680	(18,500)				
	Sample J683	(17,700)				
ICP.f.P	Sample J715	(21,100)	18,600 to 23,600	20,300	---	
	Sample J716	(23,600)				
	Sample J719	(18,600)		*1,090*		
	Sample J723	(20,300)				
	Sample J724	(19,500)				

Table A-1. Tank 241-C-110 Analytical Data: Potassium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.K	Sample J783	(77.0)	77.0 to 986	---	**436**	11.6
	Sample J778	(391)				
	Sample J775	(986)				
	Sample J800	(290)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.K	Sample J691	(557)	111 to 557	411 *87.7*	---	572
	Sample J704	(111)				
	Sample J707	(375)				
	Sample J711	(510)				
	Sample J712	(538)				
ICP.a.K Segment Sample	Sample J647	(412)	412 to 622	---	---	
	Sample J649	(416)				
	Sample J658	(606)				
	Sample J656	(622)				
ICP.a.K Core Sample	Sample J666	(566)	503 to 624	557 *28.4*	---	
	Sample J667	(563)				
	Sample J672	(503)				
	Sample J680	(581)				
	Sample J683	(624)				

Table A-1. Tank 241-C-110 Analytical Data: Selenium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Se	Sample J783	(4.62)	4.62 to 79.7	---	**32.4**	0.859
	Sample J778	(27.8)				
	Sample J775	(79.7)				
	Sample J800	(17.3)				
TCLP.ICP.Se	Sample J723	(5.35)	N/A		**5.35**	
GHAA.Se	Sample J800	(0.0690)	N/A		**0.0690**	
TCLP.GHAA.Se	Sample J723	< 0.0125	N/A		**< 0.0125**	
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Se	Sample J691	114	18.4 to 114	49.2	---	110
	Sample J704	(26.4)				
	Sample J707	18.4		*17.8*		
	Sample J711	(62.2)				
	Sample J712	(55.8)				
ICP.a.Se	Sample J647	< 7.60	< 7.60 to 76.4	---	---	
Segment Sample	Sample J649	< 7.60				
	Sample J658	(76.4)				
	Sample J656	< 8.30				
ICP.a.Se	Sample J666	28.6	< 7.60 to 112	70.0	---	
Core Sample	Sample J667	26.3				
	Sample J672	(112)		*42.5*		
	Sample J680	< 7.60				
	Sample J683	< 7.60				
ICP.f.Se	Sample J715	(181)	< 41.5 to 181	107	---	
	Sample J716	(147)				
	Sample J719	(50.9)		*80.0*		
	Sample J723	(< 41.5)				
	Sample J724	(< 41.5)				
GHAA.Se	Sample J666	(0.653)	0.609 to 1.71	0.928	---	
	Sample J667	0.756				
	Sample J672	0.609				
	Sample J680	1.22		*0.472*		
	Sample J683	1.71				

Table A-1. Tank 241-C-110 Analytical Data: Silicon

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Si	Sample J783	(10.6)	10.6 to 144	---	**65.5**	1.74
	Sample J778	(74.5)				
	Sample J775	(32.7)				
	Sample J800	(144)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Si	Sample J691	(491)	25.4 to 491	236 *79.7*	---	7,350
	Sample J704	25.4				
	Sample J707	(217)				
	Sample J711	(282)				
	Sample J712	(186)				
ICP.a.Si Segment Sample	Sample J647	(357)	357 to 812	---	---	
	Sample J649	(381)				
	Sample J658	(639)				
	Sample J656	(812)				
ICP.a.Si Core Sample	Sample J666	(907)	340 to 990	726 *185*	---	
	Sample J667	(731)				
	Sample J672	(990)				
	Sample J680	397				
	Sample J683	340				
ICP.f.Si	Sample J715	(7,500)	6,270 to 7,720	7,160 *423*	---	
	Sample J716	(7,380)				
	Sample J719	(7,720)				
	Sample J723	(6,400)				
	Sample J724	(6,270)				

Table A-1. Tank 241-C-110 Analytical Data: Silver

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Ag	Sample J783	(0.500)	0.500 to 1.17	---	**0.798**	0.0211
	Sample J778	(0.510)				
	Sample J775	(1.17)				
	Sample J800	(1.01)				
TCLP.ICP.Ag	Sample J723	< 0.0504	N/A		**< 0.0504**	
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Ag	Sample J691	(1.02)	0.550 to 2.13	1.05	---	1.08
	Sample J704	2.13				
	Sample J707	0.550		*0.516*		
	Sample J711	(1.02)				
	Sample J712	(1.02)				
ICP.a.Ag Segment Sample	Sample J647	(< 0.490)	< 0.476 to < 0.985	---	---	
	Sample J649	(< 0.476)				
	Sample J658	(< 0.951)				
	Sample J656	(< 0.985)				
ICP.a.Ag Core Sample	Sample J666	(0.503)	N/A	0.733	---	
	Sample J667	< 0.500				
	Sample J672	< 1.00		*0.325*		
	Sample J680	(< 0.500)				
	Sample J683	(0.963)				
ICP.f.Ag	Sample J715	(< 5.00)	N/A	---	**< 5.00**	
	Sample J716	(< 5.00)				
	Sample J719	(< 5.00)				
	Sample J723	(< 5.00)				
	Sample J724	(< 5.00)				

Table A-1. Tank 241-C-110 Analytical Data: Sodium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Na	Sample J783	(8,970)	8,970 to 92,600	---	**44,700**	1,190
	Sample J778	(46,900)				
	Sample J775	(92,600)				
	Sample J800	(30,400)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Na	Sample J691	(94,900)	9,740 to 94,900	66,300 *15,600*	---	84,800
	Sample J704	(9,740)				
	Sample J707	(66,700)				
	Sample J711	(77,000)				
	Sample J712	(82,500)				
ICP.a.Na Segment Sample	Sample J647	(79,000)	77,300 to 121,000	---	---	
	Sample J649	(79,500)				
	Sample J658	(77,300)				
	Sample J656	(121,000)				
ICP.a.Na Core Sample	Sample J666	(84,800)	59,700 to 84,800	77,000 *5,640*	---	
	Sample J667	(83,800)				
	Sample J672	(79,900)				
	Sample J680	(74,000)				
	Sample J683	(59,700)				
ICP.f.Na	Sample J715	(80,600)	77,300 to 88,500	82,600 *2,920*	---	
	Sample J716	(85,300)				
	Sample J719	(77,300)				
	Sample J723	(88,500)				
	Sample J724	(86,800)				

Table A-1. Tank 241-C-110 Analytical Data: Strontium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/ml	**μg/mL**	kg
ICP.d.Sr	Sample J783	(0.200)	0.200 to 1.59	---	**0.807**	0.0214
	Sample J778	(1.14)				
	Sample J775	(0.298)				
	Sample J800	(1.59)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Sr	Sample J691	(19.0)	1.58 to 19.0	5.25 *3.58*	---	134
	Sample J704	(17.0)				
	Sample J707	(3.80)				
	Sample J711	(1.59)				
	Sample J712	(1.58)				
ICP.a.Sr Segment Sample	Sample J647	(174)	73.3 to 174	---	---	
	Sample J649	(172)				
	Sample J658	(102)				
	Sample J656	(73.3)				
ICP.a.Sr Core Sample	Sample J666	(150)	80.5 to 152	128 *21.5*	---	
	Sample J667	(152)				
	Sample J672	(149)				
	Sample J680	(80.5)				
	Sample J683	(90.1)				
ICP.f.Sr	Sample J715	(140)	84.3 to 162	131 *22.8*	---	
	Sample J716	(162)				
	Sample J719	(156)				
	Sample J723	(86.8)				
	Sample J724	(84.3)				

Table A-1. Tank 241-C-110 Analytical Data: Sulfur

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.S	Sample J783	(534)	534 to 6,210	---	**2,950**	78.2
	Sample J778	(3,110)				
	Sample J775	(6,210)				
	Sample J800	(1,950)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.S	Sample J691	(4,340)	423 to 4,760	3,650 *858*	---	4,190
	Sample J704	(423)				
	Sample J707	(3,880)				
	Sample J711	(4,760)				
	Sample J712	(4,610)				
ICP.a.S Segment Sample	Sample J647	(4,270)	3,540 to 4,300	---	---	
	Sample J649	(4,300)				
	Sample J658	(3,580)				
	Sample J656	(3,540)				
ICP.a.S Core Sample	Sample J666	(3,610)	3,580 to 4,790	4,080 *345*	---	
	Sample J667	(3,580)				
	Sample J672	(3,900)				
	Sample J680	(4,790)				
	Sample J683	(4,690)				
ICP.f.S	Sample J715	(3,390)	3,310 to 4,820	3,960 *421*	---	
	Sample J716	(3,310)				
	Sample J719	(3,760)				
	Sample J723	(4,820)				
	Sample J724	(4,710)				

Table A-1. Tank 241-C-110 Analytical Data: Tin

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Sn	Sample J783	(1.15)	1.15 to 2.32		**1.45**	0.0384
	Sample J778	(1.17)				
	Sample J775	(1.17)				
	Sample J800	(2.32)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Sn	Sample J691	(2.34)	1.63 to 3.22	2.25 *0.580*	---	13.1
	Sample J704	(3.22)				
	Sample J707	(1.63)				
	Sample J711	(2.34)				
	Sample J712	(2.34)				
ICP.a.Sn Segment Sample	Sample J647	(7.90)	7.90 to 11.3	---	---	
	Sample J649	(9.12)				
	Sample J658	(11.3)				
	Sample J656	(9.26)				
ICP.a.Sn Core Sample	Sample J666	(7.73)	6.72 to 9.37	8.02 *1.17*	---	
	Sample J667	(6.72)				
	Sample J672	(9.37)				
	Sample J680	(6.94)				
	Sample J683	(8.00)				
ICP.f.Sn	Sample J715	(11.5)	11.4 to 18.2	12.8 *2.19*	---	
	Sample J716	(11.4)				
	Sample J719	(11.5)				
	Sample J723	(12.3)				
	Sample J724	(18.2)				

Table A-1. Tank 241-C-110 Analytical Data: Titanium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
ICP.d.Ti	Sample J783	(0.200)	0.200 to 0.404	---	**0.253**	0.00670
	Sample J778	(0.204)				
	Sample J775	(0.204)				
	Sample J800	(0.404)				
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
ICP.w.Ti	Sample J691	(1.15)	0.406 to 1.15	0.631	---	10.8
	Sample J704	(1.01)				
	Sample J707	(0.407)				
	Sample J711	(0.406)		*0.389*		
	Sample J712	(0.407)				
ICP.a.Ti	Sample J647	(4.41)	4.40 to 5.38	---	---	
Segment Sample	Sample J649	(4.40)				
	Sample J658	(5.38)				
	Sample J656	(5.17)				
ICP.a.Ti	Sample J666	(5.46)	4.03 to 5.50	5.09	---	
Core Sample	Sample J667	(5.16)				
	Sample J672	(5.50)		*0.336*		
	Sample J680	(4.03)				
	Sample J683	(4.85)				
ICP.f.Ti	Sample J715	(6.45)	6.45 to 14.3	10.5	---	
	Sample J716	(9.22)				
	Sample J719	(14.3)		*3.37*		
	Sample J723	(6.95)				
	Sample J724	(11.9)				

Table A-1. Tank 241-C-110 Analytical Data: Uranium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
LF.Total U	Sample J800	(322)	N/A	---	**322**	8.53
Metal (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
LF.Total U	Sample J715	(2,020)	1,010 to 2,020	1,480 *274*	---	1,520
	Sample J716	(2,010)				
	Sample J719	(1,390)				
	Sample J723	(1,010)				
	Sample J724	(1,110)				

Table A-1. Tank 241-C-110 Analytical Data: Vanadium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.V	Sample J783	(0.400)	0.400 to 4.02	---	**1.61**	0.0427
	Sample J778	(0.824)				
	Sample J775	(4.02)				
	Sample J800	(1.19)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.V	Sample J691	(1.02)	0.509 to 2.22	1.01	---	6.33
	Sample J704	(2.22)				
	Sample J707	(0.509)		0.563		
	Sample J711	(0.820)				
	Sample J712	(1.00)				
ICP.a.V Segment Sample	Sample J647	(5.26)	4.89 to 6.73	---	---	
	Sample J649	(5.49)				
	Sample J658	(4.89)				
	Sample J656	(6.73)				
ICP.a.V Core Sample	Sample J666	(8.15)	3.96 to 8.53	6.17	---	
	Sample J667	(8.53)				
	Sample J672	(3.96)		*1.26*		
	Sample J680	(5.96)				
	Sample J683	(6.43)				
ICP.f.V	Sample J715	(< 4.00)	< 4.00 to 6.69	6.07	---	
	Sample J716	(5.45)				
	Sample J719	(6.69)		*0.877*		
	Sample J723	(< 4.00)				
	Sample J724	(< 4.00)				

Table A-1. Tank 241-C-110 Analytical Data: Zinc

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
ICP.d.Zn	Sample J783	(1.25)	1.25 to 2.52	---	**1.58**	0.0419
	Sample J778	(1.28)				
	Sample J775	(1.28)				
	Sample J800	(2.52)				
Metal (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
ICP.w.Zn	Sample J691	(31.5)	3.73 to 31.5	11.3 *5.55*	---	230
	Sample J704	(5.03)				
	Sample J707	(11.7)				
	Sample J711	(4.32)				
	Sample J712	(3.73)				
ICP.a.Zn Segment Sample	Sample J647	105	78.9 to 156	---	---	
	Sample J649	145				
	Sample J658	156				
	Sample J656	(78.9)				
ICP.a.Zn Core Sample	Sample J666	(227)	97.0 to 227	139 *41.1*	---	
	Sample J667	(216)				
	Sample J672	(97.6)				
	Sample J680	(101)				
	Sample J683	97.0				
ICP.f.Zn	Sample J715	261	132 to < 261	224 *8.72*	---	
	Sample J716	243				
	Sample J719	(248)				
	Sample J723	(132)				
	Sample J724	(210)				

Table A-1. Tank 241-C-110 Analytical Data: Zirconium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Metal (Liquid)		µg/mL	µg/mL	µg/mL	µg/mL	kg
ICP.d.Zr	Sample J783	(0.425)	0.182 to 0.876	---	**0.575**	0.0152
	Sample J778	(0.818)				
	Sample J775	(0.876)				
	Sample J800	(0.182)				
Metal (Solid)		µg/g	µg/g	µg/g	µg/g	kg
ICP.w.Zr	Sample J691	(40.4)	2.22 to 40.4	11.8	---	177
	Sample J704	(2.22)				
	Sample J707	(8.69)		*7.44*		
	Sample J711	(5.14)				
	Sample J712	(5.76)				
ICP.a.Zr Segment Sample	Sample J647	(32.2)	29.7 to 33.7	---	---	
	Sample J649	(33.7)				
	Sample J658	(30.0)				
	Sample J656	(29.7)				
ICP.a.Zr Core Sample	Sample J666	(46.6)	26.3 to 54.4	41.6	---	
	Sample J667	(41.6)				
	Sample J672	(54.4)		*8.20*		
	Sample J680	(26.3)				
	Sample J683	(26.3)				
ICP.f.Zr	Sample J715	(170)	135 to 199	172	---	
	Sample J716	(178)				
	Sample J719	(199)		*15.7*		
	Sample J723	(153)				
	Sample J724	(135)				

Table A-2. Tank 241-C-110 Analytical Data: Ammonium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Cation (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
Dist/Tit.NH_4^+	Sample J800	(86.4)	N/A	---	**86.4**	2.29
Cation (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
Dist/Tit.NH_4^+	Sample J691	< 4,500	N/A	---	**< 4,500**	< 4,620
	Sample J704	< 4,500				
	Sample J707	< 4,500				
	Sample J711	< 4,500				
	Sample J712	< 4,500				

Table A-2. Tank 241-C-110 Analytical Data: Chloride

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
IC.d.Cl^-	Sample J800	729	365 to 1,910	---	**996**	26.4
	Sample J783	365				
	Sample J778	979				
	Sample J775	1,910				
Anion (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
IC.w.Cl^-	Sample J694	794	698 to 2,020	1,060 *281*		1,090
	Sample J695	698				
	Sample J698	883				
	Sample J702	2,020				
	Sample J703	1,110				

Table A-2. Tank 241-C-110 Analytical Data: Cyanide

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
Spectrophot. CN^-	Sample J799	2.62	N/A	---	**2.62**	0.0694
Anion (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
Spectrophot. CN^-	Sample J674	< 5.00	N/A	---	**< 5.00**	< 5.13
	Sample J678	< 5.00				
	Sample J682	< 5.00				
	Sample J687	< 3.23				
	Sample J688	< 3.23				

Table A-2. Tank 241-C-110 Analytical Data: Fluoride

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
IC.d.F^-	Sample J800	809	214 to 809	---	**516**	13.7
	Sample J783	214				
	Sample J778	(609)				
	Sample J775	431				
Anion (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
IC.w.F^-	Sample J694	8,640	4,600 to 9,260	7,630 *1,020*		7,830
	Sample J695	9,260				
	Sample J698	8,200				
	Sample J702	6,900				
	Sample J703	4,600				

Table A-2. Tank 241-C-110 Analytical Data: Nitrate

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
IC.d.NO_3^-	Sample J800	60,300	21,000 to 182,000	---	**90,800**	2,410
	Sample J783	21,000				
	Sample J788	100,000				
	Sample J775	182,000				
Anion (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
IC.w.NO_3^-	Sample J694	96,400	94,000 to 121,000	110,000 *7,530*		114,000
	Sample J695	94,000				
	Sample J698	116,000				
	Sample J702	121,000				
	Sample J703	118,000				

Table A-2. Tank 241-C-110 Analytical Data: Nitrite

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		μg/mL	μg/mL	μg/mL	**μg/mL**	kg
IC.d.NO_2^-	Sample J800	4,600	1,680 to 18,700	---	**7,850**	208
	Sample J783	1,680				
	Sample J778	6,430				
	Sample J775	18,700				
Anion (Solid)		μg/g	μg/g	μg/g	**μg/g**	kg
IC.w.NO_2^-	Sample J694	2,710	2,710 to 12,900	6,890 *3,040*		7,070
	Sample J695	2,820				
	Sample J698	5,090				
	Sample J702	12,900				
	Sample J703	12,800				

Table A-2. Tank 241-C-110 Analytical Data: Phosphate

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
IC.d.PO_4^{-3}	Sample J800	4,610	2,030 to 7,970	---	**5,530**	147
	Sample J783	2,030				
	Sample J778	7,520				
	Sample J775	7,970				
Anion (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
IC.w.PO_4^{-3}	Sample J694	37,600	15,800 to 37,600	28,100 *7,200*		28,800
	Sample J695	45,400				
	Sample J698	25,500				
	Sample J702	15,800				
	Sample J703	19,200				

Table A-2. Tank 241-C-110 Analytical Data: Sulfate

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Anion (Liquid)		µg/mL	µg/mL	µg/mL	**µg/mL**	kg
IC.d.SO_4^{-2}	Sample J800	7,320	4,810 to 22,000	---	**11,100**	294
	Sample J783	4,810				
	Sample J778	10,200				
	Sample J775	22,000				
Anion (Solid)		µg/g	µg/g	µg/g	**µg/g**	kg
IC.w.SO_4^{-2}	Sample J694	11,100	10,800 to 22,300	14,800 *2,990*		15,200
	Sample J695	10,800				
	Sample J698	12,900				
	Sample J702	19,100				
	Sample J703	22,300				

Table A-3. Tank 241-C-110 Analytical Data: Americium-241

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide (Liquid)		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
GEA.^{241}Am	Sample J783	(< 0.0344)	< 0.0116 to < 0.0516	---	**< 0.0516**	< 1.37
	Sample J778	(< 0.0286)				
	Sample J775	(< 0.0516)				
	Sample J800	< 0.0116				
Alpha Spec. ^{241}Am	Sample J800	(1.57E-05)	N/A	---	---	---
Radionuclide (Solid)		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
GEA.^{241}Am	Sample J715	(< 0.280)	N/A	---	**< 0.280**	< 287
	Sample J716	(< 0.266)				
	Sample J719	< 0.203				
	Sample J723	< 0.220				
	Sample J724	< 0.216				
GEA.^{241}Am Segment Sample	Sample J647	(< 0.260)	N/A	---	---	
	Sample J649	(< 0.250)				
	Sample J658	(< 0.175)				
	Sample J656	(< 0.176)				
Alpha Spec. ^{241}Am	Sample J715	(0.00522)	0.00454 to 0.00522	0.0050	---	
	Sample J716	(0.00454)				
	Sample J719	< 0.00563				
	Sample J723	< 0.00755				
	Sample J724	< 0.00801				

Table A-3. Tank 241-C-110 Analytical Data: Carbon-14

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
LSC.^{14}C (Liquid)	Sample J800	(1.99E-04)	N/A	---	**1.99E-04**	0.00527
Radionuclide		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
LSC.^{14}C (Solid)	Sample J702	(6.02E-04)	< 6.14E-05 to 6.63E-04	4.59E-04 *1.70E-04*	---	0.471
	Sample J694	(2.39E-04)				
	Sample J695	(2.87E-04)				
	Sample J698	(< 6.14E-05)				
	Sample J703	(6.63E-04)				

Table A-3. Tank 241-C-110 Analytical Data: Cesium-137

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide (Liquid)		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
GEA.^{137}Cs	Sample J783	(0.841)	0.841 to 20.3	---	**7.98**	211
	Sample J778	(5.94)				
	Sample J775	(20.3)				
	Sample J800	4.85				
Radionuclide (Solid)		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
GEA.^{137}Cs	Sample J715	(15.3)	14.6 to 24.1	19.5 *2.53*	---	20,000
	Sample J716	(14.6)				
	Sample J719	19.8				
	Sample J723	23.4				
	Sample J724	24.1				
GEA.^{137}Cs Segment Sample	Sample J647	(14.2)	---	---	---	
	Sample J649	(14.1)				
	Sample J658	(21.3)				
	Sample J656	(20.5)				

Table A-3. Tank 241-C-110 Analytical Data: Cobalt-60

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide		μCi/mL	μCi/mL	μCi/mL	**μCi/mL**	Ci
GEA.^{60}Co (Liquid)	Sample J783	(< 0.00720)	< 8.31E-04 to < 0.00720	---	**< 0.00720**	< 0.191
	Sample J778	(< 0.00142)				
	Sample J775	(< 0.00180)				
	Sample J800	< 8.31E-04				
Radionuclide		μCi/g	μCi/g	μCi/g	**μCi/g**	Ci
GEA.^{60}Co (Solid)	Sample J715	(< 0.0310)	< 0.0276 to < 0.0433	---	**< 0.0433**	< 44.5
	Sample J716	(< 0.0276)				
	Sample J719	< 0.0416				
	Sample J723	< 0.0433				
	Sample J724	< 0.0415				
GEA.^{60}Co Segment Sample	Sample J647	(< 0.0300)	< 0.00760 to < 0.0300	---	---	
	Sample J649	(< 0.0200)				
	Sample J658	(< 0.00760)				
	Sample J656	(< 0.0100)				

Table A-3. Tank 241-C-110 Analytical Data: Europium-154

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/ml	Ci
GEA.^{154}Eu (Liquid)	Sample J783	(< 0.0192)	< 0.00229 to < 0.0192	---	**< 0.0192**	< 0.509
	Sample J778	(< 0.00551)				
	Sample J775	(< 0.00607)				
	Sample J800	(< 0.00229)				
Radionuclide		µCi/g	µCi/g	µCi/g	µCi/g	Ci
GEA.^{154}Eu (Solid)	Sample J715	(< 0.0678)	< 0.00678 to < 0.120	---	**< 0.120**	< 123
	Sample J716	(< 0.0720)				
	Sample J719	< 0.113				
	Sample J723	< 0.119				
	Sample J724	< 0.120				
GEA.^{154}Eu Segment Sample	Sample J647	(< 0.0900)	---	---	---	
	Sample J649	(< 0.0700)				
	Sample J658	(< 0.0290)				
	Sample J656	(< 0.0350)				

Table A-3. Tank 241-C-110 Analytical Data: Europium-155

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide		μCi/mL	μCi/mL	μCi/mL	**μCi/ml**	Ci
GEA.^{155}Eu (Liquid)	Sample J783	(< 0.0146)	< 0.00576 to < 0.0216	--	**< 0.0216**	< 0.572
	Sample J778	(< 0.0118)				
	Sample J775	(< 0.0216)				
	Sample J800	< 0.00576				
Radionuclide		μCi/g	μCi/g	μCi/g	**μCi/g**	Ci
GEA.^{155}Eu (Solid)	Sample J715	(< 0.122)	< 0.103 to < 0.122	---	**< 0.122**	< 125
	Sample J716	(< 0.122)				
	Sample J719	< 0.103				
	Sample J723	< 0.108				
	Sample J724	< 0.109				
GEA.^{155}Eu Segment Sample	Sample J647	(< 0.120)	< 0.0780 to < 0.120	---	---	
	Sample J649	(< 0.110)				
	Sample J658	(< 0.0780)				
	Sample J656	(< 0.0800)				

Table A-3. Tank 241-C-110 Analytical Data: Iodine-129

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide (Liquid)		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
Low Energy Gamma.^{129}I	Sample J800	(< 2.38E-05)	N/A	---	**< 2.38E-05**	< 0.0211
Radionuclide (Soild)		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
GEA.^{129}I	Sample J715	(< 0.0154)	N/A	---	**< 0.0250**	< 25.7
	Sample J716	(< 0.0186)				
	Sample J719	(< 0.0191)				
	Sample J723	(< 0.0130)				
	Sample J724	(< 0.0250)				

Table A-3. Tank 241-C-110 Analytical Data: Neptunium-237

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide (Liquid)		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
APC.^{237}Np	Sample J800	(< 6.49E-05)	N/A	---	**< 6.49E-05**	0.0574
Radionuclide (Solid)		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
	Sample J715	(< 0.0324)	< 0.0323 to < 0.0541	---	**< 0.0541**	< 55.6
	Sample J716	(< 0.0323)				
	Sample J719	(< 0.0541)				
	Sample J723	(< 0.0323)				
	Sample J724	(< 0.0324)				

Table A-3. Tank 241-C-110 Analytical Data: Plutonium-238

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
GEA.^{238}Pu (Liquid)	Sample J800	(< 9.00E-06)	N/A	---	**< 9.00E-06**	< 1.59E-04
Radionuclide		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
GEA.^{238}Pu (Solid)	Sample J715	< 0.00450	N/A	---	**< 0.00498**	< 51.1
	Sample J716	(< 0.00448)				
	Sample J719	(< 0.00225)				
	Sample J723	(< 0.00498)				
	Sample J724	(< 0.00450)				

Table A-3. Tank 241-C-110 Analytical Data: Plutonium-239/240

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
Alpha Spec. $^{239/240}Pu$ (Liquid)	Sample J800	(0.00176)	N/A	---	**0.00176**	0.0466
Radionuclide		µCi/g	µCi/g	µCi/g	µCi/g	Ci
Alpha Spec. $^{239/240}Pu$ (Solid)	Sample J715	(0.00450)	0.00450 to 0.144	0.0802 *0.0178*	---	82.4
	Sample J716	(0.0634)				
	Sample J719	(0.0825)				
	Sample J723	(0.144)				
	Sample J724	(0.0531)				

Table A-3. Tank 241-C-110 Analytical Data: Strontium-90

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
BPC.^{90}Sr (Liquid)	Sample J800	(0.0278)	N/A	---	**0.0278**	0.737
Radionuclide		µCi/g	µCi/g	µCi/g	µCi/g	Ci
BPC.^{90}Sr (Solid)	Sample J715	(7.17)	3.61 to 7.17	5.00 *1.76*	---	5,140
	Sample J716	(6.38)				
	Sample J719	(4.32)				
	Sample J723	(3.61)				
	Sample J724	(3.75)				

Table A-3. Tank 241-C-110 Analytical Data: Selenium-79

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide		μCi/mL	μCi/mL	μCi/mL	**μCi/mL**	Ci
LSC.^{79}Se (Liquid)	Sample J800	(6.17E-05)	N/A	---	**6.17E-05**	0.00163
Radionuclide		μCi/g	μCi/g	μCi/g	**μCi/g**	Ci
LSC.^{79}Se (Solid)	Sample J715	(2.72E-04)	N/A	0.00130	---	1.34
	Sample J716	(2.88E-04)				
	Sample J719	(0.00368)		*0.00169*		
	Sample J723	(< 0.00259)				
	Sample J724	(< 0.00250)				

Table A-3. Tank 241-C-110 Analytical Data: Technicium-99

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide (Liquid)		μCi/mL	μCi/mL	μCi/mL	**μCi/mL**	Ci
LSC.^{99}Tc	Sample J800	(0.0162)	N/A	---	**0.0162**	0.429
Radionuclide (Solid)		μCi/g	μCi/g	μCi/g	**μCi/g**	Ci
LSC.^{99}Tc	Sample J715	(0.0463)	0.0198 to 0.0463	0.0328	---	33.7
	Sample J716	(0.0394)				
	Sample J719	(0.0198)		*0.0118*		
	Sample J723	(0.0353)				
	Sample J724	(0.0362)				

Table A-3. Tank 241-C-110 Analytical Data: Tritium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
LSC.^{3}H (Liquid)	Sample J800	(7.18E-04)	N/A	---	**7.18E-04**	0.0190
Radionuclide		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
LSC.^{3}H (Solid)	Sample J694	(8.20E-04)	8.20E-04 to 0.00164	0.00118 *2.01E-04*	---	1.21
	Sample J695	(9.07E-04)				
	Sample J698	(0.00115)				
	Sample J702	(0.00145)				
	Sample J703	(0.00164)				

Table A-3. Tank 241-C-110 Analytical Data: Uranium-238

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Radionuclide (Liquid)		µCi/mL	µCi/gmL	µCi/mL	**µCi/mL**	Ci
LF.^{238}U	Sample J800	2.59E-06	N/A	---	**2.59E-06**	6.86E-05
Radionuclide (Solid)		µCi/g	µCi/g	µCI/g	**µCi/g**	Ci
LF.^{238}U	Sample J800	2.59E-06	3.37E-04 to 6.71E-04	4.95E-04 *1.06E-04*	---	0.508
	Sample J715	6.71E-04				
	Sample J716	6.67E-04				
	Sample J719	4.63E-04				
	Sample J723	3.37E-04				
	Sample J724	3.70E-04				

Table A-3. Tank 241-C-110 Analytical Data: Total Alpha

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
APC.Total Alpha (Liquid)	Sample J775	0.00436	< 3.69E-07 to 0.00436	---	**7.02E-04**	0.186
	Sample J761	(< 3.69E-07)				
	Sample J800	0.00207				
	Sample J783	< 7.34E-04				
	Sample J778	< 0.02E-04				
Radionuclide		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
APC.Total Alpha (Solid)	Sample J715	0.136	0.00436 to 0.140	0.125 *0.00744*	---	128
	Sample J716	0.140				
	Sample J719	0.126				
	Sample J723	0.113				
	Sample J724	0.113				
Total Alpha Homogenized Sample	Sample J647	0.132	0.111 to 0.133	---	---	
	Sample J649	0.133				
	Sample J658	0.120				
	Sample J656	0.111				

Table A-3. Tank 241-C-110 Analytical Data: Total Beta

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	**µCi/mL**	Ci
BPC.Total Beta (Liquid)	Sample J761	3.93E-04	3.93E-04 to 8.15	---	**3.76**	99.6
	Sample J800	5.68				
	Sample J783	1.20				
	Sample J775	27.6				
	Sample J778	8.15				
Radionuclide		µCi/g	µCi/g	µCi/g	**µCi/g**	Ci
BPC.Total Beta (Solid)	Sample J715	41.6	27.6 to 45.8	42.4 *1.69*	---	43,500
	Sample J716	40.1				
	Sample J719	40.9				
	Sample J723	(45.7)				
	Sample J724	(45.8)				

Table A-4. Tank 241-C-110 Analytical Data: Percent Water

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Physical Propeties		%	%	%	%	
% Water Core Sample	Sample J786	57.88	57.88 to 63.50	59.8	---	---
	Sample J789	61.7)				
	Sample J791	61.8		*2.77*		
% Water Segment Sample	Sample J583	60.4	---	---	---	
	Sample J587	58.6				
	Sample J614	61.15				
	Sample J620	63.50				
	Sample J625	59.25				
	Sample J627	60.6				
	Sample J629	60.4				

Table A-4. Tank 241-C-110 Analytical Data: pH

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Physical Propeties						
pH	Sample J800	10.43	10.43	---	---	---
	Sample J694	11.04	10.78 to 11.31	11.0	---	
	Sample J695	11.31				
	Sample J698	10.78		*0.104*		
	Sample J702	10.88				
	Sample J703	11.12				

Table A-4. Tank 241-C-110 Analytical Data: Total Inorganic Carbon

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Physical Propeties		µg/mL	µg/mL	µg/mL	µg/mL	kg
TIC (Liquid)	Sample J800	(< 543)	N/A	---	< 543	1,440
TIC	Sample J694	(2,990)	1,590 to 2,990	2,030	---	
	Sample J695	(1,590)				
Core Sample	Sample J698	1,660		*327*		
	Sample J702	1,710				
	Sample J703	(2,540)				

Table A-4. Tank 241-C-110 Analytical Data: Total Organic Carbon

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
Physical Propeties		µg/mL	µg/mL	µg/mL	µg/mL	kg
TOC (Liquid)	Sample J800	(580)	410 to 580		592	15.7
	Sample J783	410				
	Sample J778	603				
	Sample J775	775				
Physical Properties		µg/g	µg/g		µg/g	Kg
TOC (Solid)	Sample J694	(< 1,050)	< 500 to 1,090	802	---	823
	Sample J695	1,090				
	Sample J698	< 500		*407*		
	Sample J702	514				
	Sample J703	< 500				

Table A-4. Tank 241-C-110 Analytical Data: Thermogravimetric Analysis

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Physical Propeties		%	%	%	%	
TGA	Sample J634	58.7	52.0 to 62.0	57.5	---	
	Sample J635	54.1				
	Sample J636	62.0		*2.07*		
	Sample J639	56.3				
	Sample J640	52.0				
Physical Properties		%	%	%	%	
TGA	Sample J591	50.6	50.1 to 54.2	---	---	
	Sample J593	54.2				
	Sample J596	53.8				
	Sample J598	50.1				
	Sample J599	53.2				

Table A-4. Tank 241-C-110 Analytical Data: Specific Gravity

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
Physical Propeties						kg
SpG	Sample J783	1.00	1.00 to 1.18	---	**1.09**	---
	Sample J778	1.10				
	Sample J635	1.18				

Table A-5. Tank 241-C-110 Analytical Data: Volatile Organics

Analyte	Result ug/L	Analyte	Result ug/L
Chloromethane	ND	1,2-Dichloropropane	ND
Bromomethane	ND	Tetrachloroethene	ND
Vinyl Chloride	ND	Trichloroethene	ND
Chloroethane	ND	Dibromochloromethane	ND
Methylene Chloride	ND	1,1,2-Trichloroethane	ND
Acetone	ND	Benzene	ND
Carbon Disulfide	ND	2-Hexanone	ND
1,1-Dichloroethene	ND	Bromoform	ND
1,1-Dichloroethane	ND	4-Methyl-2-Pentanone	ND
trans-1,2-Dichloroethene	ND	trans-1,3-Dichloropropene	ND
cis-1,2-Dichloroethene	ND	cis-1,3-Dichloropropene	ND
Chloroform	ND	1,1,2,2-Tetrachloroethane	ND
1,2-Dichloroethane	ND	Toluene	ND
2-Butanone	ND	Chlorobenzene	ND
1,1,1-Trichloroethane	ND	Ethylbenzene	ND
Carbon Tetrachloride	ND	Styrene	ND
Vinyl Acetate	ND	Xylene (total)	ND
Bromodichloromethane	ND		

Table A-5. Tank 241-C-110 Analytical Data: Decane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
VOA		μg/kg	μg/kg	μg/kg	**μg/kg**	kg
GC/MS.Decane	Sample J742	(4,850)	2,050 to 5,600	3,470 *988*	---	3.57
	Sample J745	(3,600)				
	Sample J747	(2,350)				
	Sample J748	(5,600)				
	Sample J749	(2,050)				

Table A-5. Tank 241-C-110 Analytical Data: Undecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
VOA		μg/kg	μg/kg	μg/kg	**μg/kg**	kg
GC/MS. Undecane	Sample J742	(4,900)	2,650 to 5,050	3,540 *773*	---	3.65
	Sample J745	(3,150)				
	Sample J747	(2,650)				
	Sample J748	(5,050)				
	Sample J749	(2,850)				

Table A-5. Tank 241-C-110 Analytical Data: Dodecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
VOA		µg/kg	µg/kg	µg/kg	µg/kg	kg
GC/MS. Dodecane	Sample J742	(44,500)	26,500 to 44,500	33,800 *6,430*	---	3.48
	Sample J745	(33,000)				
	Sample J747	(26,500)				
	Sample J748	(34,500)				
	Sample J749	(37,500)				

Table A-5. Tank 241-C-110 Analytical Data: Tridecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
VOA		µg/kg	µg/kg	µg/kg	µg/kg	kg
GC/MS. Tridecane	Sample J742	(19,000)	10,400 to 19,000	15,300 *4,270*	---	15.8
	Sample J745	(15,500)				
	Sample J747	(10,400)				
	Sample J748	(17,500)				
	Sample J749	(19,000)				

Table A-5. Tank 241-C-110 Analytical Data: Tetradecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
VOA		µg/kg	µg/kg	µg/kg	µg/kg	kg
GC/MS. Tetradecane	Sample J742	(3,750)	2,050 to 4,650	3,080 *1,010*	---	3.17
	Sample J745	(2,500)				
	Sample J747	(2,050)				
	Sample J748	(4,650)				
	Sample J749	(3,500)				

Table A-6. Tank 241-C-110 Analytical Data: Semivolatile Organic

Analyte	Result ug/L	Analyte	Result ug/L
Phenol	ND	3-Nitroaniline	ND
bis(2-Chloroethyl)ether	ND	Acenaphthene	ND
2-Chlorophenol	ND	2,4-Dinitrophenol	ND
1,3-Dichlorobenzene	ND	4-Nitrophenol	ND
1,4-Dichlorobenzene	ND	Dibenzofuran	ND
Benzyl alcohol	ND	2,4-Dinitrotoluene	ND
1,2-Dichlorobenzene	ND	Diethylphthalate	ND
2-Methylphenol	ND	Fluorene	ND
bis(2-Chloroisopropyl)ether	ND	4-Chlorophenyl-phenylether	ND
4-Methylphenol	ND	4-Nitroaniline	ND
N-Nitroso-di-n-propylamine	ND	4,6-Dinitro-2-methylphenol	ND
Hexachloroethane	ND	4-Bromophenyl-phenylether	ND
Nitrobenzene	ND	N-Nitrosodiphenylamine (1)	ND
Isophorone	ND	Hexachlorobenzene	ND
2-Nitrophenol	ND	Dibenz(a,h)anthracene	ND
2,4-Dimethylphenol	ND	Benzo(g,h,i)perylene	ND
Benzoic acid	ND	Pentachlorophenol	ND
bis(2-Chloroethoxy)methane	ND	Phenanthrene	ND
2,4-Dichlorophenol	ND	Anthracene	ND
1,2,4-Trichlorobenzene	ND	Di-n-butylphthalate	ND
Naphthalene	ND	Fluoranthene	ND
4-Chloroaniline	ND	Pyrene	ND
Hexachlorobutadiene	ND	Butylbenzylphthalate	ND
4-Chloro-3-methylphenol	ND	3,3'-Dichlorobenzidine	ND
2-Methylnaphthalene	ND	Benzo(a)anthracene	ND
Hexachlorocyclopentadiene	ND	Chrysene	ND
2,4,6-Trichlorophenol	ND	bis-(2-Ethylexyl)phthalate	ND
2,4,5-Trichlorophenol	ND	Di-n-octylphthalate	ND
2-Chloronaphthalene	ND	Benzo(b)fluoranthene	ND
2-Nitroaniline	ND	Benzo(k)fluoranthene	ND
Dimethylphthalate	ND	Benzo(a)pyrene	ND
Acenaphthalate	ND	Indeno(1,2,3-cd)pyrene	ND
2,6-Dinitrotoluene	ND		

Table A-6. Tank 241-C-110 Analytical Data: Decane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
SVOA		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS.Decane	Sample 92-08309	(8,700)	8,600 to 8,700	8,650	---	8.91
	Sample 92-08311	(8,600)		*70.7*		

Table A-6. Tank 241-C-110 Analytical Data: Undecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
SVOA		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS. Undecane	Sample 92-08307	(19,000)	15,000 to 19,000	17,800	---	18.3
	Sample 92-08309	(15,000)				
	Sample 92-08311	(18,000)		*1,770*		

Table A-6. Tank 241-C-110 Analytical Data: Dodecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weight Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
SVOA		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS. Dodecane	Sample 92-08307	(8.60E+05)	6.40E+05 to 8.60E+05	7.69E+05	---	792
	Sample 92-08309	(6.40E+05)				
	Sample 92-08311	(7.15E+05)		*1.29E+05*		

Table A-6. Tank 241-C-110 Analytical Data: Tridecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
SVOA (Liquid)		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS. Tridecane	Sample 92-09437	(9,500)	N/A	—	**9,500**	0.275
SVOA (Solid)		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS. Tridecane	Sample 92-08303	(8,400)	8,400 to 1.95E+06	1.15E+06 *1.01E+06*	—	1,180
	Sample 92-08305	(9,350)				
	Sample 92-08307	(1.95E+06)				
	Sample 92-08309	(1.40E+06)				
	Sample 92-08311	(1.55E+06)				

Table A-6. Tank 241-C-110 Analytical Data: Tetradecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	**Evaluated Data Result**	Projected Inventory
SVOA (Liquid)		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS. Tetradecane	Sample 92-09437	(11,000)	N/A	—	**11,000**	0.318
SVOA (Solid)		µg/kg	µg/kg	µg/kg	**µg/kg**	kg
GC/MS. Tetradecane	Sample 92-08305	(9,000)	9,000 to 1.45E+06	7.28E+05 *6.23E+05*	—	750
	Sample 92-08307	(1.45E+06)				
	Sample 92-08309	(1.04E+06)				
	Sample 92-08311	(1.15E+06)				

Table A-6. Tank 241-C-110 Analytical Data: Pentadecane

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
SVOA		µg/kg	µg/kg	µg/kg	µg/kg	kg
GC/MS. Pentadecane	Sample 92-08307	(62,500)	47,500 to 62,500	51,500 *5,660*	---	53.0
	Sample 92-08309	(47,500)				
	Sample 92-08311	(55,500)				

Table A-6. Tank 241-C-110 Analytical Data: Phosphoric acid tributyl ester

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Weighted Mean/ *Standard Error*	Evaluated Data Result	Projected Inventory
SVOA		µg/kg	µg/kg	µg/kg	µg/kg	kg
GC/MS. Phosphoric acid tributyl ester	Sample 92-08303	(8,100)	8,100 to 39,500	14,400 *8,260*	---	14.8
	Sample 92-08305	(39,500)				
	Sample 92-08307	(8,350)				
	Sample 92-08309	(12,000)				
	Sample 92-08311	(10,000)				

APPENDIX B

HISTORICAL INVENTORY ESTIMATES COMPARISON

B.1 TRAC Model Estimates

The Track Radioactive Constituents (TRAC) computer program was developed to estimate the composition of the wastes in single-shell tanks (SSTs). The TRAC program estimates waste inventories based on nuclear fuels production models, reprocessing and waste management flowsheets, tank transfers, and radioactive decay calculations. The output consists of the approximate inventories of 65 radionuclides and 30 nonradioactive chemical constituents in each of the 149 SSTs. Validation of the codes used in the TRAC Model has not been performed. For this reason, the conclusions and model outputs should be regarded as approximations at best, and only used for informational purposes. A detailed description of the TRAC system can be found in *TRAC: Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980* (Jungfleisch, 1984).

The TRAC Model estimates for Tank 241-C-110 are presented in Table B-1. Although TRAC includes the concentrations of almost 100 waste constituents, Table B-1 contains only those radionuclides for which analyses are performed regularly or those with an activity greater than 1.0 μCi/L. The TRAC estimates are for 1980; the shorter lived radionuclides will have decayed significantly, if not completely, from the TRAC estimates; the volume of waste in the tank has also changed. In the absence of more conclusive or higher quality data, the results and estimates of the TRAC model are used as a preliminary approximation for expected tank contents and inventory.

Table B-1. TRAC Model Estimates (Jungfleisch, 1984).
TRAC Waste Volume (Total): 211,000 gallons
Estimated Waste Density: 1.8 g/L

Element/ Isotope	Inventory		Concentration		
	Moles	Curies	g/L	μCi/L	ppm
Am-241	2.0E-02	2.0E+01		2.50E+01	
Cs-137	1.0E-10	2.0E-06		2.50E-06	
Pu-238	3.0E-03	1.0E+01		1.25E+01	
Pu-239	8.0E+00	1.0E+02		1.25E+02	
Pu-240	5.0E-01	3.0E+01		3.75E+01	
Pu-241	1.0E-02	3.0E+02		3.75E+02	
Sm-151	9.0E-02	3.0E+02		3.75E+02	
Sr-90	1.0E+00	1.0E+04		1.25E+04	
Tc-99	2.0E-10	3.0E-10		3.75E-10	
U-233	8.0E-09	2.0E-08		2.50E-08	
U-234	4.0E-04	5.0E-04		6.26E-04	
U-235	1.0E+01	6.0E-03		7.51E-03	
U-238	2.0E+03	1.0E-01		1.25E-01	

Table B-1. TRAC Model Estimates (Jungfleisch, 1984).
TRAC Waste Volume (Total): 211,000 gallons
Estimated Waste Density: 1.8 g/L

Element/ Isotope	Inventory		Concentration		
	Moles	Curies	g/L	μCi/L	ppm
Y-90	3.0E-04	2.0E+04		2.50E+04	
Zr-93	3.0E+00	8.0E-01		1.00E+00	
Ag	3.0E-17		4.05E-21		2.25E-18
Al	8.0E+02		2.70E-02		1.50E+01
Ba	6.0E-01		1.03E-04		2.72E-02
Bi	7.0E+04		1.83E+01		1.02E+04
$C_2H_3O_3$	0.0E+00		0.00E+00		0.00E+00
$C_6H_5O_7$	0.0E+00		0.00E+00		0.00E+00
CO_3	4.0E-05		3.00E-09		1.67E-06
Ca	4.0E-14		2.01E-18		1.17E-15
Ce	1.0E-08		1.75E-12		9.72E-10
Cl	1.0E-14		4.44E-19		2.47E-16
Cr	1.0E+04		6.51E-01		3.62E+02
EDTA	0.0E+00		0.00E+00		0.00E+00
F	4.0E-05		9.51E-10		5.28E-07
Fe	2.0E+05		1.40E+01		7.78E+03
$Fe(CN)_6$	1.0E-08		2.65E-12		1.47E-09
HEDTA	0.0E+00		0.00E+00		0.00E+00
K	2.0E-08		9.79E-13		5.44E-10
La	0.0E+00		0.00E+00		0.00E+00
Mn	0.0E+00		0.00E+00		0.00E+00
NO_2	1.0E-05		5.76E-10		3.20E-07
NO_3	2.0E-04		1.55E-08		8.61E-06
Na	8.0E+01		2.30E-03		1.28E+00
Ni	2.0E-11		1.47E-15		8.17E-13
OH	6.0E+05		1.28E+01		7.11E+03
PO_4	7.0E+04		8.32E+00		4.62E+03
Pb	3.0E-11		7.78E-15		4.32E-12

Table B-1. TRAC Model Estimates (Jungfleisch, 1984).
TRAC Waste Volume (Total): 211,000 gallons
Estimated Waste Density: 1.8 g/L

Element/ Isotope	Inventory		Concentration		
	Moles	Curies	g/L	µCi/L	ppm
Pu	8.0E+00		2.39E-03		1.33E+00
SiO_3	1.0E-06		9.52E-11		5.29E-08
SO_4	6.0E-01		7.22E-05		4.01E-02
Sr	8.0E-08		8.77E-12		4.87E-09
U (total)	2.0E+03		5.96E-01		3.31E+02
ZrO	2.0E+04		2.68E+00		1.49E+03

B-2. Previous Sampling Results

The contents of Tank 241-C-110 have been sampled in the past to support different characterization needs. The resulting analytical results are summarized in Table B-2. Two of the samples analyzed were tank liquids; the third sample was from the tank sludge. The level of validation, if any, that these results have received is not known, so this data is presented for informational purposes only.

Liquid samples, T-5491 (from 1975) and R8087 (from 1990), contain high concentrations of the soluble waste constituents. Both liquid samples were between 75% and 85% water, which indicated that quantities of suspended solids were also analyzed. As is to be expected from the liquid samples, R8087 contained substantial amounts of the soluble anions, including nitrates, nitrites, phosphates, sulfates, and carbonates. The majority of the activity from both liquid samples came from ^{137}Cs.

Tank sludge sample #9501, collected in 1977, was primarily analyzed for metals. The predominant constituent from these analyses was aluminum; silicon and iron were also represented. According to these results, plutonium is present in Tank 241-C-110 waste at a level of approximately five to 10 parts per million (ppm), and uranium is present at approximately 1 ppm.

Table B-2. Analytical Results of Single-Shell Tank 241-C-110 Samples. (2 pages)

Sample Number	T-5491	9501 - JS-17	R8087
Sample Information Source	Wheeler, 1975	Starr, 1977	Edrington, 1991
Sampling Date	June 19, 1975	August 31, 1977	November 1990
Type of Sample	Liquid	Sludge	Supernatant
Sample Preparation	N/A	KOH Fusion	N/A
ANALYSIS	**SAMPLE RESULTS**		
% Water	83.36%		75%
pH	11.8		10.2
Specific Gravity	1.134		1.20
Total Organic Carbon			0.632 g/L
D.T.A	No exotherm below 200oC		
ANIONS			
OH-	0.831 mol/L		0.489 mol/L
NO_2	32,700 p[pm	NR	22,620 ppm
NO_3	29,600 ppm	NR	135,400 ppm
CO_3			0.252 mol/L
SO_4		NR	20,960 ppm
PO_4		NR	8,822 ppm
CATIONS*			
Ag			6 ppm
Al	911 ppm	164,000 ppm	36 ppm
As			0.4 ppm
B			21 ppm
Ba		800 ppm	
Bi			21 ppm
Ca		2,000 ppm	2 ppm
Cd		<260 ppm	
Ce			35 ppm
Cr		867 ppm	369 ppm
Fe		21,000 ppm	3 ppm

Table B-2. Analytical Results of Single-Shell Tank 241-C-110 Samples. (2 pages)

CATIONS* (cont.)			
Hg		14,000 ppm	0.875 ppm
K			1,140 ppm
Mg		810 ppm	2 ppm
Mn		610 ppm	0.4 ppm
Mo			25 ppm
Na			83,900 ppm
Ni		2,000 ppm	
Se			0.2 ppm
Si		15,000 ppm	30 ppm
Sr			1 ppm
Zr			6 ppm
Pu		0.69 ppm	
U		0.075 ppm	
RADIOCHEMISTRY			
Total Alpha		NR	55.6 µCi/L
Total Beta			35,550 µCi/L
GEA Cs-134 Cs-137	 14.99 µCi/L 84,500 µCi/L	 140,000 µCi/L	 24,300 µCi/L
Sr-89/90	8.7 µCi/L	49,000 µCi/L	8.38 µCi/L
Tc-99			70.13 µCi/L
Pu 239/240			44 µCi/L
Am-241			ND

* Sludge density of 1.8 g/ml used to maintain consistency with TRAC Model (Jungfleish, 1984)
N/A Not Applicable or Not Available
ppm parts per million
NR Not Reliable
GEA Gamma Energy Analysis
ND Not Detected

APPENDIX C

THE ANOVA MODEL
(Remund and Jensen, 1984)

C.1 The ANOVA Model (Remund and Jensen, 1984)

This appendix contains a description of the statistical model that describes the structure of the data from supernate samples taken from Tank 241-102-AP. Equations are also presented for estimates of the mean concentration, the variance for the mean concentration, and the confidence intervals on the mean concentration.

The statistical model that describes the structure of the data is

$$y_{ijk} = \mu + L_i + B_{ij} + A_{ijk}, \; i=1,\ldots a, \; j=1,\ldots b_i, \; k=1,\ldots n_{ij}, \qquad (1)$$

where

y_{ijk} = laboratory results from the k^{th} duplicate of the j^{th} bottle of the i^{th} location in the tank,

μ = the grand mean of all the data,

L_i = the effect of the i^{th} location (measuring spatial variability),

B_{ij} = the effect of the j^{th} bottle at the i^{th} location (measuring local sampling variability), and

A_{ijk} = the analytical error associated with the k^{th} duplicate in the j^{th} bottle in the i^{th} location.

For the inorganic and radiological analytes, there are generally only three tank locations that have duplicate bottles and all others locations have one bottle (i.e., b_i = 1 or 2). Reruns of the samples and duplicates (within each bottle) were obtained for some of the locations (i.e., n_{ij} = 2, 4 or 6).

L_i and B_{ij} are treated as random effects. It is assumed that L_i, B_{ij} and A_{ijk} are each distributed normally with mean zero and a variances σ_L^2, σ_B^2, and σ_A^2, respectively. Estimates of σ_L^2, σ_B^2, and σ_A^2 were obtained using Restricted Maximum Likelihood Estimation (REML). This method applied to variance component estimation is described by Harville (1977).

The mean concentration of each analyte of interest in the tank was calculated using the following equation:

$$\bar{y}_T = \frac{\sum_{i=1}^{a} \bar{y}_{i..}}{a} = \frac{\sum_{i=1}^{a} \frac{\sum_{j=1}^{b_i}\sum_{k=1}^{n_{ij}} y_{ijk}}{\sum_{j=1}^{b_i} n_{ij}}}{a} = \frac{\sum_{i=1}^{a} \frac{\sum_{j=1}^{b_i}\sum_{k=1}^{n_{ij}} (\mu + L_i + B_{ij} + A_{ijk})}{\sum_{j=1}^{b_i} n_{ij}}}{a}. \qquad (2)$$

The ANOVA Model (con't)

The variance of $\bar{y}_T$ is

$$V(\bar{y}_T) = C_1\sigma_L^2 + C_2\sigma_B^2 + C_3\sigma_A^2 \tag{3}$$

where

$$C_1 = \frac{1}{a}, \quad C_2 = \sum_{i=1}^{a} \frac{\left[\dfrac{\sum_{j=1}^{b_i} n_{ij}^2}{\left[\sum_{j=1}^{b_i} n_{ij}\right]^2}\right]}{a^2}, \quad C_3 = \sum_{i=1}^{a} \frac{\left[\dfrac{\sum_{j=1}^{b_i} n_{ij}}{\left[\sum_{j=1}^{b_i} n_{ij}\right]^2}\right]}{a^2} \tag{4}$$

Using $\hat{\sigma}_L^2$, $\hat{\sigma}_B^2$, and $\hat{\sigma}_A^2$ (REML variance component estimates), an estimated variance of $\bar{y}_T$ is

$$\hat{\sigma}^2(\bar{y}_T) = C_1\hat{\sigma}_L^2 + C_2\hat{\sigma}_B^2 + C_3\hat{\sigma}_A^2. \tag{5}$$

The approximate degrees of freedom used for $\hat{\sigma}^2(\bar{y}_T)$ is the number of locations sampled minus one (which varies for each analyte).

A 95% two-sided confidence interval on the mean concentration ($\bar{y}_T$) for a given analyte is

$$\bar{y}_T \pm t_{.975}\sqrt{\hat{\sigma}^2(\bar{y}_T)} \tag{6}$$

where $t_{.975}$ is the .975 quantile from a Student's t-distribution with the approximate degrees of freedom associated with $\hat{\sigma}^2(\bar{y}_T)$.

A 95% upper-tailed confidence interval on $\bar{y}_T$ is

$$\bar{y}_T + t_{.95}\sqrt{\hat{\sigma}^2(\bar{y}_T)} \tag{7}$$

where $t_{.95}$ is the .95 quantile from a Student's t-distribution with the approximate degrees of freedom associated with $\hat{\sigma}^2(\bar{y}_T)$.