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0038363

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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 608043

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 Double-Shell Tank 241-AP-102. 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:		12. Major Assm. Dwg. No.: NA
		13. Permit/Permit Application No.: NA
		14. Required Response Date: Aug. 31, 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-358		0	Tank Characterization Report for Double Shell Tank 241-AP-102	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 4. Review 2. Release 5. Post-Review 3. Information 6. Dist. (Receipt Acknow. Required)	1. Approved 4. Reviewed no/comment 2. Approved w/comment 5. Reviewed w/comment 3. Disapproved w/comment 6. Receipt acknowledged

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

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
2	1	Cog.Eng. B.C. Simpson	BC Simpson	8/11/94	R2-12	T. L. Welsh	TL Welsh	8/11/94	T6-07	2	1
2	1	Cog. Mgr. C. S. Haller	CS Haller	8/11/94							
		QA NA									
		Safety NA									
		Env. NA									
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18.	19.	20.	21. DOE APPROVAL (if required)
B. C. Simpson BC Simpson Signature of EDT Originator 8/11/94 Date	Authorized Representative for Receiving Organization Date	C. S. Haller CS Haller 8/11/94 Cognizant Manager Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (04/94) GEF097

SEP 1994 RECEIVED EDMC

BD-7400-172-1 (07/91)

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RELEASE AUTHORIZATION

Document Number:	WHC-SD-WM-ER-358 REVISION 0
Document Title:	Tank Characterization Report for Double-Shell Tank 241-AP-102
Release Date:	9/6/94

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SUPPORTING DOCUMENT

1. Total Pages ~~415~~ 109

2. Title	3. Number	4. Rev No.
Tank Characterization Report for Double-Shell Tank 241-AP-102	WHC-SD-WM-ER-358	0

5. Key Words

Waste Characterization; Double-Shell Tank; AP-102; Tank Characterization Report; Waste Inventory; AP Farm; Grout Feed Tank; Grout Campaign 101; Grout

APPROVED FOR PUBLIC RELEASE

KMB 9/6/94

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7. Abstract

This document provides the characterization information and interprets the data for Double-Shell Tank AP-102

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WHC-SD-WM-ER-358 REV 0

Tank Characterization Report for Double-Shell Tank 241-AP-102

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LATA-TCR-9401

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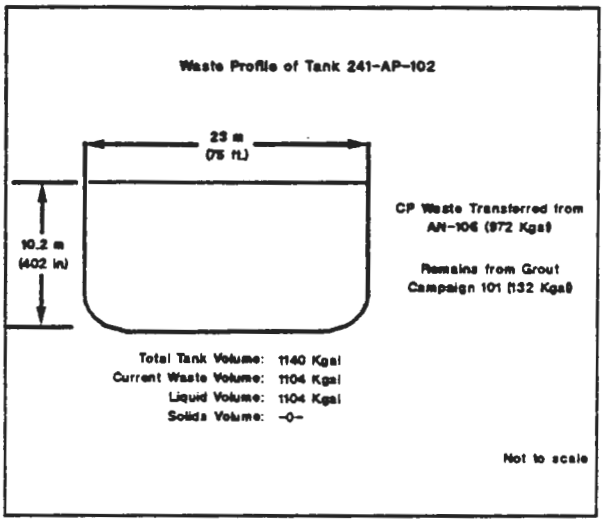
EXECUTIVE SUMMARY

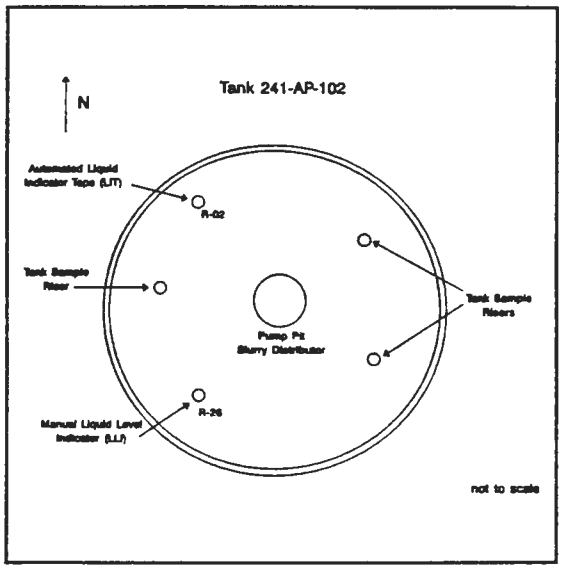
Double-Shell Tank 241-AP-102 is a radioactive waste tank most recently sampled in April of 1993. Sampling and characterization of the waste in Tank 241-AP-102 fulfills Milestone M-44-05 of the *Hanford Federal Facility Agreement and Consent Order*.

Tank 241-AP-102, located in the 200 East Area AP Tank Farm, was constructed and went into service in 1986 as the feed tank for the Grout Treatment Facility. With the cancellation of the Grout Program, the final disposal of the waste in Tank 241-AP-102 will be as high- and low-level glass fractions. Tank 241-AP-102 has a operational capacity of 1,140,000 gallons and currently contains 1,104,000 gallons of concentrated phosphate and dilute non-complexed waste. All of the waste is liquid. The tank is not classified as a Watch List tank and is considered to be sound. There are no Unreviewed Safety Questions associated with Tank 241-AP-102 at this time.



The waste in Tank 241-AP-102 exists as an aqueous solution of inorganic salts and radionuclides, with limited amounts of organic complexants. At current in-tank temperatures (above 80°F), no solids form. The most prevalent soluble analytes include aluminum, phosphorus, potassium, sodium, chloride, hydroxide, nitrate, nitrite, phosphate, and sulfate. The major radionuclide constituent is ^{137}Cs. The calculated pH of 13.7 is above the *Resource Conservation and Recovery Act* established limit in corrosivity. In addition, cadmium and chromium concentrations were found in concentrations greater than their regulatory thresholds. Careful regard should be given to any future evaporation processing of this waste. Substantial reduction of the water content of the waste could increase the TOC levels of concentrations of concern to processing. 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 Double-Shell Tank System; this permit is discussed in the *Tank Characterization Reference Guide* (De Lorenzo, et al., 1994).



TANK 241-AP-102	
TANK DESCRIPTION	
Type:	Double-Shell
Constructed:	1986
In Service:	1986
Diameter:	75' (23 m)
Usable Depth:	35' (10.7 m)
Capacity:	1,140,000 gal (4,320,000 L)
Bottom Shape:	Flat
Hanford Coordinates:	40.666° North 46.968° West
Ventilation:	Operating Exhauster
TANK STATUS: as of April, 1994	
Contents:	Concentrated Phosphate
Total Waste:	1,104,000 gal (4,195,000 L)
Liquid Volume:	1,104,000 gal (4,195,000 L)
Drainable Interstitial Liquid:	-0-
Manual Tape Surface Level	401 inches
FIC Surface Level:	Out of Service 1/27/93
Integrity Category:	Sound

Double-Shell Tank 241-AP-102 Concentrations and Inventories for Critical List Analytes (as of April, 1994)		
Total Tank Volume	1,140,000 gallons (4,320,000 L)	
Total Waste Volume and Mass	1,104,000 gallons (4,180,000 L) 5,016,000 kg	
Liquid Volume and Mass	1,104,000 gallons (4,180,000 L) 5,016,000 kg	
Physical Properties		
Density	1.20 g/cm^3	
H_2O	75.0 wt% 3,762,000 kg Inventory	
Temperature	82°F (end of December, 1993)	
pH	13.7	
Estimated Heat Load	4.60 kW	
Chemical Constituents	**Average Concentration**	**Bulk Inventory**
Al (Aluminum)	0.97 wt%	48,500 kg
P (Phosphorus)	0.26 wt%	12,800 kg
K (Potassium)	0.11 wt%	5,390 kg
Na (Sodium)	8.50 wt%	426,000 kg
CO_3^{2-} (Carbonate)	2.23 wt%	112,00 kg
Cl^- (Chloride)	0.24 wt%	12,100 kg
OH^- (Hydroxide)	0.76 wt%	38,200 kg
NO_3^- (Nitrate)	6.52 wt%	327,000 kg
NO_2^- (Nitrite)	3.17 wt%	159,000 kg
PO_4^{3-} (Phosphate)	0.97 wt%	48,500 kg
$SO_4^=$ (Sulfate)	0.38 wt%	19,800 kg
Total Organic Carbon	0.27 wt%	13,700 kg
Radionuclides		
Total Plutonium	< 0.177 μCi/L	< 00466 kg
Total Uranium	3.85 E-04 wt%	19.3 kg
^{137}Cs	228,000 μCi/L	953,000
Heat Generation	---	4.48 kW

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LIST OF TERMS

AA	atomic absorption
AEA	alpha energy analysis
ANOVA	analysis of variance
APC	alpha proportional counting
BPC	beta proportional counting
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CP	concentrated phosphate
CVAA	cold vapor atomic absorption [waste]
DN	dilute non-complexed [waste]
DP	dilute phosphate [waste]
DNFSB	Defense Nuclear Facilities Safety Board
DOE	United States Department of Energy
DSC	differential scanning calorimetry
DST	Double-Shell Tank
EPA	United States Environmental Protection Agency
FAA	flame atomic absorption
FIC	Food Instrument Corporation
GC	gas chromatography
GEA	gamma energy analysis
GFAA	graphite furnace atomic absorption
GHAA	gaseous hydride atomic absorption
GTF	Grout Treatment Facility
HPLC	high performance liquid chromatography
HGDP	Hanford Grout Disposal Program
HWVP	Hanford Waste Vitrification Plant
IC	Ion Chromatograph
ICP	Inductively Coupled Plasma Atomic Emission Spectrometry
IDL	instrument detection limit
ISE	ion selective electrode
LDR	Land Disposal Restrictions
LE	low energy
LSC	liquid scintillation counting
MDL	method detection limit
MW	mixed waste
PAL	222-S Process and Analytical Laboratory (Westinghouse Hanford Company)
PNL	Pacific Northwest Laboratory
PUREX	Plutonium-Uranium Extraction Plant
RPD	relative percent difference
RSD	relative standard deviation
SpG	specific gravity
SVOA	semivolatile organic analysis
TCLP	toxicity characteristic leach procedure
TCR	Tank Characterization Report
TGA	thermogravimetric analysis

LIST OF TERMS (continued)

TIC	total inorganic carbon
TOC	total organic carbon
TWRS	Tank Waste Remediation System
VOA	volatile organic analysis
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

In April 1993, Double-Shell Tank 241-AP-102 was sampled to determine waste feed characteristics for the Hanford Grout Disposal Program. This Tank Characterization Report presents an overview of that tank sampling and analysis effort, and contains observations regarding waste characteristics, expected bulk inventory, and concentration data for the waste contents based on this latest sampling data and information on the history of the tank. Finally, this report makes recommendations and conclusions regarding tank operational safety issues.

1.1 PURPOSE

The purpose of this Tank Characterization Report is to describe and characterize the waste in Double-Shell Tank 241-AP-102 (hereafter Tank 241-AP-102) based on information given from various sources. This report summarizes this available information, and arranges it in a useful format for making management and technical decisions concerning this particular waste tank. In addition, conclusions and recommendations based on safety issues and further characterization needs are given. This report presents a comprehensive overview of the material in Tank 241-AP-102. Specific objectives reached by the sampling and characterization of the waste in Tank 241-AP-102 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 and DOE, 1993).

- Complete safety screening of the contents of Tank 241-AP-102 to meet the characterization requirements of the *Defense Nuclear Facilities Safety Board* (DNFSB) *Recommendation 93-05* (Conway, 1993).

- Provide tank waste characterization information to the Tank Waste Remediation System (TWRS) Program Elements in accordance with the *TWRS Tank Waste Characterization Plan*, WHC-SD-WM-PLN-047, Rev. 0 (Bell, 1993).

1.2 SCOPE

This report presents a broad background of historical information that was available prior to the latest sampling activity. The result of this review is the detailed estimation of the contents of Tank 241-AP-102 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 quantitatively. The information obtained from historical sources is then compared with the actual waste measurements to arrive at final waste inventory and concentration estimates. Finally, specific safety issues and program element needs are addressed based on the results of the waste characterization.

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 Double-Shell Tank 241-AP-102. This Tank Characterization Report incorporates all available previous sampling, characterization, and transfer data concerning Tank 241-AP-102. In addition, estimates of the current tank contents based on process knowledge and waste transaction records provide important cross-checks and corroboration to the inventory estimates derived from recent analytical data. Based on the statistical determination that the tank waste is homogenous, and given that the analytical data is valid and defensible, this report is therefore the definitive characterization of the contents of Tank 241-AP-102.

The term "analytical results" is used in this report to denote sample results from the most recent sampling event, the characterization of Tank 241-AP-102 waste for the Hanford Grout Disposal Program. Characterization data from these samples are used for the analytical section of this report, Section 5.0. The historical characterization of this tank, Section 2.0, is based on the available "historical results" prior to the 1993 sampling.

2.0 HISTORICAL TANK INFORMATION

The purpose of this section is to describe Tank 241-AP-102 based on historical tank information, and to use this information to predict the constituents of the tank and their concentrations. This section is divided into six parts. A brief description and historical background of the tank comprise the first two parts, 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-AP-102 based on historical information. The final part details the surveillance data taken on the tank.

2.1 TANK HISTORY

Double-Shell Tank 241-AP-102 is a tank-in-tank design consisting of a heat-treated primary steel liner, inside a second steel liner. The tank has a design capacity for storing 1.16 million gallons of waste; however, safety considerations require a maximum operating capacity of 1.14 million gallons. Instruments access the tank through risers and monitor the pressure, temperature, liquid level and other bulk tank characteristics (Bell, 1993). A detailed diagram of a double-shell tank is presented in Figure 2-1.

Tank 241-AP-102 was constructed and went into service in 1986 as the feed tank for the Grout Treatment Facility (GTF), and is located in Hanford's 200 East Area between the PUREX Plant and the GTF and Disposal Site. Figure 2-2 contains a map showing the location of the 241-AP Tank Farm.

241-AP-102 is used to collect and store solutions from several sources. These sources include the Plutonium-Uranium Extraction Plant (PUREX) Ammonia Scrubber supernate from Tank 241-AN-106, which contained decontamination waste from Hanford's 100 Area N-Reactor, Tank 241-AP-104, waste consisting of dilute phosphate and dilute non-complexed waste from the 100 N area, and miscellaneous flush water.

During Grout Campaign 101, in which grout was blended and poured into Vault 101, all of the contents of Tank 241-AP-102 were transferred to grout, except for a residual "heel" of dilute phosphate (DP) waste which originated in Tank 241-AP-104. The leachate and excess drainable liquids resulting from the grout curing process were returned back to Tank 241-AP-102 and combined with this heel. PUREX Ammonia Scrubber Feed (PASF), consisting of neutralizing agents, were then added to Tank 241-AP-102 to ensure waste compatibility by raising the pH of the waste. The majority of the tank's present contents were then received in several transfers of concentrated phosphate (CP) solution from Tank 241-AN-106 in the third and fourth quarters of 1992.

2.2 TANK STATUS

Tank 241-AP-102 currently contains 1,104,000 gallons of concentrated phosphate (CP) and dilute phosphate (DP) waste. The waste is entirely composed of liquid with no sludge or salt cake (Hanlon, 1994). The tank is at 97% capacity (volume) with the waste occupying approximately the bottom 401 inches of the tank. Tank surveillance thermocouple data indicate the tank temperature to be 82 °F as of 12/93. The tank is not currently

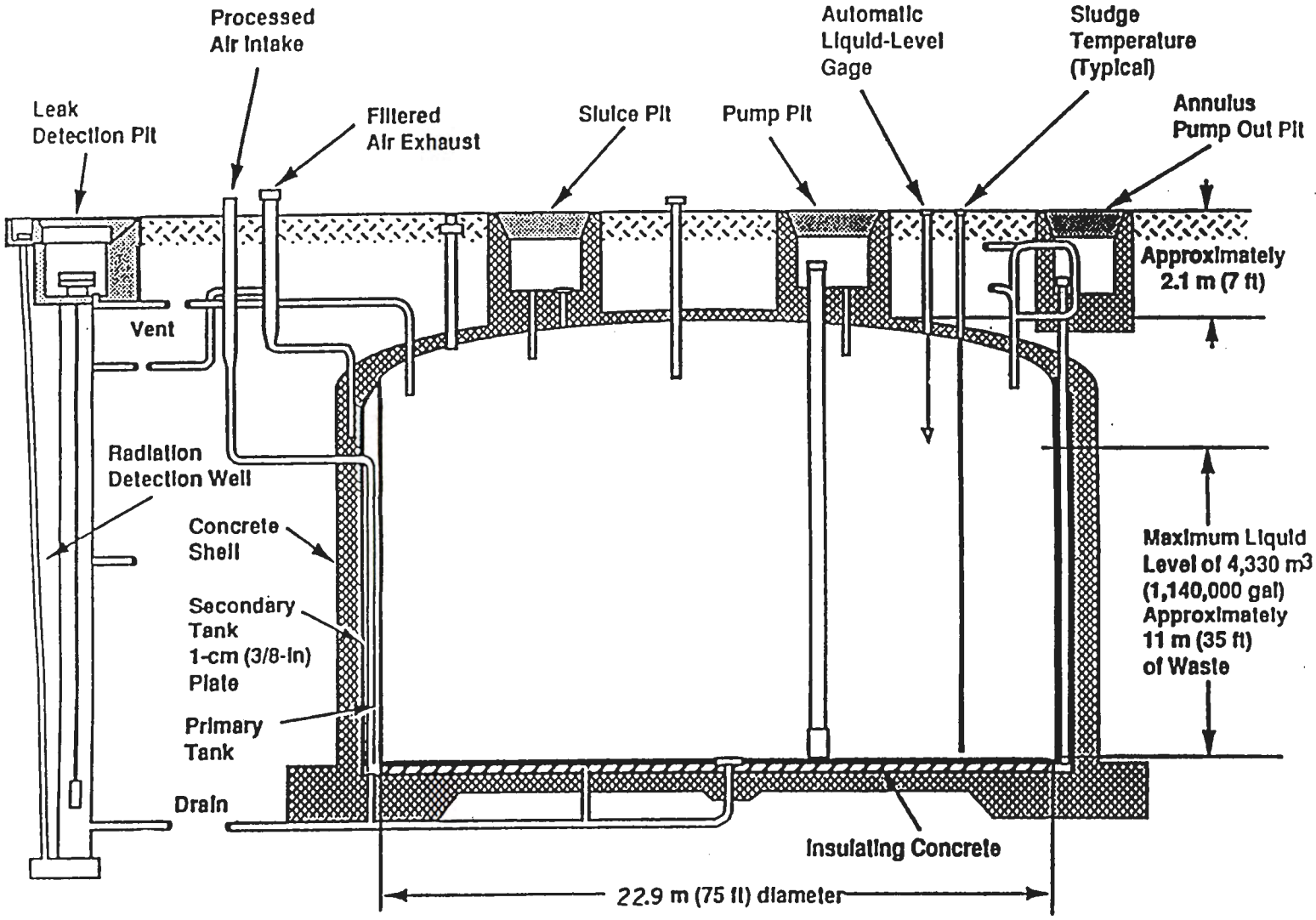
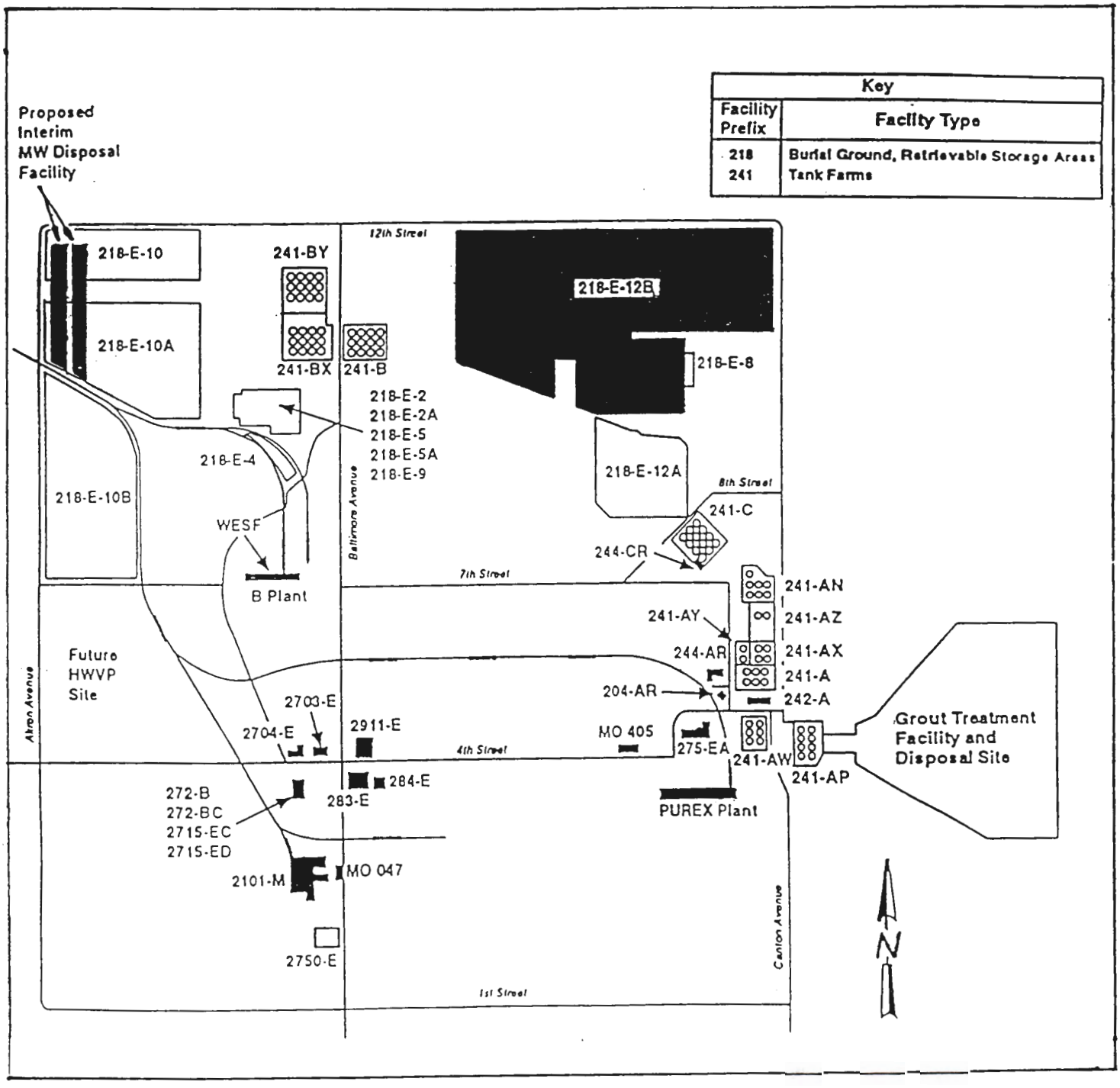


Figure 2-1. Double-Shell Tank Configuration (Anderson, 1992).

Figure 2-2. Location of the 241-AP Tank Farm (Husa et al., 1993)



designated as a watch list tank and the tank integrity is classified as sound. There are no Unreviewed Safety Questions (USQs) associated with Tank 241-AP-102 at this time. Tank 241-AP-102 remains in active service for waste management operations. The tank contains a mixing pump which stopped working prior to sampling.

2.3 PROCESS KNOWLEDGE

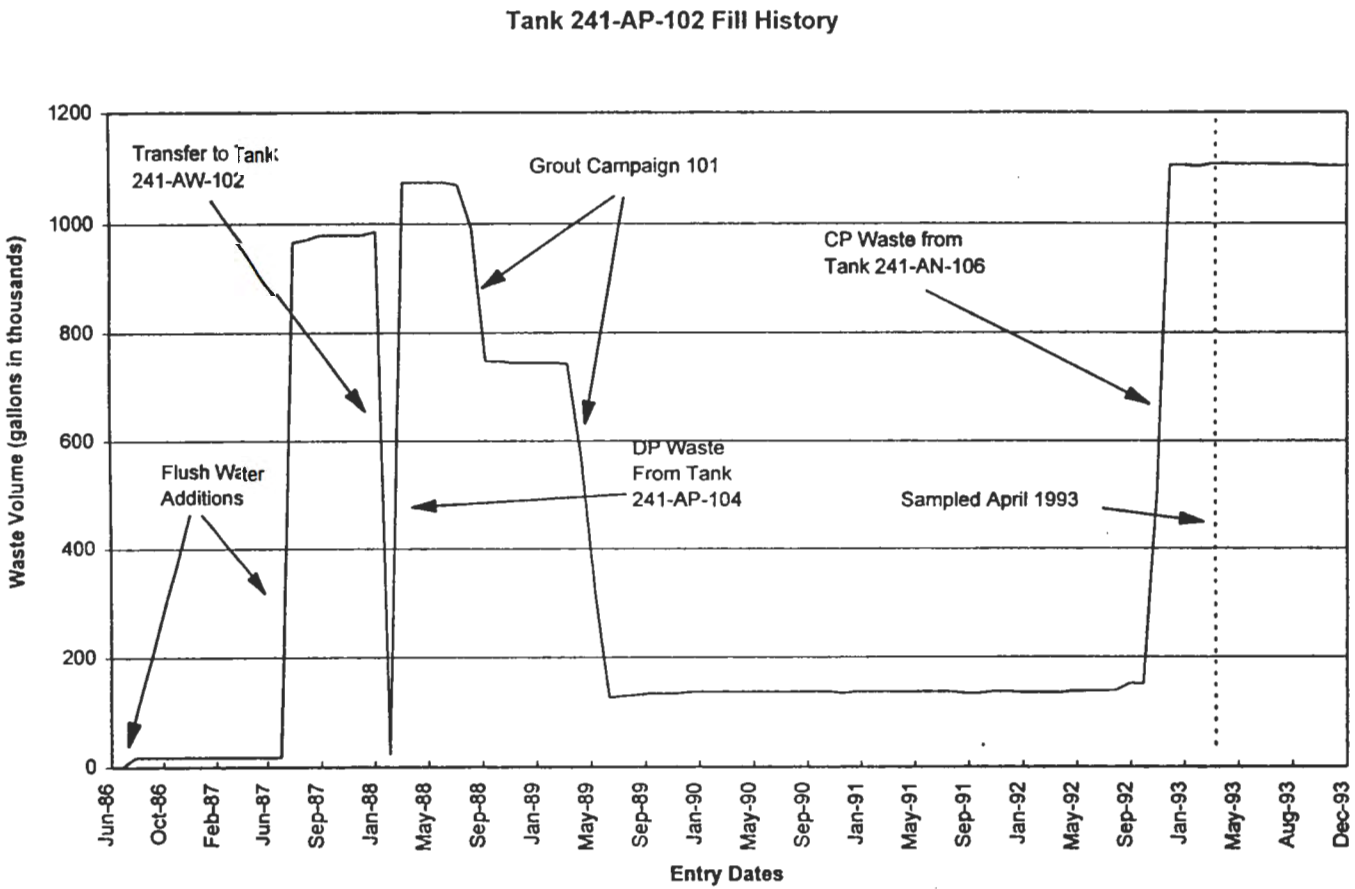
Figure 2-3 depicts the fill history of Tank 241-AP-102 for the time period from 1986, when the tank became operational, to the first quarter 1993, the time at which the most recent samples were collected. The waste volume presented in this figure corresponds to the data contained in the *Waste Volume Projection Database* (Koreski, 1994). The entries contained in this database are broken down by waste type and by quarter. As seen in Figure 2-3, only two general types of waste were added to Tank 241-AP-102: concentrated phosphate waste from Tank 241-AN-106; and dilute phosphate waste from Tank 241-AP-104, the PUREX Ammonia Scrubber, Grout product leachate returns, and flush water from miscellaneous sources.

A detailed description of the events that contributed to waste being added to or transferred from this tank, and an estimated characterization of the waste types, follows. (Several sources were used to write this section; however, the actual volume measurements are taken from the *Waste Volume Projection Database* [Koreski, 1994] unless noted otherwise.) Volume measurement discrepancies that were detected between reference sources have also been noted in this section.

Waste from Tank 241-AP-104, consisting of dilute phosphate waste from the 100 N Area, and flush water from miscellaneous sources were added to Tank 241-AP-102 between 1986 and 1988. Grout Campaign 101 began in the third quarter of 1988 and continued through the third quarter of 1989. This campaign consisted of the cementitious disposal of phosphate/sulfate waste from the 100 N-Reactor decontamination activities. During Campaign 101, nearly all of the contents from Tank 241-AP-102 were retrieved and grouted. At the completion of this campaign, approximately 72,000 gallons of the original dilute phosphate feed material remained in Tank 241-AP-102 as a residual "heel" of liquid (Hendrickson et al., 1993).

After the grout product was cured, approximately 55,000 gallons of excess liquid and leachate from disposal Vault 101 were returned to Tank 241-AP-102 in July 1989. Uncertainties in waste pH compatibility to the tank required that two small transfers of sodium nitrite/sodium hydroxide solution from the PUREX Ammonia Scrubber be conducted during September and October 1989 to protect the steel liner of Tank 241-AP-102. According to Hendrickson et al., (1993) this transfer involved approximately 7,150 gallons. However, only 5,000 gallons are noted by Koreski (1994) as being transferred from the PUREX Ammonia Scrubber to Tank 241-AP-102. Leachate which had developed over a longer period from Vault 101 was subsequently transferred into Tank 241-AP-102 in two small transfers totalling 2,550 gallons (Hendrickson et al., 1993). The tank activity between the first quarter of 1990 and third quarter 1992 consisted of numerous gains and losses of no more than 3,000 gallons each that were attributed to unknown sources. These fluctuations may be attributed to several causes; possibly evaporation, moisture gain from the air in the tank, flushing the tank with water, or even measurement inconsistencies, since an inch on the measuring tape is equivalent to approximately 2,750 gallons of waste.

Figure 2-3. Waste Volume History of Tank 241-AP-102.



Tank 241-AP-102 contained approximately 137,000 gallons of dilute phosphate (DP) waste in the third quarter 1992, prior to the addition of the majority of the tank's current waste from Tank 241-AN-106. The resident DP waste was composed of residual phosphate/sulfate waste, leachate returns from Vault 101, and chemical additions from PUREX to increase the alkalinity of the leachates; this waste comprises 12 percent of the current tank waste volume. In November and December of 1992, the tank received approximately 88 percent of its final volume with the transfer of supernatant liquor contents from Tank 241-AN-106, consisting primarily of concentrated phosphate (CP) waste. The CP waste was partially evaporated phosphate waste resulting from the decontamination of Hanford's N-Reactor. The volume for this transfer was estimated at 972,000 gallons by Koreski (1994) and by Hendrickson et al., (1993); however, according to Welsh (1993) this volume equaled 973,500 gallons. The discrepancy between the sources is not significant in this case.

Following the transfer of CP waste from Tank 241-AN-106, the tank's fill activity was minimal. The transfers that took place between first quarter 1993 and fourth quarter 1993 consisted of several small gains and losses, each of no more than 4,000 gallons that were attributed to unknown sources. The final volume for the tank was reported at 1,104,000 gallons at the end of fourth quarter 1993: 970,000 gallons of CP waste and 134,000 gallons of DP waste.

2.4 HISTORICAL ESTIMATION OF THE CONTENTS OF TANK 241-AP-102

By reviewing the historical characterization data for Tank 241-AP-102, a preliminary estimate of its present waste constituents can be made and used as a baseline for comparison. This estimate then appears as the Historic Tank Content Estimated in Table 5-4. Following are descriptions of the tables that were created using these historical sources to generate concentration and inventory estimates.

Table 2-1 presents the estimated waste composition of Tank 241-AN-106 when it was fully mixed prior to its transfer to Tank 241-AP-102 (Hendrickson et al., 1993). As explained in Section 2.4, 88 percent of the waste currently in Tank 241-AP-102 resulted from several transfers of concentrated phosphate (CP) waste from Tank 241-AN-106. Results are reported to three significant digits; those reported with a less than (<) sign were below the detection limit of the analytical procedure, meaning they may be present at any concentration less than this value or not present at all.

Table 2-2 presents the estimated waste composition of Tank 241-AP-102 prior to the transfer of Tank 241-AN-106 (hendrickson et al., 1993). Twelve percent of the tank's current contents is comprised of dilute phosphsate (DP) waste that occupied the tank prior to the Tank 241-AN-106 transfer of CP waste in the fourth quarter of 1992. The most recent historical sample results from Tank 241-AP-102 were taken in April 1988 prior to Grout Campaign 101. The analytical results from these samples have been used as a basis for the characterization of the tank's contents prior to the grout transfer. It should be noted that these results can only provide an estimated characterization of the waste in the tank prior to the transfer, since numerous transfers involving large percentages of the tank's contents took place between the sampling in 1988 and the addition of the CP waste in 1992. However, the 1988 samples were the most recent results, and were therefore considered the best available source for characterization.

Table 2-1. Characterization of Tank 241-AN-106 Constituents (Hendrickson et al., 1993). (2 pages)

Analyte	Analytical Data Result Composite Mean
Metals	(μg/L)
Al	9.28 E+06
As	72
Ba	< 11,100
Bi	< 145,000
Cd	< 49,600
Ca	90,200
Cr	564,000
Cu	< 3,750
Fe	< 6,900
Pb	< 460,000
Mg	2,780
Mn	< 55,700
Hg	< 50
Mo	< 66,600
Np	< 3,000
P	6.11 E+06
K	1.08 E+06
Se	134
Ag	< 3,630
Na	9.03 E+07
Ti	< 3,510
U	4,000
Zn	< 9,440
Zr	< 27,800
Ions	(μg/L)
NH_3	123,000
CO_3^{2-}	1.962 E+07
Cl^-	2.46 E+06

Table 2-1. Characterization of Tank 241-AN-106 Constituents (Hendrickson et al., 1993). (2 pages)

Analyte	Analytical Data Result Composite Mean
Ions (continued)	(μg/L)
CN^-	6,000
OH^-	8.06 E+06
F^-	< 61,600
NO_2^-	2.96 E+07
NO_3^-	6.85 E+07
PO_4^{3-}	1.84 E+07
SO_4^{2-}	2.15 E+06
Radionuclides	(μCi/L)
^{241}Am	0.606
^{14}C	0.335
^{134}Cs	< 24
^{137}Cs	205,000
^{60}Co	< 9
^{243}Cm	0.0470
^{129}I	< 0.0750
^{94}Nb	< 23
^{238}Pu	0.0200
$^{239/240}Pu$	0.0378
$^{106}Ru/Rh$	< 1,390
^{79}Se	0.240
^{90}Sr	2,230
^{99}Tc	69
^{3}H	3
Physical Properties	--
Water	77.6%
Density	1.23 g/cm^3
TOC	3.26 E+06 μg/L

Table 2-2. Estimated Constituent Concentrations of the DP Waste in Tank 241-AP-102 Prior to Transfer (Hendrickson et al., 1993).

Analyte	Analytical Data Result
Metals(1)	(μg/L)
B	5,000
Ca	5,300
Cr	1,700
Fe	1,900
Mg	1,500
P	5.59 E+06
Si	4,000
Na	1.25 E+07
Ions	(μg/L)
CO_3^{2-}	2.01 E+06
Cl^-	15,500
F^-	12,600
NO_2^-	810
NO_3^-	123,000
PO_4^{3-}	1.48 E+07
SO_4^{2-}	1.42 E+06
Radionuclides(2)	(μCi/L)
^{241}Am	7.44 E-03
^{137}Cs	0.489
^{60}Co	6.35
^{242}Cm	9.34 E-03
^{244}Cm	0.0366
$^{89/90}Sr$	0.0341
Total α	0.0333

(1) Values reported for metals and anions based on single sample result.

(2) Values reported for radionuclides based on highest reported activity of four sample results.

Table 2-3 presents the final estimated waste composition of Tank 241-AP-102 based on historical sample results. The final historical result has been derived for each constituent by taking a weighted sum of the two sets of characterization data. Specifically, the historical estimate is derived by adding 88% of the value in Table 2-1 and 12% of the value in Table 2-2. Several assumptions were necessary in deriving these final values. First, in the case where an analyte was present at a value less than the instrument detection limit, the detection limit value was maintained as the tank estimate. This provides a conservative estimate which does not attempt to alter the predetermined lower limit of quantitation. Second, the number of analytes reported in Table 2-2 is considerably smaller than those reported in Table 2-1, because only a limited number of analyses were requested in the characterization of Tank 241-AP-102. Since these constituents were not analyzed, they were assumed to be zero (even though they may be present), and 88% of the result in Table 2-1 was taken as the historical estimate of the concentration of that particular analyte in the tank. Finally, an exception to the above method applied to the density and percent water values. These values were only available for the characterization of Tank 241-AN-106 and were assumed to be characteristic of the waste currently in the tank.

2.5 SURVEILLANCE DATA

2.5.1 Surface Level Readings

Tank 241-AP-102 is equipped with a liquid level gauge manufactured by the Food Instrument Corporation (FIC) which can be monitored either automatically or manually. The FIC indicator uses a conductivity probe to detect the level of the tank's contents and, in the automatic mode, is electrically connected to a computer for data transmission via the Computer Automated Surveillance System. Tank 241-AP-102 is also equipped with a manual tape from which readings are taken when the FIC indicator is out of service. The most recent liquid level measurement available was 401 inches on March 4, 1994 based on manual tape readings (Rios, 1994). The FIC indicator has been out of service since January 1993 (Hanlon, 1994).

2.5.2 Internal Tank Temperatures

Tank 241-AP-102, as well as all other double-shell tanks, is equipped with thermocouples (thermoelectric temperature measuring devices) in the tank interior, the annular space and in the concrete outer shell. A thermocouple tree with eighteen thermocouples assembled in a pipe and inserted into a waste tank, is used to monitor the waste temperatures at various levels in the primary tank, usually every two feet. Temperature readings for Tank 241-AP-102 have been automatically and manually recorded since July 1989 by surveillance analysis computer systems. The maximum waste temperatures from the weekly manual readings has been plotted over time and are presented in Figure 2-4 (Rios, 1994). Maximum temperatures are typically reported from thermocouples located in the vertical center of the tank, and a slight negative temperature gradient exists with waste depths above and below the tank center.

Table 2-3. Estimated Waste Composition of Tank 241-AP-102. (2 pages)

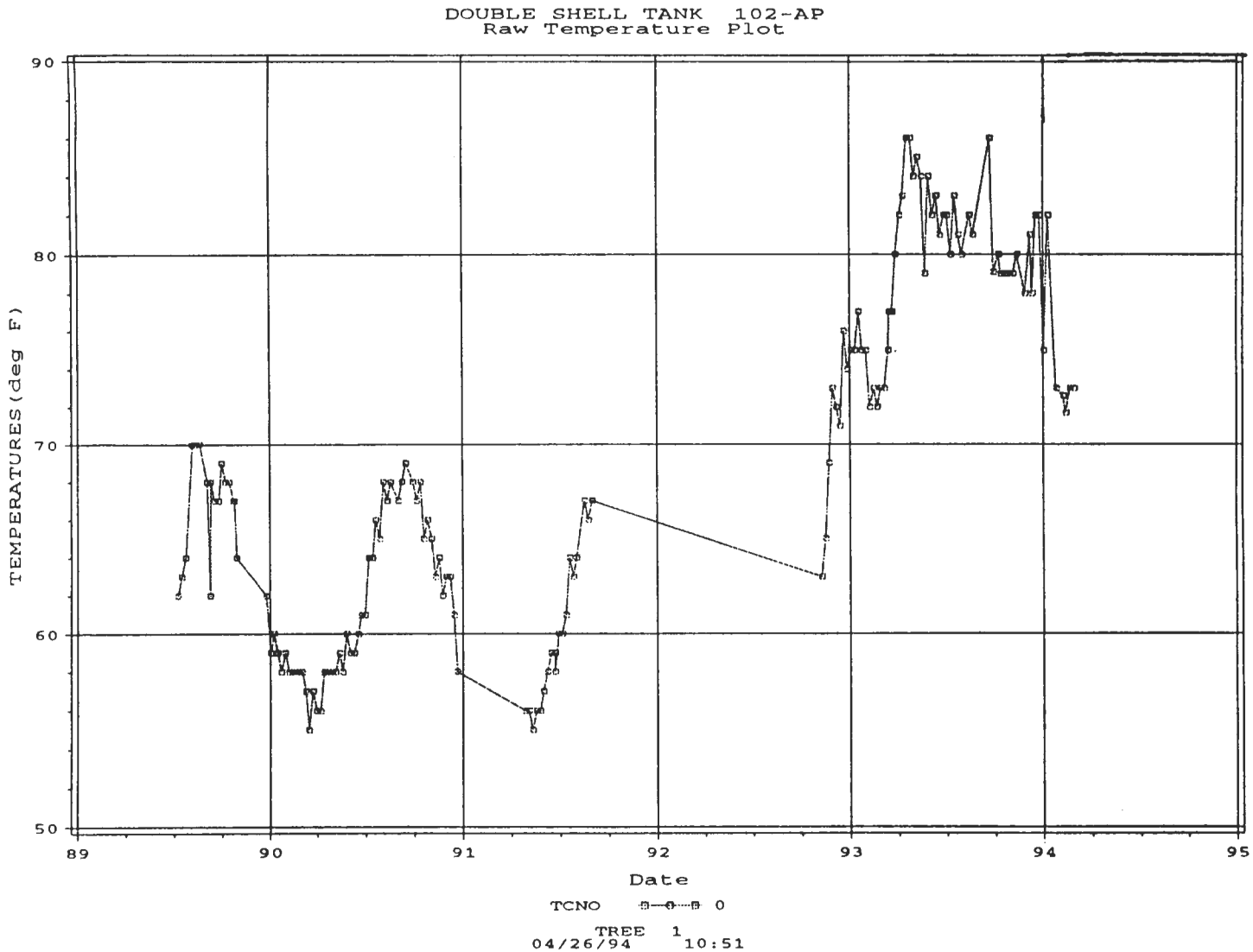
Analyte	Final Estimated Result
Metals	(μg/L)
Al	8.17 E+06
As	63.4
Ba	< 11,100
Bi	< 145,000
B	600
Cd	< 49,600
Ca	80,000
Cr	496,000
Cu	< 3,750
Fe	< 6,900
Pb	< 460,000
Mg	2,630
Mn	< 55,700
Hg	< 50
Mo	< 66,600
Np	< 3,000
P	6.05 E+06
K	950,000
Se	118
Si	480
Ag	< 3,630
Na	8.10 E+07
Ti	< 3,510
U	3,520
Zn	< 9,440
Zr	< 27,800
Ions	(μg/L)
NH_3	108,000
CO_3^{2-}	1.74 E+07
Cl^-	2.16 E+06
CN^-	5,280

Table 2-3. Estimated Waste Composition of Tank 241-AP-102. (2 pages)

Analyte	Final Estimated Result
Ions (continued)	(μg/L)
OH^-	7.09 E+06
F^-	< 61,600
NO_2^-	2.6 E+07
NO_3^-	6.03 E+07
PO_4^{3-}	1.8 E+07
SO_4^{2-}	2.06 E+06
Radionuclides	(μCi/L)
^{241}Am	0.534
^{14}C	0.295
^{134}Cs	< 24
^{137}Cs	180,000
^{60}Co	< 9
^{242}Cm	1.12 E-03
^{243}Cm	0.0414
^{244}Cm	4.39 E-03
^{129}I	< 0.0750
^{94}Nb	< 23
^{238}Pu	0.0176
$^{239/240}Pu$	0.0333
$^{106}Ru/Rh$	< 1390
^{79}Se	0.211
$^{89/90}Sr$	1,960
Tc^{99}	60.7
Total α	4.00 E-03
^{3}H	2.6
Physical Properties	
Water(1)	77.6%
pH	13.62
Density(1)	1.23 g/cm^3
TOC	2.87 E+06 μg/L

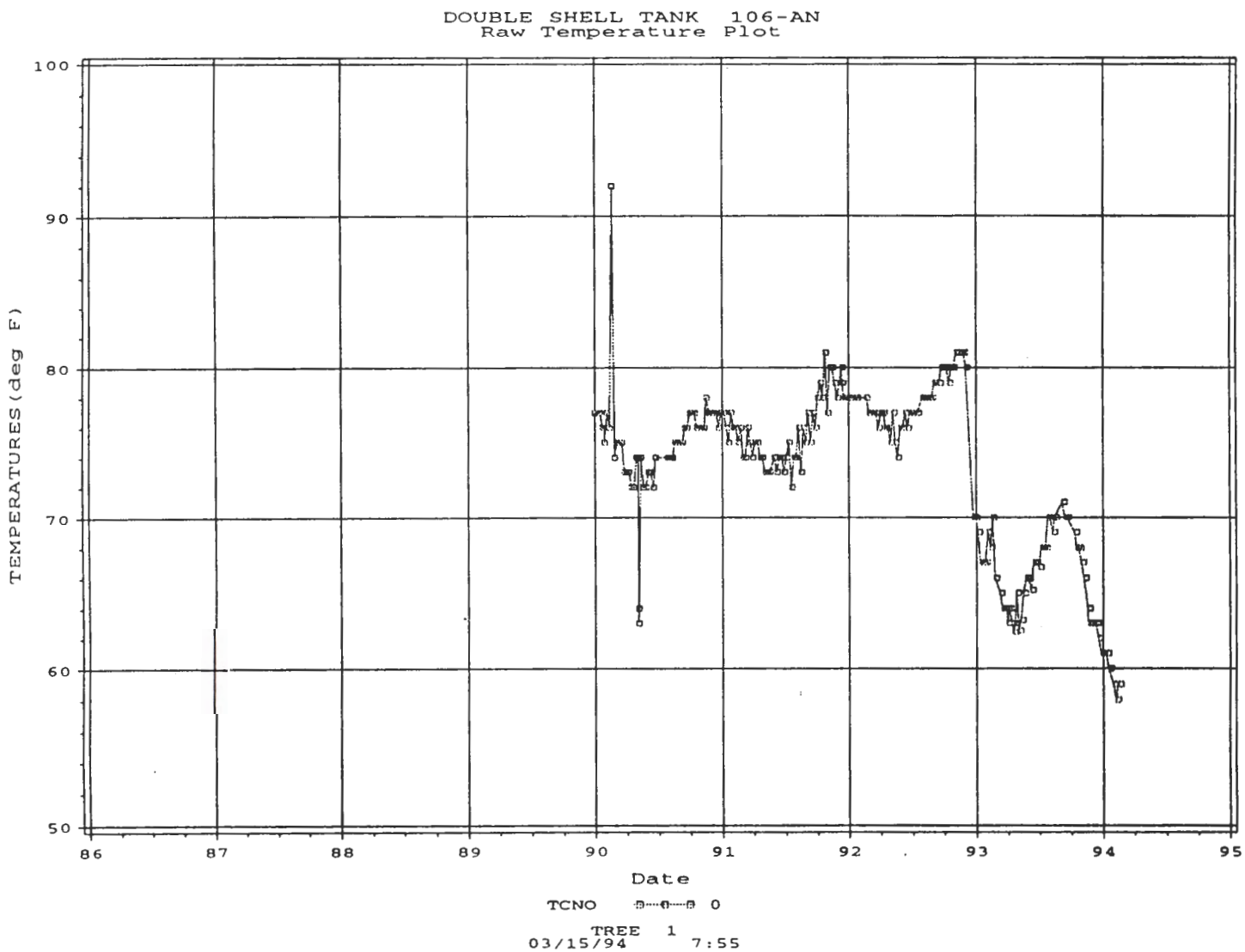
(1) These values were not multiplied by 88%, rather this value was assumed to be constant for the entire contents of the tank.

Figure 2-4. Tank 241-AP-102 Thermocouple Tree Raw Temperature Plot.



With the exception of two periods where the thermocouple equipment was out of service, the internal temperature of Tank 241-AP-102 has been monitored approximately weekly. From the time the first thermocouple reading was taken to the time the concentrated phosphate (CP) waste transfer from Tank 241-AN-106 took place, the temperatures ranged from a high of 70°F in the summer months to a low of 55°F in the winter months. For unknown reasons, there were no readings available for approximately a one year time period between September 1991 to October 1992. In the fourth quarter of 1992, the temperature of the waste increased significantly, reaching a high of 86°F in the summer months and a low of 78°F in the winter months. This temperature increase was caused by the transfer of 616,000 gallons of CP waste from Tank 241-AN-106, which was substantially higher in radionuclide content than the previous waste contained in Tank 241-AP-102 (see Section 5.2). The temperature of the waste in Tank 241-AN-106 at the time of the transfer was 80°F. This can be seen in Figure 2-5, which plots Tank 241-AN-106's maximum waste temperature readings. Also of note in Figure 2-5 is the corresponding reduction in the maximum temperature of Tank 241-AN-106's waste after the transfer into Tank 241-AP-102, a result of losing almost 97% of its waste volume. The heat load in Tank 241-AP-102 due to its radionuclide inventory is presented in Section 6.2. Also, a temperature increase near the end of the second quarter of 1993 can be attributed to operation of the tank mixing pumps prior to the 1993 sampling event. The last available temperature reading for Tank 241-AP-102 was 82°F, taken at the end of December, 1993. Since the addition of the 241-AN-106 waste, Tank 241-AP-102 is assumed to have reached homogeneous thermal stability at a higher temperature range.

Figure 2-5. Tank 241-AN-106 Thermocouple Tree Raw Temperature Plot.



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3.0 TANK SAMPLING OVERVIEW

The sampling program was designed to accomplish two objectives. First, it was designed to characterize Tank 241-AP-102 for permitting purposes and to show that the waste was suitable feed for the grout process. Second, it was designed to demonstrate that the action of the in-tank mixer pump was sufficient to homogenize the tank wastes.

3.1 DESCRIPTION OF SAMPLING EVENT

Tank 241-AP-102 was sampled on 04/28, 04/29, and 04/30/1993. To ensure sampling homogeneity, the tank was mixed for 53 days before sampling occurred. The absence of a sludge layer was confirmed by the sound of a weighted tape hitting the metal bottom of the tank (Welsh, 1993).

Samples were obtained by using the "bottle-on-a-string" method. Each glass sample bottle collected approximately 125 mL of liquid. To be consistent with safety procedures that help to limit personnel exposure to hazardous ionizing radiation, no attempt was made to ensure completely full bottles; as a result, there was the potential for headspace in all sample bottles.

To demonstrate homogeneity required that samples representative of the entire volume be obtained (Duchsherer, 1993). Therefore, samples were collected from 3 fixed, vertical 4-inch risers (Riser Type 1), located 120 degrees apart at a radius of 20 feet from the tank center. Also, the samples' locations varied in depth to cover the entire vertical range of the contents in the tank (Figure 3-1). Because of the shielding requirements for the shipping containers, refrigeration of the sample was not possible. In addition, preservatives were not used in the sample bottles because the waste was not expected to contain any biological activity that might influence the results of an unpreserved sample.

3.2 SAMPLE NUMBERS AND REQUESTED ANALYTES

Eighteen samples (five per riser, plus three duplicates) were submitted to the Westinghouse Hanford Company 222-S Process and Analytical Laboratory for analysis. Table 3-1 presents the laboratory numbers for these samples along with sampling location within the Tank. These sample results were used to characterize the inorganic and radiochemical properties of the tank. In addition, two samples per riser plus one duplicate were shipped to the Pacific Northwest Laboratory for organic analyses. Table 3-2 displays the numbers assigned to the samples by the laboratory along with the sampling location in the tank. A list of the analytes requested for evaluation from each laboratory is presented in Table 3-3.

Figure 3-1. Double-Shell Tank 241-AP-102 Sample Locations and 222-S Sample Numbers.

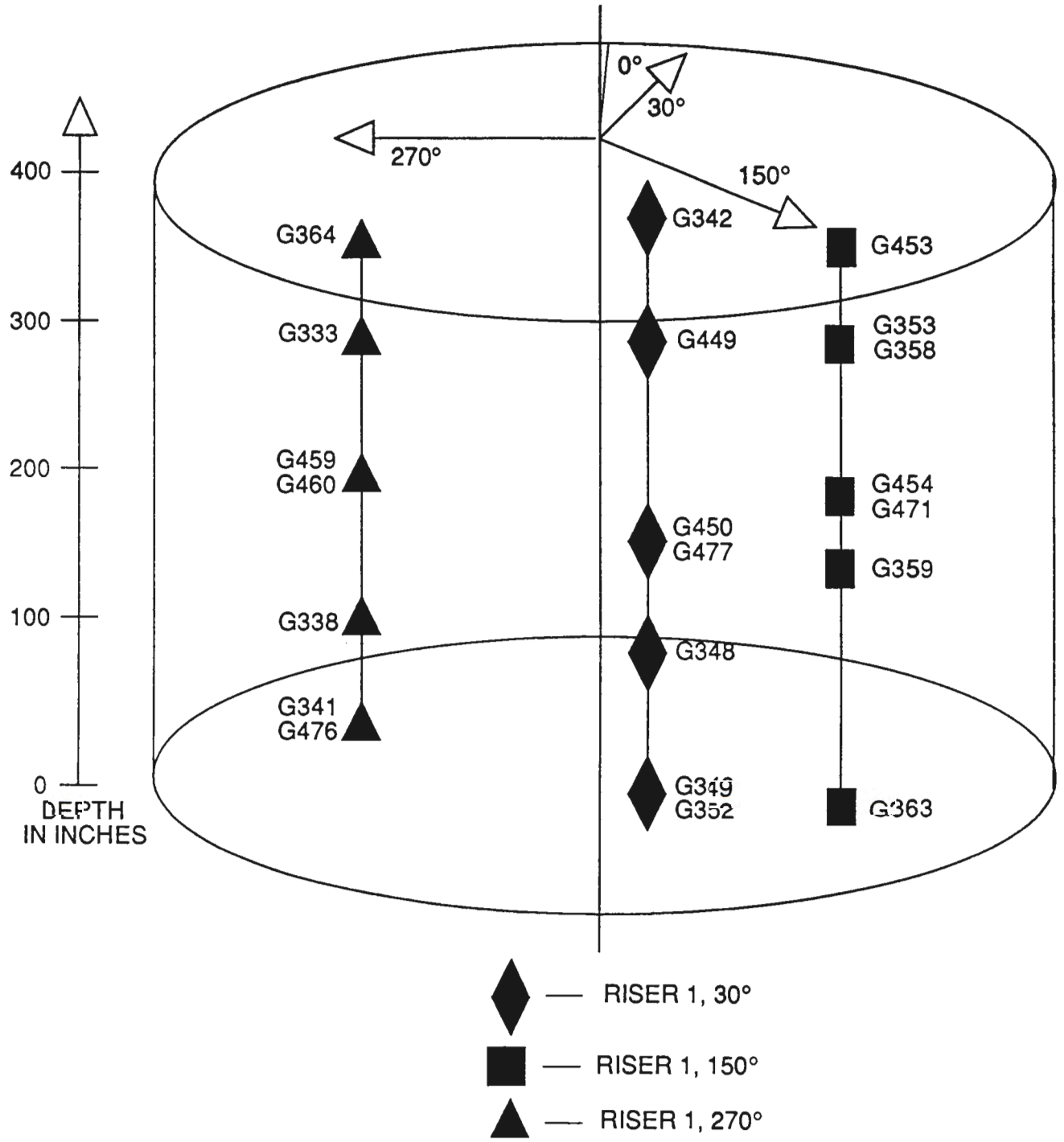

Table 3-1. WHC Sample Numbers (Welsh, 1993).

Riser, Angle	Depth (inches from the bottom of the tank)	Tank Farm Sample Number	Laboratory Sample Number
1(NE), 30°	360 Inches	G299	G342, G509*
1(NE), 30°	271 Inches	G301	G449, G523*
1(NE), 30°	182 Inches	G302	G450, G477*
1(NE), 30°	125 Inches	G303	G348, G510*
1(NE), 30°	34 Inches	G305	G239, G511*
1(NE), 30°	34 Inches	G306	G352, G521*
1(SE), 150°	391 Inches	G307	G453, G527*
1(SE), 150°	334 Inches	G308	G353, G522*
1(SE), 150°	334 Inches	G309	G358, G515*
1(SE), 150°	208 Inches	G310	G454, G471*
1(SE), 150°	162 Inches	G311	G359, G516*
1(SE), 150°	18 Inches	G313	G363, G533*
1(W), 270°	372 Inches	G315	G364, G534*
1(W), 270°	334 Inches	G317	G333, G528*
1(W), 270°	226 Inches	G318	G459, G517*
1(W), 270°	226 Inches	G319	G460, G536*
1(W), 270°	148 Inches	G322	G338, G529*
1(W), 270°	99 Inches	G323	G341, G476*
Composite	---	---	G443, G470*

*: Heated sample

Table 3-2. PNL Sample Numbers (Welsh, 1993).

Riser, Angle	Depth inches from the bottom of the tank	Position	Tank Farm sample number	PNL Laboratory sample number
1(NE), 30°	306 Inches	1	G300	93-06634
1(NE), 30°	125 Inches	4	G304	93-06635
1(SE), 150°	162 Inches	9	G312	93-06636
1(SE), 150°	18 Inches	10	G314	93-06637
1(W), 270°	372 Inches	11	G316	93-06638
1(W), 270°	226 Inches	13A	G320	93-06639
1(W), 270°	226 Inches	13B	G321	93-06640
Field Blank	---	---	G324	93-06641

Table 3-3. 102-AP Samples and Requested Analytes (Welsh, 1993).

Tank Farm Sample Numbers	Laboratory Sample Numbers	Laboratory	Requested Analytes
G299, G303 G305, G306 G308, G309 G311, G313 G315, G318 G319, G323	G342, G348 G349, G352 G353, G358 G359, G363 G364, G459 G460, G341	222-S Laboratory	Al, Sb, Ba, Be, Cd, Cr, Fe, Ni, K, Na, P, Pb, Ag, F^-, Cl^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, ^{137}Cs, ^{134}Cs, ^{60}Co, $^{144}Ce/Pr$, ^{125}Sb, $^{106}Ru/Rh$, ^{94}Nb, SpG, % Water, OH^-, TIC, TOC, Se, ^{241}Am, ^{99}Tc, ^{14}C, ^{90}Sr, ^{237}Np, ^{238}Pu, $^{239/240}Pu$, $^{243/244}Cm$
G301, G302 G307, G310 G317, G322	G449, G450 G453, G454 G333, G338	222-S Laboratory	Al, Sb, Ba, Be, Cd, Cr, Fe, Ni, K, Na, P, Pb, Ag, F^-, Cl^-, NO_2, NO_3, PO_4^{3-}, SO_4^{2-}, ^{137}Cs, ^{134}Cs, ^{60}Co, $^{144}Ce/Pr$, ^{125}Sb, $^{106}Ru/Rh$, ^{94}Nb
	Composite sample G443, G470	222-S Laboratory	Al, Sb, Ba, Be, Cd, Cr, Fe, Ni, K, Na, P, Pb, Ag, F^-, Cl^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, ^{137}Cs, ^{134}Cs, ^{60}Co, $^{144}Ce/Pr$, ^{125}Sb, $^{106}Ru/Rh$, ^{94}Nb, SpG, % Water, OH^-, TOC, Se, ^{241}Am, ^{99}Tc, ^{90}Sr, $^{243/244}Cm$, CN^-, U, As, Hg, ^{129}I, ^{3}H, NH_3/NH_4^+
G300, G304 G312, G314 G316, G320 G321	93-06634, 93-06635 93-06636, 93,06637 93-06638, 93-06639 93-06640	PNL	Volatiles, Semivolatiles, EDTA, HEDTA, Citrate, Oxalate, Glycolate

EDTA: ethylenediaminetetraacetic acid.
HEDTA: N-(2-hydroxyethyl)ethylenediaminetriacetic acid.

4.0 SAMPLE HANDLING AND ANALYTICAL SCHEME

4.1 WASTE DESCRIPTION

At the time the samples were collected, all samples were a clear, yellowish liquid free of solids (Duchsherer, 1993). The samples were stored outdoors at ambient temperatures for the first 24 hours. During this initial storage period, a white precipitate formed in the bottom of each sample bottle. The samples were subsequently moved indoors and stored at room temperature in an effort to resolubilize the precipitate. However, the solid precipitate remained in the sample bottles

From this observation, it was assumed that low temperature conditions will likely lead to the formation of solid precipitates in Tank 241-AP-102. The waste previously contained in Tank 241-AN-106, the predominant source of the waste in Tank 241-AP-102, existed in two layers: high phosphate salts on top and high sodium salts on bottom. When the two layers are mixed at temperatures below 81 °F, such as occurred after tank sampling, a solid precipitate forms. However, this precipitate can be resolubilized upon heating to at least 104 °F. The waste was transferred from Tank 241-AN-106 "in place," to minimize mixing of the two layers and possible precipitation of solids. Prior to sampling Tank 241-AP-102, the tank was mixed and the temperature elevated from 71 °F to 81 °F. It was predicted that, during this mixing prior to sampling, some solid precipitation of hydrated sodium phosphate may have occurred (Hendrickson et al., 1993).

Westinghouse Hanford Company 222-S Process and Analytical Laboratory personnel described the solid precipitate crystals as approximately 3 to 5 mm long, prismatic in shape, with the length exceeding the width by a factor of 5 to 10. Inspection by polarized light microscopy of one of the smaller crystals revealed six-sided prisms, typical for hydrated sodium phosphate ($Na_3PO_4 \bullet 12H_2O$) crystals. This observation was supported by the birefringence (difference between refractive indexes in x and y directions) which was characteristic of hydrated sodium phosphate. Based upon this evidence and the chemistry of the sample, it was concluded that the precipitate was hydrated sodium phosphate (Duchsherer, 1993).

4.2 HOLD TIME CONSIDERATIONS

For a description of hold time considerations, see the *Tank Characterization Reference Guide* (De Lorenzo, et al., 1994).

4.2.1 WHC - Process and Analytical Laboratories

Tank 241-AP-102 was sampled on 04/28, 04/29, and 04/30/1993. The samples were delivered to the Westinghouse Hanford Company 222-S Process and Analytical Laboratory on 05/01/93 and placed in the care of laboratory personnel. Aliquots were then submitted to the 222-S Laboratory for analysis. The acid digestion for the individual inductively coupled plasma (ICP) samples was conducted on 05/20/93 and ICP analyses were completed on 07/15/93. A composite sample was prepared on 05/14/93 and acid digestion of the composite was completed on 05/18/93. The ICP metal analysis for the composite was completed on 07/01/93.

4.2.2 Pacific Northwest Laboratory - Analytical Chemistry Laboratory

The volatile organic analysis (VOA) and semivolatile organic analysis (SVOA) samples were delivered to the Pacific Northwest Laboratory (PNL) Analytical Chemistry Laboratory on 05/03/93. The samples for the remaining analyses were received on 07/16/93 and 07/21/93.

Eight samples from Tank 241-AP-102 were delivered to PNL for VOA, SVOA, glycolate, oxalate, EDTA/HEDTA, and citrate analyses. All analyses were completed within a 14-day holding time based on sample receipt (Duchsherer, 1993). Maximum holding time limits for EDTA/HEDTA, citrate, glycolate, and oxalate have yet to be determined.

4.3 SAMPLE PREPARATION

Routine sample preparation procedures are discussed in the *Tank Characterization Reference Guide* (De Lorenzo et al., 1994). Additional procedures specific to this tank are described below.

4.3.1 Adjustments Due to Solid Precipitate

The presence of solid precipitate in samples taken from Tank 241-AP-102 required evaluation of the analytical methods used to detect the analytes. This evaluation was necessary to determine if the presence of the precipitate skewed the analytical results, and if so, what corrective actions needed to be taken. A description of the activities which took place at the 222-S Laboratory as a result of the solid precipitate is given below.

Upon discovery of the precipitate crystals, a technique was developed to keep the solids in solution prior to subsequent analysis. This technique involved gentle heating of the samples immediately prior to sample analysis, followed by a brief cooling period in order to obtain accurate volume measurements. This procedure was not communicated to all personnel working within the 222-S Laboratory, and analyses were performed on samples containing solids. Recognition of this error resulted in the development of a recovery plan which included the following items (Duchsherer, 1993):

- Each analytical method was reviewed to determine which ones would likely dissolve solids as part of the procedural steps. It was found that only inductively coupled plasma (ICP) and atomic absorption methods employed an acid digest (heating/dilution) preparation step, to adequately solubilize any solids prior to analysis.

- All samples were reanalyzed for those elements that comprised the solid compound.

- Four samples were picked at random to be reanalyzed for the full protocol of constituents. The only constituents that were omitted were those in which the analytical method employed a digestion/heating step. This was performed in order to demonstrate that no constituents other than those found comprising the hydrated sodium phosphate were carried down or co-precipitated with the solids.

Based on the results of the sodium phosphate precipitate crystals (see Section 4.1), the laboratory concluded that as long as no other constituents co-precipitated, sodium and phosphorous were the only analytes that needed to be redetermined. Sodium and elemental phosphorous were determined by ICP from samples prepared by acid digestion; therefore they were not reanalyzed. New samples, heated aliquots from each parent sample, were obtained for redetermination of phosphate by ion chromatography (IC) analysis. Special handling instructions accompanied the new aliquots to prevent the reformation of solids. To determine if any other anions were carried down with the sodium phosphate, four of the above samples submitted for IC analyses were reanalyzed for all constituents in the full grout characterization protocol.

As discussed in section 5.1.2, results from the analyses performed on the heated samples revealed consistently higher concentrations of both phosphate and sulfate anions. Therefore, the final reported concentrations of both phosphate and sulfate within Tank 241-AP-102 are based on the heated samples. Interpretation and discussion of the results from the heated samples is addressed in Section 5.1.2 of this report.

4.4 ANALYTICAL METHODS

This section briefly describes the analytical methods used to characterize the waste in Tank 241-AP-102, as well as those methods used to characterize the grout product produced from composite samples from the tank.

4.4.1 Physical Tests

Physical tests performed on the samples included weight percent water and specific gravity (SpG). The weight percent water procedure used approximately 1 ml of sample, which was heated in an oven at 120°C for 18 $\pm$ hours. The weight percent water was performed on all individual and composite samples in duplicate. The specific gravity analysis was performed on samples submitted for full characterization and the composite samples.

4.4.2 Homogeneity of Waste

Statistical analysis of the sodium, phosphate, and ^{137}Cs results was performed to determine the homogeneity of Tank 241-AP-102 (see Section 7.2 for a discussion of tank waste homogeneity). Data taken from 18 of the 25 samples taken from Tank 241-AP-102 were used to determine if the tank contents were homogeneous. The 18 samples consisted of 15 original samples and 3 duplicates. The following analyses were performed by the 222-S Laboratory on the samples: gamma energy analysis (GEA) for ^{137}Cs; ICP for sodium; and IC for phosphate. The tank waste was determined to be homogeneous after an analysis of variance (ANOVA) was performed on the results. The statistical method and results of this analysis may be found in Sections 7.2 and 7.3 of this characterization report. Determination of homogeneity early in the laboratory work allowed for preparation of a composite sample and conduction of the product tests concurrently with the comprehensive testing of the individual samples.

4.4.3 Chemical and Radionuclide Constituent Analysis

Twelve of the 18 samples used in the homogeneity analyses were randomly selected and tested for chemical and radionuclide constituents. The 12 samples consisted of 3 samples from each riser and 3 duplicates. From each of the 12 samples, two subsamples were taken for a total of 24 samples analyzed. Additionally, two subsamples from the composite sample (see Section 4.4.5) were analyzed for chemical and radionuclide composition. Table 4-1 lists the analytical methods.

Table 4-1. Analytical Methods (Hendrickson et. al., 1993). (2 pages)

Analyte	Method	Procedure
Hg	CVAA[1]	LA-325-104
As, Se	GHAA[2]	LA-355-131 LA-365-131
^{238}Pu, $^{239/240}Pu$, ^{241}Am, $^{243/244}Cm$, ^{237}Np	separation/Alpha/AEA[3]	LA-503-156 LA-933-141
Ag, Ba, Cd, Cr, Na, Ne, Pb, P, Al, Be, Sb, Fe	Inductively Coupled Plasma	LA-503-156 LA-508-051 LA-505-151
$^{235, 237, 238}U$	Uranium	LA-925-106
NH_3	Kjeldahl[4]	LA-634-102
CN^-	Dist/Spec[5]	LA-695-102
F^-, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}, PO_4^{3-}	Ion Chromatography	LA-533-105
TOC	Total Organic Carbon	LA-344-105
CO_3^{2-}	Total Inorganic Carbon	LA-622-102
^{90}Sr	separation/Beta[5]	LA-220-101
^{99}Tc	separation/LSC[6]	LA-438-101
^{14}C	separation/LSC	LA-348-104
^{134}Cs, ^{137}Cs, ^{94}Nb, $^{106}Ru/Rh$, ^{125}Sb, ^{144}Ce, ^{60}Co	Gamma Energy Analysis	LA-548-121 LA-508-052
^{129}I	separation/LE GEA[7]	LA-378-103
^{3}H	separation/LSC	LA-218-104

[1]Cold Vapor Atomic Absorption
[2]Gaseous Hydride Atomic Absorption
[3]Chemical Separation along with Alpha Proportional Counting and Alpha Energy Analysis
[4]Ammonia analysis by caustic addition, distillation, and capture in a boric acid solution
[5]Chemical Separation along with total Beta Proportional Counting
[6]Chemical Separation followed by Liquid Scintillation Counting
[7]Chemical Separation followed by Low Energy Gamma Energy Analysis

4.4.4 Volatile and Semivolatile Organic Constituent Analysis

Seven samples of waste from Tank 241-AP-102 were analyzed for volatile and semivolatile constituents by Pacific Northwest Laboratories (PNL). The seven samples (six samples plus one duplicate) were tested using the following methods (Hendrickson et al., 1993):

- Rapid screening by Headspace/Gas Chromatography to establish laboratory dilution requirements. PNL procedure PNL-ALO-331 is a modified version of EPA Method 3810 (EPA, 1986).

- Extracting the non-polar organics into Hexane or Isooctane followed by Gas Chromatography (GC) for volatile component analysis. PNL procedure PNL-ALO-335 follows the USEPA Contract Laboratory Program (CLP) Statement of Work (EPA, 1991).

- Gas Chromatograph Mass Spectrometry for semivolatile component analysis. PNL procedure PNL-ALO-345 follows the CLP protocol (EPA, 1991).

Quality assurance techniques of EPA methods cited were followed as closely as technically feasible. Section 7.5 of this report addresses the data validation findings from the analyses performed above.

4.4.5 Preparation of Composite Sample

Upon determination that Tank 241-AP-102 was homogeneous, a composite sample was generated from each of the 15 original samples (not duplicate). Before generating the composite sample, each of the original samples were brought to ambient conditions by incubation in an ultrasonic water bath for about 30 minutes and were vigorously mixed for approximately the last 5 minutes of this incubation. At the conclusion of the incubation/mixing period, 70 mL from each of the 15 original inorganic samples were combined to create the composite sample.

4.4.6 Grout Product Tests

Product tests of the final grout waste were conducted with material prepared from the composite samples (Welsh, 1993). Analyses included individual tests for viscosity, critical flow rate, frictional pressure drop, density, 10 minute gel strength, and drainable liquid (%v/v) after 28 days. The cured grout specimens were tested for compressive strength at 28 days, toxicity characteristic leaching procedure, and leach indices over 5 days with two of the three indices extended to 90 days. Additional assays regarding gas generation testing for the determination of radiolytic generation of hydrogen, nitrous oxides, and possibly other gases as the grout cured were performed on the hot grout samples. Proper procedures and protocols for the grout product tests can be found in Hendrickson, et al. (1993). The results from the grout product tests are not reported in this document since they do not reflect the contents of Tank 241-AP-102 and are not relevant to its characterization.

4.5 MODULE SPECIFIC ANALYSES

The characterization program for Tank 241-AP-102 was intended to satisfy criteria set by the Tank Waste Remediation System (TWRS) and the Hanford Grout Disposal Program (HGDP). The TWRS sample characterization objectives are to provide adequate characterization 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, 1993). The HGDP was one of the program elements of the TWRS designed for the retrieval and final disposal of low level wastes prior to a policy change eliminating grout as a disposal option. The needs of the HGDP are separate and in addition to those of the TWRS.

Low level waste from Tank 241-AP-102 was designated as potential feed for the (now terminated) Grout Treatment Facility (GTF). Having received this designation, the waste in Tank 241-AP-102 was sampled, analyzed, and tested to determine feed processability and to demonstrate compliance with regulatory requirements. The analytical requirements for the Grout Program not only entailed determination of the waste's suitability for disposal as grout, but also included determination of the grout product's physical and chemical characteristics to ensure regulatory compliance.

5.0 ANALYTICAL RESULTS AND WASTE INVENTORY

The chemical, radiochemical, physical, and organic complexant results associated with Tank 241-AP-102 are presented in Appendix A, Tables A-1 through A-5. Data corresponding to the volatile and semivolatile organic analyses are found in Tables A-6 through A-8. Table 5-1 summarizes, the presentation layout of the analytical data in Appendix A. The samples from which these results were derived were collected between 4-28-93 and 4-30-93 after the waste had been thoroughly blended by the action of a mixer pump. This sampling event was the most recent regarding Tank 241-AP-102 and reflects the most accurate characterization of the tank waste available at the present time. A detailed discussion of the sampling process was presented in Section 3.

Table 5-1. Analytical Data Presentation Tables.

Table	Analyses
A-1	Metals
A-2	Ions
A-3	Radionuclides
A-4	Organic Complexants
A-5	Physical Properties
A-6	Volatile Organics
A-7	Semivolatile Organics
A-8	Organic Compounds
5-7	Tank Characterization Report Results

In cases where a duplicate analysis was performed on a sample, the data presented in the Appendix A tables were obtained by calculating an average concentration value from the initial and duplicate results. If an analyte was detected by the original but not by the duplicate sample evaluation, or vise-versa, only the single positive result was reported. When both sample runs failed to detect an analyte, the detection limit preceded by a less than (<) sign was recorded as the sample results.

A representative tank concentration for each analyte was included in the Appendix A tables. Most of these values were derived according to a statistical model (Welsh, 1993) and were accompanied by a standard error estimate. When the statistical model could not be applied due to insufficient data, representative tank concentrations were obtained by calculating simple averages. If all available sample analyses failed to detect a particular analyte, the tank concentration of the analyte was reported to be less than the highest recorded detection limit. Detection limit values were not utilized in any of the calculations from which representative tank concentration values and standard error estimates were derived.

The range of the tabulated sample data associated with each analyte was also included in the Appendix A tables. The projected tank inventory value reported in the Appendix A tables was obtained by multiplying the representative tank concentration of each analyte by the volume of waste in the tank. At the time of sampling, the tank contained 4.18E+06 liters of waste. The appropriate conversion factors were included in the calculations to obtain the reported units.

5.1 CHEMICAL ANALYSES

5.1.1 Elemental Constituents

The following analytes were evaluated by ICP: Al, Sb, Ba, Be, Cd, Cr, Fe, Ni, K, Na, P, Pb, and Ag. Arsenic and selenium were analyzed by GHAA, and mercury was determined by CVAA. The laser fluorimetry method was utilized to evaluate uranium. As previously mentioned in Section 4, sodium phosphate apparently precipitated from the samples. The potential for obtaining artificially low sodium and phosphorus results due to the formation of sodium phosphate precipitate in samples designated for ICP analysis was eliminated by the acid digestion preparation step; therefore, the precaution of storing aliquots at elevated temperatures to prevent precipitation was deemed to be unnecessary. As a consequence, results obtained from the few available heated samples were not included in the determination of mean analyte concentrations of Tank 241-AP-102 unless specifically stated otherwise.

Sodium is the major elemental constituent in Tank 241-AP-102 and exhibits a concentration of 85,000 ppm. Of the remaining detected metal or elemental constituents, the concentrations of aluminum, chromium, phosphorous, and potassium exceeded 500 ppm and were relatively high compared to the remaining analytes. Mercury and silver were evaluated by the laboratory, but their concentrations proved to be below their corresponding detection limits.

With respect to uranium, two separate runs, each consisting of initial and duplicate analyses, were conducted on the unheated composite sample. These results were then confirmed by the analysis of four samples which were preserved under elevated temperature conditions. The representative tank concentration of uranium wa, therefore, derived from data obtained from both heated and unheated samples.

Arsenic was only detected in the composite sample, G443. The analysis of several samples which were stored at 40°C failed to detect arsenic and were not recorded in Appendix A. The reported arsenic value, therefore, represents a worse case estimate.

Elemental constituents, for which both laboratory data and historical estimates are available, are listed in Table 5-2. Relative percent differences were calculated in order to facilitate their comparison.

Table 5-2. Comparison of Analytical and Historical Estimates of Elemental Constituents in Tank 241-AP-102.

Analyte	Laboratory Result (μg/L)	Historical Estimate (μg/L)	Relative Percent Difference
Al	1.67E+06	8.17E+06	35%
As	88.7	63.4	33%
Ba	284	< 11,100	N/A
Cd	1,470	< 49,000	N/A
Cr	618,000	496,000	22%
Fe	3,810	< 6,900	N/A
Pb	3,290	< 460,000	N/A
Hg	< 5.00	< 50	N/A
P	3.06E+06	6.05E+06	66%
K	1.29E+06	9.50E+05	30%
Se	367	118	103%
Ag	< 125	< 3,630	N/A
Na	1.02E+08	8.10E+07	23%
U	4,620	3,520	27%

5.1.2 Anions

The following anions were determined by ion chromatography (IC): fluoride, chloride, nitrite, nitrate, sulfate, and phosphate. The samples involved with the IC analyses were analogous to those utilized in the ICP evaluations; however, two complete sets of data were reported by the laboratory for the IC analytes. One set of data was derived from samples which were stored at ambient temperature during the time interval between collection and analysis; sodium phosphate had precipitated in this group. The second set of results was obtained from samples which were heated to 40°C prior to their analysis. The elevated temperature prevented sodium phosphate precipitation and allowed the entire phosphate component to be appropriately analyzed in solution.

The greater sulfate concentrations observed in the heated versus unheated specimens indicated that a sulfate salt, in addition to a phosphate salt, may have also precipitated from the samples, but the sulfate salt is not likely to be a sodium derivative. This possibility is supported by the solubility data listed in Table 5-3 obtained from the *CRC Handbook of Chemistry and Physics*, (Lide, 1991-92).

Table 5-3. Solubility of Common Sodium Salts.

Salt	Solubility in Water g/100 mL
$Na_3PO_4 \bullet 12\ H_2O$	1.5
$Na_2SO_4 \bullet 7\ H_2O$	19.5
NaCl	35.7
$NaNO_2$	81.5
$NaNO_3$	92.1

The heptahydrate of sodium sulfate is considerably less soluble in water than the corresponding chloride, nitrite, and nitrate salts but not nearly as insoluble as the dodecahydrate of sodium phosphate. This information is consistent with the laboratory findings which concluded that the precipitate was hydrated sodium phosphate, and results from solubility product calculations demonstrate that sodium sulfate heptahydrate will not precipitate with respect to the reported ion concentrations in the tank. Since the multivalent nature of sulfate, as well as phosphate, contributes to decreased solubility compared to the monovalent anions, it is still reasonable to suspect sulfate to precipitate to some extent. As a consequence, the data listed for F^-,Cl^-, NO_2^-, and NO_3^- in Table A-2 were derived from unheated samples; the sulfate and phosphate results were acquired from the heated specimens.

Another explanation regarding the observed increase in the sulfate concentration derived from heated versus non-heated samples involves the possible dissociation of a complex ion. When sulfate acts as a ligand in a complex ion, it cannot be detected by ion chromatography. An increase in temperature could cause the dissociation of a hypothetical complex ion and allow a larger number of free sulfate ions to be analyzed. This argument is somewhat supported by the nitrate results, since several samples exhibited higher concentration values after having been heated. The chloride and nitrite data, however, seem to contradict the complex ion theory.

Fluoride was not detected in any of the samples by the IC analyses and was further evaluated by an ion selective electrode (ISE) method; however, the anion failed to be detected by the ISE technique as well. According to the data validation report (Duchsherer, 1993), the IC data were considered to be more reliable than the ISE results; therefore, the detection limit associated with the IC analyses was recorded in Table A-2.

The only detectable cyanide data for Tank 241-AP-102 was obtained from sample G443, the composite sample, at an average tank concentration of 24.6 μg/mL. Several samples which were stored at 40° C were analyzed for cyanide and yielded consistently lower results when compared to the unheated composite specimen. The data from heated samples were, therefore, disregarded in order to avoid calculating a mean tank cyanide concentration possessing a low bias.

Comparisons between the laboratory data and historical estimates associated with ammonia and the anionic constituents are presented in Table 5-4. The reported analytical carbonate value was calculated from the total inorganic carbon data. Table 5-4 also demonstrates that the ion chromatography phosphate result shows better agreement with the historical estimate that the ICP derived phosphate value.

Table 5-4. Comparison of Analytical and Historical Estimates of Anionic Constituents in Tank 241-AP-102.

Analyte	Laboratory Result (µg/L)	Historical Estimate (µg/L)	Relative Percent Difference
Ammonia	273,000	108,000	87%
Carbonate	2.68E+07	1.74E+07	43%
Chloride	2.90E+06	2.16E+06	29%
Cyanide	24,600	5,280	129%
Fluoride	< 168,000	< 61,600	N/A
Hydroxide	9.15E+06	7.09E+06	25%
Nitrate	7.82E+07	6.03E+07	26%
Nitrite	3.80E+07	2.60E+07	38%
Phosphate (IC)	1.16E+07	1.80E+07	43%
Phosphate (ICP)	9.38E+06	1.80E+07	63%
Sulfate	4.51E+06	2.06E+06	75%

5.2 RADIOLOGICAL DETERMINATIONS

The major radioactive constituents in the waste were ^{137}Cs and ^{90}Sr; ^{99}Tc and ^{60}Co were present to a lesser extent. Of the alpha emitting isotopes, only ^{241}Am demonstrated a detectable activity. The results from the tritium analyses were qualified as unusable due to poor matrix spike recoveries; however, the tritium value reported by the laboratory is relatively unimportant since it is dwarfed by the ^{137}Cs activity. The analytical and historical results pertaining to several isotopes are listed in Table 5-5.

5.3 ORGANIC CONSTITUENTS

Most of the target analytes associated with the volatile and semivolatile organic analyses were not detected in the waste. However, detectable concentrations of acetone, 2-butanone, toluene, and 1-butanol were reported by the laboratory, and their individual sample results are specifically tabulated in Appendix A.

The total organic carbon (TOC) analysis revealed the presence of 3.28 g/L of carbon in Tank 241-AP-102, and this result was consistent with the historical estimate. A list of organic complexants which were expected to account for some of the total organic carbon detected in the tank waste is presented in Table 5-6; the concentration of each ligand and the concentration of carbon associated with each ligand were also reported.

Table 5-5. Comparison of Analytical and Historical Isotopic Results for Tank 241-AP-102.

Analyte	Laboratory Result (μCi/L)	Historical Estimate (μCi/L)	Relative Percent Difference
^{137}Cs	228,000	180,000	24%
^{90}Sr	1,440	1,960	31%
^{14}C	0.499	0.295	51%
^{99}Tc	85.6	60.7	34%
^{60}Co	76.3	< 9	N/A
^{241}Am	0.419	0.534	24%

Table 5-6. Organic Complexant Concentration Data.

Complexant or Ligand	grams of COMPLEXANT per liter (g/L)	grams of CARBON per liter (g/L)
Citrate	0.515	0.196
EDTA	0.519	0.216
HEDTA	0.110	0.048
Glycolate	1.10	0.352
Oxalate	0.760	0.207
Total Carbon from Analyzed Complexants		1.02

As demonstrated in the table, the amount of carbon attributable to these complexants is 1.02 g/L and accounts for approximately 30% of the 3.28 g/L TOC value. Since the organic carbon contribution from volatile and semivolatile organic compounds in Tank 241-AP-102 is negligible, the remaining organic carbon in the waste is attributed to the presence of additional complexants, either intact molecules or decomposition products.

5.4 PHYSICAL PROPERTIES

5.4.1 Specific Gravity, Percent Water, and pH

The specific gravity and percent water results from the tank samples agreed within 3% and 4%, respectively, of the historic tank content estimated values (see Table 5-7). The determined values for the specific gravity and percent water of the waste are 1.20 g/cm^3 and 75.0% respectively. The pH of the waste in Tank 241-AP-102 was calculated from the hydroxide ion concentration and reported to be 13.7. The historical pH estimate was 13.6.

5.4.2 Rheology

Due to the lack of rheology measurements, the viscosity of the tank waste was estimated. The specific gravity of the waste is 1.20 g/ml, and according to the Total Dissolved Solids analysis, the percentage of water, by weight, is 75%. Since a 25%, by weight, sodium chloride solution has a specific gravity of 1.19, its corresponding viscosity of 1.9 centipoise (0.0013 lbs/ft. sec) was considered to be the viscosity of the waste. It is recommended, however, that the viscosity be determined experimentally by a laboratory.

5.4.3 Energetics

Energetics were not analyzed as part of the test suite of assays because the high water content of the double-shell tank waste makes them unlikely candidates for an exothermic reaction occurring under the present tank operating conditions.

5.5 DATA PRESENTATION

The Tank Characterization Report Results recorded in Table 5-7 are the final constituent estimates for this document. The values are equal to the representative tank concentrations presented in the Appendix A tables. 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 5-7. Tank Characterization Report Data for Double-Shell Tank 241-AP-102. (3 pages)

Analyte	Historic Tank Content Estimate	Tank Characterization Result		Total Tank Inventory
Metals	(µg/L)	(µg/L)	µg/g	(kg)
Aluminum (Al)	8.17 E+06	1.16E+07	9,670	48,500
Antimony (Sb)	---	6,610	5.51	27.6
Arsenic (As)	63.4	88.7	0.0739	0.371
Barium (Ba)	< 11,100	284	0.237	1.19
Beryllium (Be)	---	146	0.122	0.610
Bismuth (Bi)	< 1.45E+05	---	< 121	< 606
Boron (B)	600	---	0.00209	2.51
Cadmium (Cd)	< 49,600	1,470	1.23	6.14
Calcium (Ca)	80,000	---	66.7	334
Chromium (Cr)	4.96E+05	6.18E+05	515	2,580
Copper (Cu)	< 3,750	---	< 3.13	< 15.7
Iron (Fe)	< 6,900	3,810	3.18	15.9
Lead (Pb)	< 4.60E+05	3,290	2.74	13.8
Magnesium (Mg)	2,630	---	2.19	11.0
Manganese (Mn)	< 55,700	---	< 46.4	233
Mercury (Hg)	< 50	< 5.00	< 0.00417	< 0.0209
Molybdenum (Mo)	< 66,600	---	< 55.5	< 278
Neptunium (Np)	< 3,000	---	< 2.50	< 12.5
Nickel (Ni)	---	26,600	22.2	111
Phosphorus (P)	6.05E+06	3.06E+06	2,550	12,800
Potassium (K)	9.50E+05	1.29E+06	1,080	5,390
Selenium (Se)	118	0.367	0.306	1.53
Silicon (Si)	480	---	0.400	2.01
Silver (Ag)	< 3,630	< 125	< 0.104	< 0.523
Sodium (Na)	8.10 E+07	1.02E+08	85,000	4.26E+05
Titanium (Ti)	< 3,510	---	< 2.93	14.7
Uranium (U)	3,520	4,620	3.85	19.3
Zinc (Zn)	< 9,440	---	< 7.87	< 39.5
Zirconium (Zr)	< 27,800	---	< 23.2	< 116

Table 5-7. Tank Characterization Report Data for Double-Shell Tank 241-AP-102. (3 pages)

Analyte	Historic Tank Content Estimate	Tank Characterization Result		Total Tank Inventory
Ions	(µg/L)	(µg/L)	µg/g	(kg)
Ammonia (NH_3)	1.08E+05	2.73E+05	228	1,140
Carbonate ($CO_3^{=}$)	1.74 E+07	2.68E+07	22,300	1.12E+05
Chloride (Cl^-)	2.16E+06	2.90E+06	2,420	12,100
Cyanide (CN^-)	5,280	24,600	20.5	103
Fluoride (F^-)	< 61,600	< 1.68E+05	< 140	< 702
Hydroxide (OH^-)	7.09E+06	9.15E+06	7,630	38,200
Nitrate (NO_3^-)	6.03E+07	7.82E+07	65,200	3.27E+05
Nitrite (NO_2^-)	2.60E+07	3.80E+07	31,700	1.59E+05
Phosphate ($PO_4^{=}$)	1.80E+07	1.16E+07	9,670	48,500
Sulfate ($SO_4^{=}$)	2.06E+06	4.51E+06	3,760	18,900
Radionuclides	(µCi/L)	(µCi/L)	µCi/g	(Ci)
^{241}Am	0.534	0.419	3.49E-04	1.75
^{125}Sb	---	< 431	< 0.359	< 1,800
^{14}C	0.295	0.499	4.16E-04	2.09
$^{144}Ce/Pr$	---	< 1,030	< 0.00108	< 4,310
^{134}Cs	< 24	< 29.8	< 0.0248	< 125
^{137}Cs	180,000	2.28E+05	190	9.53E+05
^{60}Co	< 9	76.3	0.0636	319
^{242}Cm	0.00112	---	9.33E-07	0.00468
^{2143}Cm	0.0414	---	3.45E-05	0.173
^{244}Cm	0.00439	< 0.0637	< 5.31E-05	< 0.266
^{129}I	< 0.0750	< 0.0370	< 3.08E-05	< 0.155
^{237}Np	---	< 1.00	< 8.33E-04	< 4.18
^{94}Nb	< 23	< 25.7	< 0.0214	< 107
^{238}Pu	0.0176	< 0.163	< 1.36E-04	< 0.681
$^{239/240}Pu$	0.0333	< 0.0748	< 6.23E-05	< 0.313
$^{106}Ru/Rh$	< 1,390	< 1,390	< 1.16	< 5,810
^{79}Se	0.211	---	1.76E-04	0.882
$^{89/90}Sr$	1,960	1,440	1.20	6,020

Table 5-7. Tank Characterization Report Data for Double-Shell Tank 241-AP-102. (3 pages)

Analyte	Historic Tank Content Estimate	Tank Characterization Result		Total Tank Inventory
Radionuclides (cont.)	(μCi/L)	(μCi/L)	μCi/g	(Ci)
^{99}Tc	60.7	85.6	0.0713	358
Total alpha	0.004	---	3.33E-06	0.0167
^{3}H	2.6	~~13.0~~	0.00217	10.9
Organic Complexants	(mg/L)	(mg/L)	μg/g	(kg)
Citrate	---	515	429	2.15
EDTA	---	519	433	2.17
HEDTA	---	110	91.7	0.460
Glycolate	---	1,100	917	4,600
Oxalate	---	760	633	3,180
Physical Properties				
Water	77.6%	75.0%		N/A
pH	13.6	13.7		N/A
Specific Gravity	1.23 g/cm^3	1.20 g/cm^3		N/A
TOC	2.87E+06 μg/L	3.28E+06 μg/L	2,730 μg/g	13,700 kg
TIC	---	5.35E+06 μg/L	4,460 μg/g	22,400 kg
Organics	(μg/L)	(μg/L)	μg/g	(kg)
Acetone	---	< 500	< 0.417	< 2.09
1-Butanol	---	618	0.515	2.58
2-Butanone	---	< 500	< 0.417	< 2.09
Toluene	---	< 500	< 0.417	< 2.09

6.0 ANALYTICAL RESULTS INTERPRETATION

6.1 TANK WASTE PROFILE

Examination of the analytical results shows that the waste in Tank 241-AP-102 is primarily an aqueous solution of inorganic salts. The most abundant constituents in the tank are sodium, nitrite, nitrate, and phosphate. The high phosphate contents is consistent with the fill history of the tank since the majority of the waste added to Tank 241-AP-102 consisted of concentrated phosphate (CP) waste from Tank 241-AP-106. The concentrated phosphate waste originated from the decontamination of Hanford's N-Reactor and contained appreciable levels of ^{137}Cs and ^{90}Sr as confirmed by the analyses of the contents of Tank 241-AP-102. Most of the organic compounds in the waste are attributed to the presence of organic complexants or their decomposition products.

6.2 WASTE SUMMARY AND CONDITIONS

6.2.1 In-Tank Chemistry

The most significant characteristic of the tank chemistry is the high dissolved solids content and the potential for precipitation upon cooling. At the temperature sampled, the tank contents will remain a homogenous, non-viscous liquid. It is unclear however, if the tank temperature of 81°F at sampling was due to the physical stirring of the tank contents prior to sampling, heats of solution resulting from increased mixing, radiological heating, the onset of spring weather, or simply calibration problems with the thermocouples. The amount of heat resulting from radioactivity in the tank is calculated in Table 6-1. If cooling effects are neglected, the reported value, 4,630 Watts, translates into a temperature increase in Tank 241-AP-102 of approximately 7°C, or 13°F, per year. Since the temperature of the tank ranges between 78 and 86°F, it may be concluded that the elevated temperature is due to radioactive activity, however most of the heat generated throughout the year is dissipated.

6.2.2 Regulatory Limits

The following constituents were found at concentrations greater than the toxicity characteristic leach procedure (TCLP) thresholds (40 CFR Part 261):

Constituent	Concentration (mg/L)	TCLP Limit (mg/L)
Cadmium	1.47	1.0
Chromium	618	5.0

In addition, the calculated pH of 13.7 was well above the *Resource Conservation and Recovery Act* pH limit of 12.5 for corrosivity; however, buffering effects were not taken into consideration.

Table 6-1. Tank 241-AP-102 Radionuclide Inventory and Projected Heat Load.

Radionuclide	Ci	Watts
^{241}Am	1.75	0.0574
^{125}Sb	< 1,800	< 6.01
$^{144}Ce/Pr$	< 4,310	< 34.5
^{134}Cs	< 123	< 1.25
^{137}Cs	9.53E+05	4,490
^{60}Co	319	4.91
^{242}Cm	0.00468	1.69E-04
^{244}Cm	< 0.265	< 9.15E-03
^{129}I	< 0.155	< 7.25E-05
^{237}Np	< 4.18	< 0.120
^{238}Pu	< 0.681	< 0.0220
$^{239/240}Pu$	< 0.312	< 0.00952
$^{106}Ru/Rh$	< 5,810	< 56.1
$^{89/90}Sr$	6,020	40.3
^{99}Tc	358	0.179
Total Watts		**~ 4,630**

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 (DQO) process, and expressed in a series of program specific DQO 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-AP-102. 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 6-2 is a summary of which program data needs are fulfilled through this characterization of the waste in Tank 241-AP-102, 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 6-2. Applicability of Characterization Information to the Data Needs of the TWRS Program Elements.

Data Quality Objective	Applicability to Characterization of Tank 241-AP-107
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	applies
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-AP-102 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-AP-107.

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.

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7.0 STATISTICAL INTERPRETATION

7.1 MASS AND CHARGE BALANCES

The principal objective for performing a mass and charge balance is to determine if the measurements are self-consistent. In calculating the balances, only analytes detected at a concentration of 1 ppm or greater were considered. All phosphorous in the tank was assumed to be present as phosphate; therefore, the IC phosphate value rather than the ICP phosphorous result was included in the calculations. Aluminum was theorized to exist as tetrahydroxoaluminate, $Al(OH)_4^-$. Table 7-1a lists the cations and anions used in the analysis.

Even though the free hydroxide concentration of Tank 241-AP-102 was measured by the laboratory, it was treated as an unknown during this exercise. Since a calculated charge imbalance resulted in the absence of hydroxide, a theoretical hydroxide value was determined by utilizing the ion to correct for the deficient negative charge. The mass of hydroxide was then predicted from the derived charge.

Mass and charge balance results are reported in Table 7-1b. The mass concentration, μg/g, resulting from the sum of the cations, anions, and hydroxide 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 Table 7-1b demonstrates that the predicted values for hydroxide and water agree to within $\pm$ 5% of the recorded Tank Characterization Report results which were derived from the analytical data.

7.2 HOMOGENIZATION TESTS

This discussion of homogeneity in Tank 241-AP-102, along with the supporting tables, were taken from Welsh (1993).

The characterization test plan requested that the homogeneity of the waste within Tank 241-AP-102 be determined based on the analytical results of Na, ^{137}Cs, and PO_4^{3-}. Differences between the analytical results at the 15 locations sampled within Tank 241-AP-102 were used to address this request. The composite analytical results are included as a sixteenth location for the statistical analysis and random analytical error estimate calculation.

An analysis of variance (ANOVA) was calculated on the sample results using the structure in the model described later in section B.1 of Appendix B. The ANOVA table contains a test that determines if the variability between locations (σ_L^2) is significantly greater than zero. If the test indicates that σ_L^2 is significantly greater than zero, then it is concluded that the tank is not homogenous with respect to that analyte. If the test indicates that σ_L^2 is not significantly different from zero, then it is concluded that the tank is homogenous with respect to that analyte. These tests, one for each analyte (Na, ^{137}Cs, and PO_4^{3-}) were conducted at the 0.05 level of significance. The p-values from the statistical tests were 0.7952 for Na, 0.5178 for ^{137}Cs, and 0.2447 for PO_4^{3-}; if the p-value was less than 0.05 then σ_L^2 is significantly different than zero.

Table 7-1a. Mass and Charge Balance.

	Mass µg/g	Charge µmol/g
Cations		
Antimony	5.51	0.226
Cadmium	1.23	0.022
Calcium	66.7	3.34
Chromium	515	19.8
Iron	3.18	0.171
Magnesium	2.19	0.180
Potassium	1,080	27.6
Sodium	85,000	3,700
Uranium	3.85	0.970
Anions		
Chloride	2,420	68.3
Cyanide	20.5	0.788
Nitrate	65,200	1,052
Nitrite	31,700	689
Phosphate	9,670	305
Sulfate	3,760	78.3
Carbonate (TIC)	22,300	743
Tetrahydroxoaluminate $Al(OH)_4^-$	34,000	358

Table 7-1b. Mass and Charge Balance Totals

Totals		
Cations	86,700	+3752
Anions	169,000	-3294
Predicted Hydroxide from Charge Balance	7,790	-458
Predicted Water from Mass Balance	737,000	
Hydroxide (TCR result)	7,630	
Water (TCR result)	750,000	

The Na, ^{137}Cs, and PO_4^{3-} data are contained in Tables 7-2, 7-3, and 7-4 respectively. For all three analytes the ANOVA indicated that σ_L^2 is not significantly different from zero. Therefore, based on the Na, ^{137}Cs, and PO_4^{3-} analytical results, the contents of Tank 241-AP-102 are considered to be homogenous.

The ANOVA was calculated using the sample results for the remaining analytes that were reported with "real" numbers (no "less than" values). The ANOVA indicated that σ_L^2 is not significantly different from zero at the 0.05 level of significance for Al, Ba, Cd, Cr, Fe, Ni, K, P, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}, TOC, percent water, OH^-, ^{90}Sr, ^{14}C, ^{99}Tc, ^{241}Am, Se, HEDTA, EDTA, and Citrate. The ANOVA indicated that σ_L^2 is significantly different from zero for Be and TIC.

7.3 ANALYTICAL ERROR ESTIMATION

Analytical error consists of two parts, random and systematic. Table 7-5 outlines both the analytical and systematic error estimates with actual data, organized by analyte (Welsh, 1993). Error estimates were not done for analytes with "less than" (non-detected) values.

Random Analytical Error

The estimate of the random analytical error for each analyte can be determined from the analytical results from the duplicate samples, from the analysis of standards. However, the analysis of standards does not account for all sources of variability, such as matrix interferences.

The duplicate sample results were analyzed to determine if any had a relative percent difference (RPD) or relative standard deviation (RSD) value exceeding the criterion of three times the random analytical error from sample results of the analyte values listed in the first data column of Table 7-5. Barium has three duplicate samples with an RPD or RSD over the criterion and beryllium, cadmium, iron, nickel, hydroxide, EDTA, and HEDTA each had one duplicate pair over the criterion. The problem with barium was due to the sample concentration being near the detection limit. Detection limit proximity also resulted in the high RSD for uranium, although none of the sample duplicates exceeded the criterion. When the single sample pair over the criterion were deleted from the analysis for iron and TIC, the RSDs became 16.5 and 3.8, respectively (Table 7-5).

An extremely large error estimate, 76%, was calculated for the sample results of ^3H. This can be attributed to problems in the analytical methodology. Distillation techniques used to recover tritiated water vapor from samples (tritium must be in the form of tritiated water) did not perform well. Therefore, the ^3H results are questionable and may exhibit a low bias.

A statistical analysis of glycolate was not performed since all of the data were the same value. For the organic constituents, it was not possible to calculate measurement error estimates from standard results since the High Performance Liquid Chromatography (HPLC) and Ion Chromatography (IC) methods utilized to analyze them are relatively new procedures currently under development.

Table 7-2. Na Data. (Welsh, 1993)

Sample Number	Position	Na µg/L Result 1	Na µg/L Result 2	Na µg/L mean	RPD
G342	1	1.00E+08	1.00E+08	1.00E+08	0.1
G449	2	1.02E+08	1.01E+08	1.01E+08	0.9
G450	3	1.04E+08	1.04E+08	1.04E+08	0.3
G348	4	1.03E+08	1.02E+08	1.03E+08	1.0
G352	5A	1.02E+08	1.01E+08	1.01E+08	0.2
G349	5B	1.06E+08	1.02E+08	1.04E+08	3.6
G453	6	1.02E+08	1.05E+08	1.04E+08	2.7
G358	7A	1.03E+08	9.98E+07	1.01E+08	4.2
G353	7B	1.00E+08	1.01E+08	1.00E+08	0.8
G454	8	1.03E+08	1.03E+08	1.03E+08	0.6
G359	9	9.91E+07	9.80E+07	9.58E+07	1.1
G363	10	1.01E+08	9.99E+07	1.00E+08	0.7
G364	11	1.03E+08	1.00E+08	1.03E+08	2.4
G333	12	9.97E+07	1.00E+08	1.00E+08	0.5
G459	13A	1.02E+08	1.02E+08	1.03E+08	0.7
G460	13B	1.02E+08	1.00E+08	1.01E+08	1.3
G338	14	1.03E+08	1.03E+08	1.03E+08	0.3
G341	15	1.01E+08	1.01E+08	1.01E+08	0.3
G443	COMP	1.02E+08	1.02E+08	1.02E+08	0.2
G470*	COMP	1.06E+08	1.05E+08	1.05E+08	0.8

Table 7-3. ^{137}Cs Data. (Welsh, 1993).

Sample Number	Position	^{137}Cs µCi/mL Result 1	^{137}Cs µCi/mL Result 2	^{137}Cs µCi/mL mean	^{137}Cs Standard Deviation	RPD or RSD
G342	1	2.32E+02	2.35E+02	2.335E+02	-	1.3
G449	2	2.30E+02	2.30E+02	2.300E+02	-	0.0
G450	3	2.29E+02	2.35E+02	2.320E+02	-	2.6
G477*	3	2.20E+02	2.22E+02	2.210E+02	-	0.9
G348	4	2.32E+02	2.17E+02	2.245E+02	-	6.7
G352	5A	2.25E+02	2.25E+02	2.250E+02	-	0.0
G349	5B	2.36E+02	2.38E+02	2.370E+02	-	0.8
G453	6	2.33E+02	2.33E+02	2.330E+02	-	0.0
G358	7A	2.15E+02	2.16E+02	2.178E+02	3.6	1.7
G358	7A RR	2.17E+02	2.23E+02			
G353	7B	2.28E+02	2.28E+02	2.255E+02	3.0	1.3
G353	7B RR	2.22E+02	2.24E+02			
G454	8	2.29E+02	2.28E+02	2.285E+02	-	0.4
G471*	8	2.15E+02	2.10E+02	2.125E+02	-	2.4
G359	9	2.25E+02	2.25E+02	2.250E+02	-	0.0
G363	10	2.37E+02	2.35E+02	2.360E+02	-	0.8
G364	11	2.25E+02	2.22E+02	2.235E+02	-	1.3
G333	12	2.25E+02	2.24E+02	2.245E+02	-	0.4
G459	13A	2.15E+02	2.19E+02	2.170E+02	-	1.8
G460	13B	2.12E+02	2.16E+02	2.140E+02	-	1.9
G338	14	2.26E+02	2.27E+02	2.265E+02	-	0.4
G341	15	2.34E+02	2.36E+02	2.350E+02	-	0.9
G476*	15	2.24E+02	2.25E+02	2.245E+02	-	0.4
G443	COMP	2.41E+02	2.42E+02	2.235E+02	20.9	9.3
G443	COMP RR	2.03E+02	2.08E+02			
G470*	COMP	2.15E+02	2.17E+02	2.160E+02	-	0.9

*: Heated sample.
RR: Re-run.

Table 7-4. PO_4^{-3} Data. (Welsh, 1993).

Sample Number	Position	^{137}Cs µCi/mL Result 1	^{137}Cs µCi/mL Result 2	^{137}Cs µCi/mL mean	^{137}Cs Standard Deviation	RPD or RSD
G509	1	1.19E+04	1.22E+04	1.205E+04	-	2.5
G523*	2	1.16E+04	1.15E+04	1.155E+04	-	0.9
G477*	3	1.14E+04	1.29E+04	1.140E+04	1.061E+03	9.5
G477*	3 RR	1.06E+04	1.07E+04			
G510*	4	1.07E+04	1.18E+04	1.125E+04	-	9.8
G521*	5A	1.23E+04	1.20E+04	1.215E+04	-	2.5
G511*	5B	1.13E+04	1.11E+04	1.205E+04	-	1.8
G527*	6	1.24E+04	1.02E+04	9.740E+03	2.014E+03	20.7
G527*	6 RR	8.09E+04	8.27E+04			
G515*	7A	1.15E+04	1.23E+04	1.190E+04	-	6.7
G522*	7B	1.24E+04	1.24E+04	1.240E+04	-	0.0
G471*	8	1.28E+04	1.19E+04	1.235E+04	-	7.3
G516*	9	1.03E+04	1.03E+04	1.160E+04	8.680E+02	7.5
G516*	9 RR	1.21E+04	1.21E+04			
G533*	10	1.22E+04	1.22E+04	1.220E+04	-	0.0
G534*	11	1.20E+04	1.20E+04	1.190E+04	-	1.7
G528*	12	1.05E+04	1.05E+04	1.075E+04	-	4.7
G517*	13A	1.14E+04	1.14E+04	1.150E+04	-	1.7
G536*	13B	1.18E+04	1.18E+04	1.185E+04	-	0.8
G528*	14	1.13E+04	1.13E+04	1.130E+04	-	0.0
G476*	15	1.28E+04	1.28E+04	1.235E+04	-	7.3
G470*	COMP	1.29E+04	1.29E+04	1.330E+04	-	6.0

*: Heated sample.
RR: Re-run.

Systematic Analytical Error

The estimate of the systematic error is determined from the analysis of standards or spike recoveries. The third and fourth columns of Table 7-5 list the systematic analytical error estimates for each analyte (Welsh, 1993). Spike precision was good for all analytes except citrate, in which both spikes were outside the specified limits of 100 $\pm$ 25%.

Table 7-5. Measurement Error Estimates (Welsh, 1993). (2 pages)

Analyte	Random analytical error estimate 1 RSD (%)		Systematic error estimate 1 RSD (%)	
	From sample results	From standard results	From standard results*	From spike analyses
Al	1.2	4.6	4.7	1.3
Ba	16.1	2.1	2.4	2.9
Be	6.6	3.7	0.8	4.8
Cd	6.7	3.4	2.4	5.4
Cr	1.8	3.4	1.3	5.5
Fe Fe *	37.1 16.5	2.3 2.3	2.2 2.2	3.7 3.7
Ni	2.1	3.0	0.4	3.6
K	1.8	3.8	2.6	2.7
Na	2.3	2.2	2.4	NA**
P	2.7	3.7	4.4	NA
Cl^-	5.6	4.6	0.8	2.9
NO_2^-	5.8	3.8	0.4	2.6
NO_3^-	5.7	4.6	2.8	5.6
PO_4^{3-}	7.5	4.0	1.5	8.0
SO_4^{2-}	5.8	3.7	2.7	9.0
SpG	0.2	0.6	1.1	NA
TIC	3.9	3.5	3.2	2.6
TOC TOC #	14.6 3.8	3.0 3.0	4.7 4.7	2.7 2.7
% Water	0.3	1.2	1.4	NA
OH^-	1.7	2.0	0.2	NA
^{137}Cs	3.4	5.1	6.3	NA
^{90}Sr	6.9	8.1	3.6	NA
^{14}C	15.3	3.7	10.5	6.1
^{99}Tc	5.5	8.6	9.4	4.9
^{241}Am	23.9	13.6	4.8	NA
Se	4.5	7.7	5.1	7.0
CN^-	1.3	2.3	5.5	7.2
U	42.0	7.3	4.1	1.9

Table 7-5. Measurement Error Estimates (Welsh, 1993).
(2 pages)

Analyte	Random analytical error estimate 1 RSD (%)		Systematic error estimate 1 RSD (%)	
	From sample results	From standard results	From standard results[&]	From spike analyses
NH_3/NH_4^+	4.2	7.5	3.7	7.6
^3H	76	5.2	4.8	***
HEDTA	45.7	NA	NA	11
EDTA	27.9	NA	NA	10
Citrate	11.8	NA	NA	33
Glycolate	NA	NA	NA	20
Oxalate	6.8	NA	NA	0

*: Excluded results from position 7A.
#: Excluded results from position 10.
&: Calculated from the Laboratory Measurement Control System standards analyzed in conjunction with the samples.
**: Analyses not performed.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 SAFETY ISSUES

Characterization of Double-Shell Tank 241-AP-102 supports the designation of the tank as non-Watch List. Given the current tank inventory of fissionable radionuclides, organic, and exothermic waste constituents, no credible potential exists for loss of tank integrity or release of radioactivity due to in-tank processes. Tank 241-AP-102 is within established operating safety requirements as defined by applicable Data Quality Objectives.

Tank 241-AP-102 is considered sound and non-leaking (Hanlon, 1994), and examination of the waste volume history supports this conclusion (Koreski, 1994). Thermocouple data indicate that while tank temperatures are elevated above ambient soil temperatures, there is no credible risk of self-boiling or excessive heating of the current tank contents. Given the present tank integrity and waste properties, the continued active operation of Tank 241-AP-102 for waste management and storage functions poses no unreasonable risk to personnel, the public, or the environment.

8.2 FURTHER CHARACTERIZATION NEEDS

Characterization of the liquid contents of Tank 241-AP-102 has been performed in this report. Further sampling and analysis of the contents of Tank 241-AP-102 is suggested for the following waste properties:

- Analysis of the tank vapor space would allow final resolution of any safety concerns regarding the presence of flammable or noxious vapors in the vapor phase.

- Characterization of the physical properties of the waste prior to retrieval or transfer operations is necessary to resolve potential waste property uncertainties. Specifically, precipitation studies should be performed to ensure that solids formation does not interfere with retrieval operations. In addition, X-Ray Diffractometry can be employed to determine the species present in the tank waste. Rheological analyses also need to be conducted.

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Appendix A. Analytical Results Presentation

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Appendix A. Analytical Results Presentation

A.1 Introduction

Appendix A presents the chemical and radiological characteristics of Tank 241-AP-102 in a tabular form, in terms of the specific concentrations of anions, metals, radionuclides, organic complexants, physical properties, and volatile and semivolatile organic compounds.

The data table for each analyte lists laboratory sample identification, analytical result, standard deviation, range of results, 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 and 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

Ions:

COL - Colorometric Spectrophotometry

COUL - Coulorometric Titration

DT - Distillation and Titration

IC - Ion Chromatograph

ISE - Ion Selective Electrode

Radio-nuclides

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 followed by acid digestion.

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". The 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. The "Sampling 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. Note that the results for SO_4 and PO_4 are from heated samples.

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 Tank 241-AP-102 data package (Duchsherer, M.J., 1993). Data which was qualified as estimated (denoted by "J" or "UJ" in the data package) has been enclosed in parentheses, i.e., (395) ug/mL. Unusable data (denoted by "R" in the data package) has been entered with a strikeout, i.e., ~~395~~ ug/mL. Unqualified data will be entered in standard form.

A.3.4 "Standard Error" is computed for those results greater than the detection limit.

A.3.5 The "Range of Values" column lists the highest and the lowest values for a particular analyte.

A.3.6 The "Evaluated Data Result" is derived as discussed in Section 5.0.

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Table A-1. Tank 241-AP-102 Analytical Data: Aluminum

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Al	Sample G342	(1.15E+07)	1.12E+07 to 1.19E+07	1.16E+07	43,400	48,500
	Sample G449	(1.15E+07)				
	Sample G450	(1.18E+07)				
	Sample G348	(1.17E+07)				
	Sample G349	(1.19E+07)				
	Sample G352	(1.15E+07)				
	Sample G453	(1.17E+07)				
	Sample G353	(1.13E+07)				
	Sample G358	(1.14E+07)				
	Sample G454	(1.17E+07)				
	Sample G359	(1.12E+07)				
	Sample G363	(1.14E+07)				
	Sample G364	(1.15E+07)				
	Sample G333	(1.14E+07)				
	Sample G459	(1.17E+07)				
	Sample G460	(1.15E+07)				
	Sample G338	(1.17E+07)				
	Sample G341	(1.16E+07)				
	Sample G443	(1.16E+07)				

Table A-1. Tank 241-AP-102 Analytical Data: Antimony

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Sb	Sample G342	(6,950)	< 5,250 to 7,500	6,610	N/A	27.6
	Sample G449	(< 5,250)				
	Sample G450	< 5,620				
	Sample G348	(< 5,250)				
	Sample G349	(< 5,250)				
	Sample G352	(< 5,250)				
	Sample G453	< 6,220				
	Sample G353	(< 5,250)				
	Sample G358	(< 5,250)				
	Sample G454	(5,380)				
	Sample G359	< 6,380				
	Sample G363	(7,500)				
	Sample G364	< 5,250				
	Sample G333	< 5,540				
	Sample G459	(< 5,250)				
	Sample G460	(< 5,250)				
	Sample G338	< 5,900				
	Sample G341	< 5,620				
	Sample G443	< 5,250				

Table A-1. Tank 241-AP-102 Analytical Data: Arsenic

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
GHAA.a.As	Sample G443	88.7	N/A	88.7	N/A	0.371

Table A-1. Tank 241-AP-102 Analytical Data: Barium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Ba	Sample G342	(214)	130 to 392	284	16.8	1.19
	Sample G449	340				
	Sample G450	357				
	Sample G348	264				
	Sample G349	332				
	Sample G352	(281)				
	Sample G453	(273)				
	Sample G353	(313)				
	Sample G358	243				
	Sample G454	333				
	Sample G359	305				
	Sample G363	288				
	Sample G364	(130)				
	Sample G333	(317)				
	Sample G459	(262)				
	Sample G460	(230)				
	Sample G338	(392)				
	Sample G341	(211)				
	Sample G443	(194)				

Table A-1. Tank 241-AP-102 Analytical Data: Beryllium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Be	Sample G342	146	127 to 160	146	2.45	0.610
	Sample G449	(127)				
	Sample G450	(128)				
	Sample G348	(147)				
	Sample G349	(144)				
	Sample G352	145				
	Sample G453	155				
	Sample G353	138				
	Sample G358	145				
	Sample G454	160				
	Sample G359	135				
	Sample G363	142				
	Sample G364	(148)				
	Sample G333	158				
	Sample G459	(152)				
	Sample G460	153				
	Sample G338	158				
	Sample G341	150				
	Sample G443	146				

Table A-1. Tank 241-AP-102 Analytical Data: Cadmium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Cd	Sample G342	1,450	1,330 to 1,650	1,470	19.7	6.14
	Sample G449	1,390				
	Sample G450	(1,430)				
	Sample G348	1,360				
	Sample G349	1,540				
	Sample G352	(1,390)				
	Sample G453	(1,650)				
	Sample G353	(1,470)				
	Sample G358	(1,390)				
	Sample G454	(1,590)				
	Sample G359	(1,330)				
	Sample G363	(1,490)				
	Sample G364	(1,560)				
	Sample G333	1,470				
	Sample G459	1,470				
	Sample G460	(1,470)				
	Sample G338	1,500				
	Sample G341	1,470				
	Sample G443	(1,500)				

Table A-1. Tank 241-AP-102 Analytical Data: Chromium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Cr	Sample G342	6.13E+05	5.99E+05 to 6.50E+05	6.18E+05	2,850	2,580
	Sample G449	6.06E+05				
	Sample G450	6.06E+05				
	Sample G348	6.36E+05				
	Sample G349	6.50E+05				
	Sample G352	6.16E+05				
	Sample G453	(6.30E+05)				
	Sample G353	6.19E+05				
	Sample G358	(6.10E+05)				
	Sample G454	(6.15E+05)				
	Sample G359	(5.99E+05)				
	Sample G363	6.10E+05				
	Sample G364	6.16E+05				
	Sample G333	6.25E+05				
	Sample G459	(6.19E+05)				
	Sample G460	(6.23E+05)				
	Sample G338	6.24E+05				
	Sample G341	6.23E+05				
	Sample G443	6.23E+05				

Table A-1. Tank 241-AP-102 Analytical Data: Iron

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Fe	Sample G342	(3,780)	2,910 to 6,500	3,810	295	15.9
	Sample G449	(3,130)				
	Sample G450	(3,100)				
	Sample G348	(6,080)				
	Sample G349	(2,970)				
	Sample G352	(2,950)				
	Sample G453	(5,910)				
	Sample G353	(4,180)				
	Sample G358	(6,500)				
	Sample G454	(3,470)				
	Sample G359	(3,140)				
	Sample G363	(3,130)				
	Sample G364	(3,620)				
	Sample G333	(2,910)				
	Sample G459	(3,110)				
	Sample G460	(3,970)				
	Sample G338	(3,490)				
	Sample G341	(3,480)				
	Sample G443	(5,610)				

Table A-1. Tank 241-AP-102 Analytical Data: Lead

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Pb	Sample G342	< 1,550	< 1,550 to 5,330	3,290	N/A	13.8
	Sample G449	< 1,550				
	Sample G450	< 1,550				
	Sample G348	(< 1,550)				
	Sample G349	(2,640)				
	Sample G352	< 1,550				
	Sample G453	(< 1,550)				
	Sample G353	< 1,550				
	Sample G358	(< 1,550)				
	Sample G454	(1,950)				
	Sample G359	(3,220)				
	Sample G363	(< 1,550)				
	Sample G364	(5,330)				
	Sample G333	(< 1,550)				
	Sample G459	< 1,550				
	Sample G460	< 1,550				
	Sample G338	(< 1,550)				
	Sample G341	< 1,550				
	Sample G443	< 1,550				

Table A-1. Tank 241-AP-102 Analytical Data: Mercury

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
CVAA.a.Hg	Sample G443	< 5.00	N/A	< 5.00	N/A	< 0.0209

Table A-1. Tank 241-AP-102 Analytical Data: Nickel

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Ni	Sample G342	26,300	25,900 to 28,000	26,600	124	111
	Sample G449	(26,000)				
	Sample G450	(26,200)				
	Sample G348	27,500				
	Sample G349	28,000				
	Sample G352	26,300				
	Sample G453	(27,100)				
	Sample G353	26,400				
	Sample G358	(26,300)				
	Sample G454	(26,600)				
	Sample G359	(25,900)				
	Sample G363	26,400				
	Sample G364	26,500				
	Sample G333	(26,900)				
	Sample G459	(26,700)				
	Sample G460	(26,600)				
	Sample G338	(26,800)				
	Sample G341	26,900				
	Sample G443	(27,000)				

Table A-1. Tank 241-AP-102 Analytical Data: Phosphorus

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.P	Sample G342	(3.03E+06)	2.60E+06 to 3.44E+06	3.06E+06	62,700	12,800
	Sample G449	(2.93E+06)				
	Sample G450	(3.03E+06)				
	Sample G348	(2.99E+06)				
	Sample G349	(3.19E+06)				
	Sample G352	(2.88E+06)				
	Sample G453	(3.42E+06)				
	Sample G353	(2.84E+06)				
	Sample G358	(2.92E+06)				
	Sample G454	(3.40E+06)				
	Sample G359	(3.04E+06)				
	Sample G363	(2.63E+06)				
	Sample G364	(2.60E+06)				
	Sample G333	(3.27E+06)				
	Sample G459	(3.22E+06)				
	Sample G460	(3.13E+06)				
	Sample G338	(3.44E+06)				
	Sample G341	(3.06E+06)				
	Sample G443	2.86E+06				

Table A-1. Tank 241-AP-102 Analytical Data: Potassium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.K	Sample G342	(1.30E+06)	1.20E+06 to 1.33E+06	1.29E+06	9,640	5,390
	Sample G449	(1.29E+06)				
	Sample G450	(1.30E+06)				
	Sample G348	(1.26E+06)				
	Sample G349	(1.28E+06)				
	Sample G352	(1.25E+06)				
	Sample G453	(1.33E+06)				
	Sample G353	(1.26E+06)				
	Sample G358	(1.21E+06)				
	Sample G454	(1.31E+06)				
	Sample G359	(1.20E+06)				
	Sample G363	(1.29E+06)				
	Sample G364	(1.32E+06)				
	Sample G333	(1.31E+06)				
	Sample G459	(1.30E+06)				
	Sample G460	(1.32E+06)				
	Sample G338	(1.33E+06)				
	Sample G341	(1.32E+06)				
	Sample G443	(1.32E+06)				

Table A-1. Tank 241-AP-102 Analytical Data: Selenium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metal		µg/mL	µg/mL	µg/mL	µg/mL	kg
GHAA.Se	Sample G342	0.364	0.260 to 0.463	0.367	0.0184	1.53
	Sample G348	0.329				
	Sample G349	0.302				
	Sample G352	0.463				
	Sample G353	0.460				
	Sample G358	0.397				
	Sample G359	0.372				
	Sample G363	0.445				
	Sample G364	0.260				
	Sample G459	0.370				
	Sample G460	0.378				
	Sample G341	0.346				
	Sample G443	0.412				

Table A-1. Tank 241-AP-102 Analytical Data: Silver

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Ag	Sample G342	(< 125)	N/A	< 125	N/A	< 0.523
	Sample G449	(< 125)				
	Sample G450	(< 125)				
	Sample G348	(< 125)				
	Sample G349	(< 125)				
	Sample G352	(< 125)				
	Sample G453	(< 125)				
	Sample G353	(< 125)				
	Sample G358	(< 125)				
	Sample G454	(< 125)				
	Sample G359	(< 125)				
	Sample G363	(< 125)				
	Sample G364	(< 125)				
	Sample G333	(< 125)				
	Sample G459	(< 125)				
	Sample G460	(< 125)				
	Sample G338	(< 125)				
	Sample G341	(< 125)				
	Sample G443	(< 125)				

Table A-1. Tank 241-AP-102 Analytical Data: Sodium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
ICP.a.Na	Sample G342	(1.00E+08)	9.85E+07 to 1.04E+08	1.02E+08	406,000	426,000
	Sample G449	(1.01E+08)				
	Sample G450	(1.04E+08)				
	Sample G348	(1.03E+08)				
	Sample G349	(1.04E+08)				
	Sample G352	(1.01E+08)				
	Sample G453	(1.04E+08)				
	Sample G353	(1.00E+08)				
	Sample G358	(1.01E+08)				
	Sample G454	(1.03E+08)				
	Sample G359	(9.85E+07)				
	Sample G363	(1.00E+08)				
	Sample G364	(1.02E+08)				
	Sample G333	(1.00E+08)				
	Sample G459	(1.02E+08)				
	Sample G460	(1.01E+08)				
	Sample G338	(1.03E+08)				
	Sample G341	(1.01E+08)				
	Sample G443	(1.02E+08)				

Table A-1. Tank 241-AP-102 Analytical Data: Uranium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Metals		µg/L	µg/L	µg/L	µg/L	kg
LF.U	Sample G443	6,700	2,370 to 6,700	4,620	N/A	19.3
	Sample G443	2,370				
	Sample G470	4,530				
	Sample G471	4,770				
	Sample G476	5,270				
	Sample G477	4,050				

Table A-2. Tank 241-AP-102 Analytical Data: Ammonia

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Cation		µg/mL	µg/mL	µg/mL	µg/mL	kg
$KTN.NH_3$	Sample G470	(262)	198 to 395	273	N/A	1,140
	Sample G471	(359)				
	Sample G476	(198)				
	Sample G477	(272)				

Table A-2. Tank 241-AP-102 Analytical Data: Chloride

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
$IC.Cl^-$	Sample G342	2,790	2,710 to 4,460	2,900	N/A	12,100
	Sample G449	2,980				
	Sample G450	3,010				
	Sample G348	2,710				
	Sample G349	2,790				
	Sample G352	2,840				
	Sample G453	2,980				
	Sample G353	2,820				
	Sample G358	2,800				
	Sample G454	2,910				
	Sample G359	2,820				
	Sample G363	2,880				
	Sample G364	2,940				
	Sample G333	2,920				
	Sample G459	2,850				
	Sample G460	3,600				
	Sample G338	3,010				
	Sample G341	2,800				
	Sample G443	4,460				

Table A-2. Tank 241-AP-102 Analytical Data: Cyanide

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
Dist/Spec. CN^-	Sample G443	24.6	N/A	24.6	N/A	103

Table A-2. Tank 241-AP-102 Analytical Data: Fluoride

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
IC.F^-	Sample G342	< 168	N/A	< 168	N/A	< 702
	Sample G449	< 168				
	Sample G450	< 168				
	Sample G348	< 168				
	Sample G349	< 168				
	Sample G352	< 168				
	Sample G453	< 168				
	Sample G353	< 168				
	Sample G358	< 168				
	Sample G454	< 168				
	Sample G359	< 168				
	Sample G363	< 168				
	Sample G364	< 168				
	Sample G333	< 168				
	Sample G459	< 168				
	Sample G460	< 168				
	Sample G338	< 168				
	Sample G341	< 168				
	Sample G443	< 168				

Table A-2. Tank 241-AP-102 Analytical Data: Hydroxide

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
POT Autotit. OH^-	Sample G342	9,010	9,010 to 9,340	9,150	37.5	38,200
	Sample G348	9,040				
	Sample G349	9,270				
	Sample G352	9,340				
	Sample G353	9,140				
	Sample G358	9,240				
	Sample G359	9,080				
	Sample G363	9,200				
	Sample G364	9,240				
	Sample G459	9,180				
	Sample G460	9,080				
	Sample G341	9,170				
	Sample G443	9,110				

Table A-2. Tank 241-AP-102 Analytical Data: Nitrate

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
IC.NO_3^-	Sample G342	75,900	54,800 to 97,100	78,200	1,760	3.27E+05
	Sample G449	78,000				
	Sample G450	79,200				
	Sample G348	75,900				
	Sample G349	76,200				
	Sample G352	75,900				
	Sample G453	79,400				
	Sample G353	76,100				
	Sample G358	75,900				
	Sample G454	78,600				
	Sample G359	77,200				
	Sample G363	77,600				
	Sample G364	78,500				
	Sample G333	79,400				
	Sample G459	76,500				
	Sample G460	97,100				
	Sample G338	78,700				
	Sample G341	76,500				
	Sample G443	54,800				

Table A-2. Tank 241-AP-102 Analytical Data: Nitrite

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
IC.NO_2^-	Sample G342	36,500	36,500 to 54,800	38,000	1,100	1.59E+05
	Sample G449	38,600				
	Sample G450	38,200				
	Sample G348	36,800				
	Sample G349	37,300				
	Sample G352	36,700				
	Sample G453	38,700				
	Sample G353	36,500				
	Sample G358	36,500				
	Sample G454	38,500				
	Sample G359	37,200				
	Sample G363	37,800				
	Sample G364	38,100				
	Sample G333	39,000				
	Sample G459	37,400				
	Sample G460	47,300				
	Sample G338	38,100				
	Sample G341	37,700				
	Sample G443	54,800				

Table A-2. Tank 241-AP-102 Analytical Data: Phosphate

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
IC.PO_4^{-3}	Sample G509	12,100	10,800 to 13,300	11,600	210	48,500
	Sample G523	11,600				
	Sample G477	12,200				
	Sample G510	11,300				
	Sample G511	11,200				
	Sample G521	12,200				
	Sample G527	11,300				
	Sample G522	12,400				
	Sample G515	11,900				
	Sample G471	12,400				
	Sample G516	11,200				
	Sample G533	12,200				
	Sample G534	11,900				
	Sample G528	10,800				
	Sample G517	11,500				
	Sample G536	11,900				
	Sample G529	11,300				
	Sample G476	12,400				
	Sample G470	13,300				

Table A-2. Tank 241-AP-102 Analytical Data: Sulfate

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Anion		µg/mL	µg/mL	µg/mL	µg/mL	kg
IC.SO_4^{2-}	Sample G509	(4,810)	3,710 to 4,850	4,510	89.9	18,900
	Sample G523	(4,580)				
	Sample G477	(3,730)				
	Sample G510	(4,750)				
	Sample G511	(4,750)				
	Sample G521	(4,660)				
	Sample G527	(4,790)				
	Sample G522	(4,760)				
	Sample G515	(4,830)				
	Sample G471	(3,710)				
	Sample G516	(4,640)				
	Sample G533	(4,580)				
	Sample G534	(4,600)				
	Sample G528	(4,550)				
	Sample G517	(4,850)				
	Sample G536	(4,540)				
	Sample G529	(4,650)				
	Sample G476	(3,780)				
	Sample G470	(3,910)				

Table A-3. Tank 241-AP-102 Analytical Data: Americium-241

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
APC/AEA. ^{241}Am	Sample G342	3.26E-04	2.35E-04 to 8.49E-04	4.19E-04	6.16E-05	1.75
	Sample G348	2.38E-04				
	Sample G349	4.76E-04				
	Sample G352	4.58E-04				
	Sample G353	4.89E-04				
	Sample G358	8.49E-04				
	Sample G359	7.19E-04				
	Sample G363	2.35E-04				
	Sample G364	2.45E-04				
	Sample G459	4.38E-04				
	Sample G460	3.74E-04				
	Sample G341	4.80E-04				
	Sample G443	3.81E-04				

Table A-3. Tank 241-AP-102 Analytical Data: Antimony-125

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. ^{125}Sb	Sample G342	< 0.427	< 0.285 to < 0.431	< 0.431	N/A	< 1,800
	Sample G449	< 0.420				
	Sample G450	< 0.425				
	Sample G348	< 0.418				
	Sample G349	< 0.427				
	Sample G352	< 0.291				
	Sample G453	< 0.295				
	Sample G353	< 0.417				
	Sample G358	< 0.414				
	Sample G454	< 0.295				
	Sample G359	< 0.291				
	Sample G363	< 0.427				
	Sample G364	< 0.414				
	Sample G333	< 0.292				
	Sample G459	< 0.288				
	Sample G460	< 0.285				
	Sample G338	< 0.293				
	Sample G341	< 0.425				
	Sample G443	< 0.431				

Table A-3. Tank 241-AP-102 Analytical Data: Carbon-14

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
LSC. ^{14}C	Sample G342	4.73E-04	4.34E-04 to 5.37E-04	4.99E-04	1.56E-05	2.09
	Sample G348	5.18E-04				
	Sample G349	5.06E-04				
	Sample G352	(5.20E-04)				
	Sample G353	(4.78E-04)				
	Sample G358	(4.91E-04)				
	Sample G359	5.20E-04				
	Sample G363	(4.35E-04)				
	Sample G364	5.23E-04				
	Sample G459	(5.37E-04)				
	Sample G460	4.81E-04				
	Sample G341	5.16E-04				

Table A-3. Tank 241-AP-102 Analytical Data: Cerium/Praesedymium-144

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. $^{144}Ce/Pr$	Sample G342	< 1.02	< 0.522 to < 1.03	< 1.03	N/A	4,310
	Sample G348	< 0.997				
	Sample G352	< 0.535				
	Sample G349	< 1.03				
	Sample G358	< 0.983				
	Sample G353	< 0.996				
	Sample G359	< 0.533				
	Sample G363	< 1.02				
	Sample G364	< 0.979				
	Sample G459	< 0.526				
	Sample G460	< 0.522				
	Sample G341	< 1.02				
	Sample G443	< 1.03				

Table A-3. Tank 241-AP-102 Analytical Data: Cesium-134

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. ^{134}Cs	Sample G342	< 0.0280	< 0.0147 to < 0.0298	< 0.0298	N/A	< 125
	Sample G449	< 0.0285				
	Sample G450	< 0.0272				
	Sample G348	< 0.0295				
	Sample G349	< 0.0285				
	Sample G352	< 0.0156				
	Sample G453	< 0.0159				
	Sample G353	< 0.0289				
	Sample G358	< 0.0270				
	Sample G454	< 0.0158				
	Sample G359	< 0.0159				
	Sample G363	< 0.0254				
	Sample G364	< 0.0255				
	Sample G333	< 0.0162				
	Sample G459	< 0.0150				
	Sample G460	< 0.0148				
	Sample G338	< 0.0147				
	Sample G341	< 0.0214				
	Sample G443	< 0.0298				

Table A-3. Tank 241-AP-102 Analytical Data: Cesium-137

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. ^{137}Cs	Sample G342	234	214 to 237	228	1.67	9.53E+05
	Sample G449	230				
	Sample G450	232				
	Sample G348	225				
	Sample G349	237				
	Sample G352	225				
	Sample G453	233				
	Sample G353	226				
	Sample G358	218				
	Sample G454	229				
	Sample G359	225				
	Sample G363	236				
	Sample G364	224				
	Sample G333	225				
	Sample G459	217				
	Sample G460	214				
	Sample G338	227				
	Sample G341	235				
	Sample G443	224				

Table A-3. Tank 241-AP-102 Analytical Data: Cobalt-60

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA.^{60}Co	Sample G342	< 0.0169	< 0.0110 to 0.0809	0.0763	N/A	319
	Sample G449	< 0.0181				
	Sample G450	< 0.0157				
	Sample G348	< 0.0163				
	Sample G349	< 0.0169				
	Sample G352	< 0.0123				
	Sample G453	< 0.0117				
	Sample G353	0.0717				
	Sample G358	0.0809				
	Sample G454	< 0.0138				
	Sample G359	< 0.0122				
	Sample G363	< 0.0197				
	Sample G364	< 0.0181				
	Sample G333	< 0.0110				
	Sample G459	< 0.0130				
	Sample G460	< 0.0136				
	Sample G338	< 0.0123				
	Sample G341	< 0.0169				
	Sample G443	< 0.0207				

Table A-3. Tank 241-AP-102 Analytical Data: Curium-244

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
AEA. ^{244}Cm	Sample G342	< 6.37E-05	< 2.55E-05 to < 6.37E-05	< 6.37E-05	N/A	< 0.266
	Sample G348	< 6.37E-05				
	Sample G352	< 6.37E-05				
	Sample G349	< 6.37E-05				
	Sample G358	< 6.37E-05				
	Sample G353	< 6.37E-05				
	Sample G359	< 6.37E-05				
	Sample G363	< 6.37E-05				
	Sample G364	< 6.37E-05				
	Sample G459	< 6.37E-05				
	Sample G460	< 6.37E-05				
	Sample G341	< 6.37E-05				
	Sample G443	< 2.55E-05				

Table A-3. Tank 241-AP-102 Analytical Data: Iodine-129

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. ^{129}I	Sample G443	< 3.70E-05	N/A	<3.70E-05	N/A	< 0.155

Table A-3. Tank 241-AP-102 Analytical Data: Neptunium-237

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
APC. ^{237}Np	Sample G342	< 0.001	< 2.81E-04 to < 0.001	< 0.001	N/A	< 4.18
	Sample G348	< 3.89E-04				
	Sample G349	< 3.89E-04				
	Sample G352	< 3.89E-04				
	Sample G353	< 3.89E-04				
	Sample G358	< 4.65E-04				
	Sample G359	< 3.89E-04				
	Sample G363	< 4.32E-04				
	Sample G364	< 2.81E-04				
	Sample G459	< 4.32E-04				
	Sample G460	< 4.32E-04				
	Sample G341	< 4.32E-04				

Table A-3. Tank 241-AP-102 Analytical Data: Niobium-94

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. ^{94}Nb	Sample G342	< 0.0246	< 0.0146 to < 0.0257	< 0.0257	N/A	< 107
	Sample G449	< 0.0237				
	Sample G450	< 0.0257				
	Sample G348	< 0.0235				
	Sample G349	< 0.0236				
	Sample G352	< 0.0152				
	Sample G453	< 0.0161				
	Sample G353	< 0.0238				
	Sample G358	< 0.0225				
	Sample G454	< 0.0162				
	Sample G359	< 0.0151				
	Sample G363	< 0.0241				
	Sample G364	< 0.0236				
	Sample G333	< 0.0157				
	Sample G459	< 0.0146				
	Sample G460	< 0.0161				
	Sample G338	< 0.0150				
	Sample G341	< 0.0246				
	Sample G443	< 0.0246				

Table A-3. Tank 241-AP-102 Analytical Data: Plutonium-238

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
APC/AEA. ^{238}Pu	Sample G342	< 1.00E-04	< 9.64E-05 to < 1.63E-04	< 1.63E-04	N/A	< 0.681
	Sample G348	< 9.64E-05				
	Sample G349	< 9.87E-05				
	Sample G352	< 1.11E-04				
	Sample G353	< 1.23E-04				
	Sample G358	< 1.63E-04				
	Sample G359	< 1.50E-04				
	Sample G363	< 9.88E-05				
	Sample G364	< 1.22E-04				
	Sample G459	< 1.01E-04				
	Sample G460	< 1.02E-04				
	Sample G341	< 1.08E-04				

Table A-3. Tank 241-AP-102 Analytical Data: Plutonium-239/240

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
APC/AEA. $^{239/240}Pu$	Sample G342	< 6.72E-05	< 6.64E-05 to < 7.48E-05	< 7.48E-05	N/A	< 0.313
	Sample G348	< 6.96E-05				
	Sample G349	< 6.96E-05				
	Sample G352	< 6.64E-05				
	Sample G353	< 6.74E-05				
	Sample G358	< 6.82E-05				
	Sample G359	< 6.81E-05				
	Sample G363	< 6.86E-05				
	Sample G364	< 6.99E-05				
	Sample G459	< 6.90-05				
	Sample G460	< 6.86E-05				
	Sample G341	< 7.48E-05				

Table A-3. Tank 241-AP-102 Analytical Data: Ruthenium/Rhodium-106

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
GEA. $^{106}Ru/Rh$	Sample G342	< 1.35	< 1.01 to < 1.39	< 1.39	N/A	< 5,810
	Sample G449	< 1.33				
	Sample G450	< 1.34				
	Sample G348	< 1.35				
	Sample G349	< 1.39				
	Sample G352	< 1.03				
	Sample G453	< 1.04				
	Sample G353	< 1.33				
	Sample G358	< 1.32				
	Sample G454	< 1.04				
	Sample G359	< 1.03				
	Sample G363	< 1.39				
	Sample G364	< 1.32				
	Sample G333	< 1.03				
	Sample G459	< 1.01				
	Sample G460	< 1.01				
	Sample G338	< 1.03				
	Sample G341	< 1.39				
	Sample G443	< 1.38				

Table A-3. Tank 241-AP-102 Analytical Data: Strontium-90

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
BPC. ^{90}Sr	Sample G342	(1.45)	1.37 to 1.49	1.44	0.0174	6,020
	Sample G348	(1.41)				
	Sample G349	(1.48)				
	Sample G352	(1.37)				
	Sample G353	(1.39)				
	Sample G358	(1.42)				
	Sample G359	(1.43)				
	Sample G363	(1.39)				
	Sample G364	(1.42)				
	Sample G459	(1.41)				
	Sample G460	(1.40)				
	Sample G341	(1.39)				
	Sample G443	(1.49)				

Table A-3. Tank 241-AP-102 Analytical Data: Technetium-99

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
LSC. ^{99}Tc	Sample G342	(0.0899)	0.0489 to 0.0954	0.0856	0.00204	358
	Sample G348	(0.0884)				
	Sample G349	(0.0890)				
	Sample G352	(0.0839)				
	Sample G353	(0.0521)				
	Sample G358	(0.0489)				
	Sample G359	(0.0537)				
	Sample G363	(0.0853)				
	Sample G364	(0.0859)				
	Sample G459	(0.0824)				
	Sample G460	(0.0691)				
	Sample G341	(0.0899)				
	Sample G443	(0.0954)				

Table A-3. Tank 241-AP-102 Analytical Data: Tritium

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Radionuclide		µCi/mL	µCi/mL	µCi/mL	µCi/mL	Ci
LSC.^{3}H	Sample G443	~~0.0130~~	N/A	N/A	N/A	N/A

Table A-4. Tank 241-AP-102 Analytical Data: Organic Complexant Analyses (page 1 of 2)

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Organic Complexant		mg/L	mg/L	mg/L	mg/L	kg
HPLC.Citrate	Sample G300	(570)	415 to 600	515	N/A	2.15
	Sample G304	(600)				
	Sample G312	(560)				
	Sample G314	(545)				
	Sample G316	(425)				
	Sample G320	(415)				
	Sample G321	(490)				
HPLC.EDTA	Sample G300	450	450 to 625	519	N/A	2.17
	Sample G304	520				
	Sample G312	500				
	Sample G314	500				
	Sample G316	505				
	Sample G320	530				
	Sample G321	(625)				
HPLC.HEDTA	Sample G300	93	80 to 140	110	N/A	0.460
	Sample G304	(140)				
	Sample G312	(135)				
	Sample G314	(80)				
	Sample G316	85				
	Sample G320	87				
	Sample G321	(130)				

Table A-4. Tank 241-AP-102 Analytical Data: Organic Complexant Analyses. (page 2 of 2)

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Organic Complexant		mg/L	mg/L	mg/L	mg/L	kg
IC.Glycolate	Sample G300	1100	N/A	1,100	N/A	4,600
	Sample G304	1100				
	Sample G312	1100				
	Sample G314	1100				
	Sample G316	1100				
	Sample G320	1100				
	Sample G321	1100				
IC.Oxalate	Sample G300	800	700 to 800	760	N/A	3,180
	Sample G304	800				
	Sample G312	800				
	Sample G314	700				
	Sample G316	700				
	Sample G320	750				
	Sample G321	800				

Table A-5. Tank 241-AP-102 Analytical Data: Percent Water

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)
Physical Property		wt%	wt%	wt%	
% H_2O	Sample G342	(74.6)	74.1 to 75.5	75.0	0.144
	Sample G348	(75.4)			
	Sample G349	(75.3)			
	Sample G352	(75.0)			
	Sample G353	(75.4)			
	Sample G358	(75.4)			
	Sample G359	(75.4)			
	Sample G363	(74.7)			
	Sample G364	(74.6)			
	Sample G459	(74.1)			
	Sample G460	(75.5)			
	Sample G341	(75.3)			
	Sample G443	(74.2)			

Table A-5. Tank 241-AP-102 Analytical Data: Specific Gravity

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)
Physical Property					
Specific Gravity	Sample G342	(1.20)	1.19 to 1.21	1.20	0.00167
	Sample G348	(1.21)			
	Sample G349	(1.20)			
	Sample G352	(1.20)			
	Sample G353	(1.20)			
	Sample G358	(1.20)			
	Sample G359	(1.20)			
	Sample G363	(1.20)			
	Sample G364	(1.19)			
	Sample G459	(1.20)			
	Sample G460	(1.20)			
	Sample G341	(1.20)			
	Sample G443	(1.20)			

Table A-5. Tank 241-AP-102 Analytical Data: Total Inorganic Carbon

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Physical Property		µg/mL	µg/mL	µg/mL	µg/mL	kg
COUL.TIC	Sample G342	(5,540)	4,760 to 5,880	5,350	111	22,400
	Sample G348	(5,110)				
	Sample G349	(5,190)				
	Sample G352	(5,290)				
	Sample G353	(5,150)				
	Sample G358	(5,230)				
	Sample G359	(5,700)				
	Sample G363	(5,330)				
	Sample G364	(5,880)				
	Sample G333	(5,060)				
	Sample G459	(4,860)				
	Sample G460	(4,760)				
	Sample G338	(5,130)				
	Sample G341	(5,840)				

Table A-5. Tank 241-AP-102 Analytical Data: Total Organic Carbon

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Statistical Mean	Standard Error (Mean)	Projected Inventory
Physical Property		µg/mL	µg/mL	µg/mL	µg/mL	kg
COUL.TOC	Sample G342	(3,180)	3,060 to 3,480	3,280	42.2	13,700
	Sample G348	(3,240)				
	Sample G349	(3,060)				
	Sample G352	(3,340)				
	Sample G353	(3,340)				
	Sample G358	(3,480)				
	Sample G359	(3,420)				
	Sample G363	(3,180)				
	Sample G364	(3,440)				
	Sample G459	(3,060)				
	Sample G460	(3,290)				
	Sample G341	(3,320)				
	Sample G443	(3,240)				

Table A-6. Tank 241-AP-102 Analytical Data: Volatile Organic Analyses

Volatile Organic Compound	Result µg/L	Volatile Organic Compound	Result µg/L
Chloromethane	ND	Bromoform	ND
Bromomethane	ND	4-Methyl-2-Pentanone	ND
Vinyl Chloride	ND	2-Hexanone	ND
Chloroethane	ND	Tetrachloroethene	ND
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	ND
Acetone	ND	Toluene	ND
Carbon Disulfide	ND	Chlorobenzene	ND
1,1-Dichloroethene	ND	Ethlybenzene	ND
1,1-Dichloroethane	ND	Styrene	ND
trans-1,2-Dichloroethene	ND	m&p-Xylene	ND
cis-1,2-Dichloroethene	ND	o-Xylene	ND
Chloroform	ND	Isopropylbenzene	ND
1,2-Dichloroethane	ND	1,3,5-Trimethylbenzene	ND
2-Butanone	ND	1,2,4-Trimethylbenzene	ND
1,1,1-Trichloroethane	ND	1,2,3-Trimethylbenzene	ND
Carbon Tetrachloride	ND	Dibromochloromethane	ND
Vinyl Acetate	ND	1,1,2-Trichloroethane	ND
Bromodichloromethane	ND	Benzene	ND
1,2-Dichloropropane	ND	trans-1,3-Dichloropropene	ND
cis-1,3-Dichloropropene	ND	Trichloroethene	ND

Table A-7. Tank 241-AP-102 Analytical Data: Semivolatile Organic Analyses

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

Table A-8. Tank 241-AP-102 Analytical Data: Acetone

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Largest Detection Limit	Standard Error (Mean)	Projected Inventory
Organic		µg/L	µg/L	µg/L	µg/L	kg
VOA. Acetone	Sample G300	< 500	230 to < 500	< 500	N/A	2.09
	Sample G304	< 500				
	Sample G312	< 500				
	Sample G314	230				
	Sample G314D	< 500				
	Sample G316	< 500				
	Sample G320	< 500				
	Sample G321	< 500				

Table A-8. Tank 241-AP-102 Analytical Data: 1-Butanol

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Organic		µg/L	µg/L	µg/L	µg/L	kg
SVOA. 1-Butanol	Sample G300-1	370	370 to 820	618	N/A	2.58
	Sample G300-2	470				
	Sample G304	< 1000				
	Sample G312	750				
	Sample G314	820				
	Sample G316-1	600				
	Sample G316-2	690				
	Sample G320	730				
	Sample G321	510				
	Sample G324	< 1000				

Table A-8. Tank 241-AP-102 Analytical Data: 2-Butanone

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Organic		µg/L	µg/L	µg/L	µg/L	kg
VOA. 2-Butanone	Sample G300	< 500	< 500 to 590	< 500	N/A	2.09
	Sample G304	< 500				
	Sample G312	< 500				
	Sample G314	590				
	Sample G314D	< 500				
	Sample G316	< 500				
	Sample G320	< 500				
	Sample G321	< 500				

Table A-8. Tank 241-AP-102 Analytical Data: Toluene

Analyte	Laboratory Sample Identification	Analytical Data Result	Range of Values	Simple Mean	Standard Error (Mean)	Projected Inventory
Organic		µg/L	µg/L	µg/L	µg/L	kg
VOA. Toluene	Sample G300	< 500	43 to < 500	< 500	N/A	2.09
	Sample G304	< 500				
	Sample G312	< 500				
	Sample G314	140				
	Sample G314D	< 500				
	Sample G316	43				
	Sample G320	< 500				
	Sample G321	< 500				

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Appendix B. Statistical Analysis Presentation

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B.1 The ANOVA Model (Welsh 1993)

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 kth duplicate of the jth bottle of the ith location in the tank,

μ = the grand mean of all the data,

L_i = the effect of the ith location (measuring spatial variability),

B_{ij} = the effect of the jth bottle at the ith location (measuring local sampling variability), and

A_{ijk} = the analytical error associated with the kth duplicate in the jth bottle in the ith 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 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 $\hat{\sigma}^2(\bar{y}_T)$.

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