DISTRIBUTION SHEET

To Distribution	From Characterization Support	Page 1 of 4			
		Date 6/9/95			
Project Title/Work Order Tank Characterization Report for Double-Shell Tank 241-SY-102, WHC-SD-WM-ER-366, Rev. 0		EDT No. 612091			
		ECN No. NA			
Name	MSI N	Text With All Attac h.	Text Only	Attach. / Append ix Only	EDT/E CN Only

OFFSITE

Sandia National Laboratory

P.O. Box 5800
MS-0744, Dept. 6404
Albuquerque, NM 87815

D. Powers

X

Nuclear Consulting Services Inc.

P. O. Box 29151
Columbus, OH 43229-01051

J. L. Kovach

X

Chemical Reaction Sub-TAP

202 Northridge Court
Lindsborg, KS 67456

B. C. Hudson

X

Tank Characterization Panel

Senior Technical Consultant
Contech
6301 Indian School Road, NW, Suite 614
Albuquerque, NM 87110

J. Arvisu

X

U. S. Department of Energy - Headquarters

Office of Environmental Restoration and Waste Management EM-563
12800 Middlebrook Road
Germantown, MD 20874

K. T. Lang

X

J. A. Poppitti

X

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

SAIC

20300 Century Boulevard, Suite 200-B
Germantown, MD 20874

H. Sutter X

Los Alamos Laboratory

CST-14 MS-J586

P. O. Box 1663

Los Alamos, NM 87545

S. F. Agnew (6) X

Los Alamos Technical Associates

750 Swift Boulevard, Suite 4

Richland, WA 99352

A. T. DiCenso X

Ogden Environmental

101 East Wellsian Way

Richland, WA 99352

R. J. Anema X

CH2M Hill

P. O. Box 91500

Bellevue, WA 98009-2050

M. McAfee X

Tank Advisory Panel

102 Windham Road

Oak Ridge, TN 37830

D. O. Campbell X

ONSITEDepartment of Ecology

A. B. Stone B5-18 X

Department of Energy - Richland Operations

L. Erickson S7-53 X

J. F. Thompson S7-54 X

W. S. Liou S7-54 X

ICF-Kaiser Hanford Company

C. H. Brevick S3-10 X

L. A. Gaddis S3-09 X

R. B. Johnson S7-40 X

T. J. Kunthara S3-10 X

W. W. Pickett S3-09 X

Pacific Northwest Laboratory

G. H. Beeman	S7-71	X
S. F. Bobrowski	K7-28	X
N. G. Colton	K3-75	X
E. J. Eschbach	K7-15	X
J. R. Gormsen	K7-28	X
S. A. Hartley	K5-12	X
J. G. Hill	K7-94	X
L. K. Holton	K9-73	X
G. J. Lumetta	P7-25	X
B. D. McVeety	K6-84	X
I. C. McVeety	K7-22	X
A. F. Noonan	K9-81	X
L. R. Pederson	K2-44	X
K. M. Remund	K5-12	X

Westinghouse Hanford Company

H. Babad	S7-30	X
J. J. Badden	R2-54	X
D. A. Ball	S4-58	X
D. A. Barnes	R1-80	X
G. R. Bloom	S4-53	X
A. L. Boldt	H5-49	X
T. M. Brown	R2-12	X
T. H. Bushaw	T6-30	X
M. P. Campbell	R1-52	X
R. J. Cash	S7-15	X
C. S. Cho	G3-20	X
W. L. Cowley	H4-64	X
M. L. Deffenbaugh	R2-06	X
R. A. Dodd	S5-07	X
G. L. Dunford	S7-81	X
S. J. Eberlein	R2-12	X
D. B. Engelman	R1-49	X
K. O. Fein	H4-65	X
G. D. Forehand	S7-31	X
J. S. Garfield	H5-49	X
K. D. Gibson	H4-61	X
C. E. Golberg	H5-49	X
R. D. Gustavson	R1-51	X
V. W. Hall	H4-21	X
D. L. Herting	T6-09	X
B. A. Higley	H5-27	X
G. Jansen	H6-33	X
L. Jensen	T6-07	X
G. D. Johnson	S7-15	X
K. K. Kawabata	S7-55	X
T. J. Kelley	S7-30	X
N. W. Kirch	R2-11	X
J. G. Kristofzski	T6-06	X
M. J. Kupfer	H5-49	X
D. L. McGrew	R3-27	X
G. A. Meyer	S4-54	X
W. C. Miller	R1-30	X
C. T. Narquis	T6-16	X
R. H. Palmer	R2-58	X

M. A. Payne	S7-84	X
D. E. Place	H5-27	X
R. S. Popielarczyk	R1-30	X
S. H. Rifaey	T4-07	X
D. A. Reynolds	R2-11	X
L. M. Sasaki (10)	R2-12	X
F. A. Schmittroth	H0-35	X
N. J. Scott-Proctor	R1-80	X
B. C. Simpson	R2-12	X
G. L. Smith	H4-62	X
R. H. Stubbs	S7-12	X
M. J. Sutey	T4-07	X
G. L. Troyer	T6-50	X
D. A. Turner	S7-15	X
C. J. Udell	G3-43	X
D. J. Washenfelder	H5-27	X
M. S. Waters	S6-30	X
W. I. Winters (3)	T6-50	X
TFIC (Tank Farm Information Center)	R1-20	X
Central Files (2)	L8-04	X
EDMC	H6-08	X
OSTI (2)	L8-07	X
TCRC (2)	R2-12	X
Document Processing and Distribution (2)	H8-15	X

14 ②
JUN 09 1995

ENGINEERING DATA TRANSMITTAL

Page 1 of 1
1. EDT No 612091

2. To: (Receiving Organization) Distribution		3. From: (Originating Organization) Characterization Plans and Reports		4. Related EDT No.: NA				
5. Proj./Prog./Dept./Div.: WM/Characterization		6. Cog. Engr.: W. I. Winters		7. Purchase Order No.: NA				
8. Originator Remarks:				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: February 3, 1995				
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-366		0	Tank Characterization Report for Double-Shell Tank 241-SY-102	NA	2	1	1
16. KEY								
Approval Designator (F)		Reason for Transmittal (G)			Disposition (H) & (I)			
F, S, Q, D or N/A (See WHC-CM-3-5, Sec. 12.7)		1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)			1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged			
(A)	(H)	17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)					(G)	(H)
Dis P.		(J) Name	(K) Signature (M) MSIN	(L) Date	(J) Name	(K) Signature (M) MSIN	(L) Date	Reason Dis P.
1		Cog. Eng. W. I. Winters	W. I. Winters per telecon. J. G. Kristofzski	6/9/95				
1		Cog. Mgr. J. G. Kristofzski	R. J. [Signature]	6/9/95				
		QA NA						
		Safety NA						
		Env. NA						
18. Signature of EDT Date Originator W. I. Winters per telecon. W. I. Winters 6/9/95		19. Authorized Representative Date for Receiving Organization NA		20. Cognizant Manager Date J. G. Kristofzski 6-9/95		21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments		

RELEASE AUTHORIZATION

Document Number: WHC-SD-WM-ER-366, REV 0

Document Title: Tank Characterization Report for Double-Shell Tank
241-SY-102

Release Date: 6/9/95

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Kara M. Broz

June 9, 1995

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy. Available in paper copy and microfiche. Printed in the United States of America. Available to the U.S. Department of Energy and its contractors from:

U.S. Department of Energy
Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, TN 37831
Telephone: (615) 576-8401

Available to the public from:

U.S. Department of Commerce
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 487-4650

SUPPORTING DOCUMENT

1. Total Pages **89**

2. Title

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

3. Number

WHC-SD-WM-ER-366

4. Rev No.

0

5. Key Words

Waste Characterization; Double-Shell Tank; SY-102;
Tank Characterization Report; SY Farm; Waste
Inventory; SY Farm; TPA Milestone M-44.

6. Author

Name: W. I. Winters

L. M. Sasaki for W.I.W. (per telecon)
Signature

Name: A. T. DiCenso, LATA

A. T. DiCenso 6-8-95
Signature

Organization/Charge Code 75310/N4168

7. Abstract

This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in tank 241-SY-102. This report supports the requirements of Tri-party Agreement Milestone M-44-08.

8. RELEASE STAMP

OFFICIAL RELEASE
BY WHC
DATE JUN 09 1995

Sta 4

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

A. T. DiCenso
L. C. Amato
Los Alamos Technical Associates

W. I. Winters
Westinghouse Hanford Company

Date Published
June 1995

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company

P.O. Box 1970
Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

EXECUTIVE SUMMARY

This tank characterization report summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in the double-shell underground storage Tank 241-SY-102. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-08 (Ecology, EPA, DOE 1994).

Tank 241-SY-102 is located in the SY Tank Farm in the Hanford Site's 200 West area. The tank went into service in 1977 and was used as the feed tank for the 242-S Evaporator/Crystallizer, receiving supernates from S, SX, T and U Tank Farms. From 1981 to the present the primary sources of wastes have been from 200 West Area facilities such as T-Plant decontamination operations, Plutonium Finishing Plant (PFP) operations and the 222-S Laboratory. Receipt of single-shell salt well pump liquids from 200 West area tanks was also initiated in 1981 but was interrupted between 1983 and 1993. These liquids are now a major contributor to the tank wastes. It is an active double-shell tank in the 200 West Area, and is still used as the staging tank for cross-site transfers to 200 East Area double-shell tanks.

A description and status of the tank are summarized in the attached table and figures to this summary. Because the tank is active and presently receiving or transferring waste, the volume and composition of the supernate will be changing. The tank, which has an operational capacity of 4,310 kL (1,140 kgal), presently contains 2,880 kL (761 kgal) of waste in the form of supernate and sludge. When last sampled, it contained 2,560 kL (676 kgal) of supernate (March 1994) and 466 kL (123 kgal) of sludge (February 1990).

This report summarizes three sampling and analysis events. Sludge composition and properties are based on core samples taken from the tank in 1988 and 1990 to support development of retrieval, pretreatment and disposal processes. Supernate composition is based on a grab sample taken in March of 1994 to evaluate waste compatibility. These samples were taken before the data quality objective (DQO) process was implemented; therefore, the data may not fully comply with the recent requirements of the safety screening and waste compatibility DQOs.

Even though the fuel content of the waste has not been measured by differential scanning calorimetry (DSC), the total organic carbon (TOC), the cyanide content of the supernate, and historical uses of the tank indicate that excessive fuel is not present. If the sludge is sampled again the analyses should include an evaluation of the fuel content by DSC to confirm the fuel estimates based on historical information and TOC and cyanide analysis. About 90% of the waste is supernate and the moisture level of the driest sludge was estimated to be 33% to 39% water, significantly above the 17% safety screening criteria (Babad and Redus 1994). The heat generated by the radioactivity in the tank is estimated to be 7,100 Btu/hr. The temperature of the tank has been less than 25°C since the mid 1990s. The Pu-239/240 levels in the sludge were measured to be 6.11 $\mu\text{Ci/g}$, or about six times below the criticality safety criteria (Babad and Redus 1994). Based on this information, the waste does not appear to have any immediate safety concerns; however, this report does not include any tank head space vapor sampling and analysis information for evaluation.

The 1994 supernate analysis indicates that the liquid meets compatibility criteria for criticality and corrosion. The supernate Pu-239/240 and Am-241 levels are below the transuranic (TRU) classification limit of 100 nCi/g. The TOC concentration in the supernate is 0.25 g/L, well below the organic complexant classification criteria of 10 g/L.

The concentration and tank inventory for the centrifuged sludge and liquid are summarized in the attached table. The sludge contained high concentrations of Na, Al, Fe, Cr, Si, Ca and Mn. High Al, Fe and Cr concentrations are expected based on REDOX sludges that are found in 200 West Area single-shell tanks. The 1990 samples also showed a relatively high concentration of thorium which is not normally found in tank waste. In addition to having the expected high concentrations of nitrates and nitrites, the sludge also contains large amounts of phosphate. Based on the 1988 sample analysis, the higher actinide concentrations are found near the top of the sludge which agrees with the later additions of PFP waste to the tank. The sludge is classified as transuranic (TRU). The composition of the sludge measured from two different risers for the 1988 and 1990 events appears to be consistent and uniform for most analytes.

Tank 241-SY-102

TANK DESCRIPTION

Type:	Double-Shell
Constructed:	1976
In-Service:	1977
Diameter:	23 m (75 ft)
Usable Depth:	10.7 m (35 ft)
Operating Capacity:	4,310 kL (1,140 kgal)
Bottom Shape:	Flat
Ventilation:	Operating Exhauster

TANK STATUS

Total Waste Volume (Dec. 1994):	2,880 kL (761 kgal)
Sludge Volume (1987 Measurement):	269 kL (71 kgal)
Sludge Volume (Feb. 1990 estimate):	466 kL (123 kgal)
Supernatant Volume (Dec. 1994):	2,610 kL (690 kgal)
Supernatant Volume (Mar. 1994):	2,560 kL (676 kgal)
ENRAF Surface Level:	703 cm (277 in.)
Temperature:	15.7°C (60.3°F) to 18.9°C (66°F) (1/16/95)
Integrity Category	Sound

Sampling Dates:	
Core Sample:	October 1988
Two Core Samples:	February/March 1990
Grab Sample:	March 1994

SERVICE STATUS

Active service

Double-Shell Tank 241-SY-102 Concentrations and Inventories for Major Analytes and Analytes of Concern				
Physical Properties	Sludge Results		Liquid Results	
Density	1.56 g/mL		1.03 g/mL	
Percent Water	39.5%		95.4%	
Heat Load	2,080 W (7,100 Btu/hr)			
Chemical Constituents	Sludge ^(a) Concentration (µg/g)	Sludge Inventory (kg)	Liquid ^(b) Concentration (µg/g)	Liquid Inventory (kg)
Metals				
Al (Aluminum)	28,900	21,000	617	1,630
Ca (Calcium)	6,970	5,070	---	---
Cr (Chromium)	11,170	8,480	---	---
Fe (Iron)	24,800	18,000	<5.04	<13.3
Mn (Manganese)	6,600	4,800	---	---
Si (Silicon)	8,310	6,040	---	---
Na (Sodium)	1.19E+05	86,200	16,800	44,300
Th (Thorium)	3,840	2,790	---	---
U (Uranium)	1,190	862	---	---
Total Inorganic Carbon (µgC/g)	3,910	2,840	<19.4	<51.2
Ions				
NO ₃ ⁻ (Nitrate)	76,300	55,500	22,800	60,200
NO ₂ ⁻ (Nitrite)	21,200	15,400	3,130	8,240
PO ₄ ³⁻ (Phosphate)	22,600	16,400	385	1,020
OH ⁻ (Hydroxide)	---	---	3,370	8,880
Organics				
Total Organic Carbon (µgC/g)	4,290	3,120	243	640
Radionuclides	µCi/g	Ci	µCi/g	Ci
¹³⁷ Cs	79.5	57,800	6.57	17,300
⁹⁰ Sr	82.3	59,800	0.00113	3.00
^{239/240} Pu	6.11	4,440	3.00E-04	0.791
²⁴¹ Am	48.0	34,900	<2.59E-05	<0.0684

(a) Calculated analyte concentration for actual sludge based on 1990 analysis of centrifuged sludge

(b) Based on 1994 Sampling and Analysis

Tank 241-SY-102

Waste Profile of Tank 241-SY-102

Total Tank Volume: 4,310 kL (1,140 kgal)
 Total Waste Volume (December 1994): 2,880 kL (761 kgal)
 Sludge Volume (February 1990 (estimate)): 466 kL (123 kgal)
 Supernate Volume (December 1994): 2,610 kL (690 kgal)

CONTENTS

1.0 INTRODUCTION	1-1
1.1 PURPOSE	1-1
1.2 SCOPE	1-1
2.0 HISTORICAL TANK INFORMATION	2-1
2.1 TANK STATUS	2-1
2.2 TANK DESIGN	2-1
2.3 PROCESS KNOWLEDGE	2-4
2.3.1 Waste Transfer History	2-4
2.3.2 Historical Estimation of the Contents of Tank 241-SY-102	2-9
2.4 SURVEILLANCE DATA	2-10
2.4.1 Surface Level Readings	2-10
2.4.2 Internal Tank Temperatures	2-11
2.4.3 In-Tank Photographs	2-11
3.0 TANK SAMPLING OVERVIEW	3-1
3.1 DESCRIPTION OF 1988 SAMPLING EVENT	3-1
3.1.1 Sample Handling (1988)	3-1
3.1.2 Sample Analysis (1988)	3-2
3.2 DESCRIPTION OF 1990 SAMPLING EVENT	3-2
3.2.1 Sample Handling (1990)	3-3
3.2.2 Sample Analysis (1990)	3-5
3.3 DESCRIPTION OF 1994 SAMPLING EVENT	3-5
3.3.1 Sample Handling and Analysis (1994)	3-5
4.0 ANALYTICAL RESULTS AND WASTE INVENTORY ESTIMATES	4-1
4.1 OVERVIEW	4-1
4.2 DATA PRESENTATION	4-2
4.3 PHYSICAL MEASUREMENTS	4-8
4.3.1 Density, Percent Solids and Settling Behavior	4-8
4.3.2 Particle Size	4-10
4.3.3 Thermodynamic Analyses	4-10
4.3.4 Penetrometry	4-10
4.3.5 Shear Strength	4-10
4.3.6 Shear Stress Versus Shear Rate for 102-SY-4B Dilutions	4-10
5.0 INTERPRETATION OF CHARACTERIZATION RESULTS	5-1
5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS	5-1
5.1.1 Field/Laboratory Observations	5-1
5.1.2 Quality Control Assessment of Analytical Data	5-3
5.1.3 Data Consistency Checks	5-4
5.2 COMPARISON OF 1988 AND 1990 SUPERNATE ANALYTICAL RESULTS	5-7
5.3 TANK WASTE PROFILE	5-8
5.4 COMPARISON OF ANALYTICAL AND TRANSFER HISTORY INFORMATION	5-10

CONTENTS (continued)

5.5	EVALUATION OF PROGRAM REQUIREMENTS	5-11
5.5.1	Safety Evaluation	5-11
5.5.2	Operational Evaluations	5-12
5.5.3	Environmental Evaluation	5-13
5.5.4	Process Development Evaluation	5-14
6.0	CONCLUSIONS AND RECOMMENDATIONS	6-1
7.0	REFERENCES	7-1
Appendix A	February/March 1990 Analytical Results	A-i
Appendix B	March 1994 Grab Sample Analytical Results	B-i
Appendix C	1988 Core Sample Results	C-i
Appendix D	1990 Photographs: Core 16, Segments 3 and 4	D-i
Appendix E	Analytical Procedure Numbers	E-i
Appendix F	Particle Size Distribution	F-i

LIST OF FIGURES

2-1.	Riser Configuration of Tank 241-SY-102	2-2
2-2.	Basic Design of a Double-Shell Tank.	2-3
2-3.	200 West Area Location of the SY-Tank Farm	2-5
2-4.	Waste Volume History of Tank 241-SY-102	2-6
2-5.	Tank 241-SY-102 Temperature History	2-12
3-1.	Flow Chart for Data Collection and Preparation	3-6

LIST OF TABLES

2-1.	Estimated Total Volume of Waste Types Received By Tank 241-SY-102	2-7
2-2.	Tank 241-SY-102 Waste Transfers 1977-1994	2-8
3-1.	Tank 241-SY-102, 1988 Sample Data	3-1
3-2.	Subsampling Scheme of the 1988 Sample	3-2
3-3.	Segment Location and Numbering for Tank 241-SY-102	3-3
3-4.	Tank 241-SY-102 Drill String Dose Rates	3-4
3-5.	Description Summary of the 1990 Core 17 Sample	3-4
4-1.	Analytical Data Presentation Tables	4-1
4-2.	Centrifuged Solids (from sludge) Chemical Composition Data Summary	4-2
4-3.	Tank Characterization Summary for Tank 241-SY-102	4-6
4-4.	Tank 241-SY-101 Sludge Physical Measurements	4-9
4-5.	Settling Behavior for 4B Sample	4-9
4-6.	Power Law Curve Fit Parameters	4-11
4-7.	Turbulent Flow Model Calculations	4-11
5-1.	Relative Percent Differences Between the Core 17 Composite and Core 16 and PCL Samples	5-1
5-2.	Summary of Blank Measurements	5-3
5-3.	Tank 241-SY-102 Comparison of Gross Beta Activities with the Total of the Individual Activities	5-4
5-4.	Tank 241-SY-102 Comparison of Gross Alpha Activities with the Total of the Individual Activities	5-5
5-5.	Cation Mass and Charge Data	5-6
5-6.	Anion Mass and Charge Data	5-6
5-7.	Mass Balance Totals	5-7

LIST OF TABLES (continued)

5-8.	Comparison of Centrifuged Sludge Liquid from 1988 and 1990 Sampling Events	5-8
5-9.	Comparison of Sludge Values Between the 1990 and 1988 Data	5-9
5-10.	Tank 241-SY-102 Projected Heat Load	5-12
5-11.	Compatibility Assessment for Tank 241-SY-102 Supernate	5-13

LIST OF TERMS

AEA	alpha energy analysis
APC	alpha proportional counting
BPC	beta proportional counting
DN	dilute non-complexed waste
DOE	U.S. Department of Energy
DQO	data quality objectives
DSC	differential scanning calorimetry
EPA	U.S. Environmental Protection Agency
GEA	gamma energy analysis
IC	ion chromatography
ICP/AES	inductively coupled plasma/atomic emission spectrometry
LSC	liquid scintillation counting
NR	not reported
PCL	Process Chemistry Laboratory
PFP	Plutonium Finishing Plant
PNL	Pacific Northwest Laboratory
REDOX	reduction-oxidation
RPD	relative percent difference
RSD	relative standard deviation
SST	single-shell tank
TIC	total inorganic carbon
TOC	total organic carbon
TRU	transuranic
WHC	Westinghouse Hanford Company

1.0 INTRODUCTION

This tank characterization report presents an overview of Double-Shell Tank 241-SY-102 (hereafter, Tank 241-SY-102) and its waste contents. It provides estimated concentrations and inventories for the waste components based on the latest sampling and analysis activities and background tank information. This report describes the results of three sampling events. The first core sample was taken in October 1988. The tank supernate and sludge were next core sampled in February and March of 1990 (Tingey and Sasaki 1995). A grab sample of the supernate was taken in March of 1994. Tank 241-SY-102 is in active service and can be expected to have additional transfers to and from the tank that will alter the composition of the waste. The concentration and inventory estimates reported in this document no longer reflect the exact composition of the waste but represent the best estimates based on the most recent and available data. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-08 (Ecology, EPA, DOE 1994).

1.1 PURPOSE

The purpose of this report is to summarize information about the use and contents of Tank 241-SY-102. When possible, this information will be used to assess issues associated with safety, operations, environmental and process development activities. This report also provides a reference point for more detailed information about Tank 241-SY-102.

1.2 SCOPE

The core samples taken in 1988 and 1990 were intended to support process development activities for retrieval, pretreatment, vitrification and grouting of Hanford Site wastes. Selected chemical, radiochemical and physical properties were measured on the supernate and sludge phases of these samples. Other than total organic carbon, no specific organic analyses were performed. The historical uses of the tank were evaluated to establish expected waste composition and tank condition.

The supernate samples acquired in 1994 were taken to support tank operations in assessing the compatibility of Tank 241-SY-102 supernate with other waste for transfer purposes. The technical basis for this compatibility assessment is described in *Data Quality Objectives for the Waste Compatibility Program* (Carothers 1994) which was issued at about the same time as the sampling event. The supernate was analyzed for a smaller set of chemical (metals and anions) and radiochemical constituents than was the 1990 sampling event.

Neither sampling event included any differential scanning calorimetry (DSC) analyses to evaluate the potential for exothermic reactions in the waste at elevated temperatures. Therefore, assessment of safety issues in accordance with the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994) cannot be completed.

This report does not include any information on vapor space sampling and analysis to determine the composition of the tank head space gases.

2.0 HISTORICAL TANK INFORMATION

Tank 241-SY-102 is in active service and can be expected to have additional transfers to and from the tank that will alter the volume and composition of the tank contents. The most current volume status of the tank is provided in routinely updated reports. Tank history includes tank design information, waste transfer history, and waste temperature and level surveillance information.

2.1 TANK STATUS

According to Hanlon (1994a), Tank 241-SY-102 contains 2,880,000 liters (761,000 gallons) of waste; 269,000 liters (71,000 gallons) are sludge and 2,610,000 liters (690,000 gallons) are supernate. The sludge volume estimate reported in Hanlon (1994a) is based on a measurement obtained on 5/12/87 and is not considered to be accurate. The sludge portion of waste represents a relatively small fraction (10%) of the tank contents and some uncertainty exists in the estimated volume because of the multiple transfers and settling effects. The tank has continued to receive solids from the Plutonium Finishing Plant (PFP) and T-Plant since this date. When the tank was sampled in February 1990, the sludge volume was approximately 466,000 liters (123,000 gallons). This estimate was used to calculate analyte concentrations and inventory projections associated with the sludge. Presently, Westinghouse Hanford Company (WHC) Tank Surveillance personnel estimate that Tank 241-SY-102 may contain as much as 503,000 liters (133,000 gallons) of sludge; however, this estimate may have a high bias since it does not account for settling.

On January 16, 1995 in-tank temperatures ranged between 15.7 °C (60.3 °F) and 18.9 °C (66 °F). Waste levels and tank temperatures are further discussed in Section 2.4. The tank is classified as a structurally sound, non-Watch List tank. There are no unreviewed safety questions associated with Tank 241-SY-102 at this time. All tank monitoring instruments are in compliance with documented standards (Hanlon 1994a).

Tank 241-SY-102 is actively ventilated and remains in service. The "in service" designation allows the tank to continue receiving waste to support production and/or waste processing. As one of the few "in service" double-shell tanks in the 200 West Area, Tank 241-SY-102 serves as the major receiver of waste from numerous sources within the area. This waste often consists of liquids pumped from single-shell tanks as part of the stabilization effort. Waste from PFP and T Plants has also been sent to Tank 241-SY-102. The tank is used as a staging tank for cross-site transfers to 200 East Area double-shell tanks.

2.2 TANK DESIGN

Double-Shell Tank 241-SY-102 is a tank-in-tank design consisting of a heat-treated primary steel liner inside a second steel liner surrounded by a reinforced concrete shell. The tank has a design capacity for storing 4.39 million liters (1.16 million gallons) of waste; however, safety considerations restrict the maximum operating capacity to 4.31 million liters (1.14 million gallons). The tank has a diameter of 23 m (75 ft) and a usable depth of 10.7 m (35 ft). Instruments access Tank 241-SY-102 through risers and monitor the pressure, temperature, liquid level, sludge level, and other bulk tank characteristics (Bell 1994). The locations of these risers are depicted in Figure 2-1. A diagram of a double-shell tank is presented in Figure 2-2. For more information about the SY Tank Farm and double-shell tanks see the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Figure 2-1. Riser Configuration of Tank 241-SY-102.

Figure 2-2. Basic Design of a Double-Shell Tank.

Not to Scale

Tank 241-SY-102 was constructed in 1976 and went into service in 1977. It is the western-most of three tanks that comprise the 241-SY Tank Farm located at the south end of the 200 West Area. Figure 2-3 details the Hanford Site's 200 West Area and the location of the 241-SY Tank Farm.

2.3 PROCESS KNOWLEDGE

The fill history of Tank 241-SY-102 can be summarized as collecting evaporator feed from 200 West single-shell tanks and wastes from the 222-S Laboratory, T-Plant decontamination operations, and the PFP processing facility. Wastes from the PFP processing facility may contain significant amounts of Pu and Am which should be found in the sludge. Figure 2-4 graphically illustrates the service life of Tank 241-SY-102 from 1981 to January 1995. The surface-level fluctuations are the result of the active transfer history of this tank. (Fill data before 1981 were not available from the Computer Automated Surveillance System database). Many waste types have been transferred into and out of the tank. Table 2-1 uses a compilation of transaction records to present an estimate of the total volume of the various waste types that have entered the tank up to December 31, 1994. Table 2-2 summarizes the transfer history of Tank 241-SY-102 from 1977 to January 1995.

2.3.1 Waste Transfer History

Tank 241-SY-102 was a feed tank for the 242-S Evaporator/Crystallizer and has been used to collect waste from 200 West Area tanks and processes. From the time it began service in 1977 until 1981, Tank 241-SY-102 mostly received supernate from the 241-S, SX, T, and U Tank Farms (Jungfleisch 1984). Transfers from 1978-1980 involved partial neutralization feed for the 242-S Evaporator/Crystallizer. Following the last campaign of the 242-S Evaporator/Crystallizer in 1980, the tank was used to stage cross-site transfers to the 242-A Evaporator (Jungfleisch 1984).

All transaction information since 1981 is taken from the *Waste Volume Projection Historical Database* (Koreski 1994). In 1981, the tank started consistently receiving process waste from 200 West Area facilities. This included sludge and dilute non-complexed waste from T Plant and dilute non-complexed waste from the 222-S Laboratory. The T Plant waste was generated as a result of equipment decontamination agents, decontamination products, and other chemicals added to bring the waste within tank farm specifications. In 1982, additions of wastes from PFP to the tank began. The PFP operations produced a slurry composed of liquid and transuranic solids. The slurry was transferred to Tank 241-SY-102 where it was combined with other 200 West Area wastes and the solids were allowed to settle. The sludge that accumulated in the tank from PFP waste largely remains within it (Agnew 1994). A 1987 solids measurement (Hanlon 1994a) indicates that Tank 241-SY-102 continued to receive sludge and solids from T-Plant and PFP through 1989. The records also indicated the tank sludge volume should be significantly greater than 269,000 liters (71,000 gallons). The transfer records, however, do not account for settling and possible compaction of the sludge layers over time. Other dilute non-complexed liquids from PFP and supernate from other 200 West Area single-shell tanks were also added to the tank.

Figure 2-4. Waste Volume History of Tank 241-SY-102 (1981-1995).

Table 2-1. Estimated Total Volume of Waste Types Received By Tank 241-SY-102 (Jungfleisch 1984; Koreski 1994).

Waste Type	Estimated Volume*
SST Liquid**	98,500,000 liters (26,000,000 gallons)***
222-S Laboratory	1,570,000 liters (416,000 gallons)
T Plant Sludge	450,000 liters (120,000 gallons)
T Plant DN	11,500,000 liters (3,033,000 gallons)
PFP TRU Solids	190,000 liters (51,000 gallons)
PFP DN	6,270,000 liters (1,660,000 gallons)
231-Z Dilute Phosphate	15,000 liters (4,000 gallons)
300, 400 DN	49,000 liters (13,000 gallons)

SST Single-Shell Tank
 DN Dilute Non-Complexed Waste
 TRU Transuranic Waste

- * Total volume is greater than 4,310,000 liters (1,140,000 gallons) because waste was routinely pumped from Tank 241-SY-102 to other tanks and to the evaporator.
- ** SST Liquid includes both supernate from single-shell tanks cycled through the evaporator and salt well liquor from SST stabilization efforts.
- *** A large portion of waste was cycled through Tank 241-SY-102 more than once since it was the feed tank for the 242-S Evaporator/Crystallizer. The reported value is the cumulative amount of liquid added to the tank.

A 1982 transfer of dilute non-complexed liquid is the only transfer that Tank 241-SY-102 has received from the 300 and 400 Areas.

Tank 241-SY-102 stopped receiving liquid from the salt well pumping of 200 West Area single-shell tanks in 1983. Other than this change the tank continued to receive repeated additions of the wastes described previously until 1990. Periodic transfers of the waste to 200 East Area double-shell tanks created room for these additions. In 1993, the tank again began to receive salt well liquid from 200 West Area single-shell tanks. Table 2-2 summarizes the transfer history of Tank 241-SY-102 from 1977 to January 1995. Transfer totals in Table 2-2 show a wide disparity in the amount of waste reportedly transferred out of the tank. Much of the disparity appears to come from the limited data available from the earliest years of the tank transfer history (when this tank was the feed tank for the 242-S Evaporator/Crystallizer). Jungfleisch (1984) indicates more than 94,600,000 L (25,000,000 gallons) of waste were transferred to Tank 241-SY-102 during the 1977-1980 242-S Evaporator/Crystallizer campaigns; however, Jungfleisch shows only 53,000,000 L (14,000,000 gallons) being transferred from the tank. Agnew (1994) estimates these 242-S campaigns reduced more than 132,500,000 L (35,000,000 gallons) of waste by 76%. Even though the early transfer records between the tank and the 242-S Evaporator/Crystallizer show much more waste going into the tank than leaving, this probably has little impact on the present sludge and supernate compositions because these transfers involved mostly supernate with limited quantities of solids and the tank supernate has been removed many times during the life of the tank.

Table 2-2. Tank 241-SY-102 Waste Transfers 1977-1994 (2 sheets).

Year	Waste Received by Tank 241-SY-102			Waste Transferred from Tank 241-SY-102		
	# T	Waste Type	Waste Amount L/(gallons)	# T	X TF	Waste Amount L/(gallons)
1977	3	NIT	2,110,000 (557,000)	2	U	2,660,000 (704,000)
1978	38	PNF NCPLX	21,590,000 (5,704,000)	8	U/S SX	5,495,000 (1,452,000)
1979	65	NCPLX	26,070,000 (6,888,000)	22	S/TX U	5,871,000 (1,551,000)
1980	95	PNF DSSF	47,142,000 (12,455,000)	34	S/SX U/SY	12,390,000 (3,274,000)
1981	41	Water DN/TRU	3,240,000 (856,000)	2	AW	3,160,000 (834,000)
1982	56	DN Water	9,712,000 (2,566,000)	7	AN/AW AZ	12,090,000 (3,193,000)
1983	46	Water DN/TRU	3,720,000 (982,000)	2	AN/AW	3,967,000 (1,048,000)
1984	52	Water DN/TRU	3,410,000 (900,000)	2	AY/AZ	2,060,000 (543,000)
1985	73	Water DP/DN TRU	3,380,000 (894,000)	1	AZ	1,920,000 (506,000)
1986	57	Water DN/TRU	3,370,000 (890,000)	3	AY	5,110,000 (1,350,000)
1987	53	Water DN/TRU	1,820,000 (482,000)	1	AY	1,850,000 (488,000)
1988	54	Water DN/TRU	1,620,000 (427,000)	0	—	0 (-0-)
1989	45	Water DN/TRU	1,100,000 (291,000)	2	AY	2,160,000 (570,000)
1990	7	Water DN	144,000 (38,000)	0	—	0 (-0-)
1991	2	Water	220,000 (58,000)	0	—	0 (-0-)
1992	2	DN	121,000 (32,000)	0	—	0 (-0-)
1993	3	Water DN	200,000 (53,000)	0	—	0 (-0-)
1994	7	Water DN	148,000 (39,000)	0	—	0 (-0-)

Table 2-2. Tank 241-SY-102 Waste Transfers 1977-1994 (2 sheets).

Year	Waste Received by Tank 241-SY-102			Waste Transferred from Tank 241-SY-102		
	# T	Waste Type	Waste Amount L/(gallons)	# T	X TF	Waste Amount L/(gallons)
Total:	699		129,000,000 (34,080,000)	86		58,700,000 (15,510,000)

T Number of transactions
 X TF Transfer to tank farm
 NIT HNO₃/KMNO₄ Solution
 PNF Partial Neutralization Feed
 DSSF Double Shell Slurry Feed
 NCPLX Non-Complexed Waste
 TRU Transuranic Waste
 DN Dilute Non-Complexed Waste
 DP Dilute Phosphate

Future plans for Tank 241-SY-102 include a cross-site transfer of much of the tank's contents to 200 East Area double-shell tanks (Sutey 1994a). This would make more space available to store salt well liquors pumped out during further stabilization efforts of 200 West Area single-shell tanks in addition to providing additional storage for process wastes.

2.3.2 Historical Estimation of the Contents of Tank 241-SY-102

Tank inventory estimates based on the Tank Layer Model, the Waste Status and Transaction Record Summary, and the Hanford Defined Wastes Types developed by Los Alamos National Laboratory were not yet available for Tank 241-SY-102 when this report was compiled.

Estimating the waste constituents of Tank 241-SY-102 is complicated by the level of transfer activity of this tank over its operating life. However, some assumptions can be made based on its operating history.

Because of the constant transfers into and out of the tank, the supernate composition can only be estimated based on the most recent additions. Based on this, the supernate would be expected to be characteristic of 200-West Area facility waste, a dilute non-complexed waste that contains NaOH, NaNO₃ and NaNO₂ at relatively low concentrations. This characteristic composition would be modified depending on the relative volume and composition of single-shell tank salt well liquids added to the tank compared to the volume of facility waste in the tank. Other expected chemicals would be those used at PFP, T-Plant and 222-S Operations since 1984. Because the supernate is alkaline, and no recent reprocessing waste has been generated, the only radionuclides that would be expected at significant concentrations in the supernate are ¹³⁷Cs and possibly ⁹⁰Sr.

The sludge in the tank is a better finger print of the tank history because it is impacted less by the multiple, mostly liquid transfers. The amount of sludge in the tank is relatively small because most of the waste sources were supernates that became feed to an evaporator. The NIT waste added in 1977 contained permanganate and would have resulted in the precipitation of manganese dioxide or hydrous manganese hydroxide on the bottom of the tank. Supernate from the S and SX tank farms probably would not increase the level of sludge significantly other than that carried over with the supernate in the transfer process. Since the S and SX tanks were used to receive waste from the REDOX process, it is possible that the sludge that accumulated between 1978 and 1981 may resemble this process waste. High concentrations of aluminum, chromium and iron are characteristic of some REDOX wastes. Since PFP did not add waste to the tank until the later years, the TRU (Pu and Am) would be expected to found near the top of the sludge. The volume and concentration of insoluble components from the T-Plant and 222-S Laboratory waste probably would not contribute a significant amount of material to the sludge composition.

2.4 SURVEILLANCE DATA

2.4.1 Surface Level Readings

To determine the surface level of the waste, Tank 241-SY-102 is equipped with both an automatic gauge, manufactured by the ENRAF Corporation, and a manual tape. Surface level readings are currently being taken daily with both gauges. The ENRAF gauge was installed June 30, 1994, replacing an automatic Food Instrument Corporation level gauge. The January 5, 1995 ENRAF waste level measurement was 703 cm (277 in.). The manual tape reading for January 4, 1995 was 699 cm (275 in.). Figure 2-4 shows a steady increase in the waste level since January 1990 due to recent additions of waste.

The ENRAF gauge is electrically connected to a computer for automatic data transmission, analysis, and reporting by the Computer Automated Surveillance System. The ENRAF gauge determines waste level by detecting variations in the weight of a displacer (a small disk) suspended in the waste tank through a riser (Hanlon 1994a). The displacer is suspended on a wire wound onto a precision measuring drum. Contacting the waste surface causes a change in the weight of the displacer, which is detected by a force transducer and the measurement is recorded. The manual tape uses a conductivity electrode which is lowered by a hand crank until contact is established with the waste surface and an electrical circuit is completed. Data from the manual tape are entered into the database by an operator. Data from these systems have not shown any surface level changes that would indicate the tank is leaking or that slurry growth is occurring.

2.4.2 Internal Tank Temperatures

To measure in-tank temperatures, a probe with 18 thermocouples assembled in a pipe (called a thermocouple tree) is inserted into Tank 241-SY-102 at Riser 4A (see Figure 2-1). The thermocouple tree monitors waste temperatures at various levels in the tank, usually every two feet. All 18 thermocouples are currently operating. Temperature readings are downloaded to the Surveillance Analysis Computer System weekly.

Maximum temperature readings for Tank 241-SY-102 since 1991 are plotted in Figure 2-5. These temperature data were made available from the Surveillance Analysis Computer System database. The range of temperatures measured inside the tank on January 16, 1995 was 15.7°C (60.3°F) to 18.9°C (66°F). As illustrated by Figure 2-5, maximum temperatures in the tank range between 18°C (65°F) and 24°C (75°F), and have only occasionally exceeded 24°C (75°F). The operation of the exhauster appears to dampen the thermal response of the tank, but seasonal variations are still observed. The recorded temperatures are within design limits of the tank. No temperature anomalies were identified in the history, and the general tank temperature tends to be decreasing as would be expected from the decay of the radioisotopes in the tank.

2.4.3 In-Tank Photographs

The interior of Tank 241-SY-102 was last photographed on April 29, 1981. At that time the tank contained 784,000 gallons of dilute non-complexed waste. This photograph no longer reflects the current appearance of the waste surface and is not included in this report.

Figure 2-5. Tank 241-SY-102 Temperature History.

3.0 TANK SAMPLING OVERVIEW

This section describes the three sampling and analysis events for Tank 241-SY-102. The first core samples were taken in 1988. Tank liquids and solids were taken using the push mode core sampler in 1990, and a grab sample of the supernate was taken in 1994. Vertical distribution of sludge components can only be estimated from the 1988 data since sludge segments from 1990 sampling were composited before analysis. Physical measurements of the sludge were only performed on 1988 samples. Both 1988 and 1990 sampling events were performed to support process development. The 1994 supernate sample was taken to evaluate waste compatibility before transferring. A further description of the sampling procedures may be found in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

3.1 DESCRIPTION OF 1988 SAMPLING EVENT

In October 1988 a core sample was obtained from riser 1B (Scheele and Peterson 1990). Four samples were taken from the bottom 76 inches of the tank. Segments 1 and 2 were liquid. Segments 3 and 4 contained solids with segment 3 being a very fluid slurry. A description of the samples recovered is provided in Table 3-1.

Table 3-1. Tank 241-SY-102, 1988 Sample Data.

Segment Number	Expected Length-cm (inch)	Actual Recovered Length-cm (inch)	Weight Solid Recovered-g	Drill String Dose Rate-mR/hr
1	48.3 (19.0) L	48.3 (19.0) L	0	5.00
2	48.3 (19.0) L	25.4 (10.0) L	0	10.0
3	48.3 (19.0) S	48.3 (19.0) L-S	222	23.0
4	48.3 (19.0) S	38.1 (15.0) S	285	NR

L Liquid
 S Solid (with some interstitial liquid)
 L-S Liquid and Solid
 NR Not reported

3.1.1 Sample Handling (1988)

The samples were extruded and subsampled at the 222-S Laboratory 1E-2 hot cell and sent to the Pacific Northwest Laboratory (PNL) 325 for analysis. The subsampling scheme is described in Table 3-2. Segment 4 was selected for physical analysis. This segment consisted of a top and bottom section. The top section was homogenized by WHC and a 20 mL portion provided to PNL. WHC homogenized segment 3 and provided 15 mL to PNL. The remaining waste from segments 3 and 4 were combined by WHC.

Table 3-2. Subsampling Scheme of the 1988 Sample.

Sample Identification	Sample Description
102-SY-1-2	Supernate, composite of segments #1 and #2. These were yellow liquids.
102-SY-3C	Segment #3. Slurry containing dark brown fine solids.
102-SY-3T4S	Centrifuged solids from the composite of segment #3 and the top portion of segment #4. Fine dark brown solids.
102-SY-3T4L	Centrifuged supernate from the composite of segment #3 and the top portion of segment #4. Yellow liquids.
102-SY-T4C	Top portion of segment #4. Fine, dark brown solids.
102-SY-4B	Bottom portion of segment #4.

3.1.2 Sample Analysis (1988)

Because of the numerous transfers associated with the tank, the 1988 liquid analyses do not provide accurate information on the current composition of the supernate. However the primary sources of waste (200 West facilities) to the tank prior to the 1988 sampling were the same as those today. The liquid fraction was analyzed for metals and radionuclides but not anions. No total organic carbon or organic analyses were performed on the liquid. The liquids were analyzed for radionuclides important to performance/risk base assessment. No gamma energy (^{137}Cs) or actinide analyses were performed on the liquids.

The solids, particularly the bottom of segment 4, received more extensive analyses for anions and radionuclides. Anion analyses on the sludge were only conducted on segment 4. The method for preparing the sludges for anion analysis is not described in laboratory records. The analyses could have been performed on a water wash of the solids or some other treatment such as a KOH fusion followed by a water wash. The results of the physical analyses for the 1988 core sludge sample are discussed in Section 4.3. Tables containing the results of analyses on these segments are found in Appendix C.

3.2 DESCRIPTION OF 1990 SAMPLING EVENT

In February and March of 1990 two cores were taken from Tank 241-SY-102 in support of retrieval, pretreatment, vitrification and grout process development activities. These cores, designated as cores 16 and 17, consisted of 4 segments each. Core 16 was sent to the WHC Process Chemistry Laboratory (PCL) at the 222-S Laboratory for pretreatment development. Core 17 was sent to PNL 325 Laboratory for characterization and analysis.

Both core 16 and 17 were taken from riser 13A as shown in Figure 2-1. When segment 3 from core 17 was removed from the liner, the sample valve was found in the open position which resulted in no waste being obtained. The reason is believed to be the failure of the grappler assembly to remain attached to the pintel rod which prevented the piston from ascending in the sample cylinder. A second sample (3R) was obtained from the same riser at the segment 3 depth (Gauck 1990). During extrusion of core 17 at PNL, it was observed that the physical characteristics (cohesiveness) of this core's sludge segments were more fluid than those of core 16. Because both cores were taken inches apart in the same riser, it is suspected that the sampling of core 16 may have disturbed the solid and liquid phases making core 17 more fluid. For this reason, a 50 g composite sample of core 16 segments was prepared by the PCL and sent to the PNL 325 Laboratory for characterization in addition to the core 17 material.

3.2.1 Sample Handling (1990)

Sample identification and location for cores 16 and 17 are shown in Table 3-3. The observed dose rates for core 17 are provided in Table 3-4. A description of the extruded segments from core 17 is shown in Table 3-5. Photographs of segments 3 and 4 of core 16 are provided in Appendix D. The upper three quarters of segment 3 core 16 consisted of a black sludge that failed to maintain its shape on extrusion because of higher liquid content. The bottom quarter of segment 3 core 16 and the top half of segment 4 exhibited a decrease in moisture content. The bottom half of segment 4 was a dryer black sludge that held its shape upon extrusion.

Table 3-3. Segment Location and Numbering for Tank 241-SY-102.

Core Number	Riser	Segment Number	Cask Serial Number	Sample Number	Date Sampled
16	13A	All	n/a	90-5032	2/21/90
17	13A	1	1003C	90-005	3/7/90
		2	1020C	90-006	3/7/90
		3	1010C	90-007	3/12/90
		3R	1007C	90-007R	3/13/90
		4	1008C	90-008	3/14/90
Grab Sample	1A	---	---	T-560	3/10/94

Table 3-4. Tank 241-SY-102 Drill String Dose Rates.

Smearable Contamination: < Detection Limit for alpha/beta-gamma		
Core	Segment	Drill String Dose Rate (mR/Hr)
17	1	15
	2	34
	3	3
	3R*	200
	4	800

*Resampled due to open valve

Table 3-5. Description Summary of the 1990 Core 17 Sample.

Segment	Wt. Wet Solids (g)	Wt. Drainable Liquid (g)	Consistency	Color
1	0	102	liquid	n/a
2	0	207	liquid	n/a
3R	148	125	runny/watery	brownish/black
4	311	31	runny/watery	brownish/black

Figure 3-1 is a flow chart of the steps taken by the 325 Laboratory in the extrusion and analysis of the core 17 segment. Segments 1 and 2 of core 17, which were liquid with small amounts of solids, were composited and then centrifuged to separate the solid and liquid phases. Portions of the supernate were used to dilute the sludges for rheology studies. Analytical results for the supernate composite are not included in the Appendix A tables because the supernate concentration is continually changing with transfers and is best represented today by the supernate sampling in 1994.

Segments 3 and 4 from core 17 were composited, and the liquid and solid phases separated by centrifuging. This liquid and solid were analyzed, and the results are reported in Appendix A. The 50 g composite sample from PCL's core 16 was centrifuged, and the solids portion analyzed by PNL. This PCL solid result data are also reported in Appendix A.

3.2.2 Sample Analysis (1990)

The metals and most radionuclides were determined on fused samples of sludge. The fusions were either performed in nickel crucibles with KOH or in zirconium crucibles with sodium peroxide. The fused samples were dissolved in acid and analyzed by the methods identified in Appendix E. The method for preparing samples to determine insoluble anions in solids is not identified. This is normally done by fusing the sample and dissolving the sample in water rather than acid. Anion analyses may also be performed on water washes of the solids. Liquid samples are analyzed directly or after diluting in the appropriate acid or water. The analytical methods used for physical measurements are also identified in Appendix E. Additional information on analytical methods can be obtained in the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994).

3.3 DESCRIPTION OF 1994 SAMPLING EVENT

On March 10, 1994, a single liquid grab sample was obtained from Riser 1A of Tank 241-SY-102 using the bottle-on-the-string sampling method (see Table 3-3). The sample identification number was T560 and was acquired 10.2 meters (401 inches) from the top of the riser (Sutey 1994b). This sample was taken to assess the compatibility of the waste for transfer operations.

The sample was transported to the 222-S Laboratory for analysis. The supernate was described as a clear yellow liquid that did not contain solids.

3.3.1 Sample Handling and Analysis (1994)

Because only one sample (liquid without solids) was taken, no special sample treatment or sample splitting was necessary. The supernate was analyzed directly or diluted in the appropriate acid or water. The results of the analyses on this sample are provided in Appendix B.

Figure 3-1. Flow Chart for Data Collection and Preparation.

4.0 ANALYTICAL RESULTS AND WASTE INVENTORY ESTIMATES

4.1 OVERVIEW

The purpose of this section is to summarize the sampling and analytical results from each of the events as reported in the appendices. This section takes several values from the best data sets to arrive at a single estimate of the analyte concentration and total amount of the analyte in the tank (inventory) based on the volumes of sludge and liquid layers estimated to be in the tank. The summary tables and appropriate appendices where the data can be found in this document are summarized in Table 4-1.

Table 4-1. Analytical Data Presentation Tables.

Analysis	Tabulated Result Location
Centrifuged Solids Chemical Composition Summary (1990)	Table 4-2
Tank 241-SY-102 Characterization Summary (1990)	Table 4-3
Analytical Summary for the Centrifuged Sludge and Liquid (1990)	Table A-1
Metals - Centrifuged Solid	Table A-2
Metals - Centrifuged Liquid	Table A-3
Ions - Centrifuged Solid	Table A-4
Ions - Centrifuged Liquid	Table A-5
Radionuclides - Centrifuged Solid	Table A-6
Radionuclides - Centrifuged Liquid	Table A-7
Total Carbon - Centrifuged Solid	Table A-8
1994 Grab Samples Results	Table B-1
1988 Core Sample Results	Table C-1

The sludge composition is based on the analyses of cores 16 and 17 taken in 1990 (Tingey and Sasaki 1995) and reported in Appendix A. The multiple (4) results for ICP metals generated from two different fusions on cores 16 and 17 were averaged to obtain a mean concentration. Values reported to be less than a detection limit were included in the mean calculations. The mean for most of the other analytes in the sludge are based on the average of two data points corresponding to core 16 and 17 results. The mean values for these sludges are summarized in Table 4-2. The centrifuged liquid values from core 17 are based on only one result.

The supernate composition and inventory for the tank was based on the results from the 1994 grab sample as presented in Appendix B. This composition and inventory will frequently change because of continuing transfers of liquid into and out of the tank.

Since the 1990 and 1994 sampling events produce little physical measurement information, the physical analysis results in section 4.3 are based on the results from the 1988 core sampling and analysis activity. Chemical and radiochemical results for the 1988 core sampling event are provided in Appendix C.

In deriving the inventory estimates, if all the values were below the detection limit, the mean was identified as non-detected. If at least one of the values was above the detection limits, the resulting mean was recorded as the detected value. The derivation of the tank inventory estimates is discussed in the next section.

4.2 DATA PRESENTATION

A summary of the data obtained from the analyses of the centrifuged solids samples derived from the 1990 sludge samples from Tank 241-SY-102 is presented in Table 4-2. The first column 'Analyte Method' is the method used to determine the analyte concentration. The second column 'Number of Analyses' is the total number of analyses performed for each analyte. The third column 'Percent Non-detect Analyses' is the ratio of analyses which yielded results below the detection limit, and the total number of analyses for a particular analyte, times 100. The fourth and fifth columns 'Minimum Detected Value' and 'Maximum Detected Value' present the least and the highest values (above the detection limit). The analytes which exhibited one detected value and the remainder non-detected have no values given for the minimum and maximum observed values. Likewise, the analytes for which one sample result is listed will have no minimum or maximum observed value given in the table.

Columns six and seven contain data which are taken from Appendix A of this report. The sixth column 'Mean' is the average of all the analyses from core 16 and 17 for the 1990 sampling event. This value is a simple (non-weighted) mean of all sample results. Column seven 'RSD' lists the relative standard deviation (standard deviation divided by the mean) of the sample results. Individual values for all samples are given in the Appendix A tables.

Table 4-2. Centrifuged Solids (from sludge) Chemical Composition Data Summary (3 sheets).

Analyte Method	Number of Analyses	Percent non-detect Analyses	Minimum Detected Value	Maximum Detected Value	Mean	RSD (Mean)
METALS		%	µg/g	µg/g	µg/g	%
ICP.Al	4	0	36,600	55,900	45,600	20.3
ICP.Sb	4	100	---	---	<3.34E-04	---
ICP.As	4	100	---	---	<7.98E-04	---
ICP.Ba	4	0	76.0	201	141	40.3
ICP.Be	4	0	3.00	11.0	7.00	52.2
ICP.B	4	100	---	---	<2.96E-04	---
ICP.Ca	4	0	6,550	18,100	11,500	45.9
ICP.Cd	4	0	341	1,180	742	62.2
ICP.Ce	4	100	---	---	<8.42E-04	---

Table 4-2. Centrifuged Solids (from sludge) Chemical Composition Data Summary (3 sheets).

Analyte Method	Number of Analyses	Percent non-detect Analyses	Minimum Detected Value	Maximum Detected Value	Mean	RSD (Mean)
METALS (continued)		%	µg/g	µg/g	µg/g	%
ICP.Co	4	100	---	---	<0.00165	---
ICP.Cr	4	0	17,700	19,400	18,900	4.11
ICP.Cu	4	0	126	700	428	63.3
ICP.Dy	4	100	---	---	<3.67E-05	---
ICP.Fe	4	0	20,600	64,400	40,900	57.5
ICP.La	4	0	78.0	173	121	33.5
ICP.Pb	4	0	1,470	5,000	3,090	57.4
ICP.Li	4	100	---	---	<4.88E-05	---
ICP.Mg	4	0	1,000	3,220	1,980	58.1
ICP.Mn	4	0	5,300	17,300	10,900	59.2
ICP.Mo	4	75	---	---	18.3	199
ICP.Nd	4	50	406	407	203	116
ICP.Ni	2	0	943	1,110	1,030	---
ICP.P	2	0	13,600	43,600	28,600	---
ICP.K	2	0	3,200	3,480	3,340	---
ICP.Re	4	100	---	---	<7.75E-05	---
ICP.Rh	4	75	---	---	110	199
ICP.Ru	4	100	---	---	<2.54E-04	---
ICP.Se	4	100	---	---	<7.65E-04	---
ICP.Si	4	0	7,200	22,300	13,600	55.7
ICP.Ag	4	0	129	627	359	67.0
ICP.Na	2	0	1.13E+05	1.66E+05	1.40E+05	---
ICP.Sr	4	0	81.0	372	221	61.5
ICP.Te	4	100	---	---	<3.43E-04	---
ICP.Th	4	0	1,900	11,400	6,350	79.6
ICP.Ti	4	0	178	546	351	56.7
ICP.Tl	4	100	---	---	<0.00680	---
ICP.U	4	75	---	---	1,950	200
ICP.V	4	50	---	---	35.8	129
ICP.Zn	4	0	524	1,640	1,150	48.6
ICP.Zr	2	0	296	1,190	743	---

Table 4-2. Centrifuged Solids (from sludge) Chemical Composition Data Summary (3 sheets).

Analyte Method	Number of Analyses	Percent non-detect Analyses	Minimum Detected Value	Maximum Detected Value	Mean	RSD (Mean)
IONS		%	µg/g	µg/g	µg/g	%
Cr ⁺⁶	1	0	---	---	873	---
IC.Cl ⁻	2	0	780	1,840	1,310	---
IC.F ⁻	2	0	1,160	5,200	3,180	---
IC.NO ₃ ⁻	2	0	53,000	75,600	64,300	---
IC.NO ₂ ⁻	2	0	8,200	20,600	14,400	---
IC.PO ₄ ³⁻	2	0	12,500	55,400	34,000	---
IC.SO ₄ ²⁻	2	0	3,220	5,400	4,310	---
RADIONUCLIDES		%	µCi/g	µCi/g	µCi/g	%
APC. ²⁴¹ Am	2	0	31.5	126	79.3	---
LSC. ¹⁴ C	1	0	---	---	0.00270	---
GEA. ¹⁴⁴ Ce	1	0	---	---	4.76	---
GEA. ⁶⁰ Co	2	0	0.310	0.311	0.311	---
AEA. ^{243/244} Cm	1	0	---	---	0.0950	---
GEA. ¹³⁷ Cs	2	0	40.4	112	76.2	---
GEA. ¹⁵⁴ Eu	2	0	2.30	2.72	2.51	---
GEA. ¹⁵⁵ Eu	2	0	2.40	3.10	2.75	---
GEA. ⁸⁴ Nb	1	100	---	---	<0.00141	---
APC. ²³⁷ Np	1	100	---	---	<0.00252	---
AEA. ²³⁸ Pu	1	0	---	---	1.14	---
AEA. ^{239/240} Pu	1	0	---	---	10.1	---
LSC. ⁷⁹ Se	1	100	---	---	<0.0220	---
BPC. ⁹⁰ Sr	1	0	---	---	136	---
LSC. ⁹⁹ Tc	1	0	---	---	0.0640	---
LSC. ³ H	1	0	---	---	0.00111	---
APC.TA	1	0	---	---	31.9	---
BPC.TB	1	0	---	---	355	---
PHYSICAL PROPERTIES		%			g/mL	
Solid Density	1	0	---	---	1.80	---
TOTAL CARBON		%	µg/g	µg/g	µg/g	%
Total Organic Carbon	1	0	---	---	7,100	---
Total Inorganic Carbon	2	0	5,600	7,300	6,450	---
Total Carbon	1	0	---	---	12,700	---

The chemical composition of the centrifuged sludge, the centrifuged sludge liquid, and the supernate which exists above the sludge layer is reported in Table 4-3. The projected inventory calculations associated with the sludge in the tank were calculated from a sludge volume of 466,000 liters (123,000 gal). This was the amount of sludge estimated to be present at the time of sampling, February 1990. The numerical volume was then converted from liters to grams by utilizing the following equation:

$$(466,000 \text{ L}) (1000 \text{ ml/L}) (1.56 \text{ g/ml}) = 7.27\text{E}+08 \text{ g or } 727,000 \text{ kg}$$

The overall density of the sludge, 1.56 g/ml, was determined by considering several sources of information. The analysis of a liquid sample acquired in 1988 and composed from segment 3 and the upper portion of segment 4 yielded a density of 1.18 g/ml (Weiss 1990); this sample was considered to closely resemble the centrifuged liquid associated with the composites of segments 3 and 4 of core 17 which was obtained in 1990. The density of segment 4B, a 1988 sample, was 1.80 g/ml (Scheele and Peterson 1990), and this result was deemed to represent the centrifuged solids associated with the composite of segments 3 and 4 of core 17, the 1990 sample. According to Herting (1994), solids comprise 60.5% of the sludge in 241-SY-102 by weight; therefore, the average density of the sludge was calculated as follows:

$$0.605 (1.80) + 0.395 (1.18) = 1.56 \text{ g/ml}$$

The ability to completely separate the interstitial liquid from the solids will affect the accuracy of this density estimate. However, this error probably is not significant when compared to other errors associated with the inventory estimate.

From the aforementioned weight percent solids figure, the sludge was determined to consist of 440,000 kg of solids and 287,000 kg of interstitial liquid. In Table 4-3, the total projected inventory value for each analyte detected in the sludge was determined by adding the inventory results that were derived separately from the centrifuged solid and liquid data (see Appendix A). The overall concentrations for each analyte were calculated by dividing the total projected inventory values by the total mass of the sludge, 727,000 kg.

The volume of supernatant liquid waste existing above the sludge layer in Tank 241-SY-102 was 2,560,000 liters (676 kgal) when the March 1994 sampling event occurred (Hanlon 1994b). This volume and the reported density, 1.03 g/mL, were utilized to calculate inventory estimates from the liquid grab sample data.

Table 4-3. Tank Characterization Summary for Tank 241-SY-102 (3 sheets).

Analyte	1990 Centrifuged Sludge Sample				1994 Grab Sample	
	Solid Result	Liquid Result	Calculated Analyte Concentration ^(a)	Total Projected Inventory	Liquid Sample Result	Projected Inventory
METAL	$\mu\text{g/g}$	$\mu\text{g/g}$	$\mu\text{g/g}$	kg	$\mu\text{g/g}$	kg
Al	45,600	3,100	28,900	21,000	617	1,630
Sb	< 3.34E-04	< 1.02	< 0.403	< 0.293	---	---
As	< 7.98E-04	7.88	3.11	2.26	---	---
Ba	141	3.31	86.7	63.0	---	---
Be	7.00	0.0847	4.26	3.10	---	---
B	< 2.96E-04	20.3	8.02	5.83	---	---
Cd	742	22.9	466	339	---	---
Ca	11,500	44.2	6,970	5,070	---	---
Ce	< 8.42E-04	< 2.03	< 0.802	< 0.583	---	---
Cr	18,900	564	11,700	8,480	---	---
Co	< 0.00165	5.08	2.01	1.46	---	---
Cu	428	1.53	259	188	---	---
Dy	< 3.67E-05	< 0.169	< 0.0667	< 0.0485	---	---
Fe	40,900	4.15	24,800	18,000	< 5.04	< 13.3
La	121	< 0.169	73.2	53.2	---	---
Pb	3,090	3.56	1,870	1,360	---	---
Li	< 4.88E-05	< 0.0847	< 0.0334	< 0.0243	---	---
Mg	1,980	0.508	1,200	871	---	---
Mn	10,900	0.169	6,600	4,800	---	---
Mo	18.3	25.2	26.3	19.1	---	---
Nd	203	< 0.847	123	89.7	---	---
Ni	1,030	7.46	626	455	---	---
P	28,600	1,580	17,900	13,000	---	---
K	3,340	2,350	2,940	2,140	---	---
Re	< 7.75E-05	0.339	0.134	0.0973	---	---
Rh	110	2.88	68.3	49.7	---	---
Ru	< 2.54E-04	4.07	1.61	1.17	---	---
Se	< 7.65E-04	< 1.02	< 0.403	< 0.293	---	---
Si	13,600	218	8,310	6,040	---	---
Ag	359	0.169	217	158	---	---
Na	1.40E+05	85,600	1.19E+05	86,200	16,800	44,300
Sr	221	0.169	134	97.2	---	---
Te	< 3.43E-04	2.88	1.14	0.827	---	---
Tl	< 0.00680	< 28.8	< 11.4	< 8.27	---	---

Table 4-3. Tank Characterization Summary for Tank 241-SY-102 (3 sheets).

Analyte	1990 Centrifuged Sludge Sample				1994 Grab Sample	
	Solid Result	Liquid Result	Calculated Analyte Concentration ^(a)	Total Projected Inventory	Liquid Sample Result	Projected Inventory
METAL (continued)	$\mu\text{g/g}$	$\mu\text{g/g}$	$\mu\text{g/g}$	kg	$\mu\text{g/g}$	kg
Th	6,350	< 1.53	3,840	2,790	---	---
Ti	351	< 0.0847	212	154	---	---
U	1,950	15.3	1,190	862	---	---
V	35.8	0.508	22.0	16.0	---	---
Zn	1,150	2.71	697	507	---	---
Zr	743	0.0847	450	327	---	---
ION	$\mu\text{g/g}$	$\mu\text{g/g}$	$\mu\text{g/g}$	kg	$\mu\text{g/g}$	kg
NH ₃	---	---	---	---	< 38.8	< 102
Br ⁻	---	< 3.39	< 1.34	< 0.973	---	---
Cl ⁻	1,310	2,540	1,800	1,310	194	512
Cr ⁶⁺	873	---	528	384	---	---
CN ⁻	---	---	---	---	1.01	2.66
F ⁻	3,180	373	513	1,510	730	1,930
OH ⁻	---	---	---	---	3,370	8,880
NO ₃ ⁻	64,300	94,900	76,300	55,500	22,800	60,200
NO ₂ ⁻	14,400	31,600	21,200	15,400	3,130	8,240
PO ₄ ³⁻	34,000	4,750	22,600	16,400	385	1,020
SO ₄ ²⁻	4,310	6,270	5,090	3,700	506	1,330
RADCHEM	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	Ci	$\mu\text{Ci/g}$	Ci
²⁴¹ Am	79.3	---	48.0	34,900	< 2.59E-05	< 0.0684
¹⁴ C	0.00270	---	0.00164	1.19	---	---
¹⁴⁴ Ce	4.76	---	2.87	2,090	---	---
¹³⁷ Cs	76.2	84.6	79.5	57,800	6.57	17,300
⁶⁰ Co	0.311	0.00803	0.191	139	---	---
^{234/244} Cm	0.0950	---	0.0575	41.8	---	---
¹⁵⁴ Eu	2.51	---	1.51	1,100	---	---
¹⁵⁵ Eu	2.75	---	1.66	1,210	---	---
²³⁷ Np	< 0.00252	---	< 0.00153	< 1.11	2.03E-05	0.0535
⁸⁴ Nb	< 0.00141	---	< 8.53E-04	< 0.620	---	---
²³⁸ Pu	1.14	---	0.691	502	---	---
^{239/240} Pu	10.1	---	6.11	4,440	3.00E-04	0.791
⁷⁸ Se	< 0.0220	---	< 0.0133	< 9.68	---	---
⁹⁰ Sr	136	---	82.3	59,800	0.00113	3.00
⁹⁸ Tc	0.0640	---	0.0388	28.2	---	---
Tritium	0.00111	---	6.71E-04	0.488	---	---

Table 4-3. Tank Characterization Summary for Tank 241-SY-102 (3 sheets).

Analyte	1990 Centrifuged Sludge Sample				1994 Grab Sample	
	Solid Result	Liquid Result	Calculated Analyte Concentration ^(a)	Total Projected Inventory	Liquid Sample Result	Projected Inventory
RADCHEM (continued)	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	Ci	$\mu\text{Ci/g}$	Ci
Total α	31.9	---	19.3	14,000	0.00599	15.8
Total β	355	---	215	1.56E+5	7.99	21,100
PHYSICAL PROPERTY			g/mL			
Grav. %H ₂ O	---	---	---	---	95.4%	---
TGA.H ₂ O	---	---	---	---	88.8%	---
pH	---	---	---	---	12.8	---
SpG	---	---	---	---	1.03	---
Density	---	---	1.56	---	---	---
CARBON	$\mu\text{g/g}$	$\mu\text{g/g}$	$\mu\text{g/g}$	kg	$\mu\text{g/g}$	kg
TOC	7,100	---	4,290	3,120	243	640
TIC	6,450	---	3,910	2,840	< 19.4	< 51.2

^a Concentration of analyte in sludge as it exists in the tank with interstitial liquid (not centrifuged).

4.3 PHYSICAL MEASUREMENTS

Very few physical analyses were performed on the samples obtained in 1990. Since the samples acquired in 1988 are considered to be representative of the waste and were subjected to extensive physical testing, their results are discussed in the following sections.

4.3.1 Density, Percent Solids and Settling Behavior

The density of the waste in Tank 241-SY-102 is discussed in detail in Section 4.2. Density measurements pertaining to several segment analyses from 1988 core samples are presented in Table 4-4. The 1:1 and 2:1 sample dilutions recorded in Table 4-4 were water:solids volumetric ratios.

Table 4-4. Tank 241-SY-101 Sludge Physical Measurements (Based on Physical Data Acquired in the 1988 Sampling Effort).

Physical Property		4B	4B(1:1)	4B(2:1)	T4C
Density (g/mL)		1.80	1.42	1.29	1.52
Settled solids	Vol%	(a)	58	38	(b)
Wt% Water		32.7	53.3	63.5	(b)
Wt% Oxide		38.4	(b)	(b)	(b)
Centrifuged solids	Vol%	92	30	18	62
	Wt%	93.9	35.4	20.9	60.2

(a) No free water observed in received sample.

(b) Analysis not requested.

Percent solids were measured as vol% for settled solids and vol% and wt% for centrifuged solids. Four different samples from segment 4 were analyzed: T4C (Top portion of segment), 4B (Bottom portion of segment) and two dilutions (1:1 and 2:1) of 4B. Table 4-4 shows a summary of the results.

The 4B solid samples were quite dense, with 4B having a density of 1.80 and T4C having a density of 1.52. The majority of the sample consisted of solids (92 vol% and 93.9 wt%). Sample 4B contained no free liquid; therefore, a vol% settled solids could not be determined. For the 1:1 dilution sample the settled solids exhibited a value of 58% and for a 2:1 dilution, 38%.

The settling behavior of the two 4B dilutions, 1:1 and 2:1, were determined. As shown in Table 4-5, the solids in the 1:1 dilution settled completely in approximately 27 hrs. The greatest settling rate for the 1:1 dilution was 0.23 cm/hr. The solids in the 2:1 dilution settled completely in approximately 24 hrs. The greatest settling rate for the 2:1 dilution was 0.42 cm/hr.

Table 4-5. Settling Behavior for 4B Sample.

4B 1:1 dilution		4B 2:1 dilution	
Time (Hr)	Distance settled (cm)	Time (Hr)	Distance settled (cm)
1.0	0.0	1.2	0.4
2.0	0.4	2.0	0.83
4.2	0.84	4.1	2.6
6.0	1.4	6.0	2.9
22.2	2.4	7.2	3.0
25.2	2.4	23.7	3.8
27.2	2.6	25.7	3.8
29.2	2.6	27.7	3.8
30.1	2.6	29.3	3.8
46.5	2.8		

4.3.2 Particle Size

Particle size analysis was performed using a light-scattering particle size analyzer on segment 4B (bottom portion). The particle size data were based on both the population and volume of the sample. When based on the population, particles were within the 10-20 μm range and within the 50-60 μm range when based on volume. The particle size data are presented in Appendix F.

4.3.3 Thermodynamic Analyses

Neither thermogravimetric nor differential scanning calorimetric analyses were performed.

4.3.4 Penetrometry

The penetration resistance of segment 4B was measured using the CT-421A penetrometer. This was carried out to determine whether the solids exhibited dilatant or cohesive properties. A dilatant sludge would be eroded by the mixer pump and a cohesive sludge would be broken down into large pieces of sludge by the mixer pump. A low penetration resistance (0 - 10 psi) indicates that a sludge is cohesive and a high penetration resistance (100 psi or greater) shows that a sludge is dilatant. The penetration resistance of the sample was 11 psi, indicating that the solid exhibited cohesive properties.

4.3.5 Shear Strength

Shear strength was measured on segment 4B. The shear strength was measured using a shear vane and the Haake viscometer and was reported to be approximately 39,000 dynes/cm².

4.3.6 Shear Stress Versus Shear Rate for 102-SY-4B Dilutions

Shear stress versus shear rate measurements were also made on the 1:1 and 2:1 dilutions of segment 4B. The rheograms for both dilutions showed that they exhibited pseudoplastic behavior. Neither slurry exhibited a yield stress. The data from the rheograms were fit to the pseudoplastic model yielding the following results. Table 4-6 shows the power law curve fit parameters. The power law model describes the change in shear stress as a function of shear rate and the flow behavior index, and yields the necessary parameters for the yield-pseudoplastic rheological model. For information on the power law model and additional discussion, refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Table 4-6. Power Law Curve Fit Parameters.

Segment	Water: Sample	Temp (°C)	Run	Yield Point (Pa)	Consistency Factor (Pa•s)	Flow Behavior Index
4B	1:1	30	1	(a)	0.026	0.821
			2	(a)	0.028	0.817
4B	2:1	30	1	(a)	0.013	0.808
			2	(a)	0.014	0.791

(a) Neither slurry exhibited a yield stress.

The rheological parameters along with the density of the dilutions were input into the Hank's computer model to obtain the critical Reynolds Number and the critical velocity for transferring the slurries in 3.0 inch and 2.0 inch diameter pipes. The results are summarized in Table 4-7.

Table 4-7. Turbulent Flow Model Calculations.

Sample	Pipe diameter (inch)	Critical Velocity m/s	Reynolds Number
1:1 dilution	3.0	0.305	2,210
	2.0	0.403	2,210
2:1 dilution	3.0	0.177	2,230
	2.0	0.232	2,230

5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

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

5.1.1 Field/Laboratory Observations

During the handling of the 1990 samples, two observations were made that could impact the interpretation of the data. No sample was recovered from the third segment of core 17 because of a faulty sampler. This required the resampling of the tank at this location. The representativeness of the sample on the second sampling (3R) could be affected by the removal of the first sample. Since segments 3 and 4 were composited, comparisons between segment data cannot be performed.

During extrusion of core 17, it was observed that the consistency of the waste was significantly different (more fluid) than core 16. This was attributed to potential waste mixing during core sampling since core 17 was taken after core 16 just a few inches away in the same riser. A sample of core 16 was also analyzed to evaluate this effect. The results from these two cores is compared in Table 5-1. There appears to be differences in some of the major components (Al, Ca, Fe, Mn, Th, P and Na) that are greater than would be expected from a natural localized distribution of the wastes. Since core 17 was more fluid, it may indicate that more supernate was mixed in the sludge layer. However, the data indicate that the composite of core 17 segments 3 and 4 (3/4 sample) is actually higher in concentration for many of the transition and heavy metals (Al, Ca, Fe, Pb, Mn, Th) expected to be found in sludge (not the supernate) than the undisturbed core 16. The undisturbed core 16 appears to be significantly richer in sodium and phosphate. The 1988 sampling event data in Appendix C, in which segments 3 and 4 were analyzed more separately, indicates that the core 17 sample is richer in analytes (Ca, Fe, Mn) from the upper level portion of the sludge. Based on this observation, it appears that initial sampling from the riser may have caused some mixing of the waste layers.

Table 5-1. Relative Percent Differences Between the Core 17 Composite and Core 16 and PCL Samples (2 sheets).

Analyte	3/4 Sample (Core 17) ($\mu\text{g/g}$)	PCL (Core 16) Sample	Relative percent difference*
Aluminum	53,400	37,900	34
Barium	188	94.5	66
Beryllium	10	4	86
Calcium	15,800	7,280	74
Cadmium	1,140	343	107
Chromium	18,400	19,300	5

Table 5-1. Relative Percent Differences Between the Core 17 Composite and Core 16 and PCL Samples (2 sheets).

Analyte	3/4 Sample (Core 17) ($\mu\text{g/g}$)	PCL (Core 16) Sample	Relative percent difference*
Copper	442	413	7
Iron	61,200	20,700	99
Lanthanum	138	103	29
Lead	4,600	1,590	97
Magnesium	2,960	1,000	99
Manganese	16,500	5,390	102
Nickel	1,110	943	16
Phosphorus	13,600	43,600	105
Potassium	3,480	3,200	8
Silicon	20,000	7,250	93
Silver	562	157	113
Sodium	113,000	166,000	38
Strontium	334	108	102
Thorium	10,700	2,000	137
Titanium	523	180	98
Zinc	1,080	1,220	12
Zirconium	1,190	296	120
Chlorine	1,840	780	81
Fluorine	1,160	5,200	127
Nitrate	75,600	53,000	35
Nitrite	20,600	8,200	86
Phosphate	12,500	55,400	126
Sulfate	5,400	3,220	51
Total Inorganic Carbon	7,300	5,600	26
	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	
²⁴¹ Americium	126	31.5	120
¹³⁷ Cesium	112	40.4	94
⁶⁰ Cobalt	0.31	0.311	0.3
¹⁵⁴ Europium	2.72	2.3	17
¹⁵⁵ Europium	3.1	2.4	25

$$* \text{RPD} = \left[\frac{|a-b|}{(a+b)/2} \right] * 100$$

5.1.2 Quality Control Assessment of Analytical Data

No quality control data were available for evaluating samples analyzed at PNL for the 1988 sampling event. Duplicate results for ICP using different fusions in Appendix A provide an indication of the reproducibility for these 1990 analyses and also an indication of the sample homogeneity. In general, these duplicates agree well (<20% RPD) for most of the major analytes. The raw data in the 1990 sampling event report (Tingey and Sasaki 1995) contain different amounts of blank, duplicate, spike, and standards data depending on the method that may be used to assess the results. The blank data for ICP is summarized in Table 5-2. These blank data are generated from the analysis of a deionized water sample carried through the fusion and/or dilution process. Only Ca, Ba and Ni had blank values greater than 20% of the sample mean concentration. This may indicate that these results are biased high. Other quality control data for the 1990 sampling event are not conveniently arranged or summarized for reporting in this document. Because the compatibility analyses in the 1994 supernate characterization were considered for process control purposes, the level of quality control was minimal. If a particular result causes concern, the source documents should be examined to evaluate the quality of the analysis.

Table 5-2. Summary of Blank Measurements.

Analytes Exhibiting 2 of 2 Blanks > Detection Limit	Blank concentration/ Sample Mean
Barium	22% ¹
Calcium	52%
Iron	3%
Magnesium	9%
Manganese	< 1%
Strontium	12%
Zinc	12%
Analyte Exhibiting 1 of 2 Blanks > Detection Limit	
Chromium	1% ²
Nickel	31%

¹Average of two blanks over detection limit/mean concentration.

²Blank over detection limit/mean concentration.

5.1.3 Data Consistency Checks

The ability to assess the overall consistency or trends of the data between segments and between cores is limited for the Tank 241-SY-102 sampling and analysis events because of the limited number of cores taken and the limited number of analyses on discrete segments at different depths. The comparison of the sludge results from the different events described in the next section gives an indication of the data consistency for this tank. Additional checks can be made on individual analytes when the same aliquot of sample is analyzed by two comparable methods. Some of these comparisons are provided below.

5.1.3.1 Comparison of ICP Phosphorus and IC Phosphate Analyses. When the ICP phosphorus result for the 1990 centrifuge liquid from the segment 3 and 4 composite is converted to phosphate and compared to the ion chromatographic phosphate result, the results differ by only 2%.

5.1.3.2 Comparison of Total Alpha and Beta Activities with the Sum of Individual Isotopes. This evaluation can be used to ascertain the performance of the radiochemical separation methods or as an indicator of the presence of other isotopes that may be present in significant quantities. With regard to the centrifuged solids associated with the sludge, a comparison was made between the sums of the gross beta and gross alpha activities with the sum of the individual beta and alpha emitters. The activities of the individual beta emitters were summed according to the following equation:

$$\text{Total beta} = (2 * {}^{90}\text{Sr}) + ({}^{137}\text{Cs})$$

The activities of the individual alpha emitters were summed according to:

$$\text{Total alpha} = {}^{241}\text{Am} + {}^{238}\text{Pu} + {}^{239/240}\text{Pu}$$

The comparisons are given in Tables 5-3 and 5-4. Table 5-3 is based on the average solid results from core 16 and 17 from Table 4-3. Table 5-4 is based on core 16 results from Appendix A.

Table 5-3. Tank 241-SY-102 Comparison of Gross Beta Activities with the Total of the Individual Activities.

Analyte	Half-Life	Centrifuged Solids ($\mu\text{Ci/g}$)
${}^{90}\text{Sr}^1$	28.6y	272
${}^{137}\text{Cs}$	30.17y	76.2
Total Beta Sum (a)	-----	348
Gross Beta Result (b)	-----	355
Relative percent difference ²	-----	2.00%

¹ (2 * Sr) to account for ${}^{90}\text{Y}$ daughter

² Relative Percent Difference = $[|a-b| / (a+b)/2] * 100$

The total beta analysis for cores 16 and 17 agree well with the sum of the major beta isotopes (^{137}Cs and ^{90}Sr) for the centrifuged sludge. Since total alpha analyses were not conducted for core 17 centrifuged sludge, the alpha comparison can only be performed on core 16 results. The total alpha for core 16 is about 29% lower than the sum of the individual isotopes. This discrepancy may be caused by excessive solids on the total alpha mount which absorb alpha particles and cause lower results.

Table 5-4. Tank 241-SY-102 Comparison of Gross Alpha Activities with the Total of the Individual Activities.

Analyte	Half-Life	Centrifuged Solids ($\mu\text{Ci/g}$)
^{241}Am	458y	31.5
^{238}Pu	86y	1.1
$^{239/240}\text{Pu}$	24,400/6,580y	10.1
Sum of Alpha Emitters (a)	-----	42.7
Total Alpha (b)	-----	31.9
Relative Percent Difference ¹	-----	29.0%

¹Relative Percent Difference = $[|a-b|/(a+b)/2] \times 100$

5.1.3.3 Mass and Charge Balance. The principle objective in performing a mass and charge balance is to determine if the measurements are self-consistent. In calculating the balances, only sludge phase analytes listed in Table 4-3 which were detected at a concentration of 1,500 $\mu\text{g/g}$ or greater were considered.

With the exception of sodium and potassium, all cations listed in Table 5-5 were assumed to be present in their most common hydroxide or oxide forms, and the concentrations of the assumed species were calculated stoichiometrically. There may be some argument whether or not certain species are hydroxides or oxides, but the difference in molecular weight has a minimal effect on the overall mass balance. Although smaller concentrations of other forms of the species are probably also present in the waste, they are not included in order to keep the mass-charge balance calculations simple and consistent.

Since precipitates are neutral species, all positive charge was attributed to the sodium and potassium cations. The anionic analytes listed in Table 5-6 were assumed to be present as sodium or potassium salts and were expected to balance the positive charge. The acetate and carbonate data were derived from the total organic carbon and total inorganic carbon analyses, respectively. The concentrations of the assumed species in Table 5-5, of the anionic species in Table 5-6, and the percent water were ultimately used to calculate the mass balance, shown in Table 5-7.

The mass balance was calculated from the formula below. The factor 0.0001 is the conversion factor from $\mu\text{g/g}$ to weight percent.

$$\begin{aligned} \text{Mass balance} &= \% \text{ Water} + 0.0001 \times \{\text{Total Analyte Concentration}\} \\ &= \% \text{ Water} + 0.0001 \times \{\text{Al(OH)}_3 + \text{CaO} + \text{FeO(OH)} + \text{Pb(OH)}_2 + \\ &\quad \text{MnO}_2 + \text{Na}^+ + \text{K}^+ + \text{Cr(OH)}_3 + \text{ThO}_2 + \text{C}_2\text{H}_3\text{O}_2^- + \text{CO}_3^{2-} + \text{Cl}^- + \\ &\quad \text{SiO}_3^{2-} + \text{NO}_3^- + \text{NO}_2^- + \text{PO}_4^{3-} + \text{SO}_4^{2-}\} \end{aligned}$$

The analyte concentrations from the above equation totaled 507,000 $\mu\text{g/g}$. The mean weight percent water was determined to be 39.5% since the percentage of solids in the sludge was 60.5% as previously discussed in section 4.2. The mass balance resulting from adding the percent water to the total analyte concentration is 90.2%.

Table 5-5. Cation Mass and Charge Data.

Analyte	Concentration ($\mu\text{g/g}$)	Assumed Species	Concentration of Assumed Species ($\mu\text{g/g}$)	Charge ($\mu\text{mol/g}$)
Aluminum	28,900	$\text{Al}(\text{OH})_3$	83,500	0
Calcium	6,970	CaO	9,760	0
Chromium	11,700	$\text{Cr}(\text{OH})_3$	23,200	0
Iron	24,800	$\text{Fe}(\text{O})(\text{OH})$	39,500	0
Lead	1,870	$\text{Pb}(\text{OH})_2$	2,180	0
Manganese	6,600	MnO_2	10,500	0
Potassium	2,940	K^+	2,940	75
Sodium	119,000	Na^+	119,000	5,170
Thorium	3,840	ThO_2	4,370	0
Totals			295,000	5,250

Table 5-6. Anion Mass and Charge Data.

Analyte	Concentration ($\mu\text{g/g}$)	Charge ($\mu\text{mol/g}$)
Acetate (TOC) ^a	10,500 (4,290)	179
Carbonate (TIC) ^a	19,600 (3,910)	652
Chloride	1,800	51
Silicate	22,600	595
Nitrate	76,300	1,230
Nitrite	21,200	461
Phosphate ^b	54,900	1,730
Sulfate	5,090	106
Totals	212,000	5,000

^a The values in parentheses are from the TOC and TIC analytical results, and were used to derive the acetate and carbonate values on the left.

^b Calculated from the ICP phosphorous data.

Table 5-7. Mass Balance Totals.

	Concentrations ($\mu\text{g/g}$)
Total from Table 5-5	295,000
Total from Table 5-6	212,000
Water	395,000
Grand Total	902,000

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

$$\text{Total cations (microequivalents)} = \text{Na}^+/23.0 + \text{K}^+/39.1$$

The total cation charge, 5,250 $\mu\text{mol/g}$, is calculated in Table 5-5.

$$\text{Total anions (microequivalents)}$$

$$= \text{C}_2\text{H}_3\text{O}_2^-/59.0 + \text{CO}_3^{2-}/30.0 + \text{Cl}^-/35.5 + \text{SiO}_3^{2-}/38.0 + \text{NO}_3^-/62.0 + \text{NO}_2^-/46.0 \\ + \text{PO}_4^{3-}/31.7 + \text{SO}_4^{2-}/48.0$$

The total anion charge, 5,000 $\mu\text{mol/g}$, is calculated in Table 5-6.

The ratio of microequivalents of total cations to microequivalents of total anions was 1.05; a perfect charge balance would yield a ratio equivalent to 1.00.

The charge and mass balance results (105 and 90% recovery respectively) demonstrate good agreement among analyses when considering the uncertainty in the assumptions and numerous measurements that are used to arrive at the values. These results do not indicate that large data inconsistencies or errors are present or that major components may not have been analyzed and evaluated.

5.2 COMPARISON OF 1988 AND 1990 SUPERNATE ANALYTICAL RESULTS

Analytical data for selected analytes from the 102-SY-3T4L 1988 sample were compared in Table 5-8 to the analytical results acquired from the centrifuged liquid of the 1990 composite of sludge segments 3 and 4. These two sets of data were chosen for comparison since both were derived from the centrifuged liquid of samples obtained from the sludge layer of the tank. Only analytes with detected values were used. A relative percent difference (RPD), defined as the absolute difference between two samples times 100, divided by the mean of the two, was calculated for each analyte.

As can be seen from Table 5-8, two analytes exhibited RPD's > 100%. However, these analytes were at low concentrations where analytical errors are expected to be larger. The major analyte results for Na and Al agreed very well, with RPDs < 20%. Except for K and Cr, the other analyte concentrations are relatively low. The 1988 102-SY-3T4L sample did not represent the lower half of the segment 4 sludge. Changes in tank supernate between 1988 and 1990 may also impact interstitial liquids in the sludge. With these considerations, the 1988 and 1990 centrifuged sludge liquid results agree reasonably well.

Table 5-8. Comparison of Centrifuged Sludge Liquid from 1988 and 1990 Sampling Events.

Analyte	1990 3/4 Sample (a) Cent. Liquid from Sludge)	1988 Sample (b) (102-SY-3T4L)	Relative Percent Difference (RPD) ¹
Metals	$\mu\text{g/g}$	$\mu\text{g/g}$	%
Al	3,100	2,590	17.9
B	20.3	32.4	45.9
Ca	44.2	38.4	14.0
Cr	564	312	57.5
Fe	4.15	3.35	21.3
Mo	25.2	19.2	27.0
Ni	7.46	41.1	138
K	2,350	1,210	64.0
Si	218	22.5	162.6
Na	86,600	82,800	4.49

$$^1\text{RPD} = [|a-b| / ((a+b)/2)] * 100$$

5.3 TANK WASTE PROFILE

The profile information for Tank 241-SY-102, which consists of a 90% supernate layer, is not as important as for a tank that is mostly sludge. The ability to evaluate the horizontal distribution of waste components in the tank is limited by the number of risers sampled (13A, 1B), and an investigation of vertical stratification is dependent on the number of segments or subsegments analyzed. The 1988 (Riser 1B) sampling and analysis event provides the best indication of vertical component distribution in the sludge since it provides data for an upper and lower area. The 1990 (Riser 13A) sludge information is based on a composite of the sludge segments and provides only an average sludge value with no distribution information. The 1990 samples from riser 13A were taken near the center of the tank near the pump pit. The 1988 samples from riser 1B were taken from a position near riser 13A (refer to Figure 2-1 for a depiction of riser location within the tank). Table 5-9 compares the results from all sludge samples.

The 1988 core indicates that the upper portion of the sludge may be richer in transition metals (Fe and Mn) and calcium where as the lower portion of the sludge is richer in sodium and phosphorus. Chromium and aluminum levels are similar throughout the sludge. This core also indicates that the actinide (Pu and Am) levels are significantly higher in the upper levels of the sludge.

If the average value for the 1988 results are compared to the 1990 PCL composite result, the 1990 core from Riser 13A contains the same metals at similar concentrations as the 1988 core from Riser 1B with the exception of phosphorus and silicon. This would indicate that the composition of the sludge layer across the tank is fairly consistent. The 1990 core data indicates that there is a relatively large concentration of thorium (10,000 $\mu\text{g/g}$) in the sludge. This was not reported in the 1988 data perhaps because the ICP/AES

was not configured to detect thorium or because thorium may have been added after 1988. Risers 13A and 1B are too close together to get a good view of the horizontal distribution of analytes. The anions and radionuclides cannot be compared because the 1988 results are only for the bottom of segment 4 and therefore not comparable to 1990 composite information.

The duplicate data for the 1990 ICP data permits the analytical variability for these metal analytes to be estimated. However, the limited number of core and segment samples taken during a single sampling event make it difficult to accurately quantify the spatial variability by statistical analysis.

Table 5-9. Comparison of Sludge Values Between the 1990 and 1988 Data (2 sheets).

Analyte	1990 3/4 Sample (Core 17) (µg/g)	1990 PCL Sample (Core 16) (µg/g)	1988 102-SY-48 (µg/g)	1988 102-SY-3T4S (µg/g)
Aluminum	53,400	37,900	48,100	34,800
Barium	188	94.5	27.4	93.2
Beryllium	10	4	---	---
Boron	---	---	173	194
Calcium	15,800	7,280	421	5,690
Cadmium	1,140	343	---	---
Cerium	---	---	420	560
Chromium	18,400	19,300	13,300	16,400
Copper	442	413	---	---
Dysprosium	---	---	32.6	52.2
Iron	61,200	20,700	4,460	31,900
Lanthanum	138	103	80.6	417
Lead	4,600	1,590	---	---
Magnesium	2,960	1,000	97.2	1,730
Manganese	16,500	5,390	1,370	12,600
Molybdenum	---	---	< 95.9	76.7
Neodymium	---	---	288	288
Nickel	1,110	943	294	528
Phosphorus	13,600	43,600	11,800	4,030
Potassium	3,480	3,200	2,390	2,310
Silicon	20,000	7,250	843	2,700
Silver	562	157	---	---
Sodium	113,000	166,000	194,000	101,000
Strontium	334	108	17.5	175
Thorium	10,700	2,000	---	---
Titanium	523	180	38.3	144

Table 5-9. Comparison of Sludge Values Between the 1990 and 1988 Data (2 sheets).

Analyte	1990 3/4 Sample (Core 17) ($\mu\text{g/g}$)	1990 PCL Sample (Core 16) ($\mu\text{g/g}$)	1988 102-SY-4B ($\mu\text{g/g}$)	1988 102-SY-3T4S ($\mu\text{g/g}$)
Zinc	1,080	1,220	65.4	589
Zirconium	1,190	296	64.8	456
Chloride	1,840	780	7,100	---
Chromium (Cr^{+6})	---	---	1,280	1,550
Fluoride	1,160	5,200	1,650	---
Nitrate	75,600	53,000	202,000	---
Nitrite	20,600	8,200	61,700	---
Phosphate	12,500	55,400	45,600	---
Sulfate	5,400	3,220	7,690	---
Total Inorganic Carbon	7,300	5,600	---	---
	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$
$^{241}\text{Americium}$	126	31.5	0.973	---
$^{14}\text{Carbon}$	---	0.00270	0.00180	---
$^{137}\text{Cesium}$	112	40.4	150	---
$^{60}\text{Cobalt}$	0.31	0.311	0.110	---
$^{154}\text{Europium}$	2.72	2.3	1.50	---
$^{156}\text{Europium}$	3.1	2.4	---	---
$^{239/240}\text{Plutonium}$	---	10.1	0.17	13.1
$^{90}\text{Strontium}$	---	136	67.6	---
$^{99}\text{Technetium}$	---	0.0640	0.202	0.220

5.4 COMPARISON OF ANALYTICAL AND TRANSFER HISTORY INFORMATION

The analytical results from 1988 and 1990 agree with what would be expected from the historical uses of this tank. The early addition of NIT waste would indicate that the bottom sludge layer might contain a high concentration of manganese; however, the analytical data from 1988 do not support this since the concentration of Mn in the lower sludge portion is lower than the upper sludge portion. However, the high concentration of Al, Fe and Cr are indicative of REDOX processing waste that may have been carried over from the transfers of supernate from the S and SX tank farms. Relatively high concentrations of actinides are found in the upper portion of the sludge based on the 1988 core analyses. This would be expected from the later additions of waste from the plutonium processing facility, PFP. The waste from decontamination operations and the 222-S Laboratory are highly varied and do not have distinctive characteristics. However, they may be the source for the higher than normal values for chloride (1988) and TOC (1990) that are reported in the sludge.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

Data quality objectives (DQOs) were not developed when this tank was sampled and analyzed. The waste compatibility DQO was issued at about the same time as the 1994 supernate sampling and is considered in this section. Even though DQOs were not written until after the sampling and analysis events for the sludge had occurred, criteria identified in present DQOs are used in the following evaluations. Data generated prior to 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology, EPA, DOE 1994).

5.5.1 Safety Evaluation

The data criteria identified in the safety screening DQO (Babad and Redus 1994) is used to assess the safety aspect of the waste in Tank 241-SY-102. This DQO identifies several primary and secondary factors for consideration.

The waste fuel energy value is normally determined using DSC analysis of the waste material. No DSC analyses have been performed on Tank 241-SY-102 sludge or supernate wastes. TOC and cyanide are other parameters that are indications of the fuel content of the waste. The TOC concentration of the centrifuged sludge (~ 0.7% wet weight) and supernate (~ .03 % wet weight) are well below the 5% TOC (dry weight) criteria established by the organic safety program (Babad, Blacker, and Redus 1994). Even though there are no cyanide analyses for the sludge, there is no historical basis to expect cyanide and the 1994 supernate concentration of cyanide was low (1 $\mu\text{g/mL}$).

Large amounts of moisture reduce the potential for propagating exothermic reactions in the wastes. Because the waste in Tank 241-SY-102 is 90% liquid the moisture content of the sludge is expected to be high. Based on the 1988 analysis, the bottom segment did not contain any drainable liquid and had a water content of about 33%. Based on an estimate of 60.5 wt% solids in the sludge (Herting 1994), the weight percent water would be estimated to be 39.5%. These values are well above the 17% criteria identified in the safety screening DQO.

Another factor in assessing the safety of the tank waste is the heat generation and temperature of the wastes. Heat is generated in the tanks primarily from radioactive decay. The primary contributors for Tank 241-SY-102 are ^{137}Cs , ^{90}Sr , ^{241}Am and $^{239/240}\text{Pu}$. The estimated heat generated from the isotopes in the tank is 2,080 watts (7,100 Btu/hr) as shown in Table 5-10. This is well below the 40,000 Btu/hr criteria for distinguishing a high heat tank from a low heat tank. The recorded tank temperature since the middle of 1990 has been between 18.0 °C and 24.0 °C.

Table 5-10. Tank 241-SY-102 Projected Heat Load.

Radionuclide	Curies (Ci)	Watts
²⁴¹ Am	34,900	1,140
¹³⁷ Cs	75,100	354
¹⁴⁴ Ce	2,090	16.7
⁶⁰ Co	139	2.14
^{243/244} Cm	41.8	1.44
¹⁵⁴ Eu	1,100	9.93
¹⁵⁵ Eu	1,210	.880
²³⁸ Pu	502	16.4
^{239/240} Pu	4,440	136
⁹⁰ Sr	59,800	401
Watts		2,080

The potential for criticality is assessed from either total alpha analysis or plutonium analysis. Criticality specifications for double-shell storage tanks are defined in Vail (1994). The safety screening criteria for criticality is 1 g/L. This is equivalent to 34.2 $\mu\text{Ci } ^{239}\text{Pu/g}$ of waste assuming the density of the settled sludge is 1.80 g/mL. The 1990 centrifuged sludge ^{239/240}Pu concentration was 10.1 $\mu\text{Ci/g}$. The highest concentration of ²³⁹⁻²⁴⁰Pu found in 1988 was 9.7 $\mu\text{Ci/g}$ in Segment 3. The criticality specifications also require the pH of the waste to be greater than 8.0 when the plutonium inventory exceeds 10 kg and the depth of the supernate liquid exceeds 30 cm. The supernate depth in Tank 241-SY-102 exceeds 30 cm and the Pu inventory is 71.6 kg. The pH of the supernate is 12.8, which satisfies the criticality prevention specification.

The flammability of the gas in the headspace of a tank is another safety screening consideration. Analysis of the tank head space is outside the scope of this report.

The analysis of Tank 241-SY-102 does not fully meet the safety screening requirements. However, historical and analytical information do not show that the waste composition exceeds the safety criteria for water content, heat or criticality. Even though the fuel content of the waste has not been measured by DSC, the TOC, cyanide and historical uses of the tank indicate that excessive fuel is not present.

5.5.2 Operational Evaluations

The 1994 supernate sampling and analysis were performed to evaluate compatibility of the waste for transfer to another tank. Sampling and analysis requirements for assessing waste compatibility have been addressed in the Waste Compatibility DQO (Carothers 1994). This DQO is based on both safety and operational considerations. Operational considerations include pumpability and corrosion. Some of the key criteria for evaluating compatibility and the 1994 supernate results are summarized in the following table.

Table 5-11. Compatibility Assessment for Tank 241-SY-102 Supernate.

Parameter	Criteria	1994 Result
$^{239/240}\text{Pu}$	< 0.05 g/gal (0.8 $\mu\text{Ci/g}$) *	3.0 E-04 $\mu\text{Ci/g}$
Specific Gravity	< 1.41	1.03
Energetics	exotherm/endothrm < 1	Not Performed 95.4% Water
Corrosivity	0.01 M < [OH] < 8.0 M [NO ₃] < 1.0 M 0.011 M < [NO ₂] < 5.5	0.2 M 0.38 M 0.07 M
TRU	< 100 nCi/g	6 nCi/g
TOC (DSSF ¹)	< 10 g/L	0.25 g/L

¹ DSSF = double-shell slurry feed

*Based on ^{239}Pu specific activity and an assumed supernate density of 1 g/ml.

Low phosphate (397 $\mu\text{g/mL}$) indicates that the potential for the formation of insoluble phosphates is low and the waste is pumpable. Other operational factors need to be considered as part of the assessment before the waste is transferred out of the tank.

Because of the relatively high quantities of Pu and Am in the sludge layer, it is important that any supernate transferred into Tank 241-SY-012 not contain significant quantities of complexing agents. Wastes containing complexants could solubilize the TRU in the sludge resulting in it being transferred to other tanks. This could lead to increased processing requirements for final disposal. The potential for solubilizing the TRU in Tank 241-SY-102 has been evaluated in Herting (1994).

5.5.3 Environmental Evaluation

Tank 241-SY-102 waste was not characterized to designate the waste or for evaluation of any environmental compliance issues. It has been characterized to meet regulatory requirements that the waste is being safely stored and managed. No specific organic (volatile or semi-volatile) analyses have been performed on the tank; therefore, no environmental assessment of these compounds can be made.

The 1994 analysis of the supernate indicates that the pH is 12.8. Analysis of the sludge from 1988 and 1990 indicate that the sludge contains high concentrations of environmentally sensitive metals such as chromium. The lower concentration of chromium in the centrifuged sludge liquid indicates that most of the chromium is present as insoluble Cr (III) compounds rather than more soluble Cr (VI) compounds. Lead, cadmium and silver are also relatively high in the sludge based on the 1990 results.

5.5.4 Process Development Evaluation

The metal and anion analysis of the sludges in 1988 and 1990 are important for evaluating the glass disposal waste form formulations and identifying potential components that may affect the treatment and disposal process. Because the waste sludges may be blended, washed and treated before disposal there are no specific criteria for the parameters measured. The 1988 physical measurements will be important in evaluating retrieval and pretreatment process equipment needs. No metals analyses were reported on water washed solids; therefore, solubility information could not be obtained.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The sludge in Tank 241-SY-102 was sampled and analyzed in 1988 and 1990, and the supernate was analyzed in 1994. The analysis of Tank 241-SY-102 does not fully meet the safety screening requirements. Limited samples and data from different risers and waste depths make it difficult to accurately determine the variability of the waste composition in the tank. The composition and quantity of sludge have changed since the 1990 characterization because of continuing transfers of waste into the tank. Limited quality control data on the 1988 and 1990 analyses make it difficult or impossible to assess the accuracy and variability for some measurements. However, the available historical and analytical information do not indicate that the waste composition exceeds the safety criteria for water content, heat or criticality. Even though the fuel content of the waste has not been measured by DSC, the TOC, cyanide and historical uses of the tank indicates that excessive fuel is not present. When the sludge is sampled again, the analyses should include an evaluation of the fuel content by DSC to confirm the fuel estimates based on historical information and TOC and cyanide analysis.

The sludge contains large quantities of Na, Al, Fe, Mn and Cr as expected from REDOX chemical processing wastes. The 1990 analyses indicate that it also contains relatively high concentrations of Th. The source of the thorium is not known and its presence should be confirmed in future sampling and analysis activities. In addition to high levels of nitrate and nitrite the sludge also contains large amounts of phosphate.

^{137}Cs , $^{90}\text{Sr/Y}$, ^{241}Am and $^{239/240}\text{Pu}$ are the major radioactive constituents in the waste. The sludge concentrations of ^{241}Am and $^{239/240}\text{Pu}$ (transuranics [TRU]) exceed the TRU classification limit. The heat generated by these isotopes is well below the high heat tank specification (40,000 Btu/hr). Based on the 1988 sampling and analysis data, the actinides are located in the upper region of the sludge layer. This is consistent with the receipt of PFP processing waste during the later years of service. Because of the actinide levels the addition of waste containing complexants must be controlled.

7.0 REFERENCES

- Agnew, S.F., 1994, *Hanford Defined Wastes: Chemical and Radionuclide Compositions*, WHC-SD-WM-TI-629, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Anderson, A.A., 1992, *Double-Shell Underground Waste Storage Tanks Riser Survey*, WHC-SD-RE-TI-093, Westinghouse Hanford Company, Richland, Washington.
- Babad, H., and K.S. Redus, 1994, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Babad, H., S.M. Blacker, K.S. Redus, 1994, *Data Quality Objective to Support Resolution of the Organic Fuel Rich Tank Safety Issue*, WHC-SD-WM-DQO-006, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Bell, K.E., 1994, *Tank Waste Remediation System Tank Waste Analysis Plan*, WHC-SD-WM-PLN-077, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Carothers, K.G., 1994, *Data Quality Objectives for the Waste Compatibility Program*, WHC-SD-WM-DQO-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- De Lorenzo, D.S., A.T. DiCenso, D.B. Hiller, K.W. Johnson, J.H. Rutherford, and D.J. Smith, 1994, *Tank Characterization Reference Guide*, WHC-SD-WM-TI-648, Westinghouse Hanford Company, Richland, Washington.
- Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.
- Gauck, G., 1990, *Observation Results From Laboratory Extrusion From Double-Shell Tank 102-SY*, (letter to L. Stegen, April 10), Westinghouse Hanford Company, Richland, Washington.
- Hanlon, B.L., 1994a, *Waste Tank Summary for Month Ending December 31, 1994*, WHC-EP-0182-80, Westinghouse Hanford Company, Richland, Washington.
- Hanlon, B.L., 1994b, *Waste Tank Summary for Month Ending March, 1994*, WHC-EP-0182-80, Westinghouse Hanford Company, Richland, Washington.
- Herting, D.L. 1994, *TRU Solubility Mixing Study for Tanks T-111 and 102-SY*, (internal memo to M.J. Sutey, April 4), Westinghouse Hanford Company, Richland, Washington.
- Jungfleisch, F.M., 1984, *TRAC: Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, Transaction File, SD-WM-TI-058, Rockwell Hanford Operations, Richland, Washington.

- Koreski, G.M., 1994, *Waste Volume Projection Historical Database*, Westinghouse Hanford Company, Richland, Washington.
- Scheele, R. D., and M.E. Peterson, 1990, *Results of the Characterization of Samples of Waste from Double-shell Tank 102-SY*, (letter report to A.J. DiLiberto, January 19), Westinghouse Hanford Company, Pacific Northwest Laboratory, Richland, Washington.
- Sutey, M.J., 1994a, *Cross-Site Transfer Data*, (internal memo 7CF30-94-016 to J.H. Wicks, April 22), Westinghouse Hanford Company, Richland, Washington.
- Sutey, M.J., 1994b, *Waste Compatibility Assessment of Tank 241-SY-102 with Tank 241-T-111 Via 244-TX DCRT*, (internal memo to J.H. Wicks, April 8), Westinghouse Hanford Company, Richland, Washington.
- Tingey, J.M. and Sasaki, L.M., 1995, *Analysis of Fiscal Year 1990 Core Samples from Tank 241-SY-102*, WHC-SD-WM-TI-683, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- U.S. DOE, 1994, *Tank SY-102 Riser Equipment Arrangement*, Drawing #H-2-85256, Rev. 2, ICF Kaiser Hanford Company, Richland, Washington.
- Vail, T.S., 1994, *Waste Storage in Double-Shell Tanks and Associated Equipment*, CPS-T-149-00010, Westinghouse Hanford Company, Richland, Washington.
- Weiss, R.L., 1990, *November 1988 Core Sample from Tank 241-SY-102, Process Chemistry Laboratory Efforts*, (internal memo to N.W. Kirch, November 19), Westinghouse Hanford Company, Richland, Washington.

APPENDIX A
FEBRUARY/MARCH 1990
ANALYTICAL RESULTS
DOUBLE-SHELL TANK 241-SY-102

APPENDIX A: FEBRUARY/MARCH 1990 ANALYTICAL RESULTS**INTRODUCTION**

Appendix A presents the chemical and radiological characteristics of the sludge in Tank 241-SY-102 in a tabular form, in terms of the specific concentrations of metals, ions, radionuclides, and total carbon. The data is derived from aggregate data collected (Tingey and Sasaki, 1995).

The data table for each analyte lists laboratory sample identification, the type of crucible used for samples prepared by fusion digestion, an analytical data result for each sample, a mean value for the analyte, a relative standard deviation, and a projected tank inventory for the particular analyte using the mean value as a base. The data are listed in standard notation for values greater than .001 and less than 100,000. Values outside these limits are listed in scientific notation.

TABLE DESCRIPTION

The tables are divided into groups based on the characteristics of the analytes.

Analyte Characteristic	Table Number
Appendix Summary (preferred method and digestion)	Table A-1
Metals - Centrifuged Solid	Table A-2
Metals - Centrifuged Liquid	Table A-3
Ions - Centrifuged Solid	Table A-4
Ions - Centrifuged Liquid	Table A-5
Radionuclides - Centrifuged Solid	Table A-6
Radionuclides - Centrifuged Liquid	Table A-7
Total Carbon - Centrifuged Liquid	Table A-8

The following standard abbreviations are used to describe analytical methods.

Metals:	ICP - Inductively Coupled Plasma (generic for all metals unless otherwise specified)
Anions:	IC - Ion Chromatography
Radionuclides:	GEA - Gamma Energy Analysis
	AEA - Alpha Energy Analysis
	APC - Alpha Proportional Counting
	BPC - Beta Proportional Counting
	LSC - Liquid Scintillation Counting

Table A-1

Table A-1 is a summary of the subsequent Appendix A tables and furnishes an overview of Tank 241-SY-102 constituents. The "Analyte" column (column 1) contains the name of the analyte or physical characteristic. The second column lists a mean of the centrifuged solid concentration from the sludge sample. No quality control data such as matrix spikes, serial dilutions, or duplicate analyses are listed. Numbers that are preceded by a less than symbol (<) indicate the analyte was noted, but was below the analytical instrument's calibrated detection limit for the sample. Column 3 is the relative standard deviation (RSD) of the solid, which is a measure of variance defined as the standard deviation divided by the mean. This number is expressed as a percentage.

The fourth and fifth columns are a mean of the centrifuged liquid concentration from the sludge sample. The fourth column lists the analyte concentration in $\mu\text{g/mL}$ units, while the fifth column lists the concentration in a calculated $\mu\text{g/g}$ unit. The conversion was performed using the following formula:

$$\text{Analyte Concentration } \frac{\mu\text{g}}{\text{mL}} - \text{Density of Centrifuged Liquid } \frac{1.18 \text{ g}}{\text{mL}} = \text{Analyte Concentration } \frac{\mu\text{g}}{\text{g}}$$

The "Calculated Analyte Concentration" column lists the concentration of each analyte with respect to the entire mass of the sludge. This is calculated as follows:

$$\left(\frac{\text{Centrifuged Solid Projected Inventory (kg)} + \text{Centrifuged Liquid Projected Inventory (kg)}}{\text{Total Mass of Tank Sludge: } 7.27\text{E}+08 \text{ g}} \right) \left(\frac{1.00\text{E}+09 \mu\text{g}}{1 \text{ kg}} \right)$$

The last column tabulates the total projected inventory of Tank 241-SY-102 at the time of sampling. The inventory listed is the sum of the centrifuged solid inventory and the centrifuged liquid inventory for each analyte found in the ensuing Appendix A tables.

Centrifuged Solid Analytical Results: Tables A-2, A-4, A-6, and A-8

Column one contains the name of the analyte or physical characteristic, information about the method of measurement, the method of digestion, and the type of crucible used.

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

Column two lists the laboratory sample from which the analyte was measured; this identification number is different from the number assigned to the samples at the tank farm. Sampling rationale, locations, and descriptions of sampling events are in Section 3.0.

Column three describes the core and segment from which each sample was derived. The first number listed is the core number. This number is followed by a colon and numbers that follow the colon indicate the segment or segments of the core from which the sample was derived. Core 16 does not list the segments from which the sample was derived in the data package, therefore the initials PCL are substituted to reference that this sample was analyzed at the Process Chemistry Laboratory.

Column four or "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. Numbers

that are preceded by a less than symbol (<) indicate the analyte was noted, but was below the analytical instrument's calibrated detection limit for the sample.

The "Mean" value (column five) is a simple average of all sample results for that analyte.

Column six, "Relative Standard Deviation" (RSD), is a measure of variance defined as the standard deviation divided by the mean. This number is expressed as a percentage.

Column seven, "Projected Inventory", is the product of the concentration of the analyte and the volume of the solid in the sludge (4.40E+05 kg). The inventory was calculated using the following formula.

$$\text{Solid Inventory (kg)} = (\text{Result } \mu\text{g/g}) (1\text{g}/1.00\text{E}+06 \mu\text{g}) (4.40\text{E}+05 \text{ kg})$$

Centrifuged Liquid Analytical Results: Tables A-3, A-5, and A-7

Column one contains the name of the analyte or physical characteristic, information about the method of measurement, the method of digestion, and the type of crucible used.

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

Column two lists the laboratory sample from which the analyte was measured; this identification number is different from the number assigned to the samples at the tank farm. Sampling rationale, locations, and descriptions of sampling events are in Section 3.0.

Column three describes the core and segment from which each sample was derived. The first number listed is the core number. This number is followed by a colon and numbers that follow the colon indicate the segment or segments of the core from which the sample was derived. Core 16 does not list the segments from which the sample was derived in the data package, therefore the initials PCL are substituted to reference that this sample was analyzed at the Process Chemistry Laboratory.

Columns four and five contain the specific concentration of the analyte in units of $\mu\text{g/mL}$ and $\mu\text{g/g}$, respectively. The conversion from $\mu\text{g/mL}$ to $\mu\text{g/g}$ is done as previously shown for Table A-1. Numbers that are preceded by a less than symbol (<) indicate the analyte was noted, but was below the analytical instrument's calibrated detection limit for the sample.

Column six, "Projected Inventory", is the product of the concentration of the analyte and the volume of the liquid in the sludge (2.87E+05 kg). The inventory was calculated using the following formula.

$$\text{Liquid Inventory (kg)} = (\text{result } \mu\text{g/mL})(1\text{g}/1.00\text{E}+06 \mu\text{g/g})(2.87\text{E}+05 \text{ kg})$$

Table A-1. Tank Characterization Report Analytical Summary for the Sludge in Double-Shell Tank 241-SY-102.

Analyte	Centrifuged Solid Mean	RSD (Solid)	Centrifuged Liquid Mean		Calculated Analyte Concentration	Total Projected Inventory
METALS	µg/g	%	µg/mL	µg/g	µg/g	kg
Aluminum (Al)	45,600	20.3	3,660	3,100	28,900	21,000
Antimony (Sb)	< 3.34E-04	---	< 1.20	< 1.02	< 0.403	< 0.293
Arsenic (As)	< 7.98E-04	---	9.30	7.88	3.11	2.26
Barium (Ba)	141	40.3	3.90	3.31	86.7	63.0
Beryllium (Be)	7.00	52.2	0.100	0.0847	4.26	3.10
Boron (B)	< 2.96E-04	---	24.0	20.3	8.02	5.83
Cadmium (Cd)	742	62.2	27.0	22.9	466	339
Calcium (Ca)	11,500	45.9	52.1	44.2	6,970	5,070
Cerium (Ce)	< 8.42E-04	---	< 2.40	< 2.03	< 0.802	< 0.583
Chromium (Cr)	18,900	4.11	665	564	11,700	8,480
Cobalt (Co)	< 0.00165	---	6.00	5.08	2.01	1.46
Copper (Cu)	428	63.3	1.80	1.53	259	188
Dysprosium (Dy)	< 3.67E-05	---	< 0.200	< 0.169	< 0.0667	< 0.0485
Iron (Fe)	40,900	57.5	4.90	4.15	24,800	18,000
Lanthanum (La)	121	33.5	< 0.200	< 0.169	73.2	53.2
Lead (Pb)	3,090	57.4	4.20	3.56	1,870	1,360
Lithium (Li)	< 4.88E-05	---	< 0.100	< 0.0847	< 0.0334	< 0.0243
Magnesium (Mg)	1,980	58.1	0.600	0.508	1,200	871
Manganese (Mn)	10,900	59.2	0.200	0.169	6,600	4,800
Molybdenum (Mo)	73.0	---	29.7	25.2	54.2	39.4
Neodymium (Nd)	407	---	< 1.00	< 0.847	246	179
Nickel (Ni)	1,030	---	8.80	7.46	626	455
Phosphorus (P)	28,600	---	1,860	1,580	17,900	13,000
Potassium (K)	3,340	---	2,770	2,350	2,940	2,140
Rhenium (Re)	< 7.75E-05	---	0.400	0.339	0.134	0.0973
Rhodium (Rh)	438	---	3.40	2.88	267	194
Ruthenium (Ru)	< 2.54E-04	---	4.80	4.07	1.61	1.17
Selenium (Se)	< 7.65E-04	---	< 1.20	< 1.02	< 0.403	< 0.293
Silicon (Si)	13,600	55.7	257	218	8,310	6,040
Silver (Ag)	359	67.0	0.200	0.169	217	158
Sodium (Na)	1.40E+05	---	1.01E+05	85,600	1.19E+05	86,200
Strontium (Sr)	221	61.5	0.200	0.169	134	97.2
Tellurium (Te)	< 3.43E-04	---	3.40	2.88	1.14	0.827
Thallium (Tl)	< 0.00680	---	< 34.0	< 28.8	< 11.4	< 8.27
Thorium (Th)	6,350	79.6	< 1.80	< 1.53	3,840	2,790
Titanium (Ti)	351	56.7	< 0.100	< 0.0847	< 212	< 154
Uranium (U)	1,950	---	18.0	15.3	1,190	862

Table A-1. Tank Characterization Report Analytical Summary for the Sludge in Double-Shell Tank 241-SY-102.

Analyte	Centrifuged Solid Mean	RSD (Solid)	Centrifuged Liquid Mean		Calculated Analyte Concentration	Total Projected Inventory
METAL	µg/g	%	µg/mL	µg/g	µg/g	kg
Vanadium (V)	71.5	---	0.600	0.508	43.3	31.5
Zinc (Zn)	1,150	48.6	3.20	2.71	697	507
Zirconium (Zr)	743	---	0.100	0.0847	450	327
IONS	µg/g	%	µg/mL	µg/g	µg/g	kg
Bromide (Br ⁻)	---	---	< 4.00	< 3.39	< 1.34	< 0.973
Chloride (Cl ⁻)	1,310	---	3,000	2,540	1,800	1,310
Chromium (VI) (Cr ⁶⁺)	873	---	---	---	528	384
Fluoride (F ⁻)	3,180	---	440	373	513	1,510
Nitrate (NO ₃ ⁻)	64,300	---	1.12E+05	94,900	76,300	55,500
Nitrite (NO ₂ ⁻)	14,400	---	37,300	31,600	21,200	15,400
Phosphate (PO ₄ ³⁻)	34,000	---	5,600	4,750	22,600	16,400
Sulfate (SO ₄ ²⁻)	4,310	---	7,400	6,270	5,090	3,700
RADIONULIDE	µCi/g	%	µCi/mL	µCi/g	µCi/g	Ci
Americium-241	79.3	---	---	---	48.0	34,900
Carbon-14	0.00270	---	---	---	0.00164	1.19
Cerium-144	4.76	---	---	---	2.87	2,090
Cesium-137	76.2	---	99.8	84.6	79.5	57,800
Cobalt-60	0.311	---	0.00947	0.00803	0.191	139
Curium-234/244	0.0950	---	---	---	0.0575	41.8
Europium-154	2.51	---	---	---	1.51	1,100
Europium-155	2.75	---	---	---	1.66	1,210
Neptunium-237	< 0.00252	---	---	---	< 0.00153	< 1.11
Niobium-94	< 0.00141	---	---	---	< 8.53E-04	< 0.620
Plutonium-238	1.14	---	---	---	0.691	502
Plutonium-239/240	10.1	---	---	---	6.11	4,440
Selenium-79	< 0.0220	---	---	---	< 0.0133	< 9.68
Strontium-90	136	---	---	---	82.3	59,800
Technetium-99	0.0640	---	---	---	0.0388	28.2
Tritium	0.00111	---	---	---	6.71e-04	0.488
Total Alpha	31.9	---	---	---	19.3	14,000
Total Beta	355	---	---	---	215	1.56E+05
PHYSICAL PROPERTY						
Density	---	---	---	---	1.56 g/mL	---
ORGANIC	µg/g	%	µg/mL	µg/g	µg/g	kg
TOTAL ORGANIC CARBON	7,100	---	---	---	4,290	3,120
TOTAL INORGANIC CARBON	6,450	---	---	---	3,910	2,840

Table A-2. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
METALS						
		Core:Segment	$\mu\text{g/g}$	$\mu\text{g/g}$	%	kg
ICP.f _{Zr} .Al	6010	Core 17:Seg 3, 4	55,900	45,600	20.3	20,100
	5032	Core 16:PCL	36,600			
ICP.f _{Ni} .Al	6010	Core 17:Seg 3, 4	50,900			
	5032	Core 16:PCL	39,100			
ICP.f _{Zr} .Sb	6010	Core 17:Seg 3, 4	< 3.77E-04	< 3.34E-04	---	< 1.47E-04
	5032	Core 16:PCL	< 3.26E-04			
ICP.f _{Ni} .Sb	6010	Core 17:Seg 3, 4	< 3.60E-04			
	5032	Core 16:PCL	< 2.72E-04			
ICP.f _{Zr} .As	6010	Core 17:Seg 3, 4	< 9.00E-04	< 7.98E-04	---	< 3.51E-04
	5032	Core 16:PCL	< 7.79E-04			
ICP.f _{Ni} .As	6010	Core 17:Seg 3, 4	< 8.60E-04			
	5032	Core 16:PCL	< 6.51E-04			
ICP.f _{Zr} .Ba	6010	Core 17:Seg 3, 4	201	141	40.3	62.0
	5032	Core 16:PCL	113			
ICP.f _{Ni} .Ba	6010	Core 17:Seg 3, 4	174			
	5032	Core 16:PCL	76.0			
ICP.f _{Zr} .Be	6010	Core 17:Seg 3, 4	11.0	7.00	52.2	3.08
	5032	Core 16:PCL	5.00			
ICP.f _{Ni} .Be	6010	Core 17:Seg 3, 4	9.00			
	5032	Core 16:PCL	3.00			
ICP.f _{Zr} .B	6010	Core 17:Seg 3, 4	< 3.34E-04	< 2.96E-04	---	< 1.30E-04
	5032	Core 16:PCL	< 2.89E-04			
ICP.f _{Ni} .B	6010	Core 17:Seg 3, 4	< 3.18E-04			
	5032	Core 16:PCL	< 2.41E-04			
ICP.f _{Zr} .Ca	6010	Core 17:Seg 3, 4	18,100	11,500	45.9	5,060
	5032	Core 16:PCL	8,000			
ICP.f _{Ni} .Ca	6010	Core 17:Seg 3, 4	13,400			
	5032	Core 16:PCL	6,550			
ICP.f _{Zr} .Cd	6010	Core 17:Seg 3, 4	1,180	742	62.2	326
	5032	Core 16:PCL	345			
ICP.f _{Ni} .Cd	6010	Core 17:Seg 3, 4	1,100			
	5032	Core 16:PCL	341			

Table A-2. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
METALS						
		Core:Segment	$\mu\text{g/g}$	$\mu\text{g/g}$	%	kg
ICP.f _{Zr} .Ce	6010	Core 17:Seg 3, 4	< 9.50E-04	< 8.42E-04	---	< 3.70E-04
	5032	Core 16:PCL	< 8.21E-04			
ICP.f _{Ni} .Ce	6010	Core 17:Seg 3, 4	< 9.10E-04			
	5032	Core 16:PCL	< 6.86E-04			
ICP.f _{Zr} .Cr	6010	Core 17:Seg 3, 4	19,100	18,900	4.11	8,320
	5032	Core 16:PCL	19,200			
ICP.f _{Ni} .Cr	6010	Core 17:Seg 3, 4	17,700			
	5032	Core 16:PCL	19,400			
ICP.f _{Zr} .Co	6010	Core 17:Seg 3, 4	< 0.00186	< 0.00165	---	< 7.26E-04
	5032	Core 16:PCL	< 0.00161			
ICP.f _{Ni} .Co	6010	Core 17:Seg 3, 4	< 0.00177			
	5032	Core 16:PCL	< 0.00134			
ICP.f _{Zr} .Cu	6010	Core 17:Seg 3, 4	277	428	63.3	188
	5032	Core 16:PCL	126			
ICP.f _{Ni} .Cu	6010	Core 17:Seg 3, 4	607			
	5032	Core 16:PCL	700			
ICP.f _{Zr} .Dy	6010	Core 17:Seg 3, 4	< 4.14E-05	< 3.67E-05	---	< 1.61E-05
	5032	Core 16:PCL	< 3.58E-05			
ICP.f _{Ni} .Dy	6010	Core 17:Seg 3, 4	< 3.95E-05			
	5032	Core 16:PCL	< 2.99E-05			
ICP.f _{Zr} .Fe	6010	Core 17:Seg 3, 4	64,400	40,900	57.5	18,000
	5032	Core 16:PCL	20,600			
ICP.f _{Ni} .Fe	6010	Core 17:Seg 3, 4	57,900			
	5032	Core 16:PCL	20,700			
ICP.f _{Zr} .La	6010	Core 17:Seg 3, 4	173	121	33.5	53.2
	5032	Core 16:PCL	128			
ICP.f _{Ni} .La	6010	Core 17:Seg 3, 4	103			
	5032	Core 16:PCL	78.0			
ICP.f _{Zr} .Pb	6010	Core 17:Seg 3, 4	5,000	3,090	57.4	1,360
	5032	Core 16:PCL	1,700			
ICP.f _{Ni} .Pb	6010	Core 17:Seg 3, 4	4,200			
	5032	Core 16:PCL	1,470			

Table A-2. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
METALS						
		Core:Segment	$\mu\text{g/g}$	$\mu\text{g/g}$	%	kg
ICP.f _{Zr} .Li	6010	Core 17:Seg 3, 4	< 5.52E-05	< 4.88E-05	---	< 2.15E-05
	5032	Core 16:PCL	< 4.77E-05			
ICP.f _{Ni} .Li	6010	Core 17:Seg 3, 4	< 5.26E-05			
	5032	Core 16:PCL	< 3.98E-05			
ICP.f _{Zr} .Mg	6010	Core 17:Seg 3, 4	3,220	1,980	58.1	871
	5032	Core 16:PCL	1,000			
ICP.f _{Ni} .Mg	6010	Core 17:Seg 3, 4	2,700			
	5032	Core 16:PCL	1,000			
ICP.f _{Zr} .Mn	6010	Core 17:Seg 3, 4	17,300	10,900	59.2	4,800
	5032	Core 16:PCL	5,300			
ICP.f _{Ni} .Mn	6010	Core 17:Seg 3, 4	15,700			
	5032	Core 16:PCL	5,480			
ICP.f _{Zr} .Mo	6010	Core 17:Seg 3, 4	< 8.10E-05	18.3	199	8.05
	5032	Core 16:PCL	73.0			
ICP.f _{Ni} .Mo	6010	Core 17:Seg 3, 4	< 7.18E-05			
	5032	Core 16:PCL	< 5.84E-05			
ICP.f _{Zr} .Nd	6010	Core 17:Seg 3, 4	407	203	116	89.3
	5032	Core 16:PCL	406			
ICP.f _{Ni} .Nd	6010	Core 17:Seg 3, 4	< 2.31E-04			
	5032	Core 16:PCL	< 1.75E-04			
ICP.f _{Zr} .Ni	6010	Core 17:Seg 3, 4	1,110	1,030	---	453
	5032	Core 16:PCL	943			
ICP.f _{Ni} .P	6010	Core 17:Seg 3, 4	13,600	28,600	---	12,600
	5032	Core 16:PCL	43,600			
ICP.f _{Zr} .K	6010	Core 17:Seg 3, 4	3,480	3,340	---	1,470
	5032	Core 16:PCL	3,200			
ICP.f _{Zr} .Re	6010	Core 17:Seg 3, 4	< 7.91E-05	< 7.75E-05	---	< 3.41E-05
	5032	Core 16:PCL	< 6.84E-05			
ICP.f _{Ni} .Re	6010	Core 17:Seg 3, 4	< 7.54E-05			
	5032	Core 16:PCL	< 5.71E-05			

Table A-2. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
METALS						
		Core:Segment	µg/g	µg/g	%	kg
ICP.f _{Zr} .Rh	6010	Core 17:Seg 3, 4	< 3.57E-04	110	199	48.4
	5032	Core 16:PCL	438			
ICP.f _{Ni} .Rh	6010	Core 17:Seg 3, 4	< 3.40E-04			
	5032	Core 16:PCL	< 2.57E-04			
ICP.f _{Zr} .Ru	6010	Core 17:Seg 3, 4	< 2.87E-04	< 2.54E-04	---	< 1.12E-04
	5032	Core 16:PCL	< 2.48E-04			
ICP.f _{Ni} .Ru	6010	Core 17:Seg 3, 4	< 2.74E-04			
	5032	Core 16:PCL	< 2.07E-04			
ICP.f _{Zr} .Se	6010	Core 17:Seg 3, 4	< 8.64E-04	< 7.65E-04	---	< 3.37E-04
	5032	Core 16:PCL	< 7.47E-04			
ICP.f _{Ni} .Se	6010	Core 17:Seg 3, 4	< 8.24E-04			
	5032	Core 16:PCL	< 6.23E-04			
ICP.f _{Zr} .Si	6010	Core 17:Seg 3, 4	22,300	13,600	55.7	5,980
	5032	Core 16:PCL	7,200			
ICP.f _{Ni} .Si	6010	Core 17:Seg 3, 4	17,600			
	5032	Core 16:PCL	7,300			
ICP.f _{Zr} .Ag	6010	Core 17:Seg 3, 4	627	359	67.0	158
	5032	Core 16:PCL	185			
ICP.f _{Ni} .Ag	6010	Core 17:Seg 3, 4	496			
	5032	Core 16:PCL	129			
ICP.f _{Ni} .Na	6010	Core 17:Seg 3, 4	1.13E+05	1.40E+05	---	61,600
	5032	Core 16:PCL	1.66E+05			
ICP.f _{Zr} .Sr	6010	Core 17:Seg 3, 4	372	221	61.5	97.2
	5032	Core 16:PCL	135			
ICP.f _{Ni} .Sr	6010	Core 17:Seg 3, 4	296			
	5032	Core 16:PCL	81.0			

Table A-2. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
METALS						
		Core:Segment	$\mu\text{g/g}$	$\mu\text{g/g}$	%	kg
ICP.f _{Zr} .Te	6010	Core 17:Seg 3, 4	< 3.88E-04	< 3.43E-04	---	< 1.51E-04
	5032	Core 16:PCL	< 3.35E-04			
ICP.f _{Ni} .Te	6010	Core 17:Seg 3, 4	< 3.70E-04			
	5032	Core 16:PCL	< 2.80E-04			
ICP.f _{Zr} .Ti	6010	Core 17:Seg 3, 4	< 0.00769	< 0.00680	---	< 0.00299
	5032	Core 16:PCL	< 0.00664			
ICP.f _{Ni} .Ti	6010	Core 17:Seg 3, 4	< 0.00733			
	5032	Core 16:PCL	< 0.00554			
ICP.f _{Zr} .Th	6010	Core 17:Seg 3, 4	11,400	6,350	79.6	2,790
	5032	Core 16:PCL	1,900			
ICP.f _{Ni} .Th	6010	Core 17:Seg 3, 4	10,000			
	5032	Core 16:PCL	2,100			
ICP.f _{Zr} .Ti	6010	Core 17:Seg 3, 4	546	351	56.7	154
	5032	Core 16:PCL	182			
ICP.f _{Ni} .Ti	6010	Core 17:Seg 3, 4	500			
	5032	Core 16:PCL	178			
ICP.f _{Zr} .U	6010	Core 17:Seg 3, 4	< 0.00516	1,950	200	858
	5032	Core 16:PCL	7,780			
ICP.f _{Ni} .U	6010	Core 17:Seg 3, 4	< 0.00492			
	5032	Core 16:PCL	< 0.00373			
ICP.f _{Zr} .V	6010	Core 17:Seg 3, 4	< 5.89E-05	35.8	129	15.8
	5032	Core 16:PCL	97.0			
ICP.f _{Ni} .V	6010	Core 17:Seg 3, 4	< 5.61E-05			
	5032	Core 16:PCL	46.0			
ICP.f _{Zr} .Zn	6010	Core 17:Seg 3, 4	1,640	1,150	48.6	506
	5032	Core 16:PCL	1,600			
ICP.f _{Ni} .Zn	6010	Core 17:Seg 3, 4	524			
	5032	Core 16:PCL	833			
ICP.f _{Ni} .Zr	6010	Core 17:Seg 3, 4	1,190	743	---	327
	5032	Core 16:PCL	296			

Table A-3. Tank 241-SY-102 Analytical Data: Centrifuged Liquid from Sludge

Analyte	Sample Number	Sample Identification	Result		Projected Inventory
		Core:Segment	$\mu\text{g/mL}$	$\mu\text{g/g}$	kg
ICP.d.Se	6011	Core 17:Seg 3, 4 (Liq)	< 1.20	< 1.02	< 0.293
ICP.d.Si			257	218	62.6
ICP.d.Ag			0.200	0.169	0.0485
ICP.d.Na ^x			1.01E+05	85,600	24,600
ICP.d.Sr			0.200	0.169	0.0485
ICP.d.Te			3.40	2.88	0.827
ICP.d.Tl			< 34.0	< 28.8	< 8.27
ICP.d.Th			< 1.80	< 1.53	< 0.439
ICP.d.Ti			< 0.100	< 0.0847	< 0.0243
ICP.d.U			18.0	15.3	4.39
ICP.d.V			0.600	0.508	0.146
ICP.d.Zn			3.20	2.71	0.777
ICP.d.Zr			0.100	0.0847	0.0243

^x : Sodium result 10X dilution reported

Table A-4. Tank 241-SY-102 Analytical Data : Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
IONS						
		Core:Segment	$\mu\text{g/g}$	$\mu\text{g/g}$	%	kg
Cr^{6+}	5032	Core 16:PCL	873	873	---	384
IC.Cl ⁻	6010	Core 17:Seg 3, 4	1,840	1,310	---	576
	5032	Core 16:PCL	780			
IC.F ⁻	6010	Core 17:Seg 3, 4	1,160	3,180	---	1,400
	5032	Core 16:PCL	5,200			
IC.NO ₃ ⁻	6010	Core 17:Seg 3, 4	75,600	64,300	---	28,300
	5032	Core 16:PCL	53,000			
IC.NO ₂ ⁻	6010	Core 17:Seg 3, 4	20,600	14,400	---	6,340
	5032	Core 16:PCL	8,200			
IC.PO ₄ ³⁻	6010	Core 17:Seg 3, 4	12,500	34,000	---	15,000
	5032	Core 16:PCL	55,400			
IC.SO ₄ ²⁻	6010	Core 17:Seg 3, 4	5,400	4,310	---	1,900
	5032	Core 16:PCL	3,220			

Table A-5. Tank 241-SY-102 Analytical Data: Centrifuged Liquid from Sludge

Analyte	Sample Number	Sample Identification	Result		Projected Inventory
IONS					
		Core:Segment	µg/mL	µg/g	kg
IC.Br ⁻	6011	Core 17: Seg. 3. 4 (Liq)	< 4.00	< 3.39	< 0.973
IC.Cl ⁻			3,000	2,540	729
IC.F ⁻			440	373	107
IC.NO ₃ ⁻			1.12E+05	94,900	27,200
IC.NO ₂ ⁻			37,300	31,600	9,070
IC.PO ₄ ³⁻			5,600	4,750	1,360
IC.SO ₄ ²⁻			7,400	6,270	1,800

Table A-6. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
RADIONUCLIDES						
		Core:Segment	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	%	Ci
APC. ²⁴¹ Am	6010	Core 17:Seg 3, 4	126	79.3	---	34,900
	5032	Core 16:PCL	31.5			
LSC. ¹⁴ C	5032	Core 16:PCL	0.00270	0.00270	---	1.19
GEA. ¹⁴⁴ Ce	6010	Core 17:Seg 3, 4	4.76	4.76	---	2,090
GEA. ¹³⁷ Cs	6010	Core 17:Seg 3, 4	112	76.2	---	33,500
	5032	Core 16:PCL	40.4			
GEA. ⁶⁰ Co	6010	Core 17:Seg 3, 4	0.310	0.311	---	137
	5032	Core 16:PCL	0.311			
AEA. ^{232,228} Cm	5032	Core 16:PCL	0.0950	0.0950	---	41.8
GEA. ¹⁵⁴ Eu	6010	Core 17:Seg 3, 4	2.72	2.51	---	1,100
	5032	Core 16:PCL	2.30			
GEA. ¹⁵⁵ Eu	6010	Core 17:Seg 3, 4	3.10	2.75	---	1,210
	5032	Core 16:PCL	2.40			
APC. ²³⁷ Np	5032	Core 16:PCL	< 0.00252	< 0.00252	---	< 1.11
GEA. ⁹⁴ Nb	5032	Core 16:PCL	< 0.00141	< 0.00141	---	< 0.620
AEA. ²³⁸ Pu	5032	Core 16:PCL	1.14	1.14	---	502
AEA. ^{239,240} Pu	5032	Core 16:PCL	10.1	10.1	---	4,440
LSC. ⁷⁵ Se	5032	Core 16:PCL	< 0.0220	< 0.0220	---	< 9.68
BPC. ⁹⁰ Sr	5032	Core 16:PCL	136	136	---	59,800
LSC. ⁹⁹ Tc	5032	Core 16:PCL	0.0640	0.0640	---	28.2
LSC. ³ H	5032	Core 16:PCL	0.00111	0.00111	---	0.488
APC.Total α	5032	Core 16:PCL	31.9	31.9	---	14,000
BPC.Total β	5032	Core 16:PCL	355	355	---	1.56E+05

Table A-7. Tank 241-SY-102 Analytical Data: Centrifuged Liquid from Sludge

Analyte	Sample Number	Sample Identification	Result		Projected Inventory
RADIONUCLIDE					
		Core:Segment	μCi/mL	μCi/g	Ci
GEA. ⁶⁰ Co	6011	Core 17: Seg 3, 4 (Liq)	0.00947	0.00803	2.03
GEA. ¹³⁷ Cs			99.8	84.6	24,300

Table A-8. Tank 241-SY-102 Analytical Data: Centrifuged Solid from Sludge

Analyte	Sample Number	Sample Identification	Result	Mean	RSD	Projected Inventory
ORGANIC CARBON						
		Core:Segment	$\mu\text{g/g}$	$\mu\text{g/g}$	%	kg
TOC	5032	Core 16:PCL	7,100	7,100	---	3,120
TIC	5032	Core 16:PCL	7,300	6,450	---	2,840
	6010	Core 17: Seg 3, 4	5,600			

DOUBLE-SHELL TANK 241-SY-102

ANALYTICAL RESULTS

MARCH 1994 GRAB SAMPLE

APPENDIX B

APPENDIX B: MARCH 1994 GRAB SAMPLE ANALYTICAL RESULTS

INTRODUCTION

Appendix B presents the chemical and radiological characteristics of the March 1994 grab sample from Tank 241-SY-102 in a tabular form, in terms of the specific concentrations of metals, ions, radionuclides, and physical properties. The data for Appendix B was obtained from WHC Internal Memo "Waste Compatibility Assessment of Tank 241-SY-102 with Tank 241-T-111 VIA 244-TX DCRT" (Sutey 1994b). The samples were collected on March 10, 1994 using liquid grab sample plan TFPE-YP-0172. The samples were received and analyzed by the 222-S Laboratory but only the supernate sample was reported in the Sutey document.

The data table for each analyte lists laboratory sample identification, a description of where the sample was obtained, an analytical data result for each sample, and a projected tank inventory for the particular analyte. The projected tank inventory column is not applicable for the specific gravity, pH, density, or percent water data.

The data are listed in standard notation for values greater than .001 and less than 100,000. Values outside these limits are listed in scientific notation.

COLUMN HEADINGS

Column one or "Analyte" contains the name of the analyte or physical characteristic and information about the method of measurement.

The "Sample Number" column (column two) lists the laboratory sample from which the analyte was measured. This identification number is different from the number assigned to the samples at the tank farm. Sampling rationale, locations, and descriptions of sampling events are in Section 3.0.

Column three describes the riser and the depth at which the sample was obtained. The depth (in inches) is measured from the top of riser 1A.

Columns four and five, or "Result", are the specific concentration of the analyte. Numbers that are preceded by a less than symbol (<) indicate the analyte was noted, but was below the analytical instrument's calibrated detection limit for the sample. The data was reported in $\mu\text{g/mL}$ units by the laboratory and converted to $\mu\text{g/g}$ using the following formula.

$$(\text{Result}) \frac{\mu\text{g}}{\text{mL}} \times \frac{\text{mL}}{1.03\text{g}} (\text{Specific Gravity})$$

Column six or "Projected Inventory" is the product of the concentration of the analyte and the supernate volume of the waste in the tank at the time of sampling: 676 kgal or 2,560 kL (Hanlon, 1994b). The calculation was performed using the following formula.

$$\text{Projected Inventory (kg)} = 2,560 \text{ kL} \times [\text{Result } (\mu\text{g/mL})] \times (1000\text{mL/L}) \times (\text{kg} / 1.00\text{E}+09 \mu\text{g})$$

Table B-1. Tank 241-SY-102 Analytical Data: March 10, 1994 Liquid Grab Sample

Analyte	Sample Number	Sample Identification	Result	Result	Projected Inventory
METAL		Riser:Depth	$\mu\text{g/mL}$	$\mu\text{g/g}$	kg
ICP.Al	T 560	1A:401 in.	636	617	1,630
ICP.Fe			< 5.20	< 5.04	< 13.3
ICP.Na			17,300	16,800	44,300
ION		Riser:Depth	$\mu\text{g/mL}$	$\mu\text{g/g}$	kg
NH ₄ ⁺	T 560	1A:401 in.	< 40.0	< 38.8	< 102
IC.Cl ⁻			200	194	512
IC.CN ⁻			1.04	1.01	2.66
IC.F ⁻			752	730	1,930
IC.OH ⁻			3,470	3,370	8,880
IC.NO ₃ ⁻			23,500	22,800	60,200
IC.NO ₂ ⁻			3,220	3,130	8,240
Spec.NO ₂ ⁻			2,980	2,890	7,630
IC.PO ₄ ³⁻			397	385	1,020
IC.SO ₄ ²⁻			521	506	1,330
RADIONUCLIDE		Riser:Depth	$\mu\text{Ci/mL}$	$\mu\text{Ci/g}$	Ci
²⁴¹ Am	T 560	1A:401 in.	< 2.67E-05	< 2.59E-05	< 0.0684
GEA. ¹³⁷ Cs			6.77	6.57	17,300
²³⁷ Np			2.09E-05	2.03E-05	0.0535
^{239/240} Pu			3.09E-04	3.00E-04	0.791
⁹⁰ Sr			0.00117	0.00113	3.00
Total α			0.00617	0.00599	15.8
Total β			8.23	7.99	21,100
PHYSICAL PROPERTY		Riser:Depth			
Grav. % H ₂ O	T 560	1A:401 in.	95.4 %		
TGA. Wt % H ₂ O			88.8 wt %		
pH			12.8		
Specific Gravity			1.03		
CARBON		Riser:Depth	$\mu\text{g/mL}$	$\mu\text{g/g}$	kg
Total Organic Carbon	T 560	1A:401 in.	250	243	640
Total Inorganic Carbon			< 20.0	< 19.4	< 51.2

APPENDIX C

PREVIOUS SAMPLING EFFORTS

DOUBLE-SHELL TANK 241-SY-102

APPENDIX C: PREVIOUS SAMPLING EFFORTS

INTRODUCTION

The data in Appendix C was derived from November 1988 Core Sample from Tank 241-SY-102, Process Chemistry Laboratory Effort (Weiss, 1990) and from Results of the Characterization of Samples of Waste from Double Shell Tank 102-SY (Scheele and Peterson, 1990).

The samples are identified by the laboratory number as follows:

102SY-1-2	Supernate, Composite of Segment 1 and 2
102-SY-3C	Segment 3
102-SY-3T4S	Centrifuged Solids from the Composite of Segment 3 and the top of Segment 4
102-SY-3T4L	Centrifuged Liquids from the Composite of Segment 3 and the top of Segment 4
102-SY-T4C	Top Portion of Segment 4
102-SY-4B	Bottom Portion of Segment 4

Table C-1. Previous Sampling Results for Tank 241-SY-102. (3 sheets)

Analyte	Tank Characterization Result			
	Sample Identification			
METALS	102-SY-4B (µg/g)	102-SY-3T4S (µg/g)	102-SY-3T4L (µg/g)	102-SY-1-2 (µg/g)
Aluminum (Al)	48,100	34,800	2,590	1,190
Arsenic (As)	< 6,820	---	---	---
Barium (Ba)	27.4	93.2	< 11.0	0.0411
Boron (B)	173	194	32.4	10.8
Cadmium (Cd)	---	---	---	---
Calcium (Ca)	421	5,694	38.4	2.81
Cerium (Ce)	420	560	< 280	< 5.60
Chromium (Cr)	13,300	16,400	312	9.36
Dysprosium (Dy)	32.6	52.2	< 13.0	< 0.163
Iron (Fe)	4,460	31,900	3.35	2.23
Lanthanum (La)	80.6	417	< 27.8	< 0.278
Lead (Pb)	---	---	---	---
Lithium (Li)	< 13.9	< 13.9	< 20.8	0.00694
Magnesium (Mg)	97.2	1,730	< 7.29	0.122
Manganese (Mn)	1,370	12,600	< 22.0	0.0275
Molybdenum (Mo)	< 95.9	76.7	19.2	0.959
Neodymium (Nd)	288	288	< 86.4	< 1.30
Nickel (Ni)	294	528	41.1	0.294
Phosphorus (P)	11,800	4,030	---	93.0
Potassium (K)	2,390	2,310	1,210	2,350
Rhodium (Rh)	< 206	< 412	< 309	< 30.9

Table C-1. Previous Sampling Results for Tank 241-SY-102 (continued).

Analyte	Tank Characterization Result			
	Sample Identification			
METALS (continued)	102-SY-4B ($\mu\text{g/g}$)	102-SY-3T4S ($\mu\text{g/g}$)	102-SY-3T4L ($\mu\text{g/g}$)	102-SY-1-2 ($\mu\text{g/g}$)
Ruthenium (Ru)	< 40.4	< 404	< 505	< 20.2
Selenium (Se)	< 7,110	---	---	---
Silicon (Si)	843	2,700	22.5	129
Sodium (Na)	1.94E+05	1.01E+05	82,800	20,200
Strontium (Sr)	17.5	175	< 17.5	0.0526
Tellurium (Te)	< 256	< 256	< 256	< 2.56
Titanium (Ti)	38.3	144	< 14.4	0.0958
Uranium (U)	1,300	---	---	---
Zinc (Zn)	65.4	589	< 131	1.96
Zirconium (Zr)	64.8	456	< 63.8	0.0912
IONS	102-SY-4B ($\mu\text{g/g}$)	102-SY-3T4S ($\mu\text{g/g}$)	102-SY-3T4L ($\mu\text{g/g}$)	102-SY-1-2 ($\mu\text{g/g}$)
Chloride (Cl ⁻)	7,100	---	---	---
Chromium (Cr ⁶⁺)	1,280	1,550	40.3	12.3
Fluoride (F ⁻)	1,650	---	---	---
Hydroxide (OH ⁻)	17,000	---	---	---
Nitrate (NO ₃ ⁻)	2.02E+05	---	---	---
Nitrite (NO ₂ ⁻)	61,700	---	---	---
Phosphate (PO ₄ ³⁻)	45,600	---	---	---
Sulfate (SO ₄ ²⁻)	7,690	---	---	---

Table C-1. Previous Sampling Results for Tank 241-SY-102 (continued).

Analyte	Tank Characterization Results					
	Sample Identification					
RADIONUCLIDES	102-SY-4B ($\mu\text{Ci/g}$)	102-SY-T4C ($\mu\text{Ci/g}$)	102-SY-3C ($\mu\text{Ci/g}$)	102-SY-3T4S ($\mu\text{Ci/g}$)	102-SY-3T4L ($\mu\text{Ci/g}$)	102-SY-1-2 ($\mu\text{Ci/g}$)
Americium-241	0.973	9.82	50.6	---	---	---
Antimony-125	< 1.60	---	---	---	---	---
Carbon-14	0.00180	---	---	---	---	---
Cerium-144	< 1.10	---	---	---	---	---
Cesium-134	< 0.0640	---	---	---	---	---
Cesium-137	150	---	---	---	---	---
Cobalt-60	0.110	---	---	---	---	---
Curium-243/244	0.0430	0.0190	0.240	---	---	---
Europium-152	< 0.150	---	---	---	---	---
Europium-154	1.50	---	---	---	---	---
Iodine-129	< 2.70E-04	---	---	2.40E-04	2.80E-05	1.80E-06
Neptunium-237	5.90E-04	8.10E-04	0.00130	---	---	---
Nickel-63	< 2.90	---	---	< 5.50	< 1.90E-04	< 4.00E-04
Niobium-94	< 0.00410	---	---	< 0.00230	< 3.10E-06	< 6.10E-07
Plutonium-238	0.0370	0.788	1.35	---	---	---
Plutonium-239	0.130	2.82	9.73	---	---	---
Plutonium-240	0.0390	1.19	3.40	---	---	---
Plutonium-241	1.22	35.8	117	---	---	---
Ruthenium-106	< 1.60	---	---	---	---	---
Selenium-79	3.18E-04	---	---	< 1.80E-04	6.07E-04	1.50E-05
Strontium-90	67.6	---	---	---	---	---
Technetium-99	0.202	---	---	0.220	0.0538	0.00201
Tritium	< 0.00130	---	---	< 6.20E-04	< 7.96E-05	< 2.50E-05

APPENDIX D
TANK 241-SY-102, 1990 PHOTOGRAPHS
CORE 16, SEGMENTS 3 AND 4

TANK 241-SY-102
1990 Core 16, Segment 3

D-1

TANK 241-SY-102
1990 Core 16, Segment 4

APPENDIX E
ANALYTICAL PROCEDURE NUMBERS
DOUBLE-SHELL TANK 241-SY-102

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

Analyte	Procedure
Particle Size	PNL-ALO-530
Specific Gravity	PNL-ALO-501
% Water	PNL-ALO-508
Rheology	WHC-053-1
Visual Inspection	PNL-ALO-501

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

Analyte	Method	Procedure Number
F, Cl ⁻ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻	Ion Chromatography	PNL-ALO-212
U	Laser Fluorimetry	PNL-ALO-445
Total Alpha	Proportional Counting	PNL-ALO-421
Total Beta		PNL-ALO-423
		PNL-ALO-430
		PNL-ALO-431
²³⁸ Pu, ^{239/240} Pu, ²⁴¹ Am, ²³⁷ Np	Alpha Spectrometry	PNL-ALO-423 PNL-ALO-417 PNL-ALO-425
Total Metals	Inductively Coupled Plasma	PNL-ALO-211
⁹⁰ Sr	Beta Proportional Counting	PNL-ALO-433
		PNL-ALO-431
⁹⁹ Tc	Liquid Scintillation	PNL-ALO-432
¹²⁹ I	Low Energy Gamma Analysis	PNL-ALO-454
¹⁴ C ³ H	Liquid Scintillation	PNL-ALO-442 PNL-SP-30
¹⁵⁴ Eu, ¹⁵⁵ Eu, ²⁴¹ Am, ¹³⁷ Cs, ⁶⁰ Co	Gamma Energy Analysis	PNL-ALO-450
H ⁺	pH	PNL-ALO-225
As Se	Atomic Absorption	PNL-ALO-214
		PNL-ALO-215
Pu Isotopic U Isotopic	Mass Spectrometry	PNL-ALO-455
TOC	Total Organic Carbon	PNL-ALO-381
TIC	Total Inorganic Carbon	PNL-ALO-381

APPENDIX F
PARTICLE SIZE DISTRIBUTION
DOUBLE-SHELL TANK 241-SY-102

Figure F-1. Particle Size Distribution For Tank 241-SY-102 Sample 4B.