1240169
C0075147H)

RPP-RPT-33060, Rev. 0

Retrieval Data Report for Single-Shell Tank 241-C-103

M. J. Galgoul, D. L. Parker
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

RECEIVED
SEP 13 2016
EDMC

EDT/ECN: DRF
Cost Center: 7F500
B&R Code:
UC:
Charge Code:
Total Pages: 156

Key Words: waste, retrieval, residual, modified sluicing system, C-103, 200-series tank, WMA C, technology, limit, HFFACO, TPA, M-45-00, M-45-00B

Abstract: This report describes the retrieval of waste from SST 241-C-103, which is a 100-series single-shell tank constructed to store waste in Waste Management Area C. The DOE began retrieval of waste on November 6, 2005, and completed retrieval in compliance with Milestone M-44-00 and M-45-00B requirements on August 26, 2006. The limit of technology was reached for the configuration of the modified sluicing system as deployed.

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.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

APR 19 2007
DATE:
STA: 15
HANFORD RELEASE
ID:
65
Release Stamp

Janis Aardal 04/19/2007
Release Approval Date

Approved For Public Release

RPP-RPT-33060
Revision 0

RETRIEVAL DATA REPORT FOR SINGLE-SHELL TANK 241-C-103

Prepared by
M. J. Galgoul
D. L. Parker

Date Published
April 2007

CH2MHILL
Hanford Group, Inc.

P.O. Box 1500
Richland, Washington

Contractor for the U. S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

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.

Printed in the United States of America. To obtain copies of this document, contract: Document Control Services P.O. Box 950, Mailstop H6-08, Richland, WA 99352, Phone (509) 372-2420; Fax (509) 376-4989

EXECUTIVE SUMMARY

This Retrieval Data Report (RDR) presents data showing that single-shell tank 241-C-103 (SST C-103) has been retrieved to the limits of the modified sluicing technology and that tank waste residuals in SST C-103 do not exceed 360 ft^3. These achievements satisfy the tank waste retrieval criteria established by Milestones M-45-00 and M-45-00B of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO). This RDR also summarizes the potential risk to human health from waste remaining in the tank, provides details on the modified sluicing technology and its performance in the SST C-103 retrieval campaign, and describes measures taken to prevent and detect leaks during retrieval.

The SST C-103 retrieval campaign began November 6, 2005. SST C-103 was retrieved using modified sluicing, which used high-pressure liquid spray of recycled double-shell tank (DST) supernatant to mobilize waste and a centralized pump to remove waste from the tank. Use of this system minimized addition of water to the tank farm system. Removed waste slurry was transferred to double-shell tank 241-AN-106 (DST AN-106).

The SST C-103 leak detection, monitoring, and mitigation program during retrieval used a combination of drywells, minimization of cumulative liquids, and visual inspection to detect, prevent, and control potential leaks. In addition, a high-resolution resistivity technique for leak detection was used at SST C-103 in a demonstration mode. No leaks were detected during SST C-103 retrieval operations. Review of post-retrieval data is ongoing and results of drywell scans will be summarized in RPP-RPT-33433, *Tank 241-C-103 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data.*

On August 23, 2006, representatives of the U.S. Department of Energy (DOE) and CH2M HILL Hanford Group, Inc. (CH2M HILL) determined that the technical limit of the modified sluicing to retrieve waste from SST C-103 had been reached and briefed the Washington State Department of Ecology. In determining that the capacity of the modified sluicing system to remove waste from SST C-103 had been reached, DOE and CH2M HILL relied on the following:

a. Decreases over time in the waste recovered per gallon of slurry transferred.
b. Direct visual observation of the waste remaining in the tank bottom.
c. Volume of residual waste at the end of each operating day.

Subsequent measurement of the residual waste in SST C-103 using topographical mapping and survey techniques in accordance with Attachment 1 to HFFACO Appendix H and RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, established that the volume of waste remaining in SST C-103 was 338 ft^3, with a 95% upper confidence level of 351 ft^3. SST C-103 held approximately 77,800 gal (10,400 ft^3) of waste at the start of retrieval. It should be noted that this starting waste bulk volume includes tank waste and water added to the tank during maintenance and tests prior to the start of retrieval. Based on the difference between the starting waste volume and residual waste volume estimates, approximately 75,269 gal (10,062 ft^3) of waste were retrieved from SST C-103 and transferred to DST AN-106.

The inventory of constituents in the SST C-103 residual waste was determined by laboratory analysis of waste samples taken after the completion of retrieval. The risk assessment for the residual waste in SST C-103 based on sampling analyses shows that for the groundwater pathway, the estimated risk impacts for SST C-103 were well below performance objectives. For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the estimated risk impacts for SST C-103 were well below performance objectives. For the suburban garden scenario at 500 years after closure, the effects are below performance objectives.

The DOE has no recommendations for additional retrieval actions at SST C-103 because Milestone M-45-00 retrieval criteria are satisfied and retrieval is complete.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ii

1.0 INTRODUCTION AND BACKGROUND 1-1
1.1 Purpose 1-1
1.2 History 1-1
1.3 Regulatory Requirements 1-1
1.4 Pre-Retrieval Conditions 1-2
1.4.1 Single-Shell Tank C-103 Description 1-2
1.4.2 Ancillary Equipment Providing Access to Single-Shell Tank C-103 1-3
1.4.3 Waste Description and Conditions 1-3
1.5 Document Structure 1-6

2.0 RETRIEVAL SYSTEM DESCRIPTION 2-1
2.1 Basis 2-1
2.2 Overview 2-1
2.2.1 Liquid Medium Distribution System 2-1
2.2.2 Waste Removal System 2-2
2.3 Retrieval System Instrumentation 2-2
2.4 Environmental Controls 2-2
2.4.1 Exhauster Operation 2-3
2.4.2 Corrosion Mitigation 2-3
2.4.3 Leak Detection Monitoring and Mitigation 2-3
2.4.4 Walkdown of Aboveground Portions of the Tank System 2-3
2.4.5 Secondary Containment 2-3
2.5 Waste Retrieval Campaign Chronology 2-3

3.0 RETRIEVAL SYSTEM PERFORMANCE 3-1
3.1 Waste Retrieval Process Description 3-1
3.2 Retrieval system Performance 3-1
3.2.1 Water Use 3-4
3.2.2 Waste Retrieval Rate 3-6
3.2.3 Retrieval Time 3-7
3.3 Requirements for Use of SST AN-016 Supernate 3-8
3.4 Conclusion 3-11

4.0 LEAK DETECTION, MONITORING, AND MITIGATION 4-1
4.1 Requirements 4-1
4.2 Leak Detection and Monitoring 4-1
4.2.1 Single-Shell Tank C-103 4-3
4.2.2 Double-Shell Tank AN-106 4-10
4.2.3 Ancillary Equipment 4-11
4.3 Mitigation 4-11
4.3.1 Single-Shell Tank C-103 4-12
4.3.2 Double-Shell Tank AN-106 4-13
4.3.3 Ancillary Equipment 4-13
4.4 Conclusion 4-13

5.0 LIMITS OF TECHNOLOGY 5-1
5.1 Identifying Limits of Technology 5-1
5.2 Determination That as Much Waste Was Retrieved as Possible Using the Selected Technology 5-2
5.2.1 Results of Visual Observations 5-2
5.2.2 Trend in Retrieval Efficiency 5-2
5.2.3 Waste Retrieval Progress 5-3
5.3 Conclusion 5-4

6.0 SINGLE-SHELL TANK C-103 RESIDUAL WASTE VOLUME MEASUREMENT 6-1
6.1 Residual Waste Volume Measurement Process 6-1
6.1.1 Video Camera/Computer-aided Design Modeling System 6-1
6.1.2 Estimation of Waste Remaining on Tank Surfaces 6-3
6.1.3 Estimation of Waste in Equipment 6-3
6.2 Residual Waste Volume Results 6-4
6.3 Conclusion 6-11

7.0 RESIDUAL TANK WASTE CHARACTERIZATION 7-1
7.1 Sampling and Analysis of Residual Waste 7-1
7.2 Sampling at Single-Shell Tank C-103 7-1
7.3 Sample Analyses 7-2
7.4 Calculation of Residual Inventory 7-5

8.0 POST-RETRIEVAL SINGLE-SHELL TANK C-103 RISK ASSESSMENT 8-1
8.1 Constituents Evaluated 8-1
8.2 Results for Individual Contaminants for Post-Retrieval Single-Shell Tank C-103 8-6
8.3 Cumulative Analysis Results for Single-Shell Tank C-103 and Waste Management Area C 8-7
8.4 Inadvertent Intruder 8-11
8.5 Summary 8-11

9.0 ADDITIONAL RETRIEVAL TECHNOLOGIES 9-1
9.1 Feasibility and Viability of Other Available Waste Retrieval Technologies 9-1
9.1.1 Vacuum Retrieval System 9-1
9.1.2 Remote Water Lance (Salt Mantis) 9-2
9.1.3 Chemical Addition 9-2
9.2 Feasibility of Developing Additional Technologies 9-4
9.2.1 AEA Technology Power Fluidics™ and Russian Pulsatile Mixer Pumps 9-4
9.2.2 Mobile Retrieval Tool 9-5
9.3 Conclusions 9-6

10.0 RECOMMENDATIONS FOR FURTHER ACTION 10-1
10.1 Recommendations for Single-Shell Tank 241-C-103 10-1
10.2 Opportunities for Improvement of Waste Retrieval Operations at Other Single-Shell Tanks Based on Lessons Learned from Single-Shell Tank C-103 10-1

11.0 REFERENCES 11-1

LIST OF APPENDIXES

APPENDIX A PRE-RETRIEVAL BEST BASIS INVENTORY FOR SINGLE-SHELL TANK C-103 ..... A-1

APPENDIX B SINGLE-SHELL TANK C-103 RESIDUAL WASTE CONCENTRATIONS AND INVENTORIES B-1

APPENDIX C COMPARISON OF SINGLE-SHELL TANK C-103 FINAL INVENTORY TO SINGLE-SHELL TANK C-103 INVENTORY USED IN DOE/ORP-2005-01, INITIAL SINGLE-SHELL TANK PERFORMANCE ASSESSMENT FOR THE HANFORD SITE C-1

APPENDIX D SINGLE-SHELL TANK C-103 TANK RISK DATA D-1

APPENDIX E CAUSTIC ADDITION TECHNOLOGY COST ESTIMATE E-1

LIST OF FIGURES

Figure 1-1. 100-Series Tank – Cutaway View 1-4

Figure 1-2. Configuration of Single-Shell Tank C-103 and Adjacent Facilities. 1-5

Figure 2-1. SST C-103 Modified Sluicing Waste Retrieval System. 2-1

Figure 3-1. Residual Waste in Single-Shell Tank C-103 According to Material Balance. 3-4

Figure 3-2. Water Additions During Single-Shell Tank C-103 Retrieval. 3-5

Figure 3-3. Daily Retrieval Rate During Campaign. 3-6

Figure 3-4. Daily Adjusted Waste Retrieval During Campaign. 3-7

Figure 3-5. Operating Days to Retrieve Single-Shell Tank S-103. 3-8

Figure 3-6. DST AN-106 Equipment and Sampling Layout. 3-9

Figure 3-7. Plan View of Double-Shell Tank AN-106 Riser Locations. 3-10

Figure 4-1. Plan View of C-Farm Tanks and Drywells. 4-4

Figure 4-2. Single-Shell Tank C-103 High-Resolution Resistivity Leak Detection and Monitoring Layout. 4-9

Figure 5-1. Limits of Technology Model. 5-1

Figure 5-2. Waste Retrieval Performance: Retrieval Efficiency. 5-3

Figure 5-3. Waste Retrieval Progress. 5-4

Figure 6-1. Single-Shell Tank C-103 Section View Showing Camera Elevations Used in March 23, 2006, Video Recording. 6-2

Figure 6-2. Single-Shell Tank C-103 Post-Retrieval Tank Waste Contour Map. 6-6

Figure 6-3. Single-Shell Tank C-103 Post-Retrieval Tank Waste Wire Mesh Isometric Model. 6-7

Figure 6-4. Single-Shell Tank C-103 Video Still, Recorded September 28, 2006, Camera Elevation Approximately 10 Feet from Tank Bottom. 6-8

Figure 6-5. Single-Shell Tank C-103 Video Still, Recorded August 25, 2006, Camera Elevation Approximately 5 Feet from Tank Bottom. 6-9

Figure 6-6. Single-Shell Tank C-103 Video Still, Recorded September 28, 2006, Camera Elevation Approximately 10 Feet from Tank Bottom. 6-10

Figure 6-7. Single-Shell Tank C-103 Video Still, Recorded August 25, 2006, Camera Elevation Approximately 19 Feet from Tank Bottom. 6-11

Figure 7-1. Approximate Locations for Tank 241-C-103 Post-retrieval Solids Samples (Based on RPP-RPT-32376 Appendix C) 7-3

Figure 8-1. Single-Shell Tank C-103 Residual Waste Inventory and Risk Assessment Process. 8-2

LIST OF TABLES

Table 1-1. Single-Shell Tank C-103 Pre-Retrieval Riser and Hatchway Descriptions. 1-6

Table 1-2. Crosswalk of HFFACO Appendix I, Section 2.1.7, Requirements and Corresponding Retrieval Data Report Sections. 1-8

Table 2-1. Chronology of the Single-Shell Tank C-103 Waste Retrieval Campaign. 2-4

Table 3-1. Daily Volume Calculation Data. 3-2

Table 3-2. System Performance Summary. 3-5

Table 3-3. Double-Shell Tank AN-106 Equipment and Sampling Locations. 3-9

Table 4-1. Single-Shell Tank C-103 Leak Detection and Monitoring Functions and Requirements. 4-2

Table 4-2. Leak Detection and Monitoring Methods for Each Waste Retrieval System Component. 4-2

Table 4-3. Drywell Monitoring Chronology. 4-5

Table 4-4 Groundwater Monitoring Results. 4-6

Table 4-5. Operability Summary. 4-8

Table 4-6. Single-Shell Tank C-103 Potential Condition of Concern Summary 4-10

Table 6-1. Single-Shell Tank C-103 Total Waste Volume and Component Waste Volumes. 6-4

Table 6-2. Single-Shell Tank C-103 Waste Volume in Tank Bottom. 6-4

Table 7-1. Single-Shell Tank C-103 Residual Waste Sample Analysis Techniques. 7-4

Table 8-1. List of Analytes and Available Toxicity Information. (4 sheets) 8-3

Table 8-2. Estimated Maximum Incremental Lifetime Cancer Risk/Radiological Dose During the Modeling Period for Primary Radionuclides. 8-8

Table 8-3. Estimated Maximum Value for Incremental Lifetime Cancer Risk and Hazard Quotient per Nonradionuclides. 8-9

Table 8-4. Cumulative Incremental Lifetime Cancer Risk, Hazard Index, and Radiological Drinking Water Dose from Peak Groundwater Concentration Related to Residual Waste Volume in Single-Shell Tank C-103 8-10

Table 8-5. Intruder Dose Summary for Single-Shell Tank C-103. 8-11

Table 8-6. Comparison of HTWOS Predicted Inventory used in DOE/ORP-2005-01 with the Average and 95% UCL Post-Retrieval Inventories. 8-13

LIST OF TERMS

Abbreviations, Acronyms, and Initialisms

AEA	*Atomic Energy Act of 1954*
AMS	articulating mast system
APF	all pathways farmer
CCMS	camera/computer-aided design modeling system
CCTV	closed-circuit television
CH2M HILL	CH2M HILL Hanford Group, Inc.
DOE	U.S. Department of Energy
DQO	data quality objective
DST	double-shell tank
DST AN-106	double-shell tank 241-AN-106
ECN	Engineering Change Notice
EPA	U.S. Environmental Protection Agency
HEIS	Hanford Environmental Information System
HFFACO	Hanford Federal Facility Agreement and Consent Order
HI	Hazard Index
HIHTL	hose-in-hose transfer line
HRR	high-resolution resistivity
HTWOS	Hanford Tank Waste Operations Simulator
ILCR	incremental lifetime cancer risk
ITV	in-tank vehicle
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
MBD	material balance discrepancy
MCL	maximum contaminant level
MRS	mobile retrieval system
MRT	mobile retrieval tool
NEC	National Electrical Code®
NESL	Non Entry Systems Ltd.
ORSS	off-riser sampling system
PA	performance assessment
PUREX	plutonium-uranium extraction
RAS	Radionuclide Assessment System
RDR	Retrieval Data Report
RWL	remote water lance
SST	single-shell tank
SST C-103	single-shell tank 241-C-103
TWINS	Tank Waste Information Network System
TWRWP	Tank Waste Retrieval Work Plan
UCL	upper confidence level
VRS	vacuum retrieval system
WCA	Waste Compatibility Assessments

WMA	Waste Management Area
WRS	waste retrieval system
WUF	waste unaccounted for

Units

Ci	curie
ft^3	cubic foot
ft	foot
g	gram
gal	gallon
in.	inch
kg	kilogram
L	liter
mL	milliliter
mrem	millirem
pCi	picocurie
scfm	standard cubic feet per minute
yr	year
µCi	microcurie
µg	microgram

1.0 INTRODUCTION AND BACKGROUND

Hanford Federal Facility Agreement and Consent Order (HFFACO) (Ecology et al. 1989), Milestone M-45-00 requires the U.S. Department of Energy (DOE) to retrieve waste from all single-shell tanks (SST) at the Hanford Site. This report describes the retrieval of waste from SST 241-C-103 (SST C-103), which is one of twelve 100-series SSTs constructed to store waste in Waste Management Area C (WMA C). The DOE began retrieving waste from SST C-103 on November 6, 2005, and completed retrieval operations in compliance with Milestone M-45-00 requirements on August 23, 2006.

Where information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*, as amended) has been incorporated into this document, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of Chapter 70.105, "Hazardous waste management," Revised Code of Washington and its implementing regulations, but is provided for information purposes only.

1.1 PURPOSE

This RDR provides information required by Section 2.1.7 of Appendix I to the HFFACO. This report documents the SST C-103 retrieval campaign, waste retrieval system performance, and post-retrieval activities including the residual waste volume determination and sampling and analysis of the waste. This report describes the performance of the retrieval system used to remove waste from SST C-103, presents data confirming that the amount of waste removed meets Milestone M-45-00 retrieval criteria, and summarizes the potential risk to human health posed by the waste remaining in the tank.

1.2 HISTORY

SST C-103 is one of 16 SSTs located at the 241-C Tank Farm in the 200 East Area of the Hanford Site. The tank went into service in 1946 and was declared inactive in 1979. No unplanned releases associated with SST C-103 are listed in the Waste Information Data System.

The SST C-103 retrieval campaign began on November 6, 2005, and concluded on August 23, 2006. During the campaign, 10,062 ft^3 of waste were removed from SST C-103 based on the difference between the starting waste volume and the residual waste volume.

1.3 REGULATORY REQUIREMENTS

Retrieval of waste from SST C-103 and submittal of this RDR are necessary requirements for closing the Hanford SST system. The HFFACO establishes volume and technology criteria for closing 100-series tanks, including SST C-103. The HFFACO Milestone M-45-00 provides in part:

> *Closure will follow retrieval of as much tank waste as technically possible, with tank waste residues not to exceed 360 cubic feet (cu. ft.) In each of the 100 series tanks, ... or the limit of waste retrieval technology capability, whichever is less. If*

the DOE believes that waste retrieval to these levels is not possible for a tank, then DOE will submit a detailed explanation to EPA and Ecology explaining why these levels cannot be achieved, and specifying the quantities of waste that the DOE proposes to leave in the tank. The request will be approved or disapproved by EPA and Ecology on a tank-by-tank basis.

Section 2.1.7 of Appendix I to the HFFACO Action Plan provides

2.1.7 Retrieval Data Report/Appendix H Request for Exception

Once DOE has completed the retrieval actions described in the Tank Waste Retrieval Work Plan (TWRWP), DOE will either complete the RDR and then submit it to Ecology within 120 days, or a request for exception to retrieval criteria per Agreement Appendix H. The Appendix H option is only applicable for SSTs.

At a minimum, DOE's Retrieval Data Report will include

- *Residual tank waste volume measurement, including associated calculations.*
- *The results of residual tank waste characterization.*
- *Retrieval technology performance documentation.*
- *DOE's updated post-retrieval risk assessment.*
- *Discussion of feasibility/viability of other available retrieval technologies, the feasibility of developing additional retrieval technologies, associated detailed cost estimates and amount of additional waste that could be removed*
- *Opportunities and actions being taken to refine or develop tank waste retrieval technologies, based on lessons learned.*
- *LDMM monitoring and performance results.*
- *DOE's recommendation for further action and proposed schedule(s).*

Data from this report will be used by Washington State Department of Ecology (Ecology) and DOE in making WMA-, tank- and component-specific closure decisions. Single or multiple tank and component actions will be included in this report as appropriate.

1.4 PRE-RETRIEVAL CONDITIONS

This section summarizes the physical circumstances of the tank, the ancillary equipment used during retrieval, and the waste residing in the tank when retrieval began.

1.4.1 Single-Shell Tank C-103 Description

SST C-103 is one of 16 SSTs located at the 241-C Tank Farm in the 200 East Area of the Hanford Site. It has a nominal capacity of 530,000 gal. The tank is constructed of 1-ft-thick reinforced concrete with a 0.25-in. carbon-steel liner on the bottom and sides and a 1.25-ft-thick

concrete top. The tank has a 12-in. dished bottom with a 4-ft-radius knuckle. It is the last in a three-tank cascade series that also includes 241-C-101 and 241-C-102. An ENRAF™[1] gauge installed in SST C-103 is available to measure waste levels in the tank. Figure 1-1 presents a generalized profile view of a 100-series tank such as SST C-103.

1.4.2 Ancillary Equipment Providing Access to Single-Shell Tank C-103

Tank C-103 has three reinforced-concrete process pits that were installed after initial tank construction to facilitate waste retrieval. These pits are constructed of reinforced concrete and extend above grade. The pits provide secondary containment for the primary transfer piping within and have removable cover blocks or plates that allow entry into the pits. The pit floors were constructed with drains that direct any liquid back into the tank through a tank riser located in the pit. The condenser hatchway located above the outside edge of the tank provided an indirect access path into the tank for ventilation. Each pit used for waste retrieval has a conductivity probe leak detector.

Figure 1-2 provides a top-down view of SST C-103 and includes the pit, risers, and hatchway. Table 1-1 provides basic information on the SST C-103 risers and hatchway before retrieval began.

1.4.3 Waste Description and Conditions

The volume of waste in SST C-103 at the start of retrieval consisted of approximately 77,8000 gal of waste. During its service life, the tank was used to store waste from many sources including metal waste from the bismuth phosphate process, cladding waste from the plutonium-uranium extraction (PUREX) plant, 241-AR vault solids from tank 241-C-106, and liquid wastes from other tanks at the 241-C Tank Farm. A summary of the waste that resided in SST C-103 at the start of retrieval is provided in Appendix A from the Tank Waste Information Network System (TWINS) Best Basis Inventory/Best Basis Calculation Detail, located online at http://twins.pnl.gov/data/datamenu.htm. Section 7.0 provides a comprehensive list of constituents in the SST C-103 chemical and radionuclide inventory.

Waste recovered from SST C-103 was transferred to double-shell tank 241-AN-106 (DST AN-106) for storage.

[1] ENRAF™ is a registered trademark of Enraf B. V., Delft, The Netherlands.

Figure 1-1. 100-Series Tank – Cutaway View.

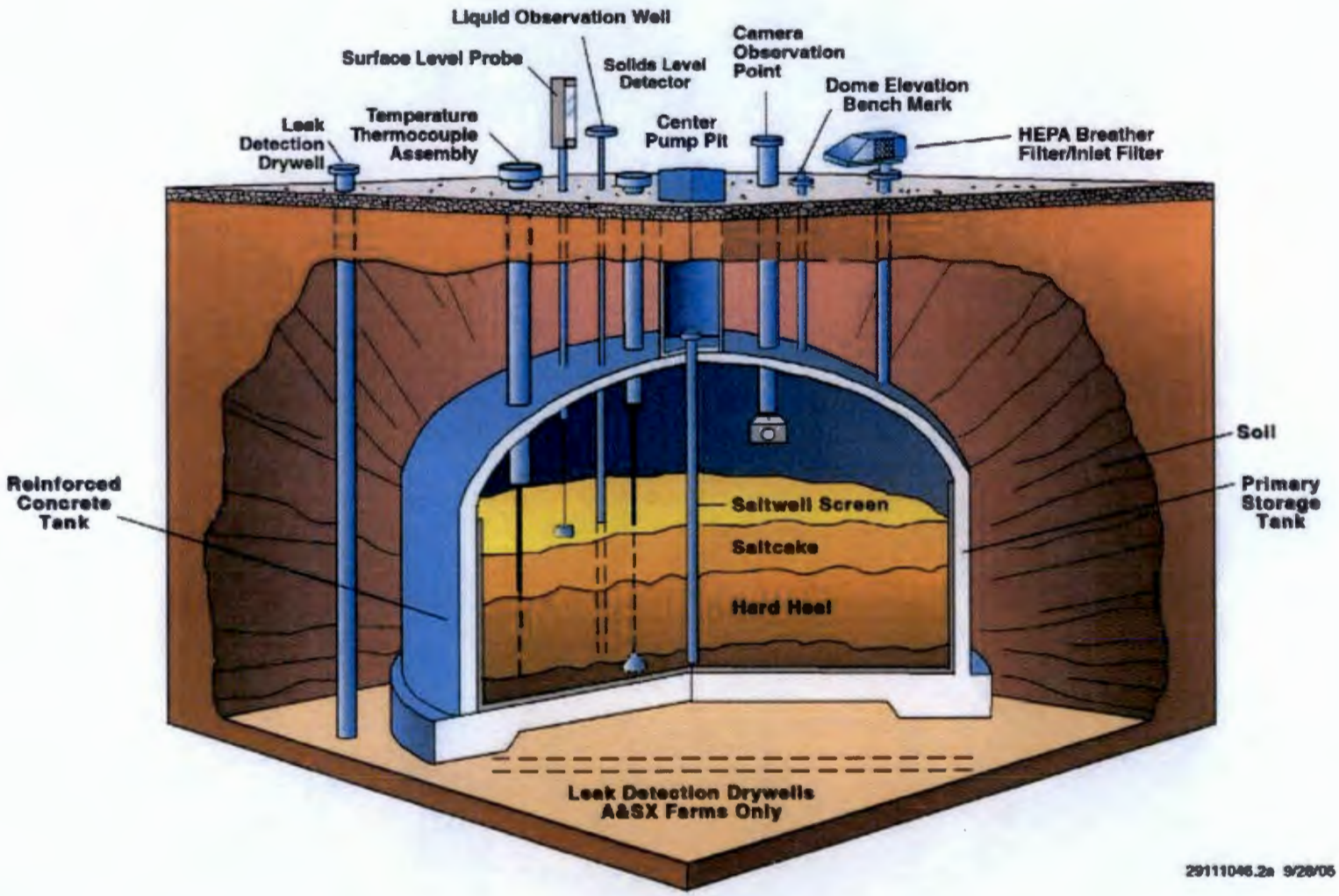


Figure 1-2. Configuration of Single-Shell Tank C-103 and Adjacent Facilities.

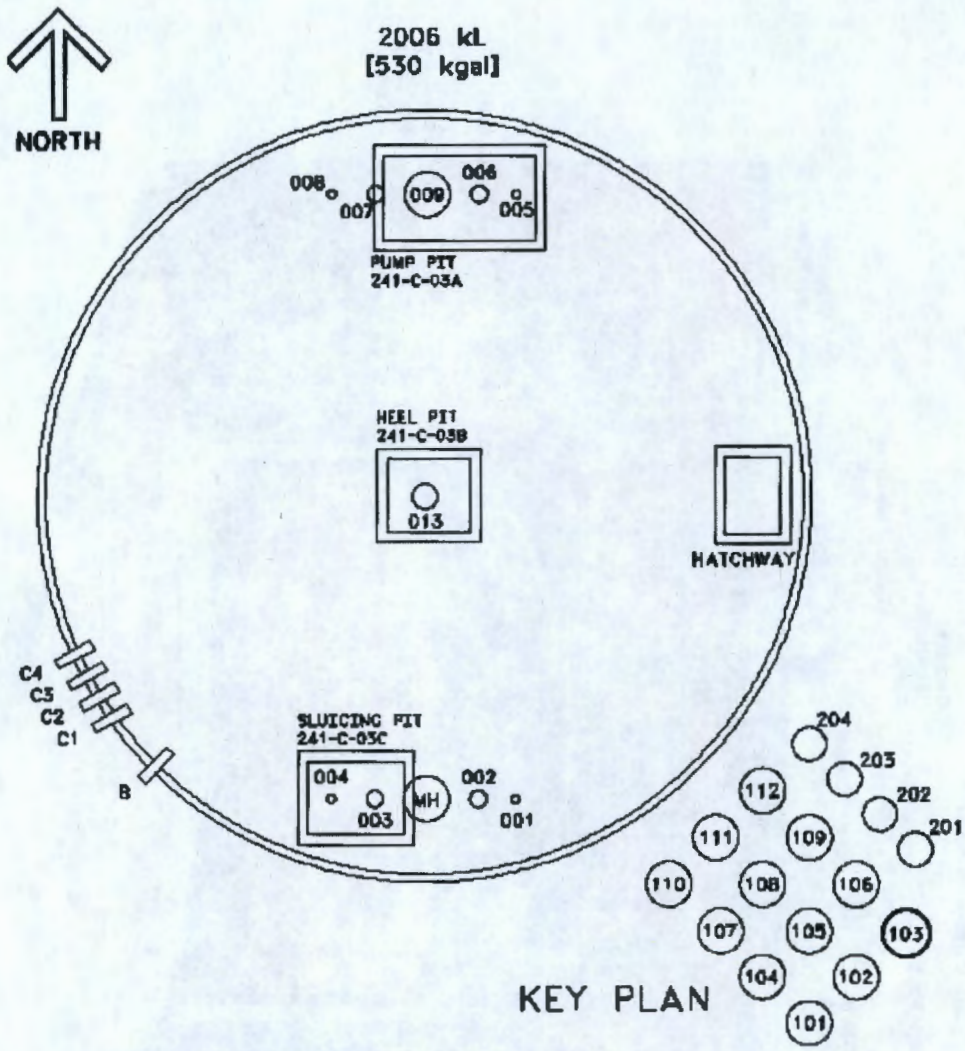


Table 1-1. Single-Shell Tank C-103 Pre-Retrieval Riser and Hatchway Descriptions.

Riser Number	Diameter (in.)	Use Description
R1	4	Temperature probe (benchmark)
R2	12	Breather filter
R3	12	Sluicing nozzle (weather covered)
R4	4	Recirculating dip leg
R5	4	Recirculating dip leg
R6	12	Sluicing nozzle
R7	12	Spare
R8	4	Level gauge (ENRAF)[a]
R9	42	Special probe
R13	26	Spare (saltwell pump has been removed)
B[b]	3	Overflow inlet (cascade line from tank C-102)
C1[b]	3	Spare inlet (capped)
C2[b]	3	Spare inlet (capped)
C3[b]	3	Spare inlet (capped)
C4[b]	3	Spare inlet (capped)

[a] ENRAF is the supplier of the identified level gauges.

[b] Cascade and/or fill line, not a riser.

Reference documents from TWINS, Web Site – http://twinsweb.pnl.gov/twins.htm and H-14-010613, *Waste Storage Tank (WST) Riser Data*, Sheet 1 (with Engineering Change Notices).

1.5 DOCUMENT STRUCTURE

This SST C-103 RDR is organized to present information required by Section 2.1.7 of Appendix I to the HFFACO Action Plan. Table 1-2 presents a crosswalk between Section 2.1.7 requirements and sections of this RDR.

- **Section 1,** *Introduction and Background*, discusses the purpose and scope of SST C-103 waste retrieval, presents requirements applicable to the tank's retrieval campaign and this report, describes the tank and certain associated equipment, summarizes the operating history and in-tank conditions when waste retrieval began, and outlines the report structure.
- **Section 2,** *Retrieval System Description,* describes waste retrieval system design, construction and operation, lists major waste retrieval system components, depicts the waste retrieval process, and presents a waste retrieval chronology.

- **Section 3**, *Retrieval System Performance*, provides an evaluation of how well the waste retrieval system performed and provides a comparison of actual performance against predicted performance.
- **Section 4**, *Leak Detection, Monitoring, and Mitigation*, describes leak detection, monitoring, and mitigation (LDMM) methods and procedures, presents an LDMM chronology for SST C-103 waste retrieval, and summarizes LDMM results.
- **Section 5**, *Limits of Technology*, reports the method and findings used to determine that the selected waste retrieval technology retrieved as much tank waste as technically possible from SST C-103.
- **Section 6**, *Single-Shell Tank C-103 Residual Waste Volume Measurement*, describes the method for determining the volume of residual waste in SST C-103 and presents results of the volume measurement process.
- **Section 7**, *Residual Tank Waste Characterization*, lists requirements for characterization of tank waste, describes methods and procedures used to sample and analyze the waste, and describes the results of laboratory analysis.
- **Section 8**, *Post-Retrieval Single-Shell Tank C-103 Risk Assessment*, summarizes the potential risk to human health from SST C-103 residual waste. This section identifies and discusses constituents of potential concern (COPC) in the waste, describes the effects of waste retrieval and closure on long-term human health risk, presents expected cumulative health effects of source terms, relates calculated risk to residual waste volume, and summarizes overall conclusions of the risk assessment.
- **Section 9**, *Additional Retrieval Technologies*, identifies other technologies considered for retrieving waste from SST C-103. This section describes available and future technologies and alternative waste retrieval scenarios, evaluates alternative methods, and assesses the utility of deploying additional technologies in SST C-103.
- **Section 10**, *Recommendations for Further Actions*, discusses recommendations for future actions associated with SST C-103 and opportunities to refine future waste retrieval operations at other tanks based on lessons learned.
- **Section 11**, *References*, contains references for material cited in the report.

Table 1-2. Crosswalk of HFFACO Appendix I, Section 2.1.7, Requirements and Corresponding Retrieval Data Report Sections.

Section 2.1.7 Requirements	RDR Section
Residual tank waste volume measurement, including associated calculations	6.0
Residual tank waste characterization data and results	7.0
Retrieval technology performance documentation	3.0, 5.0
An updated post-retrieval risk assessment	8.0
Discussion of feasibility and viability of other available retrieval technologies, the feasibility of developing additional retrieval technologies, associated detailed cost estimates, and amount of additional waste that could be removed	9.0
Opportunities and actions being taken to refine or develop tank waste retrieval technologies based on lessons learned	10.0
Leak detection monitoring, and mitigation and performance results	4.0
DOE's recommendations for further action and proposed schedules	10.0

2.0 RETRIEVAL SYSTEM DESCRIPTION

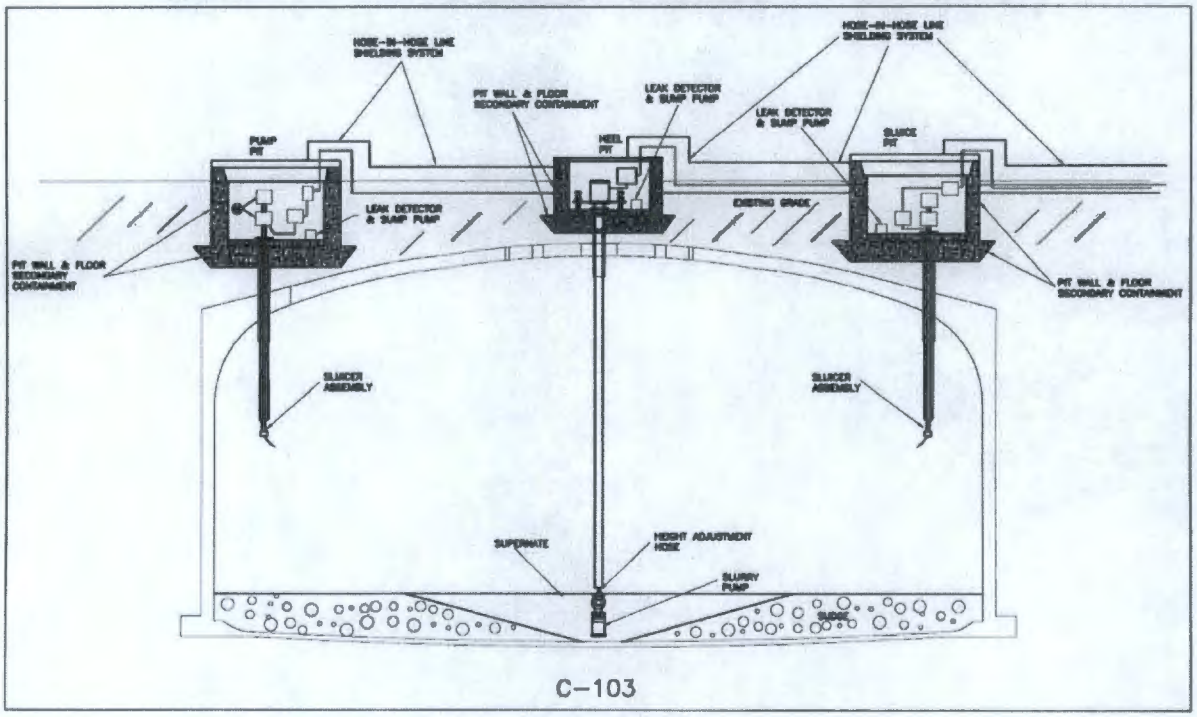
2.1 BASIS

The SST C-103 retrieval system was designed and constructed in accordance with RPP-21895, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan.* The system was operated in accordance with RPP-PLAN-25193, *Process Control Plan for Tank 241-C-103 Waste Retrieval.*

2.2 OVERVIEW

The waste retrieval method for SST C-103 was modified sluicing, a process by which the waste is sprayed with a liquid medium, such that it erodes and flows toward the pump inlet, where it is pumped out to a DST. The retrieval method is "modified" sluicing because the primary liquid medium is recycled DST supernate, not water. The retrieval system is shown in Figure 2-1.

Figure 2-1. SST C-103 Modified Sluicing Waste Retrieval System.



2.2.1 Liquid Medium Distribution System

Liquid medium was introduced to the tank through two sluicing jets. The primary liquid medium was recycled DST supernatant to minimize the overall volume of waste generated during the waste retrieval process. Raw water was also introduced, in minimal quantities, for waste conveyance and transfer line flushing through the supernatant line in the portable valve pit to the

sluicing jets. The sluicing jets have nozzles that can be remotely adjusted to direct the liquid stream. This broke down the sludge through physical erosion of the waste as well as provided a means for mobilization of the waste particulate toward the transfer pump.

2.2.2 Waste Removal System

The waste removal system was designed for the supernatant to pool in the center of the tank where it can be pumped via a hose-in-hose transfer line (HIHTL) to the DST. The pump had a capacity of approximately 100 gpm. Pump operation was integrated with liquid addition to manage the liquid level in the tank. The pump was operated at a similar rate to liquid addition to maintain a consistent liquid level. The pump was located as close to the tank bottom as possible to maximize retrieval recovery.

2.3 RETRIEVAL SYSTEM INSTRUMENTATION

Material balance calculations were used to measure system performance, retrieval progress, leak detection monitoring, and final waste inventories. Data for these calculations are obtained from various instruments and include liquid flow rates and durations, transferred slurry flow rate, video (for pool and waste volume estimation), and liquid levels in the DST.

Supernatant use was measured and recorded using a flow meter installed on the supernatant line. Raw water was added to the supernatant line in the portable valve pit and was measured by a flow meter and flow totalizer. Slurry volumetric flow rates were measured using a flow meter. Video recording through closed-circuit television (CCTV) was viewed by operators and process engineers for qualitative volume estimates in the tank. When retrieval was completed, a video was used to generate three-dimensional (3-D) images of the contents remaining in the tank. The residual waste volume was calculated using computer-aided as-built drawings of the tank and the final configuration of the waste.

Liquid levels were measured in the DST using an ENRAF gauge. The gauge functioned like a bob on a string, sensing liquid level changes through buoyancy. This instrumentation has a high degree of resolution and repeatability, is well-suited for the volumetric method in tanks with a measurable air-liquid interface, and is used throughout tank farms.

2.4 ENVIRONMENTAL CONTROLS

DE05NWP-002, *Approval of Criteria and Toxics Air Emissions Notice of Construction (NOC) Application for Operations of Waste Retrieval Systems in Single-Shell Tank (SST) Farms as supplemented with C Farm Exhauster Operations*; AIR 05-407, *Radioactive Air Emissions Notice of Construction for Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II – Waste Retrieval Operations*; and RPP-21895 impose a variety of environmental controls. Application of these controls during SST C-103 waste retrieval operations is summarized in Sections 2.4.1 through 2.4.5.

2.4.1 Exhauster Operation

SST C-103 headspace was ventilated with a portable exhauster whenever the transfer pump was operated. Active ventilation was required by AIR 05-407 and helped to reduce the headspace humidity, prevent or reduce fog formation, and reduce the headspace concentration of flammable gas. The DST headspace was operated under negative pressure using the AN-Farm exhauster.

2.4.2 Corrosion Mitigation

As specified in RPP-RPT-25160, *Waste Compatibility Assessment of Tank 241-C-103 Waste with Tank 241-AN-106 Waste and Tank 241-AN-106 Waste with Tank 241-C-103 Waste*, the waste in DST AN-106 has adequate hydroxide and nitrite to ensure the tank will remain in specification for corrosion chemistry throughout waste retrieval.

2.4.3 Leak Detection Monitoring and Mitigation

The waste retrieval operating strategy incorporated the philosophy of minimizing liquid available for leakage from the onset of retrieval. This was accomplished by the following:

a. Maintaining a benchmark waste level.
b. Removing liquid inventory between waste retrieval campaigns.
c. Using a video camera to monitor liquid levels inside the tank during retrieval.
d. Minimizing the presence of liquid pools to the extent practical.

The leak detection and monitoring techniques used are discussed in Section 4.0.

2.4.4 Walkdown of Aboveground Portions of the Tank System

The aboveground portions of the tank system were visually inspected daily to identify any abnormalities in the equipment or processes that could lead to releases to the environment.

2.4.5 Secondary Containment

Leakage from the primary HIHTL (inner hose) would be contained by the secondary confinement system (outer hose) and could be detected by leak detectors, material balance data, or radiological surveys. The secondary confinement system was designed to drain any fluid released from the primary hose to a common point for collection, detection, and removal.

2.5 WASTE RETRIEVAL CAMPAIGN CHRONOLOGY

Table 2-1 provides a chronological summary of the SST C-103 waste retrieval campaign.

Table 2-1. Chronology of the Single-Shell Tank C-103 Waste Retrieval Campaign.

Date	Description
November 6-8, 2005	Completed the first 3 days of sluicing operation with recycled supernatant. Estimated starting waste volume is 77,800 gal. An estimated 5.7% of the starting waste volume was retrieved.
December 1-2, 2005	Completed 2 days sluicing before the slurry pump in C-103 failed. An estimated 12.6% of the waste has been retrieved.
February 27, 2006	Completed slurry pump replacement and restarted sluicing.
February 27- March 17, 2006	Completed 13 more days of sluicing. An estimated 65.6% of the waste has been retrieved.
February 28- March 1, 2006	Retrieval stopped due to electrical problems with the motor-operated valve.
March 3-6, 2006	Power tripped at control panel. Restarted on swing shift after completion of electrical troubleshooting.
March 17, 2006	Camera has progressively poorer performance. Camera would not zoom and very poor visibility through dirty lens.
March 17-19, 2006	The exhauster setpoints were changed for operation with reduced waste levels.
April 6- May 10, 2006	Completed 20 more days of sluicing. An estimated 94.2% of the waste has been retrieved. Sluicer 2 failed on May 4, 2006, and retrieval continued with only one sluicer.
June 7, 2006	Completed sluicer replacement and restarted sluicing. Camera repairs and other maintenance were completed as well.
June 7-11, 2006	Completed 5 more days of sluicing. An estimated 94.9% of the waste has been retrieved.
June 22-30, 2006	Completed 7 more days of sluicing. An estimated 95.1% of the waste has been removed.
July 21- August 26, 2006	Completed three rinses. Reconfigured risers to allow sampling of final rinse before transfer to DST AN-106. An estimated 95.7% of the waste has been retrieved.

3.0 RETRIEVAL SYSTEM PERFORMANCE

This section discusses the SST C-103 waste retrieval system (WRS) performance in terms of residual waste, retrieval duration, and water use. In addition, this section compares the achieved waste retrieval results against predicted performance. Retrieval and performance data are included in this section.

The SST C-103 WRS was operated 54 days over a 290-calendar-day period and recovered 74,460 gal of waste based on material balance. The waste was retrieved at varying rates (0 gal to 10,000 gal of SST C-103 waste per day).

3.1 WASTE RETRIEVAL PROCESS DESCRIPTION

The WRS described in Section 2.0 (Figure 2-1) was designed to mobilize and retrieve sludge waste in SST C-103 and transfer it to a receiver DST in the AN tank farm. Supernate from the DST was used to break up and mobilize the waste and was recycled continuously. The volume of supernatant transferred to SST C-103 was continuously balanced by the volume pumped out of SST C-103. The flow rate of the recycled supernatant was roughly the same as the flow rate of the slurry pumped to the DST. The supernatant was directed toward the SST C-103 waste using sluicers, eroding and moving the waste to retrieve as much pumpable material as possible. In accordance with the Tank Waste Retrieval Work Plan (TWRWP), at the end of retrieval, water was used to rinse the waste of any residual DST supernatant.

3.2 RETRIEVAL SYSTEM PERFORMANCE

The performance of the WRS was monitored throughout the campaign using various indicators. Water meters and level indicators were used to determine trends in water use and waste retrieval. Material balance was used during waste retrieval operations to (1) estimate the waste removed from the tank per operating day, (2) determine retrieval efficiency, and (3) determine trends in retrieval performance.

The material balance was calculated as the difference between the measured volume that was added to the system (recycled supernatant and water) and the measured volume removed from the system (tank waste and supernatant). At the end of each day, the liquid level change in DST AN-106 was recorded to determine the volume of waste transferred from SST C-103 to DST AN-106. Water meter readings were also recorded daily to determine the volume of water that was added to SST C-103. There is uncertainty related to these volume measurements as well as to the initial SST C-103 waste volume. A detailed discussion of uncertainties and of the material balance is found in RPP-CALC-32136, *Leak Detection Monitoring Calculation for Single-Shell Tank 241-C-103*.

The material balance calculation was performed every operating day to determine the volume of waste retrieved from SST C-103. An operating day is defined as a day in which retrieval activities were performed, regardless of number of hours operated or volume of waste transferred.

The ENRAF gauge measurement in DST AN-106 provided daily values for liquid level. The difference between the measurements at the beginning and end of an operating day is normally used to determine the volume of waste and water transferred from SST C-103 each day (Table 3-1). Because of the concurrent retrieval of SST C-201, which was also using DST AN-106 as its receiver tank, the DST liquid level change incorporated the additional SST C-201 waste. To determine the volume of waste retrieved from SST C-103 on two occasions (March 9 and March 13, 2006), the waste retrieved from SST C-203 had to be subtracted from the total.

Table 3-1. Daily Volume Calculation Data. (2 sheets)

Date	Operating Day	Volume Water (gal)	Change in AN-106 Volume (gal)	Volume Retrieved[a,b] (gal)	Cumulative volume retrieved (gal)	C-103 Ending Volume (gal)	Cumulative Percent Retrieved	Retrieval Rate (gal retrieved/ gal transferred)
11/6/2005	1	2,011	3,768	1,757	1,757	76,044	2.3%	0.035
11/7/2005	2	1,087	522	-565	1,192	76,608	1.5%	0.000
11/8/2005	3	0	3,218	3,218	4,410	73,390	5.7%	0.078
12/1/2005	4	0	3,410	3,410	7,820	69,980	10.0%	0.097
12/2/2005	5	0	1,953	1,953	9,772	68,028	12.6%	0.122
2/27/2006	6	2,123	4,152	2,030	11,802	65,998	15.2%	0.054
2/28/2006	7	0	-1,788	-1,788	10,014	67,786	12.9%	0.000
3/2/2006	8	458	10,285	9,827	19,841	57,959	25.5%	0.197
3/3/2006	9	0	2,585	2,585	22,426	55,374	28.8%	0.070
3/6/2006	10	0	6,490	6,490	28,916	48,884	37.2%	0.418
3/7/2006	11	0	3,905	3,905	32,821	44,979	42.2%	0.101
3/8/2006	12	0	1,210	1,210	34,031	43,769	43.7%	0.078
3/9/2006	13	0	4,318	3,396	37,427	40,373	48.1%	0.069
3/10/2006	14	0	1,732	1,732	39,159	38,641	50.3%	0.030
3/13/2006	15	0	1,210	1,210	40,369	37,431	51.9%	0.022
3/15/2006	16	0	3,382	3,382	43,752	34,048	56.2%	0.216
3/16/2006	17	0	4,675	3,765	47,517	30,283	61.1%	0.080
3/17/2006	18	0	3,520	3,520	51,037	26,763	65.6%	0.098
4/6/2006	19	4	5,005	5,001	56,038	21,762	72.0%	0.310
4/7/2006	20	0	3,025	3,025	59,063	18,737	75.9%	0.058
4/10/2006	21	0	3,190	3,190	62,253	15,547	80.0%	0.106
4/11/2006	22	0	5,885	5,885	68,138	9,662	87.6%	0.110
4/12/2006	23	0	2,365	2,365	70,503	7,297	90.6%	0.048
4/17/2006	24	0	-605	-605	69,898	7,902	89.8%	0.000
4/18/2006	25	0	-1,128	-1,128	68,770	9,030	88.4%	0.000
4/19/2006	26	0	1,870	1,870	70,640	7,160	90.8%	0.008
4/20/2006	27	0	1,320	1,320	71,960	5,840	92.5%	0.034
4/21/2006	28	0	853	853	72,813	4,987	93.6%	0.013
4/24/2006	29	0	247	247	73,060	4,740	93.9%	0.004
4/25/2006	30	0	440	440	73,500	4,300	94.5%	0.007
4/26/2006	31	0	-1,072	-1,072	72,428	5,372	93.1%	0.000
4/27/2006	32	0	907	907	73,335	4,465	94.3%	0.000
4/28/2006	33	0	192	192	73,528	4,272	94.5%	0.074
5/2/2006	34	0	-660	-660	72,868	4,932	93.7%	0.000

Table 3-1. Daily Volume Calculation Data. (2 sheets)

Date	Operating Day	Volume Water (gal)	Change in AN-106 Volume (gal)	Volume Retrieved[a,b] (gal)	Cumulative volume retrieved (gal)	C-103 Ending Volume (gal)	Cumulative Percent Retrieved	Retrieval Rate (gal retrieved/ gal transferred)
5/3/2006	35	0	688	688	73,555	4,245	94.5%	0.001
5/4/2006	36	0	0	0	73,555	4,245	94.5%	0.000
5/8/2006	37	0	-165	-165	73,390	4,410	94.3%	0.000
5/10/2006	38	0	-110	-110	73,280	4,520	94.2%	0.000
6/7/2006	39	10,435	8,992	-1,442	71,838	5,962	92.3%	0.000
6/8/2006	40	0	770	770	72,608	5,192	93.3%	0.000
6/9/2006	41	0	-358	-358	72,251	5,549	92.9%	0.000
6/10/2006	42	0	248	248	72,498	5,302	93.2%	0.000
6/11/2006	43	0	1,348	1,348	73,846	3,954	94.9%	0.003
6/22/2006	44	0	-1,072	-1,072	72,773	5,027	93.5%	0.000
6/23/2006	45	0	1,128	1,128	73,901	3,899	95.0%	0.001
6/26/2006	46	0	-3,768	-3,768	70,133	7,667	90.1%	0.000
6/27/2006	47	0	3,328	3,328	73,461	4,339	94.4%	0.000
6/28/2006	48	0	-1,458	-1,458	72,003	5,797	92.5%	0.000
6/29/2006	49	0	1,925	1,925	73,928	3,872	95.0%	0.000
6/30/2006	50	0	55	55	73,983	3,817	95.1%	0.000
7/21/2006	51	11,593	11,578	-15	73,968	3,832	95.1%	0.000
7/25/2006	52	11,665	11,797	132	74,100	3,700	95.2%	0.010
7/26/2006	53	27,003	0	-27,003	47,097	30,703	60.5%	0.000
8/23/2006	54	0	27,363	27,363	74,460	3,340	95.7%	0.013
TOTAL		**66,378**	**142,670**	**74,460**				

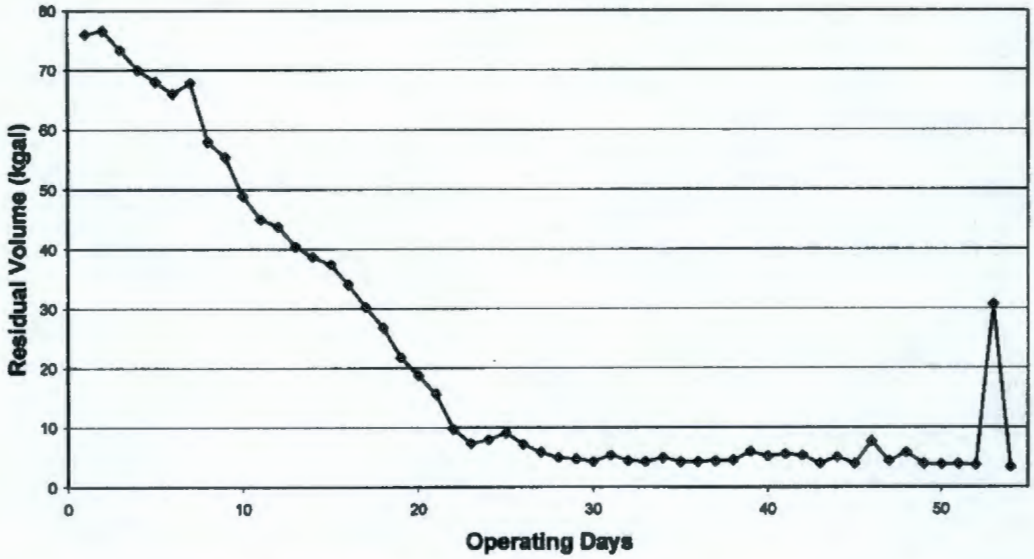
[a] Volume retrieved measured by change in DST AN-106 volume minus water additions, minus additions from SST C-201on 3/9/906 and 3/16/06.

[b] Negative values of waste retrieved result from the removal of more DST supernatant from the DST than slurry transferred back to the DST. The negative value on 7/26/06 was due to water addition for the final rinse and liquid sampling. The liquid remained in the tank due to operational and technical delays.

Figure 3-1 illustrates the SST C-103 retrieval system performance trend based on the data presented in Table 3-1 in terms of volume of waste remaining per operating day based on the assumed starting volume. The figure shows a gradual decrease in the volume of waste retrieved and that less than 1,000 gal of waste were retrieved during the last 11 operating days.

The final rinses noted on days 51, 52, and 53 served to rinse any residual DST supernatant from SST C-103. The final rinse required that the liquid pool be deep enough for liquid grab sampling to determine the residual waste inventory. During the time after the final rinse had been added, there were some delays in pumping the waste out of the tank. Delays occurred due to limited available risers to deploy the necessary equipment (sampling platform, camera, and ENRAF gauge) without removing installed equipment to make risers available for sampling, observation, and measurement. Additionally, the delays included modification and review of documents to pump the waste to an absolute minimum heel and to blow out the transfer lines following the final transfer. The volume of waste removed from the tank after this delay was slightly greater than what had been added, indicating that the added liquid and some tank waste had been effectively removed without any leak loss. The solids mounds were flattened to the extent possible, using liquid spray, to minimize the size and depth of the liquid pool.

Figure 3-1. Residual Waste in Single-Shell Tank C-103 According to Material Balance.



Note: The increase on Day 53 is due to the final water rinse of the residual waste. It was not pumped out immediately so that the liquid could be sampled, and there were operational and technical delays.

The final waste remaining in SST C-103 was calculated through camera/computer-aided design modeling system (CCMS) and topographical mapping measurements as described in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives* (DQO), for determining the final waste volume. The final volume determined by this method was 2,531 gal (338 ft^3) of waste in SST C-103. Further discussion of the residual waste volume measurement is presented in Section 6.0.

Pre-retrieval goals for the waste retrieval system performance were provided in various planning documents. The key performance measures used to evaluate the actual system performance following the campaign are described in Table 3-2.

3.2.1 Water Use

Before retrieval began, the projected water use was estimated to be 105,000 gal based on RPP-RPT-25160. The waste retrieval campaign used an estimated 66,378 gal of water.

Double-shell tank AN-106 supernatant was used to break up and mobilize solid waste in SST C-103. Use of supernatant allowed water additions to be minimized to the extent possible. Water additions were made for flushes, leak checks, equipment checks, and final rinses. Most water additions did not total more than 2,000 gal. In the final stages of retrieval, water additions consisting of 10,000 to 30,000 gal were to rinse any DST supernatant from the residual SST C-103 waste (Figure 3-2).

Table 3-2. System Performance Summary.

Measurement	Estimated Prior to Retrieval Start	Actual	Achieved Expectations?
Remaining tank waste residues volume (ft^3)	<360[a]	338[b]	Yes
Retrieval time (days)	78	54	Yes
Retrieval rate (gal of waste per gallon of slurry)	0.022[c]	0.031[d]	Yes
Total water use (gal)	105,000[e]	66,378	Yes

[a] Defined by the HFFACO as "retrieval of as much waste as technically possible, with tank residues not to exceed 360 ft^3 in each of the 100-series tanks,... or the limit of waste retrieval technology capability, whichever is less."

[b] Remaining tank waste residues volume reported in RPP-31159, *Post-Retrieval Waste Volume Determination for Single-Shell Tank 241-C-103.*

[c] This is calculated using the predicted volume of waste retrieved (71,598 gal) divided by the predicted volume of slurry transferred (3,241,008 gal), as follows:

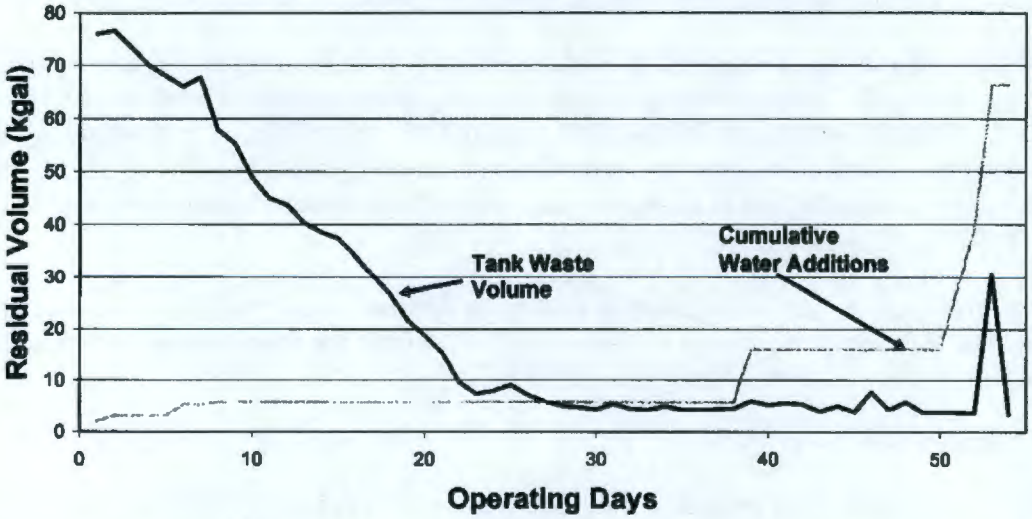
Volume of waste retrieved from SST (71,598 gal) ÷ Total slurry transferred (3,241,008 gal) = 0.022.

[d] Retrieval rate was calculated using the volume retrieved from SST C-103 by material balance (74,460 gal) and the total volume of slurry transferred (2,398,511 gal), as follows:

Volume of waste retrieved from SST C-103 by material balance (74,460 gal) ÷ Total slurry transferred (2,398,511 gal) = 0.031.

[e] Estimated water use for the SST C-103 campaign was 105,000 based on RPP-RPT-25160, *Waste Compatibility Assessment of Tank 241-C-103 Waste with Tank 241-AN-106 Waste and Tank 241-AN-106 Waste with Tank 241-C-103 Waste.*

Figure 3-2. Water Additions During Single-Shell Tank C-103 Retrieval.

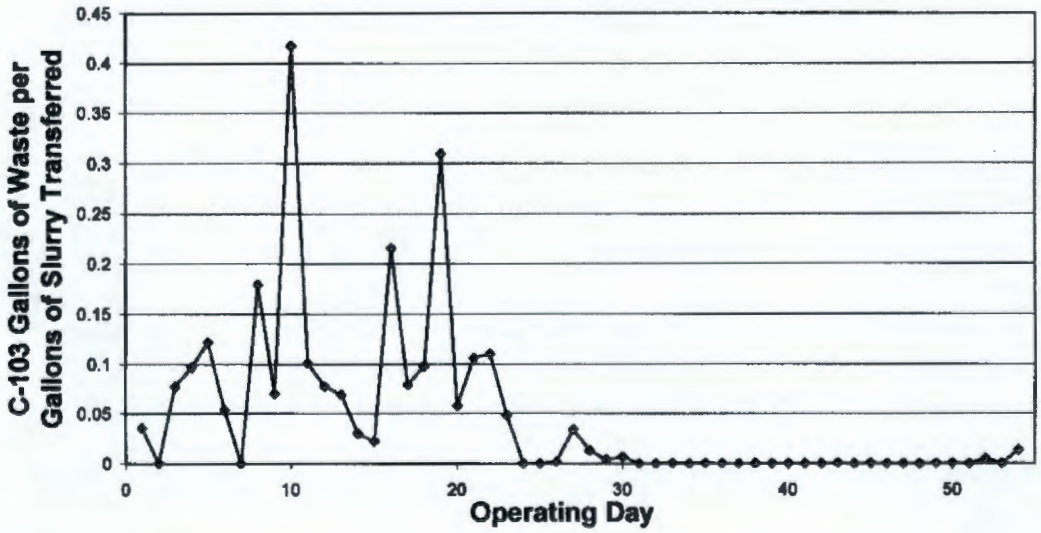


Double-shell tank supernatant was transferred from DST AN-106 to SST C-103 as the sluicing medium to break up and mobilize waste for transfer back to the DST. Although large volumes of supernatant were used daily, the cumulative volume in the tank was kept at a minimum. The pump-out of SST C-103 was operated at approximately the same rate that the sluicers added DST supernatant, maintaining a constant minimum level of fluid in the tank during retrieval. An average day of retrieval consisted of using about 43,000 gal of supernatant to sluice the SST C-103 waste. The total volume of DST supernatant recycled between SST C-103 and DST AN-106 was 2,330,258 gal.

3.2.2 Waste Retrieval Rate

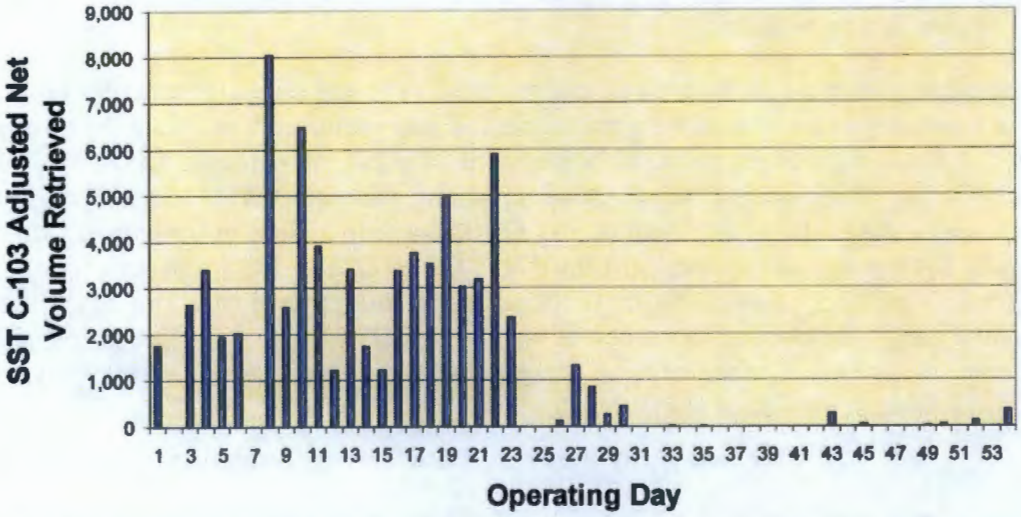
The preliminary estimate of the retrieval rate for the SST C-103 campaign was developed using predicted volumes of waste and slurry transferred. It was estimated that during the course of retrieval, 3,241,008 gal of slurry would be transferred to DST AN-106 and that 71,598 gal of that would be SST C-103 waste. Although the retrieval rate was expected to change throughout retrieval, an average ratio of 0.022 gal of SST C-103 waste to gallons of transferred slurry was estimated. On average, the system performed at 0.031 gal SST C-103 waste per gallon of slurry transferred (Figure 3-3), about 40% above the estimated pre-retrieval rate. During the first 23 operating days, the average retrieval rate was 0.11 gal SST C-103 waste per gallon of slurry transferred. After day 23, when retrieval slowed, the average retrieval rate was 0.006 gal SST C-103 waste per gallon of slurry transferred.

Figure 3-3. Daily Retrieval Rate During Campaign.



The waste retrieval rate generally met or exceeded expectations until day 24 of the campaign. After day 24, retrieval results diminished, showing little daily progress. Only 4,000 gal of SST C-103 waste were retrieved in the last 30 days of retrieval. To present the daily waste retrieved as positive values, the daily volume of waste retrieved was adjusted to take into account days when less slurry was transferred to the DST than supernate was used to sluice (Figure 3-4). Days that are shown in Table 3-1 as negative values have been given a value of zero waste retrieved. The waste deficit was subtracted from subsequent positive days to reflect positive waste retrieval throughout the retrieval campaign. For example, days 24 and 25 were given a zero value, and their volume deficit of 1,733 gal was subtracted from the volume retrieved on day 26 (1,870 gal) to arrive at a net adjusted volume retrieved on day 26 of 137 gal.

Figure 3-4. Daily Adjusted Waste Retrieval During Campaign.



Note: Sporadic values equal to zero indicate that a net positive retrieval of waste did not occur on that day.

3.2.3 Retrieval Time

The pre-retrieval estimate of 78 days was based on the estimated retrieval rate of 0.022 gal SST C-103 waste per gallon of slurry and the expected slurry used per shift (Figure 3-5). The pre-retrieval estimate of 78 days provided sufficient time to retrieve SST C-103 to the limits of the technology selected. Early in retrieval, progress was better than expected. After day 24, when the retrieval rate decreased, the limits of the technology were being approached. It was determined after little progress was made that the limits had been reached, and retrieval was allowed to cease before the estimated time frame had expired.

The total duration of the retrieval was 290 calendar days. There were four major delays during the retrieval. The first delay was 23 days due to the operating crew being assigned to retrieval in S Farm. The second delay was due to the failed slurry pump replacement and lasted 87 days. The next major delay lasted 28 days during replacement of a sluicer. The final delay also lasted 28 days due to sampling and various technical and operations difficulties.

Figure 3-5. Operating Days to Retrieve Single-Shell Tank S-103.

3.3 REQUIREMENTS FOR USE OF SST AN-016 SUPERNATE

RPP-21895, Section 3.2, requires two conditions for the use of supernate recycle during the retrieval of the waste in SST C-103 related to submittal of this RDR. The relevant discussion for each condition is presented in the following.

Condition 2 reiterates the requirement for submittal of an RDR and states:

> *This report shall include a review of the efficiency and performance of the in-tank settling of the retrieved solids in the receiving DST, an estimate of the amount of solids that were recycled during retrieval of C-103 and C-109, and the impacts these solids have on removing additional solids from C-103 and C-109.*

The efficiency and performance of the in-tank settling was acceptable. No solids measurement equipment was installed on the supernate stream from DST AN-106 to SST C-103, so the concentration of solids in the supernate stream from DST AN-106, if any, is unknown. The presence of any solids did not impact the retrieval of waste from SST C-103 since the waste in the tank was readily removed until little was left in the tank.

Samples were taken from DST AN-106 on April 30, 2006 in accordance with RPP-PLAN-28778, *Corrosion Mitigation and Compatibility 2006 Grab Sampling and Analysis Plan*. The last retrieval activities before this date occurred on April 28, 2006. Therefore, waste in the tank had approximately 2 days to settle prior to being sampled. Figure 3-6 shows the layout of the tank and its equipment, the supernate and sludge levels, and the sampling points. Table 3-3 gives the measured depths of the points of interest from Figure 3-6 at the time of sampling. Figure 3-7 shows a plan view of DST AN-106 riser locations. There were five liquid samples taken at various depths. According to RPP-RPT-29777, *Final Report for Tank 241-AN-106 Grab Samples in Support of Corrosion Mitigation and Compatibility Programs*,

four of these samples showed zero settled solids. The sample taken closest to the sludge level (5) showed a trace of settled solids with the quantity reported as <2 vol%. Thus 2 days was adequate to settle solids in AN-106.

Figure 3-6. Double-Shell Tank AN-106 Equipment and Sampling Layout.

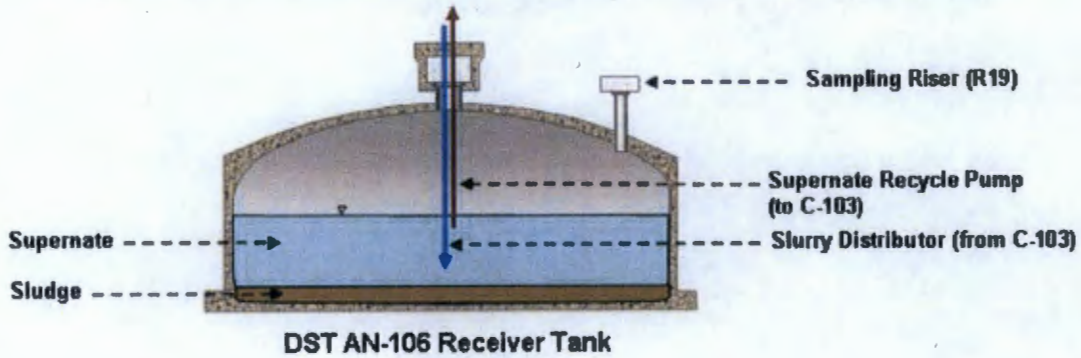


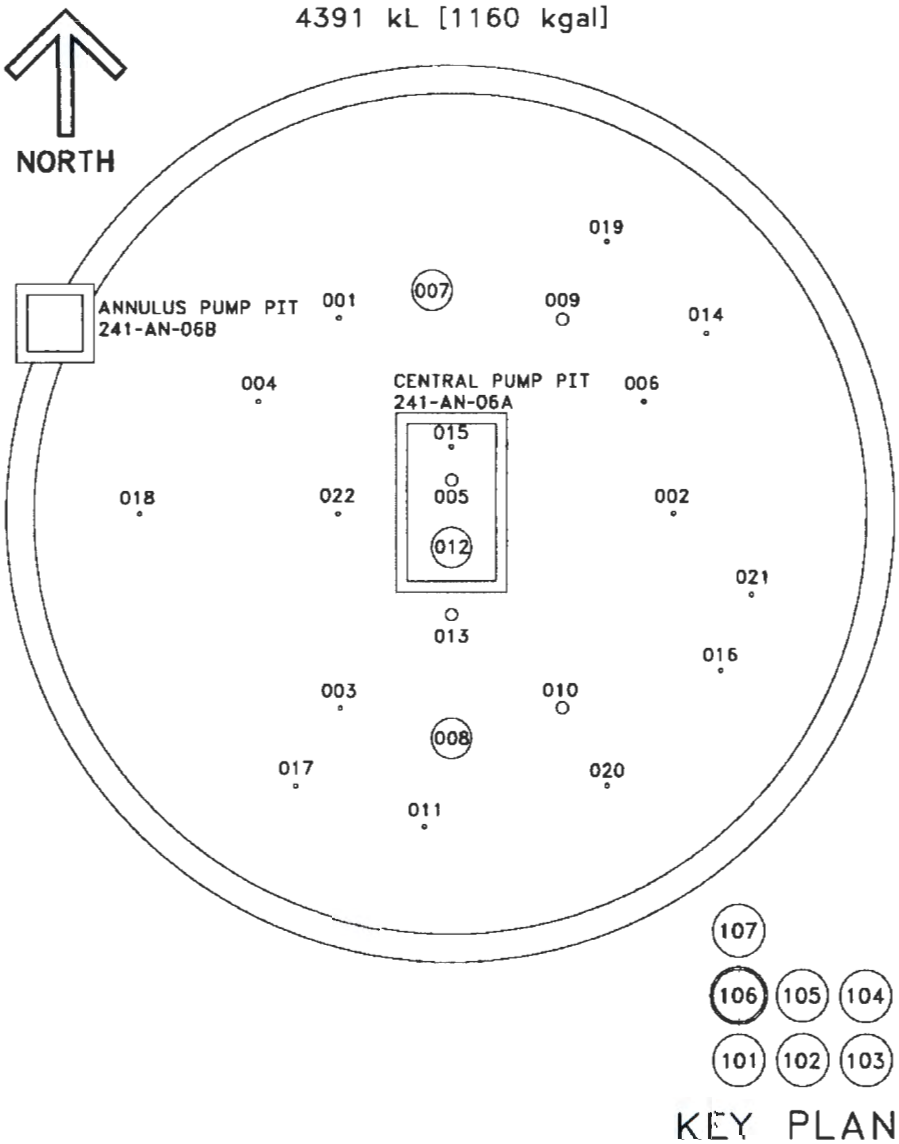
Table 3-3. Double-Shell Tank AN-106 Equipment and Sampling Locations.

Item	Height in DST AN-106 (in.)
Supernate level	300.86
Pump inlet (to SST C-103)	221
Slurry distributor (from SST C-103)	150
Sludge level	54
Liquid grab sample 1	300
Liquid grab sample 2	288
Liquid grab sample 3	228
Liquid grab sample 4	144
Liquid grab sample 5	61

Any solids which would not settle out in 48 hr in DST AN-106 would not settle out in SST C-103 with the minimum liquid level and residence time maintained there and the agitation provided during retrieval operations.

Thus, there was likely little recycle of any solids from DST AN-106 to SST C-103, and there was no impact on SST C-103 retrieval by any solids that may have been recycled from DST AN-106.

Figure 3-7. Plan View of Double-Shell Tank AN-106 Riser Locations.



Condition 3 states:

> *A chemical analysis of the Tc-99 in the supernatant of the receiving doubleshelled tank (currently AN-106) shall be obtained for DST samples taken during the retrieval process. This value shall be reported in the Retrieval Data Report, and compared with (a) the currently estimated BBI concentration, and (b) estimated flowsheet changes in the supernate Tc-99 concentration.*

The SST C-103 receiving tank supernate was sampled in DST AN-106 on April 30, 2006, during retrieval. Analytical results are reported in RPP-RPT-29777. The analytical result for ^{99}Tc of 0.0279 μCi/ml is consistent with the best-basis inventory (BBI) value of 0.0288 μCi/ml and the concentrations predicted in the flowsheet, RPP-21753, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, of 0.0302 μCi/ml concentration prior to sluicing. The flowsheet predicted that ^{99}Tc concentrations would decrease during the course of the retrieval because dilution from water additions and flushes would overcome any additional ^{99}Tc dissolved from the SST C-103 sludge. The value in the flow sheet predicted for the concentration after retrieval including flushes is 0.0267 μCi/ml. The BBI accounted for waste transfers through April 1, 2006, and assumes that dissolution and/or precipitation of ^{99}Tc is negligible in this matrix. The BBI concentrations are documented by SVF 1146, "Calculate the composition of tank AN-106 after transfers from C-201 and C-103 and tranfer [*sic*] to AW-106."

3.4 CONCLUSION

Compared to performance goals (Table 3-2), the SST C-103 WRS met all areas of expectations including residual waste remaining in the tank, retrieval time, retrieval rate, and water use.

4.0 LEAK DETECTION, MONITORING, AND MITIGATION

The LDMM program was implemented to protect the workers, public, and environment from leaks of radioactive liquid waste. The LDMM program includes technologies and methods used prior to, during, and after waste retrieval to detect leaks, reduce the potential for a leak to occur, or minimize leak volumes. Additionally, the LDMM program quantifies liquid waste release volumes should a release be detected.

The operational history and decades of waste and liquid level monitoring indicate that SST C-103 has not leaked and was sound before starting retrieval (HNF-EP-0182, *Waste Tank Summary Report for Month Ending May 31, 2006*). Additionally, there was no evidence of a leak during retrieval of waste from SST C-103.

The following sections describe the LDMM requirements, leak detection monitoring implementation, mitigative approach, chronology, and results. The major results for the LDMM program during SST C-103 demonstration are as follows:

a. Drywell moisture, gamma logging, high-resolution resistivity (HRR), and groundwater data showed no evidence of leaks during the SST C-103 waste retrieval.

b. Modified static level monitoring demonstrated no evidence to support leakage during retrieval.

c. Material balance calculations showed no evidence of leaks during the SST C-103 waste retrieval.

4.1 REQUIREMENTS

The leak detection and monitoring (LDM) system incorporating mitigation was established in RPP-21895. Requirements are also contained in the safety basis controls given in HNF-SD-WM-TSR-006, *Technical Safety Requirements for Tank Farms,* specifically Technical Safety Requirement (TSR) Limiting Condition for Operation (LCO) Section 3.1.1, "Transfer Leak Detection Systems." Material balances during transfers are required by the TSR Administrative Control (AC) Section 5.11, "Transfer Control," and RPP-12711, *Temporary Waste Transfer Line Management Program Plan.* The primary procedures governing notification and reporting of leaks are TFC-OPS-OPER-C-24, *Occurrence Reporting and Processing of Operations Information*, and TFC-ESHQ-ENV_FS-C-01, *Environmental Notification.* Table 4-1 presents the SST C-103 leak detection and monitoring functions and requirements.

4.2 LEAK DETECTION AND MONITORING

During retrieval of waste from SST C-103, LDM was accomplished by the use of drywells, visual inspection, leak monitoring, ENRAF gauges in DST AN-106, radiological monitoring, and material balances as shown in Table 4-2 and discussed in Sections 4.2.1 through 4.2.3.

Table 4-1. Single-Shell Tank C-103 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement[a]	Key Elements
Detect leaks during waste removal from SST C-103	The LDM system shall be capable of detecting liquid waste releases during all waste removal operations.	Utilize both in-tank and ex-tank LDM technologies to detect loss of liquid from a tank; see Section 4.0.
Monitor leaks from SST C-103 during waste removal	The WRS shall be capable of providing data to support quantifying leak volumes from the tanks in the event a release is detected during waste retrieval operations.	Utilize both in-tank and ex-tank LDM technologies and operating strategies that will allow estimates of leak volumes and migration rates to be developed in the event of a leak.
Mitigate leaks during SST C-103 waste retrieval	The integrated retrieval and LDM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks during waste retrieval if they occur.	Leak mitigation strategy described in Section 4.3
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features in accordance with 40 CFR 265.193 and DOE O 435.1	Provide for safe and compliant transfer of waste to the receiver DST.

[a] RPP-21895, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan.*
WRS = waste retrieval system

Table 4-2. Leak Detection and Monitoring Methods for Each Waste Retrieval System Component.

Component	LDM Method
SST C-103	Drywells, limited liquid level monitoring, visual inspection, material balance, and HRR monitoring
DST AN-106	Liquid level monitoring,[a] annulus leak detectors, radiation monitoring for annulus exhaust air
Ancillary equipment (HIHTL)	Leak detectors

[a] Except when DST AN-106 was being used concurrently to receive liquid from the SST C-201 retrieval.

The primary method for LDM for SST C-103 involved periodic gamma and neutron moisture surveys of the drywells surrounding the tanks. In-tank process control parameters were used to supplement ex-tank methods to provide a comprehensive approach to leak detection.

4.2.1 Single-Shell Tank C-103

4.2.1.1 Liquid Level Monitoring. The overall waste retrieval operating strategy for SST C-103 was to reduce the tank liquid inventory and minimize liquid additions during waste retrieval operations. Liquid levels were monitored to evaluate liquid inventories and indicate potential leaks in the system to implement this strategy. The ENRAF device installed in SST C-103 did not have a consistent liquid surface to measure and was not relied on for leak detection purposes. See Section 2.3 for a description of how the instrument functions.

4.2.1.2 Visual Inspection. Before initiating waste retrieval operations, a visual assessment and documentation of in-tank conditions in SST C-103 were performed using an in-tank video camera. Throughout waste retrieval, the CCTV system was used to identify the waste surface condition, qualitatively assess the amount of liquid in the tank, observe any significant changes, and implement the mitigation strategy of minimizing liquid pools.

Observations of the waste surface in SST C-103 indicate that the surface level decrease corresponded with waste retrieval activities. No unexplained increases or decreases in the surface level of SST C-103 were observed.

4.2.1.3 Drywell Monitoring. The results from drywell monitoring, a summary and analysis of monitoring including tools used, boreholes logged, depth of logging, frequency, and data analysis are included in RPP-RPT-33433, *Tank 241-C-103 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data.* A summary of this information is included in the following paragraphs.

A means of LDM during retrieval of SST C-103 was to monitor the soil surrounding the tank for gamma radiation and increases in soil moisture content. This was done via the existing drywells in the vicinity of SST C-103. Success of this approach is contingent on the migration of leaked liquids from the leak site to the vicinity of the drywell. The use of the retrieval monitoring system as discussed in RPP-21895 did not occur during the retrieval of SST C-103 due to administrative issues. In place of the retrieval monitoring system, handheld neutron moisture monitoring and Radionuclide Assessment System (RAS) measurements were performed.

There are 70 drywells surrounding the 100-series tanks in C Farm. Figure 4-1 shows the location of the drywells in C Farm. Five of the drywells are within 10 ft of SST C-103 (30-03-01, 30-03-03, 30-03-05, 30-03-07, and 30-03-09). One drywell is located adjacent to SST C-106 to the northwest (30-06-04). A chronology of drywell monitoring is included in Table 4-3.

Drywell logging is performed in accordance with TO-040-350, *Obtain Drywell Data Using Radionuclide Assessment System.* Calibration information for the Radionuclide Assessment System (RAS) and the moisture logging is available in GJO-2004-603-TAC, *Hanford Tank Farms Vadose Zone Monitoring Project, 2002 Recalibration of the Radionuclide Assessment System,* and DOE-EM/GJ1082-2006, *Hanford Geophysical Logging Project, Campbell Pacific Nuclear Moisture Gauge Calibration Certificate,* respectively. Weekly moisture logging was performed during waste retrieval operations. Due to operational constraints, this weekly reading was missed during the week of May 22-May 28, 2006. Ecology was notified of the missed

weekly reading as required by Section 4.2.1.1 of RPP-21895. Drywells will be rebaselined within 6 months of retrieval completion and monitored quarterly for a year to monitor plume activity. The drywell monitoring report, RPP-RPT-33433, was developed to present drywell monitoring results for this RDR. Future monitoring results required by RPP-21895 will be presented in a revision to RPP-RPT-33433.

Figure 4-1. Plan View of C-Farm Tanks and Drywells.

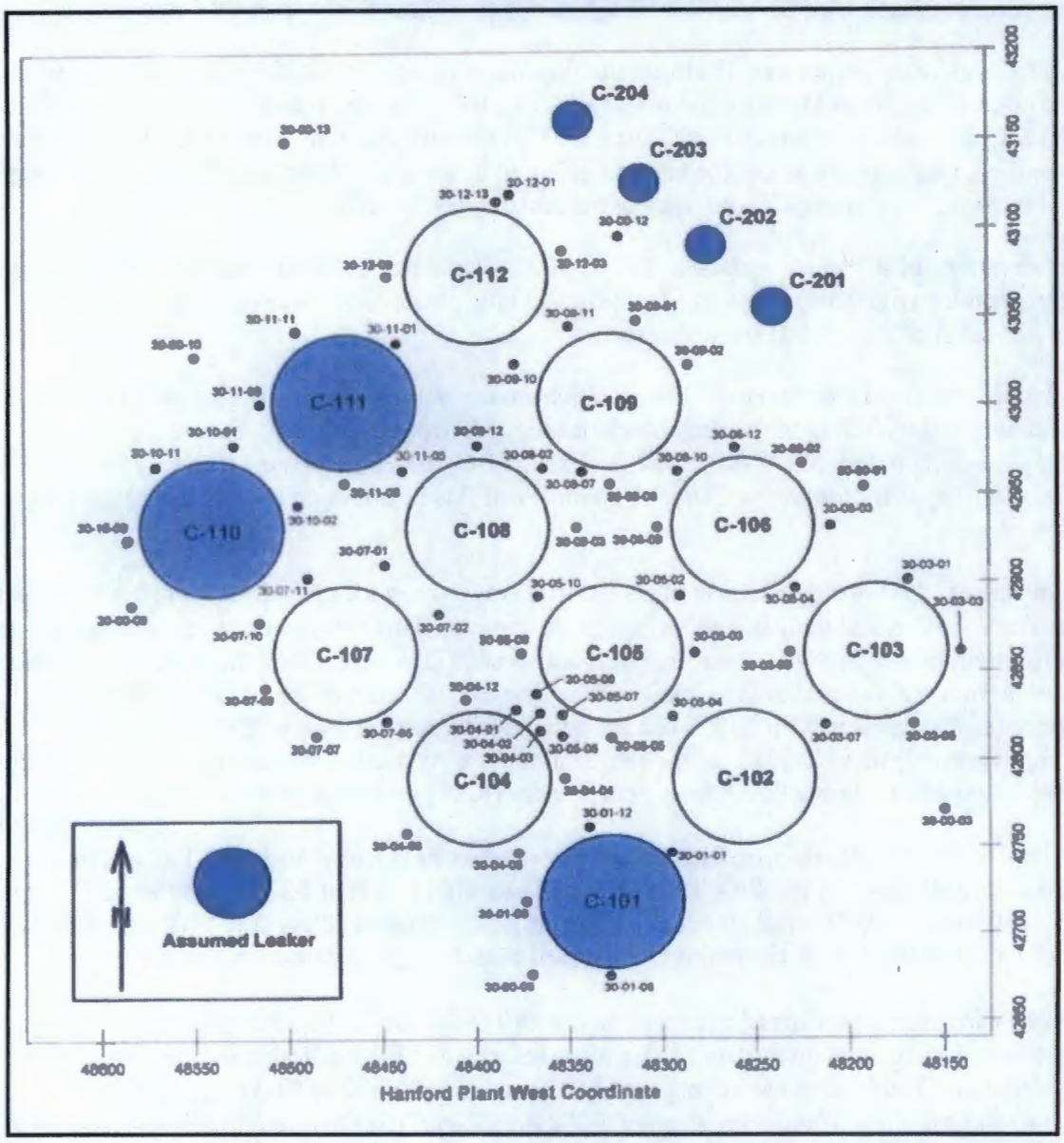


Table 4-3. Drywell Monitoring Chronology.

Date	Item
May 8, 2005	Drywell gamma logging baseline established (Drywell 30-06-04)
September 29, 2005	Drywell gamma logging performed (Drywell 30-03-01)
October 11, 2005	Drywell gamma logging performed (Drywell 30-03-09)
October 13, 2005	Drywell gamma logging performed (Drywell 30-03-07)
October 16, 2005	Drywell gamma logging performed (Drywell 30-03-05 and 30-03-03)
October 18-November 11, 2005	First neutron moisture logs performed
November 5, 2005	C-103 sluicing begins
November 5, 2005-August 23, 2006	Weekly neutron moisture logs continue
May 22-May 28, 2006	High airborne radiation level reading on air sampler prevented drywell gamma logging. Notification provided to Ecology.
August 23, 2006	Last day of C-103 sluicing , weekly neutron moisture logs continue
October 20, 2006	Last weekly neutron moisture log performed
January 10, 2007	Post-retrieval neutron moisture monitoring performed
February 2-February 27, 2007	RAS drywell logging performed (all six drywells)

The baseline leak detection methodology involved deployment of existing geophysical logging systems using both RAS and moisture monitoring tools. These systems were deployed before waste retrieval operations began and at the end of waste retrieval operations. Baseline monitoring uses gamma radiation probes and neutron moisture instruments to establish gamma and moisture profiles of the soil around the drywell, against which future data may be compared.

A baseline profile was taken prior to retrieval operations, and subsequent monitoring results were compared with that baseline profile. Moisture monitoring was done in each well prior to and after retrieval. During waste retrieval operations, manual moisture measurements were made nominally once a week in each well at depths between 32 ft and 47 ft while actively retrieving the waste. In the event of an unexplained increase in soil moisture content, additional monitoring with the RAS system would have been used to determine if there have been any changes in gamma-emitting radionuclide concentrations surrounding the drywells.

During retrieval operations, hand-held neutron moisture logging was conducted weekly. Subsequent to August 23, 2006 (completion of retrieval), logging was conducted once per week for 3 weeks. The available results from hand-held neutron moisture logging did not show indications of significant moisture increase in any of the drywells throughout the retrieval demonstration with the exception of minor moisture increases attributed to seasonal infiltration of rain and snow melt. The results of neutron moisture logging are presented in RPP-RPT-33433. Increased gamma activity was observed in drywell 30-03-05 on February 2, 2007. Subsequent RAS data taken 2 weeks later confirmed the increase. The increase is slight, and if attributed to ^{137}Cs, it would be on the order of 1 pCi/g or less. The spectral gamma logging system will be deployed in 3 to 6 months in this drywell to investigate the cause of the increase. The RAS data is presented in RPP-RPT-33433. Monitoring results related to further investigation of the increased gamma activity will be presented in a revision to RPP-RPT-33433.

4.2.1.4 Groundwater Monitoring. Groundwater monitoring data was collected between November 2005 and December 2006. The data was reviewed with results presented in Table 4-4. Detailed data can be found in the Quarterly Groundwater Monitoring reports and in the Hanford Environmental Information System (HEIS).

Table 4-4 Groundwater Monitoring Results.

Groundwater Well	Results
299-E27-04	No significant changes except nitrite. Nitrite showed a several orders of magnitude increase in the last sample taken when compared to earlier values.
299-E27-07	No significant changes. Many showed a reduction from previous values.
299-E27-12	No significant changes. Technetium-99 showed a moderate increase in the last sample.
299-E27-13	No significant changes. Nitrite showed a moderate increase in the last sample.
299-E27-14	No significant changes except nitrite. Nitrite showed a several orders of magnitude increase in the last sample taken when compared to earlier values.
299-E27-15	No significant changes. Technetium-99, Na, and ^{137}Cs showed a moderate increase.
299-E27-21	No significant changes except nitrite. Nitrite showed a several orders of magnitude increase in the last sample taken when compared to earlier values.
299-E27-22	No significant changes except nitrite. Nitrite showed a several order of magnitude increase in the last sample taken when compared to earlier values.
299-E27-23	No significant changes except nitrite. Nitrite showed a several order of magnitude increase in the last sample taken when compared to earlier values.

High nitrite values for the last quarter are flagged in HEIS and are under review by the analytical laboratory. The high values are inconsistent with other measurements and appear to be an analytical problem. Results of the review will be documented in the Quality Control section of the next Quarterly Groundwater Monitoring Report. Groundwater monitoring will continue as required by RPP-21895.

4.2.1.5 Material Balance. Process control measurements were used periodically to perform a material balance and determine the change in SST C-103 waste inventory. Once determined, the change in waste inventory was recorded and used to monitor retrieval progress. Engineering evaluation of the material balance calculations was performed to identify transfer/receipt discrepancies for indications of a leak.

Material balances were performed for all transfers between tanks. Material balances that were used to account for the water added, the slurry volume, and the volume change in the DST receiver agreed with the allowable material balance discrepancy (MBD) during the transfers. That is, the volume of liquid transferred matched the volume change in the DST receiver.

Material balances are primarily used for process performance measurements (see Section 3.2). However, they also provide useful information for determining gross indications of leaks in the system. The material balance is performed to account for all of the water and waste that moves through the system. An MBD occurs when the amount of material going in and coming out does

not match the change in the system. This calculation is presented in RPP-CALC-32136, *Leak Detection Monitoring Calculation for Single-Shell Tank 241-C-103.* The material balance is calculated using this basic equation:

Material balance discrepancy (MBD) = start volume + additions – removals – ending volume

Waste transfers all have a permissible MBD limit based on variables associated with the transfer. For this set of calculations, the MBD limit is the limit of error associated with all volume measurements or volume estimates associated with the SST C-103 retrieval process over the 42 weeks of the retrieval process. Should the MBD exceed the limit of error, the difference between the MBD and the limit of error can indicate that there is material that is unaccounted for (RPP-21895); therefore

a. If the MBD is negative, all waste is accounted for.
b. If the MBD is positive but ≤limit of error associated with the SST C-103 retrieval volume measurements or volume estimates, all waste is accounted for.
c. If the MBD is positive and >limit of error associated with the SST C-103 retrieval volume measurements or volume estimates, the waste unaccounted for (WUF) = MBD – limit of error.

The limit of error is assumed to be

$$\text{limit of error} = \left(\Sigma\ U_i^2\right)^{1/2}$$

where

U_1 = uncertainty with stream 1, U_2 = uncertainty with stream 2, etc.

The ranges of error provided for each variable (with the exception of the upper range value for the ending waste volume in SST C-103) are not confidence intervals. The square-root-of-the sum-of-the-squares method for estimating the limit of error is based on an assumption of independence between the variables.

The system material balance had an MBD of 15,462 gal, below the uncertainty value of ±18,472 gal. Therefore, the WUF is zero, establishing no evidence of leaking during retrieval. Details of the uncertainty calculations are contained in RPP-CALC-32136.

4.2.1.6 High-Resolution Resistivity. In accordance with RPP-21895, HRR was deployed at C-103 in a demonstration mode. The SST C-103 HRR LDM system was delivered to the Hanford Site on June 1, 2004. Approval to operate the installed HRR LDM control trailer was received on August 8, 2004. The system was operated gathering electrode resistance measurements from September 26, 2005, through October 5, 2006. This operating period spanned the SST C-103 retrieval, which ran from November 6, 2005, through June 30, 2006, and flushing of the heel, which was performed on July 21, July 25, and August 23, 2006.

During the period between September 26, 2005, and October 5, 2006, the system was available for data acquisition 99% of the time. The system acquired resistivity data 94% of the available time with downtime mainly attributed to drywell logging or planned system maintenance. Downtime associated with unplanned maintenance activities and/or equipment failure accounted for 0.15% of the available time. Table 4-5 shows the system operability summary from September 2005 through October 2006.

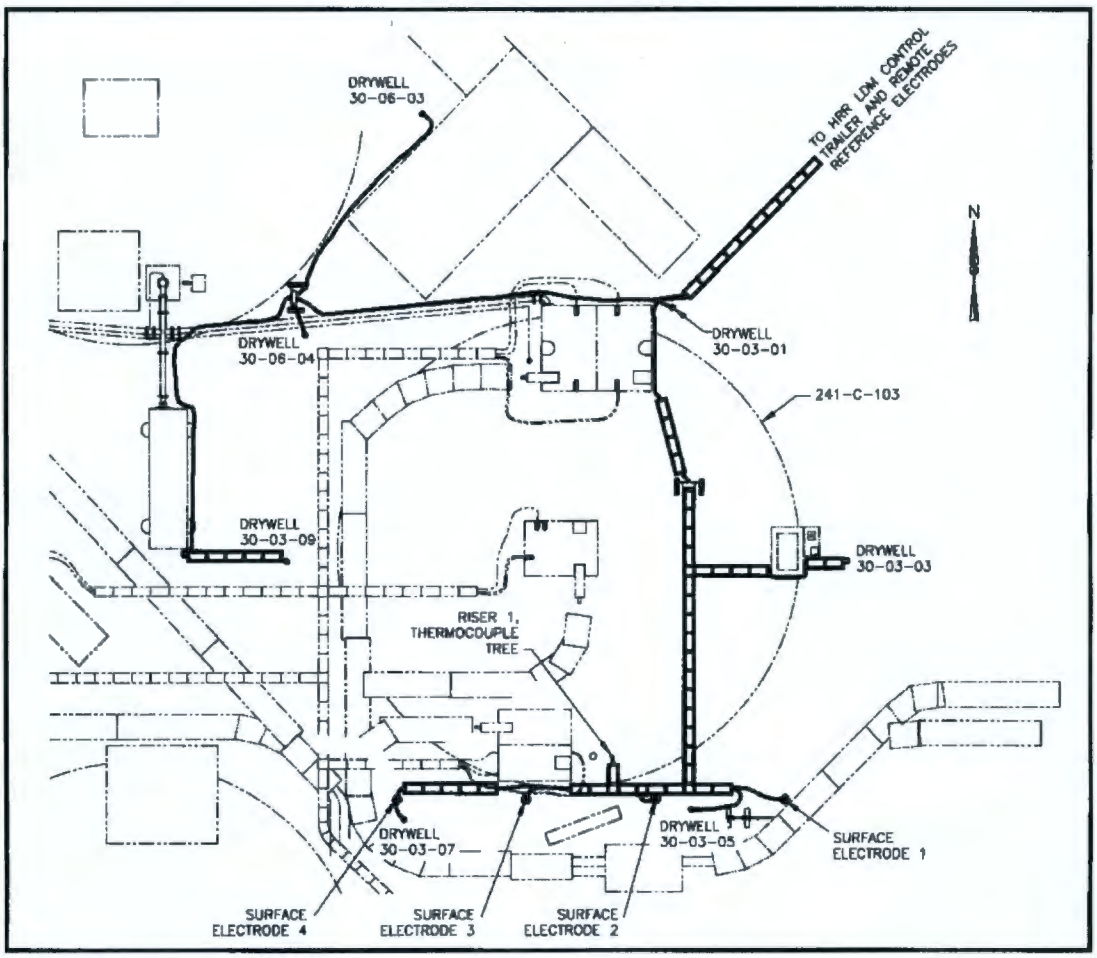
Table 4-5. Operability Summary.

System baseline start	September 26, 2005, 12:00 a.m.
System turned off	October 5, 2006, 2:30 p.m.
C-103 HRR system operation (days)	374.60
System operable	99.25%
System operated	94.35%
System down for unplanned maintenance/equipment failure	0.15%

The basis for the selection of the HRR LDM technology for deployment is contained in RPP-10604, *Ex-Tank LDMM Technology Assessment and Down Select Report.* A general description of the HRR LDM methodology as used at the Hanford Site for LDM is included with the results of the simulated leak test near tank 241-S-102 and is included in RPP-30121, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Testing Report.*

The HRR LDM system at SST C-103 used a four-pole resistivity technique to induce an electric field by applying electrical power to one electrode pair (Tx) and measuring the resultant voltage gradient on another electrode pair (Rx). Of the four poles, one transmitter (Tx remote reference electrode) and one receiver (Rx remote reference electrode) remained constant and were located at effective infinity from the in-farm electrodes. The Tx remote reference electrode was located approximately 1,900 ft west-northwest and the Rx remote reference electrode approximately 1,600 ft north-northeast from the center of SST C-103. The in-farm electrode array included one electrode in direct contact with the tank waste (thermocouple in Riser 1), seven long-length electrodes (drywells), and four surface electrodes. Figure 4-2 illustrates the in-farm electrode deployment configuration around SST C-103. Additional deployment details are documented in H-14-105635, *C-Farm HRR LDM Installation and Interface Details.*

Figure 4-2. Single-Shell Tank C-103 High-Resolution Resistivity Leak Detection and Monitoring Layout.



Three signal anomalies were identified during the deployment at C-103. The anomalies were identified in accordance with RPP-24576, *HRR LDM Data Processing, Assessment, and Reporting Procedure for C-Farm*. The anomalies are summarized in the following.

On March 18 and 19, 2006, magnitude shifts were observed when transmitting on

a. All drywells and receiving on surface electrodes 1, 2, and 3.
b. Drywell 30-03-03 and receiving on drywells 30-03-05 and 30-03-07.
c. Drywell 30-03-05 and receiving on drywells 30-03-03 and 30-03-07.
d. Drywell 30-03-07 and receiving on drywells 30-03-03 and 30-03-05.

On May 18, 2006, magnitude shifts were observed on drywells 30-03-05 and 30-06-03 where they were acting as the receiving electrodes.

On May 28, 2006, a magnitude shift was observed between drywell 30-03-03 and SST C-103.

None of these conditions were consistent with a tank leaking condition and no tank leak assessment evaluations were initiated. Details of the signal anomalies are presented in Table 4-6. More detailed explanations of the signal anomalies can be found in RPP-RPT-31843, *High-Resolution Resistivity Leak Detection and Monitoring Final Report for Single-Shell Tank 241-C-103 Retrieval Campaign.* For all current/future C Farm retrievals, HRR is considered "operational," not "demonstration mode," and therefore is equal with other LDM methods.

Table 4-6. Single-Shell Tank C-103 Potential Condition of Concern Summary.

Date Signal Anomaly Began	Description	Status	Basis
3/18/2006, 3/19/2006	Magnitude shifts on all drywells transmitting to surface electrodes 1, 2, and 3. In addition, magnitude shifts also occurred when transmitting on drywell 30-03-03 and receiving on drywells 30-03-05 and 30-03-07, when transmitting on 30-03-05 and receiving on 30-03-03 and 30-03-07, and transmitting on 30-03-07 and receiving on 30-03-03 and 30-03-05.	No leak	Response was not observed on any well-to-tank measurements. Precipitation events occurred on March 16, 2006 (0.33 in.), and March 17, 2006 (0.01 in). Surface electrodes are historically sensitive to precipitation events. The response for drywells transmitting to surface electrodes 1, 2, and 3 returned to background (previously observed response) on June 13, 2006. The drywell-to-drywell responses returned to background levels within 8 days of the initial magnitude shift. Discussions with CH2M HILL (in accordance with RPP-24576) concluded that the responses were due to the precipitation events.
5/18/2006	Magnitude shift where drywells 30-03-05 and 30-06-03 were acting as the receiving electrode. The response for drywell-to-drywell 30-03-05 and the response for drywell-to-drywell 30-06-03 returned to background on August 11, 2006.	No leak	The response was not observed on any well-to-tank measurements. The drywell-to-wells 30-03-05 and 30-06-03 measurements did not display an equivalent response on the reciprocal measurements (i.e., drywell 30-03-05-to-drywell and drywell 30-06-03-to-drywell, where drywells 30-03-05 and 30-06-03 were the transmitters).
5/28/2006	Magnitude shift on combination of drywell 30-03-03 to SST C-103 thermocouple tree. The response for drywell 30-03-03-to-SST C-103 returned to background on June 26, 2006.	No leak	The response was only observed on one drywell-to-tank measurement. (No reciprocal information is available for well-to-tank electrode combinations.) The response was not observed on any well-to-well combinations involving drywell 30-03-03.

4.2.2 Double-Shell Tank AN-106

4.2.2.1 Liquid Level Monitoring. The waste level in the DST is monitored using an ENRAF, and annulus leak detector probes provide indication of leaks, as described in Section

4.0 of OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection.*

Daily liquid level measurements were recorded for the receiving DST, which was DST AN-106. The ENRAF gauge is capable of accurately measuring liquid level changes of 0.01 in. See Section 2.4 for a description of how the instrument functions.

During waste retrieval there was no evidence of a release from DST AN-106 based on results of liquid level monitoring. A consistent increase in liquid level was noted in DST AN-106 throughout retrieval. The DST AN-106 liquid level increase corresponded with the material balance results for SST C-103, except during concurrent use of the DST to receive liquids from SST C-201 retrieval.

4.2.2.2 Leak Detectors. DST AN-106 is monitored for leaks in the inner shell by a conductivity probe leak detection system installed in the tank annulus during tank construction. Slots cut in the concrete that support the tank at the bottom are designed to drain any leakage to the annulus floor. Conductivity probe assemblies on the annulus floor would activate an audible alarm and an annunciator panel light in the event of liquid leaking to the annulus so that mitigation would begin. Throughout the SST C-103 waste retrieval campaign, no leaks were detected by any of the leak detectors in DST AN-106.

4.2.2.3 Radiation Monitoring. A continuous air monitor operated to detect airborne radionuclides entrained in the ventilation exhaust stream of the annulus of DST AN-106. Detection of radiation exceeding a set limit in the annulus of the DST would activate an audible alarm and an annunciator panel light, initiating mitigative action.

The continuous air monitor for the DST AN-106 annulus detected no radiation levels above background during retrieval that could have been attributed to leak-induced airborne radionuclides.

4.2.3 Ancillary Equipment. Leak detectors were installed in the valve boxes, pits, and HIHTL (secondary containment structures) to detect the presence of liquid through conductivity, which would activate alarms and shut down the waste retrieval system.

Transfer line leaks may also be detected by radiation monitoring of the HIHTL in accordance with RPP-12711.

Throughout the SST C-103 waste retrieval campaign, no leaks were detected by any of the leak detectors in the valve boxes, pits, or HIHTL.

4.3 MITIGATION

Leak mitigation was accomplished through design features and the operational strategy developed for the retrieval system. Mitigation included actions that reduced the chance of a leak and the environmental impact of a leak should one have occurred. Potential leaks were proactively prevented and minimized throughout the waste retrieval operations.

The leak mitigation strategy (i.e., reduction of leak loss potential) was to minimize the liquid volume within the tank during waste retrieval operations. Conditions to control leak potential involved the following.

a. In-tank liquid levels during retrieval were lower than liquid levels present before interim stabilization.

b. Retrieval from the center out.

c. Liquid removed between waste retrieval campaigns.

d. Leak assessment protocols were in accordance with procedures.

e. Periodically evaluated HRR data.

f. Conducted frequent drywell surveys.

Conditions to control leak minimization included the following:

a. Liquid addition minimized and liquid pools removed as practical.

b. Retrieval from the center out.

c. Equipment handling controls to minimize potential for dropping equipment that could penetrate tank bottom.

d. Maintaining a benchmark waste level.

4.3.1 Single-Shell Tank C-103

A summary of the SST C-103 mitigation actions to minimize or prevent a leak were as follows:

a. Addition of water to the retrieval tank was minimized as described in Section 3.3.1. Addition of recycled DST supernatant was controlled to maintain a minimum liquid level. Liquid pools that formed were removed to the extent practical.

b. Waste was retrieved to the extent practical by working from the center of the tank outwards. In the center-out waste retrieval strategy, mobilized waste and interstitial liquids drain quickly into a central pool and can be rapidly pumped from the tank if a leak is detected.

c. Waste retrieval activities were performed only while a video camera was in place to observe the sluicing operation and the waste surface.

d. Equipment handling controls were used to minimize the potential for dropping equipment into the tank, which could penetrate the tank bottom during installation.

e. A benchmark level was maintained to ensure a low head of introduced liquid. The waste level did not exceed this benchmark. For SST C-103, the benchmark was 40 in.

The SST C-103 retrieval process lasted 54 operating days, minimizing the amount of time for retrieval liquids to leak from the tank. The mitigative approach was implemented to ensure that potential leakage from SST C-103 was monitored at all times. Key mitigative actions to be taken in the event of a leak are described in Sections 4.3.2 and 4.3.3.

4.3.2 Double-Shell Tank AN-106

The only tank used to receive SST C-103 tank waste was DST AN-106. Mitigating actions for a leak from DST AN-106 primary tank piping into the secondary DST containment system during a waste transfer from SST C-103 would have included (1) stopping the flow of waste into the tank system (stopping the transfer), (2) pumping waste in the primary tank to another DST until the liquid level in the secondary containment was no longer increasing, and (3) removing the waste from the secondary containment system as soon as practicable. Leaks at or near the DST AN-106 tank bottom may also have required saltwell jet pumping to remove trapped liquids from between solid layers in the tank. Transfer line leakage would drain to a common point for collection, detection, and removal.

4.3.3 Ancillary Equipment

Leakage from an HIHTL (inner hose) into an encasement (outer hose) would have drained to an alarm location and a collection tank. The transfer would have been shut down when the alarm was activated. Response to transfer leak detection alarms and mitigation actions would have been performed in accordance with procedure TO-220-108, *Overground Transfer from 241-C-103 to AN-106 and Sluicing of Tank 241-C-103.*

4.4 CONCLUSION

Based on the available data (presented in Sections 4.2 and 4.3), no evidence of a tank leak occurred during SST C-103 waste retrieval operations. The SST C-103 LDMM program focused on a mitigation strategy to successfully control potential leaks. This strategy included the following:

a. Minimize residual tank waste.
b. Minimize in-tank water use.
c. Minimize standing liquid pools in the tank.
d. Control and monitor additions of water.
e. Visually monitor tank conditions and retrieval operations.
f. Retrieve from the center of the tank out to minimize water accumulation around the tank knuckle.

The goal of the LDMM program for SST C-103 as set forth in RPP-21895 was achieved.

5.0 LIMITS OF TECHNOLOGY

HFFACO milestone M-45-00 states in part: "Closure will follow retrieval of as much tank waste as technically possible, with tank waste residues not to exceed 360 ft^3 in each of the 100 series tanks... or the limit of waste retrieval technology capability, whichever is less."

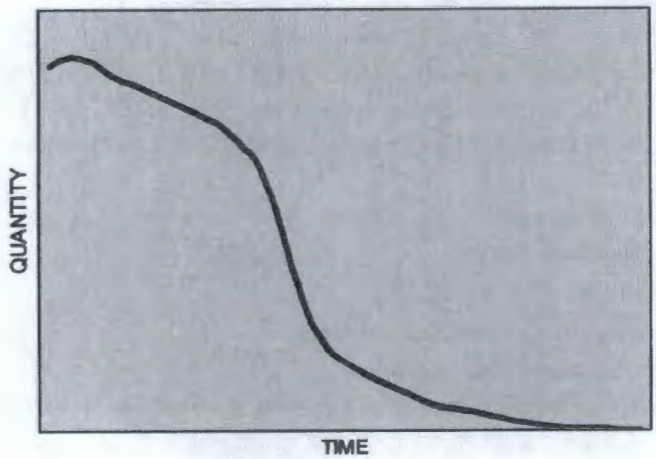
This section presents information to demonstrate completion of the M-45-00 retrieval goals milestone. Accomplishment of the M-45-00 retrieval goals milestone was achieved by administrative and engineering controls in accordance with RPP-21895 and RPP-PLAN-25193.

Unless otherwise noted, data in this section was developed in accordance with procedure TFC-ENG-CHEM-P-47, *Single-Shell Tank Retrieval Completion Evaluation.*

5.1 IDENTIFYING LIMITS OF TECHNOLOGY

Milestone M-45-00 does not prescribe a basis for determining when a technology has reached the limit of its capability to retrieve waste. Figure 5-1 illustrates the general concept of diminishing returns over time as a waste retrieval activity progresses towards its limit.

Figure 5-1. Limits of Technology Model.



The limits of technology model (Figure 5-1) shows that during the early part of the hypothetical campaign, efforts are focused on optimizing the efficiency of the technology. During the middle period, the operational parameters are in place and relatively large volumes of waste are removed efficiently.

In later stages, the small volume of waste remaining causes the retrieval operation to use additional fluid to mobilize the remaining waste and thus more operating time is required in relation to the volume of waste recovered. In the final days, the quantity of waste recovered approaches zero (using the same volume of retrieval fluids), indicating that retrieval efficiency has diminished to the point where only a negligible amount or no waste can be retrieved using a selected technology.

5.2 DETERMINATION THAT AS MUCH WASTE WAS RETRIEVED AS POSSIBLE USING THE SELECTED TECHNOLOGY

The DOE and CH2M HILL relied on the following three types of data to establish progress towards meeting the limit of the modified sluicing capacity to retrieve waste from SST C-103 and determine when the end of retrieval was reached:

a. Examination of in-tank photos/videos to observe and record the waste surface contours, form, and characteristics.

b. Estimation of retrieval performance efficiency based on daily material balance calculations.

c. Use of retrieval performance data trends estimated from material balances to demonstrate that a consistent pattern is present indicating that as much waste has been removed as possible.

5.2.1 Results of Visual Observations

A video camera inside SST C-103 allowed operational monitoring of retrieval activities and results throughout the retrieval campaign. Video observation of physical characteristics of the tank and objects in the tank aided in measuring residual waste volume change at the end of retrieval. As retrieval progressed, a reduction in waste volume was observed.

To support subsequent video evaluations, videotapes of the waste surface were taken. The videotapes show a shallow bed of waste with some visible liquid around the pump. The surface showed a layer of white or yellow granular material. The waste appeared evenly distributed on the tank bottom with slight variations in waste height and two piles of waste near the tank wall. As discussed in Section 2.0, the tank contains an old pump and a number of pipe sections. The old pump in Riser 9 and pipe sections are expected to be partially filled with waste.

During retrieval, it was observed that retrieval performance decreased as the readily mobilized sludge was depleted, leaving behind less mobile granular residues, which did not readily pass through the pump inlet screen.

5.2.2 Trend in Retrieval Efficiency

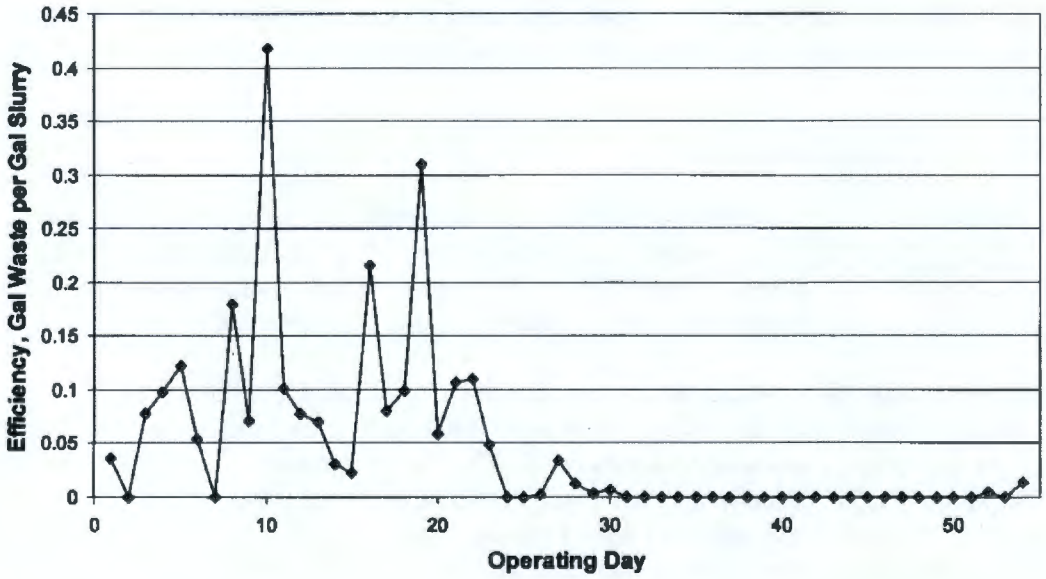
The retrieval efficiency in gallons of waste retrieved per gallons of slurry transferred was used to determine progress throughout retrieval. The volume of waste retrieved was determined by subtracting the slurry and water added to the tank from the volume transferred on a given day.

Figure 5-2 shows the retrieval efficiency for each day of retrieval operations at SST C-103. Retrieval efficiency values are lower than has been observed in other tanks due to the use of recycled supernatant. Large volumes of supernatant were able to be used to sluice the material, so low efficiencies do not indicate overuse of water but rather utilization of recycled liquid from the DST. In the initial stages of retrieval, efficiencies between 5% and 15% were normal. However, after day 24, efficiencies below 1% were typical. Retrieval performance decreased as the readily mobilized sludge was depleted, leaving behind less mobile granular residues, which

did not readily pass through the pump inlet screen. It is expected that as the volume retrieved approaches the starting waste volume, the efficiency declines and approaches zero.

The spike in volumetric efficiency during the final rinse results from efforts to minimize the supernatant pool volume during the rinse. Since the rinse water had to be intimately mixed with the solids heel, this opportunity was utilized to spread the solids into the depression surrounding the retrieval pump, thereby displacing liquid which otherwise would have remained in the supernatant pool.

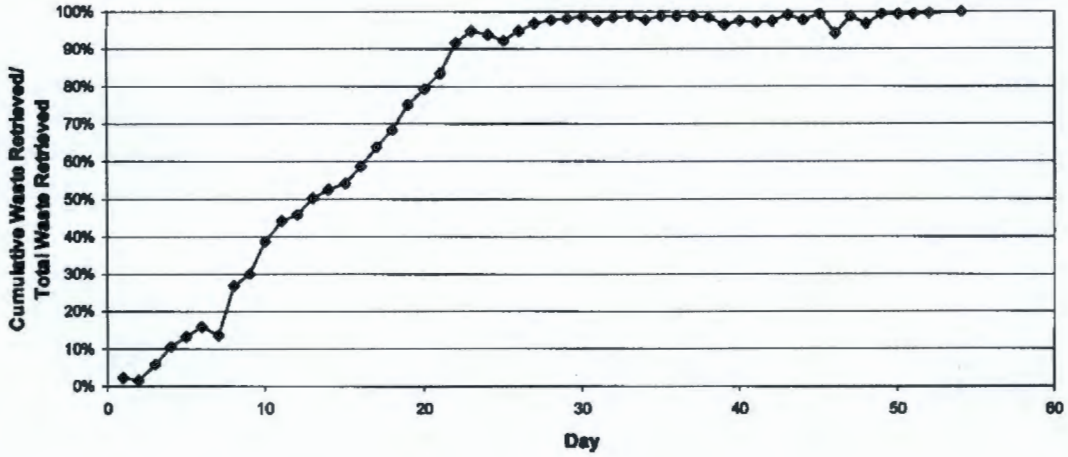
Figure 5-2. Waste Retrieval Performance: Retrieval Efficiency.



5.2.3 Waste Retrieval Progress

Waste retrieval progress as a function of operating days is shown in Figure 5-3. The volume of waste retrieved per day was estimated from a mass balance using the volume of the slurry transferred to DST AN-106 and the volume of supernate removed from DST AN-106 to perform sluicing. Waste retrieval progressed fairly steadily until day 23 when the volume of waste retrieved began to level off. No measurable progress was made from days 47 to 51. Some waste was retrieved during the last 2 days when the flush water was used to rinse the solids and the supernatant out of the tank.

Figure 5-3. Waste Retrieval Progress.



5.3 CONCLUSION

Based on visual observations of the system effectiveness and decrease in daily waste retrieved, management from Operations, Engineering, and Projects concurred that the retrieval had reached the limit of effectiveness for removing waste from SST C-103 with the modified sluicing system as deployed. The DOE was briefed and concurred. The retrieval was terminated and equipment decontamination flushes were completed.

At the end of waste retrieval operations, the waste remaining in the tank was estimated to be less than 351 ft^3 on the bottom of the tank. The residual waste volume including tank bottom, on tank walls, on the stiffener rings, and in the void spaces in equipment left in the tank was subsequently measured and documented using the video camera/CCMS to be 338 ft^3 total residual waste with a 95% upper confidence level (UCL) of 351 ft^3 (see Section 6.0).

6.0 SINGLE-SHELL TANK C-103 RESIDUAL WASTE VOLUME MEASUREMENT

This section presents the residual waste volume measurement process and the results for SST C-103. The post-retrieval measurement of the residual waste volume was performed using the method described in RPP-31159. The total measured volume of residual waste in SST C-103 was the sum of volumes remaining in the tank dish, on tank walls, on the stiffener rings, and in the void spaces in equipment left in the tank. This measurement established that the volume of the waste remaining in SST C-103 was 338 ft^3, with a 95% UCL of 351 ft^3.

6.1 RESIDUAL WASTE VOLUME MEASUREMENT PROCESS

The waste volume measurement approach is summarized in Sections 6.1.1 through 6.1.3 and is described in RPP-31159. The CCMS method was used to calculate the volume remaining in the tank dish. The waste volumes remaining on the tank wall, stiffener rings, and in void spaces were estimated using video observations, records, and equipment drawings.

6.1.1 Video Camera/Computer-aided Design Modeling System

To implement the CCMS method, in-tank videos of SST C-103 were recorded on August 25, September 19, and September 28, 2006. The videos documented the location of residual solids and liquid waste remaining in the tank. The camera was located in Riser 7 and video was recorded at heights of 5 ft, 13 ft, and 19 ft above the bottom of the tank on August 25. For the September 19 video the camera was located in Riser 5 at a height of about 8 ft above the tank bottom and on the September 28 video the camera was located in Riser 2 at a height of 10 ft above the bottom of the tank. Figure 6-1 presents a section view of SST C-103 showing representative camera elevations used for the videos.

Autodesk® Land Desktop,[2] Release R16.0 software was used as part of the CCMS approach. Using the software, a 3-D model of the SST C-103 interior was built, volumes of residual waste formations in the bottom dish were modeled and determined, and a digital terrain model of the waste surface was built that was used to determine the overall volume of residual waste in the dish.

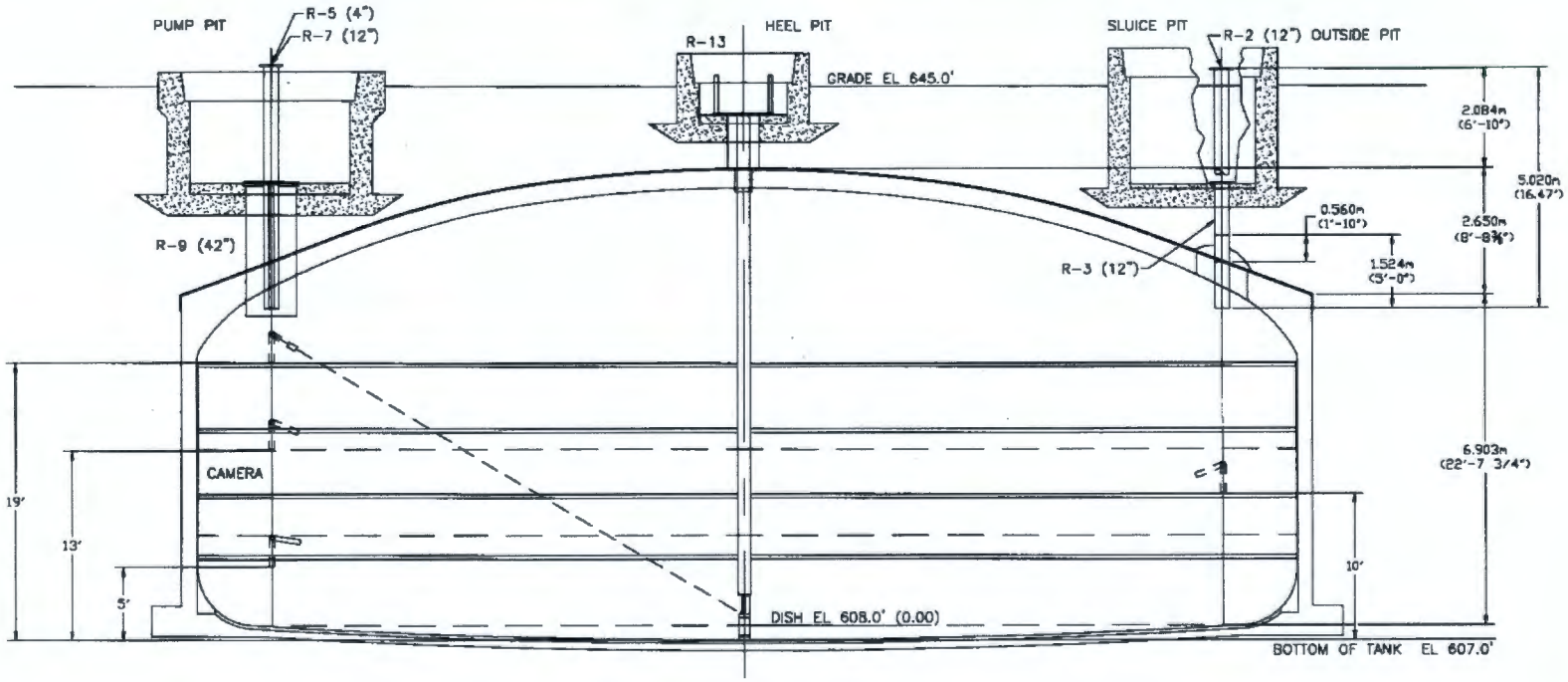
Once the residual waste volume in the bottom of the dish is determined, the 95% UCL is determined using the following statistically based equation:

$$\textit{Actual Waste Volume @ 95\% UCL, } ft^3 = 1.043 \times \textit{CCMS In-Tank Volume Est. } ft^3 + 0.852\, ft^3$$

The development of this regression equation is described in RPP-RPT-22891, *Revised Methodology to Calculating Residual Waste Volume at 95% Confidence Interval*, and was adopted in RPP-31159.

[2] Autodesk® Land Desktop is a registered trademark of Autodesk, Inc., San Rafael, California.

Figure 6-1. Single-Shell Tank C-103 Section View Showing Camera Elevations Used in March 23, 2006, Video Recording.



C-103

08/25/06 VIDEO
09/28/06 VIDEO

6.1.2 Estimation of Waste Remaining on Tank Surfaces

The volume of waste remaining on the walls and stiffener rings was estimated by video observations of the August 25 and September 28, 2006, videos.

The tank wall was observed to have a scale covering the majority of the cylinder lining that comprises the tank wall. The uppermost 1-ft section of the wall has no waste on it; this is supported by the presence of the original red primer paint. The lowest 1 ft of the knuckle region was included in the tank bottom residual waste calculation. The wall height used for the waste calculation was 16 ft. The average waste thickness was determined to be 1/16 in. from the contrast of the shadows cast in the video recording with the camera light.

SST C-103 has four stiffener rings located at 4.5-ft intervals from the top of the tank dish. Each stiffener ring extends from the tank wall approximately 5 in. The topmost stiffener ring (ring 1) was observed in video recordings to have no waste buildup on it. The waste on the lower three stiffener rings (rings 2, 3, and 4) was generally uniform in appearance and sloped downward from the tank wall to the inside edge of the rings. Stiffener rings 3 and 4 had short sections (about 5% of the total circumference of the tank) where waste was noticeably thinner or was not present. In some areas, a very small amount of waste was observed on the bottom side of the stiffener rings. Each of the three lower stiffener rings was conservatively estimated to hold waste with an average thickness of 2 in. over the entire surface of the stiffener rings.

6.1.3 Estimation of Waste in Equipment

The waste remaining in in-tank equipment was estimated using a June 21, 2006, in-process video and August 25, 2006, video recording to support the CCMS method.

SST C-103 contains several pieces of equipment and a number of pipe sections and other debris. Sluicers in Risers 3 and 6 and a slurry pump in Riser 13 were used to retrieve the waste from SST C-103. The sluicers and pump contain no waste. The sluicers were used to add the water rinses to the tank after the completion of sluicing and were blown out to remove any remaining liquid; they contain no waste. After the completion of sluicing, the slurry pump was used to pump rinse water from SST C-103 to DST AN-106 and was drained after its final use; it contains no waste.

An old pump is in Riser 9. A plate at the bottom of the pump was slightly above the post-retrieval waste level and the pump suction appears to be greater than 6 in. above the plate at the bottom of the pump. No waste was observed between the plate at the bottom of the pump and the pump suction. The diameter of the pump is estimated to be 5 in. Other waste-containing items were observed in the videos and consisted of a number of pipes and pipe-like equipment.

The volume of residual waste left in this equipment was calculated by using the videos to estimate the location and dimensions of the equipment and process knowledge to estimate the depth to which the pump could be filled with waste.

6.2 RESIDUAL WASTE VOLUME RESULTS

RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, defines the final residual waste volume as the residual waste volume in the tank dish at the 95% upper confidence level (UCL) (equation shown in Section 6.1) plus the actual residual waste volume on the stiffener rings, equipment void space, and tank walls. Using this definition, the 95% UCL volume for post-retrieval waste in SST C-103 is estimated to be a volume no greater than 351 ft^3. Table 6-1 presents the total post-retrieval volume together with waste volumes associated with various tank components.

Table 6-1. Single-Shell Tank C-103 Total Waste Volume and Component Waste Volumes.

Component	Waste Volume (ft^3)	95% UCL[a] (ft^3)
In the bottom (dish) of the tank (solids and liquids)	266	279
In equipment in the tank	3.6	3.6
On the stiffener rings	48.8	48.8
On the tank wall	19.6	19.6
Total	338	351

UCL = upper confidence level

[a] In accordance with RPP-23403, estimated error for waste in bottom of tank is calculated using

Volume at 95% upper confidence level, ft^3 = 1.043 x volume, ft^3 + 0.852 ft^3 plus the actual residual waste volume on the stiffener rings, equipment void space, and tank walls.

RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 2.

The residual solids were observed to be spread out covering approximately a 67.5-ft-diameter area of the dish-shaped bottom of the tank at an average thickness of approximately 0.50 in. The waste layer is generally thicker on the north side of the tank and thinner on the south side of the tank. Waste piles, which extend part way up the tank knuckle, are in the northwest and northeast sections of the tank.

There is one distinct pool of liquid on top of the solid waste in the bottom of the tank. The liquid pool is approximately 20-ft in diameter and located in the center of the tank. Table 6-2 shows the volumes of solids and liquids estimated by the CCMS.

Table 6-2. Single-Shell Tank C-103 Waste Volume in Tank Bottom.

Component	Waste Volume (ft^3)
Solid phase	233
Supernate phase	33
Total	266

The post-retrieval tank waste contour map (Figure 6-2) shows the configuration of residual waste in the dish bottom. The SST C-103 isometric model (Figure 6-3) portrays the volume of the residual waste in relation to the volume and configuration of the bottom dish and tank knuckle regions of SST C-103.

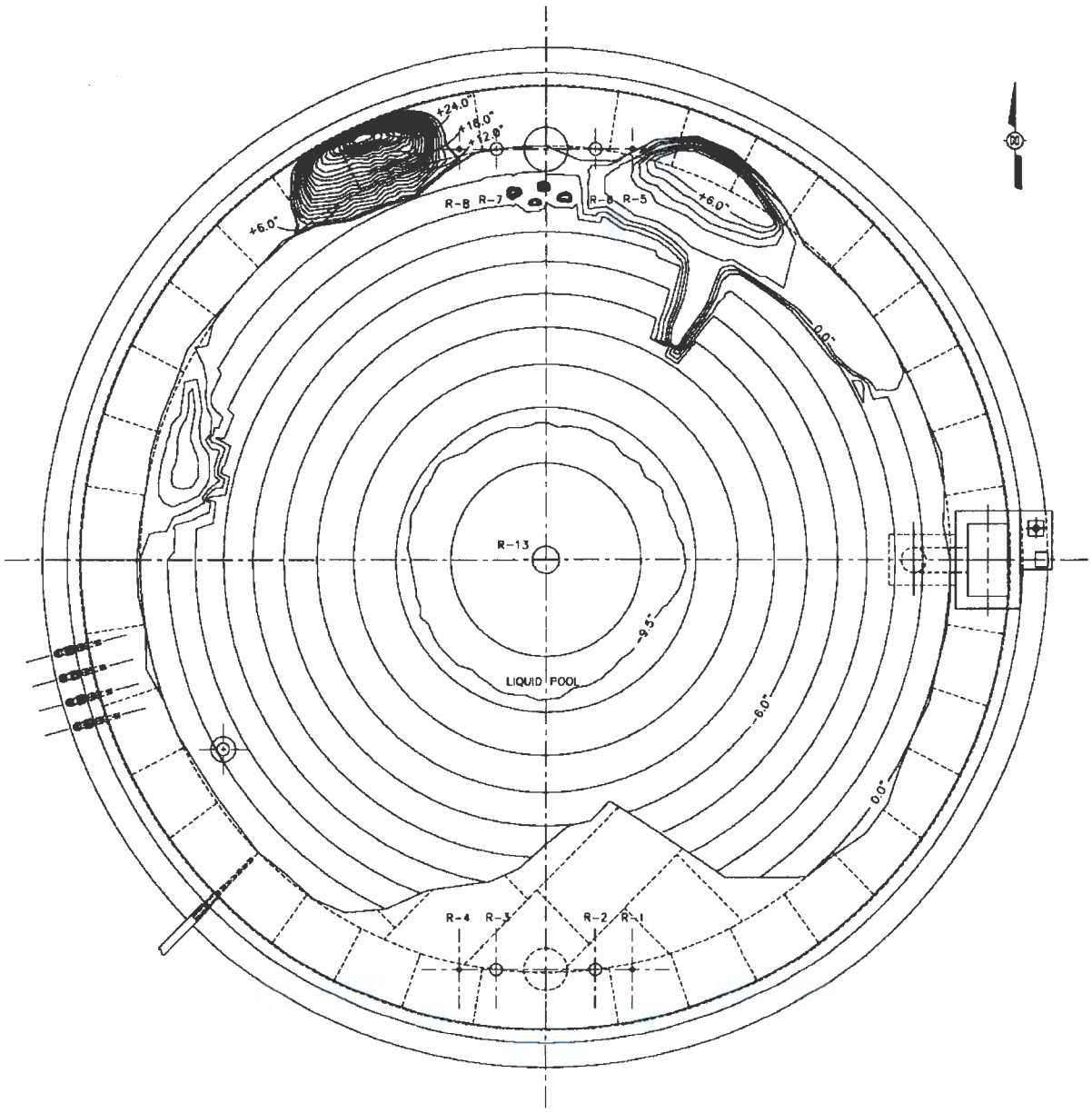
Figures 6-4 through 6-7 are still pictures taken from the August 25 and September 28, 2006, videos. Figure 6-4 through 6-6 show views of the tank bottom. Figure 6-7 shows a portion of the tank wall.

The pump in Riser 9 is expected to be partially filled with waste and was assumed to be filled with waste to a height equivalent to the maximum sludge level in the tank following saltwell pumping; based on visual observations, two large-diameter pipe sections were estimated to be partially filled with waste. All other potentially waste-containing equipment/debris was assumed to be filled with waste. The total waste contained in equipment is estimated to be 3.6 ft^3. This volume is considered to be an upper bounding estimate; many of the pipes are now covered in waste and the volumes associated with them are included in the CCMS estimate of the waste on the bottom of the tank. As provided for in RPP-23403, this estimate of the waste volume in the equipment deviates from the basic assumption that the void spaces are completely filled with waste. The calculation of the waste volume contained in equipment is provided in RPP-31159, Appendix B.

Waste on the tank wall was estimated to have an average thickness of 1/16 in. based on the contrast of shadows cast in the video recording with the camera light. The percentage of tank wall above the dish covered by waste was conservatively estimated at 100%. The volume of waste on the tank wall was estimated to be 19.6 ft^3.

SST C-103 has four stiffener rings. No waste was present on the top ring while waste on the bottom three rings was estimated to average 2 in. in depth over the entire surface of the rings. The volume of waste on the stiffener rings was estimated to be 48.8 ft^3.

Figure 6-2. Single-Shell Tank C-103 Post-Retrieval Tank Waste Contour Map.



C-103

08/25/06 VIDEO

09/28/06 VIDEO

Figure 6-3. Single-Shell Tank C-103 Post-Retrieval Tank Waste Wire Mesh Isometric Model.

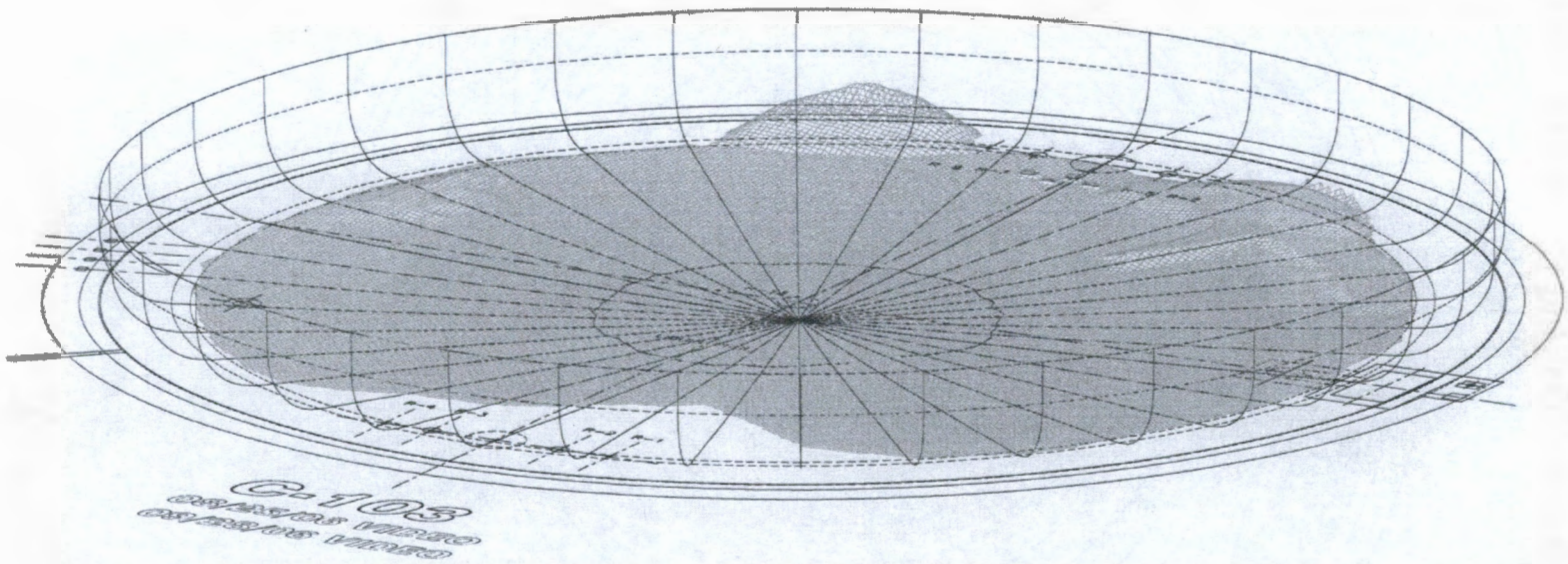


Figure 6-4. Single-Shell Tank C-103 Video Still, Recorded September 28, 2006, Camera Elevation Approximately 10 Feet from Tank Bottom.

Figure 6-5. Single-Shell Tank C-103 Video Still, Recorded August 25, 2006, Camera Elevation Approximately 5 Feet from Tank Bottom.

Figure 6-6. Single-Shell Tank C-103 Video Still, Recorded September 28, 2006, Camera Elevation Approximately 10 Feet from Tank Bottom.

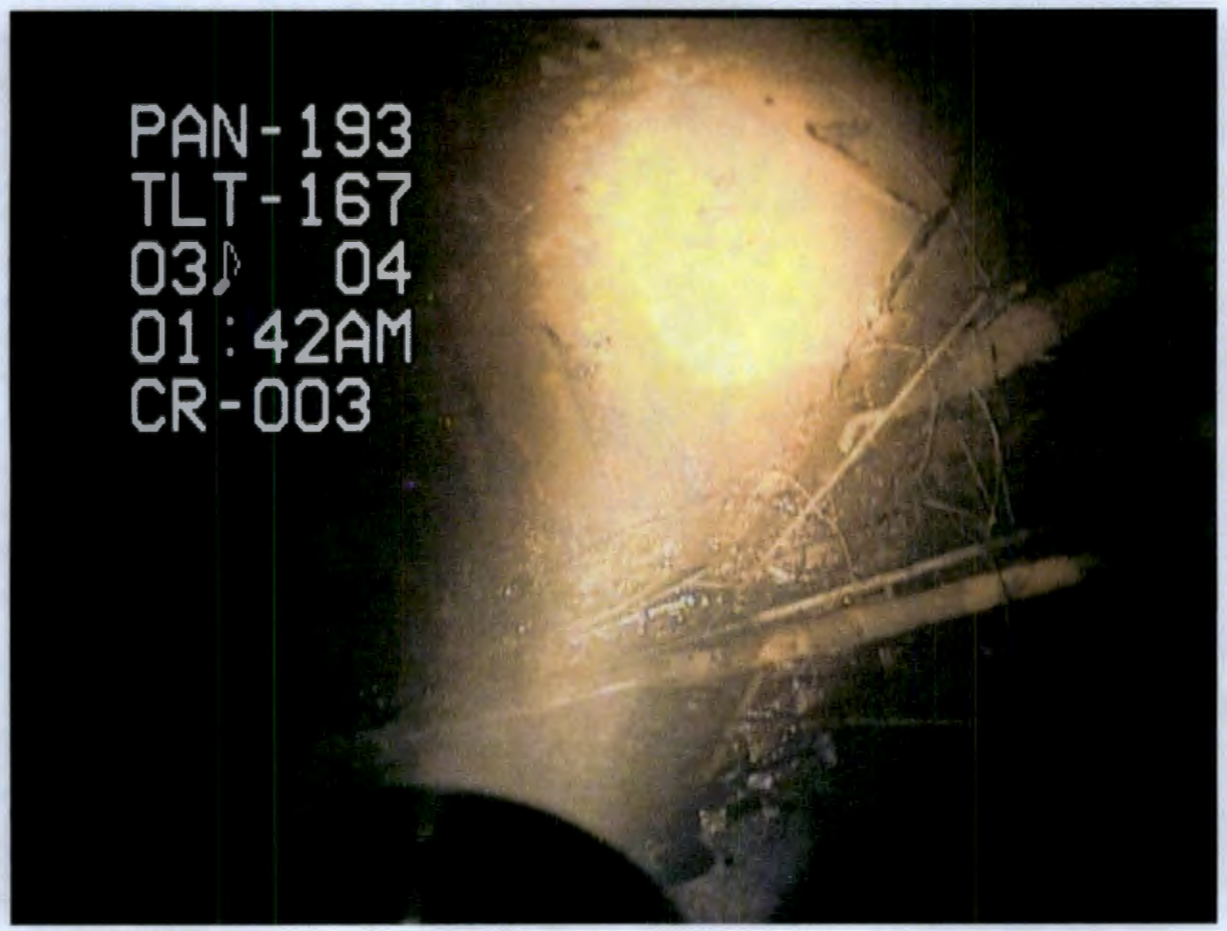
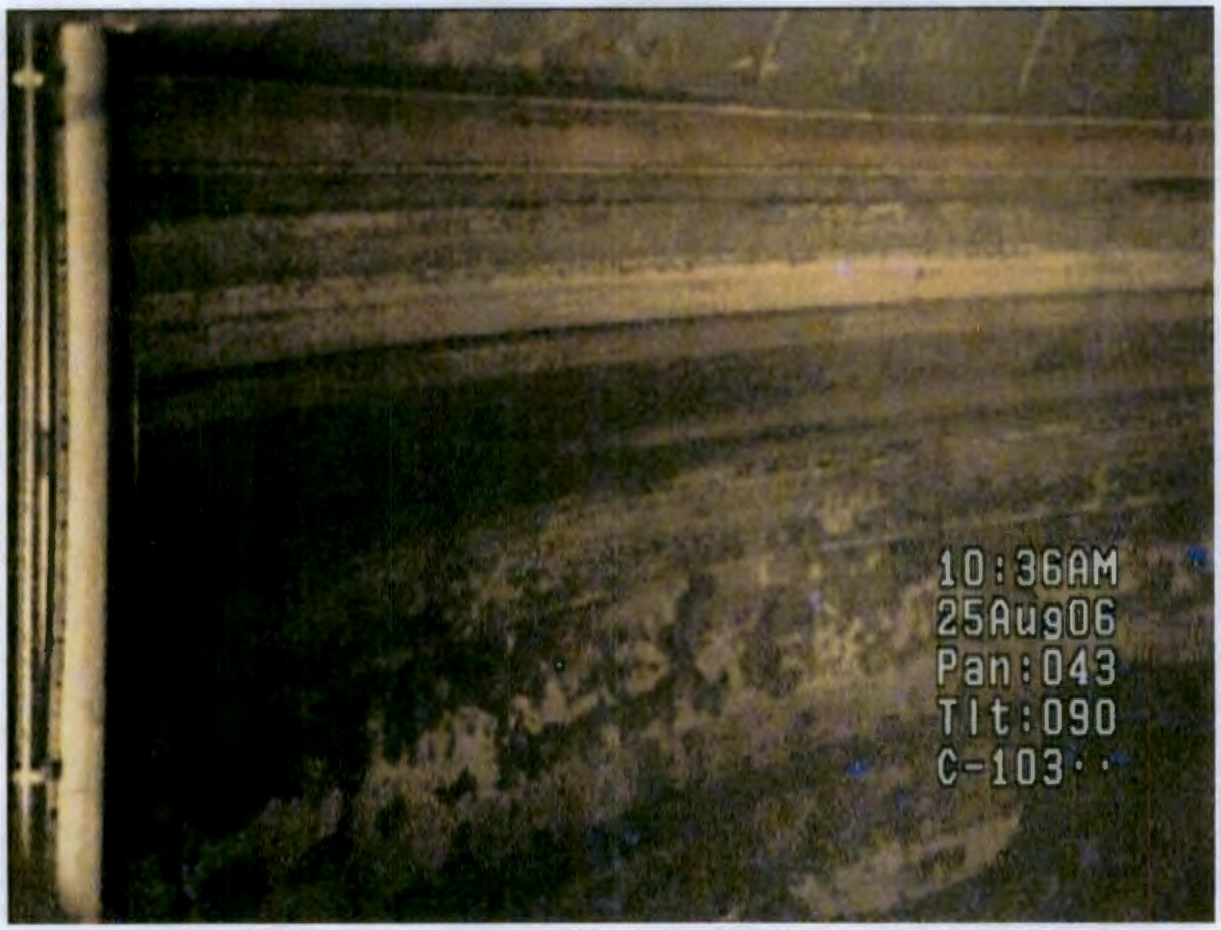


Figure 6-7. Single-Shell Tank C-103 Video Still, Recorded August 25, 2006, Camera Elevation Approximately 19 Feet from Tank Bottom.



6.3 CONCLUSION

The calculated volume of residual waste in SST C-103 is 338 ft^3. The 95% UCL estimate of the residual waste volume is 351 ft^3. Using the 95% UCL estimate for residual waste, the total residual waste volume in SST C-103 is below the 360 ft^3 HFFACO Milestone M-45-00 requirement.

7.0 RESIDUAL TANK WASTE CHARACTERIZATION

This section describes the results of residual tank waste characterization for SST C-103. Average and upper bounding estimates of residual waste inventory based on laboratory analysis of waste samples taken after completion of retrieval are presented. The calculated inventories are used as input for calculating the potential risk to human health that arises from the residual waste. This risk assessment is discussed in Section 8.0.

7.1 SAMPLING AND ANALYSIS OF RESIDUAL WASTE

The following three documents provide guidance and requirements for sampling and analysis of residual waste:

a. RPP-23403, *Single-Shell Tank Component Closure Action Data Quality Objectives*. This document describes the sampling and analysis strategy developed by implementing the DQO process to ensure appropriate data are collected to support SST C-103 component closure activities.

b. RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tank (SST) Component Closure*. This document identifies regulatory requirements for field sampling, laboratory analysis, and data reporting for residual waste samples to ensure appropriate data are collected to support SST closure activities.

c. RPP-PLAN-29586, *Grab Sampling and Analysis Plan for Residual Waste Liquid in Tank 241-C-103* and RPP-PLAN-29587, *Sampling and Analysis Plan for Residual Waste Solids in Tank 241-C-103*. These documents summarize the sampling and analysis requirements in the DQO and provide additional guidance and clarification for satisfying the requirements. The guidance and clarification are necessary to address conditions that are specific to SST C-103.

Collection and analysis of the SST C-203 residual waste samples and calculations of the constituent inventories based on the sample results are described in RPP-RPT-32376, *Tank 241-C-103 Residual Waste Inventory Estimates for Component Closure Risk Assessment*, and summarized in Sections 7.2 through 7.4.

7.2 SAMPLING AT SINGLE-SHELL TANK C-103

In accordance with the DQO, liquid in the tank was sampled through a riser (Riser 5) using the bottle-on-string method during the final water rinse and just prior to the final pump-out. Liquid was available in sufficient quantity at that time for sampling and the samples are expected to be representative of the residual liquid.

Also, in accordance with the DQO, after completion of retrieval, meetings were held with Ecology to select the appropriate sampling method and sample locations for residual solid waste samples. The off-riser sampling system (ORSS) was selected to collect the samples. The off-riser sampler is a remotely controlled six-wheeled mobile platform fitted with a scoop device to collect waste samples. The unit is connected by a tether that provides a means to lower the unit

into the tank, provide power, and allows control from the surface. It is deployed through a 12-in.-riser and can traverse the tank bottom, retrieve a waste sample from the planned location, and deposit the material into a sample bottle held by the carrier. The carrier is located directly beneath a riser and is raised to the surface after a sample bottle is filled. The off-riser sampler and the sample bottle carrier are known as the ORSS.

Nine locations for collection of the solids samples as required by the DQO were identified. The sample locations were selected based on the final waste configuration. Because the residual waste was spread throughout all regions of the tank bottom, the sample locations agreed on (see Figure 7-1) were from different regions of the tank bottom (center, north, south, east, west, northwest, northeast, southwest, and southeast) to account for waste variability.

The ORSS was lowered through Riser 7 into the tank after completion of retrieval. The sampler was then maneuvered remotely to collect solids from the nine locations. Solids from each location were deposited by the sampler into a sample bottle on the sample carrier located directly below Riser 7. After filling a bottle, the carrier was raised into a glovebag at the top of the riser above the tank. The sample was then removed from the glovebag and placed in a shielded shipping cask. This process was repeated until all nine samples were taken. The samples were then shipped to the 222-S Laboratory for analysis. A detailed description of the solid samples and the methods to form three composite samples for analysis is provided in RPP-RPT-32376.

7.3 SAMPLE ANALYSES

The 222-S Laboratory at Hanford used 22 analysis techniques to obtain the concentration of various organic constituents, inorganic constituents, and radionuclides in the liquid and solids samples. A list of the techniques is presented in Table 7-1. Analysis of the samples resulted in concentration estimates for over 150 constituents in the SST C-103 residual liquid and solids. A description of the analysis techniques and analytical data appears in RPP-RPT-31239, *Final Report for Tank 241-C-103 Liquid Grab Samples in Support of the Single-Shell Tank Component Closure Program*, and in RPP-RPT-31949, *Final Report for Tank 241-C-103 Solid Samples in Support of the Single-Shell Tank Component Closure Program*. Electronic data were also loaded into TWINS.

The 222-S Laboratory maintains a quality assurance (QA) program to ensure data quality (ATL-MP-1011, *ATL Quality Assurance Project Plan for 222-S Laboratory*). The analyses were performed according to the QA program requirements. In addition, the DQO (RPP-23403) specifies quality control criteria (e.g., standard recovery, matrix spike recovery, relative difference between duplicate analyses) that are specific to the closure project. The DQO also provides direction for addressing data that do not meet the criteria. Results for most constituents satisfied the DQO criteria; those that did not meet the criteria were addressed according to the direction provided in the DQO. RPP-PLAN-23827 contains the same data quality requirements as the DQO. The sample data were evaluated against the requirements in RPP-PLAN-29586 and RPP-PLAN-29587 and judged acceptable for use in the risk assessment.

Figure 7-1. Approximate Locations for Tank 241-C-103 Post-retrieval Solids Samples (Based on RPP-RPT-32376 Appendix C)

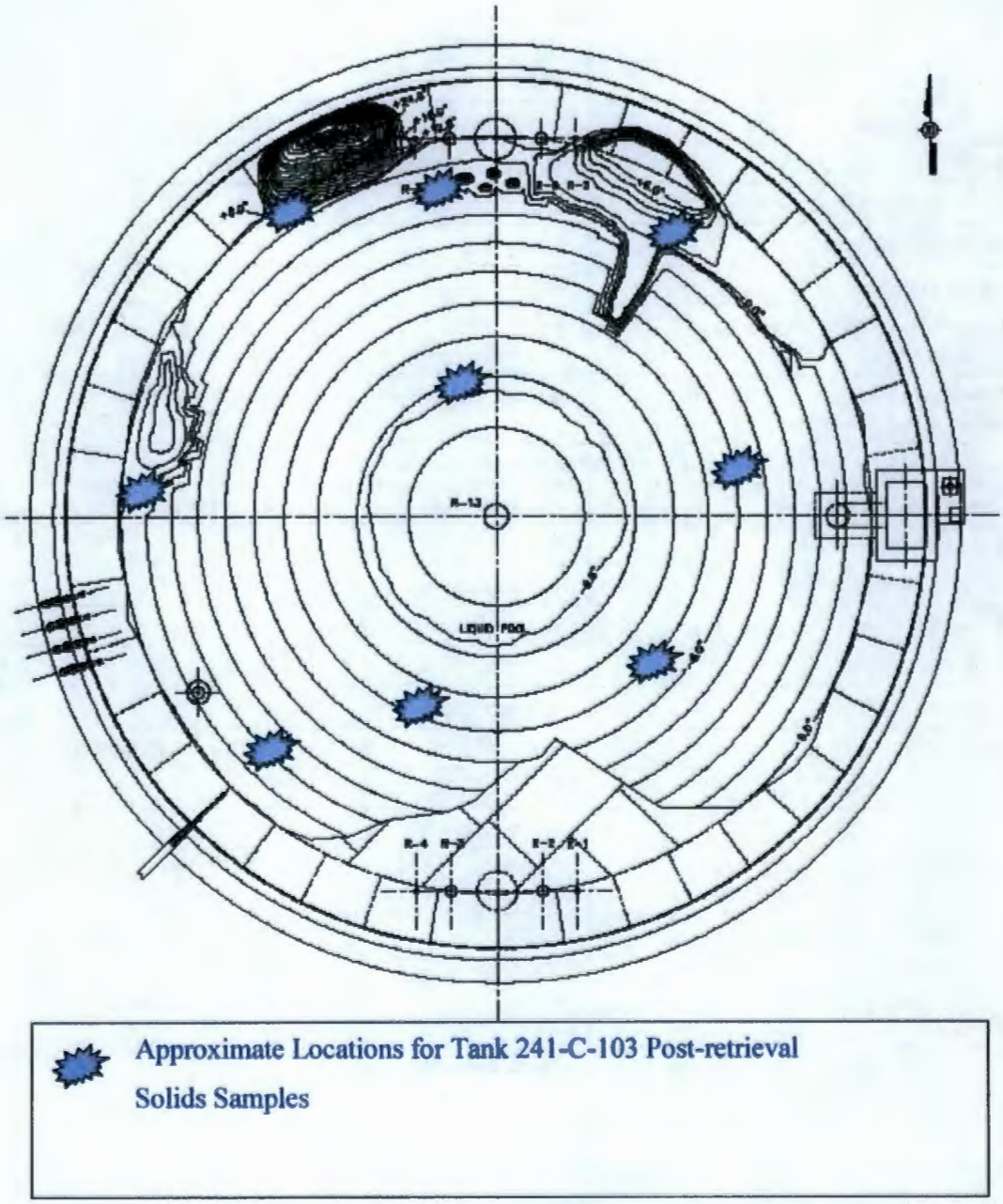


Table 7-1. Single-Shell Tank C-103 Residual Waste Sample Analysis Techniques.

Analysis Technique	SW-846 Method	Constituents
Inorganic Analyses		
Gravimetric	Not applicable	Bulk density for solids and specific gravity for liquid
pH measurement	9045C	pH
Titration (liquid only)	Not applicable	OH
Ion selective electrode	9215	Sulfide
Thermogravimetric analysis	Not applicable	Weight percent water
Spectrophotometric	9014	Cyanide
Cold vapor atomic absorption	7471A, 7470A	Mercury
Ion chromatography	EPA 300.7	Ammonium
Ion chromatography	9056	Anions
Inductively coupled plasma/mass spectrometry	6020	Uranium, neptunium, and thorium isotopes, ^{99}Tc
Inductively coupled plasma/atomic emission spectrometry	6010B	Cations (metals)
Radiochemical Analyses		
Gamma energy analysis	Not applicable	Gamma-energy emitters
Separation/beta counting	Not applicable	^{90}Sr
Liquid scintillation	Not applicable	^{14}C
Separation/gamma energy analysis	Not applicable	^{129}I
Liquid scintillation	Not applicable	^{79}Se
Liquid scintillation	Not applicable	Tritium
Alpha energy analysis	Not applicable	Alpha-energy emitters
Liquid scintillation	Not applicable	^{63}Ni
Organic Analyses		
Volatile organic analysis by gas chromatography/mass spectrometry	8260B	Volatile organic compounds
Semivolatile organic analysis by gas chromatography/mass spectrometry	8270C	Semivolatile organic compounds
Gas chromatography/electron capture detection	8082	Polychlorinated biphenyls

SW-846, *Test Method for Evaluating Solid Waste, Physical/Chemical Methods*
EPA = U.S. Environmental Protection Agency

A potential issue associated with analysis of a solids sample containing high levels of organic chemicals is incomplete dissolution of transuranic constituents, particularly $^{239/240}Pu$ (PNNL-14903, *Hanford Tanks 241-C-203 and 241-C-204: Residual Waste Contaminant*

Release Model and Supporting Data). Dissolution of SST C-103 solids samples for $^{239/240}Pu$ analysis was performed by fusion digestion. A trace amount of solids remained after the digestion was finished. The solids residue was filtered and checked with a hand-held alpha counter. Alpha activity of the residue was negligible (RPP-RPT-31949).

Estimates of average concentrations and uncertainty in the concentration estimates (presented as relative standard deviation) are shown in Appendix B, Tables B-1 and B-2 for liquid and solids, respectively.

7.4 CALCULATION OF RESIDUAL INVENTORY

Residual waste inventories were calculated by following the best-basis inventory process as described in RPP-7625, *Best Basis Inventory Process Requirements*. For each phase, two inventories were computed: an average inventory based on mean concentrations, density, and volume, and a bounding inventory that is an estimate of an inventory at the 95% UCL.

The average inventory for each liquid waste constituent-of-concern was calculated by multiplying the mean concentration and the waste volume (i.e., inventory = concentration x volume). The average inventory for each solids constituent was calculated by multiplying the mean concentration, the mean density, and the waste volume (i.e., inventory = concentration x density x volume). Solids sample data were reported on a per-unit-weight basis; therefore, a mean density was used to convert the units of solids concentration data to a per-unit-volume basis.

Analytical data and the statistical model used for estimating the means and standard deviations for concentration, density, and waste volumes are discussed in RPP-RPT-32376. For constituents that had concentrations below the detection limits, the value of the detection limits were used for calculating the mean concentrations.[3] In accordance with best-basis inventory protocol, the relative standard deviations for nondetected constituents are assumed to be 100% (RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best-Basis Inventories*). The 95% UCL inventory of each constituent was estimated based on a statistical method described in RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best-Basis Inventories*. This method is based on calculation of the average inventory and an uncertainty (standard deviation) for the inventory. The standard deviation of the average inventory was calculated based on uncertainties associated with the concentration, volume, and density (for solids) measurements. Details of the method and formula used for deriving this inventory are described in RPP-RPT-32376.

Estimates of the average inventory and the 95% UCL inventory for waste constituents in SST C-103 residual liquid and solids are presented in Appendix B, Tables B-3 and B-4.

[3] However, for the purposes of the SST C-103 risk assessment, one-half the MDL is used for the inventory.

8.0 POST-RETRIEVAL SINGLE-SHELL TANK C-103 RISK ASSESSMENT

The potential impacts to human health posed by the residual waste in SST C-103 were calculated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. Figure 8-1 provides a schematic of the process used for the SST C-103 risk assessment, and this methodology is described in detail in Chapter 3 of DOE/ORP-2005-01.

The source term used in this SST C-103 risk assessment was derived from post-retrieval residual inventory results (see Section 7.0). The source term presented in this RDR will be incorporated into future revisions of DOE/ORP-2005-01 and the WMA C performance assessment. Appendix C contains a comparison of the inventory developed from the post-retrieval sample results and the inventory used in DOE/ORP-2005-01, which is based on RPP-RPT-23412, *Hanford Tank Waste Operations Simulator Model Data Package for the Development run for the Refined Target Case.*

Effects were calculated using the average and 95% UCL inventory. Results show that for the groundwater pathway, the effects associated with SST C-103 were well below performance objectives. For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the effects associated with SST C-103 were well below performance objectives. For the suburban garden scenario at 500 years after closure, the effects are below performance objectives.

8.1 CONSTITUENTS EVALUATED

Following retrieval, the residual waste was sampled and analyzed. This risk assessment is based on the analytical results from the post-retrieval sample (Section 7.0).

Analytical data for SST C-103 were collected and analyzed as defined by the closure DQOs. The post-retrieval samples were analyzed for 160 constituents [i.e., radionuclides, volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls, and inorganics (including metals and conventional parameters)] in accordance with approved 222-S Laboratory procedures based on U.S. Environmental Protection Agency (EPA) approved methods. However, analytes flagged as a nondetect were evaluated at one-half the detection limit in accordance with EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final*. Table 8-1 presents a complete listing of the analytes evaluated, whether the analyte was detected, and whether a radiological dose, reference dose, or cancer potency factor is published for that analyte.

Figure 8-1. Single-Shell Tank C-103 Residual Waste Inventory and Risk Assessment Process.

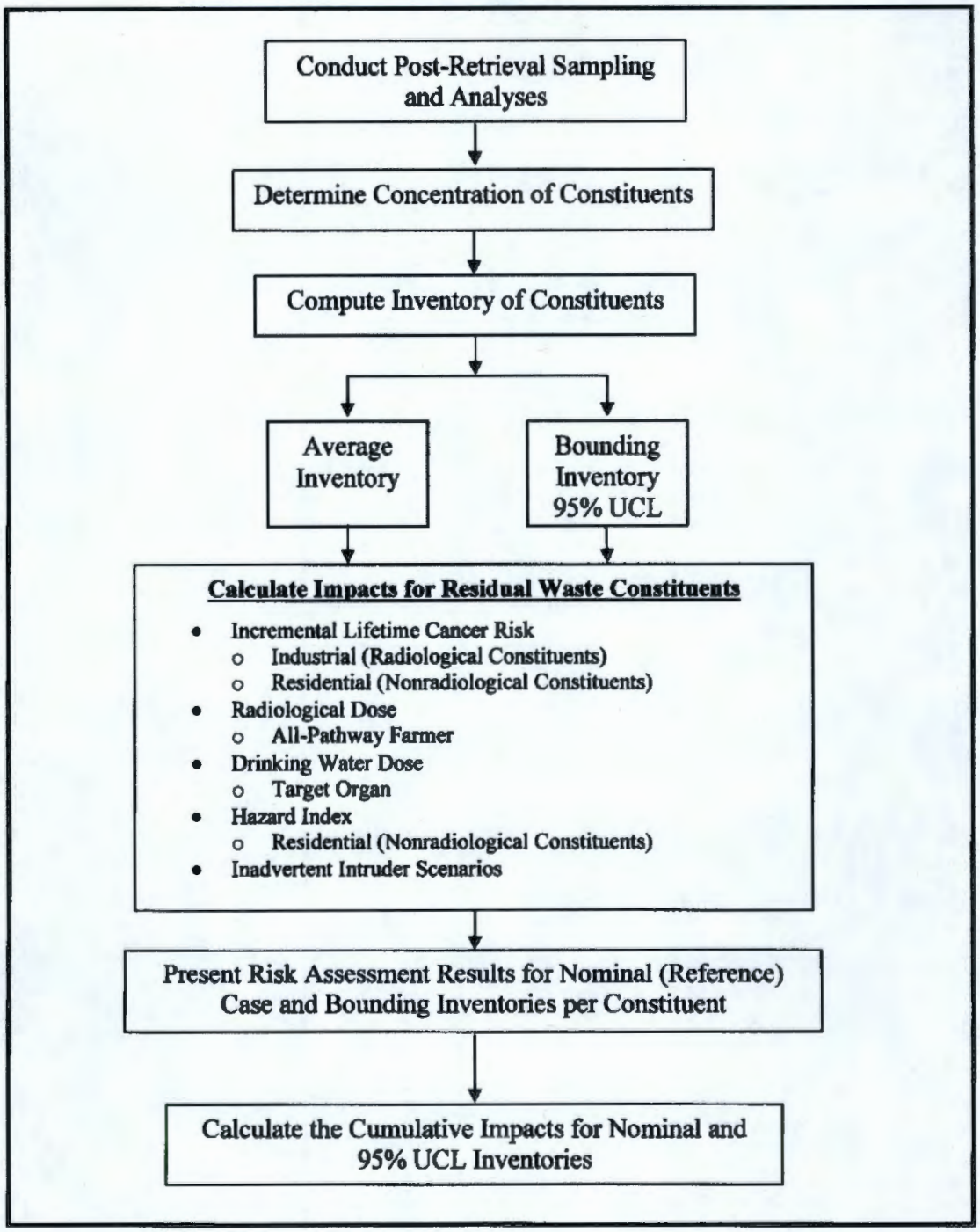


Table 8-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/CAS	Analyte	Detect	Available Toxicity Information
^{3}H	Tritium	L	Dose/Rfd	18496-25-8	Sulfide	U	No RfD or CPF
^{14}C	Carbon-14	L	Dose/Rfd	7440-25-7	Tantalum	U	No RfD or CPF
^{63}Ni	Nickel-63	L S	Dose/Rfd	13494-80-9	Tellurium	U	No RfD or CPF
^{60}Co	Cobalt-60	U	Dose/Rfd	7440-28-0	Thallium	U	Rfd
^{79}Se	Selenium-79	U	Dose/Rfd	7440-29-1	Thorium	S	No RfD or CPF
^{90}Sr	Strontium-90 + D	L S	Dose/Rfd	7440-31-5	Tin	S	Rfd
^{90}Y	Yttrium-90	L S	No RfD or CPF	7440-32-6	Titanium	L S	No RfD or CPF
^{94}Nb	Niobium-94	S	Dose/Rfd	7440-33-7	Tungsten	U	No RfD or CPF
^{99}Tc	Technetium-99	L S	Dose/Rfd	7440-61-1	Uranium	L S	Rfd
^{125}Sb	Antimony-125	U	Dose/Rfd	7440-62-2	Vanadium	U	Rfd
^{129}I	Iodine-129	S	Dose/Rfd	7440-65-5	Yttrium	S	No RfD or CPF
^{137}Cs	Cesium-137 + Daughters	L S	Dose/Rfd	7440-66-6	Zinc	S	Rfd
^{137}mBa	Barium-137m	L S	No RfD or CPF	7440-67-7	Zirconium	L S	No RfD or CPF
^{152}Eu	Europium-152	U	Dose/Rfd	71-55-6	1, 1, 1-Trichloroethane	U	Rfd
^{154}Eu	Europium-154	S	Dose/Rfd	79-34-5	1, 1, 2, 2-Tetrachloroethane	U	Rfd/CPF
^{155}Eu	Europium-155	U	Dose/Rfd	76-13-1	1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	U	Rfd
^{228}Th	Thorium-228 + D	S	Dose/Rfd	79-00-5	1, 1, 2-Trichloroethane	U	Rfd/CPF
^{230}Th	Thorium-230	U	Dose/Rfd	79-01-6	1, 1, 2-Trichloroethylene	U	Rfd/CPF
^{232}Th	Thorium-232	S	Dose/Rfd	75-35-4	1, 1-Dichloroethene	U	Rfd
^{233}U	Uranium-233	L S	Dose/Rfd	120-82-1	1, 2, 4-Trichlorobenzene	U	Rfd
^{234}U	Uranium-234	L S	Dose/Rfd	107-06-2	1, 2-Dichloroethane	U	Rfd/CPF
^{235}U	Uranium-235 + D	L S	Dose/Rfd	106-46-7	1, 4-Dichlorobenzene	U	Rfd/CPF
^{236}U	Uranium-236	L S	Dose/Rfd	95-95-4	2, 4, 5-Trichlorophenol	U	Rfd
^{238}U	Uranium-238 + D	L S	Dose/Rfd	88-06-2	2, 4, 6-Trichlorophenol	U	Rfd/CPF

Table 8-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/CAS	Analyte	Detect	Available Toxicity Information
^{237}Np	Neptunium-237 + D	S	Dose/Rfd	121-14-2	2, 4-Dinitrotoluene	U	Rfd
^{238}Pu	Plutonium-238	L S	Dose/Rfd	128-37-0	2, 6-Bis (tert-butyl)-4-methylphenol	U	No RfD or CPF
^{239}Pu	Plutonium-239	L S	Dose/Rfd	78-93-3	2-Butanone(MEK)	L S	Rfd
^{240}Pu	Plutonium-240	L S	Dose/Rfd	95-57-8	2-Chlorophenol	U	Rfd
^{241}Pu	Plutonium-241 + D	L S	Dose/Rfd	110-80-5	2-Ethoxyethanol	U	Rfd
^{241}Am	Americium-241	S	Dose/Rfd	95-48-7	2-Methylphenol (o-cresol)	U	Rfd
^{242}Cm	Curium-242	U	Dose/Rfd	79-46-9	2-Nitropropane	U	Rfd/CPF
^{243}Cm	Curium-243	L S	Dose/Rfd	67-64-1	2-Propanone (Acetone)	L S	Rfd
^{244}Cm	Curium-244	L S	Dose/Rfd	108-10-1	4-Methyl-2-pentanone (MIBK)	L	Rfd
7429-90-5	Aluminum	L S	Rfd	106-44-5	4-Methylphenol (p-cresol)	U	Rfd
7664-41-7	Ammonia -- (a)	L S	Rfd	83-32-9	Acenaphthene	U	Rfd
7440-36-0	Antimony	U	Rfd	71-50-1	Acetate C2H3O2-	U	No RfD or CPF
7440-38-2	Arsenic	U	Rfd/CPF	71-43-2	Benzene	U	Rfd/CPF
7440-39-3	Barium	L S	Rfd	85-68-7	Butylbenzylph-thalate	U	Rfd
7440-41-7	Beryllium	S	Rfd/CPF	75-15-0	Carbon disulfide	U	Rfd
7440-69-9	Bismuth	U	No RfD or CPF	56-23-5	Carbon tetrachloride	U	Rfd/CPF
7440-42-8	Boron	L	Rfd	108-90-7	Chlorobenzene	U	Rfd
24959-67-9	Bromide	U	No RfD or CPF	75-01-4	Chloroethene (vinyl chloride)	U	Rfd/CPF
7440-43-9	Cadmium	S	Rfd/CPF	67-66-3	Chloroform	U	Rfd/CPF
7440-70-2	Calcium	L S	No RfD or CPF	1319-77-3	Cresylic acid (cresol, mixed isomers)	U	No RfD or CPF
7440-45-1	Cerium	S	Rfd	108-94-1	Cyclohexanone	U	Rfd
16887-00-6	Chloride	L S	No RfD or CPF	75-09-2	Dichloromethane (methylene chloride)	U	Rfd/CPF
7440-47-3	Chromium, Total	L S	No RfD or CPF	60-29-7	Diethyl ether	U	Rfd
7440-48-4	Cobalt	U	Rfd/CPF	84-74-2	Di-n-butylphthalate	U	Rfd
7440-50-8	Copper	S	Rfd	117-84-0	Di-n-octylphthalate	U	Rfd
57-12-5	Cyanide	L	Rfd	141-78-6	Ethyl Acetate	U	Rfd

Table 8-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/CAS	Analyte	Detect	Available Toxicity Information
7440-53-1	Europium	S	No RfD or CPF	100-41-4	Ethylbenzene	U	Rfd/CPF
16984-48-8	Fluoride	L S	Rfd	206-44-0	Fluoranthene	U	Rfd
12311-97-6	Formate+A2	U	No RfD or CPF	87-68-3	Hexachloro-butadiene	U	Rfd/CPF
7439-89-6	Iron	L S	Rfd	67-72-1	Hexachloroethane	U	Rfd/CPF
7439-91-0	Lanthanum	S	No RfD or CPF	78-83-1	Isobutanol	U	Rfd
7439-92-1	Lead	S	No RfD or CPF	108-39-4	m-Cresol (3-Methylphenol)	U	Rfd
7439-93-2	Lithium	U	Rfd	108-38-3	m-Xylene	U	Rfd
7439-95-4	Magnesium	L S	No RfD or CPF	91-20-3	Naphthalene	U	Rfd
7439-96-5	Manganese	L S	Rfd	71-36-3	n-Butyl alcohol (1-butanol)	U	Rfd
7439-97-6	Mercury	L S	Rfd	98-95-3	Nitrobenzene	U	Rfd
7439-98-7	Molybdenum	L	Rfd	621-64-7	N-nitroso-di-n-propylamine	U	CPF
7440-00-8	Neodymium	S	No RfD or CPF	59-89-2	n-Nitrosomorpholine	U	No RfD or CPF
7440-02-0	Nickel	S	Rfd	95-50-1	o-Dichlorobenzene	U	Rfd
7440-03-1	Niobium	U	No RfD or CPF	88-75-5	o-Nitrophenol	U	No RfD or CPF
14797-55-8	Nitrate	L S	Rfd	95-47-6	o-Xylene	U	Rfd
14797-65-0	Nitrite	L S	Rfd	59-50-7	p-Chloro-m-cresol (4-Chloro-3-methylphenol)	U	No RfD or CPF
338-70-5	Oxalate	S	No RfD or CPF	87-86-5	Pentachlorophenol	U	Rfd/CPF
7440-05-3	Palladium	S	No RfD or CPF	108-95-2	Phenol	U	Rfd
14265-44-2	Phosphate	L S	No RfD or CPF	106-42-3	p-Xylene	U	Rfd
7440-09-7	Potassium	L S	No RfD or CPF	129-00-0	Pyrene	U	Rfd
7440-10-0	Praseodymium	S	No RfD or CPF	110-86-1	Pyridine	U	Rfd
7440-16-6	Rhodium	U	No RfD or CPF	127-18-4	Tetrachloro-ethylene	U	Rfd/CPF
7440-17-7	Rubidium	U	No RfD or CPF	108-88-3	Toluene	U	Rfd
7440-18-8	Ruthenium	S	No RfD or CPF	126-73-8	Tributyl phosphate	L S	Rfd/CPF

Table 8-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/CAS	Analyte	Detect	Available Toxicity Information
7440-19-9	Samarium	U	No RfD or CPF	75-69-4	Trichlorofluoro-methane	U	Rfd
7782-49-2	Selenium	U	Rfd	1330-20-7	Xylenes	U	Rfd
7440-21-3	Silicon	L S	No RfD or CPF	11097-69-1	Aroclor-1254	U	Rfd/CPF
7440-22-4	Silver	L S	Rfd	100-02-7	4-Nitrophenol	U	No RfD or CPF
7440-23-5	Sodium	L S	No RfD or CPF	666-14-8	Glycolate	U	No RfD or CPF
7440-24-6	Strontium	L S	Rfd	10061-02-6	Trans-1,3-Dichloropropene	U	No RfD or CPF
14808-79-8	Sulfate	L S	No RfD or CPF				

CPF = cancer potency factor available
Dose = radiological dose value available
L = analyte detected in supernatant only
L S = analyte detected in both supernatant and sludge
No RfD/CPF = no published information for a reference dose or cancer potency factor for this chemical
RfD = reference dose value available
S = analyte detected in sludge only
U = nondetect for this analyte in both supernatant and sludge (gray shaded area indicates nondetect for this analyte in both supernatant and sludge)

8.2 RESULTS FOR INDIVIDUAL CONTAMINANTS FOR POST-RETRIEVAL SINGLE-SHELL TANK C-103

Table 8-2 identifies the main contributors to the incremental lifetime cancer risk (ILCR) (industrial and residential scenarios), groundwater dose [all pathways farmer (APF) scenario], and drinking water dose for radiological components of the residual waste remaining in SST C-103. Table 8-3 identifies the primary hazardous chemicals that contribute to ILCR and the Hazard Quotient. A complete listing of all analytes for which there is either a dose (radiological), cancer potency factor (radiological and nonradiological) and reference dose (nonradiological) is provided in Tables D-1 and D-2 of Appendix D. In each of these tables, the following columns are provided.

a. **Analyte Name**.

b. **Detect** is an indicator as to whether an analyte was detected in the laboratory.

c. **Inventory**. The inventory shown here for nondetects is calculated at one-half the detection limit.

d. **WMA C Fenceline Concentration** is the maximum modeled concentration for a constituent at the WMA C fenceline over the modeling period. In some cases, individual analytes may not have a corresponding concentration at the fenceline because short-lived radionuclides will decay away before the contaminant can arrive at the WMA C

fenceline. Relatively immobile contaminants (i.e., K_d greater than 0.6 mg/L) will also result in a zero concentration at the fenceline as they will not reach the fenceline within 10,000 years (based on assumptions and transport modeling approach used).

e. **Peak Year** is the year in which the simulation estimates that peak concentration for a given analyte arrives at the fenceline.

f. **K_d** is the mobility factor used in the groundwater modeling for the analyte. The smaller the K_d, the more mobile the contaminant; if the K_d is zero, the contaminant moves with the groundwater.

g. **Half-life** is the duration in years for a radionuclide to decay to half its activity. Organic compounds were assumed not to decay (radionuclides only).

h. **ILCR Scenarios** (groundwater) are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*, for the industrial and residential exposure scenarios [including WAC-173-340 Method B (residential)].

i. **Radiological Dose Groundwater** is the estimated drinking water dose for the APF exposure scenario (radionuclides only).

j. **Radiological Dose Beta/Photon** is the drinking water dose for radionuclides using equivalent dose (radionuclides only).

k. **Hazard Quotient Scenarios** are for residential and industrial scenarios described in HNF-SD-WM-TI-707.

8.3 CUMULATIVE ANALYSIS RESULTS FOR SINGLE-SHELL TANK C-103 AND WASTE MANAGEMENT AREA C

The cumulative analysis (i.e., sum of the risk metrics) for the SST C-103 residual average and 95% UCL risk levels were calculated and are provided in this section.

a. **Average Inventory**—best estimate of the residual waste inventory computed using mean sample concentrations, mean sample density, and best estimate of the residual volume.

b. **95% Upper Confidence Level Inventory**—considered the bounding inventory. The 95% UCL of the average inventory was calculated based on uncertainties associated with the concentration, volume, and density (for solids) measurements (see Section 7.0).

The effects per performance metric associated with each inventory are given in Table 8-4. Two land use scenarios (industrial and residential) were evaluated for Hazard Index (HI) and ILCR. All effects for both the average and 95% UCL inventories were two to four orders of magnitude below the performance objectives.

Table 8-2. Estimated Maximum Incremental Lifetime Cancer Risk/Radiological Dose During the Modeling Period for Primary Radionuclides.

Analyte	Detect	Average Inventory (Ci)	WMA C Fenceline Conc. (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk Scenarios (Groundwater)[b]		Radiological Dose Groundwater (mrem/yr)[b]	Radiological Dose Beta/Photon (mrem/yr)[b]
							Industrial	Residential	All Pathway Farmer	Drinking Water
^{99}Tc	L S	4.48E-02	1.79E-01	10458	0	2.11E+05	2.46E-09	6.00E-08	3.13E-04	7.94E-04
^{129}I	S	2.99E-03	<0.001[c]	12032	0.2	1.57E+07	C/A	C/A	C/A	C/A
^{234}U	L S	1.36E-02	0	DNA	0.6	2.46E+05	0	0	0	N/A
$^{235+D}U$	L S	7.09E-04	0	DNA	0.6	7.04E+08	0	0	0	N/A
^{236}U	L S	3.74E-04	0	DNA	0.6	2.34E+07	0	0	0	N/A
$^{238+D}U$	L S	1.64E-02	0	DNA	0.6	4.47E+09	0	0	0	N/A
^{14}C	L	3.50E-03	5.40E-03	9777	0	5.73E+03	4.19E-11	3.03E-10	2.61E-05	1.08E-05
^{233}U	L S	5.85E-03	0	DNA	0.6	1.59E+05	0	0	0	N/A
Performance objective[d]							1-0E-6 to 1.0E-4[e]	1-0E-6 to 1.0E-4[e]	25[f]	4[g]

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for the radionuclides.
[b] All exposure scenarios are described in HNF-SD-WM-TI-707.
[c] Simulation predicted contaminant arrives at the fenceline, but at a concentration (<0.001 pCi/L) that is much below the minimum detection limit for standard analytical methods.
[d] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire WMA.
[e] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A, Directive* 9200.4-31P.
[f] DOE O 435.1, *Radioactive Waste Management.*
[g] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

C/A = constituent analyzed, but this risk metric was not calculated because the analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory methods to detect it.
DNA = did not arrive at fenceline within the modeling period
L = analyte detected in supernatant only
L S = analyte detected in both supernatant and sludge
N/A = radionuclide is not a beta/photon emitter.
S = analyte detected in sludge only
Shaded cells indicate nondetects in sludge or supernatant, and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

Table 8-3. Estimated Maximum Value for Incremental Lifetime Cancer Risk and Hazard Quotient per Nonradionuclides.

Analyte	Detected	Average Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[a]	Incremental Lifetime Cancer Risk Scenarios (Groundwater)[b]	Hazard Quotient Scenarios (Groundwater)[b]
						WAC-173-340 Method B	WAC-173-340 Method B
Chromium	L S	2.38E+00	9.77E-03	10481	0	No CPF	2.51E-04
Fluoride	L S	1.61E-01	<0.001[c]	10481	0	No CPF	C/A
Nitrite	L S	4.81E-01	1.97E-03	10481	0	No CPF	1.23E-06
Nitrate	L S	8.69E-01	3.57E-03	10481	0	No CPF	1.39E-07
N-nitroso-di-n-propylamine	U	5.46E-03	<0.001[c]	10481	0	C/A	No Rfd
2-Nitropropane	U	9.69E-05	<0.001[c]	10481	0	No CPF	No Rfd
1, 1, 2-Trichloroethylene	U	7.61E-05	<0.001[c]	12032	0.02	C/A	C/A
Nitrobenzene	U	6.06E-03	<0.001[c]	10481	0	No CPF	C/A
n-Butyl alcohol (1-butanol)	U	2.35E-02	<0.001[c]	10481	0	No CPF	C/A
Performance objective[d]						1.0E-06[e]	1.0[f]

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[b] All exposure scenarios are described in HNF-SD-WM-TI-707.

[c] Simulation predicted contaminant arrives at the fenceline, but at a concentration (0.001 µg/L) that is much below the minimum detection limit for standard analytical methods.

[d] Single Analyte Performance objectives apply to entire WMA, not just a single component of the WMA.

[e] *Washington Administrative Code* (WAC) 173-340-705 (2)(c)(ii), "Dangerous Waste Regulations."

[f] WAC 173-340-705 (2)(c)(i).

C/A = constituent analyzed, but this risk metric was not calculated because the analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory methods to detect it.

DNA = did not arrive at fenceline within the modeling period

L S = analyte detected in both supernatant and sludge

No CPF = no cancer potency factor available.

No RfD = no reference dose available

U = nondetect for this analyte in both supernatant and sludge

Gray shaded cells are nondetects and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

Table 8-4. Cumulative Incremental Lifetime Cancer Risk, Hazard Index, and Radiological Drinking Water Dose from Peak Groundwater Concentration Related to Residual Waste Volume in Single-Shell Tank C-103.

Metric[a]	Industrial Receptor		Residential Receptor		Performance Objective[b]
	Average Inventory	95% UCL Inventory	Average Inventory	95% UCL Inventory	
Radioactive chemicals ILCR (unitless)	2.46E-09[c]	2.94E-09[c]	6.00E-08[c]	7.16E-08[c]	1.0E-06 to 1.0E-4[e]
	(2.50E-09)[c,d]	(3.06E-09)[c,d]	(6.03E-08)[c,d]	(7.25E-08)[c,d]	
Nonradioactive chemicals ILCR (unitless)			0[c]	0[c]	1.0E-5[f]
			(0)[c,d]	(0)[c,d]	
Hazard Index (unitless)			2.53E-04[c]	3.20E-04[c]	1.0[f]
			(2.53E-04)[c,d]	(3.20E-04)[c,d]	
Dose	**Average Inventory**		**95% UCL Inventory**		**Dose**
APF (mrem/yr)	3.13E-04[c]		3.74E-04[c]		25 mrem/yr[g]
	(3.38E-04)[c,d]		(4.50E-04)[c,d]		
EPA maximum contaminant level (MCL) beta/photon emitters (mrem/yr target organ dose)	7.94E-04[c]		9.49E-04[c]		4 mrem/yr[h]
	(8.05E-04)[c,d]		(9.80E-04)[c,d]		
Groundwater Concentration	**Average Inventory**		**95% UCL Inventory**		**MCL**
^{99}Tc (pCi/L)	1.79E-01		2.13E-01		900 pCi/L
	(1.79E-01)[d]		(2.13E-01)[d]		
^{129}I (pCi/L) (detected in sludge only)	<1.0E-03		<1.0E-03		1 pCi/L
	(<1.0E-03)[d]		(<1.0E-03)[d]		
^{14}C (pCi/L) (detected in supernatant only)	<1.0E-03		<1.0E-03		2000 pCi/L
	(5.40E-03)[d]		(1.62E-02)[d]		
Chromium (µg/L)	9.77E-03		1.24E-02		100 µg/L
	(9.77E-03)[d]		(1.24E-02)[d]		
Uranium (µg/L)	<1.0E-03		<1.0E-03		30 µg/L
	(<1.0E-03)[d]		(<1.0E-03)[d]		

[a] Metric ILCR-rad were evaluated using industrial and residential land use scenarios described in HNF-SD-WM-TI-707. ILCR-nonrad and Hazard Index were evaluated using WAC 173-340-705 (4) Method B (residential).

[b] Performance objectives apply to entire WMA, not just a single component of the WMA.

[c] Analytes with a fenceline concentration of less than either 0.001 pCi/L (radioactive) or 0.001 µg/L (nonradioactive), which is a value that is well below the minimum detection limit for standard analytical methods, are not included in the total. Total does not include nondetects.

[d] Total in parenthesis includes nondetects with inventory calculated at one-half the detection limit.

[e] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A, Directive 9200.4-31P.*

[f] WAC 173-340-705 (4).

[g] DOE O 435.1, *Radioactive Waste Management.*

[h] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

8.4 INADVERTENT INTRUDER

The DOE recognizes that an inadvertent intruder may be onsite and not be discovered until after exposure has occurred. The radiological dose to an inadvertent intruder is therefore estimated as a part of this risk assessment.

The rural farmer with a dairy cow scenario was considered as the reference case in the SST performance assessment (PA), while the suburban garden and commercial farmer scenarios were sensitivity cases in the SST PA.

The dose calculated for each of the intruder scenarios in Table 8-5 are for the average and bounding inventories at 100 years and 500 years after closure. At 100 years after closure, the rural pasture, well driller, and commercial farmer are approximately 0.6, 60, and 2,600 times below the performance objectives for the average inventories, respectively, and below the performance objectives for the UCL inventory evaluations as well. However, the suburban garden scenario is approximately eight times and 1,200 times above the performance objective for the average and UCL inventories, respectively. At 500 years after closure, all inadvertent intruder scenarios are at least a factor of 25 below the performance objectives.

Table 8-5. Intruder Dose Summary for Single-Shell Tank C-103.

Years after Closure	Inventory	Inadvertent Intruder Scenario			
		SST PA Reference Case		SST PA Sensitivity Cases	
		Well Driller (mrem)	Rural Pasture (mrem/yr)	Suburban Garden (mrem/yr)	Commercial Farm (mrem/yr)
100	Average	8.2	62	876	3.8E-02
	95% UCL	10	88	1237	4.7E-02
500	Average	0.5	0.1	3.1	3.9E-03
	95% UCL	0.6	0.2	3.5	4.4E-03

Notes:
Site closure is assumed to occur on January 1, 2032.
The performance objective for the well driller is 500 mrem. The performance objective for the other scenarios is 100 mrem/yr

8.5 SUMMARY

This risk assessment is summarized in the following:

a. The effects estimated for SST C-103, using the average inventory, are three to four orders of magnitude below the performance objectives for the groundwater pathway.

b. The following analytes had the most impact per performance metric (average inventory):

1. **ILCR-Rad:** For the average inventory, ^{99}Tc contributed over 98% and over 99% of the total radiological ILCR for the industrial land use and residential land use scenarios, respectively, with ^{14}C contributing almost all of the remainder.
2. **ILCR-Nonrad:** Cr^{+6} contributes 100% of the nonradiological ILCR for the industrial land use and residential land use scenarios.
3. **HI:** Cr^{+6} contributes about 99% of the HI for WAC-173-340 Method B, with nitrate, nitrite, cerium, and, if using the 95% UCL inventory estimate, ammonia contributing the remaining HI.
4. **APF:** ^{99}Tc contributed 92.5% of the total for the APF dose, with ^{14}C contributing all of the remainder.
5. **Drinking Water Dose (Target Organ):** ^{99}Tc, with a maximum dose rate of 7.94E-04 mrem/yr, and ^{14}C, with a maximum dose rate of 1.08E-05 mrem/yr, contribute to EPA maximum contaminant level (MCL) for beta/photon emitters (mrem/yr target organ dose).
6. **Intruder Dose:** ^{90}Sr ,^{137}Cs, the plutonium isotopes, and ^{241}Am contribute most of the intruder dose, depending on the time and the scenario. ^{90}Sr and ^{137}Cs typically contribute most of the dose during the first 300 years. The plutonium isotopes and ^{241}Am contribute most of the dose after 300 years, and in the cases of the commercial farm and well driller, most of the dose after 200 years. None of the intruder cases exceed the performance objectives after 200 years.

c. Table 8-6 provides a comparison of the inventory used in DOE/ORP-2005-01 against the inventory for detected analytes calculated using the post-retrieval sample for the average inventory and the bounding inventory. For the purpose of this comparison, Table 8-6 excludes inventories calculated from the laboratory's minimum detection limit for an analyte. Inventories calculated from one half of the laboratory's minimum detection limit are included in the risk assessment analysis. For the most part there is good agreement between the Hanford Tank Waste Operations Simulator (HTWOS) predicted inventory value and the inventory from the post-retrieval sample and residual volume. The largest discrepancies exist between the estimated inventories for ^{244}Cm, ^{243}Cm, ^{233}U, and Hg, but none of these constituents exceeded 0.001 pCi/L in the groundwater at the fenceline nor did any contribute to inadvertent intruder dose.

Table 8-6. Comparison of HTWOS Predicted Inventory used in DOE/ORP-2005-01 with the Average and 95% UCL Post-Retrieval Inventories.

	Analyte[a]	DOE/ORP-2005-01[a] (HTWOS Predicted)	Average Post-Retrieval Inventory[b]	95% UCL Inventory[b]	Ratio Average/ HTWOS	Ratio Bounding/ HTWOS
Groundwater	^{14}C (Ci)	3.94E-03	3.50E-03	1.05E-02	N/A	N/A
	^{99}Tc (Ci)	7.17E-02	4.48E-02	5.35E-02	0.62	0.75
	Cr^{+6} (kg)	6.02E+00	2.38E+00	3.02E+00	0.40	0.50
	Fluoride (kg)	3.61E+00	1.61E-01	2.02E-01	0.04	0.06
	Nitrate (kg)	5.81E+00	8.69E-01	1.09E+00	0.15	0.19
	Nitrite (kg)	5.94E+01	4.81E-01	6.10E-01	0.01	0.01
Inadvertent Intruder	^{90}Sr + D (Ci)	2.48E+04	9.96E+03	1.41E+04	0.40	0.57
	^{137}Cs + D (Ci)	6.53E+02	8.78E+02	1.06E+03	1.34	1.62
	^{232}Th (Ci)	1.66E-08	1.99E-04	2.36E-04	N/A	N/A
	^{233}U (Ci)	9.80E-04	5.85E-03	6.94E-03	5.97	7.08
	^{234}U (Ci)	1.49E-02	1.36E-02	1.83E-02	0.91	1.23
	^{235}U + D (Ci)	6.34E-04	7.09E-04	8.69E-04	1.12	1.37
	^{236}U (Ci)	3.43E-04	3.74E-04	4.58E-04	1.09	1.34
	^{238}U + D (Ci)	1.52E-02	1.64E-02	2.02E-02	1.08	1.33
	^{237}Np + D (Ci)	5.04E-04	1.35E-02	1.77E-02	N/A	N/A
	^{238}Pu (Ci)	8.40E-01	1.48E+00	2.47E+00	1.76	2.94
	^{239}Pu (Ci)	4.26E+01	4.99E+00	4.99E+00	0.12	0.12
	^{240}Pu (Ci)	8.92E+00	1.04E+00	1.04E+00	0.12	0.12
	^{241}Pu + D (Ci)	3.61E+01	3.89E+00	3.89E+00	0.11	0.11
	^{241}Am (Ci)	1.94E+01	4.93E+00	7.05E+00	N/A	N/A
	^{242}Cm (Ci)	1.16E-02	3.04E-01	9.11E-01	N/A	N/A
	^{243}Cm (Ci)	5.06E-04	2.56E-02	2.56E-02	50.62	50.63
	^{244}Cm (Ci)	1.16E-02	6.39E-01	6.39E-01	55.29	55.29

[a] Inventories for contaminants having the greatest impact for groundwater or inadvertent intruder pathway.

[b] Excludes inventories in supernatant or sludge calculated from one half of the laboratory's minimum detection limit for an analyte.

HTWOS = Hanford Tank Waste Operations Simulator

N/A = Not applicable because the inventory in both supernatant and sludge was calculated from one half of the laboratory's minimum detection limit for that analyte.

9.0 ADDITIONAL RETRIEVAL TECHNOLOGIES

This section provides an analysis of the use or development of other technologies to retrieve additional waste from SST-C-103. Section 9.1 discusses the feasibility/viability of other available retrieval technologies to retrieve additional waste from SST C-103, and provides a detailed cost estimate for the deployment of an additional retrieval technology in SST C-103. Section 9.2 discusses the feasibility of developing additional retrieval technologies. Section 9.3 provides conclusions regarding the use of other technologies to retrieve additional waste from SST-C-103

9.1 FEASIBILITY/VIABILITY OF OTHER AVAILABLE WASTE RETRIEVAL TECHNOLOGIES

The feasibility/viability of other available retrieval technologies for the retrieval of additional waste from SST C-103 have been evaluated. Modified sluicing using recirculated supernatant was deployed in tank SST C-103, so technologies other than modified sluicing were considered for application to the remaining waste material in SST C-103. Available retrieval technologies are those that have been proven in the operational environment and can be readily deployed. These available retrieval technologies are the vacuum retrieval system, remote water lance (salt mantis), saltcake dissolution, rotary viper, and chemical addition.

A retrieval technology is considered feasible/viable if it could possibly remove a significant amount of additional waste from the tank. Of these available retrieval technologies, chemical addition of caustic was the only technology deemed feasible/viable, and taken forward for the completion of a cost estimate.

9.1.1 Vacuum Retrieval System

The vacuum retrieval system (VRS) consists of an articulating mast system (AMS) with a vacuum head, a vacuum pump, a slurry vessel, and a number of slurry transfer pumps. The AMS is remotely manipulated to retrieve waste from a 20-ft-diameter area on the tank floor. Vacuum pumps are used to create a vacuum to draw the waste up through the AMS and deposit the waste in the slurry vessel. From the slurry vessel, waste is pumped though an aboveground HIHTL to a DST. The AMS is comprised of a hydraulically powered articulating arm with a vacuum head that can be rotated, extended, and retracted as necessary to reach within a 20-ft diameter along the tank floor. A series of five scarifying, high-pressure, low-volume water jets, located on the outside of the vacuum head, are used to dislodge waste as needed.

A VRS system developed by Non Entry Systems Limited (NESL)[4] was deployed into the 200-series tanks in C-Farm and successfully removed waste. The VRS would not have the capacity to retrieve significant SST C-103 waste volume because much of the waste is dispersed beyond the reach of the mast, there is significant debris and large particle sizes in the tank, and

[4] Non Entry Systems Ltd., Swansea, United Kingdom.

the depth of the tank (i.e., distance waste has to travel vertically up the mast) is higher and not yet tested. Therefore, this technology is not considered feasible/viable for retrieving the residual waste in SST C-103.

It may be possible to combine the VRS with other supplemental technologies [e.g., remote water lance (RWL), mobile retrieval tool (MRT), or squeegee] to move the waste within the pickup zone of the vacuum. However, this would only address one limitation of the technology (i.e., much of the waste being dispersed beyond the reach of the mast). Therefore, combining the VRS with other supplemental technologies is not considered feasible/viable for retrieving the residual waste in SST C-103.

9.1.2 Remote Water Lance (Salt Mantis)

The RWL assists sluicing retrieval of hard saltcake waste. It uses a low-volume, high-pressure water lance to break up hard layers and push waste to the pump. TMR developed the "Salt Mantis"[5] RWL recently deployed in SST S-112. The RWL is lowered through a 12-in. riser to the bottom of the tank, where it can be maneuvered across the waste surface like an ITV. The high-pressure water is delivered in close proximity to the waste. The high-pressure system cuts into the hard waste material, increases effective surface area for dissolution, and breaks the waste into smaller pieces. It is most effective in a submerged environment to break up large stationary forms of waste. The technology would not be effective in breaking up hard mobile (i.e., nonstationary) debris since the waste would be pushed out of the way with nothing holding it in place. Additionally, the current version of the RWL is susceptible to being caught in wires and other debris. This may be remedied in future versions of the technology; however, there is not a currently available unit that can navigate through the debris in SST C-103 (see Section 6.1.3). For the reasons listed, it is not likely that the RWL technology, operated in concert with the existing retrieval system in SST C-103, would significantly reduce the volume of residual waste. The RWL is therefore not considered feasible/viable for retrieving the residual waste in SST C-103.

9.1.3 Saltcake Dissolution

Saltcake dissolution is a process by which water is added to a tank and allowed to dissolve the soluble components of the waste, and the resulting brine is then pumped out of the tank. Saltcake dissolution can be an effective technology for retrieving porous saltcake material where water addition is practical. Saltcake dissolution was demonstrated at SST S-112 (RPP-RPT-27406, *Demonstration Retrieval Data Report for Single-Shell Tank 241-S-112*). Because the residual waste in SST C-103 is not saltcake (see Section 6.0), this technology is not considered feasible/viable for retrieving the residual waste in SST C-103.

9.1.4 Rotary Viper

The Rotary Viper is a rotating spray system mounted on a long shaft that can be inserted directly into tank waste. The Rotary Viper sprays water from nozzles at approximately 32,000 psi at a flow rate of approximately 6 to 12 gpm. The water dissolves the waste and washes it to a central

[5] TMR Salt Mantis is a Mantis technology of TMR Associates, Lakewood, Colorado.

pump for removal. The Rotary Viper can also be positioned to clean pump screens which can become clogged with waste as retrieval progresses. Because the Rotary Viper uses low volumes of water, it helps minimize the amount of waste to be transferred to the double-shell tanks. The Rotary Viper has been tested in the Hanford Cold Test Facility using a mixture of potter's clay, sand and gravel; and has been deployed at SST S-102. Because the residual waste in SST C-103 is not in a hard waste layer to be broken up and does not present a solid surface to spray against (see Section 6.0), this technology is not considered feasible/viable for retrieving the residual waste in SST-C-103.

9.1.5 Chemical Addition

Chemical addition would consist of adding chemicals to the tank residuals to dissolve and loosen waste. Chemical addition technology was used in SST C-106 (RPP-20577, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*) and more recently in SST S-112 (RPP-RPT-27406). The process relies on the reaction of a chemical with the residual waste to either decrease the particle size or to convert insoluble material to soluble or vapor form to decrease the residual waste material. Decreasing the particle size enables the smaller waste pieces to be more easily suspended in the liquid and pumped out of the tank.

For SST C-106 retrieval, oxalic acid was added to the tank to dissolve residual wastes and reduce particle size. Laboratory tests at the Savannah River Site and Hanford Site showed the oxalic acid was generally as effective as any other acid for dissolving the sludges in the storage tanks (RPP-17158, *Laboratory Testing of Oxalic Acid Dissolution of Tank 241-C-106 Sludge*). Oxalic acid can be used effectively on iron oxides but is not as effective on other materials. Similarly, caustic addition can be effective on alumina or silica waste forms. During the retrieval process, after chemical addition, pH or density is monitored to determine when the chemical reaction has achieved diminishing returns. One disadvantage to oxalic acid chemical addition is that following use of this technology, the waste must be neutralized, which generates significant volumes of oxalate solids in the tank. Based on sample analysis results, iron makes up less than 10% of the remaining solids in SST C-103. It is unlikely that an oxalic acid digest of the remaining solids would have a significant effect to improve the retrieval of SST C-103.

In SST S-112, a caustic solution (NaOH) has been added to dissolve waste and assist in reducing particle size. The caustic solution addition to SST S-112 appears to have significantly aided the retrieval efforts. Sample analysis results show that aluminum is the single largest constituent of the remaining solid waste in SST C-103 (see Appendix B). Some mineral forms of aluminum are very soluble in strong caustic solutions. Other mineral forms of aluminum are very difficult to dissolve. In all cases the dissolution is a very slow process. At typical tank temperatures it would take at least 6 months for the reaction to complete. If a strong caustic solution (~25 wt%) were placed in the tank and allowed to digest for 6 months to a year, it may be possible to either dissolve or break up a significant fraction of the remaining waste. However, laboratory testing would be required to establish how effective this treatment would be.

9.1.3.1 Cost Estimate. A detailed preliminary cost estimate for deploying caustic addition in SST C-103 to treat the remaining waste is provided in Appendix E. The total estimated cost for use of this technology is $6.5 million (Appendix E). This is a total of all of the project management, design, procurement, installation, startup and readiness, chemical, and operational

costs. These activities would include but are not limited to preparing work packages, design and procurement of a system to add and measure the chemical, periodic sampling to assess effectiveness of the caustic, final transfer of waste to a DST, and documentation of the process in an RDR. It should be noted that this $6.5 million estimate is based on a number of assumptions (e.g., operating time), which cannot be validated without additional analysis, including waste testing.

9.1.3.2 Estimate of Additional Waste that could be Removed. Without additional analysis, it is not possible to predict how successful caustic addition followed by additional modified sluicing may be and how much additional waste may be removed through application of this technology. Because the application of modified sluicing satisfied the requirements set forth in HFFACO Milestone M-45-00, no additional analysis or additional retrieval are planned.

9.2 FEASIBILITY OF DEVELOPING ADDITIONAL TECHNOLOGIES

New technologies are under development that could possibly enhance retrieval performance for future tanks, but these were not available for SST C-103. A brief description of these technologies follows in Sections 9.2.1 through 9.2.3. The technologies discussed are at varying stages of development. Some require substantial investment in research and development while others have already been used elsewhere but would need to be adapted for use at the Hanford Site. Activities needed to deploy these technologies could include engineering, procurement, testing, and construction.

9.2.1 AEA Technology Power Fluidics™[6] and Russian Pulsatile Mixer Pumps

Two innovative pumps have been developed and demonstrated. They have similar characteristics and purposes. More detailed information regarding these technologies is included in RPP-20577.

The AEA power fluidic pump is designed for mixing and pumping tank waste up and out of tanks using vacuum and pressurization cycles to draw waste into a vessel and transfer waste up and out through an eductor. This technology has been evaluated for several years. The Power Fluidics pumping system was tested by the Hanford Site SST retrieval program to demonstrate potential for dissolution of saltcake waste and mobilization and retrieval of insoluble solids (e.g., sludge waste). Testing results indicate that the fluidic mixing and pumping system was capable of transferring waste but some of the key features needed further demonstration and refinement.

The Russian Integrated Mining and Chemical Combine fluidic concept for mixing and pumping tank waste is similar to the power fluidics system but has design details different for the pump mechanism and nozzles. While the power fluidics system has no moving parts in the pump, the Russian unit uses a simple check valve mechanism. Both systems use two distinct cycles, fill and discharge, to perform a mixing action. Operation of this system, like the power fluidics system, uses controlled water volumes, which minimizes total water use but would not be ideal for use in an "assumed leaker."

[6] AEA Technology Power Fluidics™ is a registered trademark of AEA Technology, Glengarnock, United Kingdom.

The overarching conclusion for SST C-103 is that this technology does not provide any new methods or means of moving the waste to the pump intake. In that regard, the technology offers no improvement over the existing modified sluicing system in SST C-103. Therefore, even though the technology has potential for future use in tank retrievals (with further development), it is not suitable for SST C-103. Likewise, all central pumping systems that do not offer a new means (or improvements over the SST C-103 sluicing system) for moving waste to the pump intake would not be effective on SST C-103 residual waste.

9.2.2 Mobile Retrieval Tool

One of the lessons learned from the past and ongoing retrievals is that it may be useful to have a technology that takes the retrieval pumping function to the waste. The mobile retrieval tool (MRT) is such a tool. The MRT is comprised of three subelements: (1) remote controlled platform that can navigate around the tank, (2) pump and transfer system that is the mechanism to move waste up and out of the tank, and (3) if necessary, booster pumps and conditioning systems that transfer an optimized waste form to the DST system. Two MRT prototypes were demonstrated at the Hanford Cold Test Facility in 2006. These vendor-specific MRTs are described in Sections 9.2.2.1 through 9.2.2.3.

9.2.2.1 Sand Mantis – TMR Associates. The Sand Mantis[7] combines a jet-pump technology with the existing "Mantis" chassis (i.e., same body as Salt Mantis RWL used in SST S-112). The Sand Mantis jet pump sucks up waste in the front end of the unit and passes the waste stream through a high energy venturi powered by a 32,000 psi water jet. The waste is then sent through an umbilical cord up and out of the tank. As the waste passes through the venturi, the size of the particles is reduced. In certain conditions an inline booster pump may be required to support transfer to a DST tank. The Sand Mantis was demonstrated to be able to pump waste up and out of an S-Farm mock tank at the Hanford Cold Test Facility while operating in submerged and emerged conditions. The retrieval rates of the prototype version were significantly lower than required, and the unit is less mobile than other MRTs; however, the technology shows promise for future applications. This technology is currently not available for deployment. Significant development and testing would be required prior to deployment in SST C-103.

9.2.2.2 FoldTrack – Non Entry Systems, Ltd. The FoldTrack[8] has an innovative design allowing a very powerful tracked platform to be lowered through a 12-in. riser. In addition, the FoldTrack is equipped with an eductor pump that entrains waste pumping it up and out of the tank, a squeegee that can aid in pushing waste to a central location, and a spray-bar equipped with 10,000 psi nozzles. The eductor pump is powered by 150 psi 80 gpm water flow. The source of water can be fresh raw water or recycled supernate. The waste is then sent through an umbilical cord up and out of the tank. The unit is heavy and performs particle size reduction by running over waste. In certain conditions an inline booster pump may be required to support transfer to a DST tank. The FoldTrack was demonstrated to be able to pump waste up and out of an S-Farm mock tank at the Hanford Cold Test Facility while operating in submerged and

[7] TMR Sand Mantis is a Mantis technology of TMR Associates, Lakewood, Colorado.
[8] NESL FoldTrack is a product of Non Entry Systems Ltd., Swansea, United Kingdom.

emerged conditions. The retrieval rates of the prototype version were moderate but not sufficient to meet current expectations; however, the technology shows promise for future applications. This technology is currently not available for deployment. Significant development and testing would be required prior to deployment in SST C-103.

9.2.2.3 Squeegee. The MRTs and RWLs can be fitted with a squeegee that enables the device to push waste to a central location or to an existing retrieval pump. A prototype unit was built for use with the Salt Mantis RWL in SST S-112, but was not deployed. The performance of squeegees is unknown at this time and none of the platforms needed to push the squeegee are available for deployment; therefore, development and testing would be required prior to deployment in SST C-103.

9.2.3 Mobile Retrieval System

The MRS consists of a VRS in combination with an in-tank vehicle (ITV). A prototype was built by ESL and demonstrated at the Hanford Cold Test Facility. The VRS as described in Section 9.1.1 would be installed through a riser in the tank, but due to its limited reach, it would be supplemented by an ITV that could be moved throughout the tank, breaking up and transporting waste within the range of the VRS mast. The ITV crushes and breaks up waste using its tracks or wheels. After breaking up the waste, the ITV pushes the waste into the 10-ft effective radius of the VRS mast. The technology has not yet been developed or tested under these conditions (i.e., 100-series tank with significant debris), so it is not currently available for deployment in SST C-103.

9.3 CONCLUSIONS

The SST C-103 modified sluicing deployment successfully removed waste to the limit of the technology and satisfied requirements set out in HFFACO Milestone M-45-00. However, it appears that additional waste removal may be possible using caustic addition followed by redeployment of a modified sluicing system. A preliminary cost estimate for using caustic addition followed by additional modified sluicing is provided in Appendix E as $6.5 million. Without additional analysis, it is not possible to predict how successful caustic addition followed by additional modified sluicing may be and how much additional waste may be removed through application of this technology. Because the application of modified sluicing satisfied requirements set forth in HFFACO Milestone M-45-00, no additional analysis or additional retrieval is planned.

10.0 RECOMMENDATIONS FOR FURTHER ACTION

This section provides recommendations for further actions and discusses opportunities to refine waste retrieval technologies based on lessons learned from the SST C-103 retrieval.

10.1 RECOMMENDATIONS FOR SINGLE-SHELL TANK 241-C-103

As demonstrated by information presented in this RDR, retrieval of SST C-103 is complete. DOE has no recommendation for additional retrieval actions at SST C-103 because M-45-00 retrieval criteria for this tank are satisfied as shown in Sections 5.0 and 6.0 of this RDR.

10.2 OPPORTUNITIES FOR IMPROVEMENT OF WASTE RETRIEVAL OPERATIONS AT OTHER SINGLE-SHELL TANKS BASED ON LESSONS LEARNED FROM SINGLE-SHELL TANK C-103

Lessons learned from the retrieval of SST C-103 were captured in a lessons learned meeting that identified opportunities to improve future retrieval operations, as well as specific lessons proposed for implementation as budget and time allows.

Opportunities for improvement for future retrieval operations include physical modifications to equipment (e.g., minimizing hose length), operational changes (e.g., operate sluicer continuously), work planning [e.g., determine sampling requirements, prepare engineering change notices (ECN), and design and fabricate equipment to support sampling in advance].

Lessons learned from SST C-103 retrieval that are proposed for potential implementation in future retrievals are the following:

a. Ensure Hanford National Electrical Code®[9] (NEC) Inspector performs final inspection of fabricated electrical equipment prior to shipment. Several issues were identified during vendor inspections which were corrected by vendors prior to shipment. Exhausters (3000 cfm) were not inspected prior to shipment and had numerous electrical issues requiring significant rework.

b. Consider changes to the camera and lighting equipment including finding equipment with longer operational life, designing a system to facilitate camera removal and repair, allowing design flexibility for installation of equipment in multiple risers, including a requirement in a procedure to retract the camera into a tophat during periods of downtime to extend camera life, not installing the camera in the ventilation duct, using reliable, bright supplemental lighting like the Luminaire[10] used in SST S-112, and procedures for camera and light installation and removal.

[9] National Electrical Code® is a registered trademark of the National Fire Protection Association, Quincy, Massachusetts.
[10] Product of Luminaire Lighting, Edison New Jersey.

c. Ensure all slurry pumps have height adjustment capability to minimize plugging. SST C-103 and S-Farm used fixed height pumps; both experienced plugging problems. The new adjustable height pump worked very well to solve the plugging issues.

d. Determine waste sampling requirements, prepare ECNs and design and fabricate equipment to support sampling well in advance to avoid operational delays.

e. Minimize the length of hydraulic hoses and quick disconnects. This was a lesson learned from SST C-103 that was corrected in the SST C-108 design.

f. Write the Waste Compatibility Assessments (WCA) with as much flexibility as possible and have a method for tracking the volumes transferred against the WCA to prevent inadvertently going over the transfer limit established in the WCA.

g. Include as many tanks as possible in the TWRWP for a given retrieval technology. Keep the TWRWP as general as possible to minimize the need for revisions.

h. Modify operating procedure to eliminate maximum sluicer flow of 120 gpm to allow two-sluicer operation at maximum supernate flow available. SST C-103 was limited to 120 gpm based on a statement in the TWRWP, which notes that the sluicer maximum flow rate is nominally 120 gpm.

i. Ensure that the sluicers will have the capacity to reach the entire tank wall and stiffener rings while staying below the top of the tank liner. A significant volume of waste in SST C-103 is on the walls and stiffener rings. The SST C-103 sluicers do not seem to have the capacity to reach the upper stiffener ring.

j. Operate the sluicer continuously during retrieval system operation and possibly around-the-clock. Long periods spent with sluicer stationary resulted in a reduced efficiency.

k. Be more responsive to changing conditions (i.e., do not wait until the following shift to change valving or switch a sluicer).

l. Ensure equipment is properly maintained (e.g., the flow meter on the water skid was nonfunctional; PI-101 reading low).

m. For the final waste volume estimate, it is important to have a good video recording made in accordance with the guidelines for taking the video. It is important to capture all surfaces of the tank interior and to provide a good look at the tank bottom using a low camera elevation.

The application of lessons learned to future retrievals will be at the discretion of the retrieval project manager.

11.0 REFERENCES

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

65 FR 76708, 2000, "National Primary Drinking Water Regulations; Radionuclides; Final Rule," *Federal Register*, Vol. 65, pp. 76707-76753 (December 7).

AIR 05-407, 2005, *Radioactive Air Emissions Notice of Construction for Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II – Waste Retrieval Operations*, Washington State Department of Health, Office of Radiation Protection, Olympia, Washington.

ATL-MP-1011, 2005, *ATL Quality Assurance Project Plan for 222-S Laboratory*, Rev. 1, Applied Technologies and Laboratories International, Inc., Richland, Washington.

Autodesk, Land Desktop, 2004, Release R16.0, Autodesk, Inc., San Raphael, California.

DE05NWP-002, 2005, *Approval of Criteria and Toxics Air Emissions Notice of Construction (NOC) Application for Operations of Waste Retrieval Systems in Single-Shell Tank (SST) Farms as supplemented with C Farm Exhauster Operations*, Rev. 1, Washington State Department of Ecology, Richland, Washington.

DOE-EM/GJ1082-2006, 2006, *Hanford Geophysical Logging Project, Campbell Pacific Nuclear Moisture Gauge Calibration Certificate*, S. M. Stoller Corporation, Grand Junction, Colorado.

DOE O 435.1, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

DOE/ORP-2005-01, 2006, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington.

EPA/540/1-89/002, 1989, *Risk Assessment Guidance for superfund volume I Human Health Evaluation Manual (Part A) Interim Final*, U.S. Environmental Protection Agency, Washington D.C.

EPA/540/R-99/006, 1999, *Radiation Risk Assessment at CERCLA Sites: Q & A*, Directive 9200.4-31P, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington D.C.

GJO-2004-603-TAC, 2006, *Hanford Tank Farms Vadose Zone Monitoring Project, 2002 Recalibration of the Radionuclide Assessment System*, S. M. Stoller Corporation, Grand Junction, Colorado.

H-14-010613, 2005, *Waste Storage Tank (WST) Riser Data*, Sheet 1, Rev. 13, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-14-106535, 2004, *C Farm HRR LDM Installation and Interface Details*, Sheets 1-9, Rev. 1, U.S. Department of Energy, Office of River Protection, Richland, Washington.

HNF-EP-0182, 2006, *Waste Tank Summary Report for Month Ending May 31, 2006*, Rev. 218, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-TI-707, 2004, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-TSR-006, 2005, *Technical Safety Requirements for Tank Farms*, Rev. 4L, CH2M HILL Hanford Group, Inc., Richland, Washington.

OSD-T-151-00031, 2003, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, CH2M HILL Hanford Group, Inc., Richland, Washington.

PNNL-13895, 2003, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14903, 2004, *Hanford Tanks 241-C-203 and 241-C-204: Residual Waste Contaminant Release Model and Supporting Data*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

RPP-6924, 2000, *Statistical Methods for Estimating the Uncertainty in the Best-Basis Inventories*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-7625, 2004, *Best Basis Inventory Process Requirements*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-10604, 2002, *Ex-Tank LDMM Technology Assessment and Down Select Report*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-12711, 2005, *Temporary Waste Transfer Line Management Program Plan*, Rev. 3B, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-17158, 2003, *Laboratory Testing of Oxalic Acid Dissolution of Tank 241-C-106 Sludge*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20577, 2004, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2005, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21895, 2006, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-23403, 2006, *Single-Shell Tank Component Closure Data Quality Objectives,* Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-23403, 2006, *Single-Shell Tank Component Closure Action Data Quality Objectives*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-24576, 2005, *HRR LDM Data Processing, Assessment, and Reporting Procedure for C-Farm*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-30121, 2006, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Testing Report*, Rev. 0A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-31159, 2006, *Post-Retrieval Waste Volume Determination for Single-Shell Tank 241-C-103*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-CALC-32136, 2007, *Leak Detection Monitoring Calculation for Single-Shell Tank 241-C-103*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-23827, 2005, *Sampling and Analysis Plan for Single-Shell Tank Component Closure*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-25193, 2005, *Process Control Plan for Tank 241-C-103 Waste Retrieval*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-28778, 2006, *Corrosion Mitigation and Compatibility 2006 Grab Sampling and Analysis Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-29586, 2006, *Grab Sampling and Analysis Plan for Residual Waste Liquid in Tank 241-C-103*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-29587, 2006, *Sampling and Analysis Plan for Residual Waste Solids in Tank 241-C-103*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-22891, 2004, *Revised Methodology to Calculating Residual Waste Volume at 95% Confidence Interval*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-23412, 2005, *Hanford Tank Waste Operations Simulator Model Data Package for the Development Run for the Refined Target Case*, Rev. 0A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-25160, 2006, *Waste Compatibility Assessment of Tank 241-C-103 Waste with Tank 241-AN-106 Waste and Tank 241-AN-106 Waste with Tank 241-C-103 Waste,* Rev. 1A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-27406, 2005, *Demonstration Retrieval Data Report for Single-Shell Tank 241-S-112*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-29777, 2006, *Final Report for Tank 241-AN-106 Grab Samples in Support of Corrosion Mitigation and Compatibility Programs*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-31239, 2007, *Final Report for Tank 241-C-103 Liquid Grab Samples in Support of the Single-Shell Tank Component Closure Program,* Rev. 0A, ATL International, Inc, Richland, Washington.

RPP-RPT-31843, 2006, *High-Resolution Resistivity Leak Detection and Monitoring Final Report for Single-Shell Tank 241-C-103 Retrieval Campaign*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-31949, 2007, *Final Report for Tank 241-C-103 Solid Samples in Support of the Single-Shell Tank Component Closure Program*, Rev. 0C, ATL International, Inc, Richland, Washington.

RPP-RPT-32376, 2007, *Tank 241-C-103 Residual Waste Inventory Estimates for Component Closure Risk Assessment*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-33433, 2007, 241-C-103 *Tank Waste Retrieval Project Final Report of Drywell Monitoring Data*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

SVF 1146, 2006, "Calculate the composition of tank AN-106 after transfers from C-201 and C-103 and tranfer [*sic*] to AW-106," Rev. 1, CH2M HILL Spreadsheet Verification and Release Form, CH2M HILL Hanford Group, Inc., Richland, Washington.

SW-846, 1986, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*, as amended, http://www.epa.gov/sw-846/sw846.htm, U.S. Environmental Protection Agency, Washington, D.C.

TFC-ENG-CHEM-P-47, 2005, *Single-Shell Tank Retrieval Completion Evaluation*, Rev. A-1, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ESHQ-ENV_FS-C-01, 2005, *Environmental Notification*, Rev. B-3, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-OPS-OPER-C-24, 2005, *Occurrence Reporting and Processing of Operations Information*, Rev. B-3, CH2M HILL Hanford Group, Inc., Richland, Washington.

TO-040-350, 2006, *Obtain Drywell Data Using Radionuclide Assessment System,* Rev. C-0, CH2M HILL Hanford Group, Inc., Richland, Washington.

TO-220-108, 2006, *Overground Transfer from 241-C-103 to AN-106 and Sluicing of Tank 241-C-10,* Rev. A-16, CH2M HILL Hanford Group, Inc., Richland, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code,* as amended.

APPENDIX A

PRE-RETRIEVAL BEST BASIS INVENTORY FOR SINGLE-SHELL TANK C-103

Table A-1. Single-Shell Tank C-103 Total Pre-Retrieval Inventory.

Analyte	Total Pre-Retrieval Sludge Inventory	Inventory Units
^{106}Ru	8.01E-06	Ci
^{113m}Cd	2.78E+00	Ci
^{125}Sb	3.98E-01	Ci
^{126}Sn	1.92E-01	Ci
^{129}I	7.49E-02	Ci
^{134}Cs	1.77E-02	Ci
^{137}Cs	3.97E+04	Ci
^{137m}Ba	3.74E+04	Ci
^{14}C	6.93E-01	Ci
^{151}Sm	4.35E+04	Ci
^{152}Eu	7.16E+00	Ci
^{154}Eu	1.95E+03	Ci
^{155}Eu	9.33E+02	Ci
^{226}Ra	2.16E-06	Ci
^{227}Ac	1.53E-05	Ci
^{228}Ra	8.22E-05	Ci
^{229}Th	7.78E-07	Ci
^{231}Pa	2.93E-05	Ci
^{232}Th	1.98E-06	Ci
^{232}U	1.81E-03	Ci
^{233}U	1.10E-01	Ci
^{234}U	1.43E+00	Ci
^{235}U	6.09E-02	Ci
^{236}U	3.29E-02	Ci
^{237}Np	5.99E-02	Ci
^{238}Pu	2.85E+01	Ci
^{238}U	1.46E+00	Ci
^{239}Pu	9.93E+02	Ci
^{240}Pu	2.13E+02	Ci
^{241}Am	2.03E+03	Ci
^{241}Pu	1.08E+03	Ci
^{242}Cm	1.25E+00	Ci
^{242}Pu	9.53E-03	Ci
^{243}Am	1.01E+00	Ci
^{243}Cm	5.44E-02	Ci
^{244}Cm	1.24E+00	Ci
^{3}H	2.96E+01	Ci

Analyte	Total Pre-Retrieval Sludge Inventory	Inventory Units
^{59}Ni	1.14E+01	Ci
^{60}Co	2.26E+02	Ci
^{63}Ni	1.06E+03	Ci
^{79}Se	4.63E-02	Ci
^{90}Sr	1.29E+06	Ci
^{90}Y	1.29E+06	Ci
^{93m}Nb	2.29E+00	Ci
^{93}Zr	2.75E+00	Ci
^{99}Tc	1.45E+01	Ci
Al	3.82E+04	kg
Bi	8.52E-02	kg
Ca	3.31E+03	kg
Cl	2.51E+02	kg
Cr	3.27E+02	kg
F	4.09E+02	kg
Fe	2.44E+04	kg
Hg	3.81E+01	kg
K	3.60E+02	kg
La	0.00E+00	kg
Mn	6.78E+02	kg
Na	1.73E+04	kg
Ni	7.24E+02	kg
NO_2	5.08E+03	kg
NO_3	5.07E+02	kg
Oxalate	9.41E+02	kg
Pb	1.67E+03	kg
PO_4	1.94E+03	kg
Si	1.93E+04	kg
SO_4	9.65E+02	kg
Sr	7.15E+01	kg
TIC as CO_3	1.08E+04	kg
TOC	5.25E+03	kg
U Total	4.37E+03	kg
Zr	5.10E+03	kg

TIC = total inorganic carbon
TOC = total organic carbon

APPENDIX B

SINGLE-SHELL TANK C-103 RESIDUAL WASTE CONCENTRATIONS AND INVENTORIES

Table B-1. Single-Shell Tank C-103 Residual Liquid Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
1,1,1-Trichloroethane	71-55-6	<	6.00E-04	µg/mL	1.00E+00
1,1,2,2-Tetrachloroethane	79-34-5	<	8.60E-04	µg/mL	1.00E+00
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<	1.68E-03	µg/mL	1.00E+00
1,1,2-Trichloroethane	79-00-5	<	5.40E-04	µg/mL	1.00E+00
1,1-Dichloroethene	75-35-4	<	7.80E-04	µg/mL	1.00E+00
1,2,4-Trichlorobenzene	120-82-1	<	2.55E-02	µg/mL	1.00E+00
1,2-Dichlorobenzene	95-50-1	<	7.11E-02	µg/mL	1.00E+00
1,2-Dichloroethane	107-06-2	<	5.40E-04	µg/mL	1.00E+00
1,4-Dichlorobenzene	106-46-7	<	1.47E-02	µg/mL	1.00E+00
1-Butanol	71-36-3	<	3.31E-01	µg/mL	1.00E+00
2,4,5-Trichlorophenol	95-95-4	<	1.63E-02	µg/mL	1.00E+00
2,4,6-Trichlorophenol	88-06-2	<	1.72E-02	µg/mL	1.00E+00
2,4-Dinitrotoluene	121-14-2	<	1.35E-02	µg/mL	1.00E+00
2,6-Bis(1,1-dimethylethyl)-4-methylphenol	128-37-0	<	9.71E-02	µg/mL	1.00E+00
2-Butanone	78-93-3		2.34E-02	µg/mL	3.95E-02
2-Chlorophenol	95-57-8	<	2.39E-02	µg/mL	1.00E+00
2-Ethoxyethanol	110-80-5	<	7.06E-02	µg/mL	1.00E+00
2-Methylphenol	95-48-7	<	2.06E-02	µg/mL	1.00E+00
2-Nitrophenol	88-75-5	<	2.24E-02	µg/mL	1.00E+00
2-Nitropropane	79-46-9	<	2.06E-03	µg/mL	1.00E+00
3-Methyl-2-butanone	563-80-4	<	1.60E-03	µg/mL	1.00E+00
4-Chloro-3-methylphenol	59-50-7	<	1.74E-02	µg/mL	1.00E+00
4-Nitrophenol	100-02-7	<	1.23E-02	µg/mL	1.00E+00
Acenaphthene	83-32-9	<	2.52E-02	µg/mL	1.00E+00
Acetate	71-50-1	<	2.54E+00	µg/mL	1.00E+00
Acetone	67-64-1		1.73E-01	µg/mL	1.21E-01
Aluminum	7429-90-5		1.21E+00	µg/mL	4.65E-01
Americium-241	14596-10-2	<	4.99E-06	µg/mL	1.00E+00
Americium-241	14596-10-2	<	4.14E-04	µg/mL	1.00E+00
Ammonium	14798-03-9		4.23E+00	µg/mL	2.43E-01
Antimony	7440-36-0	<	2.80E-02	µg/mL	1.00E+00
Antimony-125	14234-35-6	<	2.74E-04	µg/mL	1.00E+00
Aroclor 1016	12674-11-2	<	5.40E-03	µg/mL	1.00E+00

Table B-1. Single-Shell Tank C-103 Residual Liquid Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Aroclor 1221	11104-28-2	<	1.01E-03	µg/mL	1.00E+00
Aroclor 1232	11141-16-5	<	6.57E-03	µg/mL	1.00E+00
Aroclor 1242	53469-21-9	<	3.71E-03	µg/mL	1.00E+00
Aroclor 1248	12672-29-6	<	1.86E-03	µg/mL	1.00E+00
Aroclor 1254	11097-69-1	<	5.76E-04	µg/mL	1.00E+00
Aroclor 1260	11096-82-5	<	4.09E-03	µg/mL	1.00E+00
Arsenic	7440-38-2	<	5.90E-02	µg/mL	1.00E+00
Barium	7440-39-3		4.60E-02	µg/mL	8.48E-01
Benzene	71-43-2	<	5.40E-04	µg/mL	1.00E+00
Beryllium	7440-41-7	<	1.20E-03	µg/mL	1.00E+00
Bismuth	7440-69-9	<	1.02E-01	µg/mL	1.00E+00
Boron	7440-42-8		5.87E-01	µg/mL	4.74E-01
Bromide	24959-67-9	<	1.38E+00	µg/mL	1.00E+00
Butylbenzylphthalate	85-68-7	<	1.47E-02	µg/mL	1.00E+00
Cadmium	7440-43-9	<	3.00E-03	µg/mL	1.00E+00
Calcium	7440-70-2		1.15E+01	µg/mL	3.33E-02
Carbon disulfide	75-15-0	<	9.60E-04	µg/mL	1.00E+00
Carbon tetrachloride	56-23-5	<	8.80E-04	µg/mL	1.00E+00
Carbon-14	14762-75-5		3.24E-06	µg/mL	2.59E-01
Cerium	7440-45-1	<	1.50E-02	µg/mL	1.00E+00
Cerium/Praseodymium-144	Not Available	<	5.93E-04	µg/mL	1.00E+00
Cesium-134	13967-70-9	<	5.25E-05	µg/mL	1.00E+00
Cesium-137	10045-97-3		9.91E-02	µg/mL	8.17E-03
Chloride	16887-00-6		3.15E+00	µg/mL	2.49E-02
Chlorobenzene	108-90-7	<	5.40E-04	µg/mL	1.00E+00
Chloroform	67-66-3	<	6.60E-04	µg/mL	1.00E+00
Chromium	7440-47-3		1.65E-01	µg/mL	1.92E-02
Cobalt	7440-48-4	<	8.00E-03	µg/mL	1.00E+00
Cobalt-60	10198-40-0	<	1.75E-05	µg/mL	1.00E+00
Copper	7440-50-8	<	1.40E-02	µg/mL	1.00E+00
Cresol	1319-77-3	<	4.10E-02	µg/mL	1.00E+00
Cresol (m & p)	Not Available	<	2.06E-02	µg/mL	1.00E+00
Curium-242	15510-73-3	<	4.99E-06	µg/mL	1.00E+00
Curium-243/244	Not Available	<	4.99E-06	µg/mL	1.00E+00
Cyanide	57-12-5		2.81E-01	µg/mL	3.63E-02

Table B-1. Single-Shell Tank C-103 Residual Liquid Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Cyclohexanone	108-94-1	<	4.36E-02	µg/mL	1.00E+00
Di-n-butylphthalate	84-74-2	<	1.49E-02	µg/mL	1.00E+00
Di-n-octylphthalate	117-84-0	<	1.70E-02	µg/mL	1.00E+00
Ethyl acetate	141-78-6	<	5.80E-04	µg/mL	1.00E+00
Ethyl ether	60-29-7	<	7.80E-04	µg/mL	1.00E+00
Ethylbenzene	100-41-4	<	1.62E-03	µg/mL	1.00E+00
Europium	7440-53-1	<	1.00E-03	µg/mL	1.00E+00
Europium-152	14683-23-9	<	7.95E-05	µg/mL	1.00E+00
Europium-154	15585-10-1	<	5.26E-05	µg/mL	1.00E+00
Europium-155	14391-16-3	<	1.39E-04	µg/mL	1.00E+00
Fluoranthene	206-44-0	<	1.53E-02	µg/mL	1.00E+00
Fluoride	16984-48-8		1.30E+00	µg/mL	1.35E-02
Formate	12311-97-6	<	2.54E+00	µg/mL	1.00E+00
Glycolate	666-14-8	<	2.10E+00	µg/mL	1.00E+00
Hexachlorobutadiene	87-68-3	<	1.40E-02	µg/mL	1.00E+00
Hexachloroethane	67-72-1	<	9.51E-03	µg/mL	1.00E+00
Hexone	108-10-1		1.39E-03	µg/mL	3.37E-02
Hydroxide	14280-30-9		1.01E-01	µg/mL	4.03E-02
Iodine-129	15046-84-1		4.36E-06	µg/mL	8.94E-02
Iron	7439-89-6		4.30E-02	µg/mL	6.96E-01
Isobutanol	78-83-1	<	3.76E-01	µg/mL	1.00E+00
Lanthanum	7439-91-0	<	8.00E-03	µg/mL	1.00E+00
Lead	7439-92-1	<	3.60E-02	µg/mL	1.00E+00
Lithium	7439-93-2	<	9.00E-03	µg/mL	1.00E+00
Magnesium	7439-95-4		2.42E+00	µg/mL	2.08E-02
Manganese	7439-96-5		7.83E-03	µg/mL	1.03E-01
Mercury	7439-97-6		2.49E-03	µg/mL	1.06E-01
Methylenechloride	75-09-2	<	9.00E-04	µg/mL	1.00E+00
Molybdenum	7439-98-7		3.86E-02	µg/mL	8.75E-03
Morpholine, 4-nitroso-	59-89-2	<	1.44E-01	µg/mL	1.00E+00
Naphthalene	91-20-3	<	3.14E-02	µg/mL	1.00E+00
Neodymium	7440-00-8	<	8.00E-03	µg/mL	1.00E+00
Neptunium-237	13994-20-2	<	2.12E-04	µg/mL	1.00E+00
Nickel	7440-02-0	<	2.20E-02	µg/mL	1.00E+00
Nickel-63	13981-37-8		8.17E-05	µg/mL	1.82E-01

Table B-1. Single-Shell Tank C-103 Residual Liquid Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Niobium	7440-03-1	<	8.40E-02	µg/mL	1.00E+00
Nitrate	14797-55-8		5.12E+01	µg/mL	2.26E-02
Nitrite	14797-65-0		3.85E+01	µg/mL	1.10E-02
Nitrobenzene	98-95-3	<	2.35E-02	µg/mL	1.00E+00
N-Nitroso-di-n-propylamine	621-64-7	<	2.39E-02	µg/mL	1.00E+00
Oxalate	338-70-5	<	1.16E+00	µg/mL	1.00E+00
Palladium	7440-05-3	<	3.80E-02	µg/mL	1.00E+00
Pentachlorophenol	87-86-5	<	8.17E-03	µg/mL	1.00E+00
Percent Water	Not Available		9.80E+01	%	2.32E-03
Phenol	108-95-2	<	2.26E-02	µg/mL	1.00E+00
Phosphate	14265-44-2		8.81E+00	µg/mL	3.40E-02
Phosphorus	7723-14-0		4.11E+00	µg/mL	2.64E-02
Plutonium-238	13981-16-3		2.78E-06	µg/mL	8.63E-02
Plutonium-239/240	Not Available		1.17E-05	µg/mL	8.30E-02
Potassium	7440-09-7		3.95E+00	µg/mL	1.95E-02
Praseodymium	7440-10-0	<	9.00E-03	µg/mL	1.00E+00
Pyrene	129-00-0	<	1.58E-02	µg/mL	1.00E+00
Pyridine	110-86-1	<	3.12E-02	µg/mL	1.00E+00
Radium-226	13982-63-3	<	1.21E-03	µg/mL	1.00E+00
Rhodium	7440-16-6	<	2.60E-02	µg/mL	1.00E+00
Rubidium	7440-17-7	<	5.14E-01	µg/mL	1.00E+00
Ruthenium	7440-18-8	<	1.78E-02	µg/mL	1.00E+00
Ruthenium/Rhodium-106	Not Available	<	1.03E-03	µg/mL	1.00E+00
Samarium	7440-19-9	<	1.70E-02	µg/mL	1.00E+00
Selenium	7782-49-2	<	6.40E-02	µg/mL	1.00E+00
Selenium-79	15758-45-9	<	3.76E-06	µg/mL	1.00E+00
Silicon	7440-21-3		2.80E+00	µg/mL	1.97E-01
Silver	7440-22-4		1.54E-02	µg/mL	1.89E-01
Sodium	7440-23-5		1.25E+02	µg/mL	5.88E-03
Specific Gravity	Not Available		9.80E-01	unitless	7.51E-03
Strontium	7440-24-6		7.60E-02	µg/mL	8.51E-02
Strontium-89/90	10098-97-2		6.72E-02	µg/mL	5.43E-02
Sulfate	14808-79-8		1.15E+01	µg/mL	2.65E-02
Sulfide	18496-25-8	<	9.60E+00	µg/mL	1.00E+00
Sulfur	7704-34-9		4.01E+00	µg/mL	2.03E-03

Table B-1. Single-Shell Tank C-103 Residual Liquid Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Tantalum	7440-25-7	<	5.70E-02	µg/mL	1.00E+00
Technetium-99	14133-76-7		3.82E-03	µg/mL	6.57E-03
Tellurium	13494-80-9	<	8.40E-02	µg/mL	1.00E+00
Tetrachloroethene	127-18-4	<	6.20E-04	µg/mL	1.00E+00
Thallium	7440-28-0	<	5.60E-02	µg/mL	1.00E+00
Thorium	7440-29-1	<	1.45E-03	µg/mL	1.00E+00
Thorium-230	14269-63-7	<	2.80E-05	µg/mL	1.00E+00
Thorium-232	Not Available	<	1.45E-03	µg/mL	1.00E+00
Tin	7440-31-5	<	3.40E-02	µg/mL	1.00E+00
Titanium	7440-32-6		5.07E-03	µg/mL	1.07E-01
Toluene	108-88-3	<	8.60E-04	µg/mL	1.00E+00
Trans-1,3-Dichloropropene	10061-02-6	<	6.40E-04	µg/mL	1.00E+00
Tributyl phosphate	126-73-8		5.73E+00	µg/mL	5.45E-01
Trichloroethene	79-01-6	<	1.38E-03	µg/mL	1.00E+00
Trichlorofluoromethane	75-69-4	<	2.50E-03	µg/mL	1.00E+00
Tritium	15086-10-9		4.84E-06	µg/mL	1.01E-01
Tungsten	7440-33-7	<	8.94E-02	µg/mL	1.00E+00
Uranium	7440-61-1		9.69E+00	µg/mL	6.94E-03
Uranium-233	13968-55-3		1.11E-04	µg/mL	1.52E-01
Uranium-234	13966-29-5		5.03E-04	µg/mL	2.04E-02
Uranium-235	15117-96-1		6.14E-02	µg/mL	2.87E-02
Uranium-236	13982-70-2		1.23E-03	µg/mL	2.69E-02
Uranium-238	Not available		9.10E+00	µg/mL	2.34E-02
Vanadium	7440-62-2	<	6.00E-03	µg/mL	1.00E+00
Vinyl chloride	75-01-4	<	8.80E-04	µg/mL	1.00E+00
Xylene (m & p)	Not available	<	5.38E-03	µg/mL	1.00E+00
Xylene (o)	95-47-6	<	8.80E-04	µg/mL	1.00E+00
Xylenes (total)	1330-20-7	<	4.54E-03	µg/mL	1.00E+00
Yttrium	7440-65-5	<	1.10E-02	µg/mL	1.00E+00
Zinc	7440-66-6	<	4.00E-03	µg/mL	1.00E+00
Zirconium	7440-67-7		1.04E-02	µg/mL	8.05E-01

[a] In accordance with the best-basis inventory protocol, the relative standard deviation is assumed to be 1 (100%) if the constituent was not detected.

CAS Chemical Abstracts Service Registry Number

< Below

RSD relative standard deviation, representing the uncertainty of the concentration estimate

Table B-2. Single-Shell Tank 241-C-103 Residual Solids Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
1,1,1-Trichloroethane	71-55-6	<	7.81E-03	µg/g	1.00E+00
1,1,2,2-Tetrachloroethane	79-34-5	<	5.71E-03	µg/g	1.00E+00
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<	8.85E-03	µg/g	1.00E+00
1,1,2-Trichloroethane	79-00-5	<	5.71E-03	µg/g	1.00E+00
1,1-Dichloroethene	75-35-4	<	9.02E-03	µg/g	1.00E+00
1,2,4-Trichlorobenzene	120-82-1	<	7.92E-01	µg/g	1.00E+00
1,2-Dichlorobenzene	95-50-1	<	1.34E+00	µg/g	1.00E+00
1,2-Dichloroethane	107-06-2	<	5.62E-03	µg/g	1.00E+00
1,4-Dichlorobenzene	106-46-7	<	8.15E-01	µg/g	1.00E+00
1-Butanol	71-36-3	<	3.36E+00	µg/g	1.00E+00
2,4,5-Trichlorophenol	95-95-4	<	7.62E-01	µg/g	1.00E+00
2,4,6-Trichlorophenol	88-06-2	<	7.89E-01	µg/g	1.00E+00
2,4-Dinitrotoluene	121-14-2	<	8.71E-01	µg/g	1.00E+00
2,6-Bis(1,1-dimethylethyl)-4-methylphenol	128-37-0	<	2.30E+00	µg/g	1.00E+00
2-Butanone	78-93-3		9.90E-02	µg/g	2.62E-01
2-Chlorophenol	95-57-8	<	7.97E-01	µg/g	1.00E+00
2-Ethoxyethanol	110-80-5	<	1.78E+00	µg/g	1.00E+00
2-Methylphenol	95-48-7	<	8.30E-01	µg/g	1.00E+00
2-Nitrophenol	88-75-5	<	7.32E-01	µg/g	1.00E+00
2-Nitropropane	79-46-9	<	1.38E-02	µg/g	1.00E+00
4-Chloro-3-methylphenol	59-50-7	<	8.17E-01	µg/g	1.00E+00
4-Nitrophenol	100-02-7	<	7.74E-01	µg/g	1.00E+00
Acenaphthene	83-32-9	<	8.45E-01	µg/g	1.00E+00
Acetate	71-50-1	<	5.55E+00	µg/g	1.00E+00
Acetone	67-64-1		1.07E-01	µg/g	1.24E-01
Aluminum	7429-90-5		2.61E+05	µg/g	3.47E-02
Americium-241	14596-10-2		3.54E-01	µCi/g	1.95E-01
Ammonium	14798-03-9		1.73E+01	µg/g	1.81E-01
Antimony	7440-36-0	<	2.22E+01	µg/g	1.00E+00
Antimony-125	14234-35-6	<	3.59E-01	µCi/g	1.00E+00
Aroclor 1016 (dry weight)	12674-11-2	<	4.29E-02	µg/g	1.00E+00
Aroclor 1221 (dry weight)	11104-28-2	<	1.36E-02	µg/g	1.00E+00
Aroclor 1232 (dry weight)	11141-16-5	<	2.41E-01	µg/g	1.00E+00
Aroclor 1242 (dry weight)	53469-21-9	<	4.38E-02	µg/g	1.00E+00

Table B-2. Single-Shell Tank 241-C-103 Residual Solids Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Aroclor 1248 (dry weight)	12672-29-6	<	1.39E-02	µg/g	1.00E+00
Aroclor 1254 (dry weight)	11097-69-1	<	8.15E-03	µg/g	1.00E+00
Aroclor 1260 (dry weight)	11096-82-5	<	5.91E-02	µg/g	1.00E+00
Arsenic	7440-38-2	<	4.58E+01	µg/g	1.00E+00
Barium	7440-39-3		1.99E+02	µg/g	2.82E-01
Benzene	71-43-2	<	5.47E-03	µg/g	1.00E+00
Beryllium	7440-41-7		4.71E+00	µg/g	7.22E-02
Bismuth	7440-69-9	<	7.91E+01	µg/g	1.00E+00
Boron	7440-42-8	<	1.40E+01	µg/g	1.00E+00
Bromide	24959-67-9	<	2.48E+00	µg/g	1.00E+00
Bulk Density	Not available		1.61E+00	g/mL	8.71E-02
Butylbenzylphthalate	85-68-7		3.27E+00	µg/g	2.16E-02
Cadmium	7440-43-9		7.00E+01	µg/g	4.57E-02
Calcium	7440-70-2		1.56E+03	µg/g	6.13E-02
Carbon disulfide	75-15-0	<	8.08E-03	µg/g	1.00E+00
Carbon tetrachloride	56-23-5	<	1.04E-02	µg/g	1.00E+00
Carbon-14	14762-75-5	<	5.03E-04	µCi/g	1.00E+00
Cerium	7440-45-1		2.94E+01	µg/g	1.62E-01
Cesium-137	10045-97-3		5.92E+01	µCi/g	4.54E-02
Chloride	16887-00-6		1.37E+01	µg/g	7.91E-01
Chlorobenzene	108-90-7	<	6.75E-03	µg/g	1.00E+00
Chloroform	67-66-3	<	8.27E-03	µg/g	1.00E+00
Chromium	7440-47-3		1.71E+02	µg/g	9.79E-02
Cobalt	7440-48-4	<	6.20E+00	µg/g	1.00E+00
Cobalt-60	10198-40-0	<	9.01E-02	µCi/g	1.00E+00
Copper	7440-50-8		5.94E+01	µg/g	4.85E-02
Cresol	1319-77-3	<	1.63E+00	µg/g	1.00E+00
Cresol (m & p)	Not available	<	8.04E-01	µg/g	1.00E+00
Curium-242	15510-73-3	<	4.30E-02	µCi/g	1.00E+00
Curium-243/244	Not available	<	4.30E-02	µCi/g	1.00E+00
Cyanide	57-12-5	<	7.82E-01	µg/g	1.00E+00
Cyclohexanone	108-94-1	<	5.45E+00	µg/g	1.00E+00
Di-n-butylphthalate	84-74-2		6.11E+00	µg/g	7.03E-02
Di-n-octylphthalate	117-84-0	<	9.79E-01	µg/g	1.00E+00
Ethyl acetate	141-78-6	<	8.49E-03	µg/g	1.00E+00

Table B-2. Single-Shell Tank 241-C-103 Residual Solids Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Ethyl ether	60-29-7	<	7.73E-03	µg/g	1.00E+00
Ethylbenzene	100-41-4	<	1.35E-02	µg/g	1.00E+00
Europium	7440-53-1		9.91E-01	µg/g	2.24E-01
Europium-152	14683-23-9	<	3.90E-01	µCi/g	1.00E+00
Europium-154	15585-10-1		2.94E-01	µCi/g	1.09E-01
Europium-155	14391-16-3	<	2.16E-01	µCi/g	1.00E+00
Fluoranthene	206-44-0	<	8.66E-01	µg/g	1.00E+00
Fluoride	16984-48-8		1.15E+01	µg/g	8.90E-02
Formate	12311-97-6	<	5.75E+00	µg/g	1.00E+00
Glycolate	666-14-8	<	3.78E+00	µg/g	1.00E+00
Hexachlorobutadiene	87-68-3	<	8.78E-01	µg/g	1.00E+00
Hexachloroethane	67-72-1	<	8.06E-01	µg/g	1.00E+00
Hexone	108-10-1	<	1.16E-02	µg/g	1.00E+00
Iodine-129	15046-84-1		2.15E-04	µCi/g	1.02E-01
Iron	7439-89-6		8.59E+03	µg/g	1.53E-01
Isobutanol	78-83-1	<	4.49E+00	µg/g	1.00E+00
Lanthanum	7439-91-0		1.31E+01	µg/g	1.66E-01
Lead	7439-92-1		6.11E+02	µg/g	9.77E-02
Lithium	7439-93-2	<	6.98E+00	µg/g	1.00E+00
Magnesium	7439-95-4		2.22E+02	µg/g	1.22E-01
Manganese	7439-96-5		3.18E+02	µg/g	6.91E-02
Mercury	7439-97-6		7.63E+01	µg/g	2.93E-01
Methylenechloride	75-09-2	<	6.69E-03	µg/g	1.00E+00
Molybdenum	7439-98-7	<	2.40E+00	µg/g	1.00E+00
Morpholine, 4-nitroso-	59-89-2	<	1.87E+00	µg/g	1.00E+00
Naphthalene	91-20-3	<	8.38E-01	µg/g	1.00E+00
Neodymium	7440-00-8		4.66E+01	µg/g	1.30E-01
Neptunium-237	13994-20-2		1.38E+00	µg/g	1.28E-01
Nickel	7440-02-0		3.29E+02	µg/g	6.45E-02
Nickel-63	13981-37-8		1.46E+00	µCi/g	5.77E-02
Niobium	7440-03-1	<	6.51E+01	µg/g	1.00E+00
Nitrate	14797-55-8		5.92E+01	µg/g	9.99E-02
Nitrite	14797-65-0		3.21E+01	µg/g	1.11E-01
Nitrobenzene	98-95-3	<	8.71E-01	µg/g	1.00E+00
N-Nitroso-di-n-propylamine	621-64-7	<	7.81E-01	µg/g	1.00E+00

Table B-2. Single-Shell Tank 241-C-103 Residual Solids Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Oxalate	338-70-5		6.90E+00	µg/g	7.42E-02
Palladium	7440-05-3		4.88E+01	µg/g	1.91E-01
Pentachlorophenol	87-86-5	<	6.54E-01	µg/g	1.00E+00
Percent Water	Not available		9.00E+00	%	2.85E-01
Phenol	108-95-2	<	8.03E-01	µg/g	1.00E+00
Phosphate	14265-44-2		2.68E+01	µg/g	9.64E-02
Phosphorus	7723-14-0		7.00E+02	µg/g	9.50E-02
Plutonium-238	13981-16-3		1.04E-01	µCi/g	3.23E-01
Plutonium-239/240	Not available		4.33E-01	µCi/g	2.17E-01
Potassium	7440-09-7		2.58E+02	µg/g	7.82E-02
Praseodymium	7440-10-0		1.40E+01	µg/g	1.31E-01
Pyrene	129-00-0	<	8.37E-01	µg/g	1.00E+00
Pyridine	110-86-1	<	7.70E-01	µg/g	1.00E+00
Rhodium	7440-16-6	<	7.45E+01	µg/g	1.00E+00
Rubidium	7440-17-7	<	3.99E+02	µg/g	1.00E+00
Ruthenium	7440-18-8		5.96E+01	µg/g	2.39E-01
Samarium	7440-19-9	<	1.32E+01	µg/g	1.00E+00
Selenium	7782-49-2	<	4.96E+01	µg/g	1.00E+00
Selenium-79	15758-45-9	<	8.22E-04	µCi/g	1.00E+00
Silicon	7440-21-3		9.10E+03	µg/g	5.33E-02
Silver	7440-22-4		5.34E+02	µg/g	9.49E-02
Sodium	7440-23-5		6.90E+03	µg/g	1.74E-02
Strontium	7440-24-6		1.73E+02	µg/g	1.27E-01
Strontium-89/90	10098-97-2		6.70E+02	µCi/g	1.87E-01
Sulfate	14808-79-8		1.27E+01	µg/g	6.22E-02
Sulfide	18496-25-8	<	9.09E+00	µg/g	1.00E+00
Sulfur	7704-34-9		5.15E+01	µg/g	1.16E-01
Tantalum	7440-25-7	<	4.42E+01	µg/g	1.00E+00
Technetium-99	14133-76-7		1.90E-01	µg/g	3.43E-02
Tellurium	13494-80-9	<	6.51E+01	µg/g	1.00E+00
Tetrachloroethene	127-18-4	<	7.16E-03	µg/g	1.00E+00
Thallium	7440-28-0	<	4.34E+01	µg/g	1.00E+00
Thorium	7440-29-1		1.30E+02	µg/g	1.97E-02
Thorium-230	14269-63-7	<	1.36E-03	µg/g	1.00E+00
Thorium-232	Not available		1.30E+02	µg/g	1.97E-02

Table B-2. Single-Shell Tank 241-C-103 Residual Solids Mean Concentrations and Relative Standard Deviations. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[a]
Tin	7440-31-5		8.17E+01	µg/g	1.63E-01
Titanium	7440-32-6		1.19E+02	µg/g	6.76E-02
Toluene	108-88-3	<	6.40E-03	µg/g	1.00E+00
Trans-1,3-Dichloropropene	10061-02-6	<	5.58E-03	µg/g	1.00E+00
Tributyl phosphate	126-73-8		7.37E+01	µg/g	3.30E-01
Trichloroethene	79-01-6	<	1.09E-02	µg/g	1.00E+00
Trichlorofluoromethane	75-69-4	<	8.15E-03	µg/g	1.00E+00
Tritium	15086-10-9	<	6.02E-04	µCi/g	1.00E+00
Tungsten	7440-33-7	<	6.67E+01	µg/g	1.00E+00
Uranium	7440-61-1		3.53E+03	µg/g	6.89E-02
Uranium-233	13968-55-3		4.37E-02	µg/g	1.79E-02
Uranium-234	13966-29-5		1.58E-01	µg/g	1.44E-01
Uranium-235	15117-96-1		2.36E+01	µg/g	6.69E-02
Uranium-236	13982-70-2		4.16E-01	µg/g	6.45E-02
Uranium-238	Not available		3.50E+03	µg/g	6.94E-02
Vanadium	7440-62-2	<	4.72E+00	µg/g	1.00E+00
Vinyl chloride	75-01-4	<	3.89E-03	µg/g	1.00E+00
Xylene (m & p)	Not available	<	1.54E-02	µg/g	1.00E+00
Xylene (o)	95-47-6	<	4.83E-03	µg/g	1.00E+00
Xylenes (total)	1330-20-7	<	2.01E-02	µg/g	1.00E+00
Yttrium	7440-65-5		1.33E+01	µg/g	8.35E-02
Zinc	7440-66-6		1.92E+02	µg/g	2.08E-01
Zirconium	7440-67-7		9.59E+02	µg/g	7.80E-02

[a] In accordance with the best-basis inventory protocol, the relative standard deviation is assumed to be 1 (100%) if the constituent was not detected.

CAS Chemical Abstracts Service Registry Number
< Below
RSD Relative Standard Deviation, representing the uncertainty of the concentration estimate

Table B-3. Single-Shell Tank 241-C-103 Residual Liquid Waste Inventories. (5 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
1,1,1-Trichloroethane	71-55-6	<	5.40E-07	1.62E-06	kg
1,1,2,2-Tetrachloroethane	79-34-5	<	7.74E-07	2.32E-06	kg
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<	1.51E-06	4.53E-06	kg
1,1,2-Trichloroethane	79-00-5	<	4.86E-07	1.46E-06	kg
1,1-Dichloroethene	75-35-4	<	7.02E-07	2.11E-06	kg
1,2,4-Trichlorobenzene	120-82-1	<	2.30E-05	6.90E-05	kg
1,2-Dichlorobenzene	95-50-1	<	6.40E-05	1.92E-04	kg
1,2-Dichloroethane	107-06-2	<	4.86E-07	1.46E-06	kg
1,4-Dichlorobenzene	106-46-7	<	1.32E-05	3.96E-05	kg
125Sb	14234-35-6	<	4.77E-04	1.43E-03	Ci
129I	15046-84-1	<	3.92E-06	4.65E-06	Ci
137Cs	10045-97-3		9.47E-02	1.00E-01	Ci
137mBa	Not available		8.94E-02	9.44E-02	Ci
14C	14762-75-5		2.92E-06	4.44E-06	Ci
152Eu	14683-23-9	<	8.18E-05	2.45E-04	Ci
154Eu	15585-10-1	<	5.85E-05	1.76E-04	Ci
155Eu	14391-16-3	<	1.83E-04	5.49E-04	Ci
1-Butanol	71-36-3	<	2.98E-04	8.94E-04	kg
2,4,5-Trichlorophenol	95-95-4	<	1.47E-05	4.41E-05	kg
2,4,6-Trichlorophenol	88-06-2	<	1.55E-05	4.65E-05	kg
2,4-Dinitrotoluene	121-14-2	<	1.22E-05	3.66E-05	kg
2,6-Bis(1,1-dimethylethyl)-4-methylphenol	128-37-0	<	8.74E-05	2.62E-04	kg
^{230}Th	14269-63-7	<	5.20E-07	1.56E-06	Ci
^{232}Th	Not available	<	1.44E-10	4.32E-10	Ci
^{233}U	13968-55-3		9.62E-07	1.26E-06	Ci
^{234}U	13966-29-5		2.81E-06	3.00E-06	Ci
^{235}U	15117-96-1		1.19E-07	1.28E-07	Ci
^{236}U	13982-70-2		7.14E-08	7.68E-08	Ci
^{237}Np	13994-20-2	<	1.34E-07	4.02E-07	Ci
^{238}Pu	13981-16-3		2.55E-06	3.01E-06	Ci
^{238}U	Not available		2.75E-06	2.95E-06	Ci
^{239}Pu	15117-48-3		8.70E-06	1.02E-05	Ci
^{240}Pu	14119-33-6		1.81E-06	2.13E-06	Ci

Table B-3. Single-Shell Tank 241-C-103 Residual Liquid Waste Inventories. (5 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
^{241}Am	14596-10-2	<	4.48E-06	1.34E-05	Ci
^{241}Pu	14119-32-5		6.81E-06	8.00E-06	Ci
^{242}Cm	15510-73-3	<	4.55E-06	1.37E-05	Ci
^{243}Cm	15757-87-6		1.91E-07	5.73E-07	Ci
^{244}Cm	13981-15-2		4.77E-06	1.43E-05	Ci
2-Butanone	78-93-3		2.11E-05	2.31E-05	kg
2-Chlorophenol	95-57-8	<	2.15E-05	6.45E-05	kg
2-Ethoxyethanol	110-80-5	<	6.35E-05	1.91E-04	kg
2-Methylphenol	95-48-7	<	1.86E-05	5.58E-05	kg
2-Nitrophenol	88-75-5	<	2.02E-05	6.06E-05	kg
2-Nitropropane	79-46-9	<	1.85E-06	5.55E-06	kg
3H	15086-10-9		5.05E-06	6.11E-06	Ci
4-Chloro-3-methylphenol	59-50-7	<	1.56E-05	4.68E-05	kg
4-Nitrophenol	100-02-7	<	1.11E-05	3.33E-05	kg
^{60}Co	10198-40-0	<	2.22E-05	6.66E-05	Ci
^{63}Ni	13981-37-8		7.49E-05	1.02E-04	Ci
^{79}Se	15758-45-9	<	3.38E-06	1.01E-05	Ci
^{90}Sr	Not available		6.44E-02	7.22E-02	Ci
^{90}Y	Not available		6.44E-02	7.22E-02	Ci
^{99}Tc	14133-76-7		5.83E-05	6.15E-05	Ci
Acenaphthene	83-32-9	<	2.27E-05	6.81E-05	kg
Acetate	71-50-1	<	2.29E-03	6.87E-03	kg
Acetone	67-64-1		1.56E-04	1.95E-04	kg
Ag	7440-22-4		1.38E-05	1.91E-05	kg
Al	7429-90-5		1.09E-03	2.11E-03	kg
As	7440-38-2	<	5.31E-05	1.59E-04	kg
B	7440-42-8		5.28E-04	1.03E-03	kg
Ba	7440-39-3		4.14E-05	1.12E-04	kg
Be	7440-41-7	<	1.08E-06	3.24E-06	kg
Benzene	71-43-2	<	4.86E-07	1.46E-06	kg
Bi	7440-69-9	<	9.18E-05	2.75E-04	kg
Br	24959-67-9	<	1.24E-03	3.72E-03	kg
Butylbenzylphthalate	85-68-7	<	1.32E-05	3.96E-05	kg
Ca	7440-70-2		1.03E-02	1.12E-02	kg
Carbon disulfide	75-15-0	<	8.64E-07	2.59E-06	kg
Carbon tetrachloride	56-23-5	<	7.92E-07	2.38E-06	kg

Table B-3. Single-Shell Tank 241-C-103 Residual Liquid Waste Inventories. (5 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
Cd	7440-43-9	<	2.70E-06	8.10E-06	kg
Ce	7440-45-1	<	1.35E-05	4.05E-05	kg
Chlorobenzene	108-90-7	<	4.86E-07	1.46E-06	kg
Chloroform	67-66-3	<	5.94E-07	1.78E-06	kg
Cl	16887-00-6		2.84E-03	3.05E-03	kg
CN	57-12-5		2.53E-04	2.76E-04	kg
Co	7440-48-4	<	7.20E-06	2.16E-05	kg
Cr	7440-47-3		1.49E-04	1.59E-04	kg
Cresol	1319-77-3	<	3.69E-05	1.11E-04	kg
Cresol (m)	108-39-4	<	1.86E-05	5.58E-05	kg
Cresol (p)	106-44-5	<	1.86E-05	5.58E-05	kg
Cu	7440-50-8	<	1.26E-05	3.78E-05	kg
Cyclohexanone	108-94-1	<	3.93E-05	1.18E-04	kg
Di-n-butylphthalate	84-74-2	<	1.34E-05	4.02E-05	kg
Di-n-octylphthalate	117-84-0	<	1.53E-05	4.59E-05	kg
Ethyl acetate	141-78-6	<	5.22E-07	1.57E-06	kg
Ethyl ether	60-29-7	<	7.02E-07	2.11E-06	kg
Ethylbenzene	100-41-4	<	1.46E-06	4.38E-06	kg
Eu	7440-53-1	<	9.00E-07	2.70E-06	kg
F	16984-48-8		1.17E-03	1.24E-03	kg
Fe	7439-89-6		3.87E-05	9.26E-05	kg
Fluoranthene	206-44-0	<	1.37E-05	4.11E-05	kg
Formate	12311-97-6	<	2.29E-03	6.87E-03	kg
Glycolate	666-14-8	<	1.89E-03	5.67E-03	kg
Hexachlorobutadiene	87-68-3	<	1.26E-05	3.78E-05	kg
Hexachloroethane	67-72-1	<	8.56E-06	2.57E-05	kg
Hexone	108-10-1		1.25E-06	1.36E-06	kg
Hg	7439-97-6		2.24E-06	2.73E-06	kg
Isobutanol	78-83-1	<	3.38E-04	1.01E-03	kg
K	7440-09-7		3.56E-03	3.80E-03	kg
La	7439-91-0	<	7.20E-06	2.16E-05	kg
Li	7439-93-2	<	8.10E-06	2.43E-05	kg
Methylenechloride	75-09-2	<	8.10E-07	2.43E-06	kg
Mg	7439-95-4		2.18E-03	2.33E-03	kg
Mn	7439-96-5		7.05E-06	8.56E-06	kg
Mo	7439-98-7		3.47E-05	3.67E-05	kg

Table B-3. Single-Shell Tank 241-C-103 Residual Liquid Waste Inventories. (5 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
Morpholine, 4-nitroso-	59-89-2	<	1.30E-04	3.90E-04	kg
Na	7440-23-5		1.13E-01	1.19E-01	kg
Naphthalene	91-20-3	<	2.83E-05	8.49E-05	kg
Nb	7440-03-1	<	7.56E-05	2.27E-04	kg
Nd	7440-00-8	<	7.20E-06	2.16E-05	kg
NH3	7664-41-7		3.59E-03	5.34E-03	kg
Ni	7440-02-0	<	1.98E-05	5.94E-05	kg
Nitrobenzene	98-95-3	<	2.11E-05	6.33E-05	kg
N-Nitroso-di-n-propylamine	621-64-7	<	2.15E-05	6.45E-05	kg
NO_2	14797-65-0		3.47E-02	3.67E-02	kg
NO_3	14797-55-8		4.61E-02	4.93E-02	kg
Oxalate	338-70-5	<	1.04E-03	3.12E-03	kg
Pb	7439-92-1	<	3.24E-05	9.72E-05	kg
Pd	7440-05-3	<	3.42E-05	1.03E-04	kg
Pentachlorophenol	87-86-5	<	7.35E-06	2.21E-05	kg
Phenol	108-95-2	<	2.03E-05	6.09E-05	kg
PO_4	14265-44-2		1.13E-02	1.22E-02	kg
Pr	7440-10-0	<	8.10E-06	2.43E-05	kg
Pyrene	129-00-0	<	1.42E-05	4.26E-05	kg
Pyridine	110-86-1	<	2.81E-05	8.43E-05	kg
Rb	7440-17-7	<	4.63E-04	1.39E-03	kg
Rh	7440-16-6	<	2.34E-05	7.02E-05	kg
Ru	7440-18-8	<	1.61E-05	4.83E-05	kg
Sb	7440-36-0	<	2.52E-05	7.56E-05	kg
Se	7782-49-2	<	5.76E-05	1.73E-04	kg
Si	7440-21-3		2.52E-03	3.52E-03	kg
Sm	7440-19-9	<	1.53E-05	4.59E-05	kg
Sn	7440-31-5	<	3.06E-05	9.18E-05	kg
SO_4	14808-79-8		1.08E-02	1.14E-02	kg
Sr	7440-24-6		6.84E-05	8.06E-05	kg
Sulfide	18496-25-8	<	8.64E-03	2.59E-02	kg
Ta	7440-25-7	<	5.13E-05	1.54E-04	kg
Te	13494-80-9	<	7.56E-05	2.27E-04	kg
Tetrachloroethene	127-18-4	<	5.58E-07	1.67E-06	kg
Th	7440-29-1	<	1.31E-06	3.93E-06	kg
Ti	7440-32-6		4.56E-06	5.56E-06	kg

Table B-3. Single-Shell Tank 241-C-103 Residual Liquid Waste Inventories. (5 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
Tl	7440-28-0	<	5.04E-05	1.51E-04	kg
Toluene	108-88-3	<	7.74E-07	2.32E-06	kg
Trans-1,3-Dichloropropene	10061-02-6	<	5.76E-07	1.73E-06	kg
Tributyl phosphate	126-73-8		5.16E-03	1.08E-02	kg
Trichloroethene	79-01-6	<	1.24E-06	3.72E-06	kg
Trichlorofluoromethane	75-69-4	<	2.25E-06	6.75E-06	kg
U	7440-61-1		8.24E-03	8.83E-03	kg
V	7440-62-2	<	5.40E-06	1.62E-05	kg
Vinyl chloride	75-01-4	<	7.92E-07	2.38E-06	kg
W	7440-33-7	<	8.05E-05	2.42E-04	kg
Xylene (m)	108-38-3	<	4.84E-06	1.45E-05	kg
Xylene (p)	106-42-3	<	4.84E-06	1.45E-05	kg
Xylene (o)	95-47-6	<	7.92E-07	2.38E-06	kg
Xylenes (total)	1330-20-7	<	4.09E-06	1.23E-05	kg
Y	7440-65-5	<	9.90E-06	2.97E-05	kg
Zn	7440-66-6	<	3.60E-06	1.08E-05	kg
Zr	7440-67-7		9.38E-06	2.45E-05	kg
228Th	14274-82-9	<	2.66E-10	7.98E-10	kg
Aroclors (total PCB)	1336-36-3	<	5.18E-07	1.55E-06	kg

CAS Chemical Abstract Services Registry Number
PCB polychlorinated biphenyls
UCL upper confidence level
< Below

Table B-4. Single-Shell Tank C-103 Residual Solids Inventories. (5 sheets)

Constituent[a]	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
1,1,1-Trichloroethane	71-55-6	<	1.09E-04	3.27E-04	kg
1,1,2,2-Tetrachloroethane	79-34-5	<	7.94E-05	2.38E-04	kg
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<	1.23E-04	3.69E-04	kg
1,1,2-Trichloroethane	79-00-5	<	7.94E-05	2.38E-04	kg
1,1-Dichloroethene	75-35-4	<	1.25E-04	3.75E-04	kg
1,2,4-Trichlorobenzene	120-82-1	<	1.10E-02	3.30E-02	kg
1,2-Dichlorobenzene	95-50-1	<	1.87E-02	5.61E-02	kg
1,2-Dichloroethane	107-06-2	<	7.82E-05	2.35E-04	kg
1,4-Dichlorobenzene	106-46-7	<	1.13E-02	3.39E-02	kg
^{125}Sb	14234-35-6	<	1.00E+01	3.00E+01	Ci
^{129}I	15046-84-1		2.99E-03	3.80E-03	Ci
^{137}Cs	10045-97-3		8.78E+02	1.06E+03	Ci
^{137}mBa	Not available		8.29E+02	8.29E+02	Ci
^{14}C	14762-75-5	<	7.00E-03	2.10E-02	Ci
^{152}Eu	14683-23-9	<	6.25E+00	1.88E+01	Ci
^{154}Eu	15585-10-1		5.12E+00	6.57E+00	Ci
^{155}Eu	14391-16-3	<	4.51E+00	1.35E+01	Ci
1-Butanol	71-36-3	<	4.68E-02	1.40E-01	kg
2,4,5-Trichlorophenol	95-95-4	<	1.06E-02	3.18E-02	kg
2,4,6-Trichlorophenol	88-06-2	<	1.10E-02	3.30E-02	kg
2,4-Dinitrotoluene	121-14-2	<	1.21E-02	3.63E-02	kg
2,6-Bis(1,1-dimethylethyl)-4-methylphenol	128-37-0	<	3.20E-02	9.60E-02	kg
^{230}Th	14269-63-7	<	3.89E-04	1.17E-03	Ci
^{232}Th	Not available		1.99E-04	2.36E-04	Ci
^{233}U	13968-55-3		5.85E-03	6.94E-03	Ci
^{234}U	13966-29-5		1.36E-02	1.83E-02	Ci
^{235}U	15117-96-1		7.09E-04	8.69E-04	Ci
^{236}U	13982-70-2		3.74E-04	4.58E-04	Ci
^{237}Np	13994-20-2		1.35E-02	1.77E-02	Ci
^{238}Pu	13981-16-3		1.48E+00	2.47E+00	Ci
^{238}U	Not available		1.64E-02	2.02E-02	Ci
^{239}Pu	15117-48-3		4.99E+00	4.99E+00	Ci
^{240}Pu	14119-33-6		1.04E+00	1.04E+00	Ci
^{241}Am	14596-10-2		4.93E+00	7.05E+00	Ci

Table B-4. Single-Shell Tank C-103 Residual Solids Inventories. (5 sheets)

Constituent[a]	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
^{241}Pu	14119-32-5		3.89E+00	3.89E+00	Ci
^{242}Cm	15510-73-3	<	6.07E-01	1.82E+00	Ci
^{243}Cm	15757-87-6		2.56E-02	2.56E-02	Ci
^{244}Cm	13981-15-2		6.39E-01	6.39E-01	Ci
2-Butanone	78-93-3		1.38E-03	2.14E-03	kg
2-Chlorophenol	95-57-8	<	1.11E-02	3.33E-02	kg
2-Ethoxyethanol	110-80-5	<	2.47E-02	7.41E-02	kg
2-Methylphenol	95-48-7	<	1.15E-02	3.45E-02	kg
2-Nitrophenol	88-75-5	<	1.02E-02	3.06E-02	kg
2-Nitropropane	79-46-9	<	1.92E-04	5.76E-04	kg
3H	15086-10-9	<	9.79E-03	2.94E-02	Ci
4-Chloro-3-methylphenol	59-50-7	<	1.14E-02	3.42E-02	kg
4-Nitrophenol	100-02-7	<	1.08E-02	3.24E-02	kg
^{60}Co	10198-40-0	<	1.80E+00	5.40E+00	Ci
^{63}Ni	13981-37-8		2.07E+01	2.52E+01	Ci
^{79}Se	15758-45-9	<	1.14E-02	3.42E-02	Ci
^{90}Sr	Not available		9.96E+03	1.41E+04	Ci
^{90}Y	Not available		9.96E+03	9.96E+03	Ci
^{99}Tc	14133-76-7		4.47E-02	5.34E-02	Ci
Acenaphthene	83-32-9	<	1.17E-02	3.51E-02	kg
Acetate	71-50-1	<	7.72E-02	2.32E-01	kg
Acetone	67-64-1		1.49E-03	1.95E-03	kg
Ag	7440-22-4		7.43E+00	9.39E+00	kg
Al	7429-90-5		3.63E+03	4.34E+03	kg
As	7440-38-2	<	6.37E-01	1.91E+00	kg
B	7440-42-8	<	1.94E-01	5.82E-01	kg
Ba	7440-39-3		2.76E+00	4.40E+00	kg
Be	7440-41-7		6.55E-02	8.07E-02	kg
Benzene	71-43-2	<	7.61E-05	2.28E-04	kg
Bi	7440-69-9	<	1.10E+00	3.30E+00	kg
Br	24959-67-9	<	3.44E-02	1.03E-01	kg
Butylbenzylphthalate	85-68-7	<	4.55E-02	5.40E-02	kg
Ca	7440-70-2		2.17E+01	2.65E+01	kg
Carbon disulfide	75-15-0	<	1.12E-04	3.36E-04	kg
Carbon tetrachloride	56-23-5	<	1.44E-04	4.32E-04	kg
Cd	7440-43-9		9.74E-01	1.17E+00	kg

Table B-4. Single-Shell Tank C-103 Residual Solids Inventories. (5 sheets)

Constituent[a]	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
Ce	7440-45-1		4.08E-01	5.60E-01	kg
Chlorobenzene	108-90-7	<	9.40E-05	2.82E-04	kg
Chloroform	67-66-3	<	1.15E-04	3.45E-04	kg
Cl	16887-00-6		1.91E-01	4.95E-01	kg
CN	57-12-5	<	1.09E-02	3.27E-02	kg
Co	7440-48-4	<	8.63E-02	2.59E-01	kg
Cr	7440-47-3		2.38E+00	3.02E+00	kg
Cresol	1319-77-3	<	2.27E-02	6.81E-02	kg
Cresol (m)	108-39-4	<	1.12E-02	3.36E-02	kg
Cresol (p)	106-44-5	<	1.12E-02	3.36E-02	kg
Cu	7440-50-8		8.26E-01	9.96E-01	kg
Cyclohexanone	108-94-1	<	7.58E-02	2.27E-01	kg
Di-n-butylphthalate	84-74-2	<	8.50E-02	1.05E-01	kg
Di-n-octylphthalate	117-84-0	<	1.36E-02	4.08E-02	kg
Ethyl acetate	141-78-6	<	1.18E-04	3.54E-04	kg
Ethyl ether	60-29-7	<	1.08E-04	3.24E-04	kg
Ethylbenzene	100-41-4	<	1.88E-04	5.64E-04	kg
Eu	7440-53-1		1.38E-02	2.05E-02	kg
F	16984-48-8		1.60E-01	2.01E-01	kg
Fe	7439-89-6		1.19E+02	1.61E+02	kg
Fluoranthene	206-44-0	<	1.20E-02	3.60E-02	kg
Formate	12311-97-6	<	7.99E-02	2.40E-01	kg
Glycolate	666-14-8	<	5.26E-02	1.58E-01	kg
Hexachlorobutadiene	87-68-3	<	1.22E-02	3.66E-02	kg
Hexachloroethane	67-72-1	<	1.12E-02	3.36E-02	kg
Hexone	108-10-1	<	1.62E-04	4.86E-04	kg
Hg	7439-97-6		1.06E+00	1.71E+00	kg
Isobutanol	78-83-1	<	6.24E-02	1.87E-01	kg
K	7440-09-7		3.60E+00	4.46E+00	kg
La	7439-91-0		1.82E-01	2.51E-01	kg
Li	7439-93-2	<	9.71E-02	2.91E-01	kg
Methylenechloride	75-09-2	<	9.31E-05	2.79E-04	kg
Mg	7439-95-4		3.08E+00	4.02E+00	kg
Mn	7439-96-5		4.42E+00	5.43E+00	kg
Mo	7439-98-7	<	3.34E-02	1.00E-01	kg
Morpholine, 4-nitroso-	59-89-2	<	2.60E-02	7.80E-02	kg

Table B-4. Single-Shell Tank C-103 Residual Solids Inventories. (5 sheets)

Constituent[a]	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
Na	7440-23-5		9.59E+01	1.14E+02	kg
Naphthalene	91-20-3	<	1.17E-02	3.51E-02	kg
Nb	7440-03-1	<	9.06E-01	2.72E+00	kg
Nd	7440-00-8		6.48E-01	8.54E-01	kg
NH3	7664-41-7		2.27E-01	3.19E-01	kg
Ni	7440-02-0		4.58E+00	5.61E+00	kg
Nitrobenzene	98-95-3	<	1.21E-02	3.63E-02	kg
N-Nitroso-di-n-propylamine	621-64-7	<	1.09E-02	3.27E-02	kg
NO_2	14797-65-0		4.46E-01	5.74E-01	kg
NO_3	14797-55-8		8.23E-01	1.05E+00	kg
Oxalate	338-70-5		9.60E-02	1.18E-01	kg
Pb	7439-92-1		8.50E+00	1.08E+01	kg
Pd	7440-05-3		6.79E-01	9.67E-01	kg
Pentachlorophenol	87-86-5	<	9.10E-03	2.73E-02	kg
Phenol	108-95-2	<	1.12E-02	3.36E-02	kg
PO_4	14265-44-2		2.98E+01	3.77E+01	kg
Pr	7440-10-0		1.95E-01	2.57E-01	kg
Pyrene	129-00-0	<	1.16E-02	3.48E-02	kg
Pyridine	110-86-1	<	1.07E-02	3.21E-02	kg
Rb	7440-17-7	<	5.55E+00	1.67E+01	kg
Rh	7440-16-6	<	1.04E+00	3.12E+00	kg
Ru	7440-18-8		8.30E-01	1.25E+00	kg
Sb	7440-36-0	<	3.09E-01	9.27E-01	kg
Se	7782-49-2	<	6.90E-01	2.07E+00	kg
Si	7440-21-3		1.27E+02	1.54E+02	kg
Sm	7440-19-9	<	1.83E-01	5.49E-01	kg
Sn	7440-31-5		1.14E+00	1.57E+00	kg
SO_4	14808-79-8		2.15E+00	2.79E+00	kg
Sr	7440-24-6		2.41E+00	3.16E+00	kg
Sulfide	18496-25-8	<	1.26E-01	3.78E-01	kg
Ta	7440-25-7	<	6.15E-01	1.85E+00	kg
Te	13494-80-9	<	9.06E-01	2.72E+00	kg
Tetrachloroethene	127-18-4	<	9.96E-05	2.99E-04	kg
Th	7440-29-1		1.81E+00	2.15E+00	kg
Ti	7440-32-6		1.65E+00	2.02E+00	kg
Tl	7440-28-0	<	6.04E-01	1.81E+00	kg

Table B-4. Single-Shell Tank C-103 Residual Solids Inventories. (5 sheets)

Constituent[a]	CAS Number	< Detection Limit	Average Inventory	95% UCL Inventory	Inventory Units
Toluene	108-88-3	<	8.90E-05	2.67E-04	kg
Trans-1,3-Dichloropropene	10061-02-6	<	7.76E-05	2.33E-04	kg
Tributyl phosphate	126-73-8		1.03E+00	1.73E+00	kg
Trichloroethene	79-01-6	<	1.51E-04	4.53E-04	kg
Trichlorofluoromethane	75-69-4	<	1.13E-04	3.39E-04	kg
U	7440-61-1		4.91E+01	6.03E+01	kg
V	7440-62-2	<	6.56E-02	1.97E-01	kg
Vinyl chloride	75-01-4	<	5.41E-05	1.62E-04	kg
W	7440-33-7	<	9.28E-01	2.78E+00	kg
Xylene (m)	108-38-3	<	2.14E-04	6.42E-04	kg
Xylene (p)	106-42-3	<	2.14E-04	6.42E-04	kg
Xylene (o)	95-47-6	<	6.72E-05	2.02E-04	kg
Xylenes (total)	1330-20-7	<	2.80E-04	8.40E-04	kg
Y	7440-65-5		1.85E-01	2.31E-01	kg
Zn	7440-66-6		2.67E+00	3.88E+00	kg
Zr	7440-67-7		1.33E+01	1.65E+01	kg
^{228}Th	14274-82-9		2.00E-04	2.37E-04	kg
Aroclors (total PCB)	1336-36-3	<	1.03E-04	3.19E-04	kg

[a]Note that inventories used for the SST C-103 risk assessment used one-half the minimum detection limit for nondetected constituents rather than the full minimum detection limit reported in this table.

CAS = Chemical Abstracts Service Registry Number
PCB = polychlorinated biphenyls
UCL = upper confidence level
< = Below

APPENDIX C

COMPARISON OF SINGLE-SHELL TANK C-103 FINAL INVENTORY TO SINGLE-SHELL TANK C-103 INVENTORY USED IN DOE/ORP-2005-01, INITIAL SINGLE-SHELL TANK PERFORMANCE ASSESSMENT FOR THE HANFORD SITE

INVENTORY COMPARISON

The inventory used in DOE/ORP-2005-01, *Initial Single-Shell Tank Performance Assessment for the Hanford Site*, for SST C-103 was from a download of the Best Basis Inventory for SST C-103 in April 2005, and the nominal volume of 360 ft^3 estimated to remain in the tank at the end of retrieval. Table C-1 provides a comparison of the average inventory developed from the post retrieval sampling and the inventory listed in Appendix C of DOE/ORP-2005-01. Most of the large differences are related to inventories of nondetected analytes in the post-retrieval sample. The differences in inventory that are listed in Table C-1 did not affect risk assessment results as compared to performance objectives.

Table C-1. Comparison between the Average Inventory (RPP-33060) and the Single-Shell Tank Performance Assessment Inventory (DOE/ORP-2005-01). (4 sheets)

Constituent	Average Inventory (Ci or kg)	SST PA Inventory (Ci or kg)	Detected[a]	Ratio of Average/ SST P A Inventory	Constituent Groundwater Concentration (pCi/L or µg/L) if Inventory Ratio >10 or N/A
Tritium	4.90E-03	1.85E-01	L	0.03	
Carbon-14	3.50E-03	3.94E-03	L	0.89	
Nickel-63	2.07E+01	1.16E+01	L S	1.8	
Cobalt-60	9.00E-01	4.30E+00	U	0.21	
Selenium-79	5.70E-03	2.30E-04	U	25	<1.0E-03
Strontium-90 + D	9.96E+03	2.48E+04	L S	0.40	
Yttrium-90	9.96E+03	2.48E+04	L S	0.40	
Niobium-94	7.35E-06	N/A	S	N/A	<1.0E-03
Technetium-99	4.48E-02	7.17E-02	L S	0.62	
Antimony-125	5.00E+00	4.33E-03	U	1154	<1.0E-03
Iodine-129	2.99E-03	4.63E-04	S	6.5	
Cesium-137 + Daughters	8.78E+02	6.53E+02	L S	1.34	
Barium-137m	8.29E+02	6.18E+02	L S	1.34	
Europium-152	3.13E+00	7.72E-02	U	40	<1.0E-03
Europium-154	5.12E+00	3.80E+01	S	0.13	
Europium-155	2.26E+00	2.61E+01	U	0.09	
Thorium-228 + D	1.64E+02	N/A	S	N/A	<1.0E-03
Thorium-230	1.95E-04	N/A	U	N/A	<1.0E-03
Thorium-232	1.99E-04	1.66E-08	S	1.2.E+04	<1.0E-03
Uranium-233	5.85E-03	9.80E-04	L S	6.0	
Uranium-234	1.36E-02	1.49E-02	L S	0.91	
Uranium-235 + D	7.09E-04	6.34E-04	L S	1.1	
Uranium-236	3.74E-04	3.43E-04	L S	1.1	
Uranium-238 + D	1.64E-02	1.52E-02	L S	1.1	
Neptunium-237 + D	1.35E-02	5.04E-04	S	27	<1.0E-03
Plutonium-238	1.48E+00	8.40E-01	L S	1.8	
Plutonium-239	4.99E+00	4.26E+01	L S	0.12	
Plutonium-240	1.04E+00	8.92E+00	L S	0.12	
Plutonium-241 + D	3.89E+00	3.61E+01	L S	0.11	
Americium-241	4.93E+00	1.94E+01	S	0.25	
Curium-242	3.04E-01	1.16E-02	U	26	<1.0E-03
Curium-243	2.56E-02	5.06E-04	L S	51	<1.0E-03
Curium-244	6.39E-01	1.16E-02	L S	55	<1.0E-03
Aluminum	3.63E+03	8.90E+02	L S	4.1	
Ammonia -- (a)	2.31E-01	N/A	L S	N/A	<1.0E-03
Antimony	1.55E-01	1.01E-10	U	1.5E+09	<1.0E-03
Arsenic	3.19E-01	N/A	U	N/A	<1.0E-03
Barium	2.76E+00	N/A	L S	N/A	<1.0E-03
Beryllium	6.55E-02	N/A	S	N/A	<1.0E-03
Bismuth	5.50E-01	9.17E-04	U	600	2.26E-03
Boron	9.75E-02	N/A	L	N/A	<1.0E-03
Bromide	1.78E-02	N/A	U	N/A	<1.0E-03
Cadmium	9.74E-01	5.50E-12	S	1.8E+11	<1.0E-03

Table C-1. Comparison between the Average Inventory (RPP-33060) and the Single-Shell Tank Performance Assessment Inventory (DOE/ORP-2005-01). (4 sheets)

Constituent	Average Inventory (Ci or kg)	SST PA Inventory (Ci or kg)	Detected[a]	Ratio of Average/ SST P A Inventory	Constituent Groundwater Concentration (pCi/L or µg/L) if Inventory Ratio >10 or N/A
Calcium	2.17E+01	3.89E+01	L S	0.56	
Cerium	4.08E-01	N/A	S	N/A	1.68E-03
Chloride	1.94E-01	2.13E+00	L S	0.09	
Chromium	2.38E+00	6.02E+00	L S	0.40	
Cobalt	4.32E-02	5.33E-14	U	8.1E+11	<1.0E-03
Copper	8.26E-01	N/A	S	N/A	<1.0E-03
Cyanide	5.70E-03	7.23E-01	L	0.01	
Europium	1.38E-02	N/A	S	N/A	<1.0E-03
Fluoride	1.61E-01	3.61E+00	L S	0.04	
Formate+A2	4.11E-02	N/A	U	N/A	<1.0E-03
Iron	1.19E+02	3.16E+02	L S	0.38	
Lanthanum	1.82E-01	3.87E-09	S	4.7E+07	<1.0E-03
Lead	8.50E+00	2.09E+01	S	0.41	
Lithium	4.86E-02	N/A	U	N/A	<1.0E-03
Magnesium	3.08E+00	N/A	L S	N/A	<1.0E-03
Manganese	4.42E+00	7.86E+00	L S	0.56	
Mercury	1.06E+00	1.87E-01	L S	5.7	
Molybdenum	1.67E-02	N/A	L	N/A	<1.0E-03
Neodymium	6.48E-01	N/A	S	N/A	2.66E-03
Nickel	4.58E+00	8.23E+00	S	0.56	
Niobium	4.53E-01	N/A	U	N/A	<1.0E-03
Nitrate	8.69E-01	5.81E+00	L S	0.15	
Nitrite	4.81E-01	5.94E+01	L S	0.01	
Oxalate	9.65E-02	1.58E+01	S	0.01	
Palladium	6.79E-01	N/A	S	N/A	<1.0E-03
Phosphate	2.98E+01	2.04E+01	L S	1.5	
Potassium	3.60E+00	N/A	L S	N/A	1.48E-02
Praseodymium	1.95E-01	N/A	S	N/A	<1.0E-03
Rhodium	5.20E-01	N/A	U	N/A	2.13E-03
Rubidium	2.78E+00	N/A	U	N/A	1.14E-02
Ruthenium	8.30E-01	2.27E-13	S	3.7E+12	<1.0E-03
Samarium	9.15E-02	N/A	U	N/A	<1.0E-03
Selenium	3.45E-01	6.54E-10	U	5.3E+08	<1.0E-03
Silicon	1.27E+02	2.23E+02	L S	0.57	
Silver	7.43E+00	N/A	L S	N/A	<1.0E-03
Sodium	9.60E+01	2.46E+02	L S	0.39	
Strontium	2.41E+00	7.39E-01	L S	3.3	
Sulfate	2.16E+00	9.42E+00	L S	0.23	
Sulfide	6.73E-02	N/A	U	N/A	<1.0E-03
Tantalum	3.08E-01	N/A	U	N/A	1.26E-03
Tellurium	4.53E-01	N/A	U	N/A	1.86E-03
Thallium	3.02E-01	N/A	U	N/A	<1.0E-03
Thorium	1.81E+00	2.11E-07	S	8.6E+06	<1.0E-03
Tin	1.14E+00	N/A	S	N/A	<1.0E-03
Titanium	1.65E+00	N/A	L S	N/A	<1.0E-03

Table C-1. Comparison between the Average Inventory (RPP-33060) and the Single-Shell Tank Performance Assessment Inventory (DOE/ORP-2005-01). (4 sheets)

Constituent	Average Inventory (Ci or kg)	SST PA Inventory (Ci or kg)	Detected[a]	Ratio of Average/ SST P A Inventory	Constituent Groundwater Concentration (pCi/L or µg/L) if Inventory Ratio >10 or N/A
Tungsten	4.64E-01	N/A	U	N/A	1.91E-03
Uranium	4.91E+01	4.55E+01	L S	1.1	
Vanadium	3.28E-02	N/A	U	N/A	<1.0E-03
Yttrium	1.85E-01	N/A	S	N/A	<1.0E-03
Zinc	2.67E+00	4.21E+00	S	0.63	
Zirconium	1.33E+01	8.62E+01	L S	0.15	
1, 1, 1-Trichloroethane	5.48E-05	N/A	U	N/A	<1.0E-03
1, 1, 2, 2-Tetrachloroethane	4.01E-05	N/A	U	N/A	<1.0E-03
1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	6.23E-05	N/A	U	N/A	<1.0E-03
1, 1, 2-Trichloroethane	3.99E-05	N/A	U	N/A	<1.0E-03
1, 1, 2-Trichloroethylene	7.61E-05	N/A	U	N/A	<1.0E-03
1, 1-Dichloroethene	6.29E-05	N/A	U	N/A	<1.0E-03
1, 2, 4-Trichlorobenzene	5.51E-03	N/A	U	N/A	<1.0E-03
1, 2-Dichloroethane	3.93E-05	N/A	U	N/A	<1.0E-03
1, 4-Dichlorobenzene	5.66E-03	N/A	U	N/A	<1.0E-03
2, 4, 5-Trichlorophenol	5.31E-03	N/A	U	N/A	<1.0E-03
2, 4, 6-Trichlorophenol	5.51E-03	N/A	U	N/A	<1.0E-03
2, 4-Dinitrotoluene	6.06E-03	N/A	U	N/A	<1.0E-03
2, 6-Bis (tert-butyl)-4-methylphenol	1.60E-02	N/A	U	N/A	<1.0E-03
2-Butanone(MEK)	1.40E-03	N/A	L S	N/A	<1.0E-03
2-Chlorophenol	5.56E-03	N/A	U	N/A	<1.0E-03
2-Ethoxyethanol	1.24E-02	N/A	U	N/A	<1.0E-03
2-Methylphenol (o-cresol)	5.76E-03	N/A	U	N/A	<1.0E-03
2-Nitropropane	9.69E-05	N/A	U	N/A	<1.0E-03
2-Propanone (Acetone)	1.65E-03	N/A	L S	N/A	<1.0E-03
4-Methyl-2-pentanone (MIBK)	8.23E-05	N/A	L	N/A	<1.0E-03
4-Methylphenol (p-cresol)	5.61E-03	N/A	U	N/A	<1.0E-03
Acenaphthene	5.86E-03	N/A	U	N/A	<1.0E-03
Acetate C2H3O2-	3.97E-02	N/A	U	N/A	<1.0E-03
Benzene	3.83E-05	N/A	U	N/A	<1.0E-03
Butylbenzylphthalate	2.28E-02	N/A	U	N/A	<1.0E-03
Carbon disulfide	5.64E-05	N/A	U	N/A	<1.0E-03
Carbon tetrachloride	7.24E-05	N/A	U	N/A	<1.0E-03
Chlorobenzene	4.72E-05	N/A	U	N/A	<1.0E-03
Chloroethene(vinyl chloride)	2.74E-05	N/A	U	N/A	<1.0E-03
Chloroform	5.78E-05	N/A	U	N/A	<1.0E-03
Cresylic acid (cresol, mixed isomers)	1.14E-02	N/A	U	N/A	<1.0E-03
Cyclohexanone	3.79E-02	N/A	U	N/A	<1.0E-03
Dichloromethane (methylene chloride)	4.70E-05	N/A	U	N/A	<1.0E-03
Diethyl ether	5.44E-05	N/A	U	N/A	<1.0E-03
Di-n-butylphthalate	4.25E-02	N/A	U	N/A	<1.0E-03

Table C-1. Comparison between the Average Inventory (RPP-33060) and the Single-Shell Tank Performance Assessment Inventory (DOE/ORP-2005-01). (4 sheets)

Constituent	Average Inventory (Ci or kg)	SST PA Inventory (Ci or kg)	Detected[a]	Ratio of Average/ SST P A Inventory	Constituent Groundwater Concentration (pCi/L or µg/L) if Inventory Ratio >10 or N/A
Di-n-octylphthalate	6.81E-03	N/A	U	N/A	<1.0E-03
Ethyl Acetate	5.93E-05	N/A	U	N/A	<1.0E-03
Ethylbenzene	9.47E-05	N/A	U	N/A	<1.0E-03
Fluoranthene	6.01E-03	N/A	U	N/A	<1.0E-03
Glycolate C2H3O3	2.72E-02	N/A	U	N/A	<1.0E-03
Hexachlorobutadiene	6.11E-03	N/A	U	N/A	<1.0E-03
Hexachloroethane	5.60E-03	N/A	U	N/A	<1.0E-03
Isobutanol	3.14E-02	N/A	U	N/A	<1.0E-03
m-Cresol (3-Methylphenol)	5.61E-03	N/A	U	N/A	<1.0E-03
m-Xylene	1.09E-04	N/A	U	N/A	<1.0E-03
Naphthalene	5.86E-03	N/A	U	N/A	<1.0E-03
n-Butyl alcohol (1-butanol)	2.35E-02	N/A	U	N/A	<1.0E-03
Nitrobenzene	6.06E-03	N/A	U	N/A	<1.0E-03
N-nitroso-di-n-propylamine	5.46E-03	N/A	U	N/A	<1.0E-03
n-Nitrosomorpholine	1.31E-02	N/A	U	N/A	<1.0E-03
o-Dichlorobenzene	9.38E-03	N/A	U	N/A	<1.0E-03
o-Nitrophenol	5.11E-03	N/A	U	N/A	<1.0E-03
o-Xylene	3.40E-05	N/A	U	N/A	<1.0E-03
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	5.71E-03	N/A	U	N/A	<1.0E-03
Pentachlorophenol	4.55E-03	N/A	U	N/A	<1.0E-03
Phenol	5.61E-03	N/A	U	N/A	<1.0E-03
p-Xylene	1.09E-04	N/A	U	N/A	<1.0E-03
Pyrene	5.81E-03	N/A	U	N/A	<1.0E-03
Pyridine	5.36E-03	N/A	U	N/A	<1.0E-03
Tetrachloroethylene	5.01E-05	N/A	U	N/A	<1.0E-03
Toluene	4.49E-05	N/A	U	N/A	<1.0E-03
Tributyl phosphate	1.04E+00	N/A	L S	N/A	<1.0E-03
Trichlorofluoromethane	5.76E-05	N/A	U	N/A	<1.0E-03
Xylenes	1.42E-04	N/A	U	N/A	<1.0E-03
Aroclor-1254	5.18E-05	N/A	U	N/A	<1.0E-03

[a] U indicates analyte was not detected in liquid or sludge. L indicates analyte was detected in the liquid only. S indicates analyte was detected in the sludge only. L S indicates analyte was detected in liquid and sludge.

[b] These analytes were not identified as a primary contaminant of potential concern in RPP 13889, Rev. 1, but were evaluated as part of the SST PA.

N/A = Not applicable, constituent not tracked as part of the best basis inventory.

APPENDIX D

SINGLE-SHELL TANK 241-C-103 TANK RISK DATA

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory. (2 sheets)

Analyte Name	Detect[a]	Inventory (Ci)	WMA C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[b]	Half-Life (yr)	Incremental Cancer Risk Scenarios (Groundwater)		Radiological Dose Groundwater (mrem/yr)	Radiological Dose Beta/Photon (mrem/yr)
							Industrial[c]	Residential[c]	All-Pathway Farmer[d]	Drinking Water MCL[e]
Tritium	L	4.90E-03	< 1.00E-003	DNA	0	12.3	C/A	C/A	C/A	C/A
Carbon-14	L	3.50E-03	5.40E-03	9777	0	5730	4.19E-11	3.03E-10	2.61E-05	1.08E-05
Nickel-63	L S	2.07E+01	< 1.00E-003	DNA	5	100	C/A	C/A	C/A	C/A
Cobalt-60	U	9.00E-01	< 1.00E-003	DNA	0.1	5.3	C/A	C/A	C/A	C/A
Selenium-79	U	5.70E-03	< 1.00E-003	DNA	2	8.05E+05	C/A	C/A	C/A	NDF
Strontium-90 + D	L S	9.96E+03	< 1.00E-003	DNA	5	28.1	C/A	C/A	C/A	C/A
Yttrium-90	L S	9.96E+03	< 1.00E-003	DNA	0	7.3E-03	NDF	NDF	NDF	NDF
Niobium-94	S	7.35E-06	< 1.00E-003	DNA	5	2.03E+04	C/A	C/A	C/A	NDF
Technetium-99	L S	4.48E-02	1.79E-01	10458	0	2.11E+05	2.46E-09	6.00E-08	3.13E-04	7.94E-04
Antimony-125	U	5.00E+00	< 1.00E-003	DNA	1	2.7	C/A	C/A	C/A	C/A
Iodine-129	S	2.99E-03	< 1.00E-003	DNA	0.2	1.57E+07	C/A	C/A	C/A	C/A
Cesium-137 + D	L S	8.78E+02	< 1.00E-003	DNA	5	30	C/A	C/A	C/A	C/A
Barium-137m	L S	8.29E+02	< 1.00E-003	DNA	0	4.86E-06	NDF	NDF	NDF	NDF
Europium-152	U	3.13E+00	< 1.00E-003	DNA	1	13.3	C/A	C/A	C/A	C/A
Europium-154	S	5.12E+00	< 1.00E-003	DNA	1	8.6	C/A	C/A	C/A	C/A
Europium-155	U	2.26E+00	< 1.00E-003	DNA	1	4.7	C/A	C/A	C/A	C/A
Thorium-228 + D	S	1.64E+02	< 1.00E-003	DNA	2	1.9	C/A	C/A	C/A	NDF
Thorium-230	U	1.95E-04	< 1.00E-003	DNA	2	7.54E+04	C/A	C/A	C/A	NDF
Thorium-232	S	1.99E-04	< 1.00E-003	DNA	2	1.41E+10	C/A	C/A	C/A	NDF
Uranium-233	L S	5.85E-03	< 1.00E-003	DNA	0.6	1.59E+05	C/A	C/A	C/A	NDF
Uranium-234	L S	1.36E-02	< 1.00E-003	DNA	0.6	2.46E+05	C/A	C/A	C/A	NDF
Uranium-235 + D	L S	7.09E-04	< 1.00E-003	DNA	0.6	7.04E+0	C/A	C/A	C/A	NDF

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory. (2 sheets)

Analyte Name	Detect[a]	Inventory (Ci)	WMA C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[b]	Half-Life (yr)	Incremental Cancer Risk Scenarios (Groundwater)		Radiological Dose Groundwater (mrem/yr)	Radiological Dose Beta/Photon (mrem/yr)
							Industrial[c]	Residential[c]	All-Pathway Farmer[d]	Drinking Water MCL[e]
						8				
Uranium-236	L S	3.74E-04	< 1.00E-003	DNA	0.6	2.34E+07	C/A	C/A	C/A	NDF
Uranium-238 + D	L S	1.64E-02	< 1.00E-003	DNA	0.6	4.47E+09	C/A	C/A	C/A	NDF
Neptunium-237 + D	S	1.35E-02	< 1.00E-003	DNA	2	2.14E+06	C/A	C/A	C/A	NDF
Plutonium-238	L S	1.48E+00	< 1.00E-003	DNA	2	87.7	C/A	C/A	C/A	NDF
Plutonium-239	L S	4.99E+00	< 1.00E-003	DNA	2	2.41E+04	C/A	C/A	C/A	NDF
Plutonium-240	L S	1.04E+00	< 1.00E-003	DNA	2	6563	C/A	C/A	C/A	NDF
Plutonium-241 + D	L S	3.89E+00	< 1.00E-003	DNA	2	14.4	C/A	C/A	C/A	C/A
Americium-241	S	4.93E+00	< 1.00E-003	DNA	2	432.7	C/A	C/A	C/A	NDF
Curium-242	U	3.04E-01	< 1.00E-003	DNA	2	0.45	C/A	C/A	C/A	NDF
Curium-243	L S	2.56E-02	< 1.00E-003	DNA	2	28.5	C/A	C/A	C/A	NDF
Curium-244	L S	6.39E-01	< 1.00E-003	DNA	2	18.1	C/A	C/A	C/A	NDF
Performance Objectives[d]							**1-0E-6 to 1.0E-4[e]**	**1-0E-6 to 1.0E-4[e]**	**25[f]**	**4[g]**

[a] U indicates analyte was not detected in liquid or sludge. L indicates analyte was detected in the liquid only. S indicates analyte was detected in the sludge only. L S indicates analyte was detected in liquid and sludge.
[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, and Section 4.3 of PNNL-14702, *Vadose Zone Hydrogeology Data Package* for the basis for the K_d values listed for the radionuclides.
[c] All exposure scenarios are described in HNF-SD-WM-TI-707.
[d] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire WMA.
[e] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A, Directive* 9200.4-31P.
[f] DOE O 435.1, *Radioactive Waste Management.*
[g] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."
C/A = constituent analyzed, but this risk metric was not calculated because the radioactive analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory analytical methods to detect it.
DNA = did not arrive at fenceline within the 10,000 year modeling period.
MCL = maximum contaminant level
N/A = radionuclide is not a beta/photon emitter.
NDF = no dose factor.

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
Aluminum	L S	3.63E+03	<1.0E-03	DNA	1	NDF	C/A
Ammonia – (a)	L S	2.31E-01	<1.0E-03	DNA	0	NDF	NDF
Antimony	U	1.55E-01	<1.0E-03	DNA	1	NDF	C/A
Arsenic	U	3.19E-01	<1.0E-03	DNA	5	C/A	C/A
Barium	L S	2.76E+00	<1.0E-03	DNA	5	NDF	C/A
Beryllium	S	6.55E-02	<1.0E-03	DNA	5	NDF	C/A
Bismuth	U	5.50E-01	2.26E-03	10481	0	NDF	NDF
Boron	L	9.75E-02	<1.0E-03	DNA	2	NDF	C/A
Bromide	U	1.78E-02	<1.0E-03	DNA	0	NDF	NDF
Cadmium	S	9.74E-01	<1.0E-03	DNA	1	NDF	C/A
Calcium	L S	2.17E+01	<1.0E-03	DNA	2	NDF	NDF
Cerium	S	4.08E-01	1.68E-03	10481	0	NDF	NDF
Chloride	L S	1.94E-01	<1.0E-03	DNA	0	NDF	NDF
Chromium	L S	2.38E+00	9.77E-03	10481	0	NDF	2.51E-04
Cobalt	U	4.32E-02	<1.0E-03	DNA	0.1	NDF	C/A
Copper	S	8.26E-01	<1.0E-03	DNA	5	NDF	C/A
Cyanide	L	5.70E-03	<1.0E-03	DNA	5	NDF	C/A
Europium	S	1.38E-02	<1.0E-03	DNA	5	NDF	NDF
Fluoride	L S	1.61E-01	<1.0E-03	DNA	0	NDF	C/A
Formate+A2	U	4.11E-02	<1.0E-03	DNA	0	NDF	NDF
Iron	L S	1.19E+02	<1.0E-03	DNA	5	NDF	C/A
Lanthanum	S	1.82E-01	<1.0E-03	DNA	0	NDF	NDF
Lead	S	8.50E+00	<1.0E-03	DNA	5	NDF	NDF
Lithium	U	4.86E-02	<1.0E-03	DNA	5	NDF	C/A
Magnesium	L S	3.08E+00	<1.0E-03	DNA	2	NDF	NDF
Manganese	L S	4.42E+00	<1.0E-03	DNA	1	NDF	C/A
Mercury	L S	1.06E+00	<1.0E-03	DNA	5	NDF	NDF
Molybdenum	L	1.67E-02	<1.0E-03	DNA	2	NDF	C/A
Neodymium	S	6.48E-01	2.66E-03	10481	0	NDF	NDF
Nickel	S	4.58E+00	<1.0E-03	DNA	5	NDF	C/A
Niobium	U	4.53E-01	<1.0E-03	DNA	5	NDF	NDF
Nitrate	L S	8.69E-01	3.57E-03	10481	0	NDF	1.39E-07

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (pg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
Nitrite	L S	4.81E-01	1.97E-03	10481	0	NDF	1.23E-06
Oxalate	S	9.65E-02	<1.0E-03	DNA	0	NDF	NDF
Palladium	S	6.79E-01	<1.0E-03	DNA	5	NDF	NDF
Phosphate	L S	2.98E+01	1.22E-01	10481	0	NDF	NDF
Potassium	L S	3.60E+00	1.48E-02	10481	0	NDF	NDF
Praseodymium	S	1.95E-01	<1.0E-03	DNA	0	NDF	NDF
Rhodium	U	5.20E-01	2.13E-03	10481	0	NDF	NDF
Rubidium	U	2.78E+00	1.14E-02	10481	0	NDF	NDF
Ruthenium	S	8.30E-01	<1.0E-03	DNA	1	NDF	NDF
Samarium	U	9.15E-02	<1.0E-03	DNA	1	NDF	NDF
Selenium	U	3.45E-01	<1.0E-03	DNA	5	NDF	C/A
Silicon	L S	1.27E+02	<1.0E-03	DNA	5	NDF	NDF
Silver	L S	7.43E+00	<1.0E-03	DNA	2	NDF	C/A
Sodium	L S	9.60E+01	3.94E-01	10481	0	NDF	NDF
Strontium	L S	2.41E+00	<1.0E-03	DNA	5	NDF	C/A
Sulfate	L S	2.16E+00	8.87E-03	10481	0	NDF	NDF
Sulfide	U	6.73E-02	<1.0E-03	DNA	0	NDF	NDF
Tantalum	U	3.08E-01	1.26E-03	10481	0	NDF	NDF
Tellurium	U	4.53E-01	1.86E-03	10481	0	NDF	NDF
Thallium	U	3.02E-01	<1.0E-03	DNA	5	NDF	C/A
Thorium	S	1.81E+00	<1.0E-03	DNA	1	NDF	NDF
Tin	S	1.14E+00	<1.0E-03	DNA	5	NDF	C/A
Titanium	L S	1.65E+00	<1.0E-03	DNA	5	NDF	NDF
Tungsten	U	4.64E-01	1.91E-03	10481	0	NDF	NDF
Uranium	L S	4.91E+01	<1.0E-03	DNA	0.6	NDF	C/A
Vanadium	U	3.28E-02	<1.0E-03	DNA	5	NDF	C/A
Yttrium	S	1.85E-01	<1.0E-03	DNA	0	NDF	NDF
Zinc	S	2.67E+00	<1.0E-03	DNA	5	NDF	C/A
Zirconium	L S	1.33E+01	<1.0E-03	DNA	5	NDF	NDF
1, 1, 1-Trichloroethane	U	5.48E-05	<1.0E-03	DNA	0.02	NDF	C/A
1, 1, 2, 2-Tetrachloroethane	U	4.01E-05	<1.0E-03	DNA	0.02	C/A	C/A
1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	U	6.23E-05	<1.0E-03	DNA	0.2	NDF	C/A
1, 1, 2-Trichloroethane	U	3.99E-05	<1.0E-03	DNA	0.02	C/A	C/A

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[d]
						WAC-173-340 Method B	WAC-173-340 Method B
1, 1, 2-Trichloroethylene	U	7.61E-05	<1.0E-03	DNA	0.02	C/A	C/A
1, 1-Dichloroethene	U	6.29E-05	<1.0E-03	DNA	0	NDF	C/A
1, 2, 4-Trichlorobenzene	U	5.51E-03	<1.0E-03	DNA	0.2	NDF	C/A
1, 2-Dichloroethane	U	3.93E-05	<1.0E-03	DNA	0	C/A	C/A
1, 4-Dichlorobenzene	U	5.66E-03	<1.0E-03	DNA	0.1	C/A	C/A
2, 4, 5-Trichlorophenol	U	5.31E-03	<1.0E-03	DNA	0.2	NDF	C/A
2, 4, 6-Trichlorophenol	U	5.51E-03	<1.0E-03	DNA	0.1	C/A	C/A
2, 4-Dinitrotoluene	U	6.06E-03	<1.0E-03	DNA	0.1	NDF	C/A
2, 6-Bis (tert-butyl)-4-methylphenol	U	1.60E-02	<1.0E-03	DNA	5	NDF	NDF
2-Butanone(MEK)	L S	1.40E-03	<1.0E-03	DNA	0	NDF	C/A
2-Chlorophenol	U	5.56E-03	<1.0E-03	DNA	0	NDF	C/A
2-Ethoxyethanol	U	1.24E-02	<1.0E-03	DNA	0	NDF	C/A
2-Methylphenol (o-cresol)	U	5.76E-03	<1.0E-03	DNA	0.1	NDF	C/A
2-Nitropropane	U	9.69E-05	<1.0E-03	DNA	0	NDF	NDF
2-Propanone (Acetone)	L S	1.65E-03	<1.0E-03	DNA	0	NDF	C/A
4-Methyl-2-pentanone (MIBK)	L	8.23E-05	<1.0E-03	DNA	0.02	NDF	C/A
4-Methylphenol (p-cresol)	U	5.61E-03	<1.0E-03	DNA	0.1	NDF	C/A
Acenaphthene	U	5.86E-03	<1.0E-03	DNA	1	NDF	C/A
Acetate C2H3O2-	U	3.97E-02	<1.0E-03	DNA	0	NDF	NDF
Benzene	U	3.83E-05	<1.0E-03	DNA	0	C/A	C/A
Butylbenzylphthalate	U	2.28E-02	<1.0E-03	DNA	2	NDF	C/A
Carbon disulfide	U	5.64E-05	<1.0E-03	DNA	0	NDF	C/A
Carbon tetrachloride	U	7.24E-05	<1.0E-03	DNA	0	C/A	C/A
Chlorobenzene	U	4.72E-05	<1.0E-03	DNA	0.02	NDF	C/A
Chloroethene(vinyl chloride)	U	2.74E-05	<1.0E-03	DNA	0	C/A	C/A
Chloroform	U	5.78E-05	<1.0E-03	DNA	0	C/A	C/A
Cresylic acid (cresol, mixed isomers)	U	1.14E-02	<1.0E-03	DNA	0.1	NDF	NDF
Cyclohexanone	U	3.79E-02	<1.0E-03	DNA	0	NDF	C/A
Dichloromethane (methylene chloride)	U	4.70E-05	<1.0E-03	DNA	0	C/A	C/A
Diethyl ether	U	5.44E-05	<1.0E-03	DNA	0	NDF	C/A
Di-n-butylphthalate	U	4.25E-02	<1.0E-03	DNA	1	NDF	C/A
Di-n-octylphthalate	U	6.81E-03	<1.0E-03	DNA	5	NDF	C/A
Ethyl Acetate	U	5.93E-05	<1.0E-03	DNA	0	NDF	C/A

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
Ethylbenzene	U	9.47E-05	<1.0E-03	DNA	0.02	NDF	C/A
Fluoranthene	U	6.01E-03	<1.0E-03	DNA	5	NDF	C/A
Glycolate C2H3O3	U	2.72E-02	<1.0E-03	DNA	0	NDF	NDF
Hexachlorobutadiene	U	6.11E-03	<1.0E-03	DNA	5	C/A	C/A
Hexachloroethane	U	5.60E-03	<1.0E-03	DNA	5	C/A	C/A
Isobutanol	U	3.14E-02	<1.0E-03	DNA	0	NDF	C/A
m-Cresol (3-Methylphenol)	U	5.61E-03	<1.0E-03	DNA	0.1	NDF	C/A
m-Xylene	U	1.09E-04	<1.0E-03	DNA	0.02	NDF	C/A
Naphthalene	U	5.86E-03	<1.0E-03	DNA	0.6	NDF	C/A
n-Butyl alcohol (1-butanol)	U	2.35E-02	<1.0E-03	DNA	0	NDF	C/A
Nitrobenzene	U	6.06E-03	<1.0E-03	DNA	0	NDF	C/A
N-nitroso-di-n-propylamine	U	5.46E-03	<1.0E-03	DNA	0	C/A	NDF
n-Nitrosomorpholine	U	1.31E-02	<1.0E-03	DNA	0	NDF	NDF
o-Dichlorobenzene	U	9.38E-03	<1.0E-03	DNA	0.1	NDF	C/A
o-Nitrophenol	U	5.11E-03	<1.0E-03	DNA	0.02	NDF	NDF
o-Xylene	U	3.40E-05	<1.0E-03	DNA	0.02	NDF	C/A
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	U	5.71E-03	<1.0E-03	DNA	0.2	NDF	NDF
Pentachlorophenol	U	4.55E-03	<1.0E-03	DNA	0.1	C/A	C/A
Phenol	U	5.61E-03	<1.0E-03	DNA	0	NDF	C/A
p-Xylene	U	1.09E-04	<1.0E-03	DNA	0.2	NDF	C/A
Pyrene	U	5.81E-03	<1.0E-03	DNA	5	NDF	C/A
Pyridine	U	5.36E-03	<1.0E-03	DNA	0	NDF	C/A
Tetrachloroethylene	U	5.01E-05	<1.0E-03	DNA	0.02	C/A	C/A
Toluene	U	4.49E-05	<1.0E-03	DNA	0.02	NDF	C/A
Tributyl phosphate	L S	1.04E+00	<1.0E-03	DNA	0.2	C/A	C/A
Trichlorofluoromethane	U	5.76E-05	<1.0E-03	DNA	0.02	NDF	C/A
Xylenes	U	1.42E-04	<1.0E-03	DNA	0.02	NDF	C/A
Aroclor-1254	U	5.18E-05	<1.0E-03	DNA	5	C/A	C/A
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

Notes: See next page

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B

[a] U indicates analyte was not detected in liquid or sludge. L indicates analyte was detected in the liquid only. S indicates analyte was detected in the sludge only. L S indicates analyte was detected in liquid and sludge.

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[c] All exposure scenarios are described in HNF-SD-WM-TI-707.

[d] Single Analyte Performance objectives apply to entire WMA, not just a single component of the WMA.

[e] *Washington Administrative Code* (WAC) 173-340-705 (2)(c)(ii), "Dangerous Waste Regulations."

[f] WAC 173-340-705 (2)(c)(i).

C/A = constituent analyzed, but this risk metric was not calculated because the non-radioactive analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory analytical methods to detect it..

DNA = did not arrive at fenceline within the 10,000 year modeling period.

NDF = no dose factor.

No CPF = no cancer potency factor available.

No RfD = no reference dose available.

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the UCL 95% Inventory. (2 sheets)

Analyte Name	Detect[a]	Inventory (Ci)	WMA C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[b]	Half-Life (yr)	Incremental Cancer Risk Scenarios (Groundwater)		Radiological Dose Groundwater (mrem/yr)	Radiological Dose Beta/Photon (mrem/yr)
							Industrial[c]	Residential[c]	All-Pathway Farmer[d]	Drinking Water MCL[e]
Tritium	L	1.47E-02	<1.0E-03	DNA	0	12.33	C/A	C/A	C/A	C/A
Carbon-14	L	1.05E-02	1.62E-02	9777	0	5730	1.26E-10	9.08E-10	7.84E-05	3.24E-05
Nickel-63	L S	2.52E+01	<1.0E-03	DNA	5	100.1	C/A	C/A	C/A	C/A
Cobalt-60	U	2.70E+00	<1.0E-03	DNA	0.1	5.2713	C/A	C/A	C/A	C/A
Selenium-79	U	1.71E-02	<1.0E-03	DNA	2	8.05E+05	C/A	C/A	C/A	NDF
Strontium-90 + D	L S	1.41E+04	<1.0E-03	DNA	5	28.1	C/A	C/A	C/A	C/A
Yttrium-90	L S	9.96E+03	<1.0E-03	DNA	0	7.31E-03	NDF	NDF	NDF	NDF
Niobium-94	S	2.21E-05	<1.0E-03	DNA	5	2.03E+04	C/A	C/A	C/A	NDF
Technetium-99	L S	5.35E-02	2.13E-01	10458	0	2.11E+05	2.94E-09	7.16E-08	3.74E-04	9.49E-04
Antimony-125	U	1.50E+01	<1.0E-03	DNA	1	2.7	C/A	C/A	C/A	C/A
Iodine-129	S	3.81E-03	<1.0E-03	DNA	0.2	1.57E+07	C/A	C/A	C/A	C/A
Cesium-137 + Daughters	L S	1.06E+03	<1.0E-03	DNA	5	30	C/A	C/A	C/A	C/A
Barium-137m	L S	8.29E+02	<1.0E-03	DNA	0	4.86E-06	NDF	NDF	NDF	NDF
Europium-152	U	9.38E+00	<1.0E-03	DNA	1	13.3	C/A	C/A	C/A	C/A
Europium-154	S	6.57E+00	<1.0E-03	DNA	1	8.6	C/A	C/A	C/A	C/A
Europium-155	U	6.77E+00	<1.0E-03	DNA	1	4.7	C/A	C/A	C/A	C/A
Thorium-228 + D	S	1.94E+02	<1.0E-03	DNA	2	1.9	C/A	C/A	C/A	NDF
Thorium-230	U	5.84E-04	<1.0E-03	DNA	2	7.54E+04	C/A	C/A	C/A	NDF
Thorium-232	S	2.36E-04	<1.0E-03	DNA	2	1.41E+10	C/A	C/A	C/A	NDF
Uranium-233	L S	6.94E-03	<1.0E-03	DNA	0.6	1.59E+05	C/A	C/A	C/A	NDF
Uranium-234	L S	1.83E-02	<1.0E-03	DNA	0.6	2.46E+05	C/A	C/A	C/A	NDF
Uranium-235 + D	L S	8.69E-04	<1.0E-03	DNA	0.6	7.04E+08	C/A	C/A	C/A	NDF
Uranium-236	L S	4.58E-04	<1.0E-03	DNA	0.6	2.34E+07	C/A	C/A	C/A	NDF
Uranium-238 + D	L S	2.02E-02	<1.0E-03	DNA	0.6	4.47E+09	C/A	C/A	C/A	NDF
Neptunium-237 + D	S	1.77E-02	<1.0E-03	DNA	2	2.14E+06	C/A	C/A	C/A	NDF
Plutonium-238	L S	2.47E+00	<1.0E-03	DNA	2	87.7	C/A	C/A	C/A	NDF
Plutonium-239	L S	4.99E+00	<1.0E-03	DNA	2	2.41E+04	C/A	C/A	C/A	NDF
Plutonium-240	L S	1.04E+00	<1.0E-03	DNA	2	6563	C/A	C/A	C/A	NDF
Plutonium-241 + D	L S	3.89E+00	<1.0E-03	DNA	2	14.4	C/A	C/A	C/A	C/A

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the UCL 95% Inventory. (2 sheets)

Analyte Name	Detect[a]	Inventory (Ci)	WMA C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[b]	Half-Life (yr)	Incremental Cancer Risk Scenarios (Groundwater)		Radiological Dose Groundwater (mrem/yr)	Radiological Dose Beta/Photon (mrem/yr)
							Industrial[c]	Residential[c]	All-Pathway Farmer[c]	Drinking Water MCL[g]
Americium-241	S	7.05E+00	<1.0E-03	DNA	2	432.7	C/A	C/A	C/A	NDF
Curium-242	U	9.11E-01	<1.0E-03	DNA	2	0.45	C/A	C/A	C/A	NDF
Curium-243	L S	2.56E-02	<1.0E-03	DNA	2	28.5	C/A	C/A	C/A	NDF
Curium-244	L S	6.39E-01	<1.0E-03	DNA	2	18.1	C/A	C/A	C/A	NDF
Performance Objectives[d]							**1-0E-6 to 1.0E-4[e]**	**1-0E-6 to 1.0E-4[e]**	**25[f]**	**4[g]**

[a] U indicates analyte was not detected in liquid or sludge. L indicates analyte was detected in the liquid only. S indicates analyte was detected in the sludge only. L S indicates analyte was detected in liquid and sludge.

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, and Section 4.3 of PNNL-14702, *Vadose Zone Hydrogeology Data Package* for the basis for the K_d values listed for the radionuclides.

[c] All exposure scenarios are described in HNF-SD-WM-TI-707.

[d] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire WMA

[e] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A, Directive* 9200.4-31P.

[f] DOE O 435.1, *Radioactive Waste Management.*

[g] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

Notes:

C/A = constituent analyzed, but this risk metric was not calculated because the radioactive analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory analytical methods to detect it.

DNA = did not arrive at fenceline within the 10,000 year modeling period.

N/A = radionuclide is not a beta/photon emitter.

NDF = no dose factor.

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using UL 95% Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
Aluminum	L S	4.34E+03	<1.0E-03	DNA	1	NDF	C/A
Ammonia -- (a)	L S	3.25E-01	1.33E-03	10481	0	NDF	NDF
Antimony	U	4.64E-01	<1.0E-03	DNA	1	NDF	C/A
Arsenic	U	9.56E-01	<1.0E-03	DNA	5	C/A	C/A
Barium	L S	4.40E+00	<1.0E-03	DNA	5	NDF	C/A
Beryllium	S	8.07E-02	<1.0E-03	DNA	5	NDF	C/A
Bismuth	U	1.65E+00	6.77E-03	10481	0	NDF	NDF
Boron	L	2.92E-01	<1.0E-03	DNA	2	NDF	C/A
Bromide	U	5.35E-02	<1.0E-03	DNA	0	NDF	NDF
Cadmium	S	1.17E+00	<1.0E-03	DNA	1	NDF	C/A
Calcium	L S	2.65E+01	<1.0E-03	DNA	2	NDF	NDF
Cerium	S	5.60E-01	2.30E-03	10481	0	NDF	NDF
Chloride	L S	4.99E-01	2.05E-03	10481	0	NDF	NDF
Chromium	L S	3.02E+00	1.24E-02	10481	0	NDF	3.19E-04
Cobalt	U	1.29E-01	<1.0E-03	DNA	0.1	NDF	C/A
Copper	S	9.96E-01	<1.0E-03	DNA	5	NDF	C/A
Cyanide	L	1.66E-02	<1.0E-03	DNA	5	NDF	C/A
Europium	S	2.05E-02	<1.0E-03	DNA	5	NDF	NDF
Fluoride	L S	2.02E-01	<1.0E-03	DNA	0	NDF	C/A
Formate+A2	U	1.23E-01	<1.0E-03	DNA	0	NDF	NDF
Iron	L S	1.61E+02	<1.0E-03	DNA	5	NDF	C/A
Lanthanum	S	2.51E-01	1.03E-03	10481	0	NDF	NDF
Lead	S	1.08E+01	<1.0E-03	DNA	5	NDF	NDF
Lithium	U	1.46E-01	<1.0E-03	DNA	5	NDF	C/A
Magnesium	L S	4.02E+00	<1.0E-03	DNA	2	NDF	NDF
Manganese	L S	5.43E+00	<1.0E-03	DNA	1	NDF	C/A
Mercury	L S	1.71E+00	<1.0E-03	DNA	5	NDF	NDF
Molybdenum	L	5.01E-02	<1.0E-03	DNA	2	NDF	C/A
Neodymium	S	8.54E-01	3.51E-03	10481	0	NDF	NDF
Nickel	S	5.61E+00	<1.0E-03	DNA	5	NDF	C/A
Niobium	U	1.36E+00	<1.0E-03	DNA	5	NDF	NDF

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using UL 95% Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
Nitrate	L S	1.09E+00	4.49E-03	10481	0	NDF	1.76E-07
Nitrite	L S	6.10E-01	2.51E-03	10481	0	NDF	1.57E-06
Oxalate	S	1.20E-01	<1.0E-03	DNA	0	NDF	NDF
Palladium	S	9.67E-01	<1.0E-03	DNA	5	NDF	NDF
Phosphate	L S	3.77E+01	1.55E-01	10481	0	NDF	NDF
Potassium	L S	4.47E+00	1.83E-02	10481	0	NDF	NDF
Praseodymium	S	2.57E-01	1.06E-03	10481	0	NDF	NDF
Rhodium	U	1.56E+00	6.40E-03	10481	0	NDF	NDF
Rubidium	U	8.33E+00	3.42E-02	10481	0	NDF	NDF
Ruthenium	S	1.25E+00	<1.0E-03	DNA	1	NDF	NDF
Samarium	U	2.75E-01	<1.0E-03	DNA	1	NDF	NDF
Selenium	U	1.04E+00	<1.0E-03	DNA	5	NDF	C/A
Silicon	L S	1.54E+02	<1.0E-03	DNA	5	NDF	NDF
Silver	L S	9.39E+00	<1.0E-03	DNA	2	NDF	C/A
Sodium	L S	1.14E+02	4.67E-01	10481	0	NDF	NDF
Strontium	L S	3.16E+00	<1.0E-03	DNA	5	NDF	C/A
Sulfate	L S	2.80E+00	1.15E-02	10481	0	NDF	NDF
Sulfide	U	2.02E-01	<1.0E-03	DNA	0	NDF	NDF
Tantalum	U	9.23E-01	3.79E-03	10481	0	NDF	NDF
Tellurium	U	1.36E+00	5.58E-03	10481	0	NDF	NDF
Thallium	U	9.06E-01	<1.0E-03	DNA	5	NDF	C/A
Thorium	S	2.15E+00	<1.0E-03	DNA	1	NDF	NDF
Tin	S	1.57E+00	<1.0E-03	DNA	5	NDF	C/A
Titanium	L S	2.02E+00	<1.0E-03	DNA	5	NDF	NDF
Tungsten	U	1.39E+00	5.72E-03	10481	0	NDF	NDF
Uranium	L S	6.03E+01	<1.0E-03	DNA	0.6	NDF	C/A
Vanadium	U	9.84E-02	<1.0E-03	DNA	5	NDF	C/A
Yttrium	S	2.31E-01	<1.0E-03	DNA	0	NDF	NDF
Zinc	S	3.88E+00	<1.0E-03	DNA	5	NDF	C/A
Zirconium	L S	1.65E+01	<1.0E-03	DNA	5	NDF	NDF
1, 1, 1-Trichloroethane	U	1.64E-04	<1.0E-03	DNA	0.02	NDF	C/A
1, 1, 2, 2-Tetrachloroethane	U	1.20E-04	<1.0E-03	DNA	0.02	C/A	C/A
1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	U	1.87E-04	<1.0E-03	DNA	0.2	NDF	C/A

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using UL 95% Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (pg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
1, 1, 2-Trichloroethane	U	1.20E-04	<1.0E-03	DNA	0.02	C/A	C/A
1, 1, 2-Trichloroethylene	U	2.28E-04	<1.0E-03	DNA	0.02	C/A	C/A
1, 1-Dichloroethene	U	1.89E-04	<1.0E-03	DNA	0	NDF	C/A
1, 2, 4-Trichlorobenzene	U	1.65E-02	<1.0E-03	DNA	0.2	NDF	C/A
1, 2-Dichloroethane	U	1.18E-04	<1.0E-03	DNA	0	C/A	C/A
1, 4-Dichlorobenzene	U	1.70E-02	<1.0E-03	DNA	0.1	C/A	C/A
2, 4, 5-Trichlorophenol	U	1.59E-02	<1.0E-03	DNA	0.2	NDF	C/A
2, 4, 6-Trichlorophenol	U	1.65E-02	<1.0E-03	DNA	0.1	C/A	C/A
2, 4-Dinitrotoluene	U	1.82E-02	<1.0E-03	DNA	0.1	NDF	C/A
2, 6-Bis (tert-butyl)-4-methylphenol	U	4.81E-02	<1.0E-03	DNA	5	NDF	NDF
2-Butanone(MEK)	L S	2.17E-03	<1.0E-03	DNA	0	NDF	C/A
2-Chlorophenol	U	1.67E-02	<1.0E-03	DNA	0	NDF	C/A
2-Ethoxyethanol	U	3.71E-02	<1.0E-03	DNA	0	NDF	C/A
2-Methylphenol (o-cresol)	U	1.73E-02	<1.0E-03	DNA	0.1	NDF	C/A
2-Nitropropane	U	2.91E-04	<1.0E-03	DNA	0	NDF	NDF
2-Propanone (Acetone)	L S	2.14E-03	<1.0E-03	DNA	0	NDF	C/A
4-Methyl-2-pentanone (MIBK)	L	2.44E-04	<1.0E-03	DNA	0.02	NDF	C/A
4-Methylphenol (p-cresol)	U	1.68E-02	<1.0E-03	DNA	0.1	NDF	C/A
Acenaphthene	U	1.76E-02	<1.0E-03	DNA	1	NDF	C/A
Acetate $C_2H_3O_2$-	U	1.19E-01	<1.0E-03	DNA	0	NDF	NDF
Benzene	U	1.15E-04	<1.0E-03	DNA	0	C/A	C/A
Butylbenzylphthalate	U	2.70E-02	<1.0E-03	DNA	2	NDF	C/A
Carbon disulfide	U	1.69E-04	<1.0E-03	DNA	0	NDF	C/A
Carbon tetrachloride	U	2.17E-04	<1.0E-03	DNA	0	C/A	C/A
Chlorobenzene	U	1.42E-04	<1.0E-03	DNA	0.02	NDF	C/A
Chloroethene(vinyl chloride)	U	8.23E-05	<1.0E-03	DNA	0	C/A	C/A
Chloroform	U	1.73E-04	<1.0E-03	DNA	0	C/A	C/A
Cresylic acid (cresol, mixed isomers)	U	3.41E-02	<1.0E-03	DNA	0.1	NDF	NDF
Cyclohexanone	U	1.14E-01	<1.0E-03	DNA	0	NDF	C/A
Dichloromethane (methylene chloride)	U	1.41E-04	<1.0E-03	DNA	0	C/A	C/A
Diethyl ether	U	1.63E-04	<1.0E-03	DNA	0	NDF	C/A
Di-n-butylphthalate	U	5.23E-02	<1.0E-03	DNA	1	NDF	C/A
Di-n-octylphthalate	U	2.04E-02	<1.0E-03	DNA	5	NDF	C/A

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using UL 95% Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B
Ethyl Acetate	U	1.78E-04	<1.0E-03	DNA	0	NDF	C/A
Ethylbenzene	U	2.84E-04	<1.0E-03	DNA	0.02	NDF	C/A
Fluoranthene	U	1.80E-02	<1.0E-03	DNA	5	NDF	C/A
Glycolate C2H3O3	U	8.17E-02	<1.0E-03	DNA	0	NDF	NDF
Hexachlorobutadiene	U	1.83E-02	<1.0E-03	DNA	5	C/A	C/A
Hexachloroethane	U	1.68E-02	<1.0E-03	DNA	5	C/A	C/A
Isobutanol	U	9.41E-02	<1.0E-03	DNA	0	NDF	C/A
m-Cresol (3-Methylphenol)	U	1.68E-02	<1.0E-03	DNA	0.1	NDF	C/A
m-Xylene	U	3.28E-04	<1.0E-03	DNA	0.02	NDF	C/A
Naphthalene	U	1.76E-02	<1.0E-03	DNA	0.6	NDF	C/A
n-Butyl alcohol (1-butanol)	U	7.06E-02	<1.0E-03	DNA	0	NDF	C/A
Nitrobenzene	U	1.82E-02	<1.0E-03	DNA	0	NDF	C/A
N-nitroso-di-n-propylamine	U	1.64E-02	<1.0E-03	DNA	0	C/A	NDF
n-Nitrosomorpholine	U	3.92E-02	<1.0E-03	DNA	0	NDF	NDF
o-Dichlorobenzene	U	2.81E-02	<1.0E-03	DNA	0.1	NDF	C/A
o-Nitrophenol	U	1.53E-02	<1.0E-03	DNA	0.02	NDF	NDF
o-Xylene	U	1.02E-04	<1.0E-03	DNA	0.02	NDF	C/A
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	U	1.71E-02	<1.0E-03	DNA	0.2	NDF	NDF
Pentachlorophenol	U	1.37E-02	<1.0E-03	DNA	0.1	C/A	C/A
Phenol	U	1.68E-02	<1.0E-03	DNA	0	NDF	C/A
p-Xylene	U	3.28E-04	<1.0E-03	DNA	0.2	NDF	C/A
Pyrene	U	1.74E-02	<1.0E-03	DNA	5	NDF	C/A
Pyridine	U	1.61E-02	<1.0E-03	DNA	0	NDF	C/A
Tetrachloroethylene	U	1.50E-04	<1.0E-03	DNA	0.02	C/A	C/A
Toluene	U	1.35E-04	<1.0E-03	DNA	0.02	NDF	C/A
Tributyl phosphate	L S	1.75E+00	<1.0E-03	DNA	0.2	C/A	C/A
Trichlorofluoromethane	U	1.73E-04	<1.0E-03	DNA	0.02	NDF	C/A
Xylenes	U	4.26E-04	<1.0E-03	DNA	0.02	NDF	C/A
Aroclor-1254	U	1.60E-04	<1.0E-03	DNA	5	C/A	C/A
Performance Objective[d]	0					**1.0E-06[e]**	**1.0[f]**

Notes: See next page

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using UL 95% Post-Retrieval Inventory. (5 sheets)

Analyte	Detect[a]	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC-173-340 Method B	WAC-173-340 Method B

[a] U indicates analyte was not detected in liquid or sludge. L indicates analyte was detected in the liquid only. S indicates analyte was detected in the sludge only. L S indicates analyte was detected in liquid and sludge.

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[c] All exposure scenarios are described in HNF-SD-WM-TI-707.

[d] Single Analyte Performance objectives apply to entire WMA, not just a single component of the WMA.

[e] *Washington Administrative Code* (WAC) 173-340-705 (2)(c)(ii), "Dangerous Waste Regulations."

[f] WAC 173-340-705 (2)(c)(i).

C/A = constituent analyzed, but this risk metric was not calculated because the non-radioactive analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory analytical methods to detect it.

DNA = did not arrive at fenceline within the 10,000 year modeling period.

NDF = no dose factor.

No CPF = no cancer potency factor available.

No RfD = no reference dose available.

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

	Years after Site Closure (1/1/2032)								
Nuclide	100	150	200	300	400	500	600	800	1,000
Tritium	2.13E-12	1.28E-13	7.70E-15	2.79E-17	1.01E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	5.79E-08	5.75E-08	5.72E-08	5.65E-08	5.58E-08	5.51E-08	5.45E-08	5.32E-08	5.19E-08
Nickel-63	3.93E-05	2.78E-05	1.97E-05	9.85E-06	4.93E-06	2.47E-06	1.23E-06	3.09E-07	7.73E-08
Cobalt-60	3.74E-08	5.22E-11	7.29E-14	1.42E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07
Strontium-90 + D	1.04E+00	3.05E-01	8.90E-02	7.59E-03	6.47E-04	5.51E-05	4.70E-06	3.41E-08	2.48E-10
Niobium-94	2.69E-06	2.69E-06	2.68E-06	2.67E-06	2.66E-06	2.65E-06	2.64E-06	2.63E-06	2.61E-06
Technetium-99	8.49E-07	8.49E-07	8.49E-07	8.49E-07	8.49E-07	8.48E-07	8.48E-07	8.47E-07	8.47E-07
Antimony-125	8.12E-15	2.49E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	8.92E-06	8.92E-06	8.92E-06	8.92E-06	8.92E-06	8.92E-06	8.92E-06	8.92E-06	8.92E-06
Cesium-137 + Daughters	6.49E+00	2.04E+00	6.44E-01	6.38E-02	6.33E-03	6.28E-04	6.23E-05	6.13E-07	6.04E-09
Europium-152	1.23E-03	9.11E-05	6.76E-06	3.73E-08	2.06E-10	1.14E-12	8.31E-15	2.04E-15	2.04E-15
Europium-154	6.07E-05	1.07E-06	1.90E-08	5.97E-12	1.87E-15	5.87E-19	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.10E-10	1.28E-13	7.76E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	4.53E-06	4.53E-06	4.53E-06	4.53E-06	4.52E-06	4.52E-06	4.51E-06	4.51E-06	4.50E-06
Thorium-232	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04
Uranium-233	3.21E-05	3.82E-05	4.43E-05	5.65E-05	6.85E-05	8.04E-05	9.22E-05	1.15E-04	1.38E-04
Uranium-234	3.77E-05	3.80E-05	3.84E-05	3.93E-05	4.05E-05	4.18E-05	4.34E-05	4.71E-05	5.15E-05
Uranium-235 + D	2.82E-05	2.86E-05	2.90E-05	2.97E-05	3.05E-05	3.12E-05	3.20E-05	3.35E-05	3.50E-05
Uranium-236	9.66E-07	9.66E-07	9.66E-07	9.66E-07	9.66E-07	9.66E-07	9.66E-07	9.66E-07	9.66E-07
Uranium-238 + D	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04
Neptunium-237 + D	1.65E-03	1.65E-03	1.65E-03	1.65E-03	1.65E-03	1.65E-03	1.65E-03	1.65E-03	1.65E-03
Plutonium-238	2.90E-02	1.96E-02	1.32E-02	5.98E-03	2.71E-03	1.23E-03	5.60E-04	1.17E-04	2.55E-05
Plutonium-239	2.88E-01	2.88E-01	2.87E-01	2.87E-01	2.86E-01	2.85E-01	2.84E-01	2.83E-01	2.81E-01
Plutonium-240	5.95E-02	5.92E-02	5.89E-02	5.83E-02	5.76E-02	5.70E-02	5.64E-02	5.53E-02	5.41E-02
Plutonium-241 + D	6.83E-03	6.31E-03	5.83E-03	4.97E-03	4.23E-03	3.61E-03	3.07E-03	2.23E-03	1.62E-03
Americium-241	2.53E-01	2.33E-01	2.15E-01	1.83E-01	1.56E-01	1.33E-01	1.14E-01	8.24E-02	5.99E-02

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years after Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Americium-242m + D	1.97E-02	1.71E-02	1.45E-02	1.00E-02	6.66E-03	4.31E-03	2.74E-03	1.08E-03	4.15E-04
Curium-242	3.05E-05	2.05E-05	1.38E-05	6.27E-06	2.85E-06	1.29E-06	5.87E-07	1.22E-07	2.63E-08
Curium-243	8.59E-05	2.67E-05	9.16E-06	2.41E-06	1.81E-06	1.75E-06	1.75E-06	1.73E-06	1.72E-06
Curium-244	2.78E-04	1.27E-04	1.04E-04	9.91E-05	9.80E-05	9.69E-05	9.59E-05	9.39E-05	9.19E-05
Total dose	**8.19E+00**	**2.97E+00**	**1.33E+00**	**6.23E-01**	**5.23E-01**	**4.87E-01**	**4.63E-01**	**4.26E-01**	**3.99E-01**
External dose	6.99E+00	2.20E+00	6.96E-01	7.70E-02	1.50E-02	7.90E-03	6.38E-03	4.86E-03	3.83E-03
Soil inhalation	3.57E-01	3.34E-01	3.17E-01	2.93E-01	2.74E-01	2.59E-01	2.47E-01	2.27E-01	2.14E-01
Soil ingestion	8.44E-01	4.42E-01	3.16E-01	2.53E-01	2.34E-01	2.20E-01	2.10E-01	1.94E-01	1.82E-01

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years After Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Tritium	7.90E-11	4.75E-12	2.86E-13	1.03E-15	3.74E-18	1.35E-20	0.00E+00	0.00E+00	0.00E+00
Carbon-14	6.38E-06	6.34E-06	6.30E-06	6.23E-06	6.15E-06	6.08E-06	6.00E-06	5.86E-06	5.72E-06
Nickel-63	1.05E-03	7.41E-04	5.24E-04	2.62E-04	1.31E-04	6.56E-05	3.28E-05	8.22E-06	2.06E-06
Cobalt-60	4.27E-09	5.96E-12	8.32E-15	1.62E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	1.83E-06	1.83E-06	1.83E-06	1.83E-06	1.83E-06	1.83E-06	1.83E-06	1.83E-06	1.83E-06
Strontium-90 + D	6.03E+01	1.76E+01	5.14E+00	4.38E-01	3.73E-02	3.18E-03	2.71E-04	1.97E-06	1.43E-08
Niobium-94	3.08E-07	3.07E-07	3.07E-07	3.06E-07	3.04E-07	3.03E-07	3.02E-07	3.00E-07	2.98E-07
Technetium-99	1.55E-04	1.55E-04	1.55E-04	1.55E-04	1.55E-04	1.55E-04	1.55E-04	1.55E-04	1.54E-04
Antimony-125	8.50E-16	2.61E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05
Cesium-137 + Daughters	1.74E+00	5.50E-01	1.73E-01	1.72E-02	1.70E-03	1.69E-04	1.68E-05	1.65E-07	1.62E-09
Europium-152	1.39E-04	1.03E-05	7.65E-07	4.22E-09	2.33E-11	1.29E-13	1.28E-15	5.75E-16	5.75E-16
Europium-154	6.86E-06	1.21E-07	2.15E-09	6.74E-13	2.11E-16	6.63E-20	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.80E-11	1.10E-14	6.66E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.27E-06	1.27E-06
Thorium-232	2.58E-05	2.58E-05	2.58E-05	2.58E-05	2.58E-05	2.58E-05	2.58E-05	2.58E-05	2.58E-05
Uranium-233	1.30E-05	1.44E-05	1.58E-05	1.86E-05	2.14E-05	2.41E-05	2.68E-05	3.21E-05	3.73E-05
Uranium-234	2.17E-05	2.17E-05	2.18E-05	2.20E-05	2.23E-05	2.26E-05	2.29E-05	2.38E-05	2.47E-05
Uranium-235 + D	3.82E-06	3.92E-06	4.01E-06	4.21E-06	4.40E-06	4.59E-06	4.79E-06	5.17E-06	5.55E-06
Uranium-236	5.62E-07	5.62E-07	5.62E-07	5.62E-07	5.62E-07	5.62E-07	5.62E-07	5.62E-07	5.62E-07
Uranium-238 + D	3.37E-05	3.37E-05	3.37E-05	3.37E-05	3.37E-05	3.37E-05	3.38E-05	3.38E-05	3.38E-05
Neptunium-237 + D	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04
Plutonium-238	8.25E-03	5.55E-03	3.74E-03	1.70E-03	7.71E-04	3.50E-04	1.59E-04	3.35E-05	7.65E-06
Plutonium-239	8.21E-02	8.20E-02	8.18E-02	8.16E-02	8.14E-02	8.11E-02	8.09E-02	8.04E-02	8.00E-02
Plutonium-240	1.69E-02	1.69E-02	1.68E-02	1.66E-02	1.64E-02	1.62E-02	1.61E-02	1.57E-02	1.54E-02
Plutonium-241 + D	1.88E-03	1.74E-03	1.61E-03	1.37E-03	1.17E-03	9.93E-04	8.46E-04	6.14E-04	4.46E-04

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years After Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Americium-241	6.96E-02	6.42E-02	5.93E-02	5.05E-02	4.31E-02	3.67E-02	3.13E-02	2.27E-02	1.65E-02
Americium-242m + D	5.47E-03	4.77E-03	4.06E-03	2.81E-03	1.87E-03	1.21E-03	7.69E-04	3.03E-04	1.17E-04
Curium-242	8.65E-06	5.82E-06	3.92E-06	1.78E-06	8.08E-07	3.67E-07	1.67E-07	3.51E-08	7.91E-09
Curium-243	1.85E-05	5.85E-06	2.08E-06	6.38E-07	5.10E-07	4.97E-07	4.95E-07	4.92E-07	4.89E-07
Curium-244	7.97E-05	3.61E-05	2.96E-05	2.82E-05	2.79E-05	2.76E-05	2.73E-05	2.67E-05	2.62E-05
Total dose	**6.22E+01**	**1.83E+01**	**5.48E+00**	**6.11E-01**	**1.85E-01**	**1.41E-01**	**1.31E-01**	**1.21E-01**	**1.13E-01**
External dose	7.82E-01	2.46E-01	7.77E-02	8.34E-03	1.42E-03	6.66E-04	5.27E-04	4.07E-04	3.26E-04
Soil inhalation	1.00E-01	9.36E-02	8.89E-02	8.21E-02	7.68E-02	7.26E-02	6.91E-02	6.37E-02	5.98E-02
Soil ingestion	2.43E-01	1.27E-01	9.13E-02	7.31E-02	6.75E-02	6.37E-02	6.06E-02	5.60E-02	5.26E-02
Dose from milk	6.11E+01	1.79E+01	5.22E+00	4.47E-01	3.89E-02	3.85E-03	8.19E-04	4.96E-04	4.73E-04

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years After Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Tritium	6.90E-10	4.15E-11	2.50E-12	9.04E-15	3.27E-17	1.18E-19	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.12E-04	1.11E-04	1.11E-04	1.09E-04	1.08E-04	1.07E-04	1.05E-04	1.03E-04	1.00E-04
Nickel-63	7.10E-03	5.02E-03	3.55E-03	1.78E-03	8.89E-04	4.45E-04	2.23E-04	5.57E-05	1.40E-05
Cobalt-60	4.28E-08	5.97E-11	8.33E-14	1.62E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	2.97E-05	2.97E-05	2.97E-05	2.97E-05	2.97E-05	2.97E-05	2.97E-05	2.97E-05	2.97E-05
Strontium-90 + D	8.55E+02	2.50E+02	7.29E+01	6.21E+00	5.29E-01	4.51E-02	3.85E-03	2.79E-05	2.03E-07
Niobium-94	2.97E-06	2.96E-06	2.96E-06	2.95E-06	2.94E-06	2.93E-06	2.92E-06	2.90E-06	2.88E-06
Technetium-99	1.18E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02
Antimony-125	8.26E-15	2.53E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	4.50E-04	4.50E-04	4.50E-04	4.50E-04	4.50E-04	4.50E-04	4.50E-04	4.50E-04	4.50E-04
Cesium-137 + Daughters	1.69E+01	5.33E+00	1.68E+00	1.66E-01	1.65E-02	1.64E-03	1.63E-04	1.60E-06	1.57E-08
Europium-152	1.33E-03	9.90E-05	7.36E-06	4.06E-08	2.24E-10	1.24E-12	1.50E-14	8.16E-15	8.16E-15
Europium-154	6.60E-05	1.17E-06	2.07E-08	6.49E-12	2.04E-15	6.38E-19	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.77E-10	1.08E-13	6.54E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.85E-05	1.85E-05	1.84E-05	1.84E-05	1.84E-05	1.84E-05	1.84E-05	1.84E-05	1.83E-05
Thorium-232	2.99E-04	2.99E-04	2.99E-04	2.99E-04	2.99E-04	2.99E-04	2.99E-04	2.99E-04	2.99E-04
Uranium-233	5.00E-04	5.20E-04	5.40E-04	5.79E-04	6.17E-04	6.56E-04	6.93E-04	7.68E-04	8.41E-04
Uranium-234	1.03E-03	1.03E-03	1.03E-03	1.03E-03	1.04E-03	1.04E-03	1.05E-03	1.07E-03	1.09E-03
Uranium-235 + D	7.93E-05	8.13E-05	8.34E-05	8.75E-05	9.16E-05	9.57E-05	9.97E-05	1.08E-04	1.16E-04
Uranium-236	2.68E-05	2.68E-05	2.68E-05	2.68E-05	2.68E-05	2.68E-05	2.68E-05	2.68E-05	2.68E-05
Uranium-238 + D	1.26E-03	1.26E-03	1.26E-03	1.26E-03	1.26E-03	1.26E-03	1.26E-03	1.26E-03	1.26E-03
Neptunium-237 + D	2.42E-02	2.42E-02	2.42E-02	2.42E-02	2.42E-02	2.42E-02	2.42E-02	2.42E-02	2.42E-02
Plutonium-238	1.82E-01	1.23E-01	8.28E-02	3.76E-02	1.71E-02	7.76E-03	3.54E-03	7.62E-04	1.90E-04
Plutonium-239	1.82E+00	1.82E+00	1.82E+00	1.81E+00	1.81E+00	1.80E+00	1.79E+00	1.78E+00	1.77E+00
Plutonium-240	3.76E-01	3.74E-01	3.72E-01	3.68E-01	3.64E-01	3.60E-01	3.56E-01	3.49E-01	3.42E-01
Plutonium-241 + D	4.12E-02	3.81E-02	3.52E-02	3.00E-02	2.55E-02	2.18E-02	1.85E-02	1.35E-02	9.79E-03

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years After Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Americium-241	1.52E+00	1.41E+00	1.30E+00	1.11E+00	9.43E-01	8.04E-01	6.85E-01	4.98E-01	3.62E-01
Americium-242m + D	1.20E-01	1.05E-01	8.93E-02	6.18E-02	4.10E-02	2.66E-02	1.69E-02	6.67E-03	2.58E-03
Curium-242	1.91E-04	1.29E-04	8.68E-05	3.94E-05	1.79E-05	8.14E-06	3.72E-06	7.98E-07	1.97E-07
Curium-243	3.55E-04	1.13E-04	4.13E-05	1.37E-05	1.13E-05	1.10E-05	1.10E-05	1.09E-05	1.08E-05
Curium-244	1.72E-03	7.95E-04	6.55E-04	6.26E-04	6.19E-04	6.12E-04	6.06E-04	5.93E-04	5.81E-04
Total dose	**8.76E+02**	**2.59E+02**	**7.83E+01**	**9.84E+00**	**3.78E+00**	**3.11E+00**	**2.92E+00**	**2.69E+00**	**2.53E+00**
External dose	7.49E+00	2.35E+00	7.44E-01	7.99E-02	1.36E-02	6.38E-03	5.05E-03	3.90E-03	3.13E-03
Soil inhalation	9.87E-01	9.23E-01	8.77E-01	8.09E-01	7.58E-01	7.16E-01	6.82E-01	6.29E-01	5.90E-01
Soil ingestion	4.65E+00	2.44E+00	1.75E+00	1.40E+00	1.29E+00	1.22E+00	1.16E+00	1.07E+00	1.01E+00
Garden produce	8.63E+02	2.53E+02	7.49E+01	7.55E+00	1.72E+00	1.17E+00	1.07E+00	9.88E-01	9.31E-01

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years After Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Tritium	2.76E-12	1.66E-13	1.00E-14	3.62E-17	1.31E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	3.09E-10	3.07E-10	3.05E-10	3.02E-10	2.98E-10	2.94E-10	2.91E-10	2.84E-10	2.77E-10
Nickel-63	2.23E-07	1.58E-07	1.12E-07	5.59E-08	2.80E-08	1.40E-08	7.00E-09	1.75E-09	4.39E-10
Cobalt-60	1.63E-10	2.27E-13	3.16E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	2.00E-09	2.00E-09	2.00E-09	2.00E-09	2.00E-09	2.00E-09	2.00E-09	2.00E-09	2.00E-09
Strontium-90 + D	4.97E-03	1.45E-03	4.24E-04	3.61E-05	3.08E-06	2.62E-07	2.24E-08	1.62E-10	1.18E-12
Niobium-94	1.17E-08	1.17E-08	1.17E-08	1.17E-08	1.16E-08	1.16E-08	1.15E-08	1.15E-08	1.14E-08
Technetium-99	3.84E-09	3.84E-09	3.84E-09	3.84E-09	3.84E-09	3.84E-09	3.84E-09	3.83E-09	3.83E-09
Antimony-125	3.24E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	4.17E-08	4.17E-08	4.17E-08	4.17E-08	4.17E-08	4.17E-08	4.17E-08	4.17E-08	4.17E-08
Cesium-137 + Daughters	2.79E-02	8.79E-03	2.77E-03	2.75E-04	2.73E-05	2.70E-06	2.68E-07	2.64E-09	2.60E-11
Europium-152	5.29E-06	3.93E-07	2.92E-08	1.61E-10	8.89E-13	4.92E-15	4.72E-17	2.01E-17	2.01E-17
Europium-154	2.62E-07	4.63E-09	8.21E-11	2.57E-14	8.07E-18	2.53E-21	0.00E+00	0.00E+00	0.00E+00
Europium-155	6.86E-13	4.17E-16	2.54E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	4.23E-08	4.23E-08	4.23E-08	4.22E-08	4.22E-08	4.21E-08	4.21E-08	4.20E-08	4.19E-08
Thorium-232	7.70E-07	7.70E-07	7.70E-07	7.70E-07	7.70E-07	7.70E-07	7.70E-07	7.70E-07	7.70E-07
Uranium-233	2.24E-07	2.71E-07	3.18E-07	4.12E-07	5.04E-07	5.95E-07	6.86E-07	8.64E-07	1.04E-06
Uranium-234	2.40E-07	2.42E-07	2.45E-07	2.51E-07	2.57E-07	2.65E-07	2.73E-07	2.93E-07	3.16E-07
Uranium-235 + D	1.15E-07	1.18E-07	1.21E-07	1.26E-07	1.32E-07	1.37E-07	1.42E-07	1.53E-07	1.64E-07
Uranium-236	6.15E-09	6.15E-09	6.15E-09	6.15E-09	6.15E-09	6.15E-09	6.15E-09	6.15E-09	6.15E-09
Uranium-238 + D	6.18E-07	6.18E-07	6.18E-07	6.19E-07	6.19E-07	6.19E-07	6.19E-07	6.19E-07	6.19E-07
Neptunium-237 + D	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05
Plutonium-238	2.33E-04	1.57E-04	1.06E-04	4.79E-05	2.17E-05	9.86E-06	4.48E-06	9.31E-07	2.01E-07
Plutonium-239	2.31E-03	2.31E-03	2.31E-03	2.30E-03	2.29E-03	2.29E-03	2.28E-03	2.27E-03	2.25E-03
Plutonium-240	4.77E-04	4.75E-04	4.72E-04	4.67E-04	4.62E-04	4.58E-04	4.53E-04	4.43E-04	4.34E-04
Plutonium-241 + D	5.33E-05	4.92E-05	4.54E-05	3.87E-05	3.30E-05	2.81E-05	2.40E-05	1.74E-05	1.26E-05

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank C-103 (Average) Showing Major Constituents (decayed as of January 2007) and Pathways. (2 sheets)

Nuclide	Years After Site Closure (1/1/2032)								
	100	150	200	300	400	500	600	800	1,000
Americium-241	1.97E-03	1.82E-03	1.68E-03	1.43E-03	1.22E-03	1.04E-03	8.85E-04	6.43E-04	4.67E-04
Americium-242m + D	1.55E-04	1.35E-04	1.15E-04	7.94E-05	5.27E-05	3.41E-05	2.17E-05	8.55E-06	3.29E-06
Curium-242	2.44E-07	1.64E-07	1.11E-07	5.02E-08	2.28E-08	1.03E-08	4.70E-09	9.74E-10	2.08E-10
Curium-243	5.46E-07	1.72E-07	6.08E-08	1.82E-08	1.44E-08	1.40E-08	1.40E-08	1.39E-08	1.38E-08
Curium-244	2.21E-06	1.01E-06	8.33E-07	7.95E-07	7.86E-07	7.78E-07	7.69E-07	7.53E-07	7.38E-07
Total dose	**3.81E-02**	**1.52E-02**	**7.93E-03**	**4.69E-03**	**4.13E-03**	**3.87E-03**	**3.68E-03**	**3.39E-03**	**3.18E-03**
External dose	2.99E-02	9.38E-03	2.96E-03	3.18E-04	5.43E-05	2.54E-05	2.01E-05	1.55E-05	1.25E-05
Soil inhalation	3.63E-03	3.39E-03	3.22E-03	2.97E-03	2.78E-03	2.63E-03	2.50E-03	2.31E-03	2.17E-03
Soil ingestion	4.63E-03	2.43E-03	1.74E-03	1.40E-03	1.29E-03	1.22E-03	1.16E-03	1.07E-03	1.00E-03

APPENDIX E

CAUSTIC ADDITION TECHNOLOGY COST ESTIMATE

Preliminary Cost Estimate

241-C-103 Heel Recovery – Caustic Soak/Sluice

The estimate cost for 241-C-103 Heel Recovery – Caustic Soak/Sluice totals approximately $6.5 million. Table E-1 shows the cost estimate summary, which includes labor, materials, and subcontracts.

Table E-1. Cost Estimate Summary

Description	Total ($)
Project Management	608.4
Engineering, Design and Project Support	845.0
Procurement and Procurement Support	628.0
Construction	1,555.9
Construction Management and Support	787.1
Startup and Testing	523.1
Caustic Addition	137.1
Operations	1,028.0
Sample and Analytic	351.9
Total	6,464.7

The Attachment contains Excel®[1] spreadsheets for the detailed cost estimate.

Estimating Methodology

The technical basis for the cost estimate is a preliminary assessment of the activities needed to add a caustic solution to the tank and initiate a second round of retrieval operations. The cost estimate was developed by quantifying the material, equipment, and labor required to implement the systems and facilities identified in the preliminary assessment. The cost for materials, labor hours, and rates are based on recent experience with design, procurement, and installation of projects currently in process or completed in the recent past at the tank farms.

The cost estimate is grouped into the elements shown in Table C-1 for estimating ease and cost summarization.

Key Assumptions

The estimate is based on reinstalling the equipment necessary for retrieval operations and adding a caustic addition system. The following assumptions were used to complete the estimates:

[1] Excel® is a registered trademark of the Microsoft Corporation, Redmond, Washington.

a. The slurry pump and transfer pump will remain in place and can be used.

b. Two new sluicers will be installed. The two existing sluicers will be removed and put in waste boxes for disposal.

c. The hose-in-hose transfer lines within the tank area will be replaced and reconnected. The replaced hose-in-hose transfer lines will be drained, coiled, and put in waste boxes for disposal.

d. The ventilation system will be reconnected and a new vacuum breaker and pressure differential indicating transmitter installed.

e. The electrical and instrumentation will be reconnected to the control trailer.

f. An existing hydraulic power unit and sluicer control console will be relocated to SST C-103. The hydraulic lines will be reconnected.

g. A new camera system with lights will be installed inside the tank.

h. An existing LDM system will be relocated to SST C-103.

i. The DST AN-106 sluicing system will be operational and available for use.

Estimate Basis

The following sections present the basis used to develop the individual elements of the cost estimate.

Project Management

Project Management is for the specific project management and project management support required from the project inception through the retrieval operations. The cost estimates include both the cost of the tank farm personnel and subcontracted services. The estimated cost is based on a consistent level of staffing.

Engineering, Design and Project Support

The engineering, design, and project support includes Title I and Title II Design and Title III Engineering during construction. Engineering, design, and project support also includes project support which provides the Project Manager with supporting functions such as design reviews and environmental, safety and health support.

The basis for the Engineering, Design, and Project Support is a combination of identifying the labor required to provide the needed support and percentages of construction and material costs from previous experience.

Procurement and Procurement Support

Procurement includes procurement of the major equipment, significant fabricated items, and procurement support. The equipment and significant items of fabrication were determined from the available preliminary design information. Prices for equipment are based on recent

experience at the tank farms. The cost estimates for procurement support were developed using the staffing for similar activities recently completed at the tank farms. The major equipment costs are associated with the sluicers and the replacement hose in hose transfer line.

Construction

Construction includes procurement of the minor materials and equipment, field construction, equipment installation,

The quantities of materials and equipment were determined from the available preliminary design information. Prices for materials and equipment are based on recent construction at the tank farms. Field construction and installation costs are based on recent tank farm experience on similar facilities.

Construction Management and Support

Construction management and support includes the cost associated with oversight of the construction subcontractor the HPT and IH support and documentation required to safely perform the construction. The cost estimate for construction management and construction support is based on the staffing for similar projects recently completed at the tank farms.

Start Up and Testing

The estimated cost of startup for both Case 1 and Case 1a is based on the number of systems included in the startup and the complexity of the systems including the number of procedures and the amount of training required. Startup includes both tank farm labor and subcontracted services to perform the following tasks:

a. Develop, review, and approve a Tank Farm Contractor plan for the facility/system startup.
b. Develop, review, and approve an operational readiness review or readiness assessment.
c. Develop and or revise the operating procedures.
d. Develop the needed training material and train the trainer. Operator training is included in the operations.
e. Conduct the system tests in accordance with the test plan.

Caustic Addition

The cost estimate for caustic addition is based on the cost for caustic addition on other tanks at the site. The estimate includes the cost of 100,000 gal of caustic solution.

Operations

The cost estimate for operations includes operator training, operations and maintenance. The retrieval operations are estimated to occur on a continuous basis, 24 hours per day, 7 days per week for 60 days.

The specific scope of the operations function includes shift operations personnel, and other personnel that support shift operations (e.g. radcon, engineers, planners, craft personnel, and necessary supplies and consumables), and sampling and analysis.

The specific scope of the maintenance function includes the activities necessary to maintain operable equipment in a calibrated and functionally tested condition to be compliant with authorization bases, regulatory requirements and to support plant operation. This includes preventive maintenance and calibration work packages, planning, scheduling, and setup of preventive maintenance activities, work package preparation, and approval for work. The scope includes labor for the pre-job meetings, performance of the PM, and post-maintenance testing.

Sample and Analysis

The cost estimate for sample and analysis includes developing, reviewing, and approving the work packages required to collect the samples, collecting one grab sample, and completing laboratory analysis. The estimate for sample collection includes craft support, sampling crew support, and crane and rigging. The estimate for sample analysis includes 222-S Laboratory analysis of a grab sample.

ATTACHMENT TO
APPENDIX E

CH2MHILL
Hanford Group, Inc.

Cost Estimate

Title: C-103 Heel Recovery - Caustic Soak/Sluice
Estimator: Bob Williamson

Est No: 1955 R2
Date: 4/9/2007

Description	Total Labor Hrs	Labor Rate *	Labor Dollars	Material Dollars	Sub-Contract Dollars	Total Dollars
Project Management	7,550.0	76.13	574,777.34	0.00	33,600.00	608,377.34
Subtotal Project Management	**7,550.0**		**574,777.34**	**0.00**	**33,600.00**	**608,377.34**
Engineering, Design and Inspection	0.0		0.00	0.00	365,000.00	365,000.00
Subtotal ED&I	**0.0**		**0.00**	**0.00**	**365,000.00**	**365,000.00**
Project Support						
Prepare/Issue Statement of Work (SOW) for Final Design	180.0	85.46	15,382.12	0.00	3,000.00	18,382.12
CH2MHILL Design Review	1,124.0	78.20	87,900.69	0.00	0.00	87,900.69
Prepare/Issue Critical Lift Calculations	560.0	73.00	40,881.56	0.00	0.00	40,881.56
Fabrication Installation & Test (FIT) Plan	148.0	68.49	10,136.04	0.00	0.00	10,136.04
Prepare/Issue SOW for Criticality Support	70.0	93.54	6,547.97	0.00	10,000.00	16,547.97
USQ	460.0	84.71	38,965.04	0.00	0.00	38,965.04
Update F&R Documents	256.0	86.41	22,120.55	0.00	20,000.00	42,120.55
Process Engineering Support	480.0	93.47	44,865.95	0.00	52,000.00	96,865.95
NS & L Documentation Support	400.0	93.54	37,416.96	0.00	0.00	37,416.96
Title III Engineering Support During Construction	320.0	80.68	25,817.91	0.00	0.00	25,817.91
Title III Engineering Contract	0.0		0.00	0.00	60,000.00	60,000.00
NEC Inspections	0.0		0.00	0.00	5,000.00	5,000.00
Subtotal Project Support	**3,998.0**		**330,034.78**	**0.00**	**150,000.00**	**480,034.78**
Procurement						
Materials and Equipment	0.0		0.00	310,200.00	0.00	310,200.00
Fabrication	0.0		0.00	149,600.00	15,000.00	164,600.00
State Sales Tax (8.3 %)	0.0		0.00	38,200.00	0.00	38,200.00
Subtotal Procurement	**0.0**		**0.00**	**498,000.00**	**15,000.00**	**513,000.00**

CH2MHILL
Hanford Group, Inc.

Cost Estimate

Title: C-103 Heel Recovery - Caustic Soak/Sluice
Estimator: Bob Williamson
Est No: 1955 R2
Date: 4/9/2007

Description	Total Labor Hrs	Labor Rate *	Labor Dollars	Material Dollars	Sub-Contract Dollars	Total Dollars
Procurement Support						
Prepare/Revise/Issue SOW for Fabrication	80.0	66.13	5,290.39	0.00	0.00	5,290.39
Award Fabrication Contract	80.0	66.13	5,290.39	0.00	0.00	5,290.39
Procurement/Fabrication Work Release	60.0	77.31	4,638.31	0.00	0.00	4,638.31
Prepare Material Requests	40.0	49.08	1,963.21	0.00	0.00	1,963.21
Prepare ECN's to Support Fabrication	412.0	70.66	29,111.83	0.00	24,000.00	53,111.83
QAIP Support	80.0	84.40	6,752.26	0.00	0.00	6,752.26
Fabrication - Engineering Support	400.0	82.39	32,956.42	0.00	0.00	32,956.42
Offsite Inspections - Travel Allowance	0.0		0.00	0.00	5,000.00	5,000.00
Subtotal Procurement Support	**1,152.0**		**86,002.81**	**0.00**	**29,000.00**	**115,002.81**
Construction						
General Requirements	3,180.0	74.71	237,580.00	17,100.00	20,000.00	274,680.00
Subtotal General Requirements	**3,180.0**		**237,580.00**	**17,100.00**	**20,000.00**	**274,680.00**
Field Work						
Demolition	2,392.0	60.00	143,520.00	10,000.00	0.00	153,520.00
Tank Risers	1,280.0	60.00	76,800.00	11,000.00	0.00	87,800.00
Transfer Lines	3,020.0	60.00	181,200.00	500.00	2,400.00	184,100.00
Ventilation System	140.0	60.00	8,400.00	0.00	0.00	8,400.00
Ancillary Equipment	2,180.0	60.00	130,800.00	4,000.00	256,000.00	390,800.00
Subtotal Field Work	**9,012.0**		**540,720.00**	**25,500.00**	**258,400.00**	**824,620.00**
Construction Adders	5,407.2	60.00	324,432.00	0.00	132,200.00	456,632.00
Subtotal Construction Adders	**5,407.2**		**324,432.00**	**0.00**	**132,200.00**	**456,632.00**
Subtotal Construction	**17,599.2**		**1,102,732.00**	**42,600.00**	**410,600.00**	**1,555,932.00**

CH2MHILL
Hanford Group, Inc.

Cost Estimate

Title: C-103 Heel Recovery - Caustic Soak/Sluice
Estimator: Bob Williamson
Est No: 1955 R2
Date: 4/9/2007

Description	Total Labor Hrs	Labor Rate *	Labor Dollars	Material Dollars	Sub-Contract Dollars	Total Dollars
CH2MHILL Construction Support						
HPT Support - (1 to 5 Ratio of Field Craft Labor)	2,883.8	57.11	164,691.72	0.00	0.00	164,691.72
IH Technician - (1 to 8 Ratio of Field Craft Labor)	1,802.4	56.34	101,548.08	0.00	0.00	101,548.08
Planning & Work Package Prep (Moderate)	300.0	76.68	23,002.73	0.00	0.00	23,002.73
Planning & Work Package Prep (Complex)	770.0	76.81	59,143.88	0.00	0.00	59,143.88
Enhanced Work Planning	672.0	73.64	49,488.20	0.00	0.00	49,488.20
Review & Approve Work Packages	670.0	75.29	50,446.44	0.00	0.00	50,446.44
Closeout Work Packages	120.0	73.84	8,860.36	0.00	0.00	8,860.36
Prepare ECN's	160.0	79.31	12,689.49	0.00	0.00	12,689.49
Prepare USQ's	336.0	93.47	31,406.16	0.00	0.00	31,406.16
Review USQ's	108.0	93.47	10,094.84	0.00	0.00	10,094.84
Radiation Work Permit	220.0	72.84	16,025.81	0.00	0.00	16,025.81
Material Requests	80.0	49.08	3,926.43	0.00	0.00	3,926.43
Pre Job Briefings	300.0	65.94	19,782.66	0.00	0.00	19,782.66
Post Job Alara Review	48.0	70.61	3,389.09	0.00	0.00	3,389.09
Ground Scanning	128.0	91.16	11,668.19	0.00	5,120.00	16,788.19
TSR Matrix	12.0	84.13	1,009.58	0.00	0.00	1,009.58
Lock/Tagouts (Moderate)	120.0	62.00	7,439.97	0.00	0.00	7,439.97
Lock/Tagouts (Complex)	480.0	62.00	29,759.90	0.00	0.00	29,759.90
Field Work Changes (Moderate)	980.0	77.18	75,634.07	0.00	0.00	75,634.07
Construction Acceptance Test (CAT)	240.0	77.60	18,623.69	0.00	0.00	18,623.69
Subtotal Construction Support	**10,430.2**		**698,631.30**	**0.00**	**5,120.00**	**703,751.30**
STARTUP & TESTING						
Training	2,800.0	61.95	173,467.65	500.00	2,000.00	175,967.65
Testing	460.0	61.34	28,215.30	0.00	20,000.00	48,215.30
Operational Readiness	1,340.0	80.11	107,350.63	0.00	0.00	107,350.63
Startup and Test Support	2,500.0	68.64	171,596.08	0.00	20,000.00	191,596.08
Subtotal Startup and Testing	**7,100.0**		**480,629.66**	**500.00**	**42,000.00**	**523,129.66**
Caustic Addition						
Engineering	100.0	83.34	8,334.34	0.00	0.00	8,334.34
Equipment Calcs	18.0	59.64	1,073.48	0.00	0.00	1,073.48
Hose Replacement and Testing	5,200.0	1.90	9,894.46	0.00	0.00	9,894.46
NEC Inspector	0.0		0.00	0.00	819.20	819.20
FH Drivers	0.0		0.00	0.00	5,120.00	5,120.00
Surveyor	985.0	59.51	58,618.32	51,200.00	2,048.00	111,866.32
Caustic Addition						
Subtotal Caustic Addition	**6,303.0**		**77,920.59**	**51,200.00**	**7,987.20**	**137,107.79**

CH2MHILL
Hanford Group, Inc.

Cost Estimate

Title: C-103 Heel Recovery - Caustic Soak/Sluice
Estimator: Bob Williamson
Est No: 1955 R2
Date: 4/9/2007

Description	Total Labor Hrs	Labor Rate *	Labor Dollars	Material Dollars	Sub-Contract Dollars	Total Dollars
Operations						
Planning & Work Package Prep - (Minor)	264.0	76.50	20,197.21	0.00	0.00	20,197.21
Review & Approve Work Packages - (Minor)	160.0	74.88	11,980.14	0.00	0.00	11,980.14
Closeout Work Packages - (Minor)	48.0	73.84	3,544.15	0.00	0.00	3,544.15
ECNs to Support Operations - (moderate)	40.0	79.31	3,172.37	0.00	10,500.00	13,672.37
Prepare USQ's - ("Simple" - Assume 1 for each work package & EC	60.0	93.47	5,608.24	0.00	0.00	5,608.24
Procedure Change Authorization - (moderate)	275.2	76.16	20,958.74	0.00	0.00	20,958.74
Prepare/Issue PM Data Sheets (Planners)	160.0	74.79	11,966.87	0.00	0.00	11,966.87
SOW for Flammable Gas Support	40.0	67.51	2,700.49	0.00	0.00	2,700.49
Flammable Gas Support	160.0	67.51	10,801.97	0.00	0.00	10,801.97
Prepare Process Memo to Support Operations	96.0	67.51	6,481.18	0.00	0.00	6,481.18
Develop Work Packages (moderate)	275.2	76.43	21,034.89	0.00	0.00	21,034.89
Review and Approve Work Packages (moderate)	156.8	74.82	11,731.71	0.00	0.00	11,731.71
Close Out Work Packages (moderate)	76.8	73.84	5,670.63	0.00	0.00	5,670.63
Prepare Radiation Work Permit (moderate)	44.0	72.84	3,205.16	0.00	0.00	3,205.16
Operate System	12,960.0	63.88	827,832.73	0.00	0.00	827,832.73
Maintenance Support During Operations	840.0	60.28	50,632.70	0.00	0.00	50,632.70
Subtotal Operations	**15,656.0**		**1,017,519.21**	**0.00**	**10,500.00**	**1,028,019.21**
Sample and Analyze Tank						
Develop Work Packages (moderate)	275.2	76.43	21,034.89	0.00	0.00	21,034.89
Review and Approve Work Packages (moderate)	156.8	74.82	11,731.71	0.00	0.00	11,731.71
Close Out Work Packages (moderate)	76.8	73.84	5,670.63	0.00	0.00	5,670.63
Prepare Radiation Work Permit (moderate)	44.0	72.84	3,205.16	0.00	0.00	3,205.16
Collect Samples	144.0	57.06	8,216.25	0.00	302,080.00	310,296.25
Subtotal Sample and Analyze Tank	**696.8**		**49,858.65**	**0.00**	**302,080.00**	**351,938.65**
Total C-103 Heel Recovery - Caustic Soak/Sluice	**71,405.2**		**4,491,465.10**	**602,300.00**	**1,370,887.20**	**6,464,652.30**