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Ms. Hedges:

SUBMITTAL OF RETRIEVAL DATA REPORT FOR SINGLE-SHELL TANK 241-C-108, RPP-RPT-55896, REVISION 1

References:

1. ORP letter from T. W. Fletcher to J. A. Hedges, Ecology, "Request for Ecology Agreement that the U.S. Department of Energy (DOE), Office of River Protection (ORP) May Forego Implementing a Third Technology in Tank 241-C-108," 12-TF-0037, dated September 4, 2012.
1216590
2. Ecology letter from J. A. Hedges to T. W. Fletcher, ORP, "Department of Ecology Response to the United States Department of Energy's Letter 12-TF-0037, dated September 4, 2012, and Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C108, RPP-52290, Rev. 1," 12-NWP-178, dated November 16, 2012.
1217884

Attached is the Retrieval Data Report for Single-Shell Tank 241-C-108, completed in accordance with the requirement of the Hanford Federal Facility Agreement and Consent Order Milestone M-045-86, "Submit a retrieval data report to Ecology for the 19 tanks retrieved under the Consent Decree in *Washington v. DOE*, Case No. 08-5085-FVS…" RPP-RPT-55896 documents completion of waste retrieval, and post-retrieval sampling at 241-C-108 using modified sluicing as a first retrieval technology and chemical dissolution as a second retrieval technology.

The U.S. Department of Energy provided a request to forego implementing a third technology on 241-C-108 on September 4, 2012 (Reference 1) and the Washington State Department of Ecology concurred with this request on November 16, 2012 (Reference 2).

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If you have any questions, please contact me, or your staff may contact Joanne F. Grindstaff, Federal Project Director, Retrieval and Closure, at (509) 376-6202.

Kevin W. Smith
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TPD:CJK

Attachment

cc w/ attachment:
Environmental Portal, LMSI
TPA Administrative Record
WRPS Correspondence

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Retrieval Data Report for Single-Shell Tank 241-C-108

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Abstract: This report describes the retrieval of waste from single-shell tank 241-C-108, a 100-series single-shell tank, constructed to store waste in Waste Management Area C. The Department of Energy began removing the waste stored in tank 241-C-108 on December 20, 2006, and completed waste removal operations using the modified sluicing and chemical dissolution (caustic cleaning) technologies (with a subsequent heel water wash) to the limits of technology on March 22, 2012, resulting in an estimated tank 241-C-108 waste volume remaining of ~3,420 gallons or 460 cubic feet. A practicability evaluation determined that further waste retrieval action was impractical.

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RPP-RPT-55896
Revision 1

Retrieval Data Report for Single-Shell Tank 241-C-108

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EXECUTIVE SUMMARY

This Retrieval Data Report presents information showing that single-shell tank 241-C-108 (C-108) has undergone two waste retrieval campaigns, each to its limits of technology. The first waste retrieval technology deployed was modified sluicing, which removed ~90% of the initial waste inventory; a second waste removal technology comprised of chemical dissolution (caustic cleaning) with a subsequent heel water wash removed ~1,900 gal more of waste. The 95% upper confidence level of the residual waste volume contained within tank C-108 is estimated to be ~3,420 gal or 460 ft^3. This Retrieval Data Report also presents an updated post-retrieval risk assessment, provides details on the technologies deployed and their respective performances during the waste removal campaigns, and describes measures taken to prevent and detect leaks during waste retrieval operations.

The tank C-108 modified sluicing waste retrieval campaign began December 20, 2006 and was suspended on April 27, 2007, after reaching the limit of technology for modified sluicing. The caustic cleaning retrieval operations began on October 13, 2011 and concluded on March 22, 2012, after reaching the limit of technology for caustic cleaning. The tank C-108 waste that was removed was transferred to double-shell tank 241-AN-106.

RPP-52290, *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-108* was then developed to assess whether a third waste retrieval campaign should be undertaken at tank C-108. RPP-52290 was issued in May 2012 and updated as Revision 1 in August 2012 to incorporate new information. The Practicability Evaluation Request concluded that the two waste retrieval technologies deployed at tank C-108 had each been deployed to their respective limits of technology, and that a further waste removal campaign was not practicable as that term is used in Appendix C, Part 1, of the Consent Decree in *State of Washington v. Department of Energy*, Case No. 08-5085-FVS (E.D. Wa. October 25, 2010). The State of Washington Department of Ecology agreed with the RPP-52290 premise with the letter response 12-NWP-178, "Re: Department of Ecology Response to the United States Department of Energy's Letter 12-TF-0037, dated September 4, 2012, and *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-108*, RPP-52290, Rev. 1."

The tank C-108 leak detection, monitoring, and mitigation program during retrieval operations used high-resolution resistivity techniques along with readings from a combination of drywell moisture measurements, waste volume assessments (mass balances), and visual inspection to detect, prevent, and control potential leaks. No leaks were detected during tank C-108 retrieval operations.

Subsequent measurement of the residual waste in tank C-108 using topographical mapping survey techniques in accordance with RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives* estimated that the volume of waste remaining in tank C-108 was 397 ft^3, with a 95% upper confidence level of 457 ft^3 (RPP-CALC-54266, *Post-Hard Heel Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-108*).

The inventory of constituents in the residual waste remaining in tank C-108 was determined by laboratory analysis of waste samples taken once it was determined that deployment of a third

retrieval technology was not practicable. The risk assessment for the residual waste in tank C-108 based on sampling analysis shows that for the groundwater pathway, the estimated risk impacts for tank C-108 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 tank C-108 were well below performance objectives. For the suburban garden scenario at 500 years after closure, the effects are below performance objectives.

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LIST OF TERMS

Abbreviations and Acronyms

3D	three-dimensional
BBI	Best-Basis Inventory
BBIM	Best-Basis Inventory Maintenance
CAD	computer-aided design
CAS	Chemical Abstract Services
CCMS	Camera/CAD Modeling System
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
DST	double-shell tank
Ecology	State of Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
ERSS	Enhanced Reach Sluicing System
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HGI	hydroGEOPHYSICS, Inc.
HRR	high-resolution resistivity
HTWOS	Hanford Tank Waste Operations Simulator
ICP	inductively coupled plasma
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
MS	mass spectrometry
ORP	U.S. Department of Energy Office of River Protection

ORSS	Off-Riser Sampling System
PA	performance assessment
PCB	polychlorinated biphenyl
RCW	*Revised Code of Washington*
RDR	Retrieval Data Report
RSD	relative standard deviation
SST	single-shell tank
TIC	tentatively identified compound
TOC	tank operations contractor
TOE	Total Operating Efficiency
TSAP	tank sampling and analysis plan
TSR	Technical Safety Requirement
TWINS	Tank Waste Information Network System
UCL	upper confidence level
WAC	*Washington Administrative Code*
WMA	waste management area
WRPS	Washington River Protection Solutions, LLC
WRS	waste retrieval system
WTT	drywell to tank
WTW	drywell to drywell

Units

ft^3	cubic feet
gal	gallon
in.	inch
kgal	thousand gallons

1.0 INTRODUCTION AND BACKGROUND

Retrieval of single-shell tank (SST) 241-C-108 (C-108) waste occurred in two campaigns. The first campaign used modified sluicing technology to remove the bulk (~41,000 gal or ~90%) of the waste. The campaign began on December 20, 2006 and was suspended on April 27, 2007. The second campaign was a caustic cleaning retrieval operation, which was comprised of a chemical dissolution step followed by a water rinse. This campaign began on October 13, 2011 and completed on March 22, 2012, removing 1,900 gal of waste. After concluding the second waste retrieval campaign, the 95% upper confidence level (UCL) for the quantity of waste remaining in tank C-108 was estimated to be ~3,420 gal or 460 ft^3 (RPP-CALC-54266, *Post-Hard Heel Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-108*). The modified sluicing campaign is described (and approved by the State of Washington Department of Ecology [Ecology]) in Revision 3A of RPP-22393, *C-102, C-104, C-107, C-108, and C-112 Tanks Waste Retrieval Work Plan.* A chemical retrieval process (caustic cleaning) was identified as the second technology as described (and approved by Ecology) in Revision 6 of RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan.*

In accordance with Appendix C, Part 1, of the Consent Decree in *State of Washington v. Department of Energy*, Case No. 08-5085-FVS (E.D. Wa. October 25, 2010) (hereinafter "Consent Decree"), RPP-52290, *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-108* was developed to assess whether a third waste retrieval campaign should be undertaken at tank C-108. RPP-52290 was issued in May 2012 and updated as Revision 1 in August 2012 to incorporate new information. The Practicability Evaluation Request determined that a further waste removal campaign was impractical. The U.S. Department of Energy (DOE) Office of River Protection (ORP) formally requested Ecology to forego deploying a third waste retrieval technology on September 4, 2012 via a letter from T. W. Fletcher to J. A. Hedges [Letter 12-TF-0037, "Request for Ecology Agreement that the U. S. Department of Energy (DOE), Office of River Protection (ORP) May Forego Implementing a Third Technology in Tank 241-C-108"]. The Washington State Department of Ecology concurred with this request on November 16, 2012 via a letter from J. A. Hedges to T. W. Fletcher (Letter 12-NWP-178, "Re: Department of Ecology Response to the United States Department of Energy's Letter 12-TF-0037, dated September 4, 2012, and *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-108*, RPP-52290, Rev. 1").

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* (RCW 70.105) and its implementing regulations, but is provided for information purposes only.

1.1 PURPOSE

This Retrieval Data Report (RDR) provides information required by *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (HFFACO) Milestone M-045-86. The report documents the following aspects of tank C-108 retrieval:

- 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
- Opportunities and actions being taken to refine or develop tank waste retrieval technologies based on lessons learned
- Leak detection monitoring and performance results.

This report also references a discussion on the Practicability Evaluation Request to Forego a Third Retrieval Technology (RPP-52290).

1.2 REGULATORY REQUIREMENTS

Retrieval of waste from tank C-108 and submittal of this RDR are necessary requirements for closing the Hanford SST system. The HFFACO Milestone M-045-86 provides in part:

> *Submit a retrieval data report to Ecology for the 19 tanks retrieved under the Consent Decree in Washington v. DOE, Case No. 08-5085-FVS, which report shall include the following elements only of Section 2.1.7 of Appendix I to the HFFACO:*
>
> *1) Residual tank waste volume measurement, including associated calculations;*
> *2) The results of residual tank waste characterization;*
> *3) Retrieval technology performance documentation;*
> *4) DOE's updated post-retrieval risk assessment;*
> *5) Opportunities and actions being taken to refine or develop tank waste retrieval technologies, based on lessons learned and,*
> *6) LDMM monitoring and performance results.*

The Consent Decree in *Washington v. DOE*, Case No. 08-5085-FVS, Appendix C states that "If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised Tank Waste Retrieval Work Plan shall be deployed to the "limits of technology;" provided that DOE may request that the State agree

that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above *[in Appendix C, Part 1]*." A Practicability Evaluation was prepared (RPP-52290) that addressed the limits of technology and concluded that a further waste retrieval action for tank C-108 was not practicable. As noted above, the DOE submitted the Practicability Evaluation to the State of Washington with a request to forego implementing third retrieval technology, and the State of Washington (Ecology) concurred with that request.

1.3 DOCUMENT STRUCTURE

This tank C-108 RDR is organized to present information required by Milestone M-045-86 of the HFFACO Action Plan.

- **Section 1,** *Introduction and Background* discusses the purpose and scope of tank C-108 waste retrieval, presents requirements applicable to this report, and outlines the report structure.

- **Section 2,** *Single-Shell Tank 241-C-108 Residual Waste Volume Measurement* describes the method for determining the volume of residual waste in tank C-108 and presents results of the volume measurement process.

- **Section 3,** *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 4,** *Retrieval System Performance* provides an evaluation of how well the waste retrieval system (WRS) performed and provides a comparison of actual performance against predicted performance.

- **Section 5,** *Post-Retrieval Single-Shell Tank 241-C-108 Risk Assessment* describes the potential risk to human health from tank C-108 residual waste. This section identifies and discusses contaminants of potential concern 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. To satisfy recent requests by Ecology, this section also provides additional risk management information related to how concentrations of constituents remaining in waste residuals within tank C-108 compare against the *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup" cleanup standards. These soil cleanup standards are developed to be protective of direct contact exposures and groundwater use.

- **Section 6,** *Opportunities* discusses recommendations for future actions associated with tank C-108 and opportunities to refine future waste retrieval operations at other tanks based on lessons learned.

- **Section 7**, *Leak Detection, Monitoring, and Mitigation* describes leak detection, monitoring, and mitigation (LDMM) methods and procedures, presents an LDMM chronology for tank C-108 waste retrieval, and summarizes LDMM results.

- **Section 8**, *References* contains references for material cited in the report.

2.0 SINGLE-SHELL TANK 241-C-108 RESIDUAL WASTE VOLUME MEASUREMENT

The waste in tank C-108 was retrieved using modified sluicing and chemical cleaning, as described by RPP-22393. A description of the retrieval systems and chronology of the retrieval processes may be found in RPP-52290. Following retrieval, the residual waste volume was determined. This section presents the residual waste volume measurement process and the results for tank C-108. The post-retrieval residual waste volume estimate was performed using a method described in RPP-CALC-54266. The total measured volume of residual waste in tank C-108 was the sum of volumes remaining in the tank dish, on the tank walls, on the stiffener rings, and in the void spaces in equipment left in the tank.

2.1 RESIDUAL WASTE VOLUME MEASUREMENT PROCESS

The waste volume measurement approach is summarized in Sections 2.1.1 through 2.1.3 and is described in RPP-CALC-54266. The Camera/CAD (computer-aided design) Modeling System (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 observation, records, and equipment drawings.

Tank C-108 post-retrieval volumes were previously estimated using Enraf[1] displacement and engineering judgment based on video observations (see RPP-CALC-52225, *Waste Volume of Single-Shell Tank 241-C-108 Remaining After Hard Heel Retrieval*). However, some waste was not submerged after water was added for the final retrieval steps and Enraf displacement provided only a preliminary estimate of waste in the tank bottom. As a result, a post-retrieval CCMS volume estimate was required per RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives.*

In addition, as noted in RPP-CALC-52225, there were several potential sources of error in the Enraf displacement waste volume estimate. The Enraf displacement estimate appeared to be high compared with in-tank video observations. However, on one side of the tank there was little light and videos were dark. Consequently, the amount of waste remaining in the bottom of tank C-108 could not be estimated from the videos obtained during retrieval and the Enraf displacement values provided the primary basis for preliminary waste volume estimates in the retrieval completion report (RPP-RPT-52449, *Single-Shell Tank 241-C-108 Hard Heel Retrieval Completion Report*). Additional video with better lighting was obtained for the CCMS volume estimates.

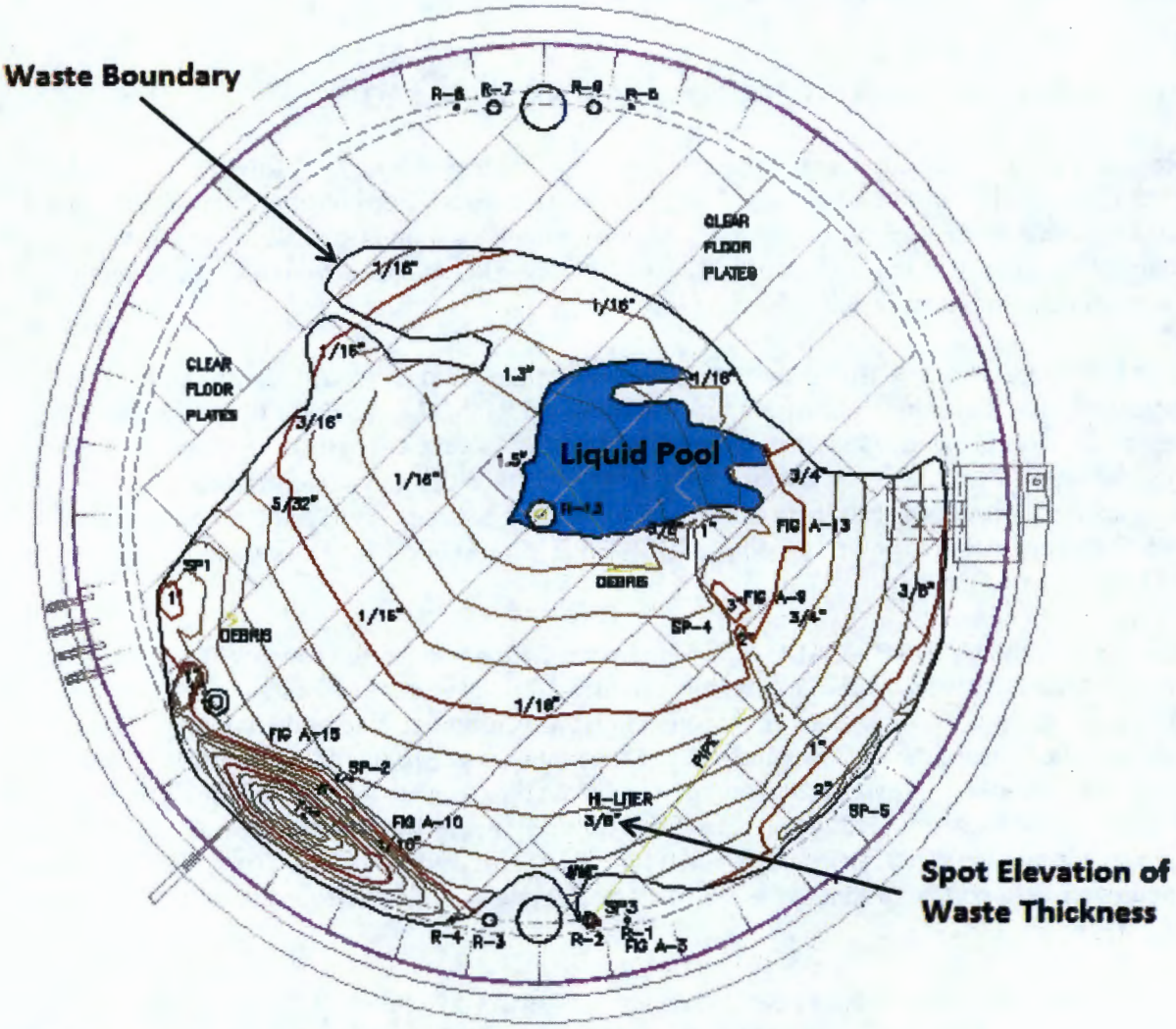
Retrieval of the tank C-108 hard heel was conducted between October 13, 2011 and March 22, 2012. The tank retrieval was declared complete at the limit of technology on March 22, 2012 with a preliminary volume estimate of 658 ft^3 (4,924 gal) of waste remaining based on Enraf displacement and tank video estimates.

[1] Honeywell Enraf is a product of Honeywell Process Solutions, Strahlenbergerstr. 110-112, 63067 Offenbach, Germany.

2.1.1 Video Camera/Computer-aided Design Modeling System

The post-hard heel retrieval waste volume in the bottom of tank C-108 (see Figure 2-1) was estimated using the CCMS method per TFC-ENG-FACSUP-CD-22, "Post-Retrieval Tank Waste Volume Determination." The CCMS videos of tank C-108 were taken on September 16, 2012 from cameras located in riser 3 and riser 8 and video was recorded at heights of ~8 ft, 13 ft, and 18 ft above the bottom of the tank.

Figure 2-1. Tank 241-C-108, AutoCAD® Civil 3D® 2011, Revision 2, Post-Hard Heel Retrieval Tank Waste Volume, Contour Map.



Reference: H-14-109829, *CCMS Residual Waste Surface Volume Tank 241-C-108.*

After the CCMS video was completed, the video was reviewed to develop an AutoCAD® Civil 3D®[2] drawing of tank C-108 and the tank waste residuals and to complete tank bottom volume estimates.

A template of the 100-series 241-C Farm tanks was developed from tank construction drawings (BPF-73550, *Specifications For Construction of Composite Storage Tanks Bldg. No. 241 Hanford Engineer Works Project 9536*, Drawing D-3). The area and depth of waste and equipment in the tank bottom was estimated based on tank features and the dimensions of equipment and debris observed in the CCMS video. The waste contour information was then added to the template drawing to show waste remaining in the tank bottom. After completing the drawings, the Civil 3D® software calculated a waste volume by integrating between the waste contour lines and the tank bottom profile.

The estimated volume of waste on the tank bottom, calculated using AutoCAD® Civil 3D®, was 304.8 ft^3. The waste volume consists of an estimated 279 ft^3 (7.902 × 35.31 ft^3/m^3) of solids piles and a 24.8-ft^3 (0.702 × 35.31 ft^3/m^3) pool of liquids and submerged solids near the center of the tank. The shape of the pool, not round and off-centered (Figure 2-1), indicates that the shape of the tank dish is not the same as in the tank template drawing. This was considered in estimating the depth of waste at different locations in the tank.

2.1.2 Estimation of Waste Remaining on Tank Surfaces

After bulk retrieval, the estimated volume of waste on the stiffener rings was 61.0 ft^3 (456 gal) (RPP-CALC-33487, *Estimate of Waste Volume and Percent Retrieved for Tank 241-C-108*). This was estimated based on the surface area of four sets of stiffener rings located at 4.5-ft intervals from the top of the tank dish and the average depth of waste on the rings at each level. The surface area of each set of stiffener rings was 97.6 ft^2. The average estimated depth of waste on the stiffener rings was as follows: no waste on the top ring (ring #1), 0.5 in. on ring #2, 3 in. on ring #3 and 4 in. on ring #4 (closest to the tank bottom).

No measurable waste was removed from the stiffener rings during hard heel retrieval. However, the waste volume estimate of 61 ft^3 is high because it includes not only the solid waste volume, but also the volume of voids in the waste. Assuming a drainable porosity value of 0.17 (HNF-2978, *Updated Pumpable Liquid Volume Estimates and Jet Pump Durations for Interim Stabilizations of Remaining Single-Shell Tanks*), the estimated volume of waste on the stiffener rings = 61.0 ft^3 × (1 – 0.17) = 50.6 ft^3 (379 gal).

After bulk retrieval, the estimated volume of waste on the tank walls was 372 gal (RPP-CALC-33487). This was based on multiplying the surface area of the walls between each of the stiffener rings by the average depth of waste on the walls. No waste was present above the top stiffener ring (ring #1) on the tank wall. The waste between stiffener rings #1 and #2 was estimated to be 0.0625 inch. The waste between stiffener rings #2 and #3 was 0.125 in. and the waste between stiffener rings #3 and #4 was ~0.375 inch. Except for bottom waste piles, no waste was observed on the walls below stiffener ring #4 in the knuckle region of the tank.

[2] AutoCAD® and Civil 3D® are trademarks of Autodesk, Inc., 111 McInnis Parkway San Rafael, California.

As for the stiffener rings, no additional waste was removed from the tank walls during hard heel retrieval. Adjusting the volume of 372 gal to account for void spaces in the waste, the estimated volume of waste on the walls is 372 gal × (1 – 0.17) = 309 gal (41.3 ft^3) at a drainable porosity of 0.17.

2.1.3 Estimation of Waste in Equipment

Per RPP-23403, tank waste remaining in equipment was included in the total waste volume, but the tank equipment was not included. A few small pipes, a steel tape and the off-riser sampler were observed in the tank video. Although the pipes may be full of waste and some waste was observed on the off-riser sampler, the volume of equipment and the volume of waste potentially remaining in residual equipment in tank C-108 was negligible compared to the volume of waste in the tank bottom, on the stiffener rings and on the walls. Therefore, no waste volume was assigned to the tank equipment. A video still of the Off-Riser Sampling System (ORSS) next to a pile of waste is shown in Figure 2-2.

Figure 2-2. Tank 241-C-108 Video Still, Recorded September 16, 2012, Camera Elevation Approximately 8 feet from Tank Bottom.

The O.R.S.S. next to SP-2 to illustrate the height of the pile.

2.2 RESIDUAL WASTE VOLUME RESULTS

The total CCMS volume of post-retrieval residual waste in tank C-108 and the waste volumes associated with the various waste components are given in Table 2-1. The best estimate for the total post-retrieval waste volume in tank C-108 is 397 ft^3 with a 95% UCL of 457 ft^3.

Table 2-1. Tank 241-C-108 Total Waste Volume and Component Waste Volumes.

Component	Waste volume			95% UCL[a] (ft^3)
	m^3	gal	ft^3	
In the bottom (dish) of the tank (solids and liquids)	8.63	2,280	305	365
Waste in tank equipment[b]	0	0	0	0
On the stiffener ring[c]	1.43	379	50.6	50.6
On the tank wall[c]	1.17	309	41.3	41.3
Total[d]	11.2	2,968	397	457

1 ft^3 = 7.481 gal, 1 m^3 = 264.2 gal, UCL = upper confidence level, CCMS = Camera/CAD (computer-aided design) Modeling System

[a] Per RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, the estimated CCMS error is calculated using: Volume at 95% UCL = 1.195 × CCMS reading + 0.27 ft^3.

[b] Negligible compared to other waste components.

[c] The estimated volume for waste on the stiffener ring and on the tank wall is the upper bounding estimate.

[d] Total may not equal sum of individual volumes because of rounding.

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3.0 RESIDUAL TANK WASTE CHARACTERIZATION

This section describes the results of residual tank waste characterization for tank C-108. Presented are the average and upper bounding estimates of residual waste inventory based on laboratory analysis of waste samples taken after waste removal actions were completed. The calculated inventories are used as input to estimate the potential risk to human health that arises from the residual waste. This risk assessment is discussed in Section 5.0.

3.1 SAMPLING AND ANALYSIS OF RESIDUAL WASTE

The following documents provide requirements for sampling and analysis of the residual waste.

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

- RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks 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.

- RPP-PLAN-40585, *Sampling and Analysis Plan for Waste Solids in Tank 241-C-108* and RPP-PLAN-52471, *Sampling and Analysis Plan for Residual Waste Solids in Tank 241-C-108* – These tank sampling and analysis plans (TSAPs) summarize the sampling and analysis requirements in the DQO for post-sluicing and post-heel removal solids, respectively. The TSAPs provide additional guidance and clarification for satisfying the requirements. The guidance and clarification are necessary to address conditions that are specific to tank C-108.

The post-sluicing and post-heel removal sampling events, respectively, are described below. Both sampling events were conducted using the ORSS.

The ORSS consists of a remotely-operated mobile sampler and a sample carrier. This tool is designed to collect samples of solids that are not located directly under a riser. The ORSS is lowered through a 12-in.-diameter riser into the tank, then maneuvered remotely to a location specified in the TSAP to collect a waste sample. The sampler deposits the waste material into a sample jar located on the sample carrier, which is then raised into the glovebag at the top of the riser. The sample is removed from the glovebag and shipped to the 222-S Laboratory for analysis. This process is repeated until the samples specified in the TSAP are collected. A photograph of an ORSS is shown in Figure 3-1.

Samples of solids remaining in tank C-108 after modified sluicing were taken for laboratory testing to evaluate additional retrieval technologies; all analyses specified in the DQO and the sampling and analysis plan were also performed on the samples. The data are reported in

RPP-RPT-43234, *Final Report for Tank 241-C-108 Solid Samples Taken after Modified Sluicing*. Ecology requested these data in order to evaluate removal of health risk contributors by the retrieval technologies. Ecology and ORP also agreed to use the sample results to develop a more focused list of analyses for samples that will be taken after completion of retrieval (i.e., samples that will be taken as directed in this TSAP). Ecology, ORP, and Washington River Protection Solutions, LLC (WRPS) personnel met on April 12, 2012 and came to an agreement on the analyses for the post-retrieval samples. Provided in document RPP-PLAN-52471 is the focus list of analyses for samples, which includes primarily the detected analytes in the earlier samples. Unlike previous component closure TSAPs, Ecology and ORP signed for approval of this TSAP because the tank C-108 sampling and analysis represents an alternative approach to that described in the DQO and sampling and analysis plan. These signatures are contained in RPP-PLAN-52471.

Figure 3-1. Photograph of an Off-Riser Sampling System.

3.2 SAMPLING AT SINGLE-SHELL TANK 241-C-108

For the post-sluicing sampling event, the ORSS was lowered through riser 3 into the tank. Eight of the nine samples specified in RPP-PLAN-40585 were taken. At this point, a malfunction of the sampling scoop ended the sampling event. Sampling objectives were re-evaluated and the sampling event was declared complete based on the following reasons.

- Most of the solids in the tank were located in two mounds on the east and west sides of the tank (see Figure B-1 in Appendix B of RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment*) where the first six samples were taken, three from each mound. The last two samples, C108-09-7 and C108-09-8, were taken near the center of the tank; since not many solids materials were present in this location, these two samples were not representative of the bulk of the residual waste in tank C-108 and consequently only the samples that were taken at locations 1 through 6 were used in the final analysis.

- The volume of waste solids collected in the first six samples was sufficient to characterize the bulk of the residual solids in the tank.

Therefore, the sampling objectives were judged to have been achieved with the collected samples. The samples were shipped to the 222-S Laboratory for analysis. Descriptions of the solids samples are provided in Table 3-1 as reported in RPP-RPT-43234.

As discussed above, because samples C108-09-7 and C108-09-8 did not represent the bulk of the waste, only samples at locations 1 through 6 were composited and analyzed in detail. Approximately 200 g each from samples C108-09-1 and C108-09-4 were taken to form Composite A; ~175 g each from samples C108-09-2 and C108-09-5 were taken to form Composite B; and ~150 g each from samples C108-09-3 and C108-09-6 were taken to form Composite C. These composite samples were used for retrieval technology development testing and analyzed for the constituents identified in RPP-23403 and RPP-PLAN-23827.

For the post-heel removal sampling event, the ORSS was lowered through riser 6. Nine samples were taken as specified in RPP-PLAN-52471. Approximate locations of the samples are shown on Figure B-2 in Appendix B of RPP-RPT-54757. Descriptions of the samples are provided in Table 3-2 as reported in RPP-RPT-54006, *Final Report for Tank 241-C-108 Residual Solid Samples*.

Approximately 50 g from each parent sample was used for preparing the composite samples. Composite A included material from samples 8C-12-21, 8C-12-22, and 8C-12-23; Composite B included material from samples 8C-12-25, 8C-12-26, and 8C-12-27; and Composite C included material from samples 8C-12-24, 8C-12-28, and 8C-12-29. As indicated in Section 3.1, Ecology and ORP agreed to use the post-sluicing sample results to develop a more focused list of analyses for the residual solids samples. This list included primarily the analytes detected in the earlier samples.

Table 3-1. Description of Post-Sluicing Samples.

Sample Identification Number*	Date Sampled	Date Received	Solid Weight (g)	Liquid Volume (mL)	Sample Description
C108-09-1	7/14/09	7/15/09	254	None	Solids mainly light gray in color with numerous small dark inclusions and larger white inclusions; one very large black inclusion was noted during composite preparation.
C108-09-2	7/14/09	7/15/09	219	None	Solids mainly light gray in color with numerous small dark inclusions and larger white and green inclusions.
C108-09-3	7/14/09	7/16/09	167	None	Solids mainly light gray in color with numerous small dark inclusions and larger white inclusions.
C108-09-4	7/14/09	7/16/09	249	5 – 10	Wet brown solids with numerous small dark inclusions and larger green inclusions.
C108-09-5	7/14/09	7/16/09	196	None	Solids mainly light gray in color with numerous small dark inclusions and larger white inclusions; a few green inclusions were observed.
C108-09-6	7/20/09	7/21/09	218	None	Solids mainly light gray in color with numerous small dark inclusions and larger white inclusions.
C108-09-7	7/21/09	7/21/09	295	None	Solids mainly light gray in color with numerous small dark inclusions and larger white inclusions. The solids in the lower ¼ of the jar appeared moist and browner in color.
C108-09-8	7/23/09	7/23/09	204	None	Solids mainly light gray in color with numerous small dark inclusions.

* Last number in sample identification number references one of the sample locations shown in Figure B-1 in Appendix B of RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

3.3 SAMPLE ANALYSES

Analytical methods performed on the samples are identified in Table 3-3. The table also shows the corresponding analysis methods found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, where applicable. Sample analysis results are reported in RPP-RPT-43234. Electronic data were also loaded into Tank Waste Information Network System (TWINS, Queried 02/07/2012, [Best-basis Inventory, Calculation Detail, Tank 241-C-108], http://twins.pnl.gov/twins.htm). Samples C108-09-7 and C108-09-8 underwent a more limited analysis that included x-ray diffraction, scanning electron microscopy, and polarized light microscopy to evaluate mineralogical characteristics of the solids.

Table 3-2. Description of Post-Heel Removal Samples.

Sample Identification Number*	Date Sampled	Date Received	Solid Weight (g)	Liquid Volume (mL)	Sample Description
8C-12-21	8/12/12	8/13/12	354	None	Received a full 240-mL bottle of dark brown sludge. Sample contains small green inclusions.
8C-12-22	8/12/12	8/13/12	280	None	Received a partially full 240-mL bottle of dark brown sludge. Sample contains small green inclusions.
8C-12-23	8/12/12	8/13/12	87.6	None	Received a partially full 240-mL bottle of yellowish brown chunks.
8C-12-24	8/12/12	8/13/12	215	None	Received a partially full 240-mL bottle of dark brown sludge. Sample contains small green inclusions.
8C-12-25	8/12/12	8/13/12	224	None	Received a partially full 240-mL bottle of yellowish brown chunks.
8C-12-26	8/12/12	8/13/12	177	None	Received a partially full 240-mL bottle of dark brown sludge. Sample contains small green inclusions.
8C-12-27	8/12/12	8/13/12	195	None	Received a partially full 240-mL bottle of dark brown sludge. Sample contains small green inclusions.
8C-12-28	8/13/12	8/13/12	187	None	Received a partially full 240-mL bottle of dark brown sludge. Sample contains small green inclusions.
8C-12-29	8/13/12	8/13/12	196	None	Received a partially full 240-mL bottle of yellowish brown chunks.

* Last number in sample identification number references one of the sample locations shown in Figure B-2 in Appendix B of RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

Analytical methods performed on the post-heel removal samples are identified in Table 3-4. Sample analysis results are reported in RPP-RPT-54006. Electronic data were also loaded into TWINS.

3.4 CALCULATION OF RESIDUAL INVENTORY

The residual waste inventories were computed by following the Best-Basis Inventory (BBI) process as described in RPP-7625, *Guidelines for Updating Best-Basis Inventory.*
Two inventories were computed: an average inventory based on mean concentrations, density, and volume and an upper bounding inventory that is an estimate of an inventory at the 95% UCL. The inventories are discussed in the following sections.

Table 3-3. Analytical Methods Used in Analysis of Post-Sluicing Samples.

Analysis Technique[a]	SW-846 Reference Method
Inorganic Analyses	
Bulk Density – Gravimetric	Not applicable
pH	9045
Weight percent water – Thermogravimetric Analysis	Not applicable
Cyanide – Spectrophotometric	9014
Mercury – Cold Vapor Atomic Absorption	7471
Ammonium – Ion Chromatography	EPA 300.7[b]
Anions and Organic Acids – Ion Chromatography	9056
Metals – Inductively Coupled Plasma/Atomic Emission Spectrometry	6010
^{99}Tc – Inductively Coupled Plasma/Mass Spectrometry	6020
Actinides – Inductively Coupled Plasma/Mass Spectrometry	6020
Radiochemical Analyses	
Gamma Energy Analysis	Not applicable
^{90}Sr – Separation/Beta counting	Not applicable
^{14}C – Liquid Scintillation	Not applicable
^{129}I – Separation/Gamma Energy Analysis	Not applicable
^{79}Se – Liquid Scintillation	Not applicable
^{3}H – Liquid Scintillation	Not applicable
^{63}Ni – Liquid Scintillation	Not applicable
^{99}Tc – Liquid Scintillation	Not applicable
^{241}Am – Separation/Alpha Energy Analysis	Not applicable
$^{239/240}$Pu, ^{238}Pu – Separation/Alpha Energy Analysis	Not applicable
Organic Analyses	
Volatile Organic Compound – Gas Chromatography-Mass Spectrometry	8260
Semivolatile Organic Compound – Gas Chromatography-Mass Spectrometry	8270
Polychlorinated Biphenyls – Gas Chromatography-Electron Capture Detection	8082

EPA = U.S. Environmental Protection Agency

[a] Analysis techniques selected during the Data Quality Objective review documented in RPP-48188, *C-108 Hard Heel Dissolution Data Quality Objectives.*

[b] EPA Method 300.7, *Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography.*

Reference: SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.*

Table 3-4. Analytical Methods Used in Analysis of Post-Heel Removal Samples.

Analysis[a]	SW-846 Reference Method
Inorganic Analyses	
Bulk Density – Gravimetric	Not applicable
pH	9045
Weight percent water – Thermogravimetric Analysis	Not applicable
Cyanide – Spectrophotometric	9014
Mercury – Cold Vapor Atomic Absorption	7471
Ammonia – Ion Chromatography	EPA 300.7[b]
Anions and Organic Acids – Ion Chromatography	9056
Metals – Inductively Coupled Plasma/Atomic Emission Spectrometry	6010[a]
^{99}Tc – Inductively Coupled Plasma/Mass Spectrometry	6020
Actinides – Inductively Coupled Plasma/Mass Spectrometry	6020
Radiochemical Analyses	
Gamma Energy Analysis	Not applicable
$^{89/90}$Sr – Separation/Beta counting	Not applicable
^{14}C – Liquid Scintillation Counting	Not applicable
^{79}Se – Separation/Liquid Scintillation Counting	Not applicable
^{3}H – Liquid Scintillation Counting	Not applicable
^{63}Ni – Separation/Liquid Scintillation Counting	Not applicable
^{99}Tc – Separation/Liquid Scintillation Counting	Not applicable
^{241}Am – Separation/Alpha Energy Analysis	Not applicable
$^{239/240}$Pu – Separation/Alpha Energy Analysis	Not applicable
Organic Analyses	
Polychlorinated Biphenyls – Gas Chromatography/Electron Capture Detection	8082

EPA = U.S. Environmental Protection Agency

[a] Analysis techniques selected during the Data Quality Objective review documented in RPP-48188, *C-108 Hard Heel Dissolution Data Quality Objectives.*

[b] EPA Method 300.7, *Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography.*

Reference: SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.*

3.4.1 Average Inventories

The average inventory for each waste constituent was calculated using the automated Best-Basis Inventory Maintenance (BBIM) tool [RPP-5945, *Best-Basis Inventory Maintenance Tool (BBIM): Database Description and User Guide*]. This tool calculates the average inventory by finding the product of the mean concentration, the mean density, and the waste volume (i.e., inventory = concentration × density × volume). The calculations by the BBIM tool are summarized below.

As described earlier, tank C-108 solids were sampled twice: first after completion of modified sluicing which removed the bulk of the solids, and again after heel retrieval which further removed a comparatively small amount of waste. The mean concentrations for each sample set were estimated as follows.

The BBIM used equations from *Variance Components* (Searle et al. 1992) to estimate the mean concentration and density, as well as the associated standard deviation for all constituents that had 50% or more of their reported values greater than the detection limit. These equations compute means by weighting results based on the variance components. Some constituents had concentrations that were below the detection limits. In these cases, the detection limits were used for calculating the mean concentrations. For a constituent with a majority of results below the detection limit, a simple average of the detection limits was calculated. Note that in accordance with BBI protocol, the relative standard deviations (RSDs) for non-detected constituents were assumed to be "1" (RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best Basis Inventories*).

The mean concentrations for the samples taken after modified sluicing are not directly applicable to the post-retrieval residual solids because additional waste was removed by heel retrieval. Estimates of these means were calculated by adjusting for the volume change [Adjusted means = sample means × volume before heel removal (960 ft^3) / volume after heel removal (397 ft^3)]. This is equivalent to assuming that no mass of the constituents of interest was removed during the heel retrieval.

To calculate the average analyte inventories, the BBIM tool automatically used the mean concentrations from the samples taken after heel retrieval when available. Otherwise, the adjusted mean concentrations of analytes from the samples taken after modified sluicing were used. The concentration means used by the BBIM tool to calculate the average inventories are provided in Appendix A.

The BBIM also used the Searle et al. (1992) equations to calculate the mean density and standard deviation for each set of samples. Only the density for the samples taken after heel retrieval was used for the inventory calculations.

As shown in Table 3-5, ~305 ft^3 of waste was left on the tank floor including a 26.7 ft^3 pool of liquid and submerged sludge. The volume of the submerged sludge is not known and was assumed to be negligible. The volume of solids on the tank bottom was estimated to be 279 ft^3 (305 – 25.7) and the total solids volume was estimated to be 371 ft^3 (279 + 50.6 + 41.3).

Table 3-5. Tentatively Identified Compounds in Tank 241-C-108 Residual Solids Samples.

Laboratory Sample Number	Result Type	Tentatively Identified Compound	Result (µg/kg)	Retention Time (minutes)	CAS Number
S09T005889 (composite of field samples C108-09-1 and C108-09-4)	Primary Analysis	Tetrahydrofuran	22	10.22	109-99-9
	Duplicate Analysis	Tetrahydrofuran	18	10.22	109-99-9

CAS = Chemical Abstract Services µg/kg = microgram per kilogram

3.4.2 Bounding Inventories

The 95% UCL inventory of each constituent was estimated based on a statistical method described in RPP-6924. This method is based on calculation of the average inventory (see Section 3.4.1) and a statistical uncertainty (quantified using a standard deviation) for the inventory. The standard deviation of the average inventory was calculated based on statistical uncertainties associated with the concentration, volume, and density measurements.

Standard deviations for the mean concentrations (provided in Appendix B) and density were calculated using the BBIM tool. The standard deviation for waste volume was estimated as described below.

RPP-CALC-54266 provides estimates of post-retrieval residual waste volumes on the tank bottom, on the tank wall, in discarded equipment in the tank, and on the tank stiffener rings (see Table 2-1). The total waste volume was estimated at 397 ft^3. The upper bounding estimates for the waste volume components added up to 457 ft^3. The estimated error for the total volume may be represented as ± 0.15 [(457 – 397) / 397]. The upper bounding estimate for the volume component that makes up the bulk of the waste (waste on the tank bottom) is at the 95% UCL. Therefore, it was assumed that the error associated with the total volume is also at the 95% UCL. Using a factor of 2 for a two-sided 95% confidence level based on a normal distribution with a known variance, the RSD for the total waste volume was estimated to be 0.075 (0.15 / 2). This RSD was used to approximate the RSD associated with the solids volume.

The BBIM tool calculated the inventory RSD using the equation:

$$RSD^2(\hat{I}) \cong RSD^2(\overline{C}) + RSD^2(\overline{D}) + RSD^2(\hat{V})$$

where $RSD^2(\hat{I})$ is the squared inventory RSD, $RSD^2(\overline{C})$ is the squared average concentration RSD, $RSD^2(\overline{D})$ is the squared average density RSD, and $RSD^2(\hat{V})$ is the squared total volume RSD.

According to RPP-6924, the Student's t distribution (or any other probability distribution) is not applicable for determining a confidence interval for the mean inventory because there are no

degrees of freedom associated with the volume measurement. The 95% UCL inventory was approximated by the equation:

$$UCL = \hat{I} + 2 \times \hat{I} \times RSD(\hat{I})$$

where $\hat{I}$ is the average inventory estimate and $RSD(\hat{I})$ is the RSD of the average inventory estimate. The factor "2 times the standard deviation of the estimate" in this equation is analogous to the factor "1.96 times the standard deviation of the mean" for a two-sided 95% confidence interval on the mean based on a normal distribution with a known variance (in accordance with the BBI process which uses a two-sided 95% confidence interval for inventory). The 95% UCL inventories were calculated using the above equation and the average inventory estimates and associated RSDs that were calculated by the BBIM tool.

3.4.3 Evaluation of Sample Data Usability

Residual waste solids were sampled after modified sluicing and heel removal using the ORSS, an accepted sampling method in the DQO (RPP-23403). In accordance with the DQO, three composites were prepared from samples taken for both sampling events. The solids RSDs in Table B-1 represent the uncertainty in the estimates due to sampling and analysis errors and to the waste variability in the tank.

The 222-S Laboratory maintains a Quality Assurance program to ensure data quality. The waste samples were analyzed according to Quality Assurance plans established by the program. In addition, the DQOs specify quality control criteria (e.g., standard recovery, matrix spike recovery, relative difference between duplicate analyses) that are specific to the closure project. The DQOs also provide 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 DQOs. Communications that were used to address data issues are included in the laboratory data reports (RPP-RPT-43234 and RPP-RPT-54006).

Based on this evaluation, it was concluded that the sampling and analysis met the DQO objectives and, therefore, the sample results are acceptable for uses discussed in the DQO, including risk assessment calculations.

3.4.4 Inventory Calculation Assumptions and Clarifications

The inventories for constituents identified in DQO RPP-48188, *C-108 Hard Heel Dissolution Data Quality Objectives* were calculated in accordance with the BBI creation rules documented in RPP-7625. The calculation includes the following assumptions and clarifications.

- Inventories were generated only for constituents specified in the DQO document (RPP-23403). Inventories for BBI analytes that are not included in RPP-23403 were not calculated.

- Only data from the post-sluicing and post-heel removal samples were used to calculate the inventories. Inventories of constituents not detected in the samples were calculated

using the analytical method detection limits. Therefore, these specific inventories are considered conservative estimates.

- Concentration data are available only for solids on the bottom of the tank. Solids on the tank stiffener ring and the tank wall were not sampled and were assumed to have the same composition as the solids on the tank bottom.

- The volume estimate for the residual waste on the tank bottom includes a 25.7-ft^3 pool of liquid and submerged solids. The volume of the submerged solids is not known and it was assumed to be negligible in comparison to the total volume of solids in the tank. The waste was sluiced and rinsed with water at the end of retrieval; therefore, the liquid was assumed to be water.

- Thorium concentration was measured by inductively coupled plasma (ICP)/atomic emission spectrometry and ^{232}Th was measured by ICP/mass spectrometry (MS). Analyses by ICP/MS are generally more reliable at low concentration; therefore, the thorium inventory was calculated based on the ICP/MS results.

- Uranium concentration was estimated from concentrations of uranium isotopes detected by ICP/MS (^{234}U, ^{235}U, ^{236}U, and ^{238}U).

- Inventory of ^{126}Sn was estimated from sample results for tin by assuming all tin in the tank C-108 samples was ^{126}Sn and applying the specific activity for ^{126}Sn. This approach is expected to yield a conservative inventory estimate for this radionuclide.

- Selenium-79 was detected in the post-sluicing samples and, therefore, the post-heel removal samples were analyzed for this radionuclide. However, the laboratory data report (RPP-RPT-54006) indicated that ^{79}Se results for the post-heel removal samples were false positives. Therefore, the post-sluicing sample results were used to estimate the inventory for this radionuclide.

- Plutonium and curium (except for ^{242}Cm) isotopes were calculated from the $^{239/240}Pu$ and $^{243/244}Cm$ analytical results, using process knowledge of the isotopic distributions ratios of tank C-108.

- In accordance with RPP-7625, the ^{137m}Ba inventory is equal to 0.944 times the ^{137}Cs inventory and the ^{90}Y inventory is equal to the ^{90}Sr inventory.

- Thorium-228 was not analyzed because an analysis method was not available. Inventory of this radionuclide was estimated from radioactive decay of ^{232}Th and ^{232}U. Based on the decay chain and radioactive half-lives of the daughter products, ^{228}Th activities due to ^{232}Th and ^{232}U decay are approximately equal to the activities of these radionuclides. Thorium-232 was analyzed; ^{232}U activity was estimated from process-knowledge isotopic distribution of total uranium concentration.

- The laboratory was not able to measure cresol (m) and cresol (p) separately; therefore, these compounds were reported as cresol (m&p). Cresol (m&p) was not detected. The inventories of the individual cresol isomers were calculated by assuming the cresol (m&p) detection limit was the upper bound for the individual isomers.

- Similarly, the laboratory was not able to distinguish xylene (m) and xylene (p). Inventories of these xylene isomers were calculated by assuming the xylene (m&p) detection limit was the upper bound for the individual isomers.

- As the name implies, tentatively identified compounds (TICs) from organic analyses were not identified with certainty. In addition, measured concentrations for these compounds are only semi-quantitative. Therefore, inventories were not computed for TICs. Only tetrahydrofuran met the TIC evaluation criteria in RPP-23403 and was reported as a TIC in RPP-RPT-43234 (see Table 3-5).

3.5 INVENTORY ESTIMATES

The average and upper-bounding inventories for the residual solids are shown in Table 3-6. Note that the symbol "<" indicates the inventory was calculated based on the analytical method detection limit because the analyte was not detected in the samples. Radionuclide inventories are decay-corrected to January 1, 2008.

Table 3-6. Inventory Estimates for Selected Constituents in Tank 241-C-108 Residual Solids. (6 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units
1,1,1-Trichloroethane	71-55-6	<	7.96E-05	2.39E-04	kg
1,1,2,2-Tetrachloroethane	79-34-5	<	1.99E-04	5.97E-04	kg
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<	1.99E-04	5.97E-04	kg
1,1,2-Trichloroethane	79-00-5	<	1.51E-04	4.53E-04	kg
1,1-Dichloroethene	75-35-4	<	1.35E-04	4.05E-04	kg
1,2,4-Trichlorobenzene	120-82-1	<	3.17E-02	9.51E-02	kg
1,2-Dichlorobenzene	95-50-1	<	4.12E-02	1.24E-01	kg
1,2-Dichloroethane	107-06-2	<	7.16E-05	2.15E-04	kg
1,4-Dichlorobenzene	106-46-7	<	4.64E-02	1.39E-01	kg
^{125}Sb	14234-35-6	<	4.27E+00	1.28E+01	Ci
^{126}Sn	15832-50-5	<	1.55E+00	4.66E+00	Ci
^{129}I	15046-84-1	<	7.78E-04	2.33E-03	Ci
^{137}Cs	10045-97-3		9.17E+01	1.15E+02	Ci
^{137m}Ba	378253-40-8		8.65E+01	1.08E+02	Ci
^{14}C	14762-75-5	<	6.67E-03	2.00E-02	Ci
^{152}Eu	14683-23-9	<	1.88E+00	5.64E+00	Ci
^{154}Eu	15585-10-1	<	1.32E+00	3.96E+00	Ci
^{155}Eu	14391-16-3	<	2.93E+00	8.79E+00	Ci
1-Butanol	71-36-3	<	1.41E-01	4.23E-01	kg
2,4,5-Trichlorophenol	95-95-4	<	1.80E-02	5.40E-02	kg
2,4,6-Trichlorophenol	88-06-2	<	2.03E-02	6.09E-02	kg
2,4-Dinitrotoluene	121-14-2	<	1.56E-02	4.68E-02	kg
2,6-Bis(1,1-dimethylethyl)-4-methylphenol	128-37-0	<	9.65E-02	2.90E-01	kg
^{228}Th	14274-82-9		1.38E-05	1.82E-05	Ci
^{230}Th	14269-63-7	<	1.14E-02	3.42E-02	Ci
^{231}Pa	14331-85-2	<	2.62E-02	7.86E-02	Ci
^{232}Th	7440-29-1		1.28E-05	1.62E-05	Ci
^{233}U	13968-55-3	<	2.02E-01	6.06E-01	Ci

Table 3-6. Inventory Estimates for Selected Constituents in Tank 241-C-108 Residual Solids. (6 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units
^{234}U	13966-29-5		2.65E-02	3.84E-02	Ci
^{235}U	15117-96-1		1.48E-03	1.80E-03	Ci
^{236}U	13982-70-2		2.32E-04	4.15E-04	Ci
^{237}Np	13994-20-2	<	7.40E-03	2.22E-02	Ci
^{238}Pu	13981-16-3		3.71E-03	4.35E-03	Ci
^{238}U	7440-61-1		3.28E-02	4.03E-02	Ci
^{239}Pu	15117-48-3		5.44E-01	6.37E-01	Ci
^{240}Pu	14119-33-6		5.92E-02	6.93E-02	Ci
^{241}Am	14596-10-2		7.85E-01	9.80E-01	Ci
^{241}Pu	14119-32-5		8.21E-02	9.62E-02	Ci
^{242}Cm	15510-73-3	<	2.41E-02	7.23E-02	Ci
^{242}Pu	13982-10-1		8.23E-07	9.64E-07	Ci
^{243}Cm	15757-87-6	<	1.14E-03	3.42E-03	Ci
^{244}Cm	13981-15-2	<	2.43E-02	7.29E-02	Ci
2-Butanone	78-93-3	<	1.06E-03	3.18E-03	kg
2-Chlorophenol	95-57-8	<	2.72E-02	8.16E-02	kg
2-Ethoxyethanol	110-80-5	<	7.47E-02	2.24E-01	kg
2-Methylphenol	95-48-7	<	2.36E-02	7.08E-02	kg
2-Nitrophenol	88-75-5	<	2.20E-02	6.60E-02	kg
2-Nitropropane	79-46-9	<	6.27E-04	1.88E-03	kg
^{3}H	15086-10-9	<	3.11E-02	9.33E-02	Ci
4-Chloro-3-methylphenol	59-50-7	<	1.77E-02	5.31E-02	kg
4-Nitrophenol	100-02-7	<	2.15E-02	6.45E-02	kg
^{60}Co	10198-40-0	<	4.29E+00	1.29E+01	Ci
^{63}Ni	13981-37-8		2.48E+00	3.26E+00	Ci
^{79}Se	15758-45-9		1.38E-03	1.75E-03	Ci
^{90}Sr	10098-97-2		1.36E+03	1.93E+03	Ci
^{90}Y	10098-91-6		1.36E+03	1.93E+03	Ci
^{99}Tc	14133-76-7		3.96E-02	4.99E-02	Ci
Acenaphthene	83-32-9	<	7.21E-03	2.16E-02	kg

Table 3-6. Inventory Estimates for Selected Constituents in Tank 241-C-108 Residual Solids. (6 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units
Acetate	71-50-1	<	1.26E+00	3.78E+00	kg
Acetone	67-64-1	<	1.74E-03	5.22E-03	kg
Ag	7440-22-4	<	4.20E-02	1.26E-01	kg
Al	7429-90-5		2.83E+03	3.39E+03	kg
Aroclors (Total PCB)	1336-36-3		3.66E-03	5.94E-03	kg
As	7440-38-2	<	2.10E-01	6.30E-01	kg
B	7440-42-8	<	4.20E-02	1.26E-01	kg
Ba	7440-39-3		3.51E-01	4.68E-01	kg
Be	7440-41-7	<	1.02E+00	3.06E+00	kg
Benzene	71-43-2	<	1.27E-04	3.81E-04	kg
Bi	7440-69-9	<	8.72E+01	2.62E+02	kg
Br	24959-67-9	<	6.74E-01	2.02E+00	kg
Butylbenzylphthalate	85-68-7	<	2.05E-02	6.15E-02	kg
Ca	7440-70-2		1.96E+01	2.33E+01	kg
Carbon disulfide	75-15-0	<	1.19E-04	3.57E-04	kg
Carbon tetrachloride	56-23-5	<	1.19E-04	3.57E-04	kg
Cd	7440-43-9	<	4.20E-02	1.26E-01	kg
Ce	7440-45-1	<	2.61E+01	7.83E+01	kg
Chlorobenzene	108-90-7	<	8.75E-05	2.63E-04	kg
Chloroform	67-66-3	<	7.16E-05	2.15E-04	kg
Cl	16887-00-6	<	7.19E-01	2.16E+00	kg
CN	57-12-5		1.34E-01	1.63E-01	kg
Co	7440-48-4	<	4.20E-02	1.26E-01	kg
Cr	7440-47-3		5.14E-01	6.51E-01	kg
Cresol	1319-77-3	<	4.37E-02	1.31E-01	kg
Cresol (m)	108-39-4	<	2.11E-02	6.33E-02	kg
Cresol (p)	106-44-5	<	2.11E-02	6.33E-02	kg
Cu	7440-50-8		4.44E-01	5.35E-01	kg
Cyclohexanone	108-94-1	<	2.29E-01	6.87E-01	kg
Di-n-butylphthalate	84-74-2	<	2.30E-01	6.90E-01	kg

Table 3-6. Inventory Estimates for Selected Constituents in Tank 241-C-108 Residual Solids. (6 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units
Di-n-octylphthalate	117-84-0	<	1.95E-02	5.85E-02	kg
Ethyl acetate	141-78-6	<	3.87E-04	1.16E-03	kg
Ethyl ether	60-29-7	<	3.52E-04	1.06E-03	kg
Ethylbenzene	100-41-4	<	9.55E-05	2.87E-04	kg
Eu	7440-53-1	<	4.20E-02	1.26E-01	kg
F	16984-48-8		9.83E+01	1.30E+02	kg
Fe	7439-89-6		2.29E+02	3.03E+02	kg
Fluoranthene	206-44-0	<	1.45E-02	4.35E-02	kg
Formate	12311-97-6	<	1.89E+00	5.67E+00	kg
Glycolate	666-14-8	<	7.19E-01	2.16E+00	kg
Hexachlorobutadiene	87-68-3	<	2.85E-02	8.55E-02	kg
Hexachloroethane	67-72-1	<	4.58E-02	1.37E-01	kg
Hexone	108-10-1	<	7.00E-04	2.10E-03	kg
Hg	7439-97-6		1.66E-02	2.03E-02	kg
Isobutanol	78-83-1	<	1.89E-01	5.67E-01	kg
La	7439-91-0	<	1.02E+00	3.06E+00	kg
Li	7439-93-2	<	1.02E+00	3.06E+00	kg
Methylenechloride	75-09-2	<	1.35E-04	4.05E-04	kg
Mg	7439-95-4		2.76E+00	3.38E+00	kg
Mn	7439-96-5		3.32E+00	5.49E+00	kg
Mo	7439-98-7	<	1.02E+00	3.06E+00	kg
Morpholine, 4-nitroso-	59-89-2	<	7.84E-02	2.35E-01	kg
Na	7440-23-5		2.66E+03	3.24E+03	kg
Naphthalene	91-20-3	<	2.56E-02	7.68E-02	kg
Nb	7440-03-1	<	2.61E+01	7.83E+01	kg
Nd	7440-00-8	<	8.72E+00	2.62E+01	kg
NH_3	7664-41-7		2.53E-02	5.68E-02	kg
Ni	7440-02-0		6.06E+01	7.32E+01	kg
Nitrobenzene	98-95-3	<	2.65E-02	7.95E-02	kg
N-Nitroso-di-n-propylamine	621-64-7	<	2.38E-02	7.14E-02	kg

Table 3-6. Inventory Estimates for Selected Constituents in Tank 241-C-108 Residual Solids. (6 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units
NO_2	14797-65-0		4.71E+00	5.59E+00	kg
NO_3	14797-55-8		7.46E+00	9.35E+00	kg
Oxalate	338-70-5		1.20E+00	1.40E+00	kg
Pb	7439-92-1		1.39E+01	1.83E+01	kg
Pd	7440-05-3	<	9.17E+00	2.75E+01	kg
Pentachlorophenol	87-86-5	<	1.54E-02	4.62E-02	kg
Phenol	108-95-2	<	2.43E-02	7.29E-02	kg
PO_4	14265-44-2		9.56E+02	1.37E+03	kg
Pr	7440-10-0	<	1.68E-01	5.04E-01	kg
Pyrene	129-00-0	<	2.58E-02	7.74E-02	kg
Pyridine	110-86-1	<	2.66E-02	7.98E-02	kg
Rb	7440-17-7	<	1.26E+00	3.78E+00	kg
Rh	7440-16-6	<	8.15E+00	2.45E+01	kg
Ru	7440-18-8	<	1.68E-01	5.04E-01	kg
Sb	7440-36-0	<	2.52E-01	7.56E-01	kg
Se	7782-49-2	<	2.52E-01	7.56E-01	kg
Si	7440-21-3		7.15E+01	1.21E+02	kg
Sm	7440-19-9	<	1.74E+01	5.22E+01	kg
Sn	7440-31-5	<	1.26E-01	3.78E-01	kg
SO_4	14808-79-8		2.38E+00	2.86E+00	kg
Sr	7440-24-6		1.60E+01	2.12E+01	kg
Ta	7440-25-7	<	4.36E+01	1.31E+02	kg
Te	13494-80-9	<	8.72E+01	2.62E+02	kg
Tetrachloroethene	127-18-4	<	1.59E-04	4.77E-04	kg
Th	7440-29-1		1.16E-01	1.47E-01	kg
Ti	7440-32-6		6.15E-02	1.00E-01	kg
Tl	7440-28-0	<	8.72E+01	2.62E+02	kg
Toluene	108-88-3	<	9.55E-05	2.87E-04	kg
Trans-1,3-Dichloropropene	10061-02-6	<	5.57E-05	1.67E-04	kg
Tributyl phosphate	126-73-8	<	4.42E-02	1.33E-01	kg

Table 3-6. Inventory Estimates for Selected Constituents in Tank 241-C-108 Residual Solids. (6 sheets)

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units
Trichloroethene	79-01-6	<	1.19E-04	3.57E-04	kg
Trichlorofluoromethane	75-69-4	<	7.92E-04	2.38E-03	kg
U	7440-61-1		9.84E+01	1.21E+02	kg
V	7440-62-2	<	4.36E+00	1.31E+01	kg
Vinyl chloride	75-01-4	<	2.55E-04	7.65E-04	kg
W	7440-33-7	<	2.52E-01	7.56E-01	kg
Xylene (m)	108-38-3	<	1.67E-04	5.01E-04	kg
Xylene (o)	95-47-6	<	7.96E-05	2.39E-04	kg
Xylene (p)	106-42-3	<	1.67E-04	5.01E-04	kg
Xylenes (total)	1330-20-7	<	2.47E-04	7.41E-04	kg
Y	7440-65-5		8.82E-02	1.10E-01	kg
Zn	7440-66-6		1.56E+00	1.97E+00	kg
Zr	7440-67-7		4.87E-01	6.16E-01	kg

CAS = Chemical Abstract Services

PCB = polychlorinated biphenyls

4.0 RETRIEVAL SYSTEM PERFORMANCE

This section discusses the performance of the tank C-108 WRSs in terms of residual waste, retrieval duration, and water use. In addition, this section compares the achieved waste retrieval results against predicted performance. The residual tank volume at the end of retrieval was described in Section 2.0.

The tank C-108 WRS campaigns consisted of a sluicing operation over a 128-calendar-day period which recovered ~41,000 gal of waste (RPP-CALC-33487). The second waste retrieval campaign removed 1,900 gal (RPP-RPT-52449) over a 161-calendar-day period with an estimated final waste volume of 3,420 gal or 460 ft^3 (RPP-CALC-54266). The BBI estimated that tank C-108 initially contained 66,000 gal (8,800 ft^3) of waste at the start of retrieval operations. The determined residual waste volume in tank C-108 on April 17, 2007 following most of the modified sluicing operations was estimated to be 7,200 gal (RPP-CALC-33487). Additional sluicing operations that occurred between April 18 and April 27, 2007 led to the removal of an estimated 440 gal of additional waste, leaving a remaining waste volume of 6,800 gal (RPP-52290). Based on the differences between the starting volume and the estimated waste transfer volume balance at the end of modified sluicing, a difference of ~19,000 gal in the original waste volume estimate was identified. This difference has been reconciled as being due to the method used to establish the BBI initial waste volume estimate, in that the BBI for this tank did not take into account retained gas. Retained gas was known to be present in the waste and was not addressed in the BBI initial waste estimate, resulting in a discrepancy in tank C-108 reference elevation used by the waste level measurement. When these aspects are taken into consideration, the amended amount of waste stored in tank C-108 at the start of waste retrieval operations was ~47,000 gal (6,300 ft^3).

4.1 WASTE RETRIEVAL PROCESS DESCRIPTION

The WRSs deployed at tank C-108 were designed to mobilize and dissolve the sludge waste so it could be transferred to a double-shell tank (DST), tank 241-AN-106 (AN-106). Descriptions of WRSs may be found in RPP-52290. The bulk WRS used supernate from the DST to break up and fluidize the waste, and transfer it to tank AN-106. Supernate from tank AN-106 was recycled continuously. The volume of supernate transferred to tank C-108 was monitored and balanced by the volume pumped out of tank C-108. The flow rate of the recycled supernate was roughly the same as the flow rate of the slurry pumped to the DST. The bulk sluicing operation directed the supernate toward the tank C-108 waste using sluicers, eroding and moving the waste toward the center transfer pump so as much pumpable material was transferred to the DST as possible.

The second waste retrieval technology deployed at tank C-108 was a combination of water dissolution of sodium fluoride phosphate and caustic cleaning to remove the gibbsite waste portion. The sodium fluoride phosphate was removed first by dissolving it in water and pumping the liquid out of tank C-108. The gibbsite was then removed by adding concentrated sodium hydroxide solution to metathesize the gibbsite to sodium aluminate, then adding water to dissolve the sodium aluminate, and finally pumping the liquid out of tank C-108.

4.2 RETRIEVAL SYSTEMS PERFORMANCE

Before modified sluicing began, most of the waste in tank C-108 consisted of a soft brown sludge. The modified sluicing progressed quickly over the first 11 days of operation as the soft sludge was readily mobilized by the sluicers and pumped from the tank. By January 11, 2007, most of the soft sludge had been removed, leaving behind larger-sized, lighter-colored solids that required more effort to break up and mobilize. Most of the area under and between the two sluicers had been cleared of solids; in these areas, the tank bottom was either exposed or covered by a relatively thin layer of solids. The sluicers were able to move these solids about the tank, but the solids tended to settle too quickly to be entrained in the slurry and pumped. The bulk of the remaining solids were near the tank knuckle (the section connecting the tank dish and the tank walls) on the east and west sides of the tank furthest from the sluicers.

Figure 4-1 shows the modified sluicing retrieval system performance as a function of the volume of slurry (solids plus recycled tank AN-106 supernate) transferred from tank C-108 to tank AN-106. The occasional decreases in the volume retrieved shown in Figure 4-1 reflect fluctuations in the ending tank C-108 liquid pool volume. It was not always possible to pump the tank C-108 liquid pool to the same minimum heel at the end of each operating period.

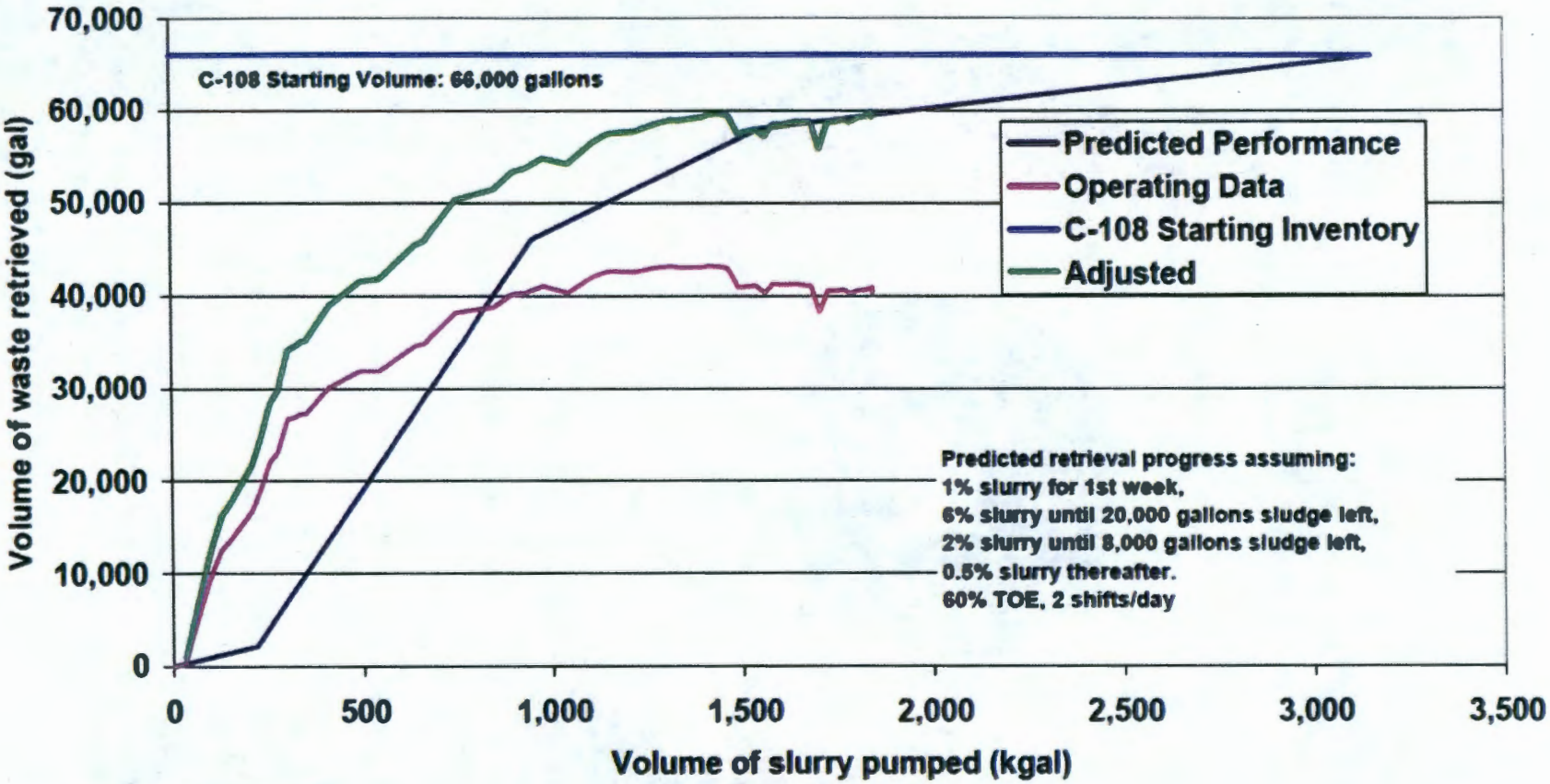
Sluicing retrieval system performance was tracked by trending the net waste volume increase in the receiver tank AN-106 after accounting for water additions; this is shown as the Operating Data line in Figure 4-1. This running volume balance did not distinguish between liquids and solids and did not account for solids dissolution or liquid evaporation. As the volume retrieved approached the starting waste volume, the estimate of the volume remaining in tank C-108 by difference became increasingly sensitive to uncertainties in the starting waste volume estimate and cumulative measurement uncertainties.

The Adjusted line in Figure 4-1 is an estimate of the actual volume of waste retrieved from tank C-108. Subtracting the results of the volume displacement measurements (RPP-CALC-33487) from the starting volume of 66,000 gal gave an estimate of 58,800 gal retrieved as of April 12, 2007, ~17,800 gal more than the volume estimated from the running volume balance (Operating Data).

Both the sluicing Operating Data and Adjusted waste retrieval volumes show the limit of technology being reached following the transfer of ~1,500,000 gal of slurry. The retrieval campaign and limits of technology are discussed in detail in RPP-52290.

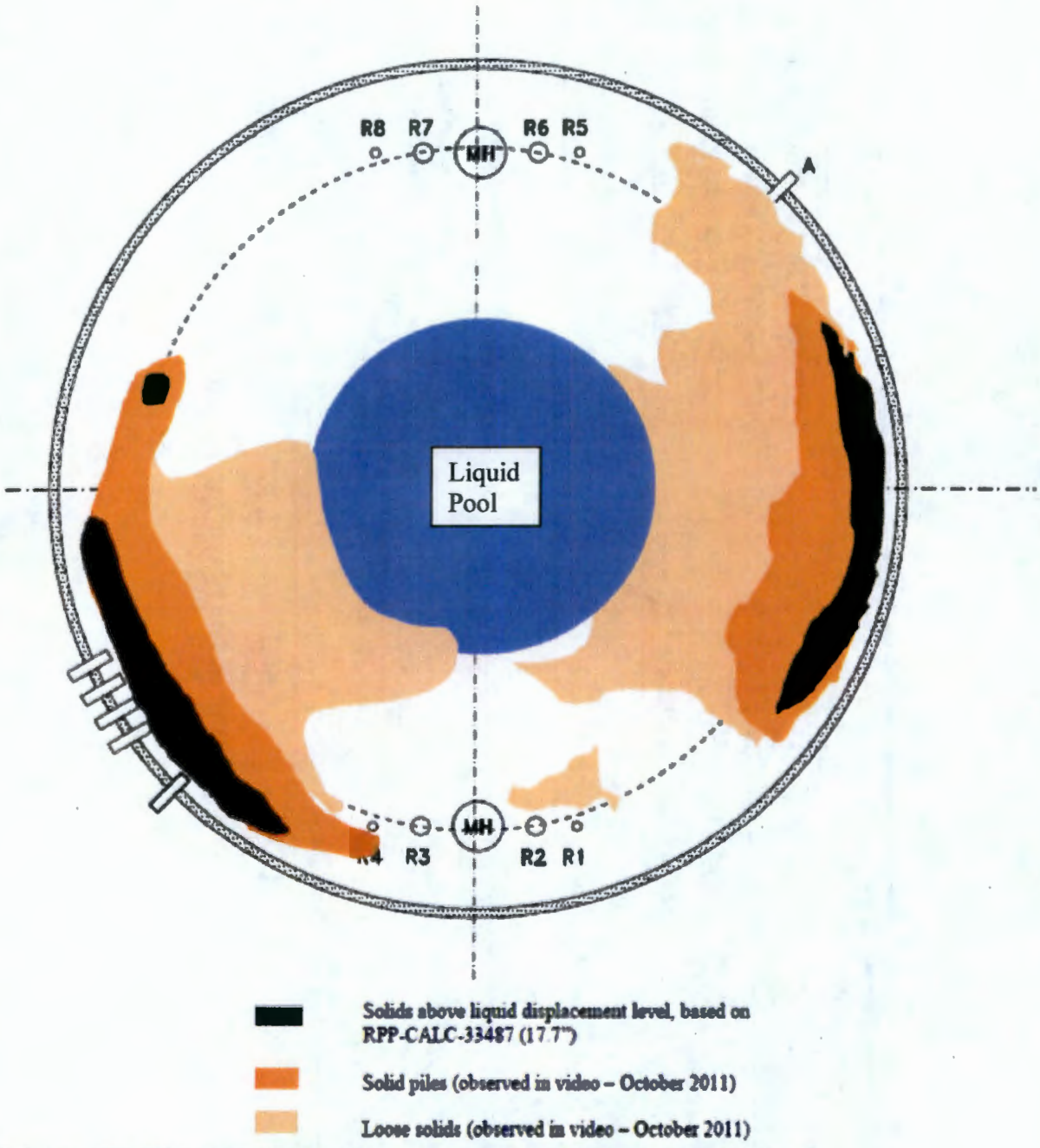
Figure 4-2 shows a diagram of the approximate distribution of solid material following modified sluicing. The bulk of the remaining waste was mostly solids (hard heel) that were not movable by sluicing action and were insoluble in the tank AN-106 supernate. Samples of the residual waste were obtained and analyzed. Solid phase characterization results show the presence of two primary constituents: $Al(OH)_3$ (gibbsite) and $Na_7F(PO_4)_2 \cdot 19\ H_2O$ (natrophosphate [sodium fluoride phosphate]) in an approximate 1:1 ratio (40 wt% gibbsite and 60 wt% natrophosphate) (LAB-RPT-10-00001, *Results of Physicochemical Characterization and Caustic Dissolution Tests on Tank 241-C-108 Heel Solids*).

Figure 4-1. Tank 241-C-108 Modified Sluicing Waste Retrieval System Performance.



TOE = Total Operating Efficiency

Figure 4-2. Approximate Distribution of Material after Modified Sluicing in Tank 241-C-108.



Reference: RPP-CALC-33487, *Estimate of Waste Volume and Percent Retrieved for Tank 241-C-108.*

Based on the characterization results, the caustic cleaning process was evaluated and selected as the best available technology due to the primary constituents of the heel waste, gibbsite and phosphate (RPP-PLAN-43858, *Single-Shell Tank 241-C-108 Hard Heel Retrieval Technology Selection*).

The caustic cleaning process was divided into two parts. Each part addressed a different chemical species; sodium fluoride phosphate and gibbsite. The progress of the water dissolution of sodium fluoride phosphate was tracked by periodic sampling of the liquid and analyzing for the fluoride concentration in the liquid. It was anticipated that the fluoride concentration would rise rapidly and then slow as the solids were depleted or the liquid became saturated. Figure 4-3 shows the sampling results as a function of the circulation/mixing time.

The diamonds (upper line, Figure 4-3) represent the first water wash and the squares (lower line) represent the second water wash. During the first water wash it was anticipated that the initial dissolution process would be completed between October 23 and November 1, 2011. Due to concerns over the possibility of equipment being damaged by freezing, the tank remained quiescent with no mixing from November 2 through December 29 and the liquid was sampled on December 30, 2011. After the initial dissolution, the dissolution rate slowed, but was fairly constant. Solubility of sodium fluoride phosphate is temperature sensitive. Under the conditions of the first wash, it was projected that the solution reached about 60% of saturation. However, it was estimated that not more than 40% of the available sodium fluoride phosphate had dissolved. Therefore, it was decided to perform a second water wash. The second wash proved to be fairly ineffective in achieving additional dissolution as can be seen by the low total concentration achieved and the lower rate of increase as graphed in Figure 4-3.

The second part of the caustic dissolution process was designed to retrieve aluminum compounds with specific emphasis on gibbsite, the second most common compound found in the tank C-108 post-sluicing sample. The process converted the aluminum compounds from a largely insoluble form to a much more soluble form by soaking in very high concentration caustic solution. This is a slow reaction and requires a long contact time to go to completion. Once the reaction went to completion, water was added to dilute the hydroxide and allow the soluble form, sodium aluminate, to dissolve. The sodium aluminate dissolution is rapid. After the dissolution was complete, the contents were pumped from tank C-108. The process of converting gibbsite to the sodium aluminate form was tracked by sampling and analyzing the caustic concentration. Because much of the waste heel was above the liquid level in tank C-108, the liquid was circulated and the waste solids were sprayed with the caustic solution. The video showed that the large piles of waste broke down and were washed below the liquid pool surface during the process. Figure 4-4 shows the results from sampling the caustic during the conversion reaction.

The diamonds shown in the curve in Figure 4-4 represent sampling events. Each sampling event is labeled with the total circulation time and measured hydroxide concentration. The reaction appears to have progressed fairly well during the first four samples. The results from the last three were within the sampling analytical error and from a practical standpoint were the same value, indicating the reaction had stopped.

There are two reasons that the reaction would stop: either the caustic concentration drops too low to sustain the reaction or the available gibbsite has already reacted. Laboratory results indicated that the reaction should continue until the caustic concentration is ~25 wt% if there is gibbsite present. Since the caustic concentration was ~30 wt%, it was concluded that the available gibbsite was reacted.

Figure 4-3. Fluoride Concentration Chart.

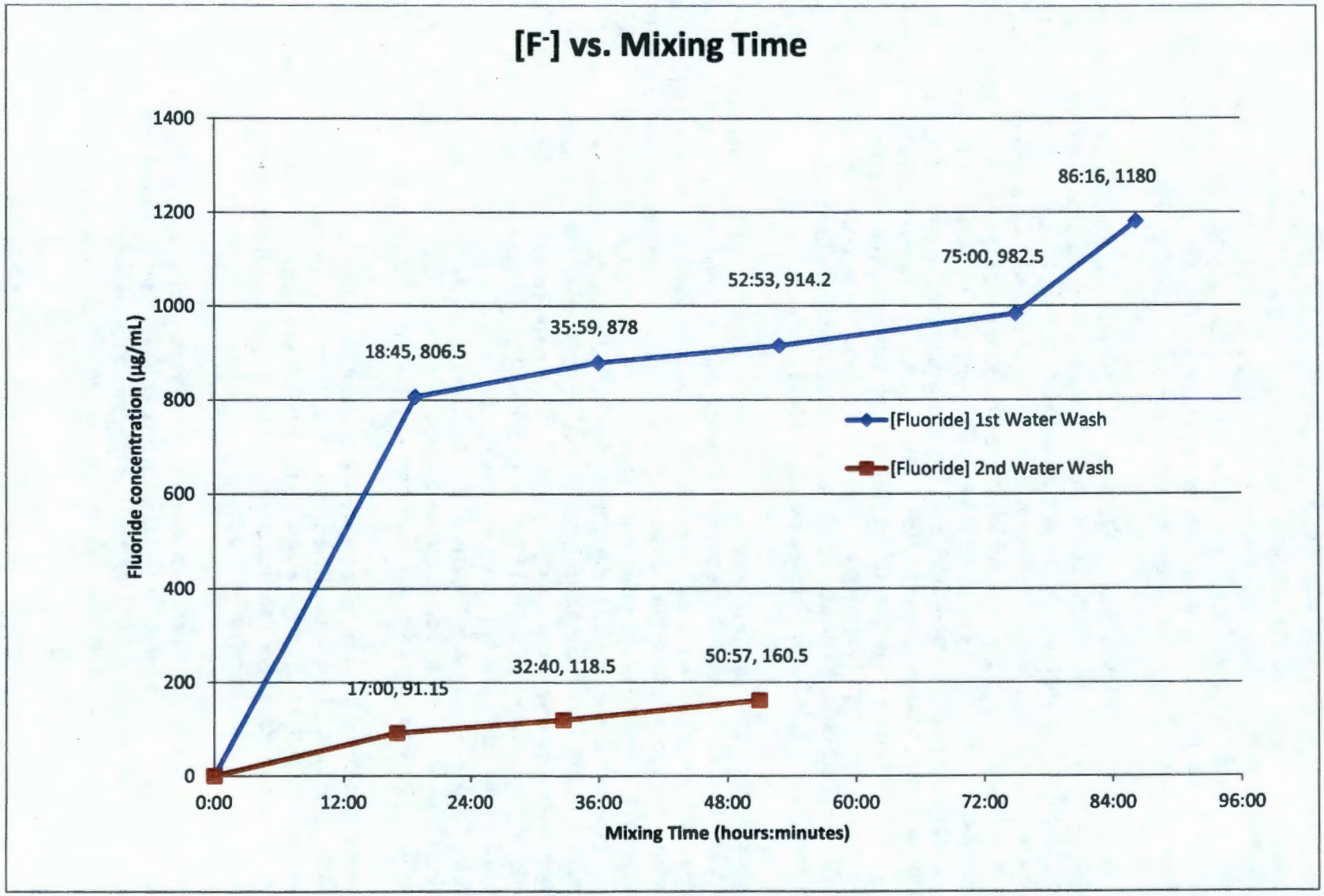
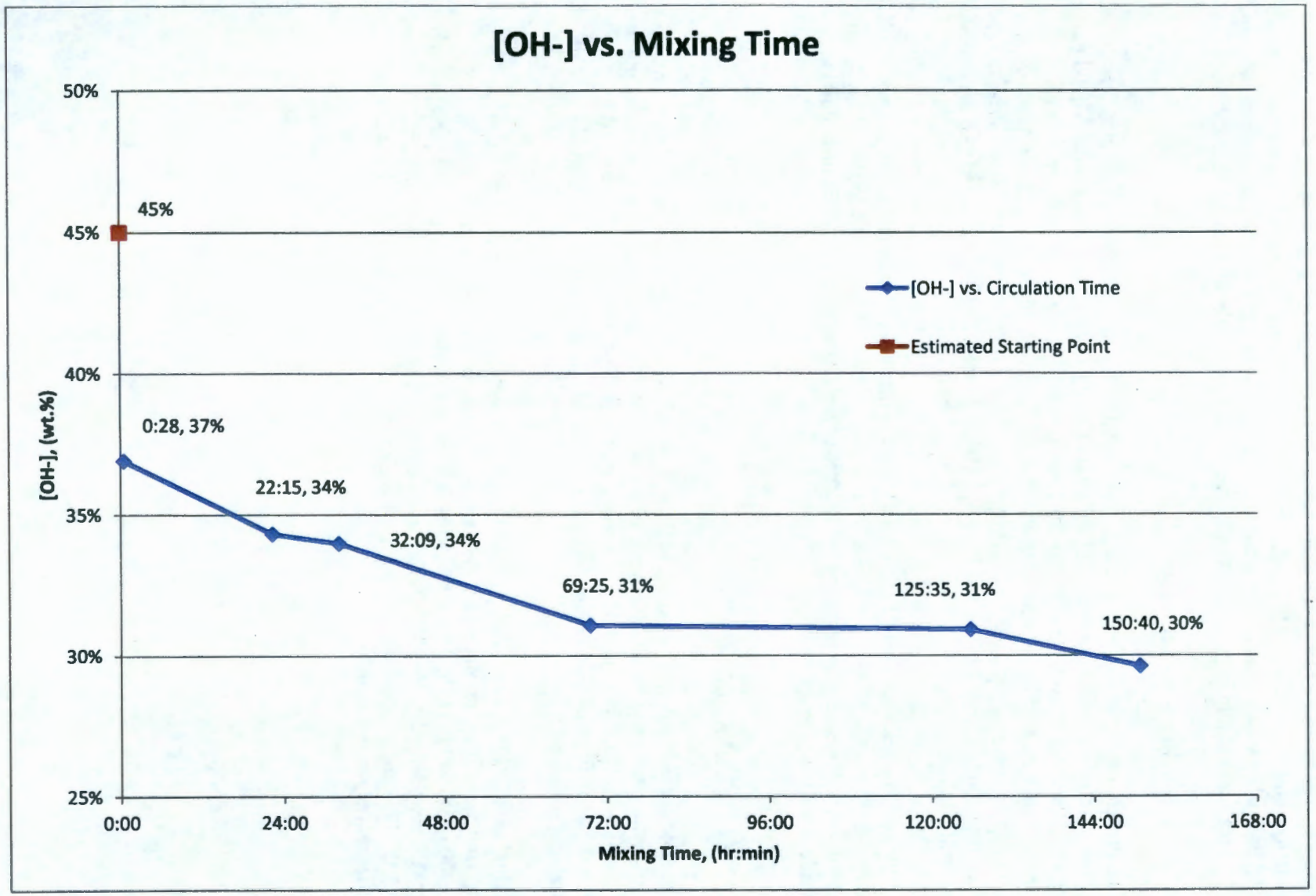


Figure 4-4. Hydroxide Concentration Chart.



From the above data, ORP concluded that the process went to completion and reached its practical limits. On March 19, 2012, tank C-108 caustic solution was circulated for ~3 hours, and little to no visual change was observed. The decision was made to add water on March 20, 2012 for sodium aluminate dissolution based on sample results and visual observations.

4.2.1 Waste Retrieval Efficiency

The preliminary estimate for the tank C-108 modified sluicing campaign indicated that the rate of waste retrieval would require 3,200,000 gal of slurry to transfer the estimated 66,000 gal of tank C-108 waste to tank AN-106. In the first 300,000 gal of the slurry pumped from tank C-108, over half of the waste stored in tank C-108 was transferred to tank AN-106, at almost twice the expected rate. However, when about a third of the forecasted slurry volume had been transferred (1,000,000 gal) to tank AN-106, the tank C-108 waste retrieval rate become insignificant.

Laboratory analysis (LAB-RPT-10-00001) showed that a significant portion of the post-sluicing tank C-108 residual waste would dissolve in a combination of water and caustic cleaning steps. The result of these actions removed only ~28% of the estimated tank C-108 post-sluicing residual waste volume.

4.3 CONCLUSION

Based on the information contained in Section 4.2 above, it was concluded that waste retrieval operations were performed to the limits of the modified sluicing technology. At that time the residual waste volume in tank C-108 was estimated (RPP-CALC-33487) to be 910 ft^3 (6,800 gal). RPP-RPT-52449 concluded that retrieval operations were completed to the limits of caustic cleaning technology.

A final tank C-108 waste volume evaluation, based largely on tank videos taken on September 16, 2012, estimated a 95% UCL for the residual waste volume in tank C-108 of ~3,400 gal (~460 ft^3) (see RPP-CALC-54266). A Practicability Evaluation Request to Forego a Third Retrieval Technology (RPP-52290) determined that the two retrieval systems deployed in tank C-108 were completed to the limits of their respective technologies, and that further retrieval was not practicable.

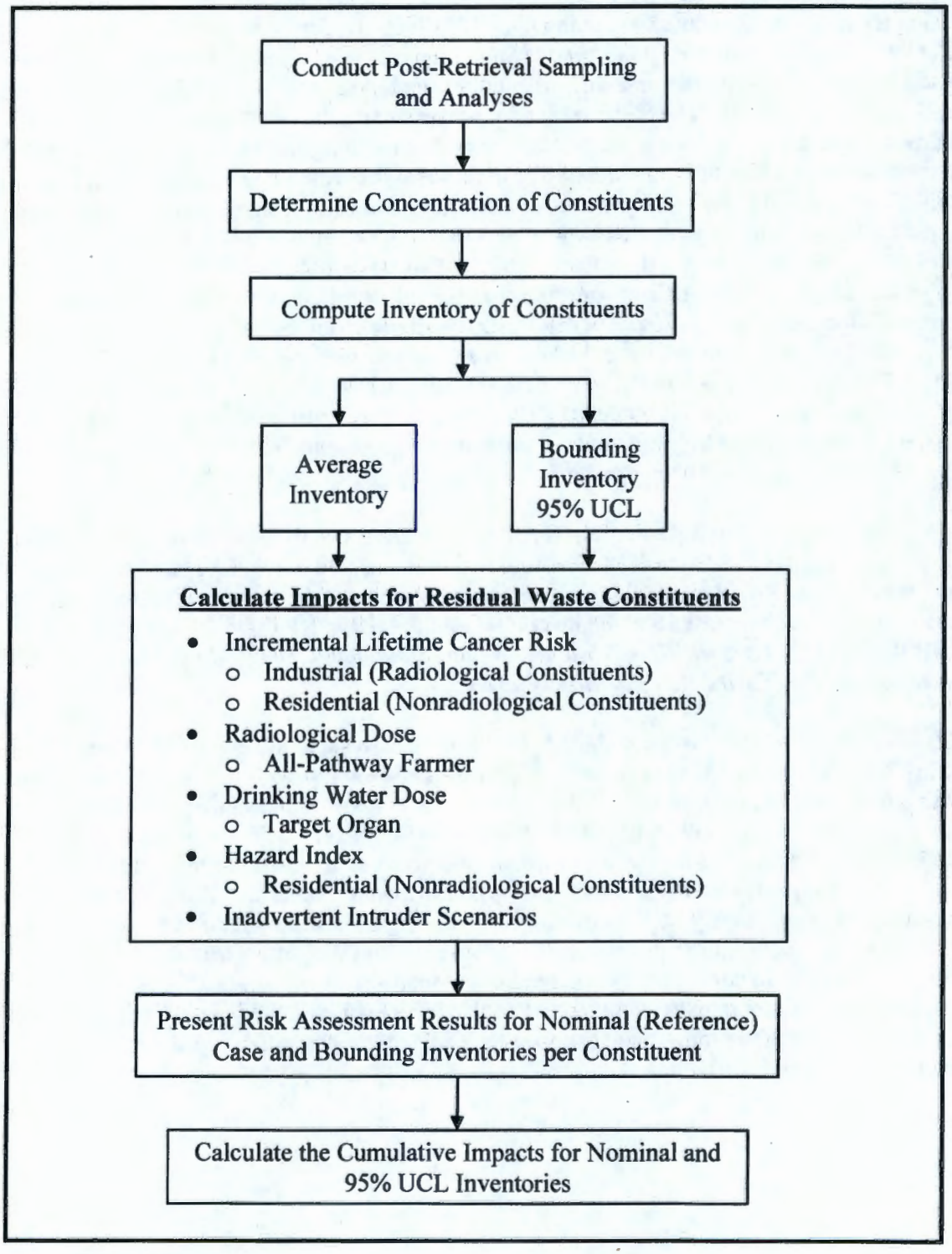
5.0 POST-RETRIEVAL SINGLE-SHELL TANK 241-C-108 RISK ASSESSMENT

The potential impacts to human health posed by the residual waste in SST C-108 were evaluated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. Figure 5-1 provides a schematic of the process used for the tank C-108 risk assessment, and this methodology is described in detail in Chapter 3 of DOE/ORP-2005-01. The SST performance assessment (PA) methodology represents the current approach being used to support the assessment of long-term impacts to human health from tank residuals left in individual SSTs in retrieval data reports. Decisions on final closure of tank C-108 and all other SSTs and ancillary facilities and equipment within Waste Management Area (WMA) C will be supported by a site-specific PA as outlined in Appendix I of the HFFACO. This single PA will evaluate whether closure conditions at WMA C will be protective of human health and the environment for all contaminants of concern, both radiological and non-radiological. The DOE intends that this PA will document by reference relevant performance requirements defined by *Resource Conservation and Recovery Act of 1976*, RCW 70.105, *Federal Water Pollution Control Act* (Clean Water Act), *Safe Drinking Water Act of 1974*, and the *Atomic Energy Act of 1954*, as well as any other performance requirements that might be Applicable or Relevant and Appropriate Requirements under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

The source term used in this tank C-108 risk assessment was derived from post-retrieval residual inventory results (see Section 3.0). The source term presented in this RDR will be incorporated into the WMA C PA. 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*.

Results of the potential impacts to human health were calculated using the average and 95% UCL inventories. Results show that for the groundwater pathway, the effects associated with tank C-108 were two to three orders of magnitude below current incremental lifetime cancer risk (ILCR) performance objectives (1.0E-06 to 1.0E-4) for radioactive analytes and two to three orders of magnitude for ILCR performance objectives (1.0E-05) for non-radioactive analytes. For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the effects associated with tank C-108 were well below both the 100 mrem/yr performance objective for chronic exposure and the 500 mrem performance objective for acute exposure. For comparison, at 500 years after closure, the effects estimated for the suburban garden scenario are two orders of magnitude below the 100 mrem/yr performance objectives for chronic exposure. Details of these results are provided in Sections 5.2 through 5.4.

Figure 5-1. Single-Shell Tank 241-C-108 Residual Waste Inventory and Risk Assessment Process.



UCL = upper confidence level

This section also provides additional risk management information related to concentrations of constituents remaining in waste residuals within tank C-108 compared against the WAC 173-340 cleanup standards. The soil cleanup standards evaluated are developed for direct contact exposures and for groundwater protection. Selected constituent concentrations estimated for the nominal and 95% UCL inventories of tank residuals are specifically compared against soil cleanup levels for the unrestricted land use (Method B) and industrial (Method C) for direct contact exposures and soil cleanup levels protective of groundwater using the fixed parameter three-phase partitioning model given in WAC 173-340-747, "Deriving Soil Concentrations for Groundwater Protection," subsection (4), "Fixed parameter three-phase partitioning model." Results of these comparisons are found in Section 5.5.1.

Section 5.5 also includes a discussion of the appropriateness of comparisons of concentrations of constituents remaining in waste residuals within tank C-108 against cleanup standards protective of ecological risk found in WAC 173-340. Because footnotes in tables containing the cleanup standards protective of ecological concerns indicate these standards are not intended to be used for evaluation of sludges or wastes, specific comparisons of concentrations of constituents remaining in waste residuals within tank C-108 against the WAC 173-340 cleanup standards related to ecosystem risk are not provided.

5.1 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 3.0).

Analytical data for tank C-108 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, semi-volatile 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 non-detect 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 5-1 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.

Table 5-1. 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	U	Dose/Rfd	18496-25-8	Sulfide		No RfD or CPF
^{14}C	Carbon-14	U	Dose/Rfd	7440-25-7	Tantalum	U	No RfD or CPF
^{63}Ni	Nickel-63*		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*		Dose/Rfd	7440-29-1	Thorium		No RfD or CPF
^{90}Sr	Strontium-90 + D		Dose/Rfd	7440-31-5	Tin	U	Rfd
^{90}Y	Yttrium-90		No RfD or CPF	7440-32-6	Titanium		No RfD or CPF
^{94}Nb	Niobium-94		Dose/Rfd	7440-33-7	Tungsten	U	No RfD or CPF
^{99}Tc	Technetium-99		Dose/Rfd	7440-61-1	Uranium		Rfd
^{125}Sb	Antimony-125*	U	Dose/Rfd	7440-62-2	Vanadium	U	Rfd
^{129}I	Iodine-129	U	Dose/Rfd	7440-65-5	Yttrium		No RfD or CPF
^{137}Cs	Cesium-137 + Daughters		Dose/Rfd	7440-66-6	Zinc		Rfd
^{137}mBa	Barium-137m*		No RfD or CPF	7440-67-7	Zirconium		No RfD or CPF
^{152}Eu	Europium-152	U	Dose/Rfd	71-55-6	1, 1, 1-Trichloroethane*	U	Rfd
^{154}Eu	Europium-154	U	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		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		Dose/Rfd	75-35-4	1, 1-Dichloroethene*	U	Rfd
^{233}U	Uranium-233	U	Dose/Rfd	120-82-1	1, 2, 4-Trichlorobenzene*	U	Rfd
^{234}U	Uranium-234		Dose/Rfd	107-06-2	1, 2-Dichloroethane*	U	Rfd/CPF
^{235}U	Uranium-235 + D		Dose/Rfd	106-46-7	1, 4-Dichlorobenzene*	U	Rfd/CPF

Table 5-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/ CAS	Analyte	Detect	Available Toxicity Information
^{236}U	Uranium-236		Dose/Rfd	95-95-4	2, 4, 5-Trichlorophenol*	U	Rfd
^{238}U	Uranium-238 + D		Dose/Rfd	88-06-2	2, 4, 6-Trichlorophenol*	U	Rfd/CPF
^{237}Np	Neptunium-237 + D	U	Dose/Rfd	121-14-2	2, 4-Dinitrotoluene*	U	Rfd
^{238}Pu	Plutonium-238		Dose/Rfd	128-37-0	2, 6-Bis (tert-butyl)-4-methylphenol	U	No RfD or CPF
^{239}Pu	Plutonium-239		Dose/Rfd	78-93-3	2-Butanone(MEK)*	U	Rfd
^{240}Pu	Plutonium-240		Dose/Rfd	95-57-8	2-Chlorophenol*	U	Rfd
^{241}Pu	Plutonium-241 + D		Dose/Rfd	110-80-5	2-Ethoxyethanol*	U	Rfd
^{241}Am	Americium-241		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	U	Dose/Rfd	67-64-1	2-Propanone (Acetone)*	U	Rfd
^{244}Cm	Curium-244	U	Dose/Rfd	108-10-1	4-Methyl-2-pentanone (MIBK)	U	Rfd
7429-90-5	Aluminum		Rfd	106-44-5	4-Methylphenol (p-cresol)	U	Rfd
7664-41-7	Ammonia -- (a)		Rfd	83-32-9	Acenaphthene	U	Rfd
7440-36-0	Antimony*	U	Rfd	71-50-1	Acetate $C_2H_3O_2^-$	U	No RfD or CPF
7440-38-2	Arsenic*	U	Rfd/CPF	71-43-2	Benzene*	U	Rfd/CPF
7440-39-3	Barium*		Rfd	85-68-7	Butylbenzylph-thalate*	U	Rfd
7440-41-7	Beryllium*	U	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	U	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*	U	Rfd/CPF	67-66-3	Chloroform*	U	Rfd/CPF
7440-70-2	Calcium		No RfD or CPF	1319-77-3	Cresylic acid (cresol, mixed isomers)*	U	No RfD or CPF
7440-45-1	Cerium	U	Rfd	108-94-1	Cyclohexanone	U	Rfd

Table 5-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/ CAS	Analyte	Detect	Available Toxicity Information
16887-00-6	Chloride	U	No RfD or CPF	75-09-2	Dichloromethane (methylene chloride)*	U	Rfd/CPF
7440-47-3	Chromium, Total*		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		Rfd	117-84-0	Di-n-octylphthalate*	U	Rfd
57-12-5	Cyanide*		Rfd	141-78-6	Ethyl Acetate	U	Rfd
7440-53-1	Europium	U	No RfD or CPF	100-41-4	Ethylbenzene	U	Rfd/CPF
16984-48-8	Fluoride		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		Rfd	67-72-1	Hexachloroethane*	U	Rfd/CPF
7439-91-0	Lanthanum	U	No RfD or CPF	78-83-1	Isobutanol	U	Rfd
7439-92-1	Lead*		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		No RfD or CPF	91-20-3	Naphthalene*	U	Rfd
7439-96-5	Manganese		Rfd	71-36-3	n-Butyl alcohol (1-butanol)	U	Rfd
7439-97-6	Mercury*		Rfd	98-95-3	Nitrobenzene*	U	Rfd
7439-98-7	Molybdenum	U	Rfd	621-64-7	N-nitroso-di-n-propylamine*	U	CPF
7440-00-8	Neodymium	U	No RfD or CPF	59-89-2	n-Nitrosomorpholine*	U	No RfD or CPF
7440-02-0	Nickel*		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		Rfd	95-47-6	o-Xylene	U	Rfd
14797-65-0	Nitrite		Rfd	59-50-7	p-Chloro-m-cresol (4-Chloro-3-methylphenol)*	U	No RfD or CPF
338-70-5	Oxalate		No RfD or CPF	87-86-5	Pentachlorophenol*	U	Rfd/CPF
7440-05-3	Palladium	U	No RfD or CPF	108-95-2	Phenol*	U	Rfd

Table 5-1. List of Analytes and Available Toxicity Information. (4 sheets)

Isotope/ CAS	Analyte	Detect	Available Toxicity Information	Isotope/ CAS	Analyte	Detect	Available Toxicity Information
14265-44-2	Phosphate		No RfD or CPF	106-42-3	p-Xylene	U	Rfd
7440-09-7	Potassium		No RfD or CPF	129-00-0	Pyrene	U	Rfd
7440-10-0	Praseodymium	U	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	U	No RfD or CPF	126-73-8	Tributyl phosphate	U	Rfd/CPF
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		No RfD or CPF	11097-69-1	Aroclor-1254		Rfd/CPF
7440-22-4	Silver*	U	Rfd	100-02-7	4-Nitrophenol*	U	No RfD or CPF
7440-23-5	Sodium		No RfD or CPF	666-14-8	Glycolate	U	No RfD or CPF
7440-24-6	Strontium		Rfd	10061-02-6	Trans-1,3-Dichloropropene*	U	No RfD or CPF
14808-79-8	Sulfate		No RfD or CPF				

*Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List."

CAS = Chemical Abstracts Service
CPF = Cancer potency factor available
Dose = Radiological dose value available
No RfD/CPF = No published information for a reference dose or cancer potency factor for this chemical
RfD = Reference dose value available
U = Analyte not detected in residual wastes

Gray shaded area indicates non-detect for this analyte.

5.2 RESULTS FOR INDIVIDUAL CONTAMINANTS FOR POST-RETRIEVAL SINGLE-SHELL TANK 241-C-108

Table 5-2 identifies the main contributors to the ILCR (industrial and residential scenarios), groundwater dose (all-pathways farmer scenario), and drinking water dose for radiological components of the residual waste remaining in tank C-108. Table 5-3 identifies the primary hazardous chemicals that contribute to ILCR and the Hazard Quotient. These results are provided for the average residual waste inventory for SST C-108. A more complete listing of all analytes for which there is either a dose (radiological), cancer potency factor (radiological and non-radiological) and reference dose (non-radiological) for the same average inventory is provided in Tables D-1 and D-2 of Appendix D. A similar set of tables based on the 95% UCL inventory is provided in Tables D-3 and D-4 of Appendix D. In each of these tables, the following columns are provided.

a. **Analyte Name**.

b. **Detected in Residual Wastes** is an indicator as to whether an analyte was detected in the laboratory.

c. **Inventory** as shown here for non-detects 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 the methodology used in DOE/ORP-2005-01, this concentration was estimated using cross-sectional modeling of vadose zone and groundwater flow and transport. 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).

Table 5-2. Estimated Maximum Incremental Lifetime Cancer Risk/Radiological Dose during the Modeling Period for Primary Radionuclides Related to Average Residual Waste Inventory in Single-Shell Tank 241-C-108.

Analyte	Above Detection Limits in Residual Waste	Inventory (Ci)	Waste Management Area C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk (Groundwater) Scenarios		Radiological Dose (mrem/yr) All Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
^{99}Tc	Yes	3.96E-02	1.58E-01	1.05E+04	0.00E+00	2.11E+05	2.18E-09	5.31E-08	2.77E-04	7.03E-04
^{129}I	No	3.89E-04	<1.00E-03[c]	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
^{234}U	Yes	2.65E-02	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
^{235}U	Yes	1.48E-03	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
^{236}U	Yes	2.32E-04	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
^{238}U	Yes	3.28E-02	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	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, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[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 waste management area.

[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."

DNA = did not arrive at fenceline within the modeling period
N/A = radionuclide is not a beta/photon emitter
NE = 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

Shaded cells indicate nondetects in sludge or supernate, and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

Table 5-3. Estimated Maximum Value for Incremental Lifetime Cancer Risk and Hazard Quotient for Selected Non-Radiological Analytes Related to Average Residual Waste Inventory in Single-Shell Tank 241-C-108.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[a]	Incremental Lifetime Cancer Risk Scenarios (Groundwater)[b]	Hazard Quotient (Groundwater)[b]
						WAC 173-340 Method B	
Total Cr*	Yes	5.14E-01	<1.00E-03	1.05E+04	0.00E+00	No CPF	NE
Fluoride	Yes	9.83E+01	<1.00E-03[c]	1.05E+04	0.00E+00	No CPF	NE
Nitrite	Yes	4.71E+00	<1.00E-03	1.05E+04	0.00E+00	No CPF	NE
Nitrate	Yes	7.46E+00	<1.00E-03	1.05E+04	0.00E+00	No CPF	NE
Uranium	Yes	9.84E+01	0.00E+00	DNA	6.00E-01	No CPF	NE
Performance Objective[d]						1.0E-06[e]	1.0[f]

Reference: *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup."

[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, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.*

[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 waste management area (WMA), not just a single component of the WMA.

[e] WAC 173-340-705, "Use of Method B" subsection (2)(c)(ii).

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

DNA = did not arrive at fenceline within the modeling period
NE = 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
No CPF = no cancer potency factor available

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III) insoluble salts.

h. **Incremental Lifetime Cancer Risk** (groundwater) is 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)]. The ILCR is derived as the estimated contaminant concentrations of identified constituents that have potential radiation dose, cancer induction risk, and hazard index to individuals or populations exposed to the hazardous materials.

i. **Radiological Dose** is the estimated drinking water dose for the all-pathways farmer exposure scenario (radionuclides only).

j. **Radiological Dose – Beta/Photon** is the drinking water dose from beta/photon emitting radionuclides using equivalent dose (radionuclides only).

k. **Hazard Quotient** (groundwater) – Hazard quotients calculated for residential and industrial scenarios described in HNF-SD-WM-TI-707.

5.3 CUMULATIVE ANALYSIS RESULTS FOR SINGLE-SHELL TANK 241-C-108 AND WASTE MANAGEMENT AREA C

The cumulative analysis (i.e., sum of the risk metrics) for tank C-108 residual average and 95% UCL risk levels was calculated and is provided in this section.

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

- **95% UCL 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 3.0).

The impacts for the groundwater pathway associated with each residual waste inventory are evaluated with a variety of performance metrics. The ILCRs are evaluated for radiological analytes using the average and 95% UCL inventories and industrial and residential exposure scenarios. The ILCR and hazard indices are examined for the same inventories using a residential exposure scenario.

Radiological doses using the same two inventories are also evaluated for an all-pathways farmer and a drinking water only exposure scenario. Estimated concentration levels of some selected analytes are also provided and compared against current maximum concentration levels.

A comparison of impacts from the average and the 95% UCL inventories and current performance metrics for ILCR, hazard indices, radiological doses, and maximum concentration limits are summarized in Table 5-4.

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Indices, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories Estimated in Single-Shell Tank 241-C-108. (2 sheets)

Metric[a]	Industrial Receptor		Residential Receptor		Performance Objective[b]
	Average Inventory	95% Upper Confidence Level Inventory	Average Inventory	95% Upper Confidence Level Inventory	
Radioactive Analytes Incremental Lifetime Cancer Risk (unitless)					
Total without non-detects[c]	2.18E-09	2.75E-09	5.31E-08	6.69E-08	1.0E-06 to
Total with non-detects[d]	2.22E-09	2.86E-09	5.33E-08	6.77E-08	1.0E-4[e]
Non-Radioactive Analytes Incremental Lifetime Cancer Risk (unitless)					
Total without non-detects[c]	-	-	7.41E-11	9.39E-11	1.0E-5[f]
Total with non-detects[d]	-	-	4.93E-08	1.48E-07	
Hazard Indices (unitless)					
Total without non-detects[c]	-	-	5.32E-04	6.99E-04	1.0[f]
Total with non-detects[d]	-	-	5.83E-04	8.53E-04	

Waste Management Area C Fenceline Concentration[c, d]				
Analyte	Detected In Residual Wastes	Average Inventory	95% Upper Confidence Level Inventory	Maximum Concentration Limit
Technetium-99	Yes	1.58E-01	1.99E-01	900 pCi/L
Iodine-129	No	<1.00E-03	<1.00E-03	1 pCi/L
Carbon-14	No	5.14E-03	1.54E-02	2,000 pCi/L
Total Cr*	Yes	<1.00E-03	<1.00E-03	100 µg/L
Uranium	Yes	0.00E+00	0.00E+00	30 µg/L

ly

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Indices, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories Estimated in Single-Shell Tank 241-C-108. (2 sheets)

[a] Incremental lifetime cancer risks (ILCRs) of radioactive analytes were evaluated using industrial and residential land use scenarios described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.* ILCRs and hazard indices for non-radiological analytes were evaluated using *Washington Administrative Code* (WAC) 173-340-705, "Use of Method B," subsection (4) "Multiple hazardous substances or pathways" (residential).

[b] Performance objectives apply to entire waste management area (WMA), not just a single component of the WMA.

[c] If detected, fenceline concentrations are based on an inventory that is calculated from actual laboratory results. Analytes with a fenceline concentration of less than either 0.001 pCi/L (radioactive) or 0.001 µg/L (nonradioactive), which are values that are well below the minimum detection limits for standard analytical methods, are reported as less than 1.00E-03 pCi/L or µg/L.

[d] If not detected, fenceline concentrations are based on an inventory that is calculated at half the detection limits of analytical results. Concentrations that are less than either 0.001 pCi/L (radioactive) or 0.001 µg/L (nonradioactive), which are values that are well below the minimum detection limits for standard analytical methods, are reported as less than 1.00E-03 pCi/L or µg/L.

[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."

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

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III) insoluble salts.

Results of the Table 5-4 comparison can be summarized as follows:

Performance Metric	Comparison(s) with Performance Objective
ILCR for Radioactive Analytes (1.0E-06 to 1.0E-04 ILCR)	• Estimated ILCRs for all radionuclides are between two to three orders of magnitude below performance objective range of 1.0E-06 to 1.0E-04 ILCR.
ILCR for Non-Radiological Analytes (1.0E-05 ILCR)	• Estimated ILCRs for all non-radionuclides are two to three orders of magnitude lower than the upper end of the performance objective of 1.0E-05 ILCR.
Hazard Indices (1.0)	• Estimated hazard indices for all analytes are between three and four orders of magnitude below performance objective of 1.0.
Radiological Dose • 25 mrem/yr All-Pathways • 4 mrem/yr Drinking Water Only	• Estimated doses for all radionuclides are between o Four and five orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr o Three and four orders of magnitude below the performance objective for drinking water dose of 4 mrem/yr.
Maximum Concentration Limits of Key Analytes: • ^{99}Tc – 900 pCi/L • ^{129}I – 1 pCi/L • ^{14}C – 2,000 pCi/L • Cr – 100 µg/L • U – 30 µg/L	• Estimated concentrations for ^{99}Tc are between three and four orders of magnitude below 900 pCi/L maximum contaminant level. • Predicted concentration levels of other constituents of potential concern (e.g., ^{129}I, ^{14}C, Cr, and U) are significantly lower than their respective maximum contaminant levels.

5.4 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 scenarios considered in this assessment for radiological doses from inadvertent intrusions included: 1) a well driller scenario that was used as a reference case for acute exposure in the SST PA and 2) a rural pasture scenario that was used as a reference case for chronic exposure in the SST PA. This assessment of doses from inadvertent intrusions also evaluated chronic exposure scenarios that included: 1) a suburban gardener scenario and 2) a commercial farmer scenario that were used as sensitivity cases for chronic exposure in the SST PA.

A summary of doses calculated for each of the intruder scenarios for the average and bounding inventories remaining at SST C-108 at 100 years and 500 years after closure for tank C-108 are provided in Table 5-5. A summary of doses calculated for each of the intruder scenarios for the average and bounding inventories at 100-year intervals between 100 and 1,000 years after closure for tank C-108 are provided in Table 5-6. Tables and plots of doses related to individual radioactive analytes are provided in Tables D-5 through D-8 and Figures D-1 through D-4 in Appendix D.

Table 5-5. Comparison of Intruder Doses at 100 and 500 years after Closure from Residual Waste for Single-Shell Tank 241-C-108.

Years after Closure[1]	Inventory	SST PA Reference Cases		SST PA Sensitivity Cases	
		Well Driller[2] (mrem)	Rural Pasture[3] (mrem/yr)	Suburban Garden[3] (mrem/yr)	Commercial Farm[3] (mrem/yr)
100	Average	1.27	8.48	119.48	5.8E-03
	95% UCL	2.25	12.07	169.88	1.0E-02
500	Average	0.43	0.06	0.82	2.1E-03
	95% UCL	1.18	0.15	1.80	5.4E-03

PA = performance assessment SST = single-shell tank UCL = upper confidence level

Notes:
[1] Site closure is assumed to occur on January 1, 2032.
[2] Performance Objective (Acute Exposure) – 500 mrem.
[3] Performance Objective (Chronic Exposure) – 100 mrem/yr.

A review of detailed results and plots in Appendix D (Tables D-5 through D-8 and Figures D-1 through D-4) resulted in the following observations about key analytes for inadvertent intruder impacts:

Inadvertent Intrusion Scenario	Key Radionuclides			
	^{137}Cs	^{90}Sr	^{239}Pu	^{241}Am
Well Driller	Primary contributor to dose up to ~240 yrs after closure	Secondary contributor to dose up to ~200 yrs after closure	Primary contributors to dose after ~240 yrs after closure	
Rural Pasture	Secondary contributor to dose up to ~240 yrs after closure	Primary contributor to dose up to ~380 yrs after closure	Secondary contributors to dose between 240 and 380 yrs after closure; primary contributor to dose after ~380 yrs post-closure	
Suburban Gardener	Secondary contributor to dose up to ~200 yrs after closure	Primary contributor to dose up to ~380 yrs after closure	Secondary contributors to dose between 200 and 380 yrs after closure; primary contributor to dose after ~380 yrs post-closure	
Commercial Farm	Primary contributor to dose up to ~200 yrs after closure	Secondary contributor to dose up to ~140 yrs after closure	Secondary contributor to dose after ~140 yrs after closure; primary contributor to dose after ~200 years post-closure	

Table 5-6. Potential Future Impacts from Inadvertent Intrusion into Residual Waste for Nominal and 95% Upper Confidence Level Inventories.

Years After Closure[1]	100	200	300	400	500	600	700	800	900	1,000
Inadvertent Intrusion Acute Dose[2] (mrem) – Well Driller Scenario										
Nominal Inventory	1.3	0.52	0.44	0.43	0.43	0.42	0.42	0.42	0.42	0.41
95% Upper Confidence Level Inventory	2.3	1.30	1.20	1.18	1.18	1.17	1.17	1.17	1.17	1.16
Inadvertent Intrusion Acute Dose[3] (mrem/yr) – Rural Pasture Scenario										
Nominal Inventory	8	1	0.12	0.07	0.06	0.06	0.06	0.06	0.06	0.06
95% Upper Confidence Level Inventory	12	1	0.24	0.16	0.15	0.15	0.15	0.15	0.15	0.15
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Suburban Gardener Scenario										
Nominal Inventory	119	11.0	1.7	0.91	0.82	0.79	0.78	0.76	0.75	0.74
95% Upper Confidence Level Inventory	170	16.2	3.1	1.9	1.8	1.8	1.7	1.7	1.7	1.7
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Commercial Farm Scenario										
Nominal Inventory	5.8E-03	2.5E-03	2.2E-03	2.1E-03	2.1E-03	2.0E-03	2.0E-03	2.0E-03	2.0E-03	2.0E-03
95% Upper Confidence Level Inventory	1.0E-02	6.0E-03	5.5E-03	5.4E-03	5.4E-03	5.4E-03	5.3E-03	5.3E-03	5.3E-03	5.3E-03

[1] Site closure is assumed to occur on January 1, 2032.

[2] Performance Objective (Acute Exposure) – 500 mrem.

[3] Performance Objective (Chronic Exposure) – 100 mrem/yr.

At 100 years after closure (see Table 5-5), doses for the well driller scenario were estimated to be about 1% and 2% of the 500 mrem acute exposure performance objective for the average and the 95% UCL inventories, respectively. At 100 years after closure (see Table 5-5), doses with the rural pasture scenario were estimated to be about 8.5% and 12% of the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively. However, doses resulting from chronic exposure in the suburban garden scenario were about 20% and 70% higher than the 100 mrem chronic exposure performance objective for the average and 95% UCL inventories, respectively (see Table 5-5). Doses resulting from the commercial farmer were well below (e.g., 0.006% and 0.01%) the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (see Table 5-5).

By 500 years after closure (see Tables 5-5 and 5-6), the estimated doses for the well driller scenario for the average and upper bound inventories was about 0.09% and 0.24% of the acute exposure performance objective of 500 mrem, respectively. At 500 years after closure, doses for all inadvertent intruder scenarios used to evaluate the doses from chronic exposure were well below the chronic exposure performance objective of 100 mrem/yr. The highest estimated dose at 500 yrs after closure was for the suburban gardener scenario using the 95% UCL inventory which yielded a dose that was estimated to be ~0.4% of the 100 mrem performance objective (see Table 5-5).

5.5 COMPARISON OF TANK RESIDUALS WITH MODEL TOXICS CONTROL ACT SOIL CLEANUP LEVELS

This section compares the concentrations of constituents remaining in tank C-108 against the WAC 173-340 cleanup standards for direct contact and soil concentrations protective of groundwater using the fixed parameter three-phase partitioning model given in WAC 173-340-747(4).

Per WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," for soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 15 ft below the ground surface. Under a closure configuration, waste residuals left in tank C-108 and other SSTs in WMA C would be expected to be below 15 ft below ground surface.

Implicit in the use of the fixed parameter three-phase partitioning model given in WAC 173-340-747 deriving soil cleanup levels for groundwater protection is the assumption that constituents of interest are found in soils and are immediately available to be leached by infiltrating precipitation. Under a closure configuration, constituents associated with waste residuals left in tank C-108 and other SSTs in WMA C would be contained within a grout-filled tank, a steel tank liner, and an underlying concrete pad below the liner and would not be immediately available for leaching by infiltrating water.

5.5.1 WAC 173-340 Direct Contact and Soil Concentrations Protective of Groundwater

Table 5-7 contains the average and 95% UCL concentrations of standard constituents estimated in residual waste for SST C-108 on a mass basis for comparison against WAC 173-340 cleanup levels for direct contact and soil concentration levels protective of groundwater which are given in the final three columns of the table. The analytes that are dangerous waste constituents per WAC 173-303-9905, "Dangerous Waste Constituents List" are identified in this table. Also provided in the table for some of the constituents is information on an upper level of background concentration for these Hanford Site-specific analytes. The 90-percentile background concentration levels provided for these analytes are taken from more detailed information and references provided in Table D-11 in Appendix D.

Tables 5-8 and 5-9 take the average and upper bound concentrations given in Table 5-7 and predict whether the quantity of residual waste remaining in the tank is above or below the cleanup level or the soil concentration protective of groundwater. Values greater than 1 correspond to an exceedence of the soil cleanup levels or soil concentration protective of groundwater. These tables also identify analytes that are considered dangerous waste constituents per WAC 173-303-9905 and also indicate average or upper bound concentration for analytes that have background values exceeding the 90th percentile of the associated concentrations. Tables D-9 and D-10 in Appendix D are a set of tables equivalent to Tables 5-8 and 5-9 that have been expanded to include a comparison of non-radioactive analytes that were not detected with the same cleanup levels.

The results for waste residual concentrations estimated for the average residual waste inventory from detected analytes are briefly summarized below.

- For direct contact under an unrestricted land use scenario, only aluminum, nickel, lead, and uranium are above the cleanup levels, with only uranium having a concentration more than 10 times the soil cleanup level (greater than 1,000 times above the concentrated predicted). Only nickel and lead are listed as dangerous constituents in WAC 173-303-9905.

- For direct contact under an industrial land use scenario, all contaminants are below the cleanup level.

- For soil concentrations protective of groundwater, chromium, cyanide, fluoride, iron, manganese, nickel, nitrite, nitrate and uranium are all above the concentration predicted by the fixed parameter three-phase model, with uranium being greater than 1,000 times above the concentration predicted by the three-phase model. Chromium, cyanide, and nickel are listed as dangerous constituents in WAC 173-303-9905.

Table 5-7. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-108, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (2 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)	Above Detection Limits
Al	1.29E+05	1.46E+05	8.00E+04	3.50E+06	1.50E+03[h]	1.18E+04[e]	Yes
Ba*	1.60E+01	2.08E+01	1.60E+04	7.00E+05	1.01E+03[h]	1.32E+02[e]	Yes
CN*	6.09E+00	7.07E+00	4.80E+01	7.0E+04	4.00E+02[h]	not applicable	Yes
Total Cr*	2.34E+01	2.85E+01	1.20E+05	5.25E+06	4.00E+01[h]	1.85E+01[e]	Yes
Cu	2.02E+01	2.30E+01	3.20E+03	1.40E+05	2.84E+02[h]	2.2E+01[e]	Yes
F	4.48E+03	5.75E+03	4.80E+03	2.10E+05	2.88E+03[h]	2.81E+00[e]	Yes
Fe	1.04E+04	1.34E+04	5.60E+04	2.45E+06	1.51E+02[h]	3.26E+04[e]	Yes
Hg*	7.55E-01	8.80E-01	2.40E+01	1.05E+03	1.20E+00[h]	1.3E-02[g]	Yes
Mn	1.51E+02	2.47E+02	1.12E+04	4.90E+04	5.00E+01[h]	5.12E+02[e]	Yes
Ni*	2.76E+03	3.16E+03	1.60E+03	7.00E+04	1.30E+02[h]	1.91E+01[g]	Yes
NO_2[c]	2.14E+02	2.38E+02	2.40E+04	1.05E+06	1.30E+01[h]	not applicable	Yes
NO_3[d]	3.40E+02	4.09E+02	5.68E+05	2.50E+07	1.80E+02[h]	5.2E+01[e]	Yes
Pb*	6.34E+02	8.13E+02	not applicable	not applicable	9.1E+00[h]	1.02E+01[e]	Yes
SO_4	1.09E+02	1.24E+02	not applicable	not applicable	1.03E+03[h]	2.37E+02[e]	Yes
Sr	7.30E+02	9.40E+02	4.80E+04	2.10E+06	4.84E+03[h]	not applicable	Yes
Ti	2.80E+00	4.51E+00	3.20E+05	1.40E+07	1.28E+06	not applicable	Yes

Table 5-7. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-108, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (2 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)	Above Detection Limits
U	4.48E+03	5.25E+03	2.40E+02	1.05E+04	1.30E+00[h]	3.21E+00[f]	Yes
Zn	7.10E+01	8.63E+01	2.40E+04	1.05E+06	2.90E+03[h]	6.78E+01[e]	Yes

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Relative Standard Deviation provided in Table B-1 in Appendix B.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[d] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43 (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 4, Volume 1).

[f] DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*

[g] ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site.*

[h] ECF-HANFORD-10-0442, *Calculation of Nonradiological Soil Concentrations Protective of Groundwater Using the Fixed Parameter 3-Phase Equilibrium Partitioning Equation for the 100 Areas and 300 Area.*

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

Table 5-8. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-108 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-108 Nominal Inventory of Residual Wastes to Soil Cleanup Standards				
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits	Above 90 Percentile Background
Al	129,000	1.61E+00	3.69E-02	8.60E+01	Yes	Yes
Ba[b]	16.0	1.00E-03	2.29E-05	1.58E-02	Yes	No
CN[b]	6.1	1.27E-01	2.90E-03	1.52E-02	Yes	not applicable
Total Cr[b]	23.4	1.95E-04	4.46E-06	1.17E-02	Yes	Yes
Cu	20.2	6.31E-03	1.44E-04	7.11E-02	Yes	No
F	4,480	9.33E-01	2.13E-02	1.56E+00	Yes	Yes
Fe	10,400	1.86E-01	4.24E-03	6.89E+01	Yes	No
Hg[b]	0.8	3.15E-02	7.19E-04	6.29E-01	Yes	Yes
Mn	151	4.02E-02	9.15E-04	3.02E+00	Yes	No
Ni[b]	2,760	1.73E+00	3.94E-02	2.12E+01	Yes	Yes
NO_2[c]	214	2.68E-02	6.11E-04	1.65E+01	Yes	not applicable
NO_3[d]	340	2.66E-03	6.07E-05	1.89E+00	Yes	Yes
Pb[b]	634	not applicable	not applicable	6.97E+01	Yes	Yes
SO_4	109	not applicable	not applicable	1.06E-01	Yes	No
Sr	730	1.52E-02	3.48E-04	1.51E-01	Yes	not applicable
Ti	2.8	8.75E-06	2.00E-07	2.19E-06	Yes	not applicable
U	4,480	1.87E+01	4.27E-01	3.45E+03	Yes	Yes
Zn	71	2.96E-03	6.76E-05	2.45E-02	Yes	Yes

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment*.

[b] Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[d] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

Table 5-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-108 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-108 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards				
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits	Above 90 Percentile Background
Al	145,847	1.82E+00	4.17E-02	9.72E+01	Yes	Yes
Ba[b]	20.8	1.30E-03	2.97E-05	2.06E-02	Yes	No
CN[b]	7.1	1.47E-01	3.37E-03	1.77E-02	Yes	not applicable
Total Cr[b]	28.5	2.38E-04	5.43E-06	1.43E-02	Yes	Yes
Cu	23.0	7.20E-03	1.65E-04	8.11E-02	Yes	Yes
F	5,752	1.20E+00	2.74E-02	2.00E+00	Yes	No
Fe	13,354	2.38E-01	5.45E-03	8.84E+01	Yes	Yes
Hg[b]	0.9	3.67E-02	8.38E-04	7.33E-01	Yes	No
Mn	247	6.57E-02	1.50E-03	4.94E+00	Yes	Yes
Ni[b]	3,156	1.97E+00	4.51E-02	2.43E+01	Yes	No
NO_2[c]	238	2.97E-02	6.79E-04	1.83E+01	Yes	Yes
NO_3[d]	409	3.20E-03	7.31E-05	2.27E+00	Yes	not applicable
Pb[b]	813	not applicable	not applicable	8.93E+01	Yes	Yes
SO_4	124	not applicable	not applicable	1.20E-01	Yes	Yes
Sr	940	1.96E-02	4.48E-04	1.94E-01	Yes	No
Ti	4.5	1.41E-05	3.22E-07	3.53E-06	Yes	not applicable
U	5,252	2.19E+01	5.00E-01	4.04E+03	Yes	not applicable
Zn	86	3.60E-03	8.22E-05	2.98E-02	Yes	Yes

[a] 95% Upper Confidence Level Concentration = Average Concentration + (1.96 × Average Concentration × Relative Standard Deviation). Relative Standard Deviations provided in Table B-1 in Appendix B. Average Concentrations and Relative Standard Deviations taken from Table A-1, Appendix A, RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[d] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

The results for waste residual concentrations estimated in the 95% UCL residual waste inventory are briefly summarized below.

- For direct contact under an unrestricted land use scenario, aluminum, fluoride, lead, nickel, and uranium are above the cleanup levels with uranium having a concentration more than 1,000 times the cleanup level. Lead and nickel are listed as dangerous constituents in WAC 173-303-9905.

- For direct contact under an industrial land use scenario, lead is above the cleanup level.

- For soil concentrations protective of groundwater, aroclor-1254, chromium, cyanide, fluorine, manganese, nickel, nitrite, nitrate, and uranium are all above the concentration predicted by the fixed parameter three-phase model, with uranium being greater than 1,000 times above the soil cleanup levels protective of groundwater predicted by the three-phase model. Chromium, cyanide, and nickel are listed as dangerous constituents per WAC 173-303-9905.

5.5.2 WAC 173-340 Ecological Risk

WAC 173-340-900, "Tables" includes the following tables:

- Table 749-2, Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure

- Table 749-3, Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals.

Each of these tables contains a footnote stating that it is not intended for the purpose of evaluating sludges or waste, as follows (key statement bolded for this report).

- Table 749-2, footnote a: "Caution on misusing these chemical concentration numbers. These values have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. **The table is not intended for purposes such as evaluating sludges or wastes.**
  This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site."

- Table 749-3, footnote a: "Caution on misusing ecological indicator concentrations. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. Natural background concentrations may be substituted for ecological indicator concentrations provided in this table. **The table is not intended for purposes such as evaluating sludges or wastes.**
  This list does not imply that sampling must be conducted for each of these chemicals at

every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site."

Because of the limitations stated above, comparisons between the concentrations of waste constituents remaining in tank C-108 have not been made against Table 749-2 [under WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures," subsection (1) "Purpose"] or Table 749-3 [under WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures," subsection (2) "Problem formulation step," (i) "The chemicals of ecological concern"].

5.6 RISK ASSESSMENT SUMMARY

Results of the risk assessment performed to examine impacts from post-retrieval inventories for SST C-108 are summarized as follows.

- The impacts estimated for residual waste left in SST C-108, using either the average or the 95% UCL inventory, are orders of magnitude below the various performance objectives identified for the groundwater pathway.
- Total ILCRs estimated for all radionuclides are between two to three orders of magnitude below the upper end of the performance objective range 1.0E-06 to 1.0E-04 ILCR.
- Total ILCRs estimated for all detectable non-radionuclides are between six and seven orders of magnitude below the performance objective of 1.0E-05 ILCR.
- Total hazard indices estimated for all detectable analytes are between three and four orders of magnitude below the performance objective of 1.0.
- Estimated doses for all detectable radionuclides are between:
    - Four and five orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr
    - Three and four orders of magnitude below the performance objective for drinking water dose of 4 mrem/yr.

Following are conclusions about the impacts from key analytes identified in the residual wastes within SST C-108 for each of the performance metrics evaluated.

- **Total ILCR for Radionuclides:** For both the average and 95% UCL inventory, ^{99}Tc contributed the majority of the total ILCR for all radionuclides with the industrial land use and residential land use scenarios. The contribution from all other detectable radionuclides, including ^{14}C, ^{129}I, and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline within the 10,000-year period of interest

below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Total ILCR for Nonradionuclides:** For both the average and 95% UCL inventory, Cr^{+6} accounts for the majority of the total ILCR for detectable non-radioactive analytes with the industrial land use and residential land use scenarios. The contribution from other non-radioactive analytes was not detectable in residual waste samples, arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 mg/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Hazard Indices:** Fluoride contributed ~86% of the hazard indices from all non-radioactive analytes evaluated for WAC 173-340 Method B, with Cr^{+6} (11.1%), nitrate (0.3%), and nitrite (2.5%) accounting for the remaining 14% of the total hazard indices. The contribution from other non-radioactive analytes was not detectable in residual waste samples, arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 mg/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **All-Pathways Dose:** ^{99}Tc contributed the majority of the total all-pathways dose estimated for the all-pathways farmer scenario. The contribution from all other radionuclides, including ^{14}C, ^{129}I, and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Drinking Water Dose (Target Organ):** ^{99}Tc, with a maximum dose rate of 7.0E-04 mrem/yr, contributed the majority of the EPA maximum contaminant level for beta/photon emitters (4 mrem/yr target organ dose). The contribution to dose from all other radionuclides, including ^{14}C, ^{129}I, and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Intruder Dose:** Doses calculated from inadvertent intrusion are primarily attributable to doses from ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. The relative contribution and timing of doses from these radionuclides to the total doses estimated during the 1,000-year period of analysis depends on the scenario considered. In general, dose contributions from ^{90}Sr and ^{137}Cs typically account for the majority of the dose during the first 200 to 300 years. Doses from ^{239}Pu and ^{241}Am contribute the majority of the dose realized after 200 to 300 years, and in the cases of the commercial farm and well driller, are the primary and secondary contributors to the total dose estimated after 200 years. For both average and 95% UCL inventories estimated for SST C-108, none of the inadvertent intruder evaluations produce results that exceed the performance objectives for either acute exposure or chronic exposure after ~120 years following closure.

Table 5-10 provides a comparison of the inventory used in DOE/ORP-2005-01 against the inventory for detected analytes calculated using post-retrieval samples for the average inventory and the 95% UCL inventories. For the purpose of this comparison, Table 5-10 includes 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. The following observations are made from the comparison of the Hanford Tank Waste Operations Simulator (HTWOS) and post-retrieval inventories.

- Comparison of the HTWOS estimated inventories and post-retrieval inventories for analytes important for assessment of groundwater impacts are as follows:
    - A good agreement exists between the HTWOS predicted inventory and the inventory from the post-retrieval inventories for ^{99}Tc, the key analytes for assessing groundwater impacts
    - Post-retrieval inventories for chromium, nitrate, and nitrite are between one and two orders of magnitude below those in the HTWOS estimates
    - Post-retrieval inventories for fluoride are between 8 to 10 times higher than the HTWOS estimate for fluoride.
- Comparison of the HTWOS estimated inventories and post-retrieval inventories for analytes important to assessing inadvertent intruder impacts are as follows:
    - Post-retrieval inventories for ^{90}Sr are between ~3 to ~5 times higher than estimated in the HTWOS inventory
    - Post-retrieval inventories for ^{137}Cs are between approximately one and two orders of magnitude below the HTWOS estimated inventory
    - Post-retrieval inventories for the plutonium isotopes are between ~4 to ~5 times higher than those in the HTWOS estimate
    - Post-retrieval inventories for ^{241}Am are between ~1.5 and ~2 times higher than those in the HTWOS estimate
    - Post-retrieval inventories for the uranium isotopes are a factor of between ~10 and ~20 times higher than estimated in the HTWOS inventory.

Table 5-10. Comparison of Hanford Tank Waste Operations Simulator Predicted Inventory Used in DOE/ORP-2005-01 with the Average and 95% Upper Confidence Level Post-Retrieval Inventories.

	Analyte[a]	Units	DOE/ORP-2005-01[a] (HTWOS Predicted)	Average Post-Retrieval Inventory[b]	95% UCL Inventory[b]	Detected in Residual Wastes	Ratio Average/ HTWOS	Ratio Bounding/ HTWOS
Analytes Important for Groundwater Impacts	^{14}C	Ci	5.90E-04	3.34E-03	1.00E-02	No	N/A	N/A
	^{99}Tc	Ci	4.05E-02	3.96E-02	4.99E-02	Yes	9.79E-01	1.23E+00
	Chromium	Kg	5.92E+00	5.14E-01	6.51E-01	Yes	8.69E-02	1.10E-01
	Fluoride	Kg	1.13E+01	9.83E+01	1.30E+02	Yes	8.67E+00	1.15E+01
	Nitrate	Kg	1.16E+02	7.46E+00	9.35E+00	Yes	6.44E-02	8.08E-02
	Nitrite	Kg	6.43E+01	4.71E+00	5.59E+00	Yes	7.33E-02	8.69E-02
Analytes Important for Inadvertent Intruder	^{90}Sr	Ci	3.54E+02	1.36E+03	1.93E+03	Yes	3.84E+00	5.45E+00
	^{137}Cs	Ci	3.51E+03	9.17E+01	1.15E+02	Yes	2.61E-02	3.28E-02
	^{232}Th	Ci	3.33E-12	1.28E-05	1.62E-05	Yes	3.85E+06	4.87E+06
	^{233}U	Ci	2.43E-09	1.01E-01	3.03E-01	No	N/A	N/A
	^{234}U	Ci	2.18E-03	2.65E-02	3.84E-02	Yes	1.21E+01	1.76E+01
	^{235}U	Ci	9.75E-05	1.48E-03	1.80E-03	Yes	1.52E+01	1.85E+01
	^{236}U	Ci	2.46E-05	2.32E-04	4.15E-04	Yes	9.42E+00	1.69E+01
	^{238}U	Ci	2.22E-03	3.28E-02	4.03E-02	Yes	1.47E+01	1.81E+01
	^{237}Np	Ci	1.81E-04	3.70E-03	1.11E-02	No	N/A	N/A
	^{238}Pu	Ci	1.01E-03	3.71E-03	4.35E-03	Yes	3.68E+00	4.32E+00
	^{239}Pu	Ci	1.43E-01	5.44E-01	6.37E-01	Yes	3.81E+00	4.46E+00
	^{240}Pu	Ci	1.55E-02	5.92E-02	6.93E-02	Yes	3.81E+00	4.46E+00
	^{241}Pu	Ci	2.64E-02	8.21E-02	9.62E-02	Yes	3.11E+00	3.64E+00
	^{241}Am	Ci	4.60E-01	7.85E-01	9.80E-01	Yes	1.71E+00	2.13E+00
	^{242}Cm	Ci	1.03E-04	1.21E-02	3.62E-02	No	N/A	N/A
	^{243}Cm	Ci	1.15E-06	5.70E-04	1.71E-03	No	N/A	N/A
	^{244}Cm	Ci	2.59E-05	1.22E-02	3.65E-02	No	N/A	N/A

[a] Inventories for contaminants having the greatest impact for groundwater or inadvertent intruder pathway.
[b] Includes inventories in sludge calculated from one half of the laboratory's minimum detection limit for an analyte.

Reference: DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site.*

HTWOS = Hanford Tank Waste Operations Simulator
N/A = Not applicable because the inventory in both supernate and sludge was calculated from one half of the laboratory's minimum detection limit for that analyte.
UCL = upper confidence level

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6.0 OPPORTUNITIES AND ACTIONS BEING TAKEN TO REFINE OR DEVELOP TANK WASTE RETRIEVAL TECHNOLOGIES, BASED ON LESSONS LEARNED

This section discusses aspects of the tank C-108 waste retrieval operations, provides recommendations for further actions, and addresses opportunities to refine waste retrieval technologies based on lessons learned from the tank C-108 retrieval operation.

There are opportunities to improve future waste retrieval operations by looking at ways to modify equipment, make operational changes (e.g., operating sequencing and conditions), plan work, and enhance the design and fabrication of equipment. All RDRs have a Lessons Learned section; accordingly, several of the identified lessons learned from earlier retrieval operations have been incorporated in the formulation and operation of subsequent tank waste retrieval operations, including the tank C-108 retrieval operation.

6.1 PRACTICABILITY EVALUATION REQUEST

The Practicability Evaluation Request (RPP-52290) was done to assess whether a third waste retrieval operation should be undertaken at tank C-108. The Practicability Evaluation Request concluded that the two waste retrieval technologies deployed at tank C-108 were operated to the limits of the technology, and that a further waste removal operation was not practicable as that term is used in Appendix C, Part 1, of the Consent Decree. The Practicability Evaluation Request concluded that the incremental reduction in inventory and risk would have been relatively small, even if the retrieval operation had been successful. The incremental increase in worker exposure, duration of field activities, potential delay in subsequent retrieval activities, and cost, are similar to those expected from other hard heel removal operations and outweigh whatever level of success may have resulted from installation and operation of a third retrieval technology.

Therefore, the practicability evaluation determined that deployment of a third technology into tank C-108 was not practicable.

6.2 PREDICTED WASTE VOLUME

A shortcoming of the deployed second technology was that the amount of waste dissolved in tank C-108, and thus the volume of waste retrieved from the tank, was less than predicted. Laboratory work predicted that all but 300 gal of solids should be removed by the second technology process. It was projected that the resulting residual material could then be easily suspended and removed by sluicing operations. In actuality, the tank C-108 residual waste was reduced to a large volume of mud-like consistency by the second technology. The waste was found to be mobile and potentially susceptible to a sluicing campaign. Future deployments of the caustic dissolution technology should include the option of a limited sluicing campaign to remove the undissolved solids.

Table 6-1. Potential Waste Removal Based on Waste Location and Configuration.

Waste Location and Configuration	Estimated Residual	Potential to Remove	Range of Volume to Remove	Final Residual Range
Waste Piles (above liquid during displacement measurement)	231 gal	0 – 100%	0 – 231 gal	0 – 231 gal
Other Waste on Tank Bottom (below liquid during displacement measurement, excluding central pool, excluding solid removed during water sluicing)	3,170 gal (not including central pool)	0 – 100%	0 – 3,170 gal	0 – 3,170 gal
Central Pool	836 gal	0	0 gal	836 gal
Tank Walls – ERSS, standard sluicer	309 gal	0 – 100%	0 – 309 gal	0 – 309 gal
Tank Walls – FoldTrack®*		0	0 gal	309 gal
Stiffener Rings – ERSS, standard sluicer	378 gal	0 – 100%	0 – 378 gal	0 – 378 gal
Stiffener Rings – FoldTrack®		0	0 gal	378 gal
Estimated Total – ERSS, standard sluicer	4,924 gal	–	0 – 4,088 gal	836 – 4,924 gal
Estimated Total – FoldTrack®			0 – 3,401 gal	1,664 – 4,924 gal

ERSS = Enhanced Reach Sluicing System

*The FoldTrack® Mobile Retrieval Tool is manufactured by Non Entry Systems Ltd., UK Patent Application No: 0718573.9.

6.3 SAMPLING ASPECTS

The deployed chemical dissolution retrieval process included a sample-based process strategy to estimate amount of solids reacted, determine reaction progress, and verify that the process worked as intended. Because sample results were analyzed while retrieval operations were being performed, unanticipated additional time was spent during and after retrieval operations to evaluate the sample data.

The process sampling events were conducted by lowering a grab sample bottle into a sleeve with a slot cut out. The sleeve was installed into a riser in the tank prior to retrieval operations. The circulated sluicing stream was aimed into the slot until the bottle was filled. This method worked successfully to sample circulated liquid when the pool was not deep enough to sample by traditional methods.

The greatest difficulty from a retrieval operations standpoint during the sampling events was aiming the sluicing stream at the slot. Due to the poor visibility and camera angles, some sampling events took longer than expected. However, all sampling events were successful in that the required volume of liquid was collected in the bottle.

Analysis of the first natrophosphate dissolution batch sample set suggested a second natrophosphate dissolution batch would be necessary prior to using caustic for metathesis.

However, analysis of the second natrophosphate dissolution batch sample set suggested that either the natrophosphate was dissolved or the second batch was relatively ineffective in a reasonable timeframe at dissolving any remaining natrophosphate.

6.4 SLUICING OPERATION

The in-tank cameras, as installed, did provide the necessary visibility to operate the retrieval system safely; however, deterioration in the video quality limited further use of the stored media for follow-on activities such as final volume estimates or close-ups of tank waste. Improving the video equipment could allow follow-on specific tasks to acquire high-resolution pictures.

During the sluicing operations, positioning the sluice stream across the tank resulted in buildup of solids on the light. Future considerations need to be made that address this operational aspect.

Addressing potential impacts is advisable when there are significant changes from the planned process (such as extended downtimes). Such changes may require additional process samples and/or more engineering time needed to evaluate the process.

6.5 SLUICER EQUIPMENT

Modified sluicing performed well for bulk retrieval of sludge. By using two sluicers, sludge could be mobilized throughout most of the tank. During testing of the tank C-108 dissolution portion of the retrieval system, no fluid flow could be established through sluicer #2. The one sluicer available in tank C-108 during the caustic recirculation process had sufficient range to contact all waste piles in the tank. Care needs to be taken when starting up a system that has not been operated for an extended period of time. Process impacts have been known to result when equipment remains for extended periods of time in adverse conditions.

As expected, the degree of mixing between the solids and liquid was limited because there was only one sluicer. For the waste located furthest from the sluicer, the sluice jet was aimed so that the liquid sprinkled down on the surface of the waste piles. Observations during caustic recirculation indicated that over time, the caustic caused the waste piles to break up into smaller chunks and finer waste pieces.

Opportunistic water sluicing was added following the sodium aluminate dissolution transfer. This added step removed significantly more of the waste solids.

The added water sluicing step allowed recovery of additional waste. Reduction in the height and overall size of all waste piles was observed.

6.6 WASTE CIRCULATION

Following the caustic addition, during circulation pre-start activities, the temperatures in the pump pit were found to be too low to begin circulation. Due to the cold temperatures in January and the strict temperature limits of 50% sodium hydroxide solution, the project was delayed while attempts were made to heat up the boxes to acceptable operating temperatures. Using caustic during the warm summer months or having some means of heating would help to mitigate such a delay.

During initial caustic circulation activities, the slurry pump showed high amperage readings indicating that the pump was transferring heavier (higher specific gravity) solution. At first, the project personnel were not sure about operating the pump at a higher electrical current level. After discussions with the vendor and based on operating experience, the pump was operated safely at the higher amp levels. After the solution was circulated for some time, the pump amps would drop into normal operating ranges. Preparation for such incidents would enable continuity in the pump operation and startup.

A water flush at the slurry pump was done after high pump amp readings were experienced during initial caustic circulation startup. Adding the water diluted the liquid and/or heated the solution near the pump, allowing the pump to circulate the solution successfully. The recommendation is to pump the caustic solution before it cools and/or use small flush volumes prior to beginning to circulate the solution.

6.7 CAUSTIC CLEANING OPERATION

There was a Lesson Learned (WRPS-IB-12-005) on caustic addition to tank C-108. During caustic addition, ~9,000 gal of 19M (50 wt%) sodium hydroxide (caustic) was added to aid in waste removal from tank C-108. The evolution commenced on the morning of January 27, 2012 and did not complete until the early morning hours of January 28, 2012. The task involved the receipt and unloading of caustic from three vendor tankers.

Infrequently performed tasks necessitate consideration (contingency planning) that the task may take longer than expected. If this happens, the task may require more personnel to staff it initially until proficiency is attained.

7.0 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 included 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. In addition, if a leak had occurred, the LDMM program would have quantified liquid waste release volumes.

The operational history and decades of waste and liquid level monitoring indicate that tank C-108 had not leaked and was sound before starting retrieval (HNF-EP-0182, *Waste Tank Summary Report for Month Ending July 31, 2013*, Rev. 304). Additionally, there was no evidence of a leak during retrieval of waste from tank C-108.

The following sections describe the LDMM requirements, leak detection monitoring implementation, mitigative approach, chronology, and results. The major results for the LDMM program during tank C-108 waste retrieval were as follows.

a. Drywell moisture and gamma logging showed no evidence of leaks during the tank C-108 waste retrieval.

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

c. Material balance calculations showed no evidence of leaks during the tank C-108 waste retrieval.

Retrieval of tank C-108 was begun and the majority of the waste in the tank was removed under RPP-22393 Revisions 3A through 3D. RPP-22393 Revision 4 was applicable to the remaining tank C-108 waste retrieval operations (as are any additional revisions to this work plan).

7.1 REQUIREMENTS

Details of the LDMM program are presented in RPP-22393. The leak detection and monitoring (LDM) system requirements are contained in the safety basis controls given in HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*, specifically Technical Safety Requirement (TSR) Limiting Condition for Operation Section 3.1.1, "Transfer Leak Detection Systems." Material balances during transfers are required by the TSR Administrative Control 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 7-1 presents the tank C-108 LDM functions and requirements.

Table 7-1. Tank 241-C-108 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from SST	The leak detection and monitoring (LDM) system shall be capable of detecting liquid waste releases during all waste removal operations.	*Washington Administrative Code* (WAC) 173-303	Utilize LDM technologies to detect loss of liquid from a tank; see Section 7.2.
Monitor leaks from SST during waste removal	The waste retrieval system (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.	WAC 173-303	Utilize both ex-tank LDM technologies and process data that will allow estimate of leak volume and migration rate to be developed to the extent practical in the event of a leak.
Mitigate leaks during SST 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.	WAC 173-303	Leak mitigation strategy described in Section 7.3.
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.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver double-shell tank.

CFR = *Code of Federal Regulations* DOE = U.S. Department of Energy SST = single-shell tank

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."
DOE O 435.1, *Radioactive Waste Management.*
HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements.*
RPP-13033, *Tank Farms Documented Safety Analysis.*
WAC 173-303, "Dangerous Waste Regulations."

7.2 LEAK DETECTION AND TANK MONITORING

During retrieval of waste from tank C-108, LDM was accomplished by the use of high-resolution resistivity (HRR), drywell monitoring, visual inspection, leak detectors, Enraf gauges in DST AN-106, radiological monitoring, and material balances as shown in Table 7-2 and discussed in Sections 7.2.1 through 7.2.4.

7.2.1 Drywell Logging and High Resolution Resistivity

During the sluicing retrieval of tank C-108 (December 20, 2006 to April 26, 2007), moisture logging with gamma scans was the primary leak detection method. High resolution resistivity leak detection and monitoring was a demonstration leak detection method, but anomalous result

tracking and reporting was required. Subcontractor hydroGEOPHYSICS, Inc. (HGI) was contracted to review the HRR LDM data, make a daily leak determination, and provide monthly reports. Sluicing operations were complete at the end of April 2007, and in the latter part of May 2007 the tank operations contractor (TOC) began monitoring and evaluating the HRR LDM data in place of HGI. During the transition from HGI to the TOC there was about a two-week disruption in HRR LDM monitoring. Monitoring with HRR LDM continued from May 2007 until the end of June 2008. In August 2008 HRR LDM became the primary leak detection method and moisture logging frequency was decreased from weekly to once every six weeks. Figure 7-1 is a timeline of the leak detection monitoring used for tank C-108 retrieval.

Table 7-2. Leak Detection and Monitoring Methods for Each Waste Retrieval System Component.

Component	Leak Detection and Monitoring Method
Tank 241-C-108	Drywells, high-resolution resistivity, groundwater wells, liquid level indicators, visual inspection, material balance
Double-shell tank 241-AN-106	Liquid level indicators, annulus leak detectors, radiation monitoring for annulus exhaust air
Ancillary equipment (Hose-in-hose transfer line)	Secondary containment, leak detectors, radiation monitoring

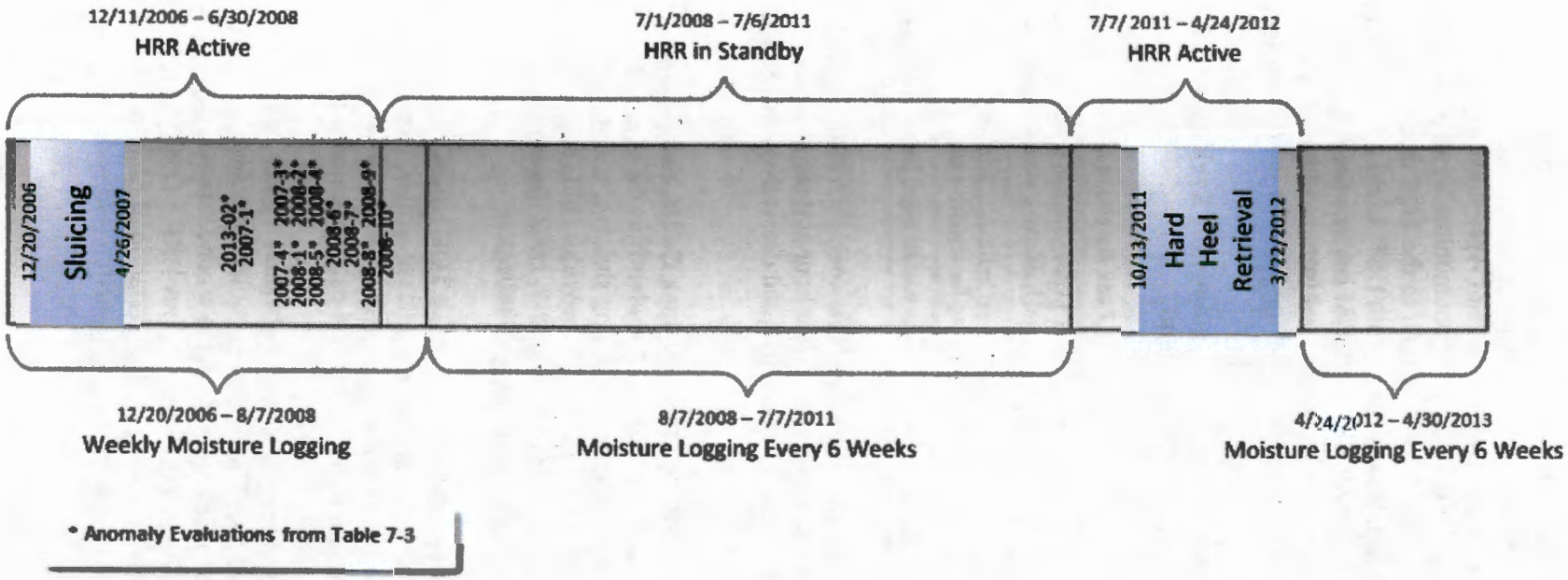
The HRR LDM system monitors the soil resistance between each measurement electrode pair. These measurements are repeated up to four times per hour and the subsequent time-series data are analyzed for changes with time. Drywell-to-tank and drywell-to-drywell resistivity measurements are available to review.

During the first phase deployment of HRR LDM on tank C-108, encompassing sluicing retrieval, several anomalous results were evaluated. Table 7-3 identifies the anomalies and provides a description of each anomaly and its resolution. During sluicing, a leak determination was made for each day of operation by the HRR LDM service provider HGI; no leaks were indicated by the data. Some data anomalies were noted in April (2008-7, *HRR Anomaly Evaluation Record*). An analysis of the data concluded that no leaks were indicated.

Shortly after sluicing operations were discontinued, the TOC began the HRR LDM data review. While gaining experience, the TOC evaluated anomalies at a higher rate than in subsequent operating periods. During this time there were no ongoing retrieval operations and very little waste in the tank. None of the anomalous HRR LDM data indicated a leak.

The second phase of retrieval, hard heel dissolution, began October 13, 2011. Due to concurrent retrieval activities and limitations of the HRR LDM equipment capacity, only drywell-to-drywell measurements were available to be monitored. In the second retrieval phase fewer anomalies occurred and were investigated. None of the anomalous HRR LDM data indicated a leak. Table 7-4 identifies the anomalies and provides a description of each anomaly and its resolution. The HRR LDM data were reviewed every day during active retrieval. No leaks were indicated by the HRR LDM data during hard heel retrieval.

Figure 7-1. Leak Detection Monitoring Timeline.



HRR = high-resolution resistivity

Table 7-3. High-Resolution Resistivity Leak Detection and Monitoring Anomaly Evaluations during and after Sluicing.

Number	Date	Anomaly Description	Resolution/Comments
N/A	4/07	Changes in data noise.	No leak indicated.
2013-02	10/18/07	Temporarily high WTT exceedance values. Similar to 2007-4, 2008-4, and 2008-9.	No leak indicated. No active retrieval.
2007-1	11/21/07	High WTW values.	Resistance measurements spiked after HRR LDM restart. No leak indicated. No active retrieval.
2007-3	12/6/07	Slow trend change in WTW data.	Ground resistance change with temperature. No leak indicated. No active retrieval.
2007-4	12/10/07	Temporarily high WTT exceedance values. Similar to 2013-02, 2008-4, and 2008-9.	Possible electrical issue. No leak indicated. No active retrieval.
2008-1	1/13/08	The leak potential for one WTW data pair exceeded 30%.	No leak indicated. No active retrieval.
2008-2	1/14/08	High WTW and WTT exceedance values.	No leak indicated. No active retrieval.
2008-4	2/9/08	Temporarily high WTT exceedance values. Similar to 2013-02, 2007-4, and 2008-9.	No leak indicated. No active retrieval.
2008-5	2/27/08	High moisture in drywell 30-07-01 prompted a review of HRR LDM data.	No leak indicated. No active retrieval.
2008-6	3/13/08	Temporarily high WTT exceedance values on several data pairs.	No leak indicated. No active retrieval.
2008-7	4/17/08	High exceedance values on tanks 241-C-108 and 241-C-109 WTT and WTW data pairs.	No leak indicated electrical interference. No active retrieval.
2008-8	5/5/08	High exceedance values on tanks 241-C-108 and 241-C-109 WTT and WTW data pairs (similar to 2008-7).	No leak indicated electrical interference. No active retrieval.
2008-9	5/11/08	Temporarily high WTT exceedance values similar to 2013-02, 2007-4, and 2008-4.	No leak indicated. No active retrieval.
2008-10	6/24/08	High exceedance values because of an open channel on 30-08-03.	No leak indicated. No active retrieval.

HRR = high-resolution resistivity
LDM = leak detection and monitoring
N/A = not applicable
WTT = drywell to tank
WTW = drywell to drywell

Subsequent to tank C-108 retrieval, additional drywell logging was performed by a subcontractor [RPP-RPT-55709, *241-C-108 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data (HGLP-MBL-011, Rev. 0)*]. With the exception of 30-08-02, none of the drywells around tank C-108 show evidence of significant changes in either gamma activity or subsurface moisture. Available data from these drywells provide no evidence of any leak or contaminant movement associated with tank retrieval operations.

Table 7-4. High-Resolution Resistivity Leak Detection and Monitoring Anomaly Evaluations during Hard Heel Retrieval.

Number	Date	Anomaly Description	Resolution/Comments
2011-05	9/19/11	Step change in all HRR LDM data.	Data needed to be filtered after restart. No leak indicated. No active retrieval.
2011-07	9/22/11	HRR LDM data associated with 30-11-05 went to zero.	The cable to 30-11-05 was temporarily disconnected. No leak indicated. No active retrieval.
2012-01	3/10/12	Step change in all HRR LDM data.	A power outage caused a hardware problem. No leak indicated. No active retrieval.

HRR LDM = high-resolution resistivity leak detection and monitoring

Drywell 30-08-02 has exhibited changes in the gamma activity profile since 1974. The changes in gamma profile indicate downward movement of gamma-emitting contaminants between ~40 and 80 ft. At least five contamination incursions have been identified from gamma log data over the past 39 years. The source(s) of these incursions is unknown, but there is no evidence to suggest any relationship to retrieval operations.

7.2.2 Single-Shell Tank 241-C-108

7.2.2.1 Liquid Level Monitoring. The overall waste retrieval operating strategy for tank C-108 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.

7.2.2.2 Visual Inspection. Before initiating waste retrieval operations, a visual assessment and documentation of in-tank conditions in tank C-108 were performed using an in-tank video camera. Throughout waste retrieval, the closed-circuit television 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 tank C-108 indicated that the surface level decrease corresponded with waste retrieval activities.

7.2.2.3 Material Balance. Process control measurements were used periodically to perform a material balance and determine the change in tank C-108 waste inventory. Once determined, the change in waste inventory was compared to the anticipated change (gallons of slurry produced and/or released per gallon of water added, adjusted for changes in the central pool and interstitial liquid volumes).

During retrieval operations, material balances were performed during transfers by Operations for tank leak detection and mitigation for the portion of the system between the portable valve pit and tank AN-106, inclusive. Radiation surveys were required for the portion of the transfer line where volume material balance could not be performed. The frequency of material balance

measurements and radiation surveys met the requirements of HNF-IP-1266, *Tank Farms Operations Administrative Controls*.

7.2.3 Double-Shell Tank 241-AN-106

7.2.3.1 Liquid Level Monitoring. The waste level in the DST was monitored using an Enraf, and annulus leak detector probes were used to 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. The Enraf gauge was capable of measuring liquid level changes to a precision of 0.1 inch.

During waste retrieval there was no evidence of a release from DST AN-106 based on results of liquid level monitoring. The DST AN-106 liquid level increase corresponded with the material balance results for tank C-108.

7.2.3.2 Leak Detection. Tank AN-106 was 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 were designed to drain any leakage to the annulus floor. Enraf assemblies in the annulus would have activated an audible alarm and an annunciator panel light in the event of liquid leaking to the annulus so that mitigation could have begun. Throughout the tank C-108 waste retrieval campaign, no leaks were detected by any of the leak detectors in DST AN-106.

7.2.3.3 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 have activated 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.

7.2.4 Ancillary Equipment

Leak detectors were installed in the valve pits to detect the presence of liquid through conductivity, which would have activated alarms and shut down the WRS.

In accordance with RPP-12711, the hose-in-hose transfer line system underwent radiation monitoring and was equipped with leak detectors as part of the leak detection program.

7.3 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. Drywell surveys were conducted.

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 have penetrated tank bottom

d. Maintaining a benchmark waste level.

7.3.1 Single-Shell Tank 241-C-108

A summary of the tank C-108 mitigation actions to minimize or prevent a leak were as follows.

a. Minimizing the addition of water to the retrieval tank 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 could have been rapidly pumped from the tank had a leak been detected.

c. Waste sluicing 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 have penetrated 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.

The mitigative approach was implemented to ensure that potential leakage from tank C-108 was monitored at all times. Key mitigative actions which would have been taken in the event of a leak are described in the Tank Waste Retrieval Work Plan (RPP-22393), Sections 4.6.2 and 4.6.3.

7.4 CONCLUSION

Based on the available data (presented in Sections 7.2 and 7.3), no evidence of a tank leak occurred during tank C-108 waste retrieval operations. The tank C-108 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 tank C-108 as set forth in RPP-22393 was achieved.

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APPENDIX A

SINGLE-SHELL TANK 241-C-108 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL

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APPENDIX A

SINGLE-SHELL TANK 241-C-108 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL

Table A-1. Single-Shell Tank 241-C-108 Best-Basis Inventory Pre-Retrieval Inventory and Post-Sluicing Operations. (2 sheets)

	BBI February 2005[a]	BBI February 2008[b]	
Volume (Kgal)	66	7.7	
Analyte	Inventory	Inventory	Unit
Al	1.93E+04	2.11E+03	Kg
Bi	4.12E+03	9.98E+02	Kg
Ca	4.69E+03	5.12E+02	Kg
Cl	2.70E+02	2.97E+01	Kg
CN	7.34E+02	4.42E+00[c]	Kg
Cr	2.26E+02	4.37E+01	Kg
F	1.57E+03	1.72E+02	Kg
Fe	2.65E+03	2.89E+02	Kg
Hg	1.23E+01	2.03E-02	Kg
K	1.44E+02	1.73E+01	Kg
La	1.02E+01	8.95E-02	Kg
Mn	6.73E+01	4.93E+00	Kg
Na	3.48E+04	3.90E+03	Kg
Ni	3.11E+03	3.40E+02	Kg
NO_2	8.92E+03	1.03E+03	Kg
NO_3	1.61E+04	1.76E+03	Kg
Oxalate	4.14E+02	2.09E+01	Kg
Pb	2.49E+02	1.03E+01	Kg
PO_4	3.04E+04	3.32E+03	Kg
Si	1.60E+03	3.23E+02	Kg
SO_4	2.48E+03	2.73E+02	Kg
Sr	1.47E+02	7.57E+00	Kg
TIC as CO_3	3.87E+03	5.00E+02	Kg
TOC	3.50E+02	3.99E+01	Kg

	BBI February 2005	BBI February 2008	
Analyte	Inventory	Inventory	Unit
^{99}Tc	5.61E+00	1.30E+00	Ci
^{106}Ru	1.36E-11	4.66E-10	Ci
^{113m}Cd	5.06E-02	1.47E-02	Ci
^{125}Sb	7.49E-04	1.09E-03	Ci
^{126}Sn	6.23E-03	1.32E-03	Ci
^{129}I	9.75E-04	6.30E-05	Ci
^{134}Cs	8.59E-05	1.26E-03	Ci
^{137}Cs	7.77E+04	7.77E+03	Ci
^{137m}Ba	7.33E+04	7.34E+03	Ci
^{151}Sm	7.45E+01	1.01E+01	Ci
^{152}Eu	2.35E-03	8.53E-04	Ci
^{154}Eu	1.63E-01	1.97E-02	Ci
^{155}Eu	7.58E-02	5.50E-03	Ci
^{226}Ra	7.65E-06	4.22E-07	Ci
^{227}Ac	4.22E-05	5.86E-06	Ci
^{228}Ra	4.27E-11	2.70E-08	Ci
^{229}Th	6.68E-09	4.60E-08	Ci
^{231}Pa	1.08E-04	2.27E-05	Ci
^{232}Th	5.63E-11	2.70E-08	Ci
^{232}U	6.26E-07	1.37E-06	Ci
^{233}U	5.22E-08	5.78E-06	Ci
^{234}U	5.10E-02	5.63E-03	Ci
^{235}U	2.28E-03	2.51E-04	Ci
^{236}U	5.75E-04	6.61E-05	Ci

Table A-1. Single-Shell Tank 241-C-108 Best-Basis Inventory Pre-Retrieval Inventory and Post-Sluicing Operations. (2 sheets)

	BBI February 2005[a]	BBI February 2008[b]				BBI February 2005	BBI February 2008	
Volume (Kgal)	66	7.7						
Analyte	Inventory	Inventory	Unit		Analyte	Inventory	Inventory	Unit
U_{TOTAL}	1.56E+02	1.71E+01	Kg		^{237}Np	4.22E-03	7.10E-04	Ci
Zr	3.15E+01	7.20E+00	Kg		^{238}Pu	2.20E-02	2.75E-03	Ci
^{3}H	1.13E+00	2.32E-02	Ci		^{238}U	5.20E-02	5.72E-03	Ci
^{14}C	8.18E-02	1.28E-02	Ci		^{239}Pu	3.12E+00	3.44E-01	Ci
^{59}Ni	1.12E+00	1.04E-03	Ci		^{240}Pu	3.39E-01	3.77E-02	Ci
^{60}Co	4.32E-02	5.36E-03	Ci		^{241}Am	1.07E+01	1.17E+00	Ci
^{63}Ni	9.98E+01	1.23E-01	Ci		^{241}Pu	5.77E-01	5.71E-02	Ci
^{79}Se	1.63E-03	3.08E-04	Ci		^{242}Cm	2.25E-03	2.03E-04	Ci
^{90}Sr	8.00E+03	7.95E+02	Ci		^{242}Pu	4.73E-06	5.88E-07	Ci
^{90}Y	8.00E+03	7.95E+02	Ci		^{243}Am	1.33E-03	1.21E-04	Ci
^{93m}Nb	3.40E-01	8.53E-02	Ci		^{243}Cm	2.52E-05	2.15E-06	Ci
^{93}Zr	3.77E-01	9.30E-02	Ci		^{244}Cm	5.68E-04	7.68E-07	Ci

BBI = Best-Basis Inventory
TIC = total inorganic carbon
TOC = total organic carbon

[a] RPP-22393, 2011, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*, Rev. 6, Washington River Protection Solutions, LLC, Richland, Washington.

[b] RPP-RPT-43035, 2009, *2009 Auto-TCR for Tank 241-C-108*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[c] Calculated using the July 2009 CN sample results of 102.3 μg/g; specific gravity 1.48.

APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-108 RESIDUAL SOLIDS

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APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-108 RESIDUAL SOLIDS

A summary of concentrations estimated for selected radioactive and non-radioactive analytes in residual waste solids left in single-shell tank 241-C-108 following final retrieval is provided in this appendix.

Waste concentrations provided in this appendix in Table B-1 were taken from Table A.1 in RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment*. These calculated concentrations were developed from sampling of waste solids in single-shell tank 241-C-108. Tank 241-C-108 solids were sampled twice: first after completion of modified sluicing which removed the bulk of the solids, and again after heel retrieval which further removed a comparatively small amount of waste. The mean concentrations for each sample set were estimated as follows.

Equations from *Variance Components* (Searle et al. 1992) were used in the automated Best-Basis Inventory Maintenance (BBIM) tool [RPP-5945, *Best-Basis Inventory Maintenance Tool (BBIM): Database Description and User Guide*] to estimate the mean concentration and density and the associated standard deviation for all constituents that had 50% or more of their reported values greater than the detection limit. These equations compute means by weighting results based on the variance components. Some constituents had concentrations that were below the detection limits. In these cases, the detection limits were used for calculating the mean concentrations. For a constituent with a majority of results below the detection limit, a simple average of the detection limits was calculated. Note that in accordance with BBI protocol, the relative standard deviations for non-detected constituents were assumed to be "1" (RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best Basis Inventories*).

The mean concentrations for the samples taken after modified sluicing are not directly applicable to the post-retrieval residual solids because additional waste was removed by heel retrieval. Estimates of these means were calculated by adjusting for the volume change [Adjusted means = sample means × volume before heel removal (960 ft^3) / volume after heel removal (397 ft^3)]. This is equivalent to assuming that no mass of the constituents of interest was removed during the heel retrieval.

To calculate the average analyte inventories provided in Table B-1, the BBIM tool automatically used the mean concentrations from the samples taken after heel retrieval when available. Otherwise, the adjusted mean concentrations of analytes from the samples taken after modified sluicing were used.

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-108. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[b]
1,1,1-Trichloroethane	71-55-6	<	3.63E-03	µg/g	1.00E+00
1,1,2,2-Tetrachloroethane	79-34-5	<	9.06E-03	µg/g	1.00E+00
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<	9.06E-03	µg/g	1.00E+00
1,1,2-Trichloroethane	79-00-5	<	6.89E-03	µg/g	1.00E+00
1,1-Dichloroethene	75-35-4	<	6.16E-03	µg/g	1.00E+00
1,2,4-Trichlorobenzene	120-82-1	<	1.44E+00	µg/g	1.00E+00
1,2-Dichlorobenzene	95-50-1	<	1.88E+00	µg/g	1.00E+00
1,2-Dichloroethane	107-06-2	<	3.26E-03	µg/g	1.00E+00
1,4-Dichlorobenzene	106-46-7	<	2.11E+00	µg/g	1.00E+00
^{125}Sb	14234-35-6	<	1.94E-01	µCi/g	1.00E+00
^{126}Sn	15832-50-5	<	7.08E-02	µCi/g	1.00E+00
^{129}I	15046-84-1	<	3.55E-05	µCi/g	1.00E+00
^{137}Cs	10045-97-3		4.18E+00	µCi/g	1.01E-01
^{137m}Ba	378253-40-8		3.94E+00	µCi/g	1.01E-01
^{14}C	14762-75-5	<	3.04E-04	µCi/g	1.00E+00
^{152}Eu	14683-23-9	<	8.57E-02	µCi/g	1.00E+00
^{154}Eu	15585-10-1	<	6.03E-02	µCi/g	1.00E+00
^{155}Eu	14391-16-3	<	1.34E-01	µCi/g	1.00E+00
1-Butanol	71-36-3	<	6.44E+00	µg/g	1.00E+00
2,4,5-Trichlorophenol	95-95-4	<	8.21E-01	µg/g	1.00E+00
2,4,6-Trichlorophenol	88-06-2	<	9.24E-01	µg/g	1.00E+00
2,4-Dinitrotoluene	121-14-2	<	7.11E-01	µg/g	1.00E+00
2,6-Bis(1,1-dimethylethyl)-4-methylphenol	128-37-0	<	4.40E+00	µg/g	1.00E+00
^{228}Th	14274-82-9		6.31E-07	µCi/g	1.39E-01
^{230}Th	14269-63-7	<	5.21E-04	µCi/g	1.00E+00
^{231}Pa	14331-85-2	<	1.20E-03	µCi/g	1.00E+00
^{232}Th	7440-29-1		5.83E-07	µCi/g	1.09E-01
^{233}U	13968-55-3	<	9.22E-03	µCi/g	1.00E+00
^{234}U	13966-29-5		1.21E-03	µCi/g	2.11E-01
^{235}U	15117-96-1		6.73E-05	µCi/g	7.61E-02
^{236}U	13982-70-2		1.06E-05	µCi/g	3.88E-01
^{237}Np	13994-20-2	<	3.37E-04	µCi/g	1.00E+00
^{238}Pu	13981-16-3		1.69E-04	µCi/g	4.05E-02
^{238}U	7440-61-1		1.50E-03	µCi/g	8.62E-02
^{239}Pu	15117-48-3		2.48E-02	µCi/g	4.05E-02
^{240}Pu	14119-33-6		2.70E-03	µCi/g	4.05E-02
^{241}Am	14596-10-2		3.58E-02	µCi/g	9.88E-02
^{241}Pu	14119-32-5		3.74E-03	µCi/g	4.05E-02

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-108. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[b]
^{242}Cm	15510-73-3	<	1.10E-03	µCi/g	1.00E+00
^{242}Pu	13982-10-1		3.75E-08	µCi/g	4.05E-02
^{243}Cm	15757-87-6	<	5.22E-05	µCi/g	1.00E+00
^{244}Cm	13981-15-2	<	1.11E-03	µCi/g	1.00E+00
2-Butanone	78-93-3	<	4.82E-02	µg/g	1.00E+00
2-Chlorophenol	95-57-8	<	1.24E+00	µg/g	1.00E+00
2-Ethoxyethanol	110-80-5	<	3.40E+00	µg/g	1.00E+00
2-Methylphenol	95-48-7	<	1.07E+00	µg/g	1.00E+00
2-Nitrophenol	88-75-5	<	1.00E+00	µg/g	1.00E+00
2-Nitropropane	79-46-9	<	2.86E-02	µg/g	1.00E+00
^{3}H	15086-10-9	<	1.42E-03	µCi/g	1.00E+00
4-Chloro-3-methylphenol	59-50-7	<	8.06E-01	µg/g	1.00E+00
4-Nitrophenol	100-02-7	<	9.82E-01	µg/g	1.00E+00
^{60}Co	10198-40-0	<	1.96E-01	µCi/g	1.00E+00
^{63}Ni	13981-37-8		1.13E-01	µCi/g	1.39E-01
^{79}Se	15758-45-9		6.30E-05	µCi/g	1.09E-01
^{90}Sr	10098-97-2		6.18E+01	µCi/g	1.96E-01
^{90}Y	10098-91-6		6.18E+01	µCi/g	1.96E-01
^{99}Tc	14133-76-7		1.80E-03	µCi/g	1.06E-01
Acenaphthene	83-32-9	<	3.28E-01	µg/g	1.00E+00
Acetate	71-50-1	<	5.73E+01	µg/g	1.00E+00
Acetone	67-64-1	<	7.94E-02	µg/g	1.00E+00
Ag	7440-22-4	<	1.91E+00	µg/g	1.00E+00
Al	7429-90-5		1.29E+05	µg/g	6.53E-02
Aroclors (Total PCB)[c]	1336-36-3		1.67E-01	µg/g	2.98E-01
As	7440-38-2	<	9.56E+00	µg/g	1.00E+00
B	7440-42-8	<	1.91E+00	µg/g	1.00E+00
Ba	7440-39-3		1.60E+01	µg/g	1.49E-01
Be	7440-41-7	<	4.64E+01	µg/g	1.00E+00
Benzene	71-43-2	<	5.80E-03	µg/g	1.00E+00
Bi	7440-69-9	<	3.97E+03	µg/g	1.00E+00
Br	24959-67-9	<	3.07E+01	µg/g	1.00E+00
Butylbenzylphthalate	85-68-7	<	9.33E-01	µg/g	1.00E+00
Ca	7440-70-2		8.92E+02	µg/g	5.87E-02
Carbon disulfide	75-15-0	<	5.44E-03	µg/g	1.00E+00
Carbon tetrachloride	56-23-5	<	5.44E-03	µg/g	1.00E+00
Cd	7440-43-9	<	1.91E+00	µg/g	1.00E+00
Ce	7440-45-1	<	1.19E+03	µg/g	1.00E+00

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-108. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[b]
Chlorobenzene	108-90-7	<	3.99E-03	µg/g	1.00E+00
Chloroform	67-66-3	<	3.26E-03	µg/g	1.00E+00
Cl	16887-00-6	<	3.28E+01	µg/g	1.00E+00
CN	57-12-5		6.09E+00	µg/g	8.05E-02
Co	7440-48-4	<	1.91E+00	µg/g	1.00E+00
Cr	7440-47-3		2.34E+01	µg/g	1.09E-01
Cr+6[d]	18540-29-9		2.34E+01	µg/g	1.09E-01
Cresol	1319-77-3	<	1.99E+00	µg/g	1.00E+00
Cresol (m)	108-39-4	<	9.59E-01	µg/g	1.00E+00
Cresol (p)	106-44-5	<	9.59E-01	µg/g	1.00E+00
Cu	7440-50-8		2.02E+01	µg/g	7.01E-02
Cyclohexanone	108-94-1	<	1.04E+01	µg/g	1.00E+00
Di-n-butylphthalate	84-74-2	<	1.05E+01	µg/g	1.00E+00
Di-n-octylphthalate	117-84-0	<	8.90E-01	µg/g	1.00E+00
Ethyl acetate	141-78-6	<	1.76E-02	µg/g	1.00E+00
Ethyl ether	60-29-7	<	1.60E-02	µg/g	1.00E+00
Ethylbenzene	100-41-4	<	4.35E-03	µg/g	1.00E+00
Eu	7440-53-1	<	1.91E+00	µg/g	1.00E+00
F	16984-48-8		4.48E+03	µg/g	1.42E-01
Fe	7439-89-6		1.04E+04	µg/g	1.42E-01
Fluoranthene	206-44-0	<	6.61E-01	µg/g	1.00E+00
Formate	12311-97-6	<	8.60E+01	µg/g	1.00E+00
Glycolate	666-14-8	<	3.28E+01	µg/g	1.00E+00
Hexachlorobutadiene	87-68-3	<	1.30E+00	µg/g	1.00E+00
Hexachloroethane	67-72-1	<	2.09E+00	µg/g	1.00E+00
Hexone	108-10-1	<	3.19E-02	µg/g	1.00E+00
Hg	7439-97-6		7.55E-01	µg/g	8.28E-02
Isobutanol	78-83-1	<	8.59E+00	µg/g	1.00E+00
La	7439-91-0	<	4.64E+01	µg/g	1.00E+00
Li	7439-93-2	<	4.64E+01	µg/g	1.00E+00
Methylenechloride	75-09-2	<	6.16E-03	µg/g	1.00E+00
Mg	7439-95-4		1.26E+02	µg/g	8.26E-02
Mn	7439-96-5		1.51E+02	µg/g	3.18E-01
Mo	7439-98-7	<	4.64E+01	µg/g	1.00E+00
Morpholine, 4-nitroso-	59-89-2	<	3.57E+00	µg/g	1.00E+00
Na	7440-23-5		1.21E+05	µg/g	7.81E-02
Naphthalene	91-20-3	<	1.17E+00	µg/g	1.00E+00
Nb	7440-03-1	<	1.19E+03	µg/g	1.00E+00

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-108. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[b]
Nd	7440-00-8	<	3.97E+02	µg/g	1.00E+00
NH_3	7664-41-7		1.15E+00	µg/g	6.17E-01
Ni	7440-02-0		2.76E+03	µg/g	7.17E-02
Nitrobenzene	98-95-3	<	1.21E+00	µg/g	1.00E+00
N-Nitroso-di-n-propylamine	621-64-7	<	1.08E+00	µg/g	1.00E+00
NO_2	14797-65-0		2.14E+02	µg/g	5.54E-02
NO_3	14797-55-8		3.40E+02	µg/g	1.02E-01
Oxalate	338-70-5		5.45E+01	µg/g	3.66E-02
Pb	7439-92-1		6.34E+02	µg/g	1.41E-01
Pd	7440-05-3	<	4.18E+02	µg/g	1.00E+00
Pentachlorophenol	87-86-5	<	7.00E-01	µg/g	1.00E+00
Phenol	108-95-2	<	1.11E+00	µg/g	1.00E+00
PO_4	14265-44-2		4.36E+04	µg/g	2.02E-01
Pr	7440-10-0	<	7.65E+00	µg/g	1.00E+00
Pyrene	129-00-0	<	1.17E+00	µg/g	1.00E+00
Pyridine	110-86-1	<	1.21E+00	µg/g	1.00E+00
Rb	7440-17-7	<	5.74E+01	µg/g	1.00E+00
Rh	7440-16-6	<	3.72E+02	µg/g	1.00E+00
Ru	7440-18-8	<	7.65E+00	µg/g	1.00E+00
Sb	7440-36-0	<	1.15E+01	µg/g	1.00E+00
Se	7782-49-2	<	1.15E+01	µg/g	1.00E+00
Si	7440-21-3		3.26E+03	µg/g	3.37E-01
Sm	7440-19-9	<	7.94E+02	µg/g	1.00E+00
Sn	7440-31-5	<	5.74E+00	µg/g	1.00E+00
SO_4	14808-79-8		1.09E+02	µg/g	6.78E-02
Sr	7440-24-6		7.30E+02	µg/g	1.44E-01
Ta	7440-25-7	<	1.99E+03	µg/g	1.00E+00
Te	13494-80-9	<	3.97E+03	µg/g	1.00E+00
Tetrachloroethene	127-18-4	<	1.00E-02	µg/g	1.00E+00
Th	7440-29-1		5.30E+00	µg/g	1.10E-01
Ti	7440-32-6		2.80E+00	µg/g	3.10E-01
Tl	7440-28-0	<	3.97E+03	µg/g	1.00E+00
Toluene	108-88-3	<	0.00E+00	µg/g	1.00E+00
Trans-1,3-Dichloropropene	10061-02-6	<	0.00E+00	µg/g	1.00E+00
Tributyl phosphate	126-73-8	<	2.01E+00	µg/g	1.00E+00
Trichloroethene	79-01-6	<	1.00E-02	µg/g	1.00E+00
Trichlorofluoromethane	75-69-4	<	4.00E-02	µg/g	1.00E+00
U	7440-61-1		4.48E+03	µg/g	9.00E-02

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-108. (5 sheets)

Constituent Name	CAS Number	< Detection Limit	Mean Concentration	Units	RSD[b]
V	7440-62-2	<	1.99E+02	µg/g	1.00E+00
Vinyl chloride	75-01-4	<	1.00E-02	µg/g	1.00E+00
W	7440-33-7	<	1.15E+01	µg/g	1.00E+00
Xylene (m)	108-38-3	<	1.00E-02	µg/g	1.00E+00
Xylene (o)	95-47-6	<	0.00E+00	µg/g	1.00E+00
Xylene (p)	106-42-3	<	1.00E-02	µg/g	1.00E+00
Xylenes (total)	1330-20-7	<	1.00E-02	µg/g	1.00E+00
Y	7440-65-5		4.02E+00	µg/g	1.00E-01
Zn	7440-66-6		7.10E+01	µg/g	1.10E-01
Zr	7440-67-7		2.22E+01	µg/g	1.10E-01

µg/g = micrograms per gram CAS = Chemical Abstract Services RSD = Relative Standard Deviation
µCi/g = microcurie per gram NA = not available

[a] Adapted from Table A-1 in RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment*. Radionuclide concentrations are decay corrected to January 1, 2008.

[b] In accordance with the Best-Basis Inventory protocol, the relative standard deviation is assumed to be 1 if the constituent was not detected.

[c] Aroclors (Total PCB [polychlorinated biphenyl]) concentration on a dry weight basis is 2.71E-01 µg/g.

[d] For purposes of this risk assessment, an estimate of chromium (VI) concentration was also made by assuming that total chromium concentration reported in RPP-RPT-54757 was all attributable to this most mobile form of chromium.

REFERENCES

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APPENDIX C

COMPARISON OF SINGLE-SHELL TANK 241-C-108 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-108 INVENTORY USED IN DOE/ORP-2005-01, *INITIAL SINGLE-SHELL TANK SYSTEM PERFORMANCE ASSESSMENT FOR THE HANFORD SITE*

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APPENDIX C

COMPARISON OF SINGLE-SHELL TANK 241-C-108 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-108 INVENTORY USED IN DOE/ORP-2005-01, *INITIAL SINGLE-SHELL TANK SYSTEM PERFORMANCE ASSESSMENT FOR THE HANFORD SITE*

Table C-1. Comparison of Single-Shell Tank 241-C-108 Final Inventory to Single-Shell Tank 241-C-108 Inventory Used in DOE/ORP-2005-01.

Analyte	Units	DOE/ORP-2005-01, Rev. 0	RPP-RPT-55896, Rev. 0 Average Inventory	RPP-RPT-55896, Rev. 0 Upper Bounding Inventory
Tritium	Ci	8.15E-03	3.11E-02	9.33E-02
C-14	Ci	5.90E-04	6.67E-03	2.00E-02
I-129	Ci	7.03E-06	7.78E-04	2.33E-03
Tc-99	Ci	4.05E-02	3.96E-02	4.99E-02
Cr	kg	5.92E+00	5.14E-01	6.51E-01
F	kg	1.13E+01	9.83E+01	1.30E+02
NO_2	kg	6.43E+01	4.71E+00	5.59E+00
NO_3	kg	1.16E+02	7.46E+00	9.35E+00
U	kg	6.67E+00	9.84E+01	1.21E+02

REFERENCE

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.

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APPENDIX D

RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-108

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APPENDIX D

RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-108

This appendix provides risk assessment information related to post-retrieval inventories estimated to remain in single-shell tank (SST) 241-C-108 (C-108). The potential risk impacts to human health posed by the residual waste in SST C-108 were evaluated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. The process used for the SST C-108 risk assessment, and this methodology, is described in detail in Chapter 3 of DOE/ORP-2005-01. The SST performance assessment methodology represents the current approach being used to support the assessment of long-term impacts to human health from tank residuals left in individual SSTs in retrieval data reports. Decisions on final closure of tank C-108, all other SSTs, and ancillary facilities and equipment within Waste Management Area C will be supported by a site-specific performance assessment as outlined in Appendix I of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

The risk assessment-related information for post-retrieval inventories estimated to remain in SST C-108 and contained in this appendix are as follows:

- Summary of incremental lifetime cancer risk, radiological dose, and drinking water dose for radionuclide contaminants of potential concern estimated in the average post-retrieval inventory for SST C-108 (see Table D-1)

- Summary of maximum value for incremental lifetime cancer risk and hazard index for non-radionuclide contaminants of potential concern estimated in the average post-retrieval inventory for SST C-108 (see Table D-2)

- Summary of incremental lifetime cancer risk, radiological dose, and drinking water dose for radionuclide contaminants of potential concern estimated in the 95% upper confidence level (UCL) post-retrieval inventory for SST C-108 (see Table D-3)

- Summary of maximum value for incremental lifetime cancer risk and hazard index for non-radionuclide contaminants of potential concern estimated in the 95% UCL post-retrieval inventory for SST C-108 (see Table D-4)

- Tables and plots of doses from a well driller scenario for radioactive contaminants of concern found within the average and 95% UCL inventory estimated for SST C-108 (see Table D-5 and Figure D-1)

- Tables and plots of doses from a rural pasture scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-108 (see Table D-6 and Figure D-2)

- Tables and plots of doses from a suburban gardener scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-108 (see Table D-7 and Figure D-3)

- Tables and plots of doses from a commercial farm scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-108 (see Table D-8 and Figure D-4).

Tables D-9 and D-10 provide additional risk management information related to (average and 95% UCL) concentrations of constituents remaining in waste residuals within tank C-108 compared against the *Washington Administrative Code* 173-340, "Model Toxics Control Act – Cleanup" cleanup standards. See Section 5.5 for additional discussion.

Table D-11 provides information on background concentration levels at the Hanford Site that have been developed for selected constituents. This is provided to bring additional perspective in the concentration levels of constituents remaining in residual wastes within tank C-108.

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-108. (2 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk (Groundwater) Scenarios[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Tritium	No	1.56E-02	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Carbon-14	No	3.34E-03	5.14E-03	9.78E+03	0.00E+00	5.73E+03	3.99E-11	2.88E-10	2.49E-05	1.03E-05
Nickel-63	Yes	2.48E+00	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Cobalt-60	No	2.15E+00	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Selenium-79	Yes	1.38E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	1.36E+03	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Yttrium-90	Yes	0.00E+00	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE
Niobium-94	Yes	0.00E+00	0.00E+00	DNA	1.00E+02	2.03E+04	NE	NE	NE	NE
Technetium-99	Yes	3.96E-02	1.58E-01	1.05E+04	0.00E+00	2.11E+05	2.18E-09	5.31E-08	2.77E-04	7.03E-04
Antimony-125	No	2.14E+00	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Iodine-129	No	3.89E-04	<1.00E-03	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
Cesium-137 + Daughters	Yes	9.17E+01	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Barium-137m	Yes	0.00E+00	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Europium-152	No	9.40E-01	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	6.60E-01	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	1.47E+00	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE
Thorium-228 + D	Yes	1.38E-05	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE
Thorium-230	No	5.70E-03	0.00E+00	DNA	3.00E+00	7.54E+04	NE	NE	NE	NE
Thorium-232	Yes	1.28E-05	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Uranium-233	No	1.01E-01	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	NE
Uranium-234	Yes	2.65E-02	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	NE
Uranium-235 + D	Yes	1.48E-03	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	NE
Uranium-236	Yes	2.32E-04	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	NE
Uranium-238 + D	Yes	3.28E-02	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	NE

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-108. (2 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk (Groundwater) Scenarios[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Neptunium-237 + D	No	3.70E-03	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Plutonium-238	Yes	3.71E-03	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	5.44E-01	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	5.92E-02	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	8.21E-02	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Americium-241	Yes	7.85E-01	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Curium-242	No	1.21E-02	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	No	5.70E-04	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	No	1.22E-02	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE
Performance Objectives[c]							**1-0E-6 to 1.0E-4[d]**	**1-0E-6 to 1.0E-4[d]**	**25[e]**	**4[f]**

[a] 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.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for the Hanford Tank Waste Performance Assessment.*

[c] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

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

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

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

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

NE = Incremental cancer risk for industrial and residential scenarios or radiological dose evaluated for the all-pathways farmer and drinking water only scenarios not evaluated because radiological constituent had no estimated initial inventory or did not arrive in concentrations greater than at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 pCi/L are considered to be effectively zero. This risk metric may have also not been 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.

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-108. (6 sheets)

Analyte	Above Detection Limits in Residual Waste	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	
Aluminum	Yes	2.83E+03	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia -- (a)	Yes	2.53E-02	<1.00E-03	1.05E+04	9.30E-04	NE	NE
Antimony[a]	No	1.26E-01	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic[a]	No	1.05E-01	0.00E+00	DNA	3.90E+01	NE	NE
Barium[a]	Yes	3.51E-01	0.00E+00	DNA	6.00E+01	NE	NE
Beryllium[a]	No	5.10E-01	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	No	4.36E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Boron	No	2.10E-02	0.00E+00	DNA	3.00E+00	NE	NE
Bromide	No	3.37E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Cadmium[a]	No	2.10E-02	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	1.96E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	No	1.31E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Chloride	No	3.60E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Total Chromium	Yes	5.14E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Cobalt	No	2.10E-02	<1.00E-03	1.20E+04	1.00E-01	NE	NE
Copper	Yes	4.44E-01	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide[a]	Yes	1.34E-01	0.00E+00	DNA	9.90E+00	NE	NE
Europium	No	2.10E-02	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	9.83E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Formate+A2	No	9.45E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Iron	Yes	2.29E+02	0.00E+00	DNA	2.50E+01	NE	NE
Lanthanum	No	5.10E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Lead[a]	Yes	1.39E+01	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	No	5.10E-01	0.00E+00	DNA	3.00E+02	NE	NE
Magnesium	Yes	2.76E+00	0.00E+00	DNA	4.50E+00	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-108. (6 sheets)

Analyte	Above Detection Limits in Residual Waste	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	
Manganese	Yes	3.32E+00	0.00E+00	DNA	1.00E+00	NE	NE
Mercury[a]	Yes	1.66E-02	0.00E+00	DNA	5.20E+00	NE	NE
Molybdenum	No	5.10E-01	0.00E+00	DNA	4.00E+00	NE	NE
Neodymium	No	4.36E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Nickel[a]	Yes	6.06E+01	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	Yes	0.00E+00	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	7.46E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Nitrite	Yes	4.71E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Oxalate	Yes	1.20E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Palladium	Yes	0.00E+00	0.00E+00	DNA	5.00E+01	NE	NE
Phosphate	Yes	9.56E+02	3.92E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Potassium	Yes	0.00E+00	0.00E+00	DNA	0.00E+00	NE	NE
Praseodymium	No	8.40E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Rhodium	No	4.08E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Rubidium	No	6.30E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Ruthenium	No	8.40E-02	0.00E+00	DNA	1.00E+00	NE	NE
Samarium	No	8.70E+00	0.00E+00	DNA	1.00E+00	NE	NE
Selenium[a]	No	1.26E-01	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	7.15E+01	0.00E+00	DNA	3.00E+01	NE	NE
Silver[a]	No	2.10E-02	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	2.66E+03	1.09E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Strontium	Yes	1.60E+01	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	2.38E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Sulfide	Yes	0.00E+00	0.00E+00	DNA	0.00E+00	NE	NE
Tantalum	No	2.18E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-108. (6 sheets)

Analyte	Above Detection Limits in Residual Waste	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	
Tellurium	No	4.36E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Thallium[a]	No	4.36E+01	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	Yes	1.16E-01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	No	6.30E-02	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	Yes	6.15E-02	0.00E+00	DNA	1.00E+03	NE	NE
Tungsten	No	1.26E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Uranium	Yes	9.84E+01	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	No	2.18E+00	0.00E+00	DNA	5.00E+01	NE	NE
Yttrium	Yes	8.82E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Zinc	Yes	1.56E+00	0.00E+00	DNA	6.20E+01	NE	NE
Zirconium	Yes	0.00E+00	0.00E+00	DNA	5.00E+02	NE	NE
1, 1, 1-Trichloroethane[a]	No	3.98E-05	<1.00E-03	1.20E+04	4.05E-02	NE	NE
1, 1, 2, 2-Tetrachloroethane[a]	No	9.95E-05	<1.00E-03	1.20E+04	2.37E-02	NE	NE
1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	No	9.95E-05	<1.00E-03	1.20E+04	3.86E-01	NE	NE
1, 1, 2-Trichloroethane[a]	No	7.55E-05	<1.00E-03	1.20E+04	2.25E-02	NE	NE
1, 1, 2-Trichloroethylene	No	5.95E-05	<1.00E-03	1.20E+04	2.82E-02	NE	NE
1, 1-Dichloroethene[a]	No	6.75E-05	<1.00E-03	1.05E+04	1.94E-02	NE	NE
1, 2, 4-Trichlorobenzene[a]	No	1.59E-02	<1.00E-03	1.20E+04	4.98E-01	NE	NE
1, 2-Dichloroethane[a]	No	3.58E-05	<1.00E-03	1.05E+04	1.14E-02	NE	NE
1, 4-Dichlorobenzene[a]	No	2.32E-02	<1.00E-03	1.20E+04	1.85E-01	NE	NE
2, 4, 5-Trichlorophenol[a]	No	9.00E-03	<1.00E-03	1.20E+04	3.57E-01	NE	NE
2, 4, 6-Trichlorophenol[a]	No	1.02E-02	<1.00E-03	1.20E+04	1.14E-01	NE	NE
2, 4-Dinitrotoluene[a]	No	7.80E-03	<1.00E-03	1.20E+04	1.09E-01	NE	NE
2, 6-Bis (tert-butyl)-4-methylphenol	Yes	0.00E+00	0.00E+00	DNA	6.90E+00	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-108. (6 sheets)

Analyte	Above Detection Limits in Residual Waste	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	
2-Butanone(MEK)[a]	No	5.30E-04	<1.00E-03	1.05E+04	1.35E-03	NE	NE
2-Chlorophenol[a]	No	1.36E-02	<1.00E-03	1.05E+04	3.00E-04	NE	NE
2-Ethoxyethanol[a]	No	3.74E-02	<1.00E-03	1.05E+04	3.00E-04	NE	NE
2-Methylphenol (o-cresol)	No	1.18E-02	<1.00E-03	1.20E+04	1.33E-01	NE	NE
2-Nitropropane[a]	No	3.14E-04	<1.00E-03	1.05E+04	7.47E-03	NE	NE
2-Propanone (Acetone)[a]	No	8.70E-04	<1.00E-03	1.05E+04	1.73E-04	NE	NE
4-Methyl-2-pentanone (MIBK)	No	3.50E-04	<1.00E-03	1.20E+04	4.02E-02	NE	NE
4-Methylphenol (p-cresol)	No	1.06E-02	<1.00E-03	1.20E+04	1.30E-01	NE	NE
Acenaphthene	No	3.61E-03	0.00E+00	DNA	1.17E+00	NE	NE
Acetate $C_2H_3O_2^-$	No	6.30E-01	<1.00E-03	1.05E+04	3.00E-04	NE	NE
Benzene[a]	No	6.35E-05	<1.00E-03	1.05E+04	1.86E-02	NE	NE
Butylbenzylphthalate[a]	No	1.03E-02	0.00E+00	DNA	4.14E+00	NE	NE
Carbon disulfide[a]	No	5.95E-05	<1.00E-03	1.05E+04	1.37E-02	NE	NE
Carbon tetrachloride[a]	No	5.95E-05	<1.00E-03	1.05E+04	1.38E-02	NE	NE
Chlorobenzene[a]	No	4.38E-05	<1.00E-03	1.20E+04	6.72E-02	NE	NE
Chloroethene (vinyl chloride)[a]	No	1.28E-04	<1.00E-03	1.05E+04	5.58E-03	NE	NE
Chloroform[a]	No	3.58E-05	<1.00E-03	1.05E+04	1.20E-02	NE	NE
Cresylic acid (cresol, mixed isomers)[a]	No	2.19E-02	<1.00E-03	1.20E+04	1.33E-01	NE	NE
Cyclohexanone	No	1.15E-01	<1.00E-03	1.05E+04	1.65E-03	NE	NE
Dichloromethane (methylene chloride)	No	6.75E-05	<1.00E-03	1.05E+04	3.00E-03	NE	NE
Diethyl ether	No	1.76E-04	<1.00E-03	1.05E+04	1.32E-03	NE	NE
Di-n-butylphthalate[a]	No	1.15E-01	0.00E+00	DNA	1.89E+00	NE	NE
Di-n-octylphthalate[a]	No	9.75E-03	0.00E+00	DNA	2.49E+04	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-108. (6 sheets)

Analyte	Above Detection Limits in Residual Waste	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	
Ethyl Acetate	No	1.94E-04	<1.00E-03	1.05E+04	1.57E-03	NE	NE
Ethylbenzene	No	4.78E-05	<1.00E-03	1.20E+04	6.00E-02	NE	NE
Fluoranthene[a]	No	7.25E-03	0.00E+00	DNA	1.47E+01	NE	NE
Glycolate $C_2H_3O_3$	No	3.60E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Hexachlorobutadiene[a]	No	1.43E-02	0.00E+00	DNA	1.61E+01	NE	NE
Hexachloroethane[a]	No	2.29E-02	0.00E+00	DNA	5.10E+00	NE	NE
Isobutanol	No	9.45E-02	<1.00E-03	1.05E+04	6.30E-04	NE	NE
m-Cresol (3-Methylphenol)	No	1.06E-02	<1.00E-03	1.20E+04	1.30E-01	NE	NE
m-Xylene	No	8.35E-05	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Naphthalene[a]	No	1.28E-02	0.00E+00	DNA	6.00E-01	NE	NE
n-Butyl alcohol (1-butanol)	No	7.05E-02	<1.00E-03	1.05E+04	2.08E-03	NE	NE
Nitrobenzene[a]	No	1.33E-02	<1.00E-03	1.05E+04	1.94E-02	NE	NE
N-nitroso-di-n-propylamine[a]	No	1.19E-02	<1.00E-03	1.05E+04	7.20E-03	NE	NE
n-Nitrosomorpholine[a]	No	3.92E-02	<1.00E-03	1.05E+04	4.77E-03	NE	NE
o-Dichlorobenzene[a]	No	2.06E-02	<1.00E-03	1.20E+04	1.14E-01	NE	NE
o-Nitrophenol	No	1.10E-02	<1.00E-03	1.20E+04	9.45E-02	NE	NE
o-Xylene	No	3.98E-05	<1.00E-03	1.20E+04	7.23E-02	NE	NE
p-Chloro-m-cresol (4-Chloro-3-methylphenol)[a]	No	8.85E-03	<1.00E-03	1.20E+04	2.15E-01	NE	NE
Pentachlorophenol[a]	No	7.70E-03	<1.00E-03	1.20E+04	1.77E-01	NE	NE
Phenol[a]	No	1.22E-02	<1.00E-03	1.05E+04	8.64E-03	NE	NE
p-Xylene	No	8.35E-05	<1.00E-03	1.20E+04	3.83E-01	NE	NE
Pyrene	No	1.29E-02	0.00E+00	DNA	2.08E+01	NE	NE
Pyridine[a]	No	1.33E-02	<1.00E-03	1.05E+04	1.50E-03	NE	NE
Tetrachloroethylene[a]	No	7.95E-05	<1.00E-03	1.20E+04	8.10E-02	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-108. (6 sheets)

Analyte	Above Detection Limits in Residual Waste	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	
Toluene[a]	No	4.78E-05	<1.00E-03	1.20E+04	4.20E-02	NE	NE
Tributyl phosphate	No	2.21E-02	<1.00E-03	1.20E+04	5.67E-01	NE	NE
Trichlorofluoromethane[a]	No	3.96E-04	<1.00E-03	1.20E+04	2.79E-02	NE	NE
Xylenes	No	1.24E-04	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

[a] Dangerous waste constituent per *Washington Administrative Code* (WAC) 173-303-9905, "Dangerous Waste Constituents List."

[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, *Exposure Scenarios and Unit Factors for the Hanford Tank Waste Performance Assessment*.

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

[e] WAC 173-340-705, "Use of Method B," subpart (2)(c)(ii).

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

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

NE = Incremental cancer risk or hazard quotient calculated under WAC-173-340, "Model Toxics Control Act – Cleanup," Method B not evaluated because hazardous chemical constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 µg/L are considered to be effectively zero. The risk metric may have also not been calculated because the chemical 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.

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 for Single-Shell Tank 241-C-108 Dose per Radionuclide Contaminant of Potential Concern for the 95% Upper Confidence Level Inventory. (2 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk (Groundwater)		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose from Beta/Photon Emitters (mrem/yr) Drinking Water Only Scenario[b]
							Industrial Scenario[b]	Residential Scenario[b]		
Tritium	No	4.67E-02	0.00E+00	0.00E+00	0.00E+00	1.23E+01	NE	NE	NE	NE
Carbon-14	No	1.00E-02	1.54E-02	9.78E+03	0.00E+00	5.73E+03	1.20E-10	8.65E-10	7.46E-05	3.08E-05
Nickel-63	Yes	3.26E+00	0.00E+00	0.00E+00	4.80E+01	1.00E+02	NE	NE	NE	NE
Cobalt-60	No	6.45E+00	0.00E+00	0.00E+00	1.00E-01	5.27E+00	NE	NE	NE	NE
Selenium-79	Yes	1.75E-03	0.00E+00	0.00E+00	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	1.93E+03	0.00E+00	0.00E+00	1.61E+01	2.81E+01	NE	NE	NE	NE
Yttrium-90	Yes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.31E-03	NE	NE	NE	NE
Niobium-94	Yes	0.00E+00	0.00E+00	0.00E+00	1.00E+02	2.03E+04	NE	NE	NE	NE
Technetium-99	Yes	4.99E-02	1.99E-01	1.05E+04	0.00E+00	2.11E+05	2.75E-09	6.69E-08	3.49E-04	8.86E-04
Antimony-125	No	6.40E+00	0.00E+00	0.00E+00	1.00E+00	2.73E+00	NE	NE	NE	NE
Iodine-129	No	1.17E-03	<1.00E-03	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
Cesium-137 + Daughters	Yes	1.15E+02	0.00E+00	0.00E+00	2.50E+01	3.00E+01	NE	NE	NE	NE
Barium-137m	Yes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.86E-06	NE	NE	NE	NE
Europium-152	No	2.82E+00	0.00E+00	0.00E+00	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	1.98E+00	0.00E+00	0.00E+00	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	4.40E+00	0.00E+00	0.00E+00	1.00E+00	4.68E+00	NE	NE	NE	NE
Thorium-228 + D	Yes	1.82E-05	0.00E+00	0.00E+00	3.00E+00	1.91E+00	NE	NE	NE	NE
Thorium-230	No	1.71E-02	0.00E+00	0.00E+00	3.00E+00	7.54E+04	NE	NE	NE	NE
Thorium-232	Yes	1.62E-05	0.00E+00	0.00E+00	3.00E+00	1.41E+10	NE	NE	NE	NE
Uranium-233	No	3.03E-01	0.00E+00	0.00E+00	6.00E-01	1.59E+05	NE	NE	NE	NE
Uranium-234	Yes	3.84E-02	0.00E+00	0.00E+00	6.00E-01	2.46E+05	NE	NE	NE	NE
Uranium-235 + D	Yes	1.80E-03	0.00E+00	0.00E+00	6.00E-01	7.04E+08	NE	NE	NE	NE
Uranium-236	Yes	4.15E-04	0.00E+00	0.00E+00	6.00E-01	2.34E+07	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-108 Dose per Radionuclide Contaminant of Potential Concern for the 95% Upper Confidence Level Inventory. (2 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk (Groundwater)		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose from Beta/Photon Emitters (mrem/yr) Drinking Water Only Scenario[b]
							Industrial Scenario[b]	Residential Scenario[b]		
Uranium-238 + D	Yes	4.03E-02	0.00E+00	0.00E+00	6.00E-01	4.47E+09	NE	NE	NE	NE
Neptunium-237 + D	No	1.11E-02	0.00E+00	0.00E+00	2.00E+00	2.14E+06	NE	NE	NE	NE
Plutonium-238	Yes	4.35E-03	0.00E+00	0.00E+00	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	6.37E-01	0.00E+00	0.00E+00	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	6.93E-02	0.00E+00	0.00E+00	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	9.62E-02	0.00E+00	0.00E+00	3.00E+00	1.44E+01	NE	NE	NE	NE
Americium-241	Yes	9.80E-01	0.00E+00	0.00E+00	3.00E+00	4.33E+02	NE	NE	NE	NE
Curium-242	No	3.62E-02	0.00E+00	0.00E+00	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	No	1.71E-03	0.00E+00	0.00E+00	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	No	3.65E-02	0.00E+00	0.00E+00	3.00E+00	1.81E+01	NE	NE	NE	NE
Performance Objectives[c]							**1-0E-6 to 1.0E-4[d]**	**1-0E-6 to 1.0E-4[d]**	**25[e]**	**4[f]**

[a] 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.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for the Hanford Tank Waste Performance Assessment.*

[c] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

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

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

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

NE = Incremental lifetime cancer risk or radiological dose not evaluated because radiological constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 pCi/L are considered to be effectively zero. This risk metric may have also not been 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.

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-108 of Potential Concern using Upper Limit 95% Post-Retrieval Inventory. (6 sheets)

Analyte	Above Detection Limits in Residual Wastes	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	
Aluminum	Yes	3.39E+03	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia -- (a)	Yes	5.68E-02	<1.00E-03	1.05E+04	9.30E-04	NE	NE
Antimony[a]	No	3.78E-01	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic[a]	No	3.15E-01	0.00E+00	DNA	3.90E+01	NE	NE
Barium[a]	Yes	4.68E-01	0.00E+00	DNA	6.00E+01	NE	NE
Beryllium[a]	No	1.53E+00	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	No	1.31E+02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Boron	No	6.30E-02	0.00E+00	DNA	3.00E+00	NE	NE
Bromide	No	1.01E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Cadmium[a]	No	6.30E-02	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	2.33E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	No	3.92E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Chloride	No	1.08E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Total Chromium[a]	Yes	6.51E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Cobalt	No	6.30E-02	<1.00E-03	1.20E+04	1.00E-01	NE	NE
Copper	Yes	5.35E-01	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide[a]	Yes	1.63E-01	0.00E+00	DNA	9.90E+00	NE	NE
Europium	No	6.30E-02	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	1.30E+02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Formate+A2	No	2.84E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Iron	Yes	3.03E+02	0.00E+00	DNA	2.50E+01	NE	NE
Lanthanum	No	1.53E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Lead[a]	Yes	1.83E+01	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	No	1.53E+00	0.00E+00	DNA	3.00E+02	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-108 of Potential Concern using Upper Limit 95% Post-Retrieval Inventory. (6 sheets)

Analyte	Above Detection Limits in Residual Wastes	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	
Magnesium	Yes	3.38E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	5.49E+00	0.00E+00	DNA	1.00E+00	NE	NE
Mercury[a]	Yes	2.03E-02	0.00E+00	DNA	5.20E+00	NE	NE
Molybdenum	No	1.53E+00	0.00E+00	DNA	4.00E+00	NE	NE
Neodymium	No	1.31E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Nickel[a]	Yes	7.32E+01	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	No	0.00E+00	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	9.35E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Nitrite	Yes	5.59E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Oxalate	No	1.40E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Palladium	No	0.00E+00	0.00E+00	DNA	5.00E+01	NE	NE
Phosphate	Yes	1.37E+03	5.62E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Potassium	No	0.00E+00	0.00E+00	DNA	0.00E+00	NE	NE
Praseodymium	No	2.52E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Rhodium	No	1.23E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Rubidium	No	1.89E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Ruthenium	No	2.52E-01	0.00E+00	DNA	1.00E+00	NE	NE
Samarium	No	2.61E+01	0.00E+00	DNA	1.00E+00	NE	NE
Selenium[a]	No	3.78E-01	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	1.21E+02	0.00E+00	DNA	3.00E+01	NE	NE
Silver[a]	No	6.30E-02	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	3.24E+03	1.33E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Strontium	Yes	2.12E+01	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	2.86E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Sulfide	No	0.00E+00	0.00E+00	DNA	0.00E+00	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-108 of Potential Concern using Upper Limit 95% Post-Retrieval Inventory. (6 sheets)

Analyte	Above Detection Limits in Residual Wastes	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	
Tantalum	No	6.55E+01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Tellurium	No	1.31E+02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Thallium[a]	No	1.31E+02	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	Yes	1.47E-01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	No	1.89E-01	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	Yes	1.00E-01	0.00E+00	DNA	1.00E+03	NE	NE
Tungsten	No	3.78E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Uranium	Yes	1.21E+02	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	No	6.55E+00	0.00E+00	DNA	5.00E+01	NE	NE
Yttrium	Yes	1.10E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Zinc	Yes	1.97E+00	0.00E+00	DNA	6.20E+01	NE	NE
Zirconium	No	0.00E+00	0.00E+00	DNA	5.00E+02	NE	NE
1, 1, 1-Trichloroethane[a]	No	1.20E-04	<1.00E-03	1.20E+04	4.05E-02	NE	NE
1, 1, 2, 2-Tetrachloroethane[a]	No	2.99E-04	<1.00E-03	1.20E+04	2.37E-02	NE	NE
1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	No	2.99E-04	<1.00E-03	1.20E+04	3.86E-01	NE	NE
1, 1, 2-Trichloroethane[a]	No	2.27E-04	<1.00E-03	1.20E+04	2.25E-02	NE	NE
1, 1, 2-Trichloroethylene	No	1.79E-04	<1.00E-03	1.20E+04	2.82E-02	NE	NE
1, 1-Dichloroethene[a]	No	2.03E-04	<1.00E-03	1.05E+04	1.94E-02	NE	NE
1, 2, 4-Trichlorobenzene	No	4.76E-02	<1.00E-03	1.20E+04	4.98E-01	NE	NE
1, 2-Dichloroethane[a]	No	1.08E-04	<1.00E-03	1.05E+04	1.14E-02	NE	NE
1, 4-Dichlorobenzene[a]	No	6.95E-02	<1.00E-03	1.20E+04	1.85E-01	NE	NE
2, 4, 5-Trichlorophenol[a]	No	2.70E-02	<1.00E-03	1.20E+04	3.57E-01	NE	NE
2, 4, 6-Trichlorophenol[a]	No	3.05E-02	<1.00E-03	1.20E+04	1.14E-01	NE	NE
2, 4-Dinitrotoluene[a]	No	2.34E-02	<1.00E-03	1.20E+04	1.09E-01	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-108 of Potential Concern using Upper Limit 95% Post-Retrieval Inventory. (6 sheets)

Analyte	Above Detection Limits in Residual Wastes	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	
2, 6-Bis (tert-butyl)-4-methylphenol	No	0.00E+00	0.00E+00	DNA	6.90E+00	NE	NE
2-Butanone(MEK)[a]	No	1.59E-03	<1.00E-03	1.05E+04	1.35E-03	NE	NE
2-Chlorophenol[a]	No	4.08E-02	<1.00E-03	1.05E+04	3.00E-04	NE	NE
2-Ethoxyethanol[a]	No	1.12E-01	<1.00E-03	1.05E+04	3.00E-04	NE	NE
2-Methylphenol (o-cresol)	No	3.54E-02	<1.00E-03	1.20E+04	1.33E-01	NE	NE
2-Nitropropane[a]	No	9.40E-04	<1.00E-03	1.05E+04	7.47E-03	NE	NE
2-Propanone (Acetone)[a]	No	2.61E-03	<1.00E-03	1.05E+04	1.73E-04	NE	NE
4-Methyl-2-pentanone (MIBK)	No	1.05E-03	<1.00E-03	1.20E+04	4.02E-02	NE	NE
4-Methylphenol (p-cresol)	No	3.17E-02	<1.00E-03	1.20E+04	1.30E-01	NE	NE
Acenaphthene	No	1.08E-02	0.00E+00	DNA	1.17E+00	NE	NE
Acetate $C_2H_3O_2$-	No	1.89E+00	<1.00E-03	1.05E+04	3.00E-04	NE	NE
Benzene[a]	No	1.91E-04	<1.00E-03	1.05E+04	1.86E-02	NE	NE
Butylbenzylphthalate[a]	No	3.08E-02	0.00E+00	DNA	4.14E+00	NE	NE
Carbon disulfide[a]	No	1.79E-04	<1.00E-03	1.05E+04	1.37E-02	NE	NE
Carbon tetrachloride[a]	No	1.79E-04	<1.00E-03	1.05E+04	1.38E-02	NE	NE
Chlorobenzene[a]	No	1.32E-04	<1.00E-03	1.20E+04	6.72E-02	NE	NE
Chloroethene (vinyl chloride)[a]	No	3.83E-04	<1.00E-03	1.05E+04	5.58E-03	NE	NE
Chloroform[a]	No	1.08E-04	<1.00E-03	1.05E+04	1.20E-02	NE	NE
Cresylic acid (cresol, mixed isomers)[a]	No	6.55E-02	<1.00E-03	1.20E+04	1.33E-01	NE	NE
Cyclohexanone	No	3.44E-01	<1.00E-03	1.05E+04	1.65E-03	NE	NE
Dichloromethane (methylene chloride)[a]	No	2.03E-04	<1.00E-03	1.05E+04	3.00E-03	NE	NE
Diethyl ether	No	5.30E-04	<1.00E-03	1.05E+04	1.32E-03	NE	NE
Di-n-butylphthalate[a]	No	3.45E-01	0.00E+00	DNA	1.89E+00	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-108 of Potential Concern using Upper Limit 95% Post-Retrieval Inventory. (6 sheets)

Analyte	Above Detection Limits in Residual Wastes	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	
Di-n-octylphthalate[a]	No	2.93E-02	0.00E+00	DNA	2.49E+04	NE	NE
Ethyl Acetate	No	5.80E-04	<1.00E-03	1.05E+04	1.57E-03	NE	NE
Ethylbenzene	No	1.44E-04	<1.00E-03	1.20E+04	6.00E-02	NE	NE
Fluoranthene[a]	No	2.18E-02	0.00E+00	DNA	1.47E+01	NE	NE
Glycolate $C_2H_3O_3$	No	1.08E+00	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Hexachlorobutadiene[a]	No	4.28E-02	0.00E+00	DNA	1.61E+01	NE	NE
Hexachloroethane[a]	No	6.85E-02	0.00E+00	DNA	5.10E+00	NE	NE
Isobutanol	No	2.84E-01	<1.00E-03	1.05E+04	6.30E-04	NE	NE
m-Cresol (3-Methylphenol)	No	3.17E-02	<1.00E-03	1.20E+04	1.30E-01	NE	NE
m-Xylene	No	2.51E-04	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Naphthalene[a]	No	3.84E-02	0.00E+00	DNA	6.00E-01	NE	NE
n-Butyl alcohol (1-butanol)	No	2.12E-01	<1.00E-03	1.05E+04	2.08E-03	NE	NE
Nitrobenzene[a]	No	3.98E-02	<1.00E-03	1.05E+04	1.94E-02	NE	NE
N-nitroso-di-n-propylamine[a]	No	3.57E-02	<1.00E-03	1.05E+04	7.20E-03	NE	NE
n-Nitrosomorpholine[a]	No	1.18E-01	<1.00E-03	1.05E+04	4.77E-03	NE	NE
o-Dichlorobenzene[a]	No	6.20E-02	<1.00E-03	1.20E+04	1.14E-01	NE	NE
o-Nitrophenol	No	3.30E-02	<1.00E-03	1.20E+04	9.45E-02	NE	NE
o-Xylene	No	1.20E-04	<1.00E-03	1.20E+04	7.23E-02	NE	NE
p-Chloro-m-cresol (4-Chloro-3-methylphenol)[a]	No	2.66E-02	<1.00E-03	1.20E+04	2.15E-01	NE	NE
Pentachlorophenol[a]	No	2.31E-02	<1.00E-03	1.20E+04	1.77E-01	NE	NE
Phenol[a]	No	3.65E-02	<1.00E-03	1.05E+04	8.64E-03	NE	NE
p-Xylene	No	2.51E-04	<1.00E-03	1.20E+04	3.83E-01	NE	NE
Pyrene	No	3.87E-02	0.00E+00	DNA	2.08E+01	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-108 of Potential Concern using Upper Limit 95% Post-Retrieval Inventory. (6 sheets)

Analyte	Above Detection Limits in Residual Wastes	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	
Pyridine[a]	No	3.99E-02	<1.00E-03	1.05E+04	1.50E-03	NE	NE
Tetrachloroethylene[a]	No	2.39E-04	<1.00E-03	1.20E+04	8.10E-02	NE	NE
Toluene[a]	No	1.44E-04	<1.00E-03	1.20E+04	4.20E-02	NE	NE
Tributyl phosphate	No	6.65E-02	<1.00E-03	1.20E+04	5.67E-01	NE	NE
Trichlorofluoromethane[a]	No	1.19E-03	<1.00E-03	1.20E+04	2.79E-02	NE	NE
Xylenes	No	3.71E-04	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Aroclor-1254	No	0.00E+00	0.00E+00	DNA	2.27E+01	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

[a] Dangerous waste constituent per *Washington Administrative Code* (WAC) 173-303-9905, "Dangerous Waste Constituents List."

[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, *Exposure Scenarios and Unit Factors for the Hanford Tank Waste Performance Assessment.*

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

[e] WAC 173-340-705, "Use of Method B," subpart (2)(c)(ii).

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

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

NE = Incremental lifetime cancer risk or hazard quotient calculated under WAC 173-340, "Model Toxics Control Act – Cleanup," Method B not evaluated because hazardous chemical constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 µg/L are considered to be effectively zero. The risk metric may have also not been calculated because the chemical 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.

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 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

A – Average Inventory										
	Years after Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	6.75E-12	2.44E-14	8.84E-17	3.20E-19	1.16E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	5.51E-08	5.44E-08	5.38E-08	5.31E-08	5.25E-08	5.19E-08	5.12E-08	5.06E-08	5.00E-08	4.94E-08
Nickel-63	4.71E-06	2.36E-06	1.18E-06	5.90E-07	2.95E-07	1.48E-07	7.39E-08	3.70E-08	1.85E-08	9.26E-09
Cobalt-60	8.92E-08	1.74E-13	3.38E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	9.28E-08	9.28E-08	9.27E-08	9.27E-08	9.27E-08	9.27E-08	9.27E-08	9.27E-08	9.27E-08	9.27E-08
Strontium-90 + D	1.43E-01	1.22E-02	1.04E-03	8.83E-05	7.52E-06	6.41E-07	5.47E-08	4.66E-09	3.97E-10	3.38E-11
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	7.52E-07	7.51E-07	7.51E-07	7.51E-07	7.51E-07	7.50E-07	7.50E-07	7.50E-07	7.50E-07	7.49E-07
Antimony-125	3.47E-15	0.00E+00	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	1.16E-06	1.16E-06	1.16E-06	1.16E-06	1.16E-06	1.16E-06	1.16E-06	1.16E-06	1.16E-06	1.16E-06
Cesium-137 + Daughters	6.77E-01	6.72E-02	6.67E-03	6.61E-04	6.56E-05	6.51E-06	6.46E-07	6.41E-08	6.36E-09	6.31E-10
Europium-152	3.69E-04	2.03E-06	1.12E-08	6.19E-11	3.42E-13	2.50E-15	6.24E-16	6.14E-16	6.13E-16	6.13E-16
Europium-154	7.82E-06	2.45E-09	7.69E-13	2.41E-16	7.57E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.36E-10	5.04E-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
Thorium-230	2.70E-04	3.78E-04	4.81E-04	5.79E-04	6.73E-04	7.64E-04	8.50E-04	9.32E-04	1.01E-03	1.09E-03
Thorium-232	9.17E-06	9.17E-06	9.17E-06	9.17E-06	9.17E-06	9.17E-06	9.17E-06	9.17E-06	9.17E-06	9.17E-06
Uranium-233	5.53E-04	7.65E-04	9.75E-04	1.18E-03	1.39E-03	1.59E-03	1.79E-03	1.99E-03	2.19E-03	2.39E-03
Uranium-234	7.34E-05	7.48E-05	7.66E-05	7.88E-05	8.15E-05	8.45E-05	8.80E-05	9.18E-05	9.59E-05	1.00E-04
Uranium-235 + D	5.89E-05	6.04E-05	6.20E-05	6.36E-05	6.52E-05	6.68E-05	6.83E-05	6.99E-05	7.15E-05	7.30E-05
Uranium-236	5.99E-07	5.99E-07	5.99E-07	5.99E-07	5.99E-07	5.99E-07	5.99E-07	5.99E-07	5.99E-07	5.99E-07
Uranium-238 + D	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04
Neptunium-237 + D	4.52E-04	4.52E-04	4.52E-04	4.52E-04	4.52E-04	4.52E-04	4.52E-04	4.52E-04	4.52E-04	4.52E-04
Plutonium-238	7.28E-05	3.30E-05	1.50E-05	6.80E-06	3.09E-06	1.40E-06	6.39E-07	2.92E-07	1.35E-07	6.40E-08

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

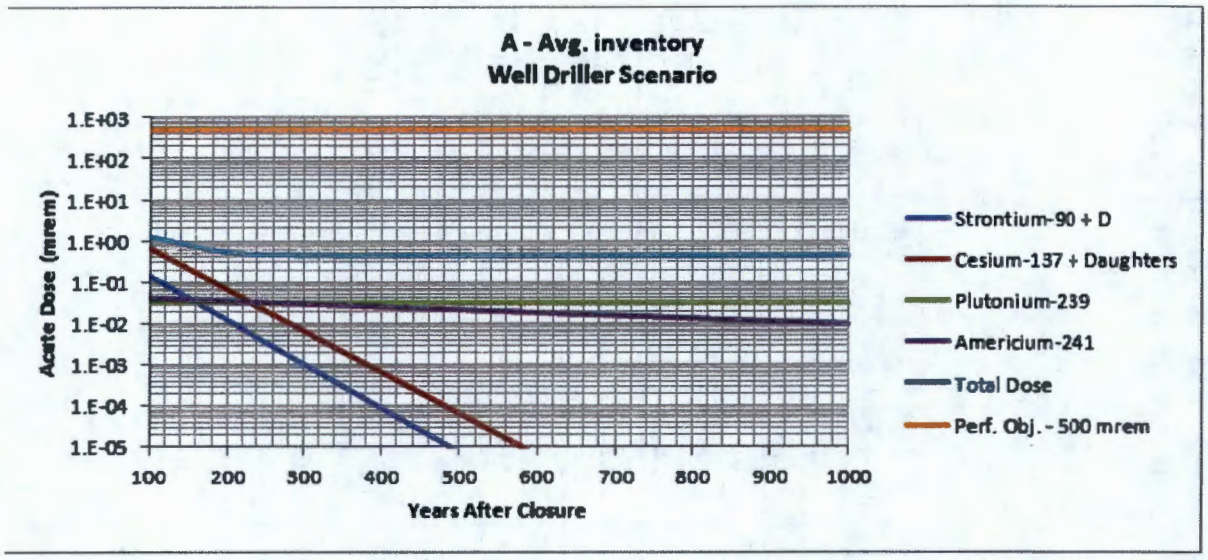
A – Average Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Plutonium-239	3.14E-02	3.13E-02	3.12E-02	3.12E-02	3.11E-02	3.10E-02	3.09E-02	3.08E-02	3.07E-02	3.06E-02
Plutonium-240	3.39E-03	3.35E-03	3.32E-03	3.28E-03	3.25E-03	3.21E-03	3.18E-03	3.15E-03	3.11E-03	3.08E-03
Plutonium-241 + D	1.44E-04	1.23E-04	1.05E-04	8.93E-05	7.61E-05	6.48E-05	5.52E-05	4.71E-05	4.01E-05	3.42E-05
Americium-241	4.02E-02	3.43E-02	2.92E-02	2.49E-02	2.12E-02	1.81E-02	1.54E-02	1.31E-02	1.12E-02	9.53E-03
Americium-242m + D	7.81E-04	5.77E-04	3.99E-04	2.64E-04	1.71E-04	1.09E-04	6.85E-05	4.28E-05	2.66E-05	1.65E-05
Curium-242	1.21E-06	5.49E-07	2.49E-07	1.13E-07	5.13E-08	2.33E-08	1.06E-08	4.84E-09	2.23E-09	1.04E-09
Curium-243	1.91E-06	2.04E-07	5.37E-08	4.03E-08	3.91E-08	3.89E-08	3.87E-08	3.86E-08	3.85E-08	3.84E-08
Curium-244	5.28E-06	1.98E-06	1.88E-06	1.86E-06	1.84E-06	1.82E-06	1.80E-06	1.79E-06	1.77E-06	1.75E-06
Total Dose	**1.27E+00**	**5.18E-01**	**4.41E-01**	**4.30E-01**	**4.25E-01**	**4.22E-01**	**4.20E-01**	**4.17E-01**	**4.15E-01**	**4.14E-01**

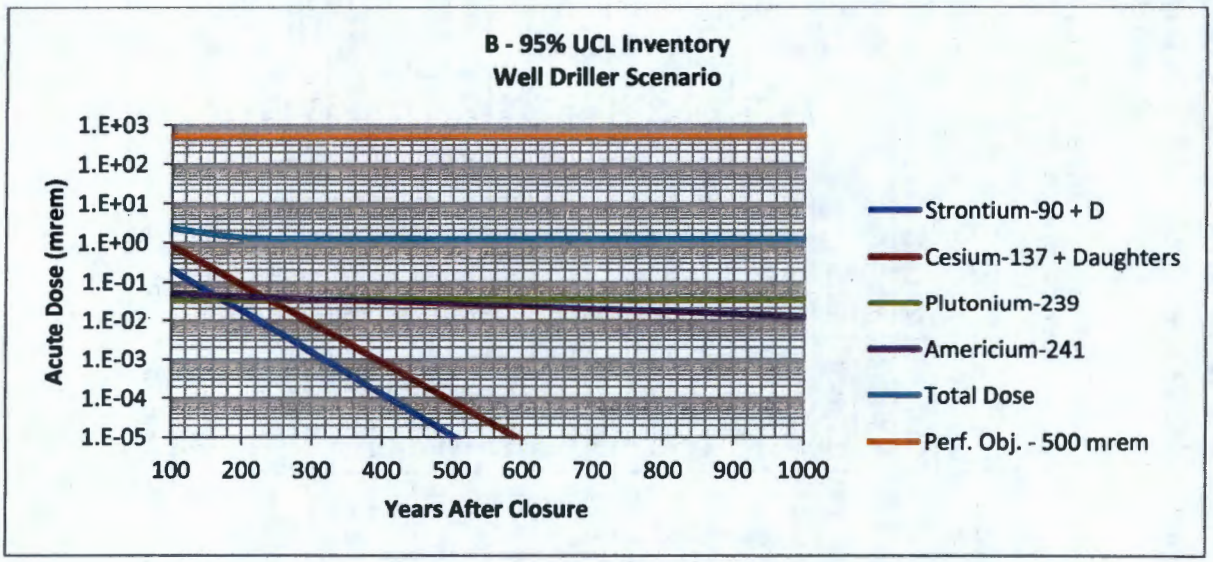
B – 95% Upper Confidence Level Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	2.03E-11	7.33E-14	2.65E-16	9.60E-19	3.47E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.65E-07	1.63E-07	1.61E-07	1.59E-07	1.57E-07	1.55E-07	1.54E-07	1.52E-07	1.50E-07	1.48E-07
Nickel-63	6.19E-06	3.10E-06	1.55E-06	7.76E-07	3.88E-07	1.94E-07	9.72E-08	4.86E-08	2.43E-08	1.22E-08
Cobalt-60	2.68E-07	5.22E-13	1.02E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	1.18E-07	1.18E-07	1.18E-07	1.18E-07	1.18E-07	1.18E-07	1.18E-07	1.18E-07	1.18E-07	1.18E-07
Strontium-90 + D	2.02E-01	1.72E-02	1.47E-03	1.25E-04	1.07E-05	9.10E-07	7.76E-08	6.61E-09	5.63E-10	4.80E-11
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	9.47E-07	9.47E-07	9.46E-07	9.46E-07	9.46E-07	9.45E-07	9.45E-07	9.45E-07	9.45E-07	9.44E-07
Antimony-125	1.04E-14	0.00E+00	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	3.47E-06	3.47E-06	3.47E-06	3.47E-06	3.47E-06	3.47E-06	3.47E-06	3.47E-06	3.47E-06	3.47E-06
Cesium-137 + Daughters	8.50E-01	8.43E-02	8.36E-03	8.30E-04	8.23E-05	8.16E-06	8.10E-07	8.03E-08	7.97E-09	7.91E-10

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
	Years after Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Europium-152	1.11E-03	6.10E-06	3.37E-08	1.86E-10	1.03E-12	7.50E-15	1.87E-15	1.84E-15	1.84E-15	1.84E-15
Europium-154	2.35E-05	7.36E-09	2.31E-12	7.24E-16	2.27E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	4.09E-10	1.51E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	8.10E-04	1.13E-03	1.44E-03	1.74E-03	2.02E-03	2.29E-03	2.55E-03	2.80E-03	3.03E-03	3.26E-03
Thorium-232	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05
Uranium-233	1.66E-03	2.30E-03	2.93E-03	3.55E-03	4.17E-03	4.78E-03	5.38E-03	5.98E-03	6.57E-03	7.16E-03
Uranium-234	1.06E-04	1.08E-04	1.11E-04	1.14E-04	1.18E-04	1.23E-04	1.27E-04	1.33E-04	1.39E-04	1.45E-04
Uranium-235 + D	7.16E-05	7.35E-05	7.54E-05	7.74E-05	7.93E-05	8.12E-05	8.31E-05	8.50E-05	8.69E-05	8.88E-05
Uranium-236	1.07E-06	1.07E-06	1.07E-06	1.07E-06	1.07E-06	1.07E-06	1.07E-06	1.07E-06	1.07E-06	1.07E-06
Uranium-238 + D	3.21E-04	3.21E-04	3.21E-04	3.21E-04	3.21E-04	3.21E-04	3.21E-04	3.21E-04	3.21E-04	3.21E-04
Neptunium-237 + D	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03
Plutonium-238	8.54E-05	3.87E-05	1.76E-05	7.98E-06	3.62E-06	1.65E-06	7.49E-07	3.43E-07	1.59E-07	7.51E-08
Plutonium-239	3.68E-02	3.67E-02	3.66E-02	3.65E-02	3.64E-02	3.63E-02	3.62E-02	3.61E-02	3.60E-02	3.59E-02
Plutonium-240	3.97E-03	3.92E-03	3.88E-03	3.84E-03	3.80E-03	3.76E-03	3.72E-03	3.68E-03	3.64E-03	3.61E-03
Plutonium-241 + D	1.69E-04	1.44E-04	1.23E-04	1.05E-04	8.92E-05	7.60E-05	6.47E-05	5.52E-05	4.70E-05	4.01E-05
Americium-241	5.02E-02	4.28E-02	3.65E-02	3.11E-02	2.65E-02	2.26E-02	1.92E-02	1.64E-02	1.40E-02	1.19E-02
Americium-242m + D	2.34E-03	1.73E-03	1.20E-03	7.93E-04	5.13E-04	3.27E-04	2.06E-04	1.28E-04	7.98E-05	4.95E-05
Curium-242	3.63E-06	1.65E-06	7.47E-07	3.39E-07	1.54E-07	6.99E-08	3.18E-08	1.45E-08	6.69E-09	3.13E-09
Curium-243	5.74E-06	6.12E-07	1.61E-07	1.21E-07	1.17E-07	1.17E-07	1.16E-07	1.16E-07	1.16E-07	1.15E-07
Curium-244	1.58E-05	5.93E-06	5.65E-06	5.59E-06	5.53E-06	5.47E-06	5.41E-06	5.36E-06	5.30E-06	5.24E-06
Total Dose	**2.25E+00**	**1.30E+00**	**1.20E+00**	**1.18E+00**	**1.18E+00**	**1.17E+00**	**1.17E+00**	**1.17E+00**	**1.17E+00**	**1.16E+00**

Figure D-1. Comparison of Well Driller Scenario Doses (mrem) with Performance Objective for Acute Exposure for Key Analytes – A) Average Inventory and B) 95% Upper Confidence Level Inventory in Residual Wastes within Single-Shell Tank 241-C-108.





UCL = upper confidence level

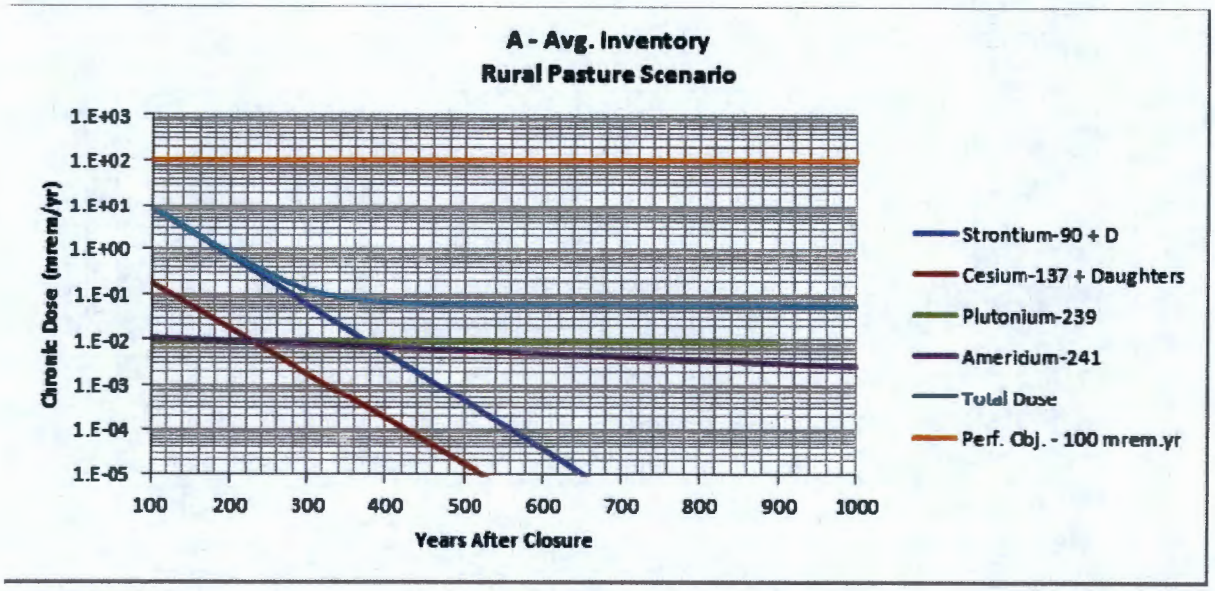
Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (2 sheets)

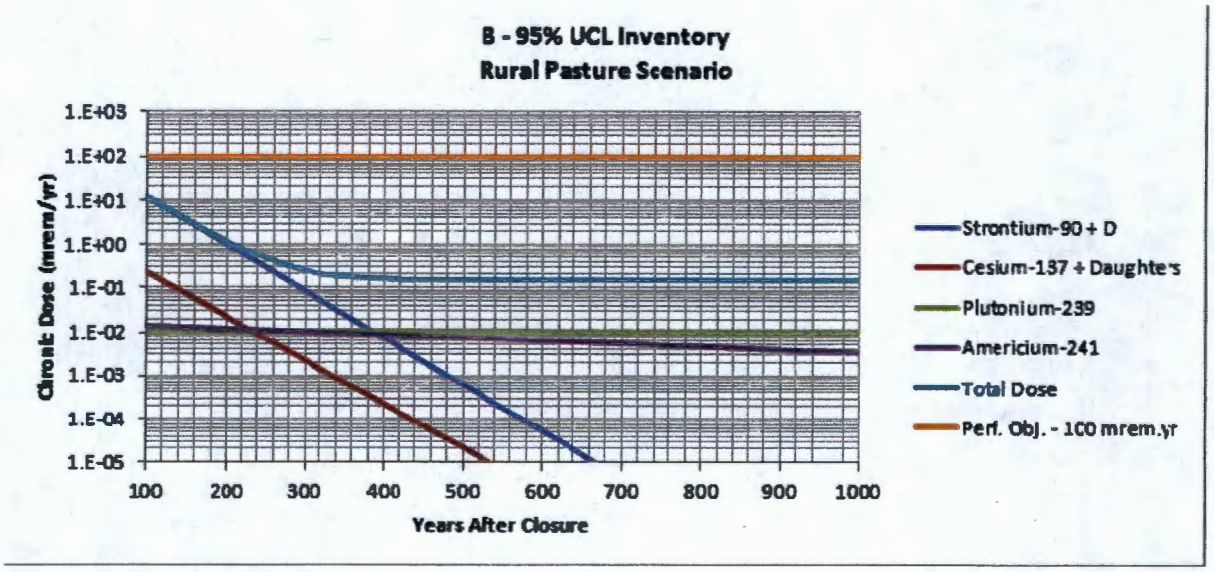
A – Average Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	2.51E-10	9.07E-13	3.28E-15	1.19E-17	4.30E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	6.07E-06	6.00E-06	5.93E-06	5.86E-06	5.79E-06	5.72E-06	5.65E-06	5.58E-06	5.51E-06	5.45E-06
Nickel-63	1.25E-04	6.28E-05	3.14E-05	1.57E-05	7.86E-06	3.93E-06	1.97E-06	9.85E-07	4.93E-07	2.47E-07
Cobalt-60	1.02E-08	1.98E-14	3.86E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	4.43E-07	4.43E-07	4.43E-07	4.43E-07	4.43E-07	4.43E-07	4.43E-07	4.43E-07	4.42E-07	4.42E-07
Strontium-90 + D	8.23E+00	7.02E-01	5.98E-02	5.10E-03	4.34E-04	3.70E-05	3.16E-06	2.69E-07	2.29E-08	1.95E-09
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04
Antimony-125	3.63E-16	0.00E+00	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	1.18E-05	1.18E-05	1.18E-05	1.18E-05	1.18E-05	1.18E-05	1.18E-05	1.18E-05	1.18E-05	1.18E-05
Cesium-137 + Daughters	1.82E-01	1.81E-02	1.79E-03	1.78E-04	1.76E-05	1.75E-06	1.74E-07	1.72E-08	1.71E-09	1.70E-10
Europium-152	4.17E-05	2.30E-07	1.27E-09	7.01E-12	3.88E-14	3.86E-16	1.74E-16	1.73E-16	1.73E-16	1.73E-16
Europium-154	8.84E-07	2.77E-10	8.69E-14	2.73E-17	8.55E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.17E-11	4.33E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	6.54E-05	8.84E-05	1.10E-04	1.32E-04	1.52E-04	1.71E-04	1.89E-04	2.07E-04	2.24E-04	2.40E-04
Thorium-232	1.66E-06	1.66E-06	1.66E-06	1.66E-06	1.66E-06	1.66E-06	1.66E-06	1.66E-06	1.66E-06	1.66E-06
Uranium-233	2.25E-04	2.73E-04	3.21E-04	3.69E-04	4.16E-04	4.63E-04	5.09E-04	5.54E-04	6.00E-04	6.44E-04
Uranium-234	4.22E-05	4.25E-05	4.29E-05	4.34E-05	4.40E-05	4.47E-05	4.55E-05	4.63E-05	4.72E-05	4.82E-05
Uranium-235 + D	7.98E-06	8.38E-06	8.78E-06	9.19E-06	9.59E-06	9.99E-06	1.04E-05	1.08E-05	1.12E-05	1.16E-05
Uranium-236	3.48E-07	3.48E-07	3.48E-07	3.48E-07	3.48E-07	3.48E-07	3.48E-07	3.48E-07	3.48E-07	3.48E-07
Uranium-238 + D	6.74E-05	6.74E-05	6.74E-05	6.75E-05	6.75E-05	6.75E-05	6.75E-05	6.75E-05	6.75E-05	6.76E-05
Neptunium-237 + D	9.61E-05	9.61E-05	9.61E-05	9.61E-05	9.61E-05	9.61E-05	9.61E-05	9.61E-05	9.61E-05	9.61E-05
Plutonium-238	2.07E-05	9.38E-06	4.26E-06	1.93E-06	8.78E-07	3.99E-07	1.82E-07	8.40E-08	3.94E-08	1.92E-08
Plutonium-239	8.95E-03	8.92E-03	8.90E-03	8.87E-03	8.85E-03	8.82E-03	8.79E-03	8.77E-03	8.74E-03	8.72E-03
Plutonium-240	9.64E-04	9.54E-04	9.44E-04	9.34E-04	9.24E-04	9.15E-04	9.05E-04	8.96E-04	8.86E-04	8.77E-04
Plutonium-241 + D	3.97E-05	3.39E-05	2.89E-05	2.46E-05	2.10E-05	1.79E-05	1.52E-05	1.30E-05	1.10E-05	9.41E-06
Americium-241	1.11E-02	9.44E-03	8.05E-03	6.86E-03	5.84E-03	4.98E-03	4.24E-03	3.61E-03	3.08E-03	2.62E-03
Americium-242m + D	2.17E-04	1.61E-04	1.12E-04	7.41E-05	4.80E-05	3.05E-05	1.92E-05	1.20E-05	7.48E-06	4.63E-06
Curium-242	3.43E-07	1.56E-07	7.07E-08	3.21E-08	1.46E-08	6.63E-09	3.03E-09	1.39E-09	6.50E-10	3.14E-10
Curium-243	4.13E-07	4.64E-08	1.42E-08	1.14E-08	1.11E-08	1.10E-08	1.10E-08	1.10E-08	1.09E-08	1.09E-08
Curium-244	1.51E-06	5.63E-07	5.36E-07	5.30E-07	5.25E-07	5.19E-07	5.14E-07	5.08E-07	5.03E-07	4.98E-07
Total Dose	**8.48E+00**	**7.83E-01**	**1.23E-01**	**6.55E-02**	**5.96E-02**	**5.83E-02**	**5.75E-02**	**5.69E-02**	**5.64E-02**	**5.59E-02**

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (2 sheets)

B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	7.52E-10	2.72E-12	9.85E-15	3.56E-17	1.29E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.82E-05	1.80E-05	1.78E-05	1.76E-05	1.73E-05	1.71E-05	1.69E-05	1.67E-05	1.65E-05	1.63E-05
Nickel-63	1.65E-04	8.25E-05	4.13E-05	2.07E-05	1.03E-05	5.17E-06	2.59E-06	1.29E-06	6.48E-07	3.24E-07
Cobalt-60	3.06E-08	5.96E-14	1.16E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	5.61E-07	5.61E-07	5.61E-07	5.61E-07	5.61E-07	5.61E-07	5.61E-07	5.61E-07	5.61E-07	5.61E-07
Strontium-90 + D	1.17E+01	9.96E-01	8.49E-02	7.23E-03	6.16E-04	5.25E-05	4.48E-06	3.82E-07	3.25E-08	2.77E-09
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.72E-04	1.72E-04	1.72E-04	1.72E-04	1.72E-04	1.72E-04
Antimony-125	1.09E-15	0.00E+00	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	3.53E-05	3.53E-05	3.53E-05	3.53E-05	3.53E-05	3.53E-05	3.53E-05	3.53E-05	3.53E-05	3.53E-05
Cesium-137 + Daughters	2.29E-01	2.27E-02	2.25E-03	2.23E-04	2.21E-05	2.20E-06	2.18E-07	2.16E-08	2.14E-09	2.13E-10
Europium-152	1.25E-04	6.91E-07	3.81E-09	2.10E-11	1.16E-13	1.16E-15	5.23E-16	5.19E-16	5.19E-16	5.19E-16
Europium-154	2.65E-06	8.32E-10	2.61E-13	8.18E-17	2.56E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	3.51E-11	1.30E-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
Thorium-230	1.96E-04	2.65E-04	3.31E-04	3.95E-04	4.55E-04	5.13E-04	5.68E-04	6.21E-04	6.72E-04	7.20E-04
Thorium-232	2.10E-06	2.10E-06	2.10E-06	2.10E-06	2.10E-06	2.10E-06	2.10E-06	2.10E-06	2.10E-06	2.10E-06
Uranium-233	6.75E-04	8.20E-04	9.64E-04	1.11E-03	1.25E-03	1.39E-03	1.53E-03	1.66E-03	1.80E-03	1.93E-03
Uranium-234	6.11E-05	6.16E-05	6.22E-05	6.29E-05	6.38E-05	6.48E-05	6.59E-05	6.71E-05	6.84E-05	6.98E-05
Uranium-235 + D	9.70E-06	1.02E-05	1.07E-05	1.12E-05	1.17E-05	1.22E-05	1.26E-05	1.31E-05	1.36E-05	1.41E-05
Uranium-236	6.23E-07	6.23E-07	6.23E-07	6.23E-07	6.23E-07	6.23E-07	6.23E-07	6.23E-07	6.23E-07	6.23E-07
Uranium-238 + D	8.28E-05	8.28E-05	8.29E-05	8.29E-05	8.29E-05	8.29E-05	8.29E-05	8.30E-05	8.30E-05	8.30E-05
Neptunium-237 + D	2.88E-04	2.88E-04	2.88E-04	2.88E-04	2.88E-04	2.88E-04	2.88E-04	2.88E-04	2.88E-04	2.88E-04
Plutonium-238	2.42E-05	1.10E-05	4.99E-06	2.27E-06	1.03E-06	4.68E-07	2.14E-07	9.85E-08	4.62E-08	2.25E-08
Plutonium-239	1.05E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.03E-02	1.03E-02	1.03E-02	1.02E-02	1.02E-02
Plutonium-240	1.13E-03	1.12E-03	1.11E-03	1.09E-03	1.08E-03	1.07E-03	1.06E-03	1.05E-03	1.04E-03	1.03E-03
Plutonium-241 + D	4.65E-05	3.97E-05	3.38E-05	2.88E-05	2.46E-05	2.09E-05	1.78E-05	1.52E-05	1.29E-05	1.10E-05
Americium-241	1.38E-02	1.18E-02	1.00E-02	8.56E-03	7.29E-03	6.21E-03	5.29E-03	4.51E-03	3.84E-03	3.28E-03
Americium-242m + D	6.52E-04	4.84E-04	3.35E-04	2.22E-04	1.44E-04	9.16E-05	5.77E-05	3.61E-05	2.24E-05	1.39E-05
Curium-242	1.03E-06	4.67E-07	2.12E-07	9.62E-08	4.37E-08	1.99E-08	9.08E-09	4.18E-09	1.95E-09	9.42E-10
Curium-243	1.24E-06	1.39E-07	4.26E-08	3.41E-08	3.32E-08	3.31E-08	3.30E-08	3.29E-08	3.28E-08	3.27E-08
Curium-244	4.54E-06	1.69E-06	1.61E-06	1.59E-06	1.57E-06	1.56E-06	1.54E-06	1.53E-06	1.51E-06	1.49E-06
Total Dose	**1.21E+01**	**1.17E+00**	**2.39E-01**	**1.58E-01**	**1.50E-01**	**1.48E-01**	**1.47E-01**	**1.47E-01**	**1.46E-01**	**1.45E-01**

Figure D-2. Comparison of Rural Pasture Scenario Doses with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-108.





UCL = upper confidence level

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (2 sheets)

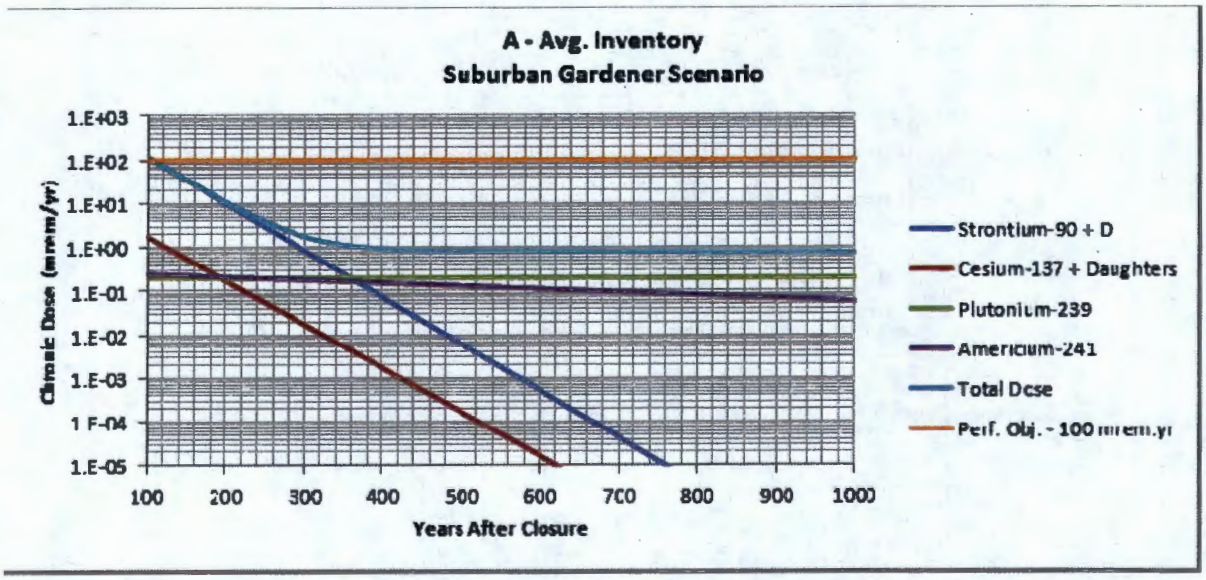
A – Average Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	2.19E-09	7.93E-12	2.87E-14	1.04E-16	3.76E-19	1.36E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.07E-04	1.05E-04	1.04E-04	1.03E-04	1.01E-04	1.00E-04	9.91E-05	9.79E-05	9.67E-05	9.55E-05
Nickel-63	8.51E-04	4.26E-04	2.13E-04	1.07E-04	5.33E-05	2.67E-05	1.33E-05	6.68E-06	3.34E-06	1.67E-06
Cobalt-60	1.02E-07	1.98E-13	3.86E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	7.20E-06	7.20E-06	7.19E-06	7.19E-06	7.19E-06	7.19E-06	7.19E-06	7.19E-06	7.19E-06	7.19E-06
Strontium-90 + D	1.17E+02	9.95E+00	8.48E-01	7.23E-02	6.16E-03	5.25E-04	4.48E-05	3.81E-06	3.25E-07	2.77E-08
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02
Antimony-125	3.53E-15	0.00E+00	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	5.85E-05	5.85E-05	5.85E-05	5.85E-05	5.85E-05	5.85E-05	5.85E-05	5.85E-05	5.85E-05	5.85E-05
Cesium-137 + Daughters	1.77E+00	1.75E-01	1.74E-02	1.72E-03	1.71E-04	1.70E-05	1.68E-06	1.67E-07	1.66E-08	1.64E-09
Europium-152	4.01E-04	2.21E-06	1.22E-08	6.73E-11	3.74E-13	4.50E-15	2.46E-15	2.45E-15	2.45E-15	2.45E-15
Europium-154	8.51E-06	2.67E-09	8.37E-13	2.62E-16	8.23E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.15E-10	4.25E-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
Thorium-230	1.12E-03	1.65E-03	2.16E-03	2.65E-03	3.12E-03	3.57E-03	3.99E-03	4.40E-03	4.79E-03	5.17E-03
Thorium-232	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05
Uranium-233	8.64E-03	9.32E-03	9.99E-03	1.07E-02	1.13E-02	1.20E-02	1.26E-02	1.33E-02	1.39E-02	1.45E-02
Uranium-234	2.00E-03	2.01E-03	2.01E-03	2.02E-03	2.03E-03	2.05E-03	2.06E-03	2.08E-03	2.10E-03	2.12E-03
Uranium-235 + D	1.65E-04	1.74E-04	1.83E-04	1.91E-04	2.00E-04	2.08E-04	2.17E-04	2.25E-04	2.34E-04	2.42E-04
Uranium-236	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05
Uranium-238 + D	2.52E-03	2.52E-03	2.52E-03	2.52E-03	2.52E-03	2.52E-03	2.52E-03	2.52E-03	2.52E-03	2.52E-03
Neptunium-237 + D	6.64E-03	6.64E-03	6.64E-03	6.64E-03	6.64E-03	6.64E-03	6.64E-03	6.64E-03	6.64E-03	6.64E-03
Plutonium-238	4.57E-04	2.07E-04	9.42E-05	4.28E-05	1.95E-05	8.89E-06	4.09E-06	1.91E-06	9.24E-07	4.77E-07
Plutonium-239	1.98E-01	1.98E-01	1.97E-01	1.97E-01	1.96E-01	1.96E-01	1.95E-01	1.95E-01	1.94E-01	1.93E-01
Plutonium-240	2.14E-02	2.12E-02	2.09E-02	2.07E-02	2.05E-02	2.03E-02	2.01E-02	1.99E-02	1.97E-02	1.95E-02
Plutonium-241 + D	8.70E-04	7.42E-04	6.32E-04	5.39E-04	4.59E-04	3.91E-04	3.34E-04	2.84E-04	2.42E-04	2.07E-04
Americium-241	2.43E-01	2.07E-01	1.76E-01	1.50E-01	1.28E-01	1.09E-01	9.30E-02	7.93E-02	6.76E-02	5.76E-02
Americium-242m + D	4.77E-03	3.54E-03	2.45E-03	1.63E-03	1.06E-03	6.72E-04	4.24E-04	2.65E-04	1.65E-04	1.02E-04
Curium-242	7.59E-06	3.45E-06	1.56E-06	7.10E-07	3.23E-07	1.48E-07	6.78E-08	3.17E-08	1.53E-08	7.82E-09
Curium-243	7.89E-06	9.19E-07	3.05E-07	2.51E-07	2.45E-07	2.44E-07	2.43E-07	2.43E-07	2.42E-07	2.41E-07
Curium-244	3.27E-05	1.25E-05	1.19E-05	1.18E-05	1.16E-05	1.15E-05	1.14E-05	1.13E-05	1.12E-05	1.10E-05
Total Dose	**1.19E+02**	**1.10E+01**	**1.73E+00**	**9.08E-01**	**8.18E-01**	**7.93E-01**	**7.76E-01**	**7.62E-01**	**7.50E-01**	**7.40E-01**

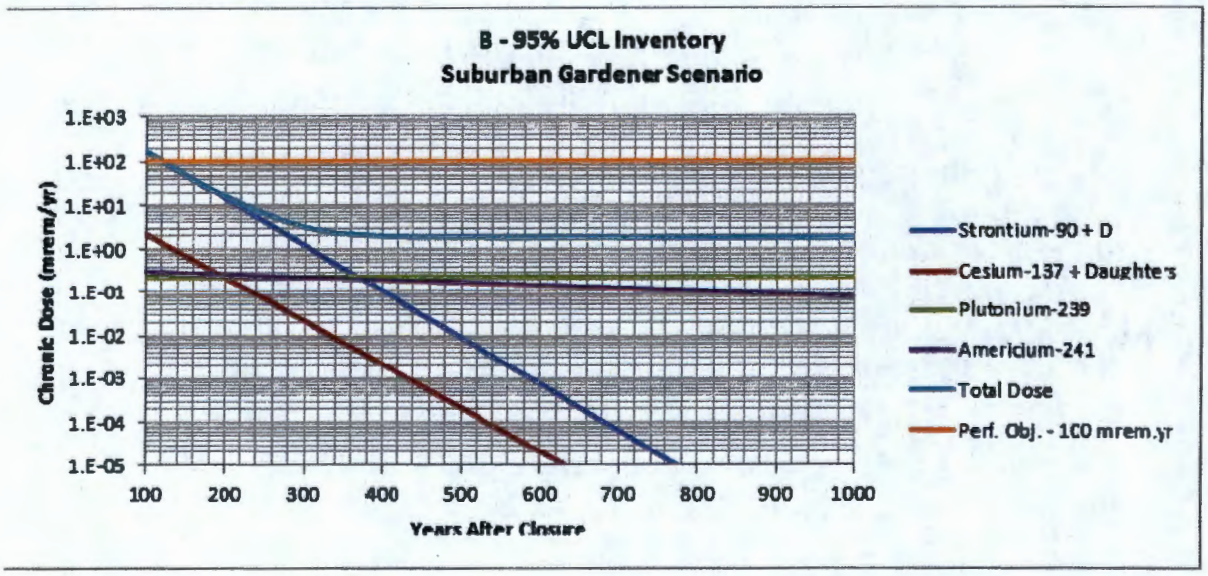
Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (2 sheets)

B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
Tritium	6.57E-09	2.38E-11	8.61E-14	3.11E-16	1.13E-18	4.08E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	3.19E-04	3.16E-04	3.12E-04	3.08E-04	3.04E-04	3.01E-04	2.97E-04	2.93E-04	2.90E-04	2.86E-04
Nickel-63	1.12E-03	5.60E-04	2.80E-04	1.40E-04	7.01E-05	3.51E-05	1.75E-05	8.78E-06	4.39E-06	2.20E-06
Cobalt-60	3.07E-07	5.97E-13	1.16E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	9.13E-06	9.12E-06	9.12E-06	9.12E-06	9.12E-06	9.12E-06	9.12E-06	9.12E-06	9.12E-06	9.12E-06
Strontium-90 + D	1.66E+02	1.41E+01	1.20E+00	1.03E-01	8.74E-03	7.45E-04	6.35E-05	5.41E-06	4.61E-07	3.93E-08
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.32E-02	1.32E-02	1.31E-02	1.31E-02	1.31E-02	1.31E-02	1.31E-02	1.31E-02	1.31E-02	1.31E-02
Antimony-125	1.06E-14	0.00E+00	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	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04
Cesium-137 + Daughters	2.21E+00	2.20E-01	2.18E-02	2.16E-03	2.15E-04	2.13E-05	2.11E-06	2.09E-07	2.08E-08	2.06E-09
Europium-152	1.20E-03	6.64E-06	3.66E-08	2.02E-10	1.12E-12	1.35E-14	7.39E-15	7.36E-15	7.36E-15	7.36E-15
Europium-154	2.55E-05	8.00E-09	2.51E-12	7.87E-16	2.47E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	3.45E-10	1.27E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	3.35E-03	4.95E-03	6.48E-03	7.95E-03	9.35E-03	1.07E-02	1.20E-02	1.32E-02	1.44E-02	1.55E-02
Thorium-232	2.44E-05	2.44E-05	2.44E-05	2.44E-05	2.44E-05	2.44E-05	2.44E-05	2.44E-05	2.44E-05	2.44E-05
Uranium-233	2.59E-02	2.79E-02	3.00E-02	3.20E-02	3.39E-02	3.59E-02	3.78E-02	3.98E-02	4.17E-02	4.36E-02
Uranium-234	2.90E-03	2.91E-03	2.92E-03	2.93E-03	2.95E-03	2.97E-03	2.99E-03	3.02E-03	3.04E-03	3.07E-03
Uranium-235 + D	2.01E-04	2.12E-04	2.22E-04	2.32E-04	2.43E-04	2.53E-04	2.64E-04	2.74E-04	2.84E-04	2.94E-04
Uranium-236	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	2.97E-05
Uranium-238 + D	3.09E-03	3.09E-03	3.09E-03	3.09E-03	3.09E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03
Neptunium-237 + D	1.99E-02	1.99E-02	1.99E-02	1.99E-02	1.99E-02	1.99E-02	1.99E-02	1.99E-02	1.99E-02	1.99E-02
Plutonium-238	5.36E-04	2.43E-04	1.10E-04	5.02E-05	2.28E-05	1.04E-05	4.79E-06	2.24E-06	1.08E-06	5.59E-07
Plutonium-239	2.32E-01	2.32E-01	2.31E-01	2.30E-01	2.30E-01	2.29E-01	2.28E-01	2.28E-01	2.27E-01	2.26E-01
Plutonium-240	2.50E-02	2.48E-02	2.45E-02	2.43E-02	2.40E-02	2.38E-02	2.35E-02	2.33E-02	2.30E-02	2.28E-02
Plutonium-241 + D	1.02E-03	8.69E-04	7.41E-04	6.31E-04	5.38E-04	4.59E-04	3.91E-04	3.33E-04	2.84E-04	2.42E-04
Americium-241	3.03E-01	2.58E-01	2.20E-01	1.88E-01	1.60E-01	1.36E-01	1.16E-01	9.90E-02	8.44E-02	7.19E-02
Americium-242m + D	1.43E-02	1.06E-02	7.36E-03	4.89E-03	3.17E-03	2.02E-03	1.27E-03	7.95E-04	4.95E-04	3.07E-04
Curium-242	2.28E-05	1.03E-05	4.69E-06	2.13E-06	9.70E-07	4.43E-07	2.03E-07	9.50E-08	4.58E-08	2.35E-08
Curium-243	2.37E-05	2.76E-06	9.16E-07	7.52E-07	7.36E-07	7.33E-07	7.30E-07	7.28E-07	7.26E-07	7.24E-07
Curium-244	9.81E-05	3.74E-05	3.57E-05	3.53E-05	3.49E-05	3.46E-05	3.42E-05	3.38E-05	3.35E-05	3.31E-05
Total Dose	**1.70E+02**	**1.62E+01**	**3.08E+00**	**1.92E+00**	**1.80E+00**	**1.77E+00**	**1.75E+00**	**1.73E+00**	**1.72E+00**	**1.71E+00**

y

Figure D-3. Comparison of Doses from Suburban Gardener Scenario with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual wastes in Single-Shell Tank 241-C-108.





UCL = upper confidence level

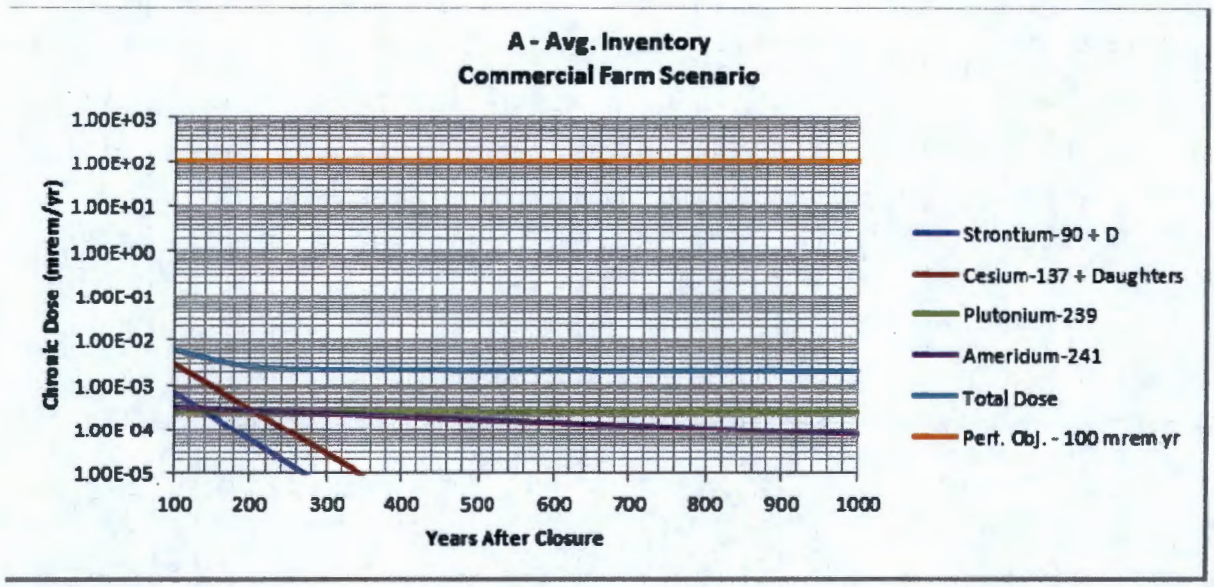
Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (2 sheets)

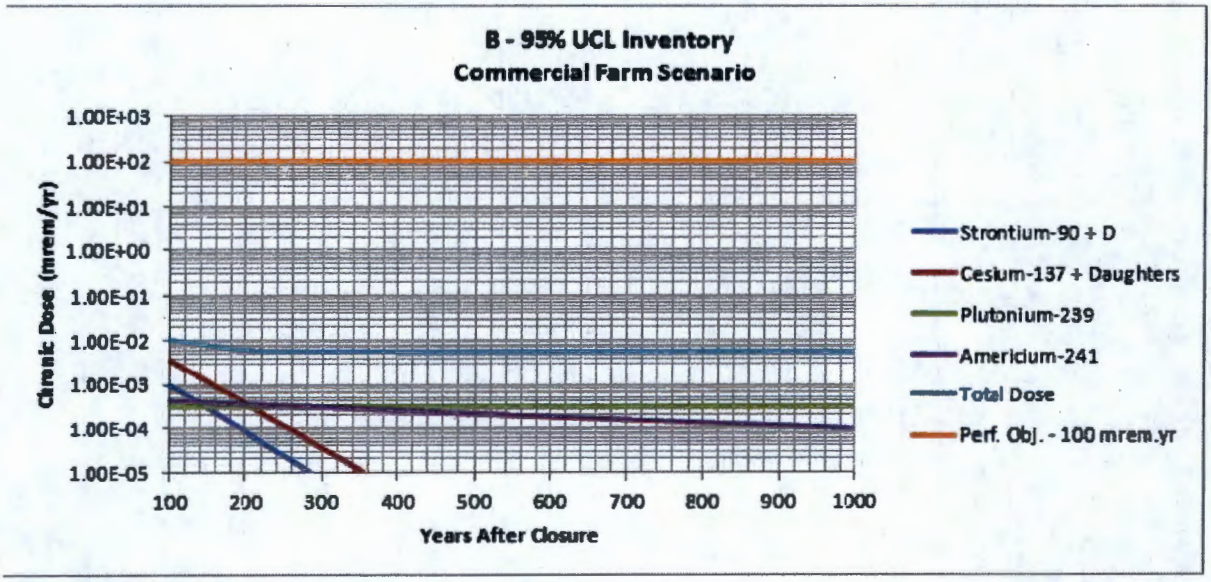
A – Average Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	8.77E-12	3.18E-14	1.15E-16	4.16E-19	1.50E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	2.94E-10	2.91E-10	2.87E-10	2.84E-10	2.80E-10	2.77E-10	2.74E-10	2.70E-10	2.67E-10	2.64E-10
Nickel-63	2.68E-08	1.34E-08	6.70E-09	3.35E-09	1.68E-09	8.39E-10	4.20E-10	2.10E-10	1.05E-10	5.26E-11
Cobalt-60	3.87E-10	7.54E-16	1.47E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	4.85E-10	4.85E-10	4.85E-10	4.85E-10	4.84E-10	4.84E-10	4.84E-10	4.84E-10	4.84E-10	4.84E-10
Strontium-90 + D	6.79E-04	5.79E-05	4.93E-06	4.20E-07	3.58E-08	3.05E-09	2.60E-10	2.22E-11	1.89E-12	1.61E-13
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	3.40E-09	3.40E-09	3.40E-09	3.40E-09	3.40E-09	3.39E-09	3.39E-09	3.39E-09	3.39E-09	3.39E-09
Antimony-125	1.38E-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	0.00E+00
Iodine-129	5.43E-09	5.43E-09	5.43E-09	5.43E-09	5.43E-09	5.43E-09	5.43E-09	5.43E-09	5.43E-09	5.43E-09
Cesium-137 + Daughters	2.92E-03	2.89E-04	2.87E-05	2.85E-06	2.82E-07	2.80E-08	2.78E-09	2.76E-10	2.74E-11	2.71E-12
Europium-152	1.59E-06	8.78E-09	4.85E-11	2.67E-13	1.48E-15	1.42E-17	6.09E-18	6.05E-18	6.05E-18	6.05E-18
Europium-154	3.37E-08	1.06E-11	3.32E-15	1.04E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	4.46E-13	1.65E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.87E-06	2.36E-06	2.83E-06	3.29E-06	3.72E-06	4.14E-06	4.53E-06	4.91E-06	5.28E-06	5.62E-06
Thorium-232	4.95E-08	4.95E-08	4.95E-08	4.95E-08	4.95E-08	4.95E-08	4.95E-08	4.95E-08	4.95E-08	4.95E-08
Uranium-233	3.87E-06	5.49E-06	7.10E-06	8.70E-06	1.03E-05	1.18E-05	1.34E-05	1.49E-05	1.64E-05	1.79E-05
Uranium-234	4.68E-07	4.77E-07	4.88E-07	5.01E-07	5.16E-07	5.33E-07	5.51E-07	5.71E-07	5.93E-07	6.16E-07
Uranium-235 + D	2.40E-07	2.52E-07	2.63E-07	2.75E-07	2.86E-07	2.97E-07	3.09E-07	3.20E-07	3.31E-07	3.43E-07
Uranium-236	3.81E-09	3.81E-09	3.81E-09	3.81E-09	3.81E-09	3.81E-09	3.81E-09	3.81E-09	3.81E-09	3.81E-09
Uranium-238 + D	1.24E-06	1.24E-06	1.24E-06	1.24E-06	1.24E-06	1.24E-06	1.24E-06	1.24E-06	1.24E-06	1.24E-06
Neptunium-237 + D	2.88E-06	2.88E-06	2.88E-06	2.88E-06	2.88E-06	2.88E-06	2.88E-06	2.88E-06	2.88E-06	2.88E-06
Plutonium-238	5.83E-07	2.65E-07	1.20E-07	5.45E-08	2.47E-08	1.12E-08	5.11E-09	2.33E-09	1.07E-09	5.04E-10
Plutonium-239	2.52E-04	2.51E-04	2.51E-04	2.50E-04	2.49E-04	2.49E-04	2.48E-04	2.47E-04	2.46E-04	2.46E-04
Plutonium-240	2.72E-05	2.69E-05	2.66E-05	2.63E-05	2.60E-05	2.58E-05	2.55E-05	2.52E-05	2.50E-05	2.47E-05
Plutonium-241 + D	1.12E-06	9.59E-07	8.17E-07	6.96E-07	5.93E-07	5.06E-07	4.31E-07	3.67E-07	3.13E-07	2.67E-07
Americium-241	3.14E-04	2.67E-04	2.28E-04	1.94E-04	1.65E-04	1.41E-04	1.20E-04	1.02E-04	8.72E-05	7.43E-05
Americium-242m + D	6.15E-06	4.56E-06	3.15E-06	2.09E-06	1.36E-06	8.63E-07	5.43E-07	3.40E-07	2.11E-07	1.31E-07
Curium-242	9.68E-09	4.39E-09	1.99E-09	9.05E-10	4.11E-10	1.86E-10	8.48E-11	3.87E-11	1.78E-11	8.26E-12
Curium-243	1.22E-08	1.35E-09	4.05E-10	3.21E-10	3.12E-10	3.11E-10	3.10E-10	3.09E-10	3.08E-10	3.07E-10
Curium-244	4.20E-08	1.58E-08	1.51E-08	1.49E-08	1.48E-08	1.46E-08	1.45E-08	1.43E-08	1.42E-08	1.40E-08
Total Dose	**5.81E-03**	**2.51E-03**	**2.16E-03**	**2.09E-03**	**2.06E-03**	**2.04E-03**	**2.02E-03**	**2.00E-03**	**1.98E-03**	**1.97E-03**

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-108 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (2 sheets)

B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Tritium	2.63E-11	9.53E-14	3.45E-16	1.25E-18	4.51E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	8.82E-10	8.71E-10	8.61E-10	8.51E-10	8.40E-10	8.30E-10	8.20E-10	8.10E-10	8.01E-10	7.91E-10
Nickel-63	3.52E-08	1.76E-08	8.80E-09	4.41E-09	2.20E-09	1.10E-09	5.52E-10	2.76E-10	1.38E-10	6.91E-11
Cobalt-60	1.16E-09	2.27E-15	4.41E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	6.15E-10	6.15E-10	6.14E-10	6.14E-10	6.14E-10	6.14E-10	6.14E-10	6.14E-10	6.14E-10	6.14E-10
Strontium-90 + D	9.64E-04	8.21E-05	7.00E-06	5.97E-07	5.08E-08	4.33E-09	3.69E-10	3.15E-11	2.68E-12	2.29E-13
Niobium-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	4.28E-09	4.28E-09	4.28E-09	4.28E-09	4.28E-09	4.28E-09	4.28E-09	4.27E-09	4.27E-09	4.27E-09
Antimony-125	4.15E-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	0.00E+00
Iodine-129	1.63E-08	1.63E-08	1.63E-08	1.63E-08	1.63E-08	1.63E-08	1.63E-08	1.63E-08	1.63E-08	1.63E-08
Cesium-137 + Daughters	3.66E-03	3.63E-04	3.60E-05	3.57E-06	3.54E-07	3.51E-08	3.49E-09	3.46E-10	3.43E-11	3.40E-12
Europium-152	4.78E-06	2.63E-08	1.45E-10	8.02E-13	4.44E-15	4.26E-17	1.83E-17	1.81E-17	1.81E-17	1.81E-17
Europium-154	1.01E-07	3.17E-11	9.95E-15	3.12E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.34E-12	4.94E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	5.60E-06	7.08E-06	8.50E-06	9.87E-06	1.12E-05	1.24E-05	1.36E-05	1.47E-05	1.58E-05	1.69E-05
Thorium-232	6.26E-08	6.26E-08	6.26E-08	6.26E-08	6.26E-08	6.26E-08	6.26E-08	6.26E-08	6.26E-08	6.26E-08
Uranium-233	1.16E-05	1.65E-05	2.13E-05	2.61E-05	3.08E-05	3.55E-05	4.02E-05	4.48E-05	4.93E-05	5.38E-05
Uranium-234	6.78E-07	6.91E-07	7.07E-07	7.26E-07	7.48E-07	7.72E-07	7.98E-07	8.27E-07	8.59E-07	8.92E-07
Uranium-235 + D	2.92E-07	3.06E-07	3.20E-07	3.34E-07	3.48E-07	3.62E-07	3.76E-07	3.89E-07	4.03E-07	4.17E-07
Uranium-236	6.82E-09	6.82E-09	6.82E-09	6.82E-09	6.82E-09	6.82E-09	6.82E-09	6.82E-09	6.82E-09	6.82E-09
Uranium-238 + D	1.52E-06	1.52E-06	1.52E-06	1.52E-06	1.52E-06	1.52E-06	1.52E-06	1.52E-06	1.52E-06	1.52E-06
Neptunium-237 + D	8.63E-06	8.63E-06	8.63E-06	8.63E-06	8.63E-06	8.64E-06	8.64E-06	8.64E-06	8.64E-06	8.64E-06
Plutonium-238	6.84E-07	3.10E-07	1.41E-07	6.39E-08	2.90E-08	1.32E-08	5.99E-09	2.74E-09	1.26E-09	5.91E-10
Plutonium-239	2.95E-04	2.94E-04	2.94E-04	2.93E-04	2.92E-04	2.91E-04	2.90E-04	2.89E-04	2.88E-04	2.88E-04
Plutonium-240	3.18E-05	3.15E-05	3.11E-05	3.08E-05	3.05E-05	3.02E-05	2.99E-05	2.95E-05	2.92E-05	2.89E-05
Plutonium-241 + D	1.32E-06	1.12E-06	9.57E-07	8.16E-07	6.95E-07	5.92E-07	5.05E-07	4.30E-07	3.67E-07	3.12E-07
Americium-241	3.92E-04	3.34E-04	2.84E-04	2.42E-04	2.06E-04	1.76E-04	1.50E-04	1.28E-04	1.09E-04	9.28E-05
Americium-242m + D	1.84E-05	1.37E-05	9.46E-06	6.28E-06	4.07E-06	2.59E-06	1.63E-06	1.02E-06	6.33E-07	3.92E-07
Curium-242	2.91E-08	1.32E-08	5.98E-09	2.71E-09	1.23E-09	5.59E-10	2.54E-10	1.16E-10	5.33E-11	2.48E-11
Curium-243	3.65E-08	4.06E-09	1.21E-09	9.62E-10	9.37E-10	9.32E-10	9.29E-10	9.27E-10	9.24E-10	9.21E-10
Curium-244	1.26E-07	4.75E-08	4.53E-08	4.48E-08	4.44E-08	4.39E-08	4.34E-08	4.30E-08	4.25E-08	4.21E-08
Total Dose	**1.02E-02**	**5.97E-03**	**5.52E-03**	**5.44E-03**	**5.40E-03**	**5.37E-03**	**5.34E-03**	**5.32E-03**	**5.31E-03**	**5.29E-03**

Figure D-4. Comparison of Doses from Commercial Farm Scenario with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual wastes in Single-Shell Tank 241-C-108.





UCL = upper confidence level

Table D-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-108 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-108 Nominal Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Aluminum	129,000	1.61E+00	3.69E-02	8.60E+01	Yes
Barium[d]	16.0	1.00E-03	2.29E-05	1.58E-02	Yes
CN	6.1	1.27E-01	2.90E-03	1.52E-02	Yes
Total Chromium[d]	23.4	1.95E-04	4.46E-06	1.17E-02	Yes
Copper	20.2	6.31E-03	1.44E-04	7.11E-02	Yes
Fluorine	4,480	9.33E-01	2.13E-02	1.56E+00	Yes
Iron	10,400	1.86E-01	4.24E-03	6.89E+01	Yes
Mercury[d]	0.8	3.15E-02	7.19E-04	6.29E-01	Yes
Manganese	151	4.02E-02	9.15E-04	3.02E+00	Yes
Nickel[d]	2,760	1.73E+00	3.94E-02	2.12E+01	Yes
NO_2[b]	214	2.68E-02	6.11E-04	1.65E+01	Yes
NO_3[c]	340	2.66E-03	6.07E-05	1.89E+00	Yes
Lead[d]	634	not applicable	not applicable	6.97E+01	Yes
SO_4	109	not applicable	not applicable	1.06E-01	Yes
Strontium	730	1.52E-02	3.48E-04	1.51E-01	Yes
Titanium	2.8	8.75E-06	2.00E-07	2.19E-06	Yes
Uranium	4,480	1.87E+01	4.27E-01	3.45E+03	Yes
Zinc	71	2.96E-03	6.76E-05	2.45E-02	Yes
Silver[d]	1.9	4.78E-03	1.09E-04	1.40E-01	No
Arsenic[d]	9.6	3.98E-01	9.10E-03	2.82E+01	No
Boron	1.9	1.19E-04	2.73E-06	9.10E-03	No
Beryllium[d]	46.4	2.90E-01	6.63E-03	7.34E-01	No
Cadmium[d]	1.9	4.78E-02	1.09E-03	2.77E+00	No
Chlorine	32.8	0.00E+00	0.00E+00	3.28E-02	No
Cobalt	1.9	7.96E-02	1.82E-03	4.39E-01	No

Table D-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-108 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-108 Nominal Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Lithium	46.4	2.90E-01	6.63E-03	2.42E-01	No
Molybdenum	46.4	1.16E-01	2.65E-03	1.44E+00	No
Antimony[d]	11.5	3.59E-01	8.21E-03	2.13E+00	No
Selenium[d]	11.5	2.88E-02	6.57E-04	2.21E+00	No
Tin	5.7	1.20E-04	2.73E-06	1.20E-04	No
Thallium[d]	3,970	7.09E+02	1.62E+01	2.50E+03	No
Vanadium	199	3.55E-01	8.12E-03	8.88E-02	No
Aroclors (Total Polychlorinated Biphenyls)	0.2	0.00E+00	0.00E+00	5.40E-02	Yes
1,2,4-Trichlorobenzene[d]	1.4	1.80E-03	4.11E-05	4.83E-01	No
1,2-Dichlorobenzene[d]	1.9	2.61E-04	5.97E-06	2.67E-01	No
1,4-Dichlorobenzene[d]	2.1	1.32E-03	3.01E-05	7.03E+01	No
2,4,5-Trichlorophenol[d]	0.8	1.03E-04	2.35E-06	2.85E-02	No
2,4,6-Trichlorophenol[d]	0.9	0.00E+00	0.00E+00	2.00E+01	No
2,4-Dinitrotoluene[d]	0.7	4.44E-03	1.02E-04	3.76E+00	No
2-Chlorophenol[d]	1.2	3.10E-03	7.09E-05	2.63E+00	No
2-Ethoxyethanol[d]	3.4	1.06E-04	2.43E-06	1.32E-01	No
2-Methylphenol	1.1	0.00E+00	0.00E+00	0.00E+00	No
2-Nitrophenol	1.0	0.00E+00	0.00E+00	0.00E+00	No
4-Chloro-3-methylphenol[d]	0.8	2.02E-04	4.61E-06	0.00E+00	No
Acenaphthene	0.3	6.83E-05	1.56E-06	3.35E-03	No
Butylbenzylphthalate[d]	0.9	5.83E-05	1.33E-06	1.04E-03	No
Cresol (m)	1.0	0.00E+00	0.00E+00	0.00E+00	No
Cresol (p)	1.0	0.00E+00	0.00E+00	0.00E+00	No
Cyclohexanone	10.4	2.60E-05	5.94E-07	6.05E-02	No

Table D-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-108 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-108 Nominal Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Di-n-butylphthalate[d]	10.5	1.31E-03	3.00E-05	1.86E-01	No
Di-n-octylphthalate[d]	0.9	5.56E-04	1.27E-05	1.67E-06	No
Fluoranthene[d]	0.7	2.07E-04	4.72E-06	1.05E-03	No
Hexachlorobutadiene[d]	1.3	8.13E-02	1.86E-03	2.15E+00	No
Hexachloroethane[d]	2.1	2.61E-02	5.97E-04	1.67E+01	No
Naphthalene[d]	1.2	7.31E-04	1.67E-05	2.62E-01	No
Nitrobenzene[d]	1.2	7.56E-03	1.73E-04	9.68E+00	No
N-Nitroso-di-n-propylamine[d]	1.1	0.00E+00	0.00E+00	1.93E+04	No
Pentachlorophenol[d]	0.7	2.92E-04	6.67E-06	4.43E+01	No
Phenol[d]	1.1	4.63E-05	1.06E-06	1.01E-01	No
Pyrene	1.2	4.88E-04	1.11E-05	1.79E-03	No
Pyridine[d]	1.2	1.51E-02	3.46E-04	3.24E+01	No
Tributyl phosphate	2.0	1.26E-04	2.87E-06	2.97E+00	No
1,1,1-Trichloroethane[d]	0.004	2.20E-08	5.19E-10	2.30E-03	No
1,1,2,2-Tetrachloroethane[d]	0.009	0.00E+00	0.00E+00	7.37E+00	No
1,1,2-Trichloro-1,2,2-trifluoroethane	0.009	3.78E-09	8.63E-11	8.16E-07	No
1,1,2-Trichloroethane[d]	0.007	2.15E-05	4.92E-07	1.61E+00	No
1,1-Dichloroethene[d]	0.006	1.54E-06	3.52E-08	1.18E+01	No
1,2-Dichloroethane[d]	0.003	2.04E-06	4.66E-08	1.41E+00	No
1-Butanol	6.4	8.05E-04	1.84E-05	1.95E+00	No
2-Butanone	0.05	1.00E-06	2.30E-08	2.46E-03	No
2-Nitropropane[d]	0.03	0.00E+00	0.00E+00	1.38E+03	No
Acetone	0.08	1.10E-06	2.52E-08	2.75E-03	No

Table D-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-108 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-108 Nominal Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Benzene[d]	0.006	1.81E-05	4.14E-07	1.29E+00	No
Carbon disulfide[d]	0.005	6.80E-07	1.55E-08	9.63E-04	No
Carbon tetrachloride[d]	0.005	1.70E-05	3.89E-07	9.46E-01	No
Chlorobenzene[d]	0.004	2.49E-06	5.70E-08	4.57E-03	No
Chloroform[d]	0.003	4.08E-06	9.31E-08	8.56E-02	No
Ethyl acetate	0.02	2.44E-07	5.59E-09	5.91E-04	No
Ethyl ether	0.02	1.00E-06	2.29E-08	2.40E-03	No
Ethylbenzene	0.004	5.44E-07	1.24E-08	7.19E-04	No
Hexone	0.03	4.98E-06	1.14E-07	1.18E-02	No
Isobutanol	8.6	3.58E-04	8.18E-06	8.86E-01	No
Methylenechloride[d]	0.01	1.28E-06	2.93E-08	2.43E-01	No
Tetrachloroethene	0.01	9.06E-06	2.07E-07	8.44E-01	No
Toluene[d]	0.00	0.00E+00	1.55E-07	9.35E-04	No
Trichloroethene	0.01	2.27E-04	5.18E-06	1.68E+00	No
Trichlorofluoromethane	0.04	1.50E-06	3.44E-08	1.27E-03	No
Vinyl chloride	0.012	4.83E-05	1.10E-06	6.30E+01	No
Xylenes (total)	0.011	7.00E-07	1.60E-08	7.67E-04	No
4-Nitrophenol[d]	0.98	1.53E-03	3.51E-05	7.55E-01	No

[a] Average Concentrations and Relative Standard Deviation taken from Table A-1, Appendix A, RPP-RPT-54757, Rev. 0, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] As nitrite; not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[c] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[d] Dangerous waste constituent per *Washington Administrative Code* 173-303-9905, "Dangerous Waste Constituents List."

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-108 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-108 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Aluminum	145,847	1.82E+00	4.17E-02	9.72E+01	Yes
Barium[d]	20.8	1.30E-03	2.97E-05	2.06E-02	Yes
CN	7.1	1.47E-01	3.37E-03	1.77E-02	Yes
Total Chromium[d]	28.5	2.38E-04	5.43E-06	1.43E-02	Yes
Copper	23.0	7.20E-03	1.65E-04	8.11E-02	Yes
Fluorine	5,752	1.20E+00	2.74E-02	2.00E+00	Yes
Iron	13,354	2.38E-01	5.45E-03	8.84E+01	Yes
Mercury[d]	0.9	3.67E-02	8.38E-04	7.33E-01	Yes
Manganese	247	6.57E-02	1.50E-03	4.94E+00	Yes
Nickel[d]	3,156	1.97E+00	4.51E-02	2.43E+01	Yes
NO_2	238	2.97E-02	6.79E-04	1.83E+01	Yes
NO_3	409	3.20E-03	7.31E-05	2.27E+00	Yes
Lead[d]	813	not applicable	not applicable	8.93E+01	Yes
SO_4	124	not applicable	not applicable	1.20E-01	Yes
Strontium	940	1.96E-02	4.48E-04	1.94E-01	Yes
Titanium	4.5	1.41E-05	3.22E-07	3.53E-06	Yes
Uranium	5,252	2.19E+01	5.00E-01	4.04E+03	Yes
Zinc	86	3.60E-03	8.22E-05	2.98E-02	Yes
Silver[d]	5.7	1.43E-02	3.27E-04	4.21E-01	No
Arsenic[d]	28.7	1.20E+00	2.73E-02	8.46E+01	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-108 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-108 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Boron	5.7	3.58E-04	8.19E-06	2.73E-02	No
Beryllium[d]	139	8.70E-01	1.99E-02	2.20E+00	No
Cadmium[d]	5.7	1.43E-01	3.27E-03	8.30E+00	No
Chlorine	98	0.00E+00	0.00E+00	9.84E-02	No
Cobalt	5.7	2.39E-01	5.46E-03	1.32E+00	No
Lithium	139	8.70E-01	1.99E-02	7.25E-01	No
Molybdenum	139	3.48E-01	7.95E-03	4.31E+00	No
Antimony[d]	34.5	1.08E+00	2.46E-02	6.39E+00	No
Selenium[d]	34.5	8.63E-02	1.97E-03	6.63E+00	No
Tin	17.2	3.59E-04	8.20E-06	3.59E-04	No
Thallium[d]	11,910	2.13E+03	4.86E+01	7.49E+03	No
Vanadium	597	1.07E+00	2.44E-02	2.67E-01	No
Aroclors (Total PCB)	0.3	0.00E+00	0.00E+00	8.63E-02	Yes
1,2,4-Trichlorobenzene[d]	4.3	5.40E-03	1.23E-04	1.45E+00	No
1,2-Dichlorobenzene[d]	5.6	7.83E-04	1.79E-05	8.02E-01	No
1,4-Dichlorobenzene[d]	6.3	3.96E-03	9.04E-05	2.11E+02	No
2,4,5-Trichlorophenol[d]	2.5	3.08E-04	7.04E-06	8.55E-02	No
2,4,6-Trichlorophenol[d]	2.8	0.00E+00	0.00E+00	6.00E+01	No
2,4-Dinitrotoluene[d]	2.1	1.33E-02	3.05E-04	1.13E+01	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-108 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-108 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
2-Chlorophenol[d]	3.7	9.30E-03	2.13E-04	7.88E+00	No
2-Ethoxyethanol[d]	10.2	3.19E-04	7.29E-06	3.97E-01	No
2-Methylphenol	3.2	0.00E+00	0.00E+00	0.00E+00	No
2-Nitrophenol	3.0	0.00E+00	0.00E+00	0.00E+00	No
4-Chloro-3-methylphenol[d]	2.4	6.05E-04	1.38E-05	0.00E+00	No
Acenaphthene	1.0	2.05E-04	4.69E-06	1.01E-02	No
Butylbenzylphthalate[d]	2.8	1.75E-04	4.00E-06	3.13E-03	No
Cresol (m)	2.9	0.00E+00	0.00E+00	0.00E+00	No
Cresol (p)	2.9	0.00E+00	0.00E+00	0.00E+00	No
Cyclohexanone	31.2	7.80E-05	1.78E-06	1.81E-01	No
Di-n-butylphthalate[d]	31.5	3.94E-03	9.00E-05	5.58E-01	No
Di-n-octylphthalate[d]	2.7	1.67E-03	3.81E-05	5.02E-06	No
Fluoranthene[d]	2.0	6.20E-04	1.42E-05	3.14E-03	No
Hexachlorobutadiene[d]	3.9	2.44E-01	5.57E-03	6.45E+00	No
Hexachloroethane[d]	6.3	7.84E-02	1.79E-03	5.02E+01	No
Naphthalene[d]	3.5	2.19E-03	5.01E-05	7.87E-01	No
Nitrobenzene[d]	3.6	2.27E-02	5.19E-04	2.90E+01	No
N-Nitroso-di-n-propylamine[d]	3.2	0.00E+00	0.00E+00	5.79E+04	No
Pentachlorophenol[d]	2.1	8.75E-04	2.00E-05	1.33E+02	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-108 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-108 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Phenol[d]	3.3	1.39E-04	3.17E-06	3.03E-01	No
Pyrene	3.5	1.46E-03	3.34E-05	5.36E-03	No
Pyridine[d]	3.6	4.54E-02	1.04E-03	9.73E+01	No
Tributyl phosphate	6.0	3.77E-04	8.61E-06	8.91E+00	No
1,1,1-Trichloroethane[d]	0.01	6.60E-08	1.56E-09	6.89E-03	No
1,1,2,2-Tetrachloroethane[d]	0.03	0.00E+00	0.00E+00	2.21E+01	No
1,1,2-Trichloro-1,2,2-trifluoroethane	0.03	1.13E-08	2.59E-10	2.45E-06	No
1,1,2-Trichloroethane[d]	0.02	6.46E-05	1.48E-06	4.84E+00	No
1,1-Dichloroethene[d]	0.02	4.62E-06	1.06E-07	3.54E+01	No
1,2-Dichloroethane[d]	0.01	6.11E-06	1.40E-07	4.22E+00	No
1-Butanol	19.3	2.42E-03	5.52E-05	5.84E+00	No
2-Butanone	0.1	3.01E-06	6.89E-08	7.38E-03	No
2-Nitropropane[d]	0.1	0.00E+00	0.00E+00	4.13E+03	No
Acetone	0.2	3.31E-06	7.56E-08	8.24E-03	No
Benzene[d]	0.02	5.44E-05	1.24E-06	3.88E+00	No
Carbon disulfide[d]	0.02	2.04E-06	4.66E-08	2.89E-03	No
Carbon tetrachloride[d]	0.02	5.10E-05	1.17E-06	2.84E+00	No
Chlorobenzene[d]	0.01	7.48E-06	1.71E-07	1.37E-02	No
Chloroform[d]	0.01	1.22E-05	2.79E-07	2.57E-01	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-108 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-108 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Ethyl acetate	0.1	7.33E-07	1.68E-08	1.77E-03	No
Ethyl ether	0.05	3.00E-06	6.86E-08	7.19E-03	No
Ethylbenzene	0.01	1.63E-06	3.73E-08	2.16E-03	No
Hexone	0.1	1.50E-05	3.42E-07	3.53E-02	No
Isobutanol	25.8	1.07E-03	2.45E-05	2.66E+00	No
Methylenechloride[d]	0.02	3.85E-06	8.80E-08	7.28E-01	No
Tetrachloroethene	0.02	2.72E-05	6.21E-07	2.53E+00	No
Toluene	0.01	0.00E+00	4.66E-07	2.81E-03	No
Trichloroethene	0.02	6.80E-04	1.55E-05	5.05E+00	No
Trichlorofluoromethane	0.1	4.51E-06	1.03E-07	3.81E-03	No
Vinyl chloride	0.035	1.45E-04	3.31E-06	1.89E+02	No
Xylenes (total)	0.034	2.10E-06	4.80E-08	2.30E-03	No
4-Nitrophenol[d]	2.9	4.60E-03	1.05E-04	2.27E+00	No

[a] 95% Upper Confidence Level Concentration = Average Concentration + (1.96 × Average Concentration × Relative Standard Deviation). Average Concentrations and Relative Standard Deviation taken from Table A-1, Appendix A, RPP-RPT-54757, *Tank 241-C-108 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[c] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[d] Dangerous waste constituent per *Washington Administrative Code* 173-303-9905, "Dangerous Waste Constituents List."

Table D-11. Background Data for Selected Constituents for the Hanford Site. (2 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Cesium-137		RAD	pCi/g	1.1	1.6	DOE/RL-96-12, Rev. 0
Cobalt-60		RAD	pCi/g	0.0084	0.039	DOE/RL-96-12, Rev. 0
Europium-154		RAD	pCi/g	0.033	0.079	DOE/RL-96-12, Rev. 0
Europium-155		RAD	pCi/g	0.054	0.1	DOE/RL-96-12, Rev. 0
Gross Beta		RAD	pCi/g	23	25	DOE/RL-96-12, Rev. 0
Plutonium-238		RAD	pCi/g	0.0038	0.019	DOE/RL-96-12, Rev. 0
Plutonium-239/240		RAD	pCi/g	0.025	0.033	DOE/RL-96-12, Rev. 0
Potassium-40		RAD	pCi/g	17	20	DOE/RL-96-12, Rev. 0
Radium-226		RAD	pCi/g	0.82	1.2	DOE/RL-96-12, Rev. 0
Strontium-90		RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Thorium-232		RAD	pCi/g	1.3	1.6	DOE/RL-96-12, Rev. 0
Total beta radiostrontium		RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Uranium-233/234		RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-234		RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-235		RAD	pCi/g	0.11	0.39	DOE/RL-96-12, Rev. 0
Aluminum	Al	Metal	µg/kg	1.18E+07	28,800,000	DOE/RL-92-24, Vol. 1, Rev. 4
Antimony*	An	Metal	µg/kg	130	385	ECF-HANFORD-11-0038
Arsenic*	Ar	Metal	µg/kg	6,470	27,700	DOE/RL-92-24, Vol. 1, Rev. 4
Barium*	Ba	Metal	µg/kg	132,000	480,000	DOE/RL-92-24, Vol. 1, Rev. 4
Beryllium*	Be	Metal	µg/kg	1,510	10,000	DOE/RL-92-24, Vol. 1, Rev. 4
Cadmium*	Cd	Metal	µg/kg	563	2,900	ECF-HANFORD-11-0038
Calcium	Ca	Metal	µg/kg	1.72E+07	105,000,000	DOE/RL-92-24, Vol. 1, Rev. 4
Chromium	Cr	Metal	µg/kg	18,500	320,000	DOE/RL-92-24, Vol. 1, Rev. 4
Cobalt	Co	Metal	µg/kg	15,700	110,000	DOE/RL-92-24, Vol. 1, Rev. 4
Copper	Cu	Metal	µg/kg	22,000	61,000	DOE/RL-92-24, Vol. 1, Rev. 4
Iron	Fe	Metal	µg/kg	3.26E+07	68,100,000	DOE/RL-92-24, Vol. 1, Rev. 4
Lead*	Pb	Metal	µg/kg	10,200	74,100	DOE/RL-92-24, Vol. 1, Rev. 4
Lithium	Li	Metal	µg/kg	13,300	19,200	ECF-HANFORD-11-0038

Table D-11. Background Data for Selected Constituents for the Hanford Site. (2 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Magnesium	Mg	Metal	µg/kg	7.06E+06	32,300,000	DOE/RL-92-24, Vol. 1, Rev. 4
Manganese	Mn	Metal	µg/kg	512,000	1,110,000	DOE/RL-92-24, Vol. 1, Rev. 4
Mercury*	Hg	Metal	µg/kg	13	29	ECF-HANFORD-11-0038
Molybdenum	Mo	Metal	µg/kg	470	3,170	ECF-HANFORD-11-0038
Nickel*	Ni	Metal	µg/kg	19,100	200,000	ECF-HANFORD-11-0038
Potassium	K	Metal	µg/kg	2.15E+06	7,900,000	ECF-HANFORD-11-0038
Silver*	Ag	Metal	µg/kg	167	273	ECF-HANFORD-11-0038
Sodium	Na	Metal	µg/kg	690,000	6,060,000	DOE/RL-92-24, V.1, Rev.4
Uranium	U	Metal	µg/kg	3,210	4,042	Isotopic Activity Conversion based on DOE/RL-96-12 values
Vanadium	V	Metal	µg/kg	85,100	140,000	DOE/RL-92-24, Vol. 1, Rev. 4
Zinc	Zn	Metal	µg/kg	67,800	366,000	DOE/RL-92-24, Vol. 1, Rev. 4
Ammonia	NH_3	Metal	µg/kg	9,230	26,400	DOE/RL-92-24, Vol. 1, Rev. 4
Chloride	Cl	Metal	µg/kg	100,000	1,480,000	DOE/RL-92-24, Vol. 1, Rev. 4
Fluoride	Fl	Metal	µg/kg	2,810	73,300	DOE/RL-92-24, Vol. 1, Rev. 4
Nitrate	NO_3	Metal	µg/kg	52,000	906,000	DOE/RL-92-24, Vol. 1, Rev. 4
Phosphate	PO_4	Metal	µg/kg	785	225,000	DOE/RL-92-24, Vol. 1, Rev. 4
Sulfate	SO_4	Metal	µg/kg	237,000	12,600,000	DOE/RL-92-24, Vol. 1, Rev. 4
Boron	Bo	Metal	µg/kg	3,890	5,860	ECF-HANFORD-11-0038
Selenium*	Se	Metal	µg/kg	780	840	Ecology Publication #94-115
Thallium*	Th	Metal	µg/kg	185	523	ECF-HANFORD-11-0038

* Dangerous waste constituent per *Washington Administrative Code* 173-303-9905, "Dangerous Waste Constituents List."

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