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CH2M HILL ENGINEERING CHANGE NOTICE

 ☒ DM ☐ FM ☐ TM

1a. **ECN** 725587 **R** 0

1b. **Proj. ECN** NA - - R

2. **Simple Modification** ☒ Yes ☐ No	3. **Design Inputs** – For full ECNs, record information on the ECN-1 Form (not required for Simple Modifications)		4. **Date** 4/30/08
5. **Originator's Name, Organization, MSIN, & Phone No.** John Schofield, Retrieval/Closure Engineering, S7-12, 373-2245	6. **PrHA Number** No. PrHA-00243 R - 0 ☐ N/A	7. **USQ Number** No. TF - 08 - 0763 - S R - 0 ☐ N/A	8. **Related ECNs** NA
9. **Title** Revise RPP-33116 Rev 1 to Rev 2	10. **Bldg. / Facility No.** NA	11. **Equipment / Component ID** NA	12. **Approval Designator** E
13. **Engineering Documents/Drawings to be Changed** (Incl. Sheet & Rev. Nos.) RPP-33116 Rev 1		14. **Safety Designation** ☐ SC ☐ SS ☐ GS ☒ N/A	15. **Expedited/Off-Shift ECN?** ☐ Yes ☒ No
16a. **Work Package Number** NA	16b. **Modification Work Completed** NA — Responsible Engineer / Date	16c. **Restored to Original Status (TM)** NA — Responsible Engineer / Date	17. **Fabrication Support ECN?** ☐ Yes ☒ No

18. **Description of the Change** (Use ECN Continuation pages as needed)

Replace RPP-33116 Rev 1 in its entirety with RPP-33116 Rev 2.

19. **Justification of the Change** (Use ECN Continuation pages as needed) Engineering Rework ☐ Yes ☒ No

Changes are required to respond to Washington State Department of Ecology comments.

20. **ECN Category**

☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type

☐ Supersedure
☐ Revision

21. **Distribution**

Name	MSIN	Name	MSIN
see distribution sheet			

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DATE: JUN 1 0 2008
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CH2M HILL ENGINEERING CHANGE NOTICE

1a. ECN 725587 **R** 0

Page 2 of 2 ☒ **DM** ☐ **FM** ☐ **TM**

1b. **Proj. ECN** NA - - R

22. **Revisions Planned** (Include a brief description of the contents of each revision)
None.

Note: All revisions shall have the approvals of the affected organizations as identified in block 12 "Approval Designator," on page 1 of this ECN.

23. **Commercial Grade Item Dedication Numbers** (associated with this design change)
None.

24. **Engineering Data Transmittal Numbers** (associated with this design change, e.g., new drawings, new documents)
None.

25. **Other Non Engineering (not in HDCS) documents that need to be modified due to this change**

Type of Document	Document Number	Update Completed On	Responsible Engineer (print/sign and date)
Alarm Response Procedure	NA		
Operations Procedure	NA		
Maintenance Procedure	NA		

Type of Document	Document Number	Type of Document	Document Number
NA			

26. **Field Change Notice(s) Used?**
☐ **Yes** ☒ **No**
If Yes, Record Information on the ECN-2 Form, attach form(s), include a description of the interim resolution on ECN Page 1, block 18, and identify permanent changes.

NOTE: ECNs are required to record and approve all FCNs issued. If the FCNs have not changed the original design media then they are just incorporated into the design media via an ECN. If the FCN did change the original design media then the ECN will include the necessary engineering changes to the original design media.

27. **Design Verification Required?**
☐ **Yes** ☒ **No**
If Yes, as a minimum attach the one page checklist from TFC-ENG-DESIGN-P-17.

28. **Approvals**

	Facility/Project Signatures		Date
Resp. Engineer	DB Parkman	D.B. Parkman	5/13/08 (DBP 6.10.08)
Resp. Manager	WT Thompson	W.T. Thompson	5/13/08 (6/10/08)
Quality Assurance	NA		
IS&H Engineer	NA		
NS&L Engineer	NA		
Environ. Engineer	~~JS Conrad~~ C.J. Kemp (CJK 5-14-08)	C.J. Ke... (CJK 6/10/08)	5-14-08
Engineering Checker	LS Krogsrud	LS Krogsrud	5/9/08
Other	JS Schofield	John Schofield (JSS 6/10/08)	4/30/08
Other	Env. Prog. MN Jaraysi	[signature]	5/15/08
Other	Project Mgr. MH Sturges	[signature]	5/15/08
Other	RE Bauer	RE Bauer (6/10/08)	5/13/08
Other			
Other			
Other			
Other			

	A/E Signatures	Date
Originator/Design Agent	NA	
Professional Engineer		
Project Engineer		
Quality Assurance		
Safety		
Designer		
Environ. Engineer		
Other	~~KOK per L. Cusak, JSS 6/10/08~~	
Other		

DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION
Signature or a Control Number that tracks the Approval Signature

ADDITIONAL SIGNATURES

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Closure Operations	Date April 30, 2008
Project Title/Work Order		EDT No. NA
RPP-33116, Rev 2, 241-C-110 Tank Waste Retrieval Work Plan		ECN No. 725587 R0

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Carpenter, KE	S7-66	x			
Robinson, RS	S7-90	x			
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Thompson, WT	S7-67	x			
Parkman, DB	S7-67	x			
Luke, JJ	H6-03	x			
Smith, RD	S7-90	x			
Sutey, MJ	S7-90	x			
Conrad, JS	S7-03	x			
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Krogsrud, S	S7-24	x			
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Kemp, CJ	S7-83	x			
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Washington State Department of Ecology					
Lyon, J	HO-57	x			
Uziemblo, N	HO-57	x			
US Environmental Protection Agency					
Bartus, D	HO-57	x			

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241-C-110 Tank Waste Retrieval Work Plan

JS Schofield
CH2M Hill Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: ECN-725587 R0 UC:
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Key Words: 241-C-110, Retrieval, TWRWP, Sluicing

Abstract: This document establishes the C-110 Tank Waste Retrieval Work Plan required by the Hanford Federal Facility Agreement and Consent Order

DATE: JUN 10 2008
STA. 3 HANFORD RELEASE ID: 18

Barbara Wolski 6/10/08
Release Approval Date Release Stamp

Approved For Public Release

Tank Farm Contractor (TFC) **RECORD OF REVISION**	(1) Document Number RPP-33116	1 Page

(2) Title: **241-C-110 Tank Waste Retrieval Work Plan**

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add and Delete Pages	Authorized for Release	
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0A	Revise to Revision 0A, replace pg 5-1 per ECN 724883 R0	DB Parkman 7/20/07	WT Thompson 7/20/07
1	Replace Rev 0 with Rev 1, general update in response to Ecology comments, per ECN 725268 R0	DB Parkman 12/19/07	WT Thompson 12/19/07
2 RS	Replace Rev 0 with Rev 1, in response to more Ecology comments, per ECN 725587 R0	DB Parkman DB Parkman 5/13/08	WT Thompson WT 6/10/08 WT Thompson 6/13/08

RPP-33116
Revision 2

241-C-110 TANK WASTE RETRIEVAL WORK PLAN

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CH2M HILL Hanford Group, Inc.

Date Published
June 2008

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

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Abbreviations, Acronyms, and Initialisms

ALARA	as low as reasonably achievable
BBI	best-basis inventory
CH2M HILL	CH2M HILL Hanford Group, Inc.
COPC	constituent of potential concern
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HIHTL	hose-in-hose transfer line
HRR	high-resolution resistivity
IH	industrial hygiene
ILCR	incremental lifetime cancer risk
IQRPE	independent, qualified registered professional engineer
IRIS	Integrated Risk Information System
ITEM	Integrated Training Electronic Matrix
k_d	distribution coefficient
LDM	leak detection and monitoring
MRS	mobile retrieval system
NOC	notice of construction
ORP	U.S. Department of Energy, Office of River Protection
OWW	organic wash waste
PCB	polychlorinated biphenyls
PUREX	plutonium-uranium extraction
RAS	radionuclide assessment system
RCRA	*Resource Conservation and Recovery Act of 1976*
RMS	radionuclide monitoring system
SGLS	spectral gamma system
SST	single-shell tank
TSD	treatment, storage, and disposal
TWINS	Tank Waste Information Network System
TWRWP	Tank Waste Retrieval Work Plan

UPR	unplanned release
WMA	waste management area
WRS	waste retrieval system
WTP	Waste Treatment and Immobilization Plant

Units

Ci	curie
ft	foot
ft^3	cubic feet
gal	gallon
gal/min	gallons per minute
hr	hour
in.	inch
kg	kilogram
mg/L	milligrams per liter
mm/yr	millimeters per year
mrem	millirem
mrem/yr	millirem per year
pCi/g	picocuries per gram
μCi/mL	microcuries per milliliter

1 INTRODUCTION

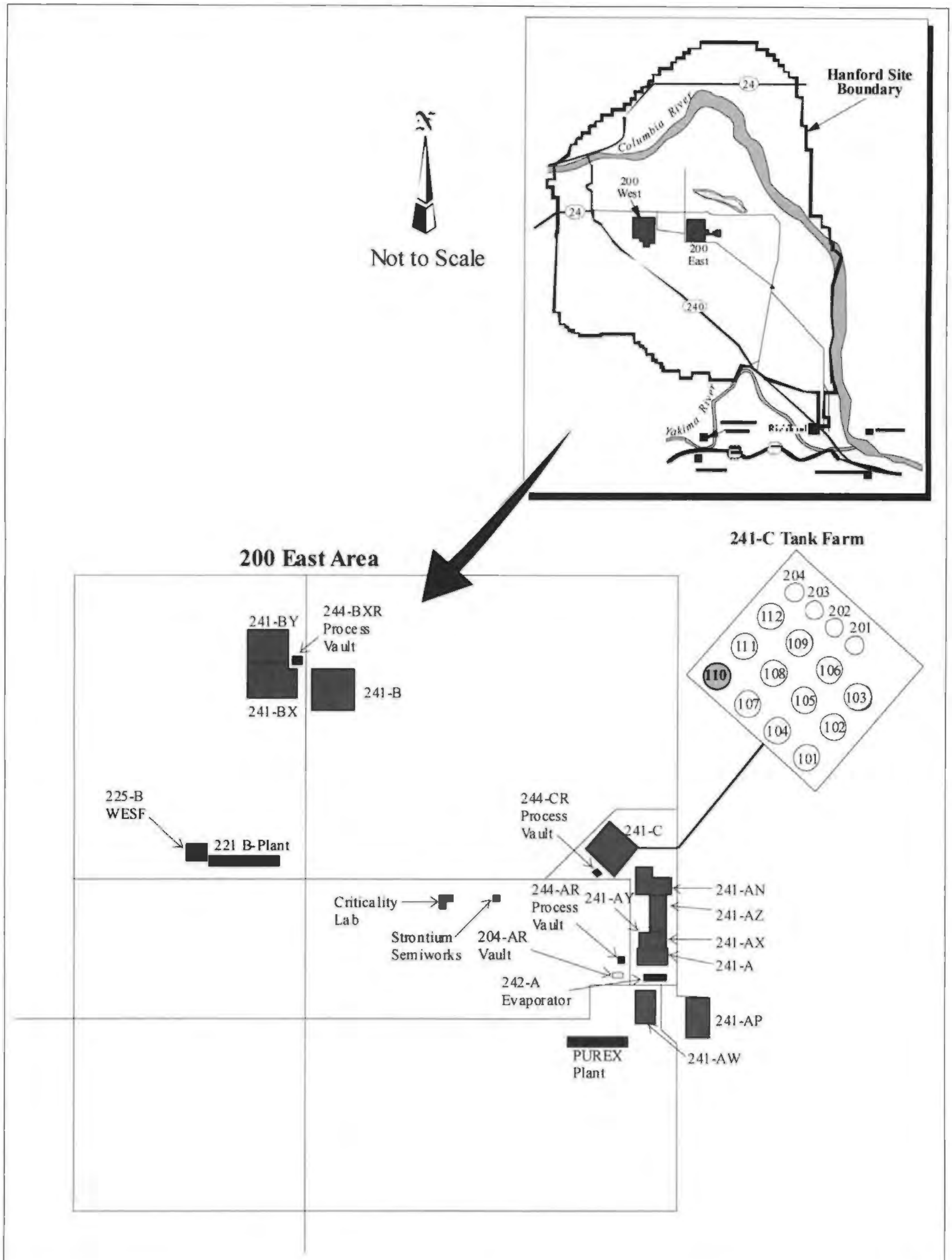
The U.S. Department of Energy, Office of River Protection (ORP) River Protection Project mission includes storage, retrieval, immobilization, and disposal of radioactive mixed waste presently stored in underground tanks located in the 200 East and 200 West Areas of the U.S. Department of Energy (DOE) Hanford Site. Single-shell tank 241-C-110 (C-110) located in the 200 East Area (Figure 1-1), is scheduled for waste retrieval using a modified sluicing system retrieval technology. Tank C-110 is classified as an "assumed leaker" as specified in HNF-EP-0182, *Waste Tank Summary Report for Month Ending September 30, 2006*. Modified sluicing is proposed for this tank since there is evidence the tank is sound below a level of 144 in. above the bottom center of the tank. During the waste retrieval process, controls will be in place to maintain any liquid surface in the tank below this level. The waste level in the tank as of March 2007 is about 70 in. above the bottom center of the tank.

This is a primary document developed to meet the requirements identified in Change Request M-45-04-01 of Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO). The purpose of this document is to provide the Washington State Department of Ecology (Ecology) information on the planned approach for retrieving waste from C-110 to allow Ecology to approve the waste retrieval action.

The relationship of the tank waste retrieval work plans (TWRWP) to the overall single-shell tank (SST) waste retrieval and closure process is described in Appendix I of the HFFACO, along with requirements for the content of TWRWPs. These requirements were subsequently clarified in letter 04-TPD-083, "Agreement on Content of Tank Waste Retrieval Work Plans" (04-TPD-083 – Letter). For clarity and guidance the requirements from 04-TPD-083 – Letter are repeated where applicable at the beginning of a section in this document.

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*) has been incorporated, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of this tank waste retrieval work plan or *Revised Code of Washington,* Chapter 70.105 RCW, "Hazardous waste management."

Figure 1-1. Location Map of Tank 241-C-110, C Tank Farm, and Surrounding Facilities in the 200 East Area.



2 TANKS AND/OR ANCILLARY EQUIPMENT CONDITION AND CONFIGURATION AND WASTE CHARACTERISTICS

2.1 TANK

List of tank(s) associated with the proposed waste retrieval action

Tank 241-C-110 is the subject of this TWRWP.

2.1.1 Start Date

Retrieval start dates for each component

The planned start date for C-110 waste retrieval operations is July 2008. This date is subject to change depending on priorities and availability of resources. In accordance with the HFFACO, Appendix I, Section 2.1.5, it is understood waste retrieval is to be completed within 12 months of this retrieval start date. The tank retrieval process will be completed within this time frame or the TWRWP will be revised to provide an estimated completion date for the retrieval process.

2.1.2 History of Tank

History of tank (date of construction, dimensions of tank, etc.)

Summary-level historical data related to the configuration and operating history for tank C-110 is provided in Table 2-1.

Table 2-1. Summary-Level Data for Tank C-110.*

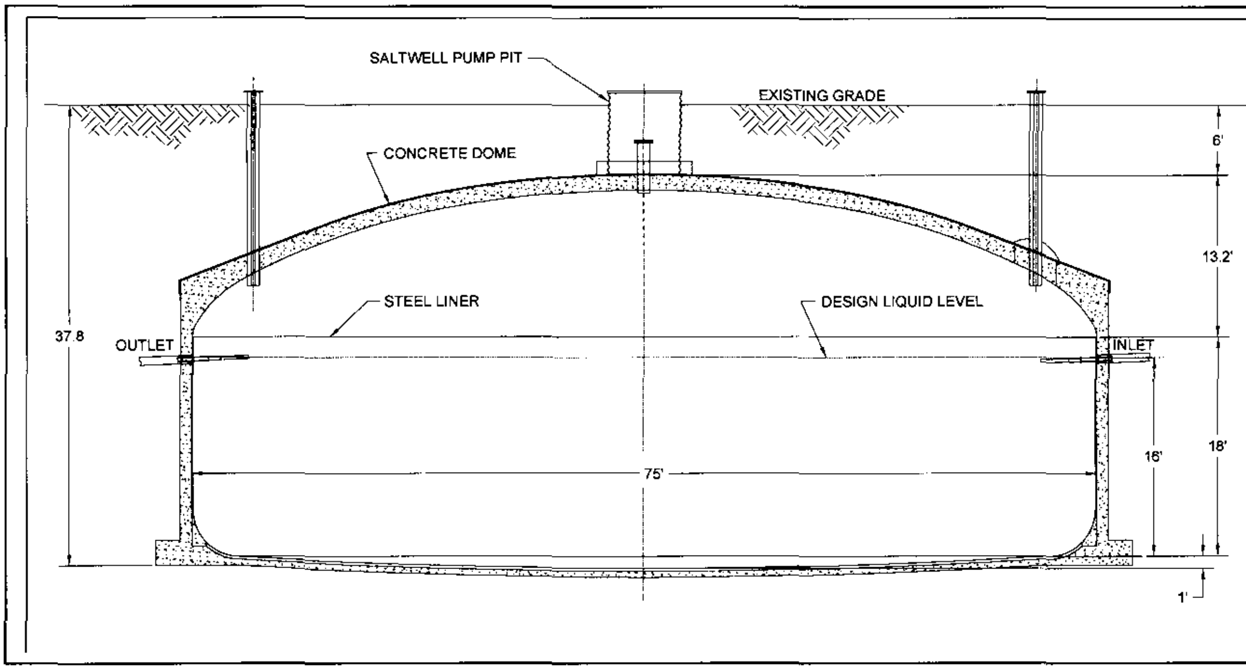
Constructed	1943-44
In service	1946
Diameter (ft)	75
Operating depth (in.)	185
Design capacity (gal.)	530,000
Bottom shape	Dish
Ventilation	Passive
Nominal burial depth (ft)	6
Declared inactive	1977
Interim stabilized	5/95

* Adapted from RPP-10435, 2002, *Single-Shell Tank System Integrity Assessment Report.*

The tank was constructed in place with a carbon steel lining on the bottom and sides, and with a reinforced concrete shell. The welded liner is independent of the reinforced-concrete tank and was designed to provide leak-tight containment of the liquid radioactive wastes and to protect the reinforced concrete from waste contact. All other loads (e.g., surface live loads, static and dynamic soil loads, dead loads, hydrostatic loads, and hydrodynamic loads) are carried by the reinforced-concrete tank structure. The tank has a concave bottom (center of tank lower than the perimeter) and a curving intersection of the sides and bottom. Inlet and outlet lines are located near the top of the liner. The outlet line is also referred to as a "cascade" line because it allowed overflow of fluids to C-111 to support the transfer and storage of waste within the series C-110/C-111/C-112.

The configuration of C-110 is depicted in the cross-section view in Figure 2-1.

Figure 2-1. Tank C-110 Cross-Section View.*



* Adapted from RPP-10435, *Single-Shell Tank System Integrity Assessment Report.*

Tank C-110 does not have any concrete pits but does have a caisson that was installed over the center riser after initial tank construction. The caisson is constructed of a section of corrugated pipe embedded in a concrete base. This caisson extends above grade and is closed off on the top with a cover plate.

Drawing H-2-38597, *Salt Well Pump Pit Assembly for Std. 12" Riser*, shows the original installation of the corrugated caisson. The caisson was installed in a groove in the concrete bottom of the pit and sealed with grout. The concrete base was sloped to a drain that connected to the tank riser so any leakage within the caisson would drain back into the tank.

Table 2-2 provides the size and current use of tank C-110 risers and fill/cascade lines and any equipment installed in or on the risers. There are nine risers of varying diameters and lengths of protrusion into the tank. Figure 2-2 provides the tank C-110 riser plan view. Planned use of the risers for waste retrieval is described in Section 3.1.1.

Table 2-2. Tank C-110 Riser and Fill/Cascade Line Descriptions.[a]

Component Identification Number	Diameter (in.)	Use Descriptions and Comments
R1	4	Spare, blind flange
R2	12	Spare, blind flange with BM
R3	12	Breather filter
R4	4	Level gauge (ENRAF)[b]
R5	4	Spare, blind flange with BM
R6	12	Spare
R7	12	Observation port
R8	4	Temperature probe
R13	12	Saltwell pump in weather covered pit
A[c]	3	Cascade line overflow to tank C-111
C1[c]	3	Fill line, sealed in diversion box 241-C-153
C2[c]	3	Fill line, sealed in diversion box 241-C-153
C3[c]	3	Fill line, sealed in diversion box 241-C-153
C4[c]	3	Spare, capped

NA = not applicable.
BM = benchmark.
[a] Best-basis inventory documents from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm.
[b] Enraf is the supplier of the identified level gauges; ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.
[c] Cascade and/or fill line, not a riser.

2.1.3 Tank Classification

Classification (sound or assumed leaker along with relevant historical information) and supporting information regarding tank integrity to the extent available. Include level measurement (or other) data that may, or may not, indicate the component is sound. If the subject tank is an assumed leaker, information shall be provided to determine the potential impacts of retrieving waste from the assumed leaker including:

(1) An evaluation of the data that led to classification of the tank as an assumed leaker.

(2) Any proposed revisions or qualifications to the tanks "assumed leaker" status. Proposed status revisions shall include justification and calculations.

Tank C-110 is classified as an assumed leaker in HNF-EP-0182. HNF-EP-0182 provides an estimated C-110 leak volume of 2,000 gal and states the volume estimate is based on 8901832B R1 - Letter, "Single-Shell Tank Leak Volumes" (8901832B R1 - Letter). 8901832B R1 – Letter bases a 2,000-gal estimated leak volume for C-110 on the fact that radiation was detected at an associated drywell with no detectable surface level decrease in the tank, and that it is unreasonable to assume that more than 2,000 gal would have leaked without a surface level decrease. Low levels of radioactivity were actually noted in two drywells when they were installed in 1974, but the level in one reduced to background by 1979 (see 2.1.3.2).

Figure 2-2. Tank C-110 Riser and Fill/Cascade Line Plan View.

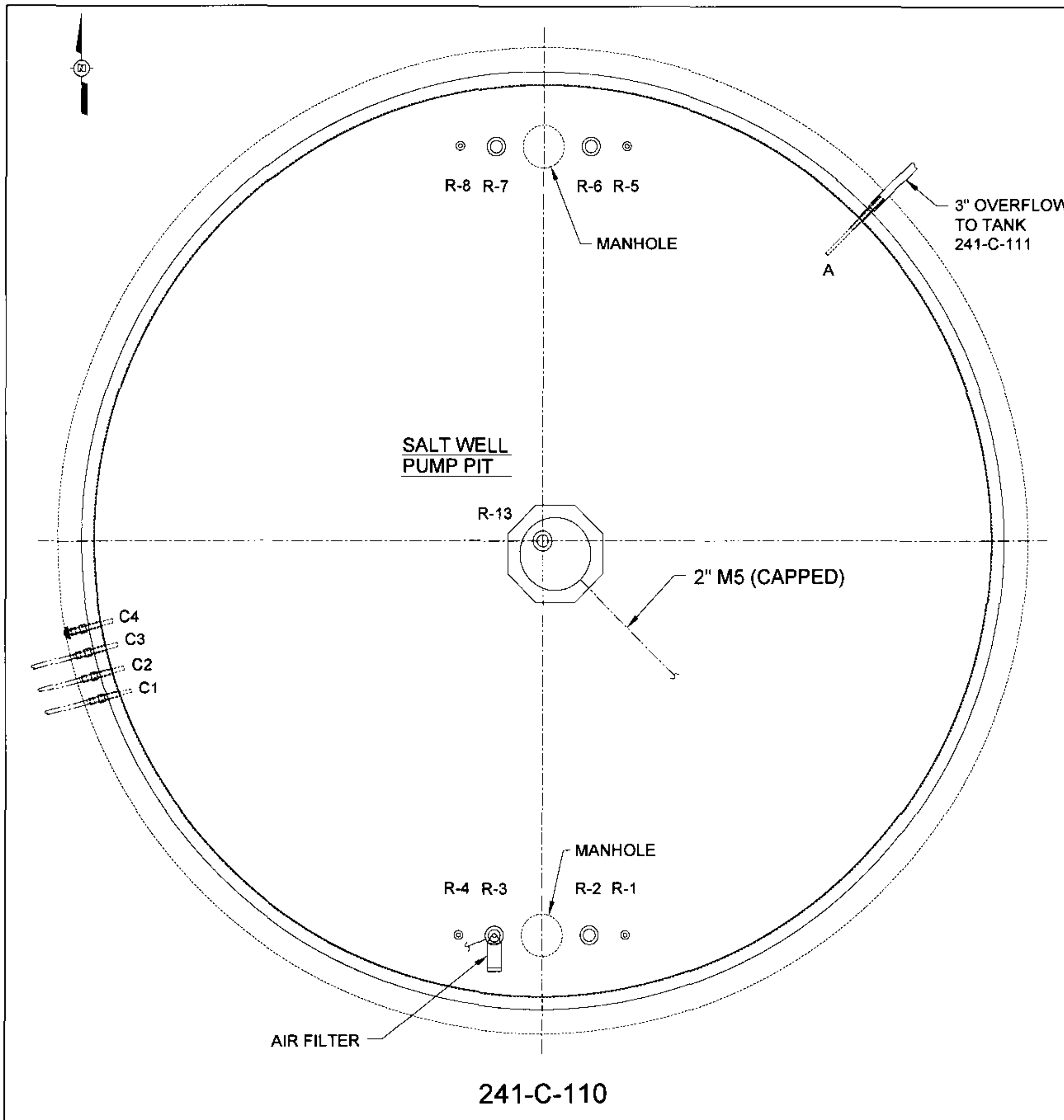


Figure 2-3 is a plot of the tank level data from the initial fill date based on historical records from the time the tank was first filled until interim stabilization was complete in 1995 (WHC-SD-WM-ER-313, *Supporting Document for the Historical Tank Content Estimate for C-Tank Farm*). The flat level from early 1972 to mid 1975 period is the basis for believing the tank is sound below 144 in. (132 in. using the top of dish reference elevation for Figure 2-3). There is no evidence of a leak from the tank bottom or side below the 144 in. level from early 1972 to mid 1975. In the middle of 1975 approximately 110 kgal were pumped to a different tank. The tank level was stable for another half year until the remainder of the supernate was pumped out in early 1976. There has not been a free liquid surface under the level gauge since early 1976. It is therefore reasonable to expect that the radioactivity noted when the C-110 drywells were first installed in 1974 came from a different source than the tank bottom, or sides below a 144-in. level.

2.1.3.1 Evaluation of Data Leading to Classification as Assumed Leaker. Tank C-110 was declared as "questionable integrity" in 1977 and an "assumed leaker" in 1984 following the discovery of unexplained activity in drywells 30-10-09 located just to the west of tank C-110, and 30-10-02 located between tanks C-110 and C-111.

In 1974 seven drywells were installed around tank C-110. During initial monitoring of these wells that year there was evidence of low gamma radiation levels in two of them, 30-10-02 and 30-10-09.

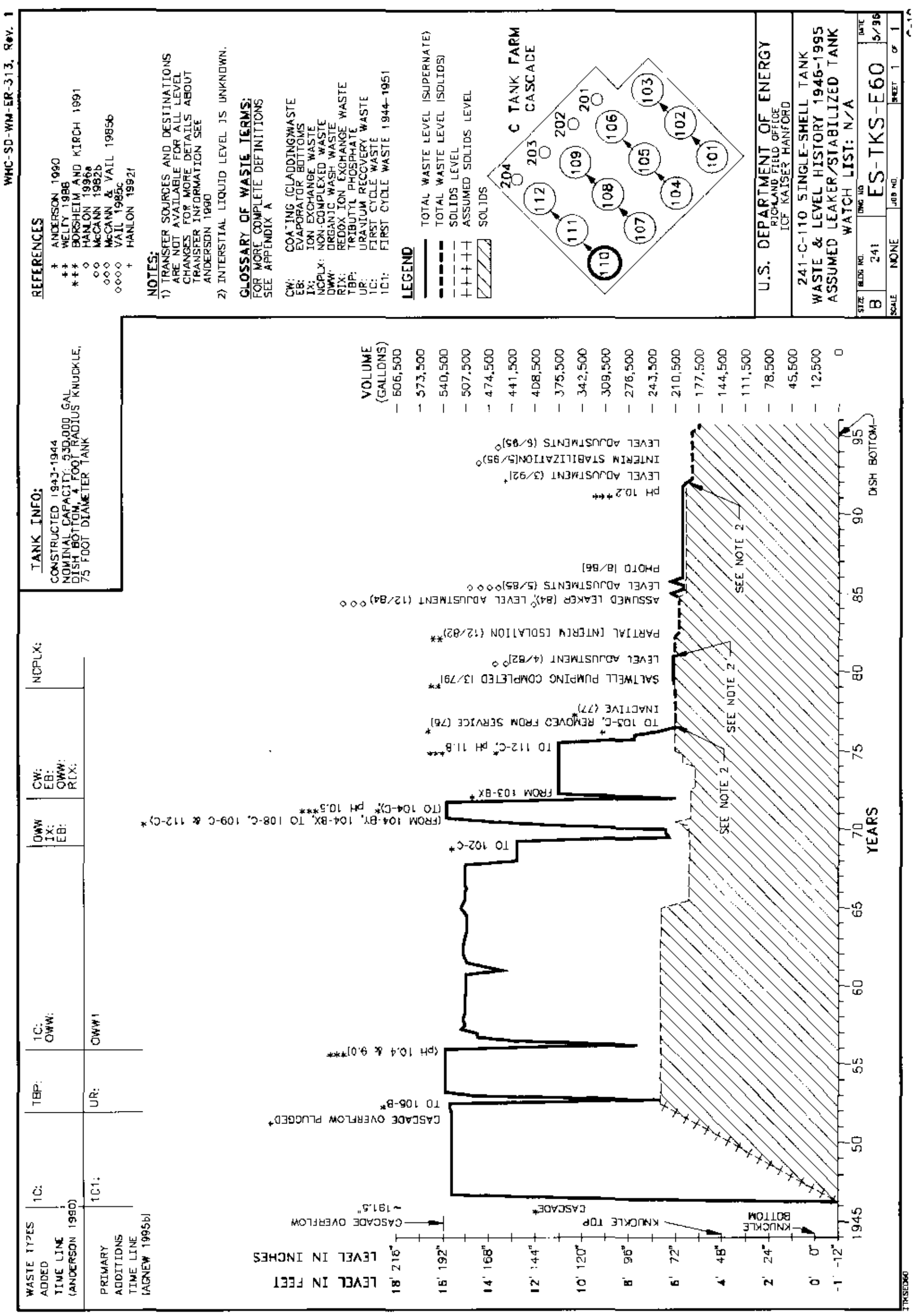
Drywell 30-10-09 showed readings above background between 53 to 56 ft below grade. The bottom of the tank is a nominal 37 ft below grade. The radiation decreased each year thereafter, and disappeared entirely by 1979. No further radiation has been detected in this well, including the most recent gamma scans performed in 1997 and 2003.

Drywell 30-10-02 shows a small peak of ^{137}Cs at about 10 to 15 pCi/g in drywell 30-10-02 at 46 to 48 ft below grade. This peak was evident in the initial scan and remains present and stable (the readings are decreasing at a rate that approximates the half-life of ^{137}Cs) in both 1997 and 2003 gamma scans.

The source of the radiation in these two wells is unknown. It has been theorized that the drywell 30-10-09 contamination may have originated when the cascade line to C-111 plugged in 1952 and the tank liquid level rose ~4 in. to cover the non leak-tight spare inlet line (C4 in Figure 2-2) located in approximately the same radial position around the tank as the drywell. The 30-10-02 contamination has not been definitely tied to any specific event.

The 30-10-09 readings decaying off within a few years and the 30-10-02 readings decaying at the rate of ^{137}Cs indicate that there was no leak from tank C-110 at the time the drywells were drilled. The stable liquid level reading from 1972 to 1975 and the lack of any radiation increase in these two drywells since 1974 indicates that the tank has not leaked since.

Figure 2-3. Tank C-110 Surface Level History from 1946 to 1995.



2.1.3.2 Proposed Revision or Qualifications to Assumed Leaker Status. There is no revision to the tank's assumed leaker status; the status is being retained. However, RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report; Tanks 241-C-101 and 241-C-110*, provides the results of a reassessment of all the available leak assessment data for C-110. This assessment was performed by a committee of personnel from Ecology, DOE-ORP, and the tank farm contractor. The conclusion of this document states: "*The C-110 leak appears to be the result of a tank overflow 17 ft 4 in (208 in) above the tank bottom. As a worst case, the liquid level in SST was steady at 144 inches from the tank center from 1971 to 1975, indicating that if there was a breach in tht tank wall, it was above this level.*"

Therefore, although the tank's assumed leaker status is retained, the information in, and conclusion of RPP-ENV-33418 provides the basis for retrieving tank C-110 waste using modified sluicing, with the qualification that the liquid level during the waste retrieval process be maintained below the level of 144 inches above the tank bottom center. This maximum controlled waste level is provided in the process control plan (PCP) as discussed further in Section 4.6.1 of this document.

2.1.4 Tank Waste Volume/Characteristics

> *Waste volume/characteristics either based on existing data (Best Basis Inventory) or assumed based on historical records. Uncertainty associated with existing characterization data. Plans for pre and/or post retrieval sampling and analysis activities if required to reduce uncertainties associated with waste transfer and storage, waste treatment, or closure. Any existing data quality objectives (DQOs) relevant to planned sampling and analysis will be referenced or plans for developing new DQOs identified.*

Tank C-110 began receiving bismuth phosphate first-cycle decontamination (1C) waste in May 1946 and by April 1947 was filled with 1C waste, as specified in HNF-SD-WM-ER-367. Waste was transferred to tank C-111 through the cascade line. Supernate waste was transferred to tank B-106 in 1952. In 1952 it was determined that the overflow line to tank C-111 had become plugged with waste.

In 1952 and 1953, the tank received uranium recovery waste as specified in WHC-MR-0132, *A History of the 200 Area Tank Farms*. In 1956, waste was transferred from tank C-110 to the CR process vault through tank C-109.

The tank received organic wash waste from plutonium-uranium extraction (PUREX) in 1956. Waste was sent to tank BY-112 in 1967 and to tank C-102 in 1969.

From 1970 until 1972, evaporator bottoms waste and ion exchange waste were sent to the tank from tanks BY-104, BX-104, and BX-103. During this time, supernate waste was sent to tanks C-108, C-109, C-112, and C-104. Waste was sent to tank C-112 in 1975 and to tank C-103 in 1976. In 1983 waste was transferred to tank AN-103.

The temperature in C-110 has been essentially ambient since 1991, which is as far back as temperature data readily available electronically go. The lack of any significant temperature decrease in the plot shows there is a relatively low level of heat producing radionuclides present. The temperature would not have been significantly higher in the past since ^{90}Sr (the predominant heat generating sludge radionuclide) has a half life of about 29 years. A 29 year half life means the heat generation rate from ^{90}Sr in 1952 when the addition of heat producing sludge was completed would have been only about 2.6 times what it was in 1991, not enough to have resulted in significant sludge temperatures in the tank in the intervening years. Figure 2-3 shows the surface and sludge level history. The majority of sludge was added between 1946 and 1952 when 1-C waste, the first cycle waste from bismuth phosphate processing, was added to the tank. Several hundred thousand gal of organic wash waste (OWW)was added to the tank in 1956, but Figure 2-3 shows negligible solids increase. The OWW liquid was subsequently pumped out of the tank. The OWW stream from Purex was a low level, primarily liquid stream, containing less than 1% of the fission products in the dissolved fuel. The heat generating potential of the OWW stream was low. The heat load in C-110 has been low compared to tanks which received more concentrated first cycle wastes.

The waste volume and physical properties of the waste stored in tank C-110 are summarized in Table 2-3.

Table 2-3. Waste Volume and Physical Properties Summary.

Waste Property	Unit	Tank C-110
Solids volume[a]	gal	177,000
Supernate volume[a]	gal	1,060
Interstitial liquid volume[b]	gal	37,000
Sludge density[a]	kg/L	1.34
Sludge percent water[a]	%	60.2

[a] Source: Best-basis inventory download from http://twinsweb.pnl.gov/twins.htm dated June 21, 2007.
[b] HNF-EP-0182, 2007, *Waste Tank Summary Report for Month Ending September 30, 2006*, Rev 222, CH2M HILL Hanford Group, Inc., Richland, Washington.

The tank waste inventory data, including uncertainty, extracted from the best-basis inventory (BBI) (http://twinsweb.pnl.gov/twins.htm) is provided in Appendix A.

The inventory uncertainty is a combination of the uncertainty associated with measurements of waste volume and concentration. Inventory uncertainty estimates have been completed for some but not all constituents and for some but not all waste types. The standard deviation is calculated from the variation in the sample analysis results. Details on the methodology used for developing inventory uncertainty values reported in the BBI are provided in RPP-7625, *Best-Basis Inventory Process Requirements*. The inventory uncertainty data associated with contaminants that drive long-term risk (e.g., ^{99}Tc) discussed in Chapter 7 can be used to provide insight to the uncertainty in long-term human health risks presented.

Although there are uncertainties associated with contaminant inventories in C-110 (Appendix A), the following items show that there is sufficient information on the characteristics that affect waste retrieval, transfer, and storage in the double-shell tanks (DSTs) to proceed with waste retrieval. The information used for waste volumes and constituents is the best available and is deemed sufficient based on knowledge of those attributes necessary for planning and design purposes to proceed with the retrieval.

a. DOE (2003), *Dangerous Waste Permit Application—Single-Shell Tank System* (Part A Permit) list of constituents contains constituents not found in the BBI because of "protective filing." The constituents listed in the BBI (25 chemicals and 46 radionuclides) account for approximately 99 wt% of the chemical inventory (not including water and hydroxide) and over 99% of the activity in terms of short- and long-term risk based on estimates developed using the Hanford Defined Waste (HDW) Model (RPP-19822, *Hanford Defined Waste Model – Revision 5.0*).

b. The above meets the requirements in Section 2.1.3 of Appendix I of the HFFACO that requires those contaminants accounting for at least 95% of the impact to groundwater risk be addressed.

There are currently no plans to perform additional pre-retrieval characterization (e.g., sampling and analyses) of the waste in tank C-110.

The BBI is the best available data; however, the Part A Permit provides a list of constituents that may or may not be present in the SSTs. To address this uncertainty, a post-retrieval sample will be taken of the residual waste for all constituents identified in the Ecology-approved sampling and analysis plan, pursuant to the requirements of that sampling and analysis plan. The information on risk and hazard values for future closure actions will be derived from post-retrieval sampling.

Sampling and analysis activities associated with component closure actions will be performed in accordance with RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*."

2.2 PIPELINES AND ANCILLARY EQUIPMENT

List of pipelines and ancillary equipment associated with the specific tank(s) or the proposed waste retrieval action

a. Existing information on condition of pipes and ancillary equipment

b. Waste volume/characteristics either based on existing data or assumed based on historical records.

Table 2-4 provides a summary of the C tank farm ancillary equipment connected to tank C-110. Nine pathways enter tank C-110 or its associated pit. The pathways include lines, a pit drain, and risers. Table 2-5 summarizes the status of the eight pathways that have already been isolated. Table 2-6 lists the plan for isolation of the remaining pathway. This work will be accomplished in accordance with the tank closure plan.

The existing buried waste transfer lines routed to tank C-110 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tank following retrieval, with the exception of the cascade line. With these isolation measures in place, the process lines are in a stable configuration and do not represent pathways for water or additional waste to enter the tanks.

The abandoned process lines used for previous waste transfers will be internally contaminated through contact with the waste. These abandoned lines were constructed with a positive slope to facilitate drainage (a design requirement). Where practical, these lines were either flushed following use or were used for dilute waste transfers that should have minimized significant solid and/or liquid waste buildup in the lines.

There is no available information on the current condition or on the volume/characteristics of any waste associated with piping and other ancillary equipment. For the purpose of assessing the long-term human health risk for the overall waste management area (WMA), an ancillary equipment source term was defined to include the residual waste in the C farm piping as described in Section 7.1.3.2.

Unplanned releases (UPR) from the ancillary equipment that are attributed to ancillary equipment leaks include the following:

a. **UPR-200-E-16.** In 1959, the transfer line between tanks C-105 and C-108 leaked and contaminated the soil near the tank C-105 pit.

b. **UPR-200-E-81.** In 1969, a transfer line leaked at the 241-C-151 diversion box resulting in a surface puddle (approximately 6 ft by 40 ft) a few feet west of 241-C-151 diversion box. Waste was being transferred from the 202-A Building to tank C-102 via the 241-C-151 diversion box at time of leak discovery.

c. **UPR-200-E-82.** In 1968, a transfer line leaked near the 241-C-152 diversion box resulting in an approximately 1,000-gal surface pool of waste. Waste was being transferred from tank C-105 to the 221-B Building via the 241-C-152 diversion box at the time of leak discovery.

d. **UPR-200-E-86.** In 1971, transfer line 812 leaked outside the southwest corner of the tank farm fence. Waste was being transferred from the 244-AR vault to the C tank farm at time of leak discovery.

Table 2-4. C Tank Farm Components Associated with Tank C-110.*

Single-Shell Tanks			
Tank 241-	**Constructed**	**Declared Inactive**	**Constructed Operating Capacity (gal)**
C-110	1943 – 1944	1977	530,000
Diversion Boxes			
Unit 241-	**Constructed**	**Removed from Service**	**Description**
241-C-151	1946	1985	Interconnected 241-C-151 diversion box and C tank farm
241-CR-152	1946	1985	Interconnected 241-C-151 diversion box and C tank farm
241-CR-153	TBD	TBD	Interconnected 241-CR-152 diversion box and C tank farm
Valve Pits			
241-C		Valve pit	
Tank Pits			
241-C-10		Covered saltwell caisson	
Transfer Lines			
Line Number	**Connecting Facilities**		
V137	241-C-110-R6	241-C-153-L2	
2-in. M-5 saltwell line to tank C-103 capped at pump pit	241-C-110-R13	Rerouted to 241-C valve pit L4	
V141	241-C-110-R3	241-C-153-L6	
V138	241-C-110-C1	241-C-153-L3	
V139	241-C-110-C2	241-C-153-L4	
V140	241-C-110-C3	241-C-153-L5	

* RPP-13774, *Single-Shell Tank System Closure Plan.*

Table 2-5. Tank C-110 Previously Isolated Lines.

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification
Nozzle C1 (V138)	Waste transfer line into tank	Yes	Isolated in diversion box 241-C-153, L3	H-2-73338
Nozzle C2 (V139)	Waste transfer line into tank	Yes	Isolated in diversion box 241-C-153, L4	H-2-73338
Nozzle C3 (V140)	Waste transfer line into tank	Yes	Isolated in diversion box 241-C-153, L5	H-2-73338
Nozzle C4	Spare nozzle	No	Isolated at tank construction; never used	H-2-37010
V137	Waste scavenging line	Yes	Cut and capped near riser	H-2-73350
V141	Pump out line	Yes	Cut and capped 50 ft from tank	H-2-73350
No number	Saltwell transfer line	Yes	Cut and capped near riser	H-2-73350
Diptubes	Two 1-in. diptubes in R-2	No	Removed and riser blanked	H-2-73350

Table 2-6. Tank C-110 Currently Open Lines.

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
Nozzle A	Cascade line to tank C-111	Yes	No action until tank fill.

3 PLANNED RETRIEVAL TECHNOLOGY

3.1 SYSTEM DESCRIPTION

System description (physical and operating)

This section provides a description of the waste retrieval system (WRS) and how it will be operated. Continued design development and incorporation of lessons learned may lead to changes in the design and/or operating strategy.

3.1.1 Physical Description

The physical equipment will consist of a modified sludge sluicing system to mobilize and retrieve waste from tank C-110. The sluicing system will include two (or more) sluice nozzles and a slurry pump in the tank. The sluice nozzles will be controlled from a control trailer located outside the tank farm fence. The sluice nozzles can be installed in existing tank risers located around the perimeter of the tank. The sluice nozzles will have the capability to direct liquid at various locations in the tank. Double-shell tank supernate will be used as the primary sluicing liquid. The WRS will also have the capacity to use raw water for sluicing with minor modifications.

The new slurry pump will be installed in a riser located in the center pit. The slurry pump design for C-110 will allow the pump installation height to be adjusted to facilitate maximum waste removal. The C-110 pump will be installed using a crane so that the inlet will be just under the waste surface to start, as determined by the in-tank camera. Little or no water should be required for this pump installation. This same installation method would be used for replacement pumps. The C-110 pump will be mounted on a system that will allow the pump to be lowered to the bottom of the tank as waste retrieval progresses. Other designs or arrangements may be used to optimize the pump installation or operation.

Double-shell tank 241-AN-106 (AN-106) is planned to be used for both waste receipt and as the source tank for supernate recycle. Tank AN-106 was selected based on its location, available space, and existing equipment.

Camera(s) will be installed in tank C-110 to provide the capability to visually monitor and aid in control of waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flow rates). This information will be used to support material balance calculations. The existing ENRAF[1] level gauge in tank C-110 will be retracted during waste retrieval operations and will be used periodically to monitor waste levels. The AN-106 ENRAF will be used to monitor the waste level in that tank.

During waste retrieval operations, tank C-110 will be actively ventilated. The ventilation system will consist of skid-mounted high-efficiency particulate air filtered portable exhauster(s). The ventilation system(s) are designed to pass air through the tank, thereby reducing

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

condensation and fog within the tank. The ventilation systems required by the Washington State Department of Health include a heater, prefilter, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Details of the ventilation systems are provided in AIR 07-305, *Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II Waste Retrieval Operations* (including as amended in updates) and DE05NWP-002R2, *Approval of Criteria and Toxics Air Emissions Notice of Construction (NOC) Application for Hanford Single-Shell Tank Waste Retrieval* (as amended in updates).

Condensate drainage from the exhauster(s) will be routed back to an SST being retrieved. Any change to this drainage routing will be covered by a change to this TWRWP.

The configuration of tank C-110 includes no concrete pits and only a single central corrugated metal caisson. The drain in this caisson will be closed off and a sump pump used to pump leakage into the tank. The WRS for tank C-110 may require design and construction of riser extensions to support the installation of the sluice nozzles and a slurry pump. Table 3-1 provides the planned riser use for tank C-110. This riser use may change.

Table 3-1. Planned Riser Use for Tank C-110 Waste Retrieval System.

Riser Number	Tank C-110
1	Spare, camera, or as required if need arises during detailed design
2	Sluicer
3	Ventilation exhaust duct/camera
4	Enraf level gauge
5	Spare, camera, or as required if need arises during detailed design
6	Vacuum relief/camera/breather filter
7	Sluicer
8	Spare, camera, or as required if need arises during detailed design
13	Slurry pump

A portable valve box serves to control the routing and flow of liquid to the sluice nozzles and to control water additions to the waste retrieval process. The valve box provides secondary containment and the collection/detection of any leakage in a sump. The portable valve box has a leak detector that is connected to the pump shutdown system in the control trailer. In the event that a leak is detected in the portable valve box, the transfer pumps in tank C-110 and in the receiver DST would be shut down. The portable valve box has a sump and a sump pump that can be configured to transfer any leakage to the SST being retrieved.

A valve/transfer line diversion box may be needed to permit routing of solutions to and from tank C-110 and other tanks which may be undergoing retrieval concurrently. If a suitable pump cannot be obtained that will provide adequate capacity, a booster pump may also be required. Any booster pump will be located within a separate steel pit. Any new pits required will be inspected, will have a leak detector, and will either drain to a tank or have a sump pump. Leak detectors may be a conductivity probe, a thermal leak detector, or another type of leak detector as appropriate.

Should a transfer leak from the primary hose occur the leak detection system is designed to shut the pump off when liquid covers the leak detection element contacts. Secondary containment structures will not overflow as a result of the transfer line leakage, including any transfer line drainback, because either the free volume of the structure exceeds the volume of leaked waste plus drainback, or there are openings in the structure which allow free-drain to the tank.

Transfer of waste from tank C-110 to AN-106 and the transfer of supernate from DST back to tank C-110 will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTL) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

The receiver DST will have a supernate pump that will be used to pump liquid back to tank C-110. The receiver DST will also have a slurry distributor to distribute the sludge received from tank C-110.

Because the elevation of the AN tank farm is approximately 22 ft higher than the C tank farm, the slurry distributor and the supernate pump incorporate anti-siphon devices to prevent unintentional flow from the DST to the SST.

The transfer lines and DSTs are RCRA compliant.

3.1.2 Operating Description

The retrieval process will be monitored using closed-circuit television to facilitate waste retrieval and aid in minimizing any liquid in the tanks. Supernate will be used as the primary retrieval liquid to minimize DST storage space. Raw water will be used in limited quantities as necessary for waste mobilization and conveyance, transfer line flushing, equipment flushing, heel flushing, or as required for miscellaneous use. During all retrieval activities the tank liquid level will be maintained below the maximum waste level designated in the process control plan.

During routine operations, waste retrieval will be initiated by starting the supernate pump in the DST source tank and using the pumped supernate to provide sluicing fluid to the selected sluice nozzle. Initial sluicing will be focused in the center portion of the tank to minimize the time required to get liquid to the slurry pump to allow it to be started. The in-tank camera will be used to provide visual input for directing the sluice nozzle. The slurry pump in tank C-110 will be started when liquid from the sluicer operation reaches the area of the pump inlet and there is enough liquid present to prime and operate the pump. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pump. Typically, one sluicer will be operated at a time at a flow rate of approximately 60 to 120 gal/min. If the pump suction is too shallow when waste retrieval is started, the sluice nozzle discharges can be aimed at the pump inlet to enable to the pump to be inserted a little deeper. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank while maximizing waste retrieval efficiency. The slurry removed will consist of the mobilized tank waste and the DST supernate or water. Maintaining a balanced pumping rate into and out of the tank is integral to minimizing the liquid volume in tank C-110 and reducing the potential for leakage.

If initial sluicing efforts show the tank C-110 sludge is not readily mobilized it may be necessary to add sufficient liquid to the tank to cover the sludge and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. Liquid can break down bonds in dried waste or dissolve salt crystals holding the waste together. The DST supernate used will not be saturated and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval. The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. The time needed to soften the waste is unknown but would likely not be more than a few days.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

Before initiating waste retrieval, a formal waste compatibility assessment will be performed in accordance with HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*. HNF-SD-WM-OCD-015 provides a formal process for determining waste compatibility through the preparation of documented waste compatibility assessments for waste transfers. The primary purpose of the program is to ensure that sufficient controls are in place to prevent the formation of incompatible mixtures during waste transfer operations. Waste compatibility assessments are prepared before all waste transfers into the DST system to ensure that the waste transfer will comply with specific administrative control, safety, regulatory, programmatic, and operational decision rules related to waste chemistry and waste properties. Waste compatibility assessments require the preparation of calculations to determine source tank and/or receiver tank compositions and to assess those compositions against specified decision rules that are provided in HNF-SD-WM-OCD-015.

Formal issuance of the compatibility assessment will not be completed until just before waste retrieval operations begin to ensure that current conditions are captured in the assessment.

Meeting the informational requirements for waste transfers meets the requirements of *Washington Administrative Code* (WAC) 173-303-300, "General Waste Analysis." Compliance with the following documents is required before initiating a waste transfer:

a. HNF-SD-WM-EV-053, *Double-Shell Tank Waste Analysis Plan*. Single-shell tanks transfers into the DSTs for any reason must meet the waste acceptance criteria presented in this plan. This plan is written pursuant to WAC 173-303-300(5) and EPA guidance document OSWER 9938.4-03, *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste*.

b. Waste Stream Profile Sheet (HNF-SD-WM-EV-053, Appendix A). The sheet addresses the applicable sections of WAC 173-303-300; Title 40, *Code of Federal Regulations*, Part 761, "Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761); 40 CFR 268, "Land Disposal Restrictions"; and WAC 173-303-140, "Land Disposal Restrictions," and also requires a waste compatibility assessment pursuant to HNF-SD-WM-DQO-001, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, to meet WAC 173-303-395(1).

Liquid will not be added to an SST for the sole purpose of obtaining a level measurement. However, heel submergence remains the easiest measurement readily available for estimating the heel volume, and level data will be obtained on an opportunistic basis when performing flushes or during retrieval activities in the latter stages or at the end of the waste retrieval process.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank or per unit of time or transfer will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue until the limits of technology have been reached for this retrieval method. The limit of technology will occur when there are little or no waste solids being removed per unit volume of sluicing fluid used or per unit of time or transfer.

The following information will be used to evaluate termination of retrieval and will be shared with Ecology prior to a decision to terminate field retrieval activities:

a. System performance and efficiency data.

b. In-tank visual confirmation of tank condition and waste retrieval.

c. Preliminary volume estimates using tank geometry and in-tank structural features.

d. Presentation and discussion of alternate system configurations and process modifications to enhance retrieval performance.

e. Presentation and discussion of residual sample location.

TFC-ENG-CHEM-P-47, *Single-Shell Tank Retrieval Completion Evaluation*, provides the methodology to follow for determining when an SST undergoing waste retrieval has reached the end of the retrieval process. The following summary of this procedure does not take the place of TFC-ENG-CHEM-P-47, and for any differences between this summary and the latest version of the procedure, the procedure takes precedence. Refer to TFC-ENG-CHEM-P-47 for details of the summary steps.

a. When waste retrieval starts, engineering personnel will begin tracking retrieval performance (e.g., percent of waste retrieved) and provide a weekly status report. Weekly status information will be forwarded to Ecology to brief them on retrieval activities, including residual volume estimates and performance parameters. Ecology will be invited to view waste retrieval activities and video images of the in-tank operations.

b. Engineering shall recommend configuration or procedure changes to enhance recovery as warranted. Management is notified after performance efficiency or retrieval rate has reduced significantly.

c. An attachment to TFC-ENG-CHEM-P-47 provides guidance for retrieval performance and limit of technology evaluations. Establishment of when the limits of technology have been reached includes the following:

   1. Examination of in-tank images to observe/record waste contours and characteristics.
   2. Estimation of waste retrieval performance efficiency and remaining waste volume.
   3. Using performance data to demonstrate that a consistent pattern is present indicating limits of technology have been reached.
   4. Evaluation of waste retrieval performance against system limitations.

Ecology is notified when it appears that the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued.

Following completion of waste retrieval and final tank flushing, the residual waste volume will be determined using the methodology defined in RPP-23403 and RPP-PLAN-23827.

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

Identify range (volume) and timing of liquid additions to be added during waste retrieval.

The pump adjustment features described previously should allow the tank C-110 pump to be installed with little or no water addition However, if tank conditions require water additions to successfully install the pump (e.g., debris under the pump installation riser), water additions would be controlled in accordance with OSD-T-151-00013, *Operating Specifications for Single-Shell Waste Storage Tanks*, Section 4.1). This water would be added through one or both of the sluicers, by lancing, or by back flushing through the pump.

Water could also be added to the tank as needed to flush equipment removed from the tank or for a number of operational reasons. The use of water is minimized to avoid taking up DST storage space. Experience to date with tanks C-103 and C-108 retrieval have shown very little water use during retrieval operations.

Utilizing recycled supernate to retrieve the waste minimizes the overall volume of waste stored in the DST system as a result of the waste retrieval process.

An estimate of the total DST supernate volume transferred and the estimated retrieval time is provided in Table 3-2. A nominal 105 kgal of raw water for tank and equipment flushing is assumed consistent with planning for past tank waste retrievals.

Table 3-2. Tank C-110 Waste Retrieval Summary Data.

Tank	Initial Tank Waste Volume prior to Retrieval (kgal)	Retrieval Flush Volume (kgal)	DST Supernate Recycle (kgal)	Estimated Operating Duration (days) [c]
C-110	178 [a]	105 [b]	6,450 [c]	94

[a] From Table 2-3.

[b] Standard flush volume assumed for past 100-Series tank modified sluicing waste retrievals (RPP-21895, *241-C-103, and 241-C-109 Tanks Waste Retrieval Work Plan*, Rev. 3A, and RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*, Rev. 3B) and assumed to be applied to the C-110 waste compatibility assessment.

[c] Duration and supernate volume estimates based on the general operating assumptions of three shifts operating 7 days/week with 60% operating efficiency. Sluicing durations assume 1 vol% solids loading in slurry first week, 6 vol% solids until 30 kgal left, 2 vol% solids until 15 kgal left, 0.5 vol% solids after that, and an average DST supernate transfer rate into the SST of 80 gal/min.

DST = double-shell tank.

The use of supernatant will be limited by the following:

a. The waste compatibility assessment for supernatant recycle will be completed and reported to Ecology. This compatibility assessment shall be made to determine if the solution is acceptable for use in retrieving the tank C-110 solids. Ecology will be notified of the results of this assessment before initiation of retrieval operations. Following notification of the results of this assessment, a copy of the assessment report shall be provided to Ecology.

b. Ecology will be notified when the cumulative volume of supernatant liquid being recycled exceeds the estimated quantity of 1,000,000 gal, and for each incremental million gallon quantity recycled. Timely notification by e-mail will be sufficient.

c. Following the use of supernatant, a minimum of three tank heel rinses using a minimum volume of raw water that is three times the estimated residual waste volume will be required to ensure that residual waste is removed to the extent practical.

d. Should tank C-110 be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.

e. Should a DST sample be required during the C-110 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample.

At the cessation of waste retrieval operations, the tank walls and heel will be flushed to the extent practical with water. Flush water will not be purposely sprayed on the walls above the maximum level stated in the process control plan. When performing the tank flushes, the flush water may be used to push some of the residual waste to a convenient sampling location. For each flush, the volume of water added will be metered and recorded. The flush liquid will be pumped to a minimum heel following each flush addition. It is assumed that performing the final tank flushes will remove residual solids to the extent practical on the walls and dilute soluble radionuclides and chemicals in the tank liquid. Any Enraf level gauge readings taken during the flushing will provide data that can be used to support the final tank residual waste measurement.

The timing for transfers out of tank C-110 is dependent on personnel resource availability, equipment availability, and DST conditions. Once waste retrieval is started, it should follow the general pattern described, but no liquid additions or removals to/from tanks C-110 can be predicted for more than a day or two in advance; therefore, no detailed timeline can be developed showing all liquid additions and removals. The water or supernate addition/removal may be intermittent or continuous. Based on experience with other modified sluicing and saltcake dissolution retrievals, it will likely last for an 8- to 16-hr period, then be followed by a one shift to several day wait, then continue. Work continuity will be dependent on resource availability. Ideally the retrieval will be completed within a few months, but delays with tank farm work and lack of available resources could increase retrieval duration.

3.2.1 Basis for Using Supernate

By using DST AN-106 supernate as the waste retrieval liquid, the waste from tank C-110 may be able to be retrieved without the need for a specific evaporator campaign or transfer of waste to other DSTs.

If water were to be used for retrieving the waste from tank C-110, the total volume of liquid required could be approximately 6.4 million gal (Table 3-2). This retrieved waste volume would exceed the capacity of the receiving DST and would require multiple waste transfers to other DSTs and evaporation of the liquid to reduce the volume. An estimated 10 to 11 waste transfers (assuming 600 kgal per transfer) from AN-106 would be required to complete the waste retrieval from C-110. To evaporate all of the water to retain DST operating space, approximately ten evaporator campaigns totaling 6 to 8 months would be required. This number of transfers and evaporator campaigns would induce significant delays to waste retrieval operations.

Because the supernate is recycled, the net liquid addition to the DST system will be the nominal 90,000 to 105,000 gal of flush water per tank plus the volume of interstitial liquid in the retrieved waste sludge. Following completion of C tank farm waste retrievals, the DST receipt tanks will be at or near their storage capacity.

The basis for the number of evaporator campaigns and their durations comes from the following group of assumptions:

a. Currently an evaporator campaign may be 400,000 to 800,000 gal. Evaporation is done on a feed tank basis. If a DST were freed to hold only retrieval water-waste slurry, up to 1 million gal could be evaporated per batch. If it were necessary to mix the dilute retrieved waste slurry with a number of other tanks, a batch size may be reduced to only approximately 300,000 gal.

b. The dilute sluicing fluid would require two passes through the evaporator to achieve full concentration.

c. The first pass through the evaporator would achieve a 50% waste volume reduction.

d. An average of 1 week of transfers is required to fill the feed tank with 1 million gal of feed.

e. A 1-million-gal campaign would last approximately 12 days, and 2 days of campaign shutdown activities would be required before the next campaign could be started.

All of these assumptions are based on prior evaporator operating experience.

The number of campaigns is determined by starting with the initial volume of waste to be processed, 6.5 million gal (assumes 6.4 million gal plus 0.1 million gal flush). To this is added the volume of waste left after the first pass through the evaporator (i.e., 0.5 × 6.5 million gal = 3.2 million gal). Summing these volumes gives 9.7 million gal. Dividing by a 1-million-gal campaign volume gives ten campaigns.

The duration of the campaigns is equal to the sum of duration of its elements [i.e., transfers (7 days) + evaporator campaign (12 days) + shutdown (2 days) = 21 days].

The duration of ten consecutive campaigns is 168 days. Adjusting this value for an operating efficiencies of between 70 and 90% gives a duration for ten consecutive 1-million-gal campaigns of between 6 and 8 months. This is a theoretical time only. To this must be added downtime for maintenance and other issues, and the additional problems associated with transferring millions of gal of waste within tank farms. The 25 DSTs in the 200 East Area contain approximately 24.6 million gal as of April 2007. At a nominal 1.1 million gal per tank, there is no room for the volumes associated with all water sluicing, nor will there be sufficient space cleared up until a number of years following Waste Treatment and Immobilization Plant (WTP) startup. Therefore, evaporation time for water sluicing only will take much longer than 6 to 8 months.

This evaluation of the impact of water-only sluicing should be considered as the minimum possible impact. Other factors (e.g., staging transfers to accumulate the required volume of waste feed, problems associated with sampling and analysis) will cause additional delays of the evaporator operations and further impact waste retrieval operations.

This advantages and disadvantages of using supernate recycle instead of water for retrieval of the waste in tank C-110 are provided in Table 3-3.:

Table 3-3. Advantages and Disadvantages of Using DST Supernate for Retrieval of Insoluble Waste Solids in Tank C-110. (2 Sheets)

Supernate Recycle Advantage	Approximately 1 million gal less liquid effluent discharged from the Liquid Effluent Treatment Facility in the 200 East Area for every 1 million gal of water saved.
Supernate Recycle Advantage	An estimated 13 to 22 fewer drums of waste sent to disposal from the Liquid Effluent Treatment Facility for every 1 million gal of water not added to the tank.
Supernate Recycle Advantage	Supernate recycle provides a huge increase in DST room available for waste retrieved from SSTs. If this volume is not available due to sluicing with water, some SST waste retrievals in addition to that discussed in this document will be delayed, resulting in wastes remaining stored in noncompliant tanks for a longer period.
Supernate Recycle Advantage	There will be a nominal two to three fewer evaporator campaigns for each 1 million gal of water saved.

Table 3-3. Advantages and Disadvantages of Using DST Supernate for Retrieval of Insoluble Waste Solids in Tank C-110. (2 Sheets)

Supernate Recycle Advantage	Supernate recycle will require less fresh NaOH and $NaNO_2$ to be added to bring the resulting DST solutions into the concentration limits specified for corrosion control in Administrative Control (AC) 5.16, "Corrosion Mitigation Controls" (HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*). Depending on other constituent concentrations in the DST solutions following mixing with the insoluble solids slurry and flush water, between 0 and 44,000 kg of 100 % NaOH will need to be added to the DST system to bring each 1 million gal of insoluble solids slurry and flush water into specification. Some additional $NaNO_2$ may also be required depending on other constituent concentrations in the DST solutions following mixing with the insoluble solids slurry and flush water.
Supernate Recycle Advantage	Elimination of the need to process the additional NaOH and $NaNO_2$ chemicals through the WTP. A 44,000-kg addition of sodium to the DST system would require about 15 days of WTP operating time.
Supernate Recycle Disadvantage	The design and equipment costs to recycle supernate are more than the design and equipment costs associated with water addition.
Supernate Recycle Disadvantage	The supernate recycle process is not as flexible due to the added difficulties of maintaining equipment that is contaminated vs. that which has only contacted water.
Supernate Recycle Disadvantage	The supernate recycle process is more complex due to the need for encased lines and leak detection equipment not needed for water only lines.
Supernate Recycle Disadvantage	A DST pump with an adjustable suction or a suction fixed in the supernate well above the sludge level is required for supernate recycle.

3.3 TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION

Technologies considered and rationale for selection

Waste retrieval technologies currently available for deployment at tank C-110 are (1) modified sluicing and (2) the mobile retrieval system (MRS). Modified sluicing uses water or DST supernate to mobilize waste to a pump where it can be removed from a tank. The MRS consists of an articulated mast system, which is a vacuum-based system deployed in the center of the tank with a crawler deployed to move sludge from the perimeter of the tank to the center of the tank where it can be removed with the vacuum system. Water is used as needed to mobilize waste solids in the tank. Water or recycled supernate is added to the aboveground batch receiver vessel for the retrieved waste to aid in transferring the slurry to a DST.

When modified sluicing is performed using DST supernate, the overall volume of waste requiring management (storage and/or volume reduction) in the DST system is significantly reduced over that associated with the MRS. The retrieval duration is also significantly less with modified sluicing.

After considering both candidate waste retrieval technologies and evaluation of the tank as discussed in Section 2.1.3.2, modified sluicing using recycled DST supernate was selected as the preferred technology for deployment in tank C-110.

3.4 ANTICIPATED PERFORMANCE COMPARED TO AGREEMENT CRITERIA

Anticipated performance compared to agreement criteria

The WRS for tank C-110 will be designed to retrieve as much waste from the tank as technically possible with waste residues not to exceed 360 ft^3 or the limit of technology, whichever is less in accordance with the requirements of HFFACO Milestone M-45-00.

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

A simplified diagram of the retrieval system (include flow path, elevation changes, and tank layout).

Figure 3-1 is a proposed installation of ventilation system(s) equipment to support waste retrieval operations. Alternate layouts may also be used. A sketch of the WRS installation planned for tank C-110 is provided in Figure 3-2. A potential HIHTL flow path routing and equipment layout in the tank farm is provided in Figure 3-3. As noted in Section 3.1.1, the elevation in the AN tank farm is approximately 22 ft higher than the elevation in the C tank farm.

3.6 FUNCTIONS AND REQUIREMENTS FOR WRS DESIGN

Functions and corresponding requirements necessary to support design of proposed waste retrieval system. Functions and requirements are to be provided at a level of detail consistent with a Level 1 specification (see RPP-7825 [S-112 F&R], Section 4 and/or RPP-18811 [C-103/105 F&R]).

This section defines the upper-level functions and corresponding requirements to which the C-110 WRS must be designed and operated. This TWRWP is not a system specification that defines design criteria for the WRS. However, the system specification for the C-110 WRS will be consistent with this TWRWP. The functions and requirements are provided in Table 3-3 and are focused on defining the upper-level requirements for the tanks.

Figure 3-1. Potential New Ventilation Equipment Layout.

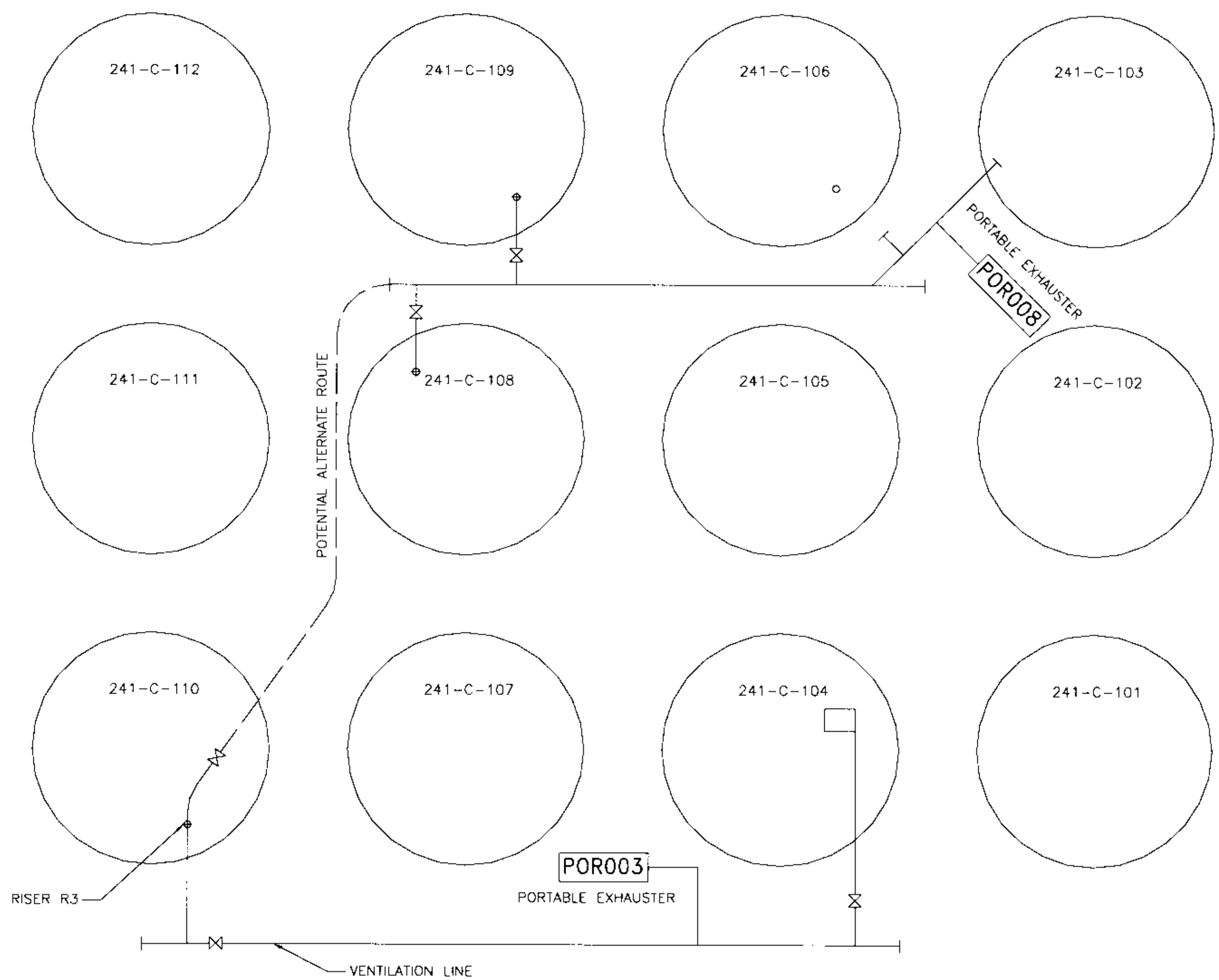


Figure 3-2. Tank C-110 Waste Retrieval System In-Tank Components.

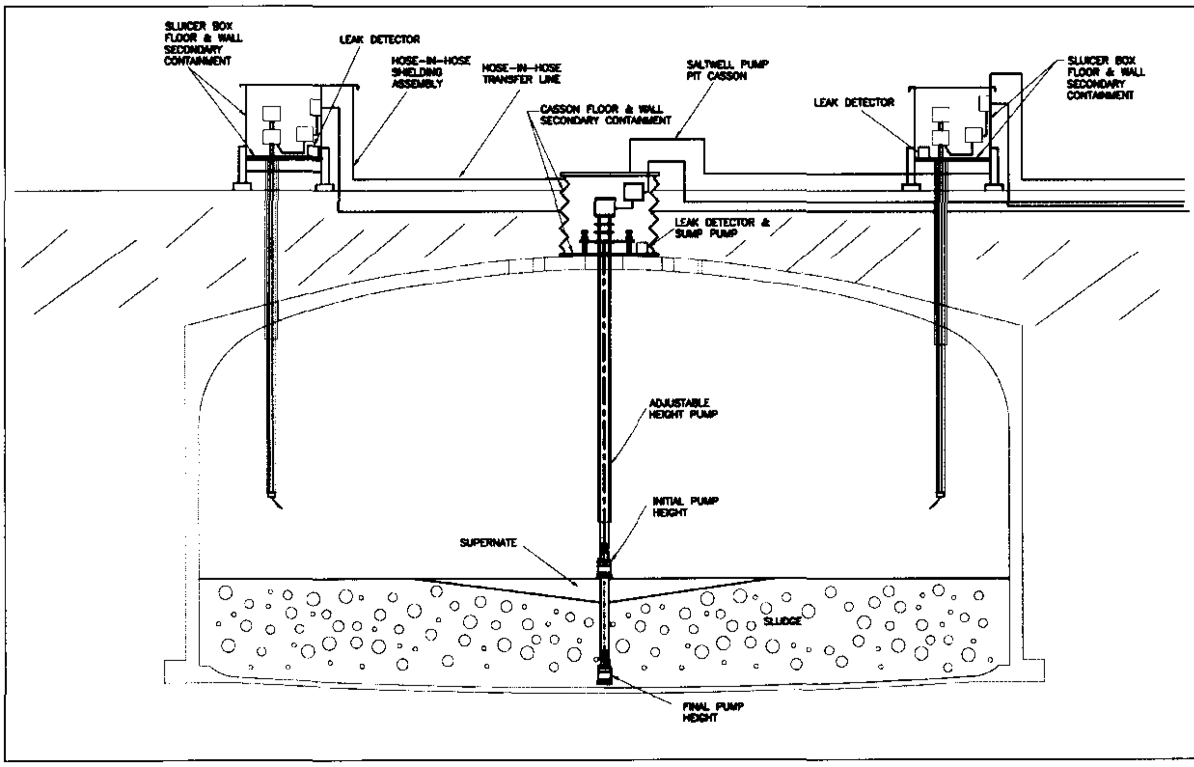


Figure 3-3. Potential HIHTL Flow Path and Equipment Layout for Tank C-110 Waste Retrieval.

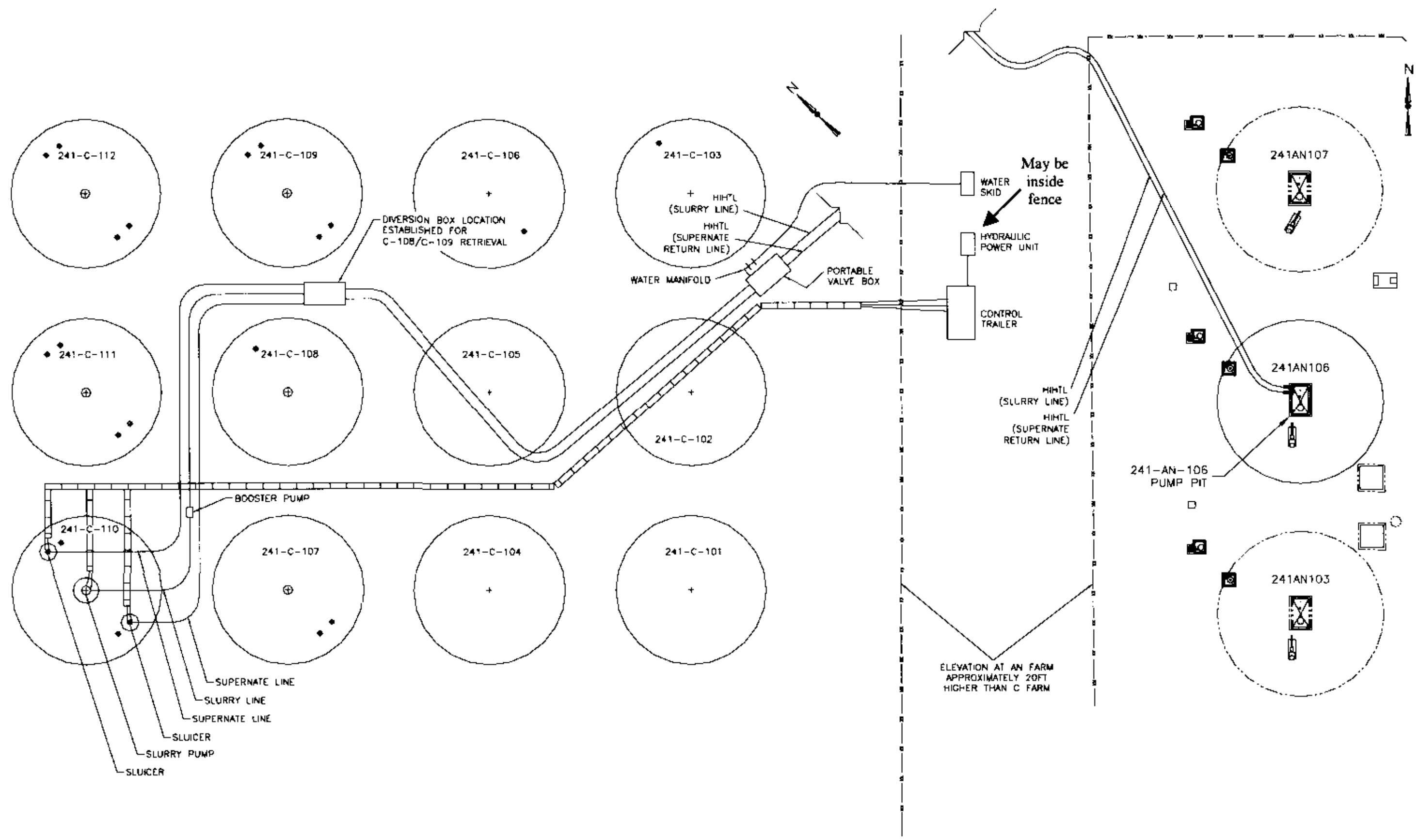


Table 3-4. Tank C-110 Waste Retrieval System Functions and Requirements. (2 Sheets)

Function	Requirement	Basis*	Key Elements
Control gaseous and particulate discharges	The ventilation system exhaust shall be filtered to restrict emissions to the environment.	WAC 173-303 WAC 173-400 WAC 173-460 WAC 246-247 TFC-ESHQ-ENV-STD-03 TFC-ESHQ-ENV-STD-04	Mitigate potential release to the public and the environment.
Mitigate potential for leaks to occur during waste retrieval	Prevent inadvertent release from tank C-110 to the environment.	RPP-13033, Section 3.3.2.3.4	Do not raise waste level above benchmark level. (Benchmark level is discussed in Section 4.6).
Control waste level in DST receiver tank	The WRS shall be operated to maintain waste level within specified allowable maximum and minimum values.	OSD-T-151-00007	Provide for safe waste storage in DSTs.
Remove waste from tank C-110	The WRS shall be capable of removing as much waste as technically possible, with tank waste residues not to exceed 360 ft^3, or the limit of the waste retrieval technology, whichever is less.	WAC 173-303 HFFACO Milestone M-45-00	The WRS shall provide the ability to retrieve as much waste as technically possible.
Control and monitor the waste removal process in tank C-110	The WRS shall provide the monitor and control capability to control the waste retrieval and transfer process. This includes controlling and monitoring the following WRS process parameters: • Pressures • Flow rates • Differential pressures across exhaust ventilation filters • Leak detection systems.	RPP-13033 HNF-SD-WM-TSR-006 WAC 173-303 WAC 246-247 TFC-ENG-STD-26	Provide for safe and effective operation of the WRS.
Minimize waste generation	The WRS shall minimize waste generation to the greatest extent practical.	WAC 173-303 40 CFR 264.73(b)(9)	No numerical requirement.
Nuclear safety	The WRS shall be designed and operated to protect workers, public, the environment, and equipment from exposure to radioactive tank waste and emissions during the retrieval campaign.	WAC 246-247 10 CFR 830 RPP-13033 HNF-SD-WM-TSR-006 HNF-IP-1266	Ensure protection of workers and the public from routine operations and potential accident conditions.
Occupational safety and health	The WRS shall be designed for safe installation, operation and maintenance.	WAC 173-303-2 83(3)(i) 29 CFR 1910 10 CFR 835 29 CFR 1926	OSHA standards. Occupational Radiation Protection.

Table 3-4. Tank C-110 Waste Retrieval System Functions and Requirements. (2 Sheets)

Function	Requirement	Basis*	Key Elements
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features.	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 DST.

* Basis documents reference information is provided in Chapter 9.

DST = double-shell tank.
Ecology = Washington State Department of Ecology.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*
OSHA = Occupational Safety and Health Administration.
WRS = waste retrieval system.

3.7 ANTICIPATED IMPACTS OF TANK WASTE RETRIEVAL ON FUTURE PIPELINE/ANCILLARY EQUIPMENT RETRIEVAL

Anticipated impacts of tank retrieval on future pipeline and ancillary equipment retrieval

The existing buried waste transfer lines routed to tank C-110 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tanks. Following waste retrieval activities, new transfer lines and auxiliary equipment will be flushed as needed and the equipment reused or disposed of as discussed in Section 3.9.

Most line flushes for new transfer lines will direct the flush solution to the receiver DST. However, because of the physical location of C tank farm at a lower elevation than the DST, there will be some line drainback unless the line is air blown after the transfer. The holdup for each transfer line is in the 150- to 200-gal range. This solution would go to tank C-110 or a valve change made to direct the drainage to another SST that had not yet completed retrieval.

Should the situation arise where a structure needs to be flushed following retrieval, it is estimated that the flush volume would be in the 100- to 200-gal range. This solution would go to tank C-110 unless a valve change was made to direct the solution to another SST that had not yet completed retrieval.

When retrieval activities are completed, the exhauster(s) used will be disconnected for use elsewhere. This will require draining the exhauster seal pot back to the receiver tank for the drain line. Such drainage will be in the 0- to 20-gal range.

It is currently planned to leave all in-tank equipment (e.g., the transfer pump) in the tank following retrieval. However, in the unlikely event it is necessary to remove such equipment, it may have to be washed down on removal to remove excess contamination or to reduce exposure for personnel protection. The volume of water expected for such purposes would likely be in the 50- to 500-gal range.

Existing risers, pits, and/or caissons associated with tank C-110 will be isolated following retrieval activities, when agreement has been reached with Ecology on tank C-110 closure. These isolation methods are designed to minimize water intrusion to the tank. However, by the general design and nature of the equipment, intrusion of rainwater or snowmelt cannot be precluded.

The old process lines and pits used for previous waste transfers should have limited potential for containing residual liquid. The abandoned lines were constructed with a positive slope to facilitate drainage (a design requirement) and were either flushed following use or were used for dilute waste transfers that should have minimized significant solid and/or liquid waste buildup in the lines. The pits also contained drains to a collection tank. In accordance with RPP-13774, disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Flushing of old lines or pits would not be done unless required or permitted by the component closure activity plan. Should such flushing be required or necessary, it would not take place until closure activities were underway, so the impact of any line flush volumes would be accounted for in the closure plan approved tank fill process.

Following retrieval, it may be necessary to add small (0 to 50 gal) volumes of water periodically to flush the Enraf plummet prior to tank closure or to flush off heel sample containers. No other activities are envisioned that will purposely add liquids back to a tank once waste retrieval is complete. Should it become necessary to add liquid to a retrieved tank for any reason other than those stated above, Ecology will be notified as specified in existing notification channels.

Post-retrieval intrusion monitoring of the tank is addressed in Section 6.3.

3.8 INFORMATION FOR NEW ABOVEGROUND TANK SYSTEMS

Information to demonstrate compliance with Washington Administrative Code (WAC) 173-303-640 for new above ground systems.

While there are no new aboveground waste tanks or waste treatment systems, the ancillary and containment equipment are considered part of a tank system in accordance with WAC-173-303-040, "Definitions." The waste tank system equipment is described in Section 3.1.1.

A written integrity assessment, reviewed and certified by an independent, qualified registered professional engineer (IQRPE), attesting that the transfer-related equipment and associated transfer lines are suitable for use during waste retrieval operations will be prepared in accordance with WAC 173-303-640(3), "Design and Installation of New Tank Systems or Components," and submitted to Ecology following completion of the design and field installation of the WRS. This includes verification that the subject equipment meets the requirements set forth in WAC 173-303-640(3) and WAC 173-303-640(4), "Containment and Detection of Releases." If additional systems or additional transfer line systems are used, each system will be evaluated by an IQRPE. The design provided to the IQRPE for review will include all new or existing transfer systems, structures or components, including secondary containment (e.g., central caisson) and leak detection equipment, used for C-110 waste retrieval.

The requirements for an IQRPE assessment need and the permitting decision logic for new equipment or repairs/upgrades to equipment will be performed in compliance with RPP-16922, *Environmental Specification Requirements*, latest revision, Section 13.0, *IQRPE Assessment Need and Permitting Decision Logic.*

Risers were assessed as part of the original SST System Integrity Assessment (RPP-10435). SST system components (e.g., risers, pits, etc.) that were identified as part of the SST system for the original Integrity Assessment are not part of the retrieval system (unless specifically identified as such) and do not require a separate or additional integrity assessment if the function of the equipment doesn't change from its original purpose (e.g., the original purpose of risers is to provide tank access) and changes to the component are not outside the original component design basis and specifications.

3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING WASTE RETRIEVAL

Describe the disposition of the system at the completion of waste retrieval.

3.9.1 Disposition of New Waste Retrieval System Components

Following completion of waste retrieval, the in-tank equipment will be left in place for disposition during component closure actions. The above-grade equipment (e.g., transfer lines, valve box, and related enclosures) will be reused to the extent possible for future waste retrieval activities. Transfer lines and related equipment will be flushed to reach acceptable exposure rates for disconnecting and relocating the equipment. Any above-grade equipment that needs to be removed and is not suitable for reuse will be packaged and disposed of as mixed waste onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds. If contaminated equipment is reused it will be controlled as specified in TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices.* Where or if required and needed to support the retrieval of SSTs, the HIHTLs will be managed to ensure the availability and functionality of each as needed for future retrievals. At the conclusion of their mission, or on reaching the end of life for an HIHTL, the HIHTL will be managed in accordance with RPP-12711, *Temporary Waste Transfer Line Management Program Plan.*

3.9.2 Disposition of Existing Ancillary Equipment

Ancillary equipment associated with tank C-110 is limited to waste transfer lines and equipment installed in pits and above-grade risers. The current status of the ancillary equipment associated with tank C-110 is described in Section 2.2. Any existing contaminated ancillary equipment located within risers that needs to be removed following waste retrieval will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds or controlled as specified in TFC-OPS-WM-C-10.

In accordance with the SST System Closure Plan (RPP-13774), disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Closure plans will be incorporated into the SST permit.

3.10 AIR MONITORING PLAN

ORP and CH2M HILL, pursuant to federal requirements for protection of their workers, will develop and implement industrial hygiene (IH) monitoring plans for exhauster stack emissions for the retrieval of tank C-110. The plans will be developed and implemented pursuant to the requirements of TFC-PLN-43, *Tank Farm Contractor Health And Safety Plan.* The constituents of potential concern (COPC) for which exhauster stack sampling and analysis will be conducted will be identified in the IH monitoring plan for the retrieval. The COPC identified in the IH monitoring plans will be all or a subset, as determined to be appropriate by CH2M HILL IH, of those constituents listed in RPP-20949, *Data Quality Objectives for the Evaluation of Tank Chemical Emissions for Industrial Hygiene Technical Basis*, Table 4-1, developed with input from Ecology. Once the initial subset of COPC is identified and listed in the IH monitoring plans, no COPC shall be dropped from that list without 90 days prior notification to and approval from Ecology. If ORP notifies Ecology of its desire to cease exhauster stack sampling for a COPC initially identified and listed in an IH monitoring plan and no response is received from Ecology within 90 days, the COPC will be deleted from the IH monitoring plan and sample and analysis activities for that COPC will cease. New COPCs may be added to an IH monitoring plan without notification to or approval from Ecology and without modifying or revising this TWRWP.

The sampling and analysis methods shall be U.S. Environmental Protection Agency (EPA), National Institute for Occupational Safety and Health, or Occupational Safety and Health Administration approved methods or an equivalent CH2M HILL-approved method, as identified in RPP-20949. The exhauster stack samples will be analyzed at the 222-S Laboratory, the Waste Sampling and Characterization Facility, or an equivalent laboratory consistent with the quality assurance/quality control procedures for that laboratory. Further, laboratory analysis data will be kept on file at the laboratory consistent with the laboratory record keeping procedures for that laboratory for a period of not less than 5 years and will be available to Ecology within 24 hr on request.

Ecology and ORP understand and agree that the activities discussed above do not restrict ORP and CH2M HILL from taking any and/or all steps necessary as ORP and CH2M HILL deem appropriate to protect its workforce in response to data and information generated by an IH monitoring plan or incidents as they might arise during waste retrieval. Ecology and ORP also understand and agree that the preceding sampling and analysis discussion is presented to ensure ORP is achieving the agreed to sampling and analysis for the protection of the public and its workers and does not modify the exemption from the requirements of 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart CC, granted to ORP under 40 CFR 265.1080(b)(6). Therefore, this discussion does not imply any change to the respective authority of either Ecology or ORP regarding the sampling, analysis, monitoring, and control of airborne emissions from Hanford Site tanks.

4 DESCRIPTION OF PLANNED LEAK DETECTION AND MONITORING TECHNOLOGIES

4.1 EXISTING TANK LEAK MONITORING

This section describes tank leak monitoring activities that have been historically performed or are currently being performed.

Prior to beginning retrieval operations, single-shell tanks are in waste storage mode. The requirements for leak detection while in waste storage mode are provided in OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection.* When retrieval operations are ready to commence for C-110 the tank enters retrieval mode as described in 4.2.

4.1.1 Drywell Monitoring

> *Identify the number and location of drywells near the subject tank. Identify ongoing routine drywell monitoring activities. (configuration, depth, frequency of and methodology for sampling)*

Seven drywells are spaced around tank C-110 between 5 and 19 ft from the edge of the tank (Figure 4-1). The seven drywells include 30-10-01, 30-10-02, 30-07-11, 30-07-10, 30-00-09, 30-10-09, and 30-10-11. Six of these seven drywells are 100 ft deep with drywell 30-00-09 being 58 ft deep.

For tanks in waste storage mode there is no routine drywell logging performed.

4.1.2 Groundwater Monitoring

> *Identify the number and location of groundwater monitoring wells associated with the Waste Management Areas (WMA). Summarize current groundwater monitoring activities.*

Groundwater monitoring at WMA C was begun in 1990 using four RCRA groundwater monitoring wells constructed in 1989 (299-E27-12, 299-27-13, 299-E27-14, and 299-E27-15). The groundwater beneath the C tank farm has been monitored since 2001 in accordance with the RCRA groundwater monitoring plan established in 2001 (PNNL-13024, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*). Figure 4-2 provides a plan view of the C tank farm and the surrounding RCRA groundwater monitoring wells. There are nine groundwater monitoring wells surrounding the C tank farm (four new wells were constructed in 2003). Since June 2002, groundwater sampling for the groundwater wells 299-E-27-7, 299-E-27-12, 299-E-27-13, 299-E-27-14, and 299-E-27-15 has been performed on a quarterly basis (PNNL-13024, ICN-1). Since December 2003, new groundwater monitoring wells 299-E-27-4, 299-E-27-21, 299-E-27-22, and 299-E-27-23 have also been sampled on a quarterly basis. Quarterly samples are analyzed at a minimum for anions, cyanide, inductively coupled plasma metals, gross beta, ^{99}Tc, and total uranium, and a low-level gamma scan is performed.

The quarterly groundwater monitoring that is currently performed is adequate for the purpose of supplementary data collection during waste retrieval. Ecology is provided quarterly groundwater monitoring sample results in the quarterly and annual groundwater monitoring reports. These reports were previously issued by Pacific Northwest National Laboratory (e.g., results from the groundwater monitoring at the C tank farm for the third quarter of 2006 are reported in PNNL-16349, *Quarterly RCRA Groundwater Monitoring Data for Period July through September 2006*), in 2007 they started being issued by Fluor Hanford.

If a leak is detected during retrieval, groundwater monitoring frequency will be reevaluated in accordance with the regulatory requirements in WAC 173-303, "Dangerous Waste Regulations."

4.1.2.1 Use of Groundwater Monitoring for Retrieval Process Control.

> *(1) Evaluate the use of appropriately located existing groundwater monitoring wells for retrieval process control.*

Based on the limitations of flow transport calculations and the time required for a retrieval leak to show up in groundwater samples, groundwater monitoring data will not be used for retrieval process control, but is available, for background reference information only, through the site groundwater monitoring program.

4.1.2.2 Groundwater Sampling Prior to and Following Retrieval.

> *(2) Ensure that appropriately located existing groundwater monitoring wells will be sampled within a two month period prior to and following the retrieval (quarterly sampling satisfies this requirement).*

PNNL-13024, ICN-1, requires quarterly groundwater sampling for the C-farm groundwater monitoring wells. In accordance with 04-TPD-083 – letter, it was agreed to in writing by ORP, Ecology, and the tank farm contractor that quarterly groundwater sampling satisfies the TWRWP outline requirement C.1.b.(2) (this wording is in italics at the start of Section 4.1.2) to take groundwater samples within a 2-month period prior to and following retrieval.

4.1.3 Existing Tank Level Monitoring Equipment and Activities

> *Identify existing level measurement instrumentation in the subject tank and receiver tank. Identify ongoing tank level monitoring activities.*

Tank C-110 currently has an operable Enraf level gauge installed on riser 4. Tank AN-106 currently has the same type of level gauge installed on its riser 4. Tank AN-106 also has three conductivity probe gauges installed in the annulus. These annulus level gauges are used for detection of leaks from the tank primary tank liner.

The waste level in C-110, while in storage mode, is monitored for intrusion only on a quarterly basis (OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*). The basis for in-tank leak detection and intrusion monitoring is provided in RPP-9937, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements Document.*

The primary level monitoring in the receiver DST is performed as described in OSD-T-151-00031, Section 4.0. The three annulus leak detector probes provide indication of tank leaks as described in OSD-T-151-00031, Section 4.0.

Level monitoring for the tank receiving the exhauster condensate, if not C-110, will be performed as specified in the applicable Ecology approved TWRWP for that tank.

Figure 4-1. Plan View of the C Tank Farm Showing Drywells.

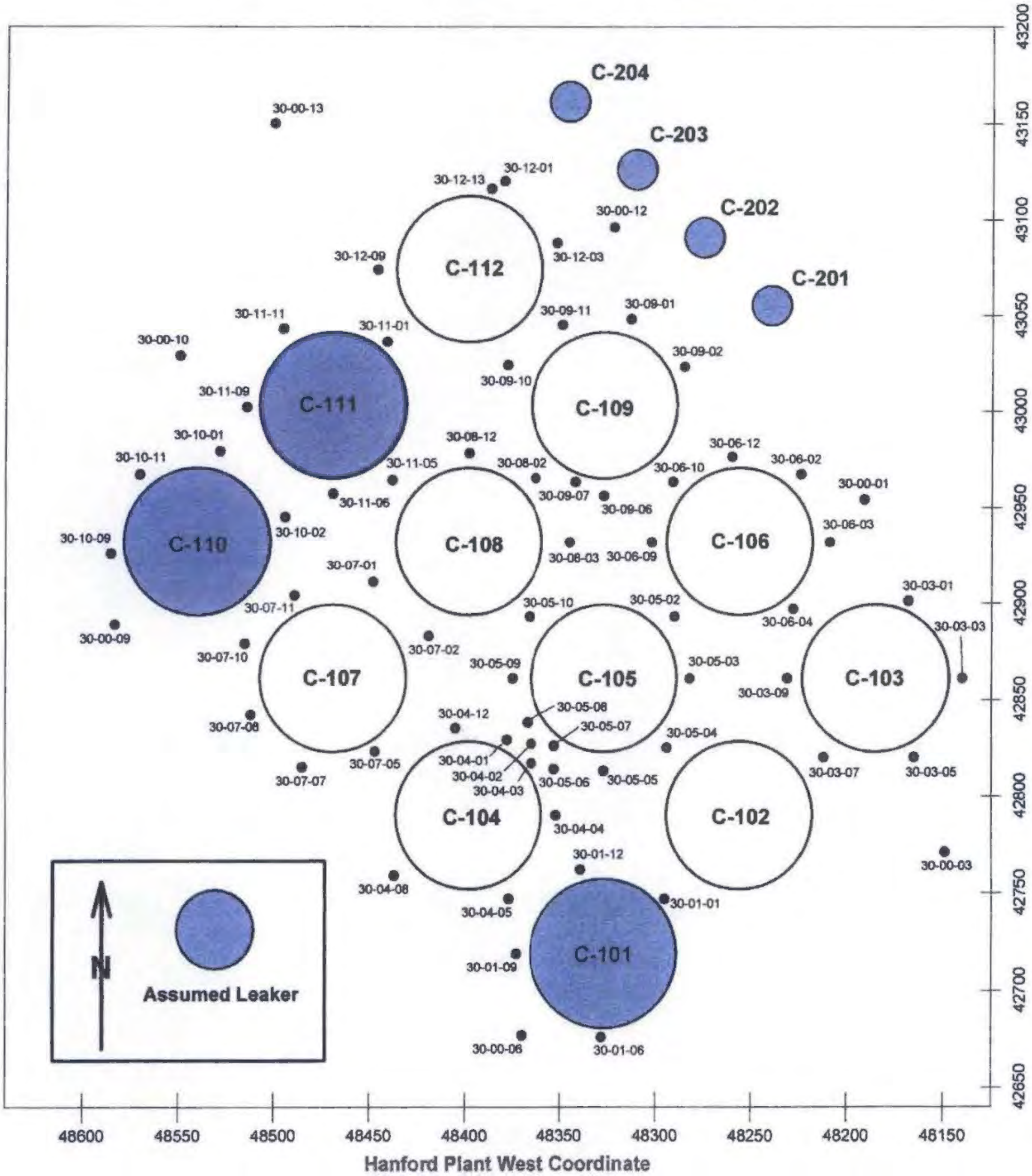
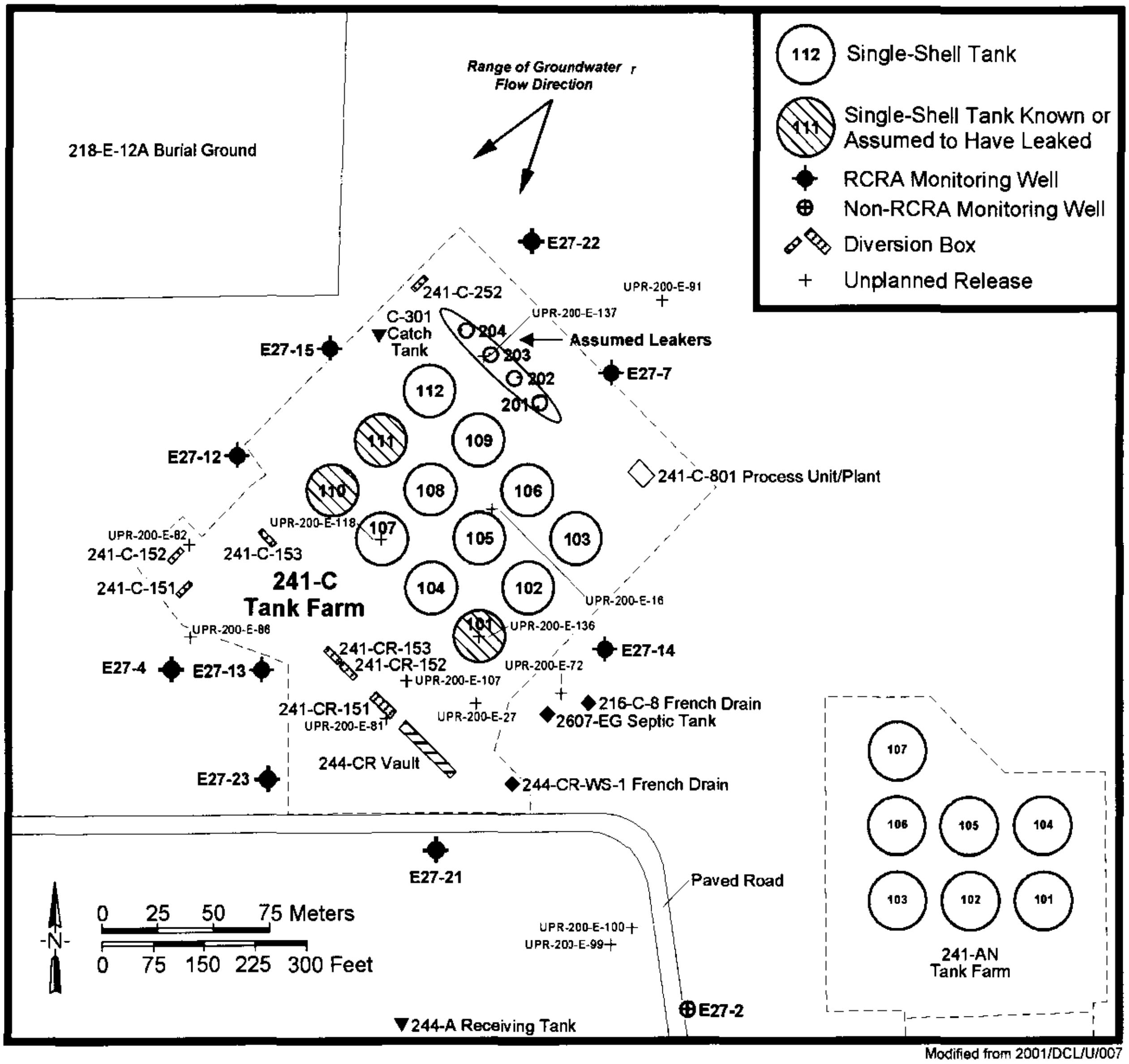


Figure 4-2. Waste Management Area C and Regulated Structures.*



* Adapted from Figure B.18 in PNNL-14548, Hanford Site Groundwater Monitoring for Fiscal Year 2003.

4.2 PROPOSED LEAK DETECTION MONITORING SYSTEM DESCRIPTION

This section provides a description of the leak detection and monitoring (LDM) system that will be deployed at tank C-110 during waste retrieval along with a description of how it will be operated.

The definition of when a tank is changed from storage mode to retrieval mode is provided in OSD-T-151-00031. A tank is considered to be officially in retrieval status if one of two conditions is met: either waste has been physically removed from the tank by retrieval operations or, preparations for retrieval operations are directly responsible for rendering a primary leak detection or intrusion monitoring device out of service. Should the definition of retrieval status change in OSD-T-151-00031, the revised definition will take precedence over that stated here.

When all waste removal operations have been completed, a final waste volume measurement obtained, and all post-retrieval monitoring required by this document completed, the tank retrieval status is maintained but retrieval leak detection is complete and the tank is monitored for intrusion as specified in Section 6.3.

4.2.1 Description of Proposed LDM System Configuration Used During Waste Retrieval

(Physical and Operating)

a. Describe the proposed LDM system configuration to be used during waste retrieval.

The leak detection and monitoring (LDM) method for tank C-110 during retrieval uses deployment of a high-resolution resistivity (HRR) LDM system with drywells and the tank thermocouple as electrodes. The HRR system will be fully implemented administratively as well as physically implemented in the field when used.

Established drywell logging methods will be used to survey the drywells surrounding C-110 prior to the start of retrieval, and will be used as a backup means of leak detection if the HRR system becomes inoperable. The use of drywell logging as a backup is specified in 4.2.1.1.

Under limited conditions, as specified in 4.2.1.2, SST liquid level measurement may also be used for leak detection and monitoring.

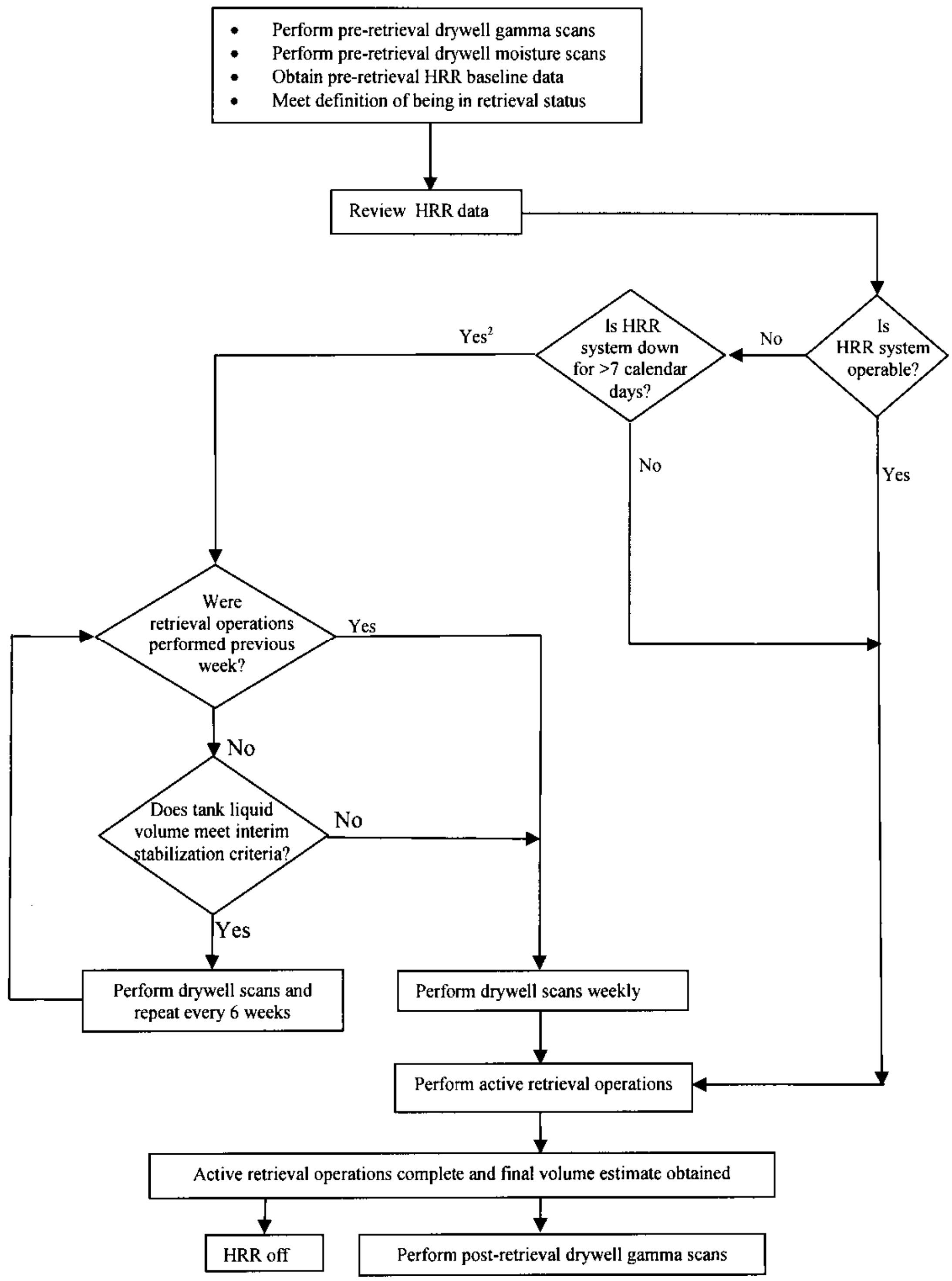
Figure 4-3 is a logic chart showing what leak detection method(s) are used, and when. Details of the methods shown in Figure 4-3 are provided in 4.2.1.1 through 4.2.1.3.

LDM systems consisting of standard leak detection arrangements are used for transfer lines and pits.

The LDM system used for AN-106 is the same one described in Section 4.1.3.

Any resulting changes to LDM activities described in this TWRWP will be approved by Ecology within 24 hours through the Change Notice form.

Figure 4-3. Leak Detection Methodology for SST Retrieval.[1]



[1]Leak detection using SST level measurement may supersede HRR and drywell monitoring when criteria in 4.2.1.2 are met
[2]Only until HRR back in service

4.2.1.1 Drywell Monitoring. Drywell logging refers to use of moisture gauges and/or gross gamma detectors to monitor soil conditions surrounding the tank for increases in moisture content and/or gamma activity that may be evidence of tank leakage. Drywell logging will be performed as follows:

- Gamma scans will be obtained for each listed drywell prior to initiation of retrieval operations in the tank
- Moisture scans will be obtained for each listed drywell, excluding 30-00-09, prior to initiation of retrieval operations in the tank
- After retrieval operations have been initiated drywell logging will only be performed if needed as a backup leak detection method.
- Gamma scans will be obtained for each listed drywell following completion of active retrieval operations in the tank

Should a pre-retrieval gamma scan show an unexpected presence of radioactivity in the soil adjacent to any of the listed drywells, and the unexpected reading is confirmed, the tank leak assessment process in procedure TFC-ENG-CHEM-D-42 would be implemented. Retrieval activities as described in this work plan would not commence until the unexpected reading had been evaluated and shown to not alter the leak status stated in 2.1.3 for the tank whose waste was to be retrieved.

Current plans include monitoring of the following drywells prior to waste retrieval from tank C-110:

> 30-10-01, 30-10-02, 30-07-11, 30-07-10, 30-00-09 (gamma only), 30-10-09, and 30-10-11.

There is a potential that access to some drywells may be precluded by the placement of equipment or shielding, restricted due to ALARA (as low as reasonably achievable) concerns, or alterations to the tank farm surface as a part of ongoing waste retrieval activities.

Drywell 30-00-09 is double-cased with 8- and 12-in. casing, and possibly (probably) annular grout. This makes it unsuitable for moisture monitoring, (and of limited use for gross-gamma monitoring).

The pre- and post-retrieval gamma scans will be obtained from near the ground surface to near the bottom of each drywell.

The pre-retrieval moisture scans will be obtained from near the ground surface to near the bottom of each drywell. Pre-retrieval moisture logging is performed to provide a baseline for comparison should moisture logging be required for backup leak detection during waste retrieval.

Should moisture logging be necessary after the start of waste retrieval activities, significant increases in soil moisture levels would be followed up by performing a gamma scan to determine if the moisture increase was due to a waste leak. If there is an unexplained increase in soil moisture content observed during moisture logging and access is not practical for any gamma monitoring system, Ecology will be informed and an alternate means of investigation proposed.

Since post-retrieval gamma scans are to be performed following retrieval, there is no need to perform a post-retrieval moisture scan.

Drywell logging, when performed as a backup leak detection method, will monitor specific region(s) of interest for increases in soil moisture (or gamma) content. These may include the interval from above the existing waste surface to below the base of the tank. The depth interval to log when drywell logging is performed as a backup leak detection method will be specified in the process control plan.

Due to operational constraints, required drywell logging may be missed occasionally if it is used as backup to HRR. Ecology will be informed of missed required drywell monitoring.

Pre- and post-retrieval drywell gamma logging and any gamma logging done during retrieval operations may be performed with the radionuclide assessment system (RAS truck), the radionuclide monitoring system (RMS), or the spectral gamma system (SGLS). Moisture logging will be performed with hand-held moisture probes or any of the vehicle mounted systems setup for moisture logging. The following background information describes the drywell logging tools, what they measure, and general measurement capabilities.

The handheld moisture gauge is a commercially available system (model 503DR HYDROPROBE®)[2] designed for manual measurement of in situ moisture content. This unit employs an ^{241}Am/Be neutron source and a neutron detector to measure the neutron flux rate at a given depth in the drywell. A formula is then used to relate the neutron flux rate to volume percent moisture in the soil. Use of the handheld moisture gauge does not require truck access into the tank farm and is more practical for frequent use.

The RAS truck was specifically designed for routine gamma monitoring against the baseline established from the spectral gamma logging system data. The RAS uses a series of three interchangeable NaI(Tl)-based scintillation detectors for measurement over the range from background levels to about 10^5 pCi/g ^{137}Cs. The RAS records counts in specific energy ranges as well as total gamma activity. Although it does not have the energy resolution capability of the spectral gamma logging system, it is mounted on a smaller truck and collects data at a faster rate.

The RMS is a modular, portable logging unit capable of concurrent measurement of gross gamma activity and neutron moisture content. The RMS will have calibrated neutron moisture and gross (total) gamma detectors on a combined probe. It will provide dual data logs over preselected depth intervals in the drywells. The overall size and portability of the RMS will minimize interference with surface equipment, and the capability of collecting both moisture and gamma data in a single log run can result in a significant reduction in the cost of monitoring activities when compared to obtaining separate neutron and gamma logs. The RMS also provides for electronic data recording. When implemented, the RMS may be substituted for the handheld moisture gauge and may also be used in place of truck-mounted logging systems. Drywells with very high gamma activity (none of the seven around tank C-110 are in this

[2] 503DR HYDROPROBE® is a registered trademark of CPN International, Inc., Concord, California.

category) may still require the use of the high rate logging system that is part of the SGLS, but it is possible that a high rate detector can be developed for the RMS. Development of the RMS is complete but as of mid 2008 it is not yet available for deployment. It is anticipated that the RMS will have a measurement range from background up to 100,000 pCi/g ^{137}Cs and 0 to 25 vol% moisture content.

The SGLS logging system was used to establish baseline conditions in 1995-2000. This logging system is based on a liquid nitrogen cooled high purity germanium detector, which provides excellent gamma energy resolution for identification and quantification of individual radionuclides from background levels (method detection limit about 0.1 pCi/g ^{137}Cs under typical conditions) up to about 10,000 pCi/g ^{137}Cs. A high rate detector with internal and external shields is available to extend the measurement range to about 10^9 pCi/g ^{137}Cs.

The SGLS truck can also be used to operate a neutron moisture logging system, which measures in situ vadose zone moisture over the range of 0 to about 25 vol% moisture content. The neutron moisture logging system uses a similar source-detector relationship as the handheld moisture gauge.

It takes about one shift of operation to obtain moisture logging data from all the drywells around a tank with the hand-held moisture probe. It takes about one shift of operation to obtain RAS data from one drywell.

The handheld moisture gauge will be deployed by qualified personnel in accordance with TO-320-022, *Operate Model 503DR Hydroprobe Neutron Moisture Detection.*

The logging systems will be deployed by qualified personnel in accordance with the applicable procedures for that equipment.

The results from drywell monitoring, as well as a summary and analysis of this monitoring, including tools used, calibration, boreholes logged, depth of logging, frequency, logging rate, and data analysis will be submitted to Ecology within the retrieval data report in accordance with Appendix I of the HFFACO.

4.2.1.2 Leak Detection Using SST Liquid Level Measurement. SST level measurement data are normally limited during periods when active retrieval operations are not being performed due to the strategy of minimizing liquid in the tank. In addition, because of the dished bottoms of the tanks and the location of the level instrumentation near the side in the C-100 series SSTs, waste levels cannot be measured below approximately 12,000 gal. However, should conditions exist where a continuous liquid surface measurement is available (e.g., a pump fail prior to removing as much liquid as practical from the tank and replacement of the pump cannot occur immediately) this measurement could provide an additional means of leak detection superior to either drywell monitoring or HRR. SST Liquid level measurement can be used for leak detection during waste retrieval under the following conditions:

a. The tank level gauge must be an Enraf level gauge of the type normally used in tank farms

b. There must be a liquid surface under the Enraf plummet, with no part of the plummet touching any waste solids or the tank bottom

c. There are no active retrieval operations being performed

d. The tank is not being actively exhausted

e. The measured waste level is not increasing, such as can occur if liquid is slowly draining from waste solids above the liquid surface

Material balance will not be credited for SST leak detection during the retrieval of C-110.

4.2.1.3 High-Resolution Resistivity. HRR will be used for leak detection during the retrieval of the waste in C-110. The equipment operates continuously except when down for repairs, calibrations, electrical outages, or similar reasons. Should a problem occur which renders the HRR leak detection system inoperable, drywell monitoring would be used as a backup means of leak detection, within the conditions specified in Figure 4-3 and 4.2.1.1.

The HRR method uses geophysical resistivity measurements as a means to detect changes in baseline soil moisture levels. The electrical resistivity of the soil around and beneath a waste tank depends on a number of parameters, one of which is moisture content. The leakage of water or tank waste into these sediments changes the soil resistivity. The HRR method detects a potential leak by comparing a present resistivity measurement against a previously obtained baseline measurement. Comparison to a baseline allows the HRR method to discount existing resistivity differences in the soil caused by factors that include conductive structures or prior leaks. Changes in soil moisture from precipitation need to be taken into consideration during monitoring to reduce the potential for making an incorrect leak determination.

HRR data processing, data review, leak evaluation methodology and definitions of anomalies and unexplained anomalies are described in RPP-32477, *High Resolution Resistivity Leak Detection Data Processing and Evaluation Methods and Requirements.* The HRR leak detection requirements in RPP-32477 and in this TWRWP will be implemented in approved procedures by trained and designated personnel prior to the start of waste retrieval operations.

The basic resistivity measurement concept utilizes the existing drywells and/or a tank electrode (normally the tank thermocouple) as measurement electrodes. There are reference transmitter and receiver electrodes located a nominal 1,500 ft or more from the tank farm. Power is applied to a drywell-reference transmitter electrode pair and an amperage measurement obtained. Concurrently, a voltage measurement is obtained at another electrode-reference receiver electrode pair. Soil resistivity is calculated by dividing the voltage measured across the receiver electrode pair by the current measured across the transmitter pair. These measurements are repeated continuously and the subsequent resistivity data analyzed for changes with time.

The HRR data may be reviewed any time. When the system is operating the raw data is normally less than an hour old.

Ecology will be informed via e-mail or phone if an unexplained HRR anomaly exists. The response to an unexplained HRR anomaly is described in 4.6. It is anticipated that three months or more may be needed to analyze all the available data and obtain any needed supporting information to enable resolution of the unexplained HRR anomaly. If, after three months, the unexplained HRR anomaly has not been resolved, Ecology will be consulted as to possible changes in groundwater and analyte monitoring frequency.

A limitation to the HRR system is that it provides data primarily as a two-dimensional diagram from the viewpoint of looking down on the tank. Thus a leak may be detected by HRR, and the general location of the leak around the tank noted, but the actual depth may or may not be able to be discerned from the data.

4.2.1.4. Leak Detection in Transfer Lines and Pits During Waste Retrieval. Supernate will be transferred from the receiver DST and liquid waste and slurry will be transferred from C-110 back to the receiver DST using temporary hose-in-hose overground transfer lines and pits. Leak detectors located in pits will be monitored during waste transfers. Leaks may also be detected by monitoring flows and by radiation monitoring of the HIHTL in accordance with the requirements of RPP-13033 and RPP-12711, *Temporary Waste Transfer Line Management Program Plan.* Pits associated with the receiver tank will also be monitored.

Leakage from the primary overground transfer hose (inner hose) will be contained by the secondary confinement system (outer hose). The secondary confinement system is designed to drain any fluid released from the primary hose to a common point for collection, detection, and removal. Leak detection elements are installed in pits at the ends of the transfer lines. If a leak occurs the liquid will contact the detector, which will actuate an alarm and the transfer pumps shut down either automatically or manually.

4.2.1.5 Leak Detection in Tank AN-106 During Waste Retrieval. The existing leak detection systems in the receiver DST will be utilized as required in OSD-T-151-00031. A leak from the primary vessel of the receiver DST will be detected by a conductivity probe installed in the annulus.

4.2.2 Use of Drywells and Groundwater Wells During and After Waste Retrieval

b. Describe the proposed use of existing drywells and groundwater monitoring wells during and after waste retrieval operations.

During waste retrieval operations existing drywells will be monitored if needed as a backup means of leak detection as described in Section 4.2.1.1.

The post-retrieval gamma scans may be done by any of the gamma logging methods discussed in Section 4.2.1.1 within 6 months following the completion of waste retrieval on the tank.

Groundwater monitoring wells will be sampled and the samples analyzed both during and after waste retrieval operations as described in Section 4.1.2.

4.3 RATIONALE FOR SELECTION OF LEAK DETECTION MONITORING TECHNOLOGY

Rationale for selection of LDM technology.

The LDM technology selected for deployment at tank C-110 represents the best available technology. The HRR system, as described in Section 4.2.1.3 is believed to provide improved leak detection monitoring over that provided by drywell monitoring.

Pre-retrieval drywell gamma scans are performed to provide an updated baseline for that drywell prior to initiation of waste retrieval activities.

Pre-retrieval drywell moisture logging is performed to provide a baseline for that drywell prior to initiation of waste retrieval activities in case moisture logging is required as a backup means of leak detection during waste retrieval activities.

A pre-retrieval HRR baseline is performed since HRR leak detection is based upon observation of resistivity change from an established baseline.

Post-retrieval gamma scans will be obtained for conservatism, to verify there has been no significant change from the pre-retrieval gamma scans.

Use of SST liquid level data for leak detection, when such data are available and obtained under the conditions listed, would provide a leak detection capability exceeding that provided by drywell logging or HRR.

4.4 LEAK DETECTION FUNCTIONS AND REQUIREMENTS

Functions and attendant requirements necessary to support design of proposed LDM system(s). Functions and requirements to be provided at a level-of-detail consistent with a Level 1 specification (see RPP-7825 [S-112 F&R], Section 4 and/or RPP-18811 [C-103/105 F&R]).

This section defines the upper-level functions and corresponding requirements to which the leak detection systems for tank C-110 must be designed and operated. The system specification for the C tank farm 100 series tanks will be consistent with this TWRWP. The functions and requirements for LDM are given in Table 4-1.

Table 4-1. Tank C-110 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from tank C-110	The LDM system shall be capable of detecting liquid waste releases during all waste removal operations.	WAC 173-303	Utilize LDM technologies to detect loss of liquid from a tank; see Section 4.2.1.
Monitor leaks from tank C-110 during waste removal	The WRS shall be capable of providing data to support quantifying leak volumes from the tanks in the event a release is detected during waste retrieval operations.	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 tank C-110 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 4.6.
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 DST.

DST = double-shell tank.
LDM = leak detection and monitoring.
WRS = waste retrieval system.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."

DOE O 435.1, 2001, *Radioactive Waste Management.*

HNF-SD-WM-TSR-006, 2005, *Tank Farms Technical Safety Requirements.*

RPP-13033, 2005, *Tank Farms Documented Safety Analysis.*

WAC 173-303, "Dangerous Waste Regulations."

4.5 ANTICIPATED TECHNOLOGY PERFORMANCE

Anticipated technology performance capability (discuss deployment, data collected, timeliness of data analysis for process control).

4.5.1 Drywell Monitoring

There is no single value that can be stated as the maximum leak that could go undetected by drywell monitoring for tank C-110.

There are a wide range of variables that influence the effectiveness of drywell monitoring. A Monte Carlo-type analysis of drywell monitoring performance for SST leak detection was prepared that considered the impact of all significant variables (RPP-10413, *Tank S-112 Saltcake Waste Retrieval Demonstration Project Leak Detection, Monitoring, and Mitigation Strategy*, Appendix B). This document provided the results of an in-depth computer analysis that evaluated the variables affecting drywell monitoring performance, varied them over selected ranges and calculated the leak volume which might occur by the time of leak detection. Over 100,000 combinations were analyzed. The following wording on drywell monitoring performance in italics is extracted from RPP-10413.

From Section 5.3 of RPP-10413:

....For slow leak rates ranging from 0.03 gal/hr to 1.44 gal/hr, the travel time and associated leak volumes for a leak originating near a drywell are small. The theoretical leak volume and associated time required to reach a drywell from the center of the tank floor to a drywell (modeled as a 45-foot distance) are larger. Detection of a slow leak from the center of the tank floor with a drywell is unrealistic as the time required for sufficient liquid to leak from the tank and migrate to the drywell is significantly longer than the planned waste retrieval duration. Summary statistics for travel time and total volume leaked under slow leak conditions are shown in Table 5.2 [this is Table 5.2 in RPP-10413, not a table in this work plan]. *The mean values for travel times are 12 days for the 10-foot distance and 2.0 years for the 45-foot distance. The corresponding mean values for volume leaked are 100 gallons and 6,200 gallons. The 5th and 95th percentile values are also listed in Table 5.2. Approximately 90% of the results fall between these two extremes.*

Table 5.2. Summary Statistical Results for Ex-Tank leak Detection Response Time (for leaks less than 1.5 gal/hr)

Parameter	***10-foot Distance (f = 0.75)***	***45-foot Distance (f = 0.50)***
Mean travel time	*12 d*	*710 d (2.0 y)*
Median travel time	*4.8 d*	*290 d (0.80 y)*
5th percentile time	*1.0 d*	*59 d*
95th percentile time	*43 d*	*2,600 d (7.1 y)*
Mean volume leaked	*100 gal*	*6,200 gal*
Median volume leaked	*73 gal*	*4,400 gal*
5th percentile volume	*20 gal*	*1,200 gal*
95th percentile volume	*300 gal*	*18,000 gal*

Notes: The mean value is the sum of the times or volumes divided by the number of trials. The median value is the time or volume is [sic] *the 50th percentile in the cumulative distribution (i.e., half the results lie below the median value). The 5th and 95th percentiles show the range of times or volumes that encompass 90% of the calculated results.*

Additional uncertainty analyses were performed to evaluate a larger range in potential leak rates. Historical leak rates were reviewed and a range in-tank leak rates from 0.03 to 102 gal/hr. To account for the higher probability of a slow leak compared to a fast leak a lognormal distribution was assigned to the leak rate parameter (referred to as the *lognormal leak rate model). For this leak range the 95th percentile volume at both the 10-foot and 45-ft distance increased over those shown in Table 5.2. The summary statistics for the larger leak rate range are provided in Table 5.3* [this is Table 5.3 in RPP-10413, not a table in this work plan]……...

Table 5.3. Summary Statistical Results for Ex-Tank leak Detection Response Time (for large leaks)

Parameter	*10-foot Distance (f = 0.75)*	*45-foot Distance (f = 0.50)*
Mean travel time	*20 d*	*1,200 d (3.3 y)*
Median travel time	*2.2 d*	*130 d*
5th percentile time	*0.07 d*	*4.1 d*
95th percentile time	*72 d*	*4,400 d (12 y)*
Mean volume leaked	*100 gal*	*6,200 gal*
Median volume leaked	*73 gal*	*4,400 gal*
5th percentile volume	*20 gal*	*1,200 gal*
95th percentile volume	*300 gal*	*18,000 gal*

Notes: The mean value is the sum of the times or volumes divided by the number of trials. The median value is the time or volume is [sic] *the 50th percentile in the cumulative distribution (i.e., half the results lie below the median value). The 5th and 95th percentiles show the range of times or volumes that encompass 90% of the calculated results.*

From Attachment B3 of RPP-10413:

The main text shows stochastic results for two leak-to-drywell distances, 10 ft. and 45 ft. In this appendix, the leak-to-drywell distance (B) is allowed to vary over the bottom and side surfaces of the tank. It will be assumed that a leak could occur anywhere on the sides or bottom of the underground tank. It is further assumed that the sides are more likely locations for the leak. A probability distribution is constructed for B and the distribution of travel times is calculated. Three cases are considered. The first has only one drywell for the tank. The second has two drywells on opposite sides of the tank. The third case has three drywells evenly spread around the tank. As might be expected, as the number of drywells, increases, the mean travel time decreases.....

...The stochastic results for these three cases are summarized in Table B3.1 [this is Table B3.1 in RPP-10413, not a table in this work plan]. *As the number of drywells increases, the moisture travel time and volume leaked decrease....*

Table B3.1 Summary of Stochastic Results

Parameter	*One*	*Two*	*Three*
Mean travel time	*2,670 d*	*650 d*	*234 d*
Median travel time	*716 d*	*144 d*	*54 d*
5^{th} percentile time	*6.6 d*	*3.4 d*	*2.5 d*
95^{th} percentile time	*10,500 d*	*2,5900 d*	*924 d*
Mean volume leaked	*23,100 gal*	*5,620 gal*	*2,030 gal*
Median volume leaked	*11,200gal*	*2,1600 gal*	*795 gal*
5^{th} percentile volume	*105 gal*	*59 gal*	*46 gal*
95^{th} percentile volume	*87,700 gal*	*22,400 gal*	*7,980 gal*

Notes: The mean value is the sum of the times or volumes divided by the number of trials. The median value is the time or volume is [sic] *the 50^{th} percentile in the cumulative distribution (i.e., half the results lie below the median value). The 5^{th} and 95^{th} percentiles show the range of times or volumes that encompass 90% of the calculated results.*

Drywell logging is a currently deployed technology and has been used for a number of years within the tank farms. Some of the equipment such as the RMS is newly developed, but the basic principles of operation remain the same. It normally requires about a shift to perform handheld moisture logging on all the drywells around a tank, assuming a 15- to 30-ft logging range with data taken every foot. Approximately one shift is required to do a gamma scan with the RAS truck on one drywell, based on a full 75-100-ft scan. If the RAS was used only over the same range as the hand-held moisture logging, more than one drywell could possibly be logged in a shift. Logging a well with the RMS vehicle, when approved for use, should take less time that for the RAS. A full SGLS scan of a single drywell will take a shift. If the SGLS scan was limited to the same depth range as the hand-held moisture monitoring, more than one drywell might be logged in a shift.

The data collected during moisture logging consists of neutron counts at different depths below grade in a drywell. These neutron counts are converted to a soil volume percent water using a formula developed for each source/detector combination. Data may be taken manually or electronically.

The data collected during gamma logging consists of count rates at different depths below grade in a drywell. These counts can be reviewed as a total count rate at that specific depth or for the SGLS converted to a soil radionuclide concentration with a formula developed for each detector. Electronic data are recorded on a storage medium.

Moisture logging data sheets are normally given to data analysis personnel the same or following day from when the logging was performed. In instances such as when logging is done on a day when personnel are normally off, it may be several days before the sheets are reviewed.

Following review, operations personnel are notified by data analysis personnel of out of the ordinary readings. This notification will thus usually be 1 to 2 days after the data are taken, but in limited instances may be up to 4 days.

The keys to leak mitigation strategy are detailed in Section 4.6.1.

Data collected with the handheld moisture gauge will be analyzed within a few days. Data collected with the truck-mounted logging system will be analyzed within a few weeks under normal operations.

Due to the uncertainty and variance in the performance of the technology, there is no instantaneous method to measure leak migration rates.

4.5.2 SST Liquid Level Monitoring

Should the conditions listed in 4.2.1.2 be met, SST level monitoring can provide a leak detection capability that exceeds that for either drywell monitoring or HRR. The accepted accuracy of an Enraf gauge is ±0.1 in., or ±275 gal when the reading is taken within the 75 ft. diameter section of the tank. The precision of the gauge is ±0.01 in., or ±28 gal. An Enraf gauge operating on a liquid surface could easily note a decrease in liquid level of less than 275 gal. Such a decrease would not automatically indicate a tank leak. The decrease would need to be evaluated to determine if there were other causes besides a leak.

4.5.3 HRR Leak Detection

During the leak injection test performed in 2006 adjacent to tank S-102 a non-radioactive salt solution was injected into the ground at depth of approximately the base of the tank. The solution for the first test was injected into the soil, and the solution for the nine additional tests injected into the soil wetted by the first test. RPP-30121, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Test Report*, indicates that these 'leaks' were detected 8 of the 10 times, and for those 8 detections the leak volumes at the time of detection were in the nominal range of 100 to 600 gal. RPP-30121 further states that the leak detection capability of the HRR injection test system, based upon all 10 tests, is a volume of 2,100 gal at a 95% confidence interval. This statement is only applicable to the HRR injection test system in the geometry and under the conditions and leak rates tested ('tank' simulated as a 6 inch diameter steel pipe extending downward approximately 100 ft with the leak occurring at a depth of approximately 45 ft., 5 to 20 gal/h leak rates).

It is reasonable to assume that the response for an HRR system deployed around an SST in C-Farm may be somewhat less than that reported in RPP-30121 for the leak injection test setup due to the differences in geometry between the test setup and a 100 Series SST in C-Farm, including the presence of concrete around the steel SST body which may diffuse or hold up leakage. There may also be a slightly lower conductivity for the liquids stored in the C-Farm tanks when compared to the injection test salt solution. Based on past tank leak experience, the rate of an actual tank leak would also likely be less than the range of leak rates tested in the leak injection test. Due to these differences and other limitations preventing direct extrapolation of test results to field deployment for C-110, a quantitative value cannot be stated for the leak detection capability of an HRR system deployed in C-Farm. However, it can be qualitatively stated that based upon experience at the Mock Test Site, the S-102 leak injection test, observation of the response of surface electrodes tested both at S-102 and C-103, and general HRR system operation both in S-Farm and C-Farm it is believed an HRR system deployed in C-Farm should provide leak detection capability better than the calculated drywell monitoring leak detection capability in Section 4.5.1. HRR interrogates the soil around and under a tank. The system sensitivity may decrease somewhat with the distance of an electrode (drywell) from the tank, but resistivity changes were still seen with drywells 100 ft. away from the injection point during the injection testing. With drywell logging, waste liquid likely needs to be less than a foot from the drywell to be detected by moisture monitoring. Gamma monitoring could probably detect a leak when the liquid was 2 to 3 ft. from the drywell, depending upon conditions. With the much larger area interrogated by HRR, HRR is expected to have a much better sensitivity for leak detection when using the drywell-to-tank electrode data upon which the leak injection test conclusions were based. Sensitivity for HRR leak detection using drywell-to-drywell data is less under most conditions than that for drywell-to-tank data, but is still expected to be better than drywell monitoring due to the larger soil volume interrogated by HRR.

The leak detection capability for HRR is also enhanced in comparison to drywell monitoring since it operates on a near continuous basis, except when out of service.

Due to the uncertainty and variance in the performance of the technology, there is no instantaneous method to measure leak migration rates.

The data collected during HRR consist of voltage and amperage readings taken at periodic intervals for all electrode combinations. These are converted into a soil resistivity reading by dividing the voltage by the amperage. The raw data are then processed through software and analyzed for trends that may be indicative of a tank leak. The raw calculated resistivity values can also be reviewed directly without processing.

The HRR data may be reviewed any time by qualified personnel. The raw data available may be an hour or less old. Processed data lags 4 to 6 hr behind the raw data due to the need to wait for a number of data sets to pass to perform spike rejection and filter the data. If the data are reviewed once a day the data used may thus be from less than 1 to 54 hrs old when first reviewed.

4.6 MITIGATION STRATEGY

Mitigation strategy including a response plan to a detected leak (identify responses to various leak rates) including notifications and provisions for obtaining approval of any remedial actions.

4.6.1 Leak Mitigation for Waste Retrieval Tank Leak

The leak mitigation strategy (i.e., reduction of leak loss potential) is to minimize the liquid volume within the tank during waste retrieval operations. Leak minimization for a waste retrieval tank leak will be provided by actions taken during waste retrieval. These include the following:

- The in-tank liquid inventory during waste retrieval will be less than liquid level present in the tank before interim stabilization activities were undertaken.
- Addition of liquid to the retrieval tank is minimized and liquid pools that form are removed as practical.
- Liquid inventories will be removed between waste retrieval campaigns.
- Waste is retrieved to the extent practical by working from the center of the tank outwards.
- Evaluating HRR system data as specified in Section 4.2.1.3.
- Equipment handling controls are used to minimize the potential for dropping equipment into the tank, which could penetrate the tank bottom during installation.
- Maintaining a benchmark level in the tank. The waste level shall not exceed this benchmark. The benchmark level shall be defined in the process control plan, but for C-110 must be below 144 in. above the bottom centerline of the tank. The benchmark will be as close to the current nominal 70 in. level in the tank as reasonably practical, while maintaining sufficient leeway for operational flexibility during the initial stages of retrieval.

If there is a need to operate the system longer than currently planned to demonstrate the limit of the technology to recover waste that is difficult to retrieve, the basic leak minimization step is still to limit the volume of any free liquid in the tank.

The 'timeliness' of any leak response action is dictated in part by how often the HRR data (or drywell monitoring data when used as a backup means of leak detection), are reviewed. Until a potential leak is noted there is no leak response, only the steps enumerated above to minimize the leak potential and leak volume. Anomalies noted during HRR data review are evaluated for leak potential. When this data review indicates an unexplained anomaly exists that may be caused by a potential tank leak, all liquid additions to the tank are stopped and the leak assessment process is begun.

The leak assessment process steps are:

- Implement TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*, leak assessment procedure. No specific completion times are stated for the referenced steps in the leak assessment process. Leak assessment steps in TFC-ENG-CHEM-D-42 include:
    - **Review available information and identify additional information needs.** Available information includes in-tank and ex-tank measured data (e.g., surface level, flow rate, barometric pressure); tank process history; historical drywell logs; photographs; etc.
    - **Develop specific leak and non-leak hypotheses.** Analysts and subject matter experts develop leak and non-leak hypotheses through a concurrence approach.

- **Assess leak probability.** The probability for each leak and non-leak hypothesis is calculated. The probability assessment is reviewed and concurred with by the analysts.

- **Prepare leak assessment report.** The leak assessment report includes the information reviewed, discussion of hypotheses considered, summary of analysts' assessments, summary of mathematical probabilities, and final determination.

- Ecology will be informed within 72 hours that the evaluation process in TFC-ENG-CHEM-D-42 was initiated and that retrieval operations have been suspended to validate if a leak has occurred.

- During the leak assessment process, continue to retrieve liquid from the tank as practical. There is also no timeline for this step; this operation would continue if it was already being performed. If waste retrieval operations were not being performed and there was free liquid in the tank that could be removed, this removal would commence as soon as resources could be assembled to begin pumping, and the route to the receiver DST, and the DST itself, were available and able to accept the transfer.

There is no specific timeline for stopping liquid addition to the tank, it would occur as soon as direction was sent to field personnel to halt liquid addition. This direction would be sent as soon as operations management was notified following receipt of information that showed an unexplained anomaly existed.

The response to a potential leak will be the same regardless of the leak rate.

If the leak assessment concludes that no leak is indicated, waste retrieval operations will resume under normal operating procedures. Should a leak be validated, the operating contractor will notify the appropriate regulatory agencies in accordance with TFC-ESHQ-ENV_FS-C-01, *Environmental Notification.* This includes notification to Ecology pursuant to the requirements of WAC 173-303.

If the event or condition meets one of the occurrence reporting criteria, TFC-OPS-OPER-C-24, *Occurrence Reporting and Processing of Operations Information*, provides a number of steps to follow leading up to the point where the environmental notification procedure TFC-ESHQ-ENV_FS-C-01 is applied. Procedures are in place that direct immediate actions necessary to stabilize the facility/operation to a safe condition and preserve conditions for subsequent investigation (TFC-OPS-OPER-C-24). The applicable steps related to Ecology notification excerpted from TFC-ESHQ-ENV_FS-C-01 include:

- Notify Tank Farm Contractor Environmental personnel of the leak.

- Determine if the spill or release exceeds 40 CFR 302, "Designation, Reportable Quantities, and Notification," reportable quantity for the material.

- Determine if a RCRA contingency plan needs to be implemented.

- Notify Ecology and the Washington State Department of Health if the reportable quantity has been exceeded and/or the RCRA contingency plan has been implemented. (Note: These notifications are performed per specific requirements on a checklist.)

4.6.2 Leak Mitigation for Receiving Tank Leak

The only receiver tank for C-110 waste is a DST. The primary mitigation strategy for a DST leak is to maintain operable leak detection systems and respond as specified in procedures to potential or confirmed leaks.

The following is a summary of leak mitigation actions for a DST. A more detailed discussion can be found in HNF-3484, *Double-Shell Tank Emergency Pumping Guide*, and RPP-5842, *Time Deployment Study for Annulus Pumping.*

Actions taken in the event of a leak of waste from primary tank piping into the secondary containment system of the DST system or other receiver tank during a waste transfer from an SST to a DST include (1) stopping the flow of waste into the tank system (stopping the transfer), (2) pumping waste in the primary tank to another DST until the liquid level in the secondary containment is no longer increasing, and (3) removing the waste from the secondary containment system as soon as practicable. Tanks that develop leaks at or near the tank bottom may also require salt well jet pumping to remove trapped liquids from between solid layers in the tank.

The response to a DST leak would be the same regardless of whether the leak was due to a transfer leak into the annulus or a leak of the DST primary tank. Notifications are performed per specific checklist requirements and transmitted to the listed parties no later than noon of the next business day.

The following specific conditions associated with DST leak detection that require Ecology notification are excerpted from TFC-ESHQ-ENV_FS-C-01:

- Leak detection equipment preventive maintenance or functional testing that will exceed 24 hours downtime.
- Leak detection equipment repair that will require more than 90 days to complete.
- Annulus leak detector alarms that are not due to operational activities; intrusion caused alarms that do not clear within four hours of annunciation must be reported.
- Operating annulus continuous air monitor readings that equal or exceed the continuous air monitor alarm setpoint, and are not due to atmospheric radon or its decay products, or not due to operational activities (e.g., annulus contamination due to vacuum imbalance between annulus and primary tank ventilation system or other operational activity).

The above leak detection and mitigation systems are approved and implemented through the DST RCRA permitting process.

4.6.3 Leak Mitigation for Transfer Line Leak

Transfer line leakage occurring near the DST would likely drain to the DST receiver tank. All other transfer line leakage will drain back to either the SST being retrieved or a containment structure on the transfer line. Leakage to the containment structure is transferred to the SST being retrieved. Response to transfer leak detection alarms is performed per procedure (procedures for waste transfer will be developed before waste retrieval operations).
Leak detection is performed in a similar manner to, and response is similar to that for, existing tank farm transfers. There is nothing unique to the tank waste retrieval leak detection system logic when compared to existing tank farms transfer leak detection. Leak mitigation is provided by the design of equipment that channels all leakage into an outer encasement that drains to an alarmed location and a collection tank. The transfer is shut down when the alarm occurs.

Should a leak be detected in the aboveground diversion boxes or pits, the waste transfer pumps would be shut down and the leakage would be transferred to the SST being retrieved using the sump pump. Leaks within one of the sluicer boxes will result in pump shutdown with leakage draining to the SST. Leaked waste will be returned to the SST being retrieved instead of the DST receiver tank because the elevation of the receiver DST farms is higher than that at the C tank farm and wastes leaked to the secondary containment of the transfer lines would drain to the containments at the C tank farm, and leaked wastes would not be transferred to the DST through a transfer system with unknown or questionable integrity. The leaks would be repaired or the leak location bypassed before resuming waste retrieval operations.

Should a visible (aboveground) leak or release be detected during waste retrieval operations, any transfers in progress would be stopped immediately and response actions defined inRPP-27869, *Building Emergency Plan for Tank Farms*, would be implemented. A visible leak or spill would only occur as a result of an accident or equipment failure. RPP-27869 identifies the facility hazards, including hazardous materials, and defines the facility-specific emergency planning and response. The emergency plan also describes incident response actions including the initial response actions to immediately protect the health and safety of persons in the affected area, determining if emergency notification is necessary, and taking steps necessary to ensure that a secondary release, fire, or explosion does not occur. The response actions also include steps taken to collect and contain released waste per the regulatory requirements of WAC 173-303.

5 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Summaries of documents (training plans, contingency plans, emergency response plans, reporting, record keeping, inspection summaries, etc.) as required for waste retrieval by WAC 173-303.

Retrieval of waste from the SSTs will be performed under the requirements of the HFFACO, the *Atomic Energy Act of 1954*, and RCRA, RCW 70.105, "Hazardous Waste Management Act" and their implementing regulations. The SSTs do not provide secondary containment and are not compliant with RCRA and RCW 70.105 interim facility standards of Subpart J of 40 CFR 265. The SSTs are currently authorized to continue operations under RCW 70.105 pending closure in accordance with WAC 173-303-610, "Closure and Post-Closure," under the authority of HFFACO Milestone M-45-00, "Complete Closure of all Single Shell Tanks Farms." Except as otherwise modified by HFFACO Milestone M-45-00, DOE conducts day-to-day operations of the SSTs in accordance with the interim facility standards established in WAC-173-303-400(3), "Interim Status Facility Standards." WAC 173-303-400(3) incorporates by reference the interim status performance standards set forth by the EPA in 40 CFR 265. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the *Atomic Energy Act of 1954* and various DOE directives incorporated into the contract between ORP and the tank farm contractor (DE-AC27-99RL-14047). These requirements are implemented through operating plans and procedures by the tank farm contractor.

Interim status facility standards in WAC 173-303-400(3)(a) incorporate by reference the interim status standards set forth by EPA in 40 CFR 265 Subpart J for tank systems. Elements of the interim status standards relevant to the WRS along with the WRS features and/or operating plans and procedures are summarized in Table 5-1.

If required, approval to retrieve waste that could contain polychlorinated biphenyls (PCBs) from tank C-110 using supernate from the receiver DST and transfer the resulting slurry to the receiver DST will be obtained from EPA before initiating waste retrieval operations. The DST supernate is classified as PCB remediation waste in accordance with Ecology et al. (2000), *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste*. Because the DST supernate is classified as PCB remediation waste, the retrieval of waste from SSTs when using DST supernate requires a Risk-Based Disposal Approval, approved by EPA, pursuant to the *Toxic Substances Control Act of 1976.*

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
265.15 [WAC 173-303-320], General Inspection Requirements	(a) The owner or operator must inspect his facility for malfunctions and deterioration, operator errors, and discharges (b) The owner or operator must develop and follow a written schedule for inspecting all monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment that are important to preventing, detecting, or responding to environmental or human health hazards. (c) The owner or operator must remedy any deterioration or malfunction of equipment or structures which the inspection reveals on a schedule which ensures that the problem does not lead to an environmental health hazard. (d) The owner or operator must record inspections in an inspection log or summary.	RPP-16922, Section 10, contains the Interim Status inspection schedule for both the SST and DST systems. The inspection requirements are implemented through Operator Rounds and Shift Office tickle files. Deficiencies discovered by operators are entered into the Problem Evaluation Request system and resolved through the Tank Farm Contractor work control process contained in TFC-OPS-MAINT-C-01.
265.16 [WAC 173-303-330], Personnel Training	(a) Facility personnel must successfully complete a program of classroom instruction or on-the-job training that teaches them to perform their duties in a way that ensures the facility's compliance with the requirements of this part. (b) Facility personnel must successfully complete the program required in paragraph (a) of this section within six months after the date of their employment or assignment to a facility, or to a new position at a facility, whichever is later. Employees hired after the effective date of these regulations must not work in unsupervised positions until they have completed the training requirements of paragraph (a) of this section. (c) Facility personnel must take part in an annual review of the initial training required in paragraph (a) of this section (d) The owner or operator must maintain records at the facility (e) Training records must be kept until closure of the facility	TFC-PLN-07 contains the training requirements for tank farm workers. Completion of the requirements is recorded in the ITEM. ITEM records are also used to support regulatory agency inquiry during compliance inspections. Tank farm employees who enter the TSD portion of the facility also complete, at a minimum, 24-hr hazardous waste worker training. Employees who may come in contact with tank waste complete the 40-hr hazardous waste worker training. Both groups complete annual 8-hr hazardous waste worker refresher training.
Subpart D [WAC 173-303-350] [WAC 173-303-360], Contingency Plan and Emergency Procedures	265.51 [WAC 173-303-350 (1)]: Each owner or operator must have a contingency plan. 265.52 [WAC 173-303-350 (2) and (3)]: (a) The contingency plan must describe the actions facility personnel must take in response to fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water	The Tank Farm Contingency Plan, which supports both the SST and DST systems, is contained in RPP-27869. Supporting the contingency plan are the abnormal operating procedures and the emergency response procedures. Required notifications are contained in TFC-ESHQ-ENV_FS-C-01. The contingency plans are maintained in the

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
	(b) If the owner or operator has already prepared a Spill Prevention, Control, and Countermeasures (SPCC) Plan or some other emergency or contingency plan, he need only amend that plan to incorporate hazardous waste management provisions. (c) The plan must describe arrangements agreed to by local police departments, fire departments, hospitals, contractors, and State and local emergency response teams. (d) The plan must list names, addresses, and phone numbers of all persons qualified to act as emergency coordinator (e) The plan must include a list of all emergency equipment at the facility (f) The plan must include an evacuation plan for facility personnel 265.53 [WAC 173-303-350 (4)]: A copy of the contingency plan must be maintained at the facility. 265.54 [WAC 173-303-350 (5)]: A contingency plan must be reviewed, and immediately amended, if necessary, whenever: (a) Applicable regulations are revised (b) The plan fails in an emergency (c) The facility changes (d) The list of emergency coordinators changes (e) The list of emergency equipment changes 265.55 [WAC 173-303-360 (1)]: At all times, there must be at least one employee either on the facility premises or on call with the responsibility for coordinating all emergency response measures. 265.56 [WAC 173-303-360 (2)]: (a) Whenever there is an imminent or actual emergency situation, the emergency coordinator must immediately: (1) Activate internal facility alarms or communication systems (2) Notify appropriate State or local agencies (b) Whenever there is a release, fire or explosion, the emergency coordinator must immediately identify the character, exact source, amount, and real extent of any released hazard. (c) The emergency coordinator must assess possible hazards to human health or	Waste Feed Operations and the Closure Operations shift office. The on-duty Shift Manager serves as the Building Emergency Director. Emergency pumping of the DST is guided by emergency pumping guide HNF-3484. The Building Emergency Plan is maintained and updated as required by the Waste Feed Operations Support group.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
	the environment (d) If the emergency coordinator determines that the facility has had a release, fire, or explosion which could threaten human health, or the environment, outside the facility, he must report his findings. (e) The emergency coordinator must take all reasonable measure necessary to ensure that fire, explosions, and releases do not occur, recur, or spread to other hazardous waste at the facility (f) If the facility stops operations in response to a fire, explosion or release, the emergency coordinator must monitor for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment, wherever this is appropriate (g) Immediately after an emergency, the emergency coordinator must provide for treating, storing, or disposing of recovered waste, contaminated soil or surface water, or any other material that results from a release, fire, or explosion (h) The emergency coordinator must ensure that no waste that may be incompatible with the released material is treated, stored, or disposed of until cleanup procedures are completed and all emergency equipment listed in the contingency plan is cleaned and fit for its intended use before operation is resumed (i) The owner or operator must notify the Regional Administrator, and appropriate State and local authorities, that the facility is in compliance with paragraph (h) before operations are resumed (j) The owner or operator must note in the operating record the time, date, and details of any incident that requires implementing the contingency plan. Within 15 days after the incident, submit a written report on the incident to the Regional Administrator.	

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
265.73 [WAC 173-303-380], Facility Recordkeeping	(a) The owner or operator must keep a written operating record	The written operating record for tank farms consists of the following: • Completed operator rounds • Shift Manager log books • Completed corrective maintenance and preventative maintenance procedures and packages
265.191, Assessment of existing tank systems integrity	(a) For each existing tank system that does not have secondary containment meeting the requirements of 265.193, the owner or operator must determine that the tank system is not leaking or is unfit for use. (b) This assessment must determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture, or fail. (d) If, as a result of the assessment conducted a tank system is found to be leaking or unfit for use, the owner or operator must comply with the requirement of 265.196.	(a) and (b): RPP-10435 prepared and submitted under HFFACO Milestone M-23-24. (d) Because the SSTs are not compliant with RCRA 40 CFR 265.191, the SSTs are currently authorized to continue operations pending closure under the authority of the HFFACO milestone M-45-00.
265-192 [WAC 173-303-640], Design and Installation of New Tank Systems or Components	(a) Owners or operators of new tank systems or components must ensure that the foundation, structural support, seams, connections, and pressure control (if applicable) are adequately designed and that the tank system has sufficient structural strength, compatibility with the waste to be stored or treated, and corrosion protection so that it will not collapse, rupture, or fail. The owner or operator must obtain a written assessment, reviewed and certified by an independent, qualified, registered professional engineer attesting that the system has sufficient structural integrity and is acceptable for the storing and treating of hazardous waste. (b) The owner or operator of a new tank systems must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation. Prior to covering, enclosing, or placing a new tank system or component in use, an independent, qualified installation inspector or an independent, qualified, registered professional engineer, either of whom is trained and experienced in the proper installation of tank systems, must inspect the system or component. (c) New tank systems or components and piping that are placed underground and that are backfilled must be provided with a backfill material that is a	The HIHTL design and installation is verified and certified by an IQRPE. Aboveground retrieval tank systems are verified and certified by an IQRPE (e.g., RPP-16666). System design and IQRPE certification ensure that parts (a), (b), (c), (d), and (e) are met. Cathodic protection is not installed on the HIHTL.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
	noncorrosive, porous, homogeneous substance that is carefully installed so that the backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported. (d) All new tanks and ancillary equipment must be tested for tightness prior to being covered, enclosed, or placed in use. (e) Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement vibration, expansion or contraction (f) The owner or operator must provide the type and degree of corrosion protection necessary to ensure the integrity of the tank system during use of the tank system. The installation of a corrosion protection system that is field fabricated must be supervised by an independent corrosion expert to ensure proper installation (g) The owner or operator must obtain and keep on file at the facility a written statement by those persons required to certify the design of the tank system and supervise the installation of the tank system in accordance with the requirements of this section to attest that the tank system was properly designed and installed and that repairs were performed. These written statements must also include the certification statement.	
265.193, Containment and Detection of Releases	(a) In order to prevent the release of hazardous waste or hazardous constituents to the environment, secondary containment must be provided (b) Secondary containment must be: (1) Designed, installed, and operated to prevent any migration of waste or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system (2) Capable of detecting and colleting releases and accumulated liquids until the collected liquid can be removed. (c) To meet the requirements of paragraph (b) of this section, secondary containment must be at a minimum: (1) Constructed of or lined with materials that are compatible with the waste(s) to be placed in the tank system and must have sufficient strength and thickness to prevent failure due to pressure gradients, physical contact with the waste to which it is exposed, climatic conditions, the stress of installation, and the stress of daily operation.	The above ground retrieval system equipment is designed with compliant secondary containment. Design documentation is available for inspection.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
	(2) Placed on a foundation or base capable of providing support to the secondary containment system and resistance to pressure gradients above and below the system and capable of preventing failure due to settlement, compression, or uplift. (3) Provided with a leak-detection system that is designed and operated so that it will detect the failure of either the primary and secondary containment structure or any release if hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the existing detection technology or site conditions will not allow detection of a release within 24 hours. (4) Sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed form the secondary containment system with 24 hours, or in as timely a manner as is possible to prevent harm to human health or the environment, if removal of the released waste or accumulated precipitation cannot be accomplished within 24 hours. (d) Secondary containment for tanks must include one or more of the following devices; (1) A line (external to the tank) (2) A vault (3) A double-walled tank (4) An equivalent device as approved by the Regional Administrator. (e) [Applies to the design of external liners, vaults, and double-walled tanks.] (f) Ancillary equipment must be provided with full secondary containment except for: (1) Aboveground piping (exclusive of flanges, joints, valves, and connections) that are visually inspected for leaks on a daily basis (2) Welded flanges, welded joints, and welded connections that are visually inspected for leaks on a daily basis (3) Sealless or magnetic coupling pumps and sealless valves that are visually inspected for leaks on a daily basis (4) Pressurized aboveground piping systems with automatic shutoff	

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
	devices that are visually inspected for leaks on a daily basis.	
265.194, General Operating Requirements	(a) Hazardous wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail. (b) The owner or operator must use appropriate controls and practices to prevent spills and overflows from tank or containment systems. They include at a minimum: (1) Spill prevention controls (2) Overfill prevention controls (3) Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation	(a) The waste compatibility assessment ensures solutions and materials are compatible prior to addition. (b) Control of the waste retrieval process is defined in the process control plan for each retrieval: (1) System design. (2) The receiving DST has primary tank level instrumentation which is monitored during transfers. (3) Not applicable.
265.195, Inspections	(a) The owner or operator must inspect, where present, at least once each operating day: (1) Overfill/spill control equipment (2) The aboveground portions of the tank system, if any, to detect corrosion or release of waste (3) Data gathered from monitoring equipment and leak-detection equipment (e.g., pressure and temperature gauges, monitoring wells) to ensure that the tank system is being operated according to its design (4) The construction materials and the area immediately surrounding the externally accessible portion of the tank system including secondary containment structures to detect erosion or signs of release of hazardous waste (b) The owner or operator must inspect cathodic protection systems, if present, according to, at a minimum, the following schedule to ensure that they are functioning properly (1) the proper operation of the cathodic protection system must be confirmed within six months after initial installation and annually thereafter (2) All sources of impressed current must be inspected and/or tested, as appropriate, at least bimonthly (c) The owner or operator must document in the operating record of the	RPP-16922, *Environmental Specification Requirements,* Section 10, contains the interim status inspection requirements for the tank farms. The inspection requirements are implemented through Operator Round Sheets. Inspection and verification of operation of the cathodic protection systems is accomplished through tank farm contractor approved procedures. The completed cathodic protection procedures and operator round sheets are part of the written operating record.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
	facility an inspection of those items *(above)*	
265.196 [WAC 173-303-640 (3)(c)(vii)], Response to leaks or spills and disposition of leaking or unfit-for-use tank systems	A tank system or secondary containment system from which there has been a leak or spill, or which is unfit for use, must be removed from service immediately, and the owner or operator must satisfy the following requirements; (a) Cessation of use; prevent flow or addition of wastes (b) Removal of waste from tank system or secondary containment system (c) Containment of visible releases to the environment (d) Notifications, reports	Responses to leak or spills applicable to requirement are defined in Sections 4.6.2 and 4.6.3.
WAC 173-303-283 (3), Performance standards	The owner/operator must design, construct, operate, or maintain a dangerous waste facility that to the maximum extent practical given the limits of technology prevents: (a) Degradation of ground water quality; (b) Degradation of air quality by open burning or other activities; (c) Degradation of surface water quality; (d) Destruction or impairment of flora and fauna outside the active portion of the facility; (e) Excessive noise (f) Conditions that constitute a negative aesthetic impact for the public using rights of ways, or public lands, or for landowners of adjacent properties; (g) Unstable hillsides or soils as a result of trenches, impoundments, excavations, etc.; (h) The use of processes that do not treat, detoxify, recycle, reclaim, and recover waste material to the extent economically feasible; and (i) Endangerment of the health of employees, or the public near the facility.	The following plans and procedures and their implementation provide the preventative measures required: (a) Groundwater monitoring plan (PNNL-13024). (b) No open burning is allowed. (c) Berms and gutters are in place to prevent surface runoff and surface run-on. (d) No destruction or impairment of flora and fauna occur outside of the tank farms. (e) Noise is monitored per tank farm contractor procedures. (f) The tank farms are within the dangerous waste facility (i.e., Hanford site). (g) Appropriate permits are obtained before excavation work is started. No excavation work is associated with tank waste retrieval. (h) The waste retrieval process is designed, constructed and will be operated to treat and recover waste to the limits of technology in accordance with HFFACO milestone M-45-00 (see Section 3.4). (i) The public is protected by the NOC per

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (9 Sheets)

Regulation	Requirement	Compliance Method
		WAC 173-303-400 & 460. Workers are protected per TFC-PLN-43.
WAC 173-303-400, Interim Status Facility Standards	Incorporates by reference 40 CFR 265 with the exception of 265.1 (c)(4), 265.149-150 and 265.430. Replaces federal terms in 40 CFR 265 (i.e., regional administrator, hazardous) with state terms (i.e., department, dangerous)	

* Documents references information is provided in Chapter 9 of this document.

CH2M HILL = CH2M HILL Hanford Group, Inc.
DST = double-shell tank.
HFFACO = *Hanford Federal Facility Agreement and Consent Order*.
HIHTL = hose-in-hose transfer line.
IQRPE = independent, qualified, registered professional engineer.
ITEM = Integrated Training Electronic Matrix.
NOC = notice of construction.
SST = single-shell tank.
TSD = treatment, storage, and disposal.

6 PRELIMINARY ISOLATION EVALUATION

(preliminary evaluation to be finalized in follow-on closure plans)

This section provides a preliminary isolation evaluation for tank C-110. Intrusion prevention measures were completed in the 1990s for this tank. The identification of tank penetrations and methods used to isolate intrusion pathways are described in Section 2.2. Isolation details for intrusion measures completed for C-110 are provided on the following drawings:

a. *Piping Waste Tank Isolation C-Tank Farm Plot Plan* (H-2-73338, Sheet 1)
b. *Piping Waste Tank Isolation Tk 241-C-110* (H-2-73350, Sheet 1).

6.1 PLANS FOR PIPELINE AND ANCILLARY EQUIPMENT ISOLATION FOLLOWING WASTE RETRIEVAL

1. *Plans for pipelines and ancillary equipment isolation following waste retrieval*

Following completion of waste retrieval, the in-tank equipment may be removed or may be left in place for disposition during tank closure activity actions. Isolation of pipelines and ancillary equipment will be performed in accordance with an Ecology-approved closure plan.

6.2 TIMING AND SEQUENCE FOR TANK OR ANCILLARY EQUIPMENT COMPONENT CLOSURE

2. *General timing/sequence of planned tank and/or ancillary equipment component closure*

Tank and/or ancillary equipment component closure will not begin until there is an approved component closure plan for WMA C.

6.3 TIMING AND PLANS FOR TANK OR ANCILLARY EQUIPMENT INTRUSION PREVENTION BEFORE COMPONENT CLOSURE

3. *General timing and plans for isolating the tank and/or ancillary equipment component from inadvertent intrusion pending component closure.*

Isolation of intrusion routes into the tank will be done within the closest diversion box to the tank when C-110 waste retrieval has been completed. Additional isolation of any other tank and/or ancillary equipment, excluding HIHTLs, once C-110 waste retrieval has been completed will be performed as needed for operational purposes related to future tank waste retrievals. HIHITLs will be handled as described in 3.9.1. Once the final closure plan has been agreed to the intrusion prevention will proceed per the schedule for final tank closure at that time.

Post-retrieval intrusion monitoring will be conducted in accordance with OSD-T-151-00031 until specific post-retrieval monitoring requirements are defined.

7 PRE-RETRIEVAL RISK ASSESSMENT

1. [The pre-retrieval risk assessment shall be] *Scoping level in nature. Information and computational capability are available to meet the outline suggested below as follows: C Farm is available now, S-SX Farm is available in June, 2004, B-BX-BY, U, T-TX-TY are available in September, 2004. Needs earlier than these dates will be met by a reduced format similar to the existing risk presentation format found in the streamlined F&Rs. (For example, see the C-200-series tanks F&R). As the more sophisticated information and analytical capabilities become available, the earlier information will be updated as appropriate.*

2. [The pre-retrieval risk assessment shall be] *Based on the best data available at the time the TWRWP is prepared.*

3. [The pre-retrieval risk assessment shall be] *Based on the current contaminant fate and transport analysis available at the time the TWRWP is prepared in order to develop long term estimates for contaminant concentrations in the groundwater at the tank farm (WMA) fenceline. Contaminant concentrations in the groundwater shall consider past leaks and spills, potential retrieval leakage (including projected volumes that could leak during retrieval), and residual waste volumes consistent with the Hanford Federal Facility Agreement and Consent Order interim retrieval goals remaining in the tanks following waste retrieval.*

Quantification of a hypothetical leak volume based on the Assumed Leaker determination and historical data (if data exists to allow the quantification) using the proposed selected retrieval technology configuration.

Tables will be included that present impacts in groundwater at the fenceline showing sources (past leaks, residual waste volume, ancillary equipment) by significant contaminant. Impacts are computed as groundwater concentrations, Incremental Lifetime Cancer Risk (ILCR) for industrial and residential scenarios, and Hazard Index (HI).

To address potential retrieval leaks, graphs will be developed for each facility (tank) providing the impact of the major leaked contaminant. For example, a graph would show ILCR-radiological (Tc-99) by Curie leaked. Each graph shows only a single contaminant. Graphs for ILCR-radiological and HI will be generated. Only contaminants that significantly contribute to the indicator will be shown. Significant contaminants are those set of contaminants that account for approximately 95% of the computed impact indicator (HI or the ILCR).

4. [The pre-retrieval risk assessment] *Will include a contaminant screening to identify the subset of contaminants to be included in the risk evaluation. The subset of contaminants to be included in the risk evaluation will include at least one radionuclide and one hazardous chemical. The results of the contaminant screening will be presented in terms of the percent contribution to the total long-term impacts for both the ILCR-rad and HI.*

For each WMA, all modeled contaminants will be screened for their contribution to the maximum level of impact computed. The screening will include the HI (non-radiological) and the ILCR-radiological for the residential and industrial scenarios.

5. *Address anticipated peak impacts to groundwater and presented as a comparison against drinking water or derived concentration guides which correspond to the drinking water Maximum Concentration Levels (MCL) for the significant contaminants.*

   Information addressing this request will be presented in the Tables described in element F3 of the TWRWP

6. [see Section 7.2]

7. *Analysis of anticipated remaining risk will include:*

   A statement on the magnitude of the residential and industrial ILCR for non-radiological components based on contaminants found in the Best-basis Inventory (BBI).

This section provides long-term human health risk information to support operational decisions in the even a leak is detected during waste retrieval operations for tank C-110. The need to consider long-term human health impacts in developing tank waste retrieval work plans was established in the HFFACO M-45 milestone series through Change Request M-45-04-01.

The risk information provided in this section was developed to meet the requirements identified in the HFFACO Appendix I. Information is provided for two main categories of impacts: (1) long-term human health risk associated with use of groundwater and (2) long-term human health risk associated with inadvertent post-closure human intrusion. Uncertainty or sensitivity evaluations of the impact of changes in assumptions, (e. g. concentration or K_d variation) will be provided in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*.

The risk assessment calculations provided in this TWRWP are based upon the methodology described in RPP-13774. This analysis provides the currently approved predictions of potential long-term groundwater impacts associated with tank waste retrieval and closure activities for WMA C. DOE/ORP-2005-01 is currently going through review and will supersede RPP-13774 when DOE/ORP-2005-01 is agreed to by Ecology. The methodology described in RPP-13774 is used in this TWRWP for consistency with past TWRWPs approved by Ecology. The groundwater contaminant concentrations used for the retrieval leak impact graphs were calculated based upon the methodology described in RPP-13774 and retrieval leak contaminant concentrations based upon DST supernate.

Groundwater pathway impacts are discussed in Section 7.1. Inadvertent intruder impacts are discussed in Section 7.2. Calculation details are provided in RPP-22521, *Tanks C-101, C-105, C-110 and C-111 Long Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan.*

7.1 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway impacts evaluation emphasizes the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. The format used for the retrieval leak impact graphs was developed with Ecology during a joint workshop on March 31, 2004. The graphs are tank-specific and are intended to provide a means to rapidly convert retrieval leak monitoring data into a rough approximation of potential groundwater pathway impacts for a particular retrieval leak.

The methodology used to develop the retrieval leak impact graphs is described in Section 7.1.1. Tank-specific retrieval leak impact results are discussed in Section 7.1.2. A WMA-level perspective on groundwater pathway impacts is provided in Section 7.1.3 to help place the potential retrieval leak impacts from an individual tank into the context of the potential impacts for the C tank farm as a whole.

7.1.1 Retrieval Leak Evaluation Methodology

The retrieval leak graphs were developed using the following methodology:

a. Focus on potential long-term groundwater pathway human health risk at the downgradient tank farm fenceline.
b. Use radiological incremental lifetime cancer risk (ILCR) and noncarcinogenic chemical hazard index (HI) as the primary human health impact metrics.
c. Use the industrial and residential exposure scenarios from *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment* (HNF-SD-WM-TI-707 Rev. 4).
d. Identify the significant contributors (95% of total) for each health impact metric and generate a separate graph for each significant contributor.
e. Derive effects of contaminant release and transport from previous studies.
f. Use the best available published data and information to the maximum extent possible.

The human health impact values used to generate the retrieval leak impact graphs are estimates based on Equation 7-1.

$$R_i = I_i \times C_i \times H_i \qquad (7\text{-}1)$$

where

i = indicator contaminant
R_i = risk metric (radiological ILCR or chemical HI)
I_i = inventory (Ci or kg released into the environment [e.g., retrieval leakage])
C_i = unit groundwater concentration factor (pCi/L per Ci, or mg/L per kg)
H_i = health effects conversion factor (ILCR per pCi/L, or HI per mg/L).

Identification of indicator contaminants is discussed in Section 7.1.1.1. The assumed retrieval leak volume is discussed in Section 7.1.1.2. Unit groundwater concentration factors and health effects conversion factors are provided in Sections 7.1.1.3 and 7.1.1.4.

7.1.1.1 Indicator Contaminants. Retrieval leak impact graphs were generated for a subset of significant contaminants rather than for all contaminants. Significant contaminants are the contaminants estimated to dominate or drive the total impact for a particular human health impact metric. Significant contaminants serve as indicators of the magnitude of total impacts from all contaminants.

An indicator contaminant approach was used to ensure that the resulting graphical tools would provide a reasonable estimate of total impacts but at the same time be sufficiently simple to facilitate rapid decision making without requiring a lot of additional calculation in the event a leak is detected during waste retrieval. The primary human health impact metrics used were radiological ILCR and noncarcinogenic chemical HI. Nonradiological ILCR was also included for information purposes.

Indicator contaminants for each human health impact metric were identified based on the results of the WMA C risk assessment presented in RPP-13774. The *WMA C Closure Action Plan* provided as Appendix C to RPP-13774 includes the results of a comprehensive WMA C long-term groundwater pathway human health risk assessment that was supported by a site-specific numerical vadose zone and groundwater modeling effort. The *Risk Assessment for WMA C Closure Plan*, provided as Addendum C1 to RPP-13774, shows contaminant-specific impact contributions at the WMA C downgradient fenceline by source term for ^{99}Tc, ^{129}I, nitrate, nitrite, total uranium, and hexavalent chromium. Also shown are the total impacts by source term based on the contributions from all contaminants given in DOE/ORP-2003-02, *Inventory and Source Term Data Package*, for which a toxicity factor was available. Exposure scenarios and risk factors used for the RPP-13774 analysis were obtained from HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment.*

The HNF-SD-WM-TI-707 evaluation provides unit dose factors, unit risk factors, and unit HI factors for a comprehensive set of contaminants of potential concern for Hanford Site risk assessment. A total of 93 radionuclides and 161 chemicals are evaluated. The unit factors were derived from standard formulas using data considered to be the most current or technically sound. For radionuclides, the cancer morbidity risk coefficients in EPA-402-R-99-001, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, were used. For chemicals, the non-cancer toxicity reference doses and cancer induction slope factors adopted by the EPA and listed in the Integrated Risk Information System (IRIS) (http://www.epa.gov/iris) were used. Where toxicity parameters were not available in IRIS, values from the EPA-540/R-97/036, *Health Effects Assessment Summary Tables (HEAST) FY 1997 Update* and the Risk Assessment Information System (RAIS) (http://risk.lsd.ornl.gov) maintained by the Oak Ridge National Laboratory were used. To provide an indication of the importance of missing toxicity parameters, the evaluation also includes estimates of the missing parameters for chemicals that have a reference dose or slope factor for ingestion, but none for inhalation, or vice versa.

Table 7-1 is a summary from the RPP-13774 base case analysis results showing the contaminant contributions by source term for each of the human health impact metrics. Table 7-1 shows the peak impacts from WMA C potential residual tank waste, past leaks (including one tank leak and three ancillary pipeline leaks), and potential retrieval leaks (assuming an 8,000-gal. leak from each of the C farm 100-series tanks).

The RPP-13774 analysis results indicate the only contributors to total WMA C radiological ILCR at the fenceline at the time of peak would be the highly mobile (distribution coefficient [K_d] = 0 mL/g) radionuclides: ^{99}Tc, ^{129}I, and ^{14}C and tritium, with ^{99}Tc being the major driver. Technetium-99 was predicted to contribute approximately 85% to 98% of the total radiological ILCR depending on the source term and receptor scenario. Technetium-99 was therefore selected as the radiological ILCR indicator contaminant for this evaluation. It is recognized that ^{99}Tc contributes slightly less than 95% of the total radiological ILCR for the industrial scenario; however, ^{99}Tc clearly predominates the radiological impacts in all cases and is therefore considered an appropriate choice of indicators for radiological ILCR.

The RPP-13774 analysis results indicate the only contributors to the total WMA C noncarcinogenic chemical HI at the fenceline at the time of peak would be the highly mobile (K_d = 0 mL/g) chemicals: hexavalent chromium, nitrite, fluoride, and nitrate, with hexavalent chromium and nitrite being the major drivers. The RPP-13774 analysis conservatively assumed that all chromium inventory was hexavalent chromium. Hexavalent chromium and nitrite combined were predicted to contribute approximately 76% to 95% of the total HI depending on source term and receptor scenario. Hexavalent chromium and nitrite were therefore selected as the noncarcinogenic chemical HI indicator contaminants for this evaluation. It is recognized that hexavalent chromium and nitrite combined contribute slightly less than 95% of the total HI for certain source terms and receptor scenarios; however, these two chemicals combined clearly predominate the noncarcinogenic chemical impacts in all cases and are therefore considered an appropriate choice of indicators for noncarcinogenic chemical HI.

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area C Fenceline. (2 Sheets)

Source Term	Time of Peak (Yr AD)	Radiological Incremental Lifetime Cancer Risk		Nonradiological Incremental Lifetime Cancer Risk		Noncarcinogenic Chemical Hazard Quotients and Hazard Index	
		Industrial	Residential	Industrial	Residential	Industrial	Residential
Past leaks [a]	2117	Tc-99 6.9E-06 (85%) I-129 7.1E-07 (9%) C-14 5.4E-07 (6%) H-3 8.8E-10 (<1%) Total 8.1E-06 (100%)	Tc-99 1.7E-04 (95%) I-129 3.7E-06 (2%) C-14 3.9E-06 (3%) H-3 3.7E-09 (<1%) Total 1.8E-04 (100%)	Cr(VI) 1.1E-07 (100%) Total 1.1E-07 (100%)	Cr(VI) 2.4E-07 (100%) Total 2.4E-07 (100%)	Cr(VI) 1.7E-02 (52%) NO_2 1.4E-02 (43) NO_3 1.7E-03 (5%) F 1.4E-05 (<1%) Total 3.3E-02 (100%)	Cr(VI) 9.7E-02 (49%) NO_2 9.1E-02 (46%) NO_3 1.1E-02 (5%) F 9.7E-05 (<1%) Total 2.0E-01 (100%)
Retrieval leaks [b]	2082	Tc-99 5.7E-06 (89%) I-129 6.1E-07 (9%) C-14 1.3E-07 (2%) H-3 2.9E-10 (<1%) Total 6.5E-06 (100%)	Tc-99 1.4E-04 (98%) I-129 3.2E-06 (2%) C-14 9.0E-07 (<1%) H-3 1.2E-09 (<1%) Total 1.4E-04 (100%)	Cr(VI) 1.7E-07 (100%) Total 1.7E-07 (100%)	Cr(VI) 3.8E-07 (100%) Total 3.8E-07 (100%)	Cr(VI) 2.8E-02 (41%) NO_2 2.6E-02 (39) NO_3 4.1E-03 (5%) F 1.0E-02 (15%) Total 6.7E-02 (100%)	Cr(VI) 1.5E-01 (36%) NO_2 1.7E-01 (40%) NO_3 2.6E-02 (6%) F 7.3E-02 (18%) Total 4.2E-01 (100%)

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area C Fenceline. (2 Sheets)

Source Term	Time of Peak (Yr AD)	Radiological Incremental Lifetime Cancer Risk		Nonradiological Incremental Lifetime Cancer Risk		Noncarcinogenic Chemical Hazard Quotients and Hazard Index	
		Industrial	Residential	Industrial	Residential	Industrial	Residential
Residual tank waste [c]	5614	Tc-99 9.0E-07 (89%) I-129 1.0E-07 (10%) C-14 1.2E-08 (1%) H-3 0.0 (0%) Total 1.0E-06 (100%)	Tc-99 2.2E-05 (97%) I-129 5.2E-07 (2%) C-14 8.8E-08 (<1%) H-3 0.0 (0%) Total 2.3E-05 (100%)	Cr(VI) 2.8E-08 (100%) Total 2.8E-08 (100%)	Cr(VI) 6.3E-08 (100%) Total 6.3E-08 (100%)	Cr(VI) 4.5E-03 (48%) NO_2 3.4E-03 (36%) NO_3 4.5E-04 (5%) F 1.1E-03 (11%) Total 9.4E-03 (100%)	Cr(VI) 2.5E-02 (44%) NO_2 2.2E-02 (38%) NO_3 2.9E-03 (5%) F 7.8E-03 (13%) Total 5.7E-02 (100%)

[a] Source = RPP-13774, Addendum C1, Tables 33 and 34 and additional model output data (includes contributions from one tank leak [C-105] and three unplanned releases [UPR-200-E-81, UPR-200-E-82, UPR-200-E-86]).

[b] Source = RPP-13774, Addendum C1, Tables 36 and 37 and additional model output data (includes contributions from hypothetical 8,000-gal. retrieval leak from each C-100-series tank).

[c] Source = RPP-13774, Addendum C1, Tables 30 and 31 and additional model output data (includes contributions from HFFACO-specified post-retrieval residual waste volume in C-100 and C-200-series tanks).

HFFACO = *Hanford Federal Facility Agreement and Consent Order.*

RPP-13774, *Single-Shell Tank System Closure Plan.*

Total uranium was simulated in the RPP-13774 analysis as a moderately mobile (K_d = 0.6 mL/g) contaminant and was not projected to arrive at the fenceline until approximately 5,000 years after closure. At the time of first arrival, the uranium concentration was due primarily to contributions from past leaks and hypothetical retrieval leaks. Uranium from residual waste was not projected to arrive at the fenceline during the 10,000-year simulation period. Peak human health impacts were projected to occur within 100 years after closure for past leaks and retrieval leaks and within 3,500 years after closure for residual waste. The peak values in all cases was driven by contributions from the highly mobile (K_d = 0 mL/g) contaminants. Uranium had not yet broken through to the water table at the time of peak for any source term and therefore made no contribution to the peaks. Uranium exhibited increasing concentrations at the end of the 10,000-year simulation and was a primary contributor to the impacts calculated at the end of the simulation. The impacts at the end of the simulation were lower than the peak impacts by an order of magnitude or more.

The RPP-13774 analysis also included an assessment of nonradiological cancer risk. Cancer risks from radionuclides and carcinogenic chemicals are typically reported as separate metrics rather than being summed because of differences in how risk is estimated for these two categories of substances. A total of 24 nonradiological chemical contaminants are included in the BBI. Of these, only one, hexavalent chromium, has a published cancer slope factor.

Nonradiological ILCR was assessed in the RPP-13774 analysis based solely on hexavalent chromium exposure. The nonradiological ILCR results from RPP-13774 are shown in Table 7-1 for information purposes to provide an indication of the potential magnitude of nonradiological ILCR. The results indicate that nonradiological ILCR peaks would be on the order of 10^{-7} for the past leak and retrieval leak source terms and 10^{-8} for the residual waste source term. However, because it is based on only one contaminant, nonradiological ILCR was not carried forward as a separate evaluation metric (i.e., was not used to generate a separate set of retrieval leak impact graphs). The degree to which hexavalent chromium ILCR provides an indication of total ILCR is uncertain because of the limited number of chemical analytes reported in the BBI. There is additional uncertainty regarding chromium speciation and the degree of conservatism introduced by assuming that all chromium is hexavalent chromium.

Note that hexavalent chromium is classified as both a chemical toxicant (evaluated using HI) and a carcinogen (evaluated using ILCR). It is classified as toxic via both ingestion and inhalation but carcinogenic only via inhalation. The inhalation intake for the groundwater pathway exposures is based on re-suspended soil and volatilized water. The soil is assumed to be contaminated by irrigation with contaminated groundwater for both the industrial and residential scenarios. Water volatilization is assumed to occur during showering with contaminated groundwater. Further discussion of exposure parameters and scenarios is provided in HNF-SD-WM-TI-707.

Table 7-1 is intended to show all contaminants that contributed to the total metric for each source type (past leaks, retrieval leaks, residual waste) at the time of peak for that source type. As such, the contributions should sum to 100%. All BBI contaminants were included in the RPP-13774 analysis; however, not all contaminants contributed to the peaks. This was because for a contaminant to contribute to the peak it had to have a (1) reported inventory (in BBI), (2) Kd = 0 (in PNNL-13895 or other available database), and (3) a toxicity factor (CPf or Rfd as summarized in HNF-SD-WM-TI-707). The contaminants shown in Table 7-1 meet all three of these criteria. Some BBI contaminants with toxicity factors, such as uranium, were assigned a non-zero Kd (uranium Kd = 0.6) based on best available data. Results indicated that these contaminants do not reach the water table until approximately the year 6500, well after the peaks for all three source types. The non-zero Kd contaminants therefore do not contribute to any of the source term peaks and are not shown on Table 7-1. All contaminants shown in Table 7-1 were assigned Kd = 0. Some BBI contaminants with Kd = 0, such as chloride, reached groundwater by the time of the source term peaks but did not have reported toxicity factors and therefore did not contribute to the total metric and are not shown on Table 7-1.

7.1.1.2 Potential Retrieval Leak Inventories. This document presents much of the risk data assuming an 8,000-gal retrieval leak volume. This quantity is used only as a point of reference and for consistency and comparison with the volume assumed in the RPP-13774, Appendix C, risk assessment. The choice of the reference volume is arbitrary and does not affect how the risk values would be used in the event of a retrieval leak. The 8,000 gal is a hypothetical volume that represents neither an anticipated leak volume nor a leak detection limit. The WRS design and operational strategy for tank C-110 is designed to minimize the leak potential from the tank structure during waste retrieval. If a leak is detected, however, the risk graphs provided in Appendix B will allow the leak impacts to be estimated regardless of leak volume.

The retrieval leak impact graphs in Appendix B were generated by applying Equation 7-1 over a range of hypothetical retrieval leak inventories for each indicator contaminant (RPP-22521). The graphs assume DST AN-106 supernate is used as the slurry medium for waste retrieval. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. Points of reference were added to the graphs to show the estimated current tank inventory and the estimated inventory associated with a hypothetical 8,000-gal retrieval supernate leak. The 8,000-gal volume was used only for information purposes to provide a point of reference on the graphs.

Development of the tank-specific inventory shown as points of reference on the graphs for C-110 is discussed in Appendix B. Current tank C-110 inventory values were taken from the BBI by downloading from the Tank Waste Information Network System (TWINS) database. The hypothetical retrieval leak inventory for tank C-110 was estimated using the sluicing liquid concentrations estimated in RPP-22521, Appendix A.

7.1.1.3 Contaminant Transport Simulations. The RPP-13774 analysis provides the most sophisticated currently approved predictions of potential long-term groundwater impacts associated with tank waste retrieval and closure activities for WMA C. The reference for the risk calculations is provided at the end of 7.1.1.2. The methodology used in the reference is the same as described in RPP-13774, but the concentrations used were developed in the reference. Leak concentrations were based upon DST sample data that were conservatively adjusted to account for additional contaminants added to the DST following sampling.

Flow and transport were simulated in the RPP-13774 analysis using two-dimensional cross-sectional models. The cross-sections extended laterally to the tank farm fenceline and vertically downward through the vadose zone into the upper portion of the underlying aquifer. The simulations all assumed a final closure barrier was in place by 2050. The barrier was assumed to function at its design estimate recharge rate (0.5 mm/yr) for 500 years, after which recharge was assumed to increase to 3.5 mm/yr. The simulated cross-sectional groundwater concentrations were distributed uniformly along the length of the downgradient WMA C boundary. The simulations were carried out for a 10,000-year assessment period (i.e., from the year 2000 to the year 12000). The base case simulation results indicated the peak groundwater concentrations from retrieval leaks would arrive at the WMA C downgradient fenceline in the year 2082.

The RPP-13774 transport simulations were performed for the following four types of contaminant sources within WMA C:

a. Past leaks from tanks
b. Past leaks from ancillary equipment (i.e., past pipe leaks)
c. Potential leaks during waste retrieval
d. Residual waste remaining in tanks and ancillary equipment.

A total of 14 individual simulation cases were included in the analysis. Each case described the behavior of seven surrogate contaminants of varying distribution coefficients under variable waste release modes for the selected sources. The simulations were all performed using a unit source inventory (i.e., 1 Ci or kg). The contaminants simulated represented seven different measures of contaminant mobility through the use of distribution coefficients (K_d = 0, 0.01, 0.03, 0.1, 0.3, 0.6, and 1.0 mL/g). By using a range of distribution coefficients, the analysis examined a wide variety of contaminants by applying the appropriate inventory and decay rate to the unit results for the contaminant of interest. The indicator contaminants for the current evaluation (^{99}Tc, hexavalent chromium, nitrite) were all assigned to the highly mobile (K_d = 0 mL/g) surrogate contaminant group.

Table 7-2 shows the RPP-13774 unit-source simulation results for the highly mobile (K_d = 0 mL/g) contaminant group in the retrieval leak source term. The values shown are the predicted peak contaminant concentrations in groundwater at the downgradient WMA C fenceline from release of 1 Ci of radionuclide or 1 kg of chemical. The retrieval leak impact graphs were generated by multiplying the simulated unit-source results by the retrieval leak inventory and the health effects conversion factors to obtain an estimate of peak groundwater impacts (Equation 7-1).

Table 7-2. Mobile Contaminant (K_d = 0 mL/g) Unit Inventory Simulation Results for Waste Management Area C Retrieval Leak Source Term.

Contaminant	Peak Groundwater Concentration at WMA C Fenceline*	Units	Time of Peak (Yr AD)
Radionuclide	8.4E+01	pCi/L	2082
Chemical	8.4E-05	mg/L	2082

* Addendum C1, Figure 9, from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

WMA = waste management area.

7.1.1.4 Exposure Scenarios. Human health impacts were generated and displayed on the retrieval leak impact graphs for an industrial and a residential exposure scenario, consistent with the requirements in HFFACO Appendix I. Both scenarios are based on scenarios described in DOE/RL-91-45, *Hanford Site Risk Assessment Methodology*. The health effects conversion factors for both scenarios are shown in Table 7-3 for the three indicator contaminants.

Table 7-3. Groundwater Unit Health Effects Factors for Industrial and Residential Exposure Scenarios.

Contaminant	Units	Industrial [a]	Residential [b]
Technetium-99	ILCR per pCi/L	1.38E-08	3.36E-07
Hexavalent chromium	HQ per mg/L	3.88E+00	2.34E+01
Nitrite	HQ per mg/L	9.89E-02	6.36E-01

[a] Source: HNF-SD-WM-TI-707, Rev. 4, Tables 22 and 23.
[b] Source: HNF-SD-WM-TI-707, Rev. 4, Tables 26 and 27.

HI = hazard quotient.
ILCR = incremental lifetime cancer risk.

HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*.

The conversion factors shown in Table 7-3 were taken from tables provided in HNF-SD-WM-TI-707. For ^{99}Tc, the conversion factors provide the lifetime cancer morbidity risk per unit concentration in the groundwater. For hexavalent chromium and nitrite, the conversion factors provide the noncarcinogenic chemical HQ per unit concentration in the groundwater. The factors were applied to the retrieval leak impact calculations as shown in Equation 7-1.

The industrial scenario represents 20 years of occupational exposure in an industrial setting. The receptor is an individual whose work activity is primarily indoors but also includes outdoor activities such as building and grounds maintenance. Contaminants enter the worker primarily through use of groundwater for drinking water and showering. External exposure to irrigated soil and soil inhalation are also included.

The residential scenario represents 30 years of exposure in a residential setting. The receptor is an individual who resides on the land, grows fruits and vegetables, and raises livestock and poultry for personal consumption. Contaminants enter the receptor through use of groundwater for domestic needs (drinking, cooking, and showering); for irrigation (ingestion of produce, soil, and water; inhalation of soil and water; and external exposure); and for watering livestock (ingestion of meat, poultry, and dairy products).

Uncertainty in the exposure scenarios contributes to the overall uncertainty in long-term risk predictions. To address uncertainty, exposure scenario parameters are generally biased to yield higher exposure and risk values. Inputs to the scenario unit risk factors that could contribute to exposure scenario uncertainty include the various models used (e.g., food chain model, toxicokinetic model) and model parameters (e.g., food chain transfer factors, exposure factors, dose factors, risk factors). Complete descriptions of the exposure scenario parameters, assumptions, and unit risk factor calculations can be found in HNF-SD-WM-TI-707.

7.1.2 Retrieval Leak Impact Analysis Results

Tank-specific retrieval leak impact graphs for C-110 generated using the methodology described in Section 7.1.1 are provided in Appendix B. Three graphs, one for each indicator contaminant, are provided. An example calculation is also provided to illustrate how the formula given in Equation 7-1 was applied in generating the graphs.

7.1.3 Waste Management Area C Risk Assessment

This section provides information to allow the potential retrieval leak impacts from an individual tank to be placed in the context of the potential impacts from the C tank farm as a whole. The information presented was summarized from the WMA C risk assessment results presented in RPP-13774.

Sections 7.1.3.1 through 7.1.3.3 summarize the RPP-13774 analysis results by source term in terms of the projected peak impacts at the WMA C downgradient fenceline from potential retrieval leaks, residual waste, and past leaks.

The RPP-13774 risk assessment was a first-iteration risk assessment developed to show the current understanding of the risks associated with waste retrieval and closure activities for WMA C. The RPP-13774 analysis contained significant limitations and uncertainties.
To address these uncertainties, the parameters used for the analysis were in general biased to yield higher risk values. The RPP-13774 analysis provides a list of the uncertainties associated with the risk assessment and how each uncertainty could impact the assessment results. It is expected that as waste retrieval from the C-100-series tanks progresses, new information will become available that could reduce the uncertainties presented in RPP-13774.

7.1.3.1 Potential Retrieval Leaks. Potential WMA C retrieval leak impacts are summarized in Table 7-4 from the results of the base case analysis presented in RPP-13774. Table 7-4 shows the predicted time of peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C retrieval leak source term.

The retrieval leak source term was simulated in the RPP-13774 analysis based on a hypothetical 8,000-gal. retrieval leak from each of the twelve C farm 100-series tanks. The four C farm 200-series tanks were assumed not to leak during waste retrieval. A sensitivity case with a larger waste retrieval leak volume was also included. The retrieval leak inventories used for the RPP-13774 analysis were generated with the Hanford Tank Waste Operations Simulator (HTWOS) model assuming a raw water sluicing scenario. Retrieval leak inventories for a DST supernate sluicing scenario were not assessed in the RPP-13774 analysis. For this retrieval work plan, the C-110 retrieval leak inventories for a DST supernate sluicing scenario were estimated in Appendix A of RPP-22521. These inventories are shown as reference points on the retrieval leak impact graphs presented in Appendix B.

The RPP-13774 base case simulation results indicate the peak groundwater concentrations from retrieval leaks would occur at the WMA C downgradient fenceline in the year 2082. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline. The peak groundwater concentrations from retrieval leaks were projected to overlap in time and be additive with the peak groundwater concentrations from past leaks but were not projected to be additive with the peaks from residual waste.

Table 7-4. Peak Impacts at the Waste Management Area C Fenceline from Potential Retrieval Leaks.

Contaminant	Time of Peak Groundwater Concentration (Yr AD) [a]	Incremental Lifetime Cancer Risk [b]		Hazard Quotients and Index [c]		Groundwater Concentration [d]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	2082	5.7E-06	1.4E-04	NA	NA	420 pCi/L	900 pCi/L
Hexavalent chromium	2082	1.7E-07	3.8E-07	2.8E-02	1.5E-01	0.0064 mg/L	0.1 mg/L [e]
Nitrite	2082	NA	NA	2.6E-02	1.7E-01	0.26 mg/L	3.3 mg/L [f]
Total radiological	2082	6.5E-06	1.4E-04	NA	NA	NA	NA
Total nonradiological	2082	1.7E-07	3.8E-07	6.7E-02	4.2E-01	NA	NA

[a] Source: RPP-13774, Addendum C1, Tables 36 and 37.
[b] Source: RPP-13774, Addendum C1, Table 36.
[c] Source: RPP-13774, Addendum C1, Table 37.
[d] Source: RPP-13774, Addendum C1, Table 38.
[e] The MCL for chromium is from 40 CFR 141.62(b) and is for total chromium.
[f] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen in nitrite is 1 mg/L, which is equal to 3.3 mg/L for the ion

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NA = not applicable.

RPP-13774, *Single-Shell Tank System Closure Plan*, Rev. 2.

7.1.3.2 Residual Waste. Potential WMA C residual tank waste impacts are summarized in Table 7-5 from the results of the base case analysis presented in RPP-13774. Table 7-5 shows the predicted time of peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C residual tank waste source term.

The RPP-13774 simulation results indicate the peak groundwater concentrations from residual tank waste would arrive at the fenceline approximately 3,600 years after closure (in the year 5614). The peak groundwater concentrations from residual tank waste were not projected to overlap in time or be additive with the peak groundwater concentrations from retrieval leaks or past leaks.

The base case residual waste simulations used a diffusion-dominated release model for 360 ft^3 and 30 ft^3 of post-retrieval residual tank waste in the 12 C-100-series tanks and four C-200-series tanks, respectively. The residual waste inventories were estimated using the selective phase removal method, which takes into account removal of selected phases of waste (e.g., sludge, supernate) during retrieval. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline.

The nature and amount of waste left in WMA C ancillary equipment and pipelines is unknown. The RPP-13774 analysis included an assumed inventory for the waste in these components to show their expected relative contribution to the total WMA C impacts. Waste in the ancillary equipment tanks (244-CR vault and C-301 catch tank) was assumed to be retrieved to a residual volume proportional to that required under the HFFACO for the 200-series tanks. The ancillary equipment tanks are smaller than the 200-series tanks and the ancillary tank residual volume was calculated by multiplying the 200-series tanks residual volume goal (30 ft^3) by the ratio of the volume of the ancillary equipment tank to the 200-series tanks (55,000 gal.). Currently, there is no BBI inventory associated with these ancillary tanks. Ancillary tank residual inventories were calculated as the product of the residual volume and the averaged contaminant-specific concentration from the combined contents of the C farm 100- and 200-series tank solids.

The WMA C piping system comprises multiple layers of waste transfer piping that were installed over time within WMA C. An estimated total volume of 1,000 ft^3 of waste transfer piping was assumed for the RPP-13774 analysis. To estimate a residual waste inventory related to the piping system, 25% of the pipe (250 ft^3) was assumed to be plugged and filled with residual solids. Currently, there is no BBI inventory associated with the ancillary piping components. Contaminant concentrations in the residual solids were calculated from the combined contents of the C farm 100- and 200-series tank waste solids.

Table 7-5. Peak Impacts at the Waste Management Area C Fenceline from Potential Residual Tank Waste.

Contaminant	Time of Peak Groundwater Concentration (Yr AD) [a]	Incremental Lifetime Cancer Risk [b]		Hazard Quotients and Index [c]		Groundwater Concentration [d]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	5610	9.0E-07	2.2E-05	NA	NA	66 pCi/L	900 pCi/L
Hexavalent chromium	5614	2.8E-08	6.3E-08	4.5E-03	2.5E-02	0.001 mg/L	0.1 mg/L [e]
Nitrite	5614	NA	NA	3.4E-03	2.2E-02	0.034 mg/L	3.3 mg/L [f]
Total radiological	5614	1.0E-06	2.3E-05	NA	NA	NA	NA
Total nonradiological	5614	2.8E-08	6.3E-08	9.4E-03	5.7E-02	NA	NA

[a] Source: RPP-13774, Addendum C1, Tables 30 and 31.
[b] Source: RPP-13774, Addendum C1, Table 30.
[c] Source: RPP-13774, Addendum C1, Table 31.
[d] Source: RPP-13774, Addendum C1, Table 38.
[e] The MCL for chromium is from 40 CFR 141.62(b) and is for total chromium.
[f] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen in nitrite is 1 mg/L, which is equal to 3.3 mg/L for the ion

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NA = not applicable.

RPP-13774, *Single-Shell Tank System Closure Plan.*

The impacts shown in Table 7-5 are for residual tank waste and do not include the contributions from residual waste in WMA C ancillary equipment and pipelines. The residual waste in those components was estimated to cause a small increase to the impacts shown in Table 7-5. For example, for the industrial scenario, the total radiological ILCR increased to 1.1×10^{-6}, the total nonradiological ILCR increased to 3.1×10^{-8}, and the total HI increased to 1.0×10^{-2}. The RPP-13774 analysis indicated the peak impacts from ancillary tank residuals would arrive coincident with the peak from SST residuals (in the year 5614) and the peak from piping system residuals would arrive approximately 700 years earlier than the peak from SST residuals.

The diffusion-dominated residual waste release model used in the base case simulations was representative of a stabilized, grouted waste form. Additional sensitivity cases were simulated using an advection-dominated residual waste release model representative of an unstabilized waste form covered with backfill sand and gravel or failed grout. Peak groundwater concentrations for the advection-dominated release model were projected to arrive at the WMA C fenceline approximately 1,000 years earlier (in the year 4653) and be approximately an order of magnitude higher than the peaks for the base case diffusion-dominated release model.

7.1.3.3 Past Leaks. Waste Management Area C past leak impacts are summarized in Table 7-6 from the results of the base case analysis presented in RPP-13774. Table 7-6 shows the predicted time of peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HQ for the indicator contaminants at the downgradient fenceline from the WMA C past leak source term.

The RPP-13774 base case simulation results indicate that peak groundwater concentrations from past leaks would arrive at the WMA C downgradient fenceline in the year 2092 for past tank leaks and the year 2117 for past ancillary equipment leaks. The past leaks source term was based on vadose zone contamination associated with past unplanned releases in the vicinity of tank C-105 and three ancillary pipelines (UPR-200-E-81, UPR-200-E82, UPR-200-E-86).

Other reported unplanned ancillary equipment releases in WMA C were considered but disregarded in the RPP-13774 analysis because they were determined not to represent significant sources of contamination compared to the sources analyzed. Table 5 in Addendum C1 of RPP-13774 lists sources considered in the WMA C risk assessment conceptual model. This same table indicates whether the source was included in the risk assessment and, if not included, the reason why. A number of UPRs that occurred in the general area of tank C-110 were not included in the risk assessment. These are UPR-200-E-16, UPR-200-E-27, UPR-E-68, UPR-E-72, UPR-E-91, UPR-E-99, UPR-E-100, UPR-200-E-107, UPR-200-E-118, and UPR-200-E-136. (Depending on future sampling or closure decisions, these UPRs may be included in future C farm risk assessments.) The reasons given in Table 5 of RPP-13774 Addendum C1 for why they were not included in the risk assessment are the following:

a. **UPR-200-E-16:** A small (approximately 50 gal.) overground transfer line leak near the north side of tank C-105. This UPR was not included in the risk analysis because its limited volume was significantly smaller than that in three other UPRs that were included.

b. **UPR-200-E-27:** An airborne release. This UPR was not included in the risk analysis because it was an airborne release that did not result in significant soil contamination.

c. **UPR-200-E-68:** An airborne release. This UPR was not included in the risk analysis because it was an airborne release that did not result in significant soil contamination.

d. **UPR-200-E-72:** This is a solid waste burial consisting of miscellaneous trash and debris. It is located outside of WMA C.

e. **UPR-200-E-91:** A contaminated soil area which has been remediated.

f. **UPR-200-E-99:** An airborne release. This UPR was not included in the risk analysis because it was an airborne release that did not result in significant soil contamination.

g. **UPR-200-E-100:** An airborne release. This UPR was not included in the risk analysis because it was an airborne release that did not result in significant soil contamination.

h. **UPR-200-E-107:** A small (4 to 5 gal.) amount was sprayed on the ground from erroneous operation of an air valve; this UPR is believed to be near tank C-110. This UPR was not included in the risk analysis because its limited volume was significantly smaller than that in three other UPRs that were included.

i. **UPR-200-E-118:** An airborne release from tank C-107. This UPR was not included in the risk analysis because it was an airborne release that did not result in significant soil contamination.

j. **UPR-200-E-136:** A reported 24,000-gal. leak from tank C-101. (The same UPR also includes a reported 400-gal. leak from tank C-203). This UPR was not included in the risk analysis because this reported leak has not been verified through either geophysical logging or sampling in the vadose zone and/or groundwater. See footnote 4 to Table 5 of RPP-13774 Addendum C1 for a more detailed explanation.

Although the peak from past tank leaks was projected to arrive ahead of the peak from unplanned pipeline releases by approximately 26 years, the contributions from these sources were summed and reported as a single peak arriving in the year 2117. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline. The peak groundwater concentrations from past leaks were projected to overlap in time and be additive with the peak groundwater concentrations from retrieval leaks but were not projected to be additive with the peaks from residual waste. The peak from retrieval leaks was projected to arrive in 2082 compared with 2092 for the past tank leak. This occurred because the retrieval leak volume used in the RPP-13774 analysis was 8,000 gal. whereas the past leak (tank C-105) volume assumed for risk assessment purposes was 1,000 gal. An 8,000-gal volume has a greater driving force and lower tendency to spread laterally in the vadose zone than a 1,000-gal volume.

Transport of existing vadose zone contamination was simulated in the RPP-13774 analysis based on water flow from natural recharge only (i.e., surface infiltration of meteoric water). The effect on existing contamination of artificial recharge, such as a retrieval leak or water line leak, was not evaluated. Should the fluid released in a retrieval leak intercept an existing vadose zone plume, there is a potential for the contamination to be flushed more quickly to the water table. The effect of the flushing on peak groundwater concentration and arrival time would depend on a number of factors, including initial plume depth and the rate, volume, and location of the retrieval leak. There is no potential for a retrieval leak to affect the movement of contamination from the three unplanned pipeline releases included in the WMA C risk assessment (UPR-200-E-81, UPR-200-E-82, UPR-200-E-86). These releases all occurred along the southwest boundary of WMA C, well away from the nearest tank row. There is a potential for a retrieval leak to affect the movement of the existing vadose zone contamination in the vicinity of tank C-105. If this were to occur, the WMA C past leak impacts could differ from the projected impacts shown in Table 7-6, which were calculated assuming meteoric infiltration.

Seven C farm tanks (C-101, C-110, C-111, and the four C-200-series tanks) are currently classified as assumed leakers in HNF-EP-0182 (see Figure 4-1). However, the past leak source term modeled in the RPP-13774 risk assessment included only leaks and discharges that have been verified either through geophysical logging or sampling in the vadose zone and/or groundwater.

Spectral gamma logging data reported in RPP-14430 shows little evidence of vadose zone contamination consistent with a tank leak in the vicinity of the tanks classified as leakers in HNF-EP-0182. Although no leaks have been reported from tank C-105, there is contamination reported in the vadose zone from routine geophysical monitoring between this tank and tank C-104. The measured vadose zone contamination in the vicinity of tank C-105 was therefore included in the RPP-13774 risk assessment, along with the measured vadose zone contamination associated with three verified leaks from ancillary equipment associated with WMA C. Additional information on WMA C vadose zone contamination can be found in RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Areas*; RPP-15317, *241-C Waste Management Area Inventory Data Package*; GJPO-HAN-18, *Vadose Zone Characterization Project at the Hanford Tank Farms, C Tank Farm Report*; and GJO-98-39-TARA GJO-HAN-18, *Vadose Zone Characterization Project at the Hanford Tank Farms, Addendum to the C Tank Farm Report*. Additional perspective on the integrity of tanks in WMA C can be found in RPP-10435.

Table 7-6. Peak Impacts at the Waste Management Area C Fenceline from Past Leaks.

Contaminant	Time of Peak Groundwater Concentration (Yr AD) [a]	Incremental Lifetime Cancer Risk [b]		Hazard Quotients and Index [c]		Groundwater Concentration [d]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	2117	6.9E-06	1.7E-04	NA	NA	497 pCi/L	900 pCi/L
Hexavalent chromium	2117	1.1E-07	2.4E-07	1.7E-02	9.7E-02	0.004 mg/L	0.1 mg/L [e]
Nitrite	2117	NA	NA	1.4E-02	9.1E-02	0.14 mg/L	3.3 mg/L [f]
Total radiological	2117	8.1E-06	1.8E-04	NA	NA	NA	NA
Total nonradiological	2117	1.1E-07	2.4E-07	3.3E-02	2.0E-01	NA	NA

[a] Source: RPP-13774, Addendum C1, Tables 33 and 34.
[b] Source: RPP-13774, Addendum C1, Table 33.
[c] Source: RPP-13774, Addendum C1, Table 34.
[d] Source: RPP-13774, Addendum C1, Table 38.
[e] The MCL for chromium is from 40 CFR 141.62(b) and is for total chromium.
[f] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen in nitrite is 1 mg/L, which is equal to 3.3 mg/L for the ion.

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NA = not applicable.

RPP-13774, *Single-Shell Tank System Closure Plan.*

7.2 INTRUDER RISK

6. *Address anticipated impacts from an acute and chronic intruder scenario. Exposures are assumed to occur 500 years after closure. Scenarios for chronic exposure will include residential gardener and rural farmer.*

Inadvertent waste site intrusion risk is an assessment of the health impacts from unknowingly intruding into a waste site at some point in the future following closure. Intruder impact estimates are included in this TWRWP to provide perspective on potential post-closure risks associated with closing tank C-110 assuming waste is retrieved to the HFFACO interim retrieval goal of 360 ft^3 of residual waste and the residuals are closed in place (Ecology et al. 1989).

Inadvertent intruder impacts were analyzed using the same methodology used to analyze WMA C intruder impacts in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington.* That report used exposure scenarios defined in HNF-SD-WM-TI-707 and was based on intruder analyses presented in earlier Hanford Site performance assessments (WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; WHC-EP-0875, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*; DOE/RL-97-69, *Hanford Immobilized Low-Activity Tank Waste Performance Assessment*; DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version*).

7.2.1 Intruder Scenarios and Performance Objectives

The DOE/ORP-2003-11 analysis included several inadvertent intrusion scenarios, all of which assumed that no institutional memory of the closed facility remains following closure. The credible post-closure intrusion scenarios identified were the following:

a. An intruder who inadvertently drills into the closed site and brings some of the waste to the surface, receiving an acute dose (driller scenario).

b. A post-drilling resident who lives where waste has been exhumed and scattered over the surface, receiving a chronic dose (post-intrusion residential scenarios). Three such residential scenarios were included:

    1. Suburban resident with a garden
    2. Rural farmer with a dairy cow
    3. Commercial farmer.

Detailed descriptions of the scenarios are presented in DOE/ORP-2003-11 and HNF-SD-WM-TI-707. A basement scenario, in which exposure occurs during excavation for a basement or building foundation, was not considered credible in DOE/ORP-2003-11 and was not analyzed. This was because the top of the waste is 35 ft or more below the surface and neither basements for home residences nor foundations for commercial structures are likely to extend this far below the surface.

The performance objective identified in DOE/ORP-2003-11 for the driller scenario was 500 mrem effective dose equivalent (EDE) for a one-time exposure. The performance objective for the post-intrusion residential scenarios was 100 mrem/yr EDE for a continuous exposure. Doses were calculated at 100-year intervals over the period from 0 to 1,000 years after closure. The time of compliance (or soonest time when the intrusion was assumed to occur) for the DOE/ORP-2003-11 analysis was 500 years after closure, which was assumed to occur in the year 2050.

7.2.2 Methodology

The main elements of the intruder calculation method used for this analysis can be summarized as follows:

a. Use a time of compliance of 500 years after closure (consistent with DOE/ORP-2003-11)
b. Use radiological dose as the health impact metric
c. Calculate acute dose using the driller scenario
d. Calculate chronic dose using the suburban resident with a garden and rural farmer with a dairy cow scenarios
e. Assume the borehole diameter is 6.5 in. for well driller and suburban resident with a garden and 10.5 in. for rural farmer with a dairy cow
f. Assume the tanks each contain a volume of 360 ft^3 of residual waste at closure
g. Assume the residual tank waste is embedded in a grout matrix that renders a fraction of the exhumed waste unavailable for inhalation and ingestion
h. Assume intrusion occurs before contaminants have migrated from the closed facility in any significant quantity.

The commercial farmer scenario was disregarded for this analysis. The commercial farmer was identified in the DOE/ORP-2003-11 analysis as the most likely exposure scenario given the present day land use in the Hanford environs; however, the DOE/ORP-2003-11 analysis used the rural farmer with a dairy cow for purposes of assessing compliance with performance objectives. The rural farmer with a dairy cow was more conservative than the commercial farmer but less conservative than the suburban resident with a garden. The DOE/ORP-2003-11 analysis considered a rural farmer with a dairy cow a more appropriate scenario for assessing performance than a suburban resident with a vegetable garden. The DOE/ORP-2003-11 analysis results indicated the commercial farmer dose would be a factor of 50 below that of the rural farmer with a dairy cow. Both the suburban resident with a garden scenario and the rural farmer with a dairy cow scenario are evaluated in this TWRWP.

Sections 7.2.2.1 and 7.2.2.2 discuss the calculation methodology for the two primary components of the intruder calculation, inventory, and dose. Tank-specific results for tank C-110 are provided in Appendix B. Calculation details are provided in RPP-22521.

7.2.1.1 Inventory. The starting inventories for the intruder calculation were the estimated radionuclide inventories remaining in the tanks following retrieval to the HFFACO interim retrieval goal of 360 ft^3 (2,700 gal.) of residual waste. These inventories were taken from RPP-

15317 and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the BBI are provided in RPP-15317 and were used in the calculation. The tank C-110 residual waste starting inventory is given in Appendix B.

Exhumed inventories were calculated by assuming the waste in the borehole has the same contaminant concentrations as the tank residuals, and that the height of the waste in the borehole is the same as the height of the waste in the tank residuals. Using these assumptions, the undecayed exhumed inventories for each radionuclide were estimated by multiplying the tank residual inventory by the square of the ratio of the borehole radius to the tank radius.
The mathematical basis for this is shown in Equations 7-2 through 7-5.

$$I_{EX} / V_{EX} = I_T / V_T \qquad (7\text{-}2)$$

$$I_{EX} / (\pi\, r^2 h) = I_T / (\pi\, R^2 h) \qquad (7\text{-}3)$$

$$I_{EX} = I_T\, (\pi\, r^2 h) / (\pi\, R^2 h) \qquad (7\text{-}4)$$

$$I_{EX} = I_T\, (r / R)^2 \qquad (7\text{-}5)$$

where:

I_{EX} = exhumed inventory (undecayed) (Ci)
I_T = tank residual inventory (Ci)
V_{EX} = exhumed volume (m^3)
V_T = tank residual volume (m^3)
R = borehole radius (m)
R = tank radius (m)
H = waste height (m).

To account for radiological decay, the exhumed inventory was multiplied by a radiological decay factor, as shown in Equation 7-6.

$$I_{EX}(t) = I_{EX}\, \mathrm{Exp}(-\lambda t) \qquad (7\text{-}6)$$

where:

$I_{EX}(t)$ = exhumed inventory decayed as a function of time (Ci)
I_{EX} = exhumed inventory (undecayed) (Ci)
Exp = exponential function (natural logarithm base (e) raised to some power)
Λ = radioactive decay constant, per year, calculated as ln(2)=0.6931 divided by the radionuclide half life in years
T = elapsed time since closure in years.

7.2.1.2 Dose. For each intruder scenario considered, the dose contribution from each radionuclide was calculated by multiplying the exhumed inventory (decayed) by a unit dose factor. The total dose for each scenario was then calculated as the sum of the dose contributions from all radionuclides included in the starting inventory. Unit dose factors for each radionuclide under each intruder scenario were taken from HNF-SD-WM-TI-707. Unit dose factors for the subset of radionuclides that drive intruder doses are shown in Table 7-7. Complete intruder scenario descriptions and unit dose factor calculations are provided in HNF-SD-WM-TI-707.

The total dose factors (sum of internal and external doses) given in HNF-SD-WM-TI-707 for the driller scenario assume 100% of the exhumed waste is available for inhalation and ingestion. The residual waste grout matrix is assumed to prevent a fraction of the exhumed inventory from being inhaled or ingested. Internal dose factors used in this calculation were therefore reduced by 90% (multiplied by 0.1) to account for the grouted waste form, as recommended in HNF-SD-WM-TI-707.

The driller scenario unit dose factors are given in terms of the dose per unit contaminant concentration in the drill cuttings (mrem per Ci/kg) (Table 7-7). The radiation dose to this individual is the dose (EDE) from acute exposure over a 40-hour drilling operation. The driller dose factors were multiplied by the average radionuclide concentration in the drill cuttings (Ci/kg) to obtain the dose. The average radionuclide concentrations in the drill cuttings were calculated by dividing the exhumed inventories (decayed) by the mass exhumed. The mass exhumed was calculated using Equation 7-7.

$$M_{EX} = \pi r^2 h \rho \qquad (7\text{-}7)$$

where:

M_{EX} = exhumed mass (kg)
R = borehole radius (m)
H = borehole height (depth to water table) (m)
P = average density of well cuttings (kg/m^3).

As for the driller scenario, the total dose factors (sum of internal and external doses) given in HNF-SD-WM-TI-707 for the two post-intruder resident scenarios (suburban resident with a garden and rural farmer with a dairy cow) were adjusted downward to account for a grout matrix by applying a waste form factor of 0.1 to the internal dose factors.

The post-intruder resident scenario unit dose factors are given in terms of the dose received during the first year per curie exhumed (mrem/yr per Ci) (Table 7-7). The radiation dose to this individual is the 50-year committed effective dose equivalent from the first year of exposure. The post-intruder dose factors were multiplied by the curies exhumed (decayed) to obtain the dose.

Table 7-7. Unit Dose Factors for Inadvertent Intruder Scenarios. [a]

Radionuclide	Driller (mrem per Ci/kg) [b]	Suburban Resident with a Garden (mrem/yr per Ci exhumed) [b]	Rural Farmer with a Dairy Cow (mrem/yr per Ci exhumed) [b]
Strontium-90+D	8.12E+04	3.59E+03	9.73E+01
Technetium-99	5.66E+02	5.06E+02	2.54E+00
Tin-126+D	3.09E+07	9.66E+03	3.86E+02
Cesium-137+D	8.78E+06	3.13E+03	1.25E+02
Plutonium-239	3.86E+05	7.02E+02	1.21E+01
Plutonium-240+D	3.86E+05	7.02E+02	1.21E+01
Americium-241	5.83E+05	7.60E+02	1.41E+01

[a] Source: Tables 7, 8, and 10 of HNF-SD-WM-TI-707, 2004, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment,* Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

[b] Values shown are total dose (sum of internal and external dose) after reducing internal dose by 90% to account for the waste form.

+D = includes short-lived radioactive progeny in secular equilibrium with parent nuclide.

The post-intruder dose factors consider the decrease in soil concentration during the year due to radioactive decay and leaching from irrigation (HNF-SD-WM-TI-707). Irrigation is assumed to occur only during the first half of the year. External exposure, soil ingestion, and soil inhalation occur only during the irrigation period, with none during the second half of the year. Vegetables, fruit, and grain in the suburban resident with a garden scenario and animal fodder (hay and grain) in the rural farmer with a dairy cow scenario are assumed to be harvested throughout the irrigation season. To represent this, harvest is assumed to occur midway through the irrigation season (at 0.25 year). Plant concentrations are proportional to soil concentrations at this time.

7.2.3 Intruder Analysis Results

Tank C-110 intruder impacts generated using the methodology described in Section 7.2.2 are provided in Appendix B. Appendix B gives total dose values for the driller, suburban resident with a garden, and rural farmer with a dairy cow intrusion scenarios, along with the radionuclide-specific dose contributions from the radionuclides that dominate the total dose.

8 LESSONS LEARNED

Lessons learned from previous waste retrieval operations in C-106, S-112, S-102, C-103, and C-108 will be applied where appropriate to the C-110 modified sluicing equipment and operations. Applicable lessons learned include, but are not limited to the following:

a. Select equipment materials compatible with the environmental conditions of their intended application to minimize failures resulting from corrosion, stress, and exposure to radiation. Provide adequate temperature controls (e.g., heat tracing, air conditioning) to ensure equipment performs as designed. Select radiation resistance sealants and gaskets.

b. Cold test all fluid connections and components before deployment to ensure leak tightness.

c. Incorporate features to flush components that transport slurries to prevent/correct blockages. Design the features to operate with minimal changes to the system and operator intervention.

d. Design systems to facilitate maintenance and support functions while incorporating safety and ALARA features.

e. Provide access to instrumentation and other components requiring servicing and maintenance that does not require breaching the confinement system.

f. Simplify system control screens to maximize operator efficiency and recognition of key operational parameters/data.

g. Incorporate features to unplug piping systems in the event of a line blockage.

h. Conduct comprehensive field walkdowns before system design to validate design assumptions and document as-found field conditions.

i. Identify and specify equipment shipping, handling, and lifting requirements to facilitate safe and efficient handling and deployment of equipment.

j. Conduct comprehensive post-shipping inspections to identify equipment damage and defects.

k. Minimize the use of threaded joints in equipment design.

l. Identify and obtain all spare parts required for system maintenance and for equipment repairs for anticipated failures.

Deployment of the HRR system for leak detection in the tank farms is new. Lessons learned from the demonstration deployments of the HRR systems in S-102, C-103, and C-108 will be incorporated to the extent practical in the design and operation of the C-110 HRR system.

9 REFERENCES

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APPENDIX A

AVAILABLE INVENTORY AND INVENTORY UNCERTAINTY DATA

LIST OF TABLES

Table A-1. Tank C-110 Inventory.[a] (6 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{106}Ru	Sludge	1C (Solid)	3.85E-11	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.20E-14	Not reported	Ci
	Total		3.86E-11	--	Ci
^{113m}Cd	Sludge	1C (Solid)	4.53E-02	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.87E-04	Not reported	Ci
	Total		4.56E-02	--	Ci
^{125}Sb	Sludge	1C (Solid)	6.05E-04	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.50E-06	Not reported	Ci
	Total		6.07E-04	--	Ci
^{126}Sn	Sludge	1C (Solid)	3.76E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.87E-05	Not reported	Ci
	Total		3.79E-03	--	Ci
^{129}I	Sludge	1C (Solid)	4.00E-04	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.95E-07	Not reported	Ci
	Total		4.00E-04	--	Ci
^{134}Cs	Sludge	1C (Solid)	4.61E-07	Not reported	Ci
	Supernatant	1C1 (Liquid)	6.00E-10	Not reported	Ci
	Total		4.62E-07	--	Ci
^{137}Cs	Sludge	1C (Solid)	1.35E+04	2.26E+03	Ci
	Supernatant	1C1 (Liquid)	1.50E+01	2.54E+02	Ci
	Total		1.35E+04	--	Ci
^{137m}Ba	Sludge	1C (Solid)	1.27E+04	Not reported	Ci
	Supernatant	1C1 (Liquid)	1.41E+01	Not reported	Ci
	Total		1.27E+04	--	Ci
^{14}C	Sludge	1C (Solid)	3.32E-01	1.10E-01	Ci
	Supernatant	1C1 (Liquid)	7.95E-04	1.34E-02	Ci
	Total		3.33E-01	--	Ci
^{151}Sm	Sludge	1C (Solid)	7.92E+01	Not reported	Ci
	Supernatant	1C1 (Liquid)	6.49E-01	Not reported	Ci
	Total		7.98E+01	--	Ci
^{152}Eu	Sludge	1C (Solid)	2.54E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	7.07E-06	Not reported	Ci
	Total		2.55E-03	--	Ci
^{154}Eu	Sludge	1C (Solid)	1.71E-01	Not reported	Ci
	Supernatant	1C1 (Liquid)	6.26E-04	Not reported	Ci
	Total		1.72E-01	--	Ci

Table A-1. Tank C-110 Inventory.[a] (6 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{155}Eu	Sludge	1C (Solid)	7.39E-02	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.19E-04	Not reported	Ci
	Total		7.43E-02	--	Ci
^{226}Ra	Sludge	1C (Solid)	4.96E-06	Not reported	Ci
	Supernatant	1C1 (Liquid)	5.82E-08	Not reported	Ci
	Total		5.01E-06	--	Ci
^{227}Ac	Sludge	1C (Solid)	4.23E-05	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.88E-07	Not reported	Ci
	Total		4.28E-05	--	Ci
^{228}Ra	Sludge	1C (Solid)	5.56E-11	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.77E-13	Not reported	Ci
	Total		5.61E-11	--	Ci
^{229}Th	Sludge	1C (Solid)	1.57E-08	Not reported	Ci
	Supernatant	1C1 (Liquid)	1.34E-10	Not reported	Ci
	Total		1.58E-08	--	Ci
^{231}Pa	Sludge	1C (Solid)	3.16E-04	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.62E-06	Not reported	Ci
	Total		3.20E-04	--	Ci
^{232}Th	Sludge	1C (Solid)	1.32E-10	Not reported	Ci
	Supernatant	1C1 (Liquid)	1.13E-12	Not reported	Ci
	Total		1.33E-10	--	Ci
^{232}U	Sludge	1C (Solid)	8.04E-06	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.70E-09	Not reported	Ci
	Total		8.05E-06	--	Ci
^{233}U	Sludge	1C (Solid)	6.69E-07	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.37E-10	Not reported	Ci
	Total		6.70E-07	--	Ci
^{234}U	Sludge	1C (Solid)	6.46E-01	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.23E-04	Not reported	Ci
	Total		6.46E-01	--	Ci
^{235}U	Sludge	1C (Solid)	2.89E-02	Not reported	Ci
	Supernatant	1C1 (Liquid)	1.90E-05	Not reported	Ci
	Total		2.89E-02	--	Ci
^{236}U	Sludge	1C (Solid)	7.21E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.60E-06	Not reported	Ci
	Total		7.22E-03	--	Ci
^{237}Np	Sludge	1C (Solid)	1.72E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	1.36E-05	Not reported	Ci

Table A-1. Tank C-110 Inventory.[a] (6 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
	Total		1.74E-03	--	Ci
^{238}Pu	Sludge	1C (Solid)	4.56E-01	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.23E-05	Not reported	Ci
	Total		4.56E-01	--	Ci
^{238}U	Sludge	1C (Solid)	6.59E-01	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.27E-04	Not reported	Ci
	Total		6.59E-01	--	Ci
^{239}Pu	Sludge	1C (Solid)	6.48E+01	Not reported	Ci
	Supernatant	1C1 (Liquid)	6.59E-03	Not reported	Ci
	Total		6.48E+01	--	Ci
^{240}Pu	Sludge	1C (Solid)	7.05E+00	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.44E-04	Not reported	Ci
	Total		7.05E+00	--	Ci
^{241}Am	Sludge	1C (Solid)	3.86E+01	Not reported	Ci
	Supernatant	1C1 (Liquid)	7.58E-05	1.28E-03	Ci
	Total		3.86E+01	--	Ci
^{241}Pu	Sludge	1C (Solid)	1.18E+01	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.73E-04	Not reported	Ci
	Total		1.18E+01	--	Ci
^{242}Cm	Sludge	1C (Solid)	6.79E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.84E-09	Not reported	Ci
	Total		6.79E-03	--	Ci
^{242}Pu	Sludge	1C (Solid)	9.80E-05	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.01E-09	Not reported	Ci
	Total		9.80E-05	--	Ci
^{243}Am	Sludge	1C (Solid)	3.98E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.22E-09	Not reported	Ci
	Total		3.98E-03	--	Ci
^{243}Cm	Sludge	1C (Solid)	7.58E-05	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.15E-11	Not reported	Ci
	Total		7.58E-05	--	Ci
^{244}Cm	Sludge	1C (Solid)	1.70E-03	Not reported	Ci
	Supernatant	1C1 (Liquid)	4.82E-10	Not reported	Ci
	Total		1.70E-03	--	Ci
^{3}H	Sludge	1C (Solid)	5.68E-01	1.03E-01	Ci
	Supernatant	1C1 (Liquid)	1.53E-03	2.59E-02	Ci
	Total		5.70E-01	--	Ci
^{59}Ni	Sludge	1C (Solid)	9.74E-03	Not reported	Ci

Table A-1. Tank C-110 Inventory.[a] (6 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
	Supernatant	1C1 (Liquid)	7.50E-05	Not reported	Ci
	Total		9.81E-03	--	Ci
^{60}Co	Sludge	1C (Solid)	6.20E-02	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.92E-04	Not reported	Ci
	Total		6.22E-02	--	Ci
^{63}Ni	Sludge	1C (Solid)	1.35E+00	Not reported	Ci
	Supernatant	1C1 (Liquid)	1.08E-02	Not reported	Ci
	Total		1.36E+00	--	Ci
^{79}Se	Sludge	1C (Solid)	9.97E-04	Not reported	Ci
	Supernatant	1C1 (Liquid)	2.47E-04	4.18E-03	Ci
	Total		1.24E-03	--	Ci
^{90}Sr	Sludge	1C (Solid)	3.45E+03	7.10E+02	Ci
	Supernatant	1C1 (Liquid)	8.46E-02	1.43E+00	Ci
	Total		3.45E+03	--	Ci
^{90}Y	Sludge	1C (Solid)	3.45E+03	Not reported	Ci
	Supernatant	1C1 (Liquid)	8.46E-02	Not reported	Ci
	Total		3.45E+03	--	Ci
^{93m}Nb	Sludge	1C (Solid)	1.15E+00	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.41E-03	Not reported	Ci
	Total		1.16E+00	--	Ci
^{93}Zr	Sludge	1C (Solid)	1.28E+00	Not reported	Ci
	Supernatant	1C1 (Liquid)	3.74E-03	Not reported	Ci
	Total		1.28E+00	--	Ci
^{99}Tc [b]	Sludge	1C (Solid)	3.18E+01	5.61E+00	Ci
	Supernatant	1C1 (Liquid)	7.11E-02	1.20E+00	Ci
	Total		3.18E+01	--	Ci
Al	Sludge	1C (Solid)	1.31E+04	1.67E+03	kg
	Supernatant	1C1 (Liquid)	8.34E-01	1.41E+01	kg
	Total		1.31E+04	--	kg
Bi	Sludge	1C (Solid)	1.48E+04	2.02E+03	kg
	Supernatant	1C1 (Liquid)	7.66E-01	1.30E+01	kg
	Total		1.48E+04	--	kg
Ca	Sludge	1C (Solid)	1.05E+03	3.94E+02	kg
	Supernatant	1C1 (Liquid)	5.52E-02	9.35E-01	kg
	Total		1.05E+03	--	kg
Cl	Sludge	1C (Solid)	9.88E+02	2.48E+02	kg
	Supernatant	1C1 (Liquid)	2.92E+00	4.94E+01	kg
	Total		9.91E+02	--	kg

Table A-1. Tank C-110 Inventory.[a] (6 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
CN	Sludge	1C (Solid)	2.86E+00	2.88E+00	kg
	Supernatant	1C1 (Liquid)	1.05E-02	1.78E-01	kg
	Total		2.87E+00	--	kg
Cr [b]	Sludge	1C (Solid)	4.19E+02	5.45E+01	kg
	Supernatant	1C1 (Liquid)	4.76E-01	8.06E+00	kg
	Total		4.20E+02	--	kg
F	Sludge	1C (Solid)	6.75E+03	1.13E+03	kg
	Supernatant	1C1 (Liquid)	3.23E+00	5.46E+01	kg
	Total		6.75E+03	--	kg
Fe	Sludge	1C (Solid)	9.84E+03	1.35E+03	kg
	Supernatant	1C1 (Liquid)	5.60E-01	9.47E+00	kg
	Total		9.84E+03	--	kg
Hg	Sludge	1C (Solid)	3.98E-01	6.95E-02	kg
	Supernatant	1C1 (Liquid)	4.24E-04	7.17E-03	kg
	Total		3.98E-01	--	kg
K	Sludge	1C (Solid)	5.10E+02	6.67E+01	kg
	Supernatant	1C1 (Liquid)	1.16E+00	1.96E+01	kg
	Total		5.11E+02	--	kg
La	Sludge	1C (Solid)	1.32E+00	1.33E+00	kg
	Supernatant	1C1 (Liquid)	6.48E-03	1.10E-01	kg
	Total		1.33E+00	--	kg
Mn	Sludge	1C (Solid)	4.76E+01	8.52E+00	kg
	Supernatant	1C1 (Liquid)	2.13E-03	3.60E-02	kg
	Total		4.76E+01	--	kg
Na	Sludge	1C (Solid)	7.51E+04	9.65E+03	kg
	Supernatant	1C1 (Liquid)	1.22E+02	2.06E+03	kg
	Total		7.53E+04	--	kg
Ni	Sludge	1C (Solid)	2.17E+01	5.02E+00	kg
	Supernatant	1C1 (Liquid)	4.28E-03	7.25E-02	kg
	Total		2.17E+01	--	kg
NO_2 [b]	Sludge	1C (Solid)	6.51E+03	2.23E+03	kg
	Supernatant	1C1 (Liquid)	1.84E+01	3.11E+02	kg
	Total		6.53E+03	--	kg
NO_3	Sludge	1C (Solid)	9.77E+04	1.33E+04	kg
	Supernatant	1C1 (Liquid)	2.41E+02	4.08E+03	kg
	Total		9.80E+04	--	kg
Oxalate	Sludge	1C (Solid)	7.89E+02	Not reported	kg
	Supernatant	1C1 (Liquid)	4.25E+00	Not reported	kg
	Total		7.94E+02	--	kg

Table A-1. Tank C-110 Inventory.[a] (6 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Pb	Sludge	1C (Solid)	2.20E+02	7.20E+01	kg
	Supernatant	1C1 (Liquid)	0.00E+00	Not reported	kg
	Total		2.20E+02	--	kg
PO_4	Sludge	1C (Solid)	5.67E+04	1.32E+04	kg
	Supernatant	1C1 (Liquid)	2.04E+01	3.45E+02	kg
	Total		5.68E+04	--	kg
Si	Sludge	1C (Solid)	6.33E+03	8.42E+02	kg
	Supernatant	1C1 (Liquid)	5.78E-01	9.78E+00	kg
	Total		6.33E+03	--	kg
SO_4	Sludge	1C (Solid)	1.11E+04	2.19E+03	kg
	Supernatant	1C1 (Liquid)	2.33E+01	3.94E+02	kg
	Total		1.11E+04	--	kg
Sr	Sludge	1C (Solid)	1.12E+02	2.02E+01	kg
	Supernatant	1C1 (Liquid)	6.34E-03	1.07E-01	kg
	Total		1.12E+02	--	kg
TIC as CO_3	Sludge	1C (Solid)	9.41E+03	1.78E+03	kg
	Supernatant	1C1 (Liquid)	1.09E+01	1.84E+02	kg
	Total		9.42E+03	--	kg
TOC	Sludge	1C (Solid)	4.10E+02	2.85E+02	kg
	Supernatant	1C1 (Liquid)	2.32E+00	3.92E+01	kg
	Total		4.12E+02	--	kg
U_{TOTAL}	Sludge	1C (Solid)	1.97E+03	6.34E+02	kg
	Supernatant	1C1 (Liquid)	1.29E+00	2.18E+01	kg
	Total		1.97E+03	--	kg
Zr	Sludge	1C (Solid)	1.50E+02	2.13E+01	kg
	Supernatant	1C1 (Liquid)	7.30E-03	1.23E-01	kg
	Total		1.50E+02	--	kg

[a] Reference download from http://twinsweb.pnl.gov/data dated 6/10/05.

[b] Indicator constituents as identified in Section 7.1.1.1.

1C = first-cycle bismuth phosphate waste.
1C1 = first-cycle bismuth phosphate waste.
TIC = total inorganic carbon.
TOC = total organic carbon.

APPENDIX B

TANK C-110 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

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Abbreviations, Acronyms, and Initialisms

DST	double-shell tank
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
WMA	waste management area

Units

Ci	curie
ft^3	cubic feet
gal	gallon
kg	kilogram
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picocuries per liter

B1.0 TANK C-110 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for single-shell tank 241-C-110 (C-110). The information presented was developed using the methodology described in Chapter 7. Groundwater pathway impacts are presented in Section B2.0. Inadvertent intruder impacts are presented in Section B3.0.

B2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for C-110. The methodology used to generate the graphs is described in Section 7.1. Calculation detail for the graphs is provided in RPP-22521, *Tanks C-101, C-105, C-110, and C-111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan.*

NOTE: The leak concentrations for RPP-33116 Rev 0A were obtained from calculations in RPP-22521 Rev 2. The solution in AN-106 upon which the C-110 risk calculations in RPP-33116 Rev 0A were based was changed when solution in AN-106 was pumped out and solution from a different DST added. RPP-22521 Rev 3 updated the C-110 leak concentrations to reflect the revised AN-106 composition. The C-110 leak concentrations in RPP-33116 Rev 2 (and Rev 1) are from RPP-22521 Rev 3. The nitrite leak concentration was changed between RPP-22521 Rev 2 and Rev 3 because the calculated nitrite concentration increased. The calculated ^{99}Tc concentration in RPP-22521 Rev 3 was lower by 0.4% than that in RPP-22521 Rev 2, and the calculated Cr concentration was lower by 2.8%. For conservatism the ^{99}Tc and Cr leak concentrations were not changed between RPP-22521 Rev 2 and Rev 3, as is explained in RPP-22521 Rev 3. Thus, only the nitrite risk value changed between RPP-33116 Rev 0A and RPP-33116 Rev 2 (and Rev 1), the ^{99}Tc and Cr risk values stayed the same.

B2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures B-1 through B-3 provide the C-110 waste retrieval leak impact graphs for the three indicator contaminants (^{99}Tc, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure B-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from ^{99}Tc as a function of the amount of ^{99}Tc leaked from C-110 during waste retrieval. Figures B-2 and B-3 show the peak groundwater pathway hazard quotient (HQ) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from C-110 during waste retrieval.

The ILCR and HQ values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System*

Closure Plan. The graphs provide a retrieval leak risk picture for C-110 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The data points for these lines were calculated as described in Section 7.1.1 over a range of ^{99}Tc, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end.

Figure B-1. Tank C-110 Technetium-99 Risk Plot.

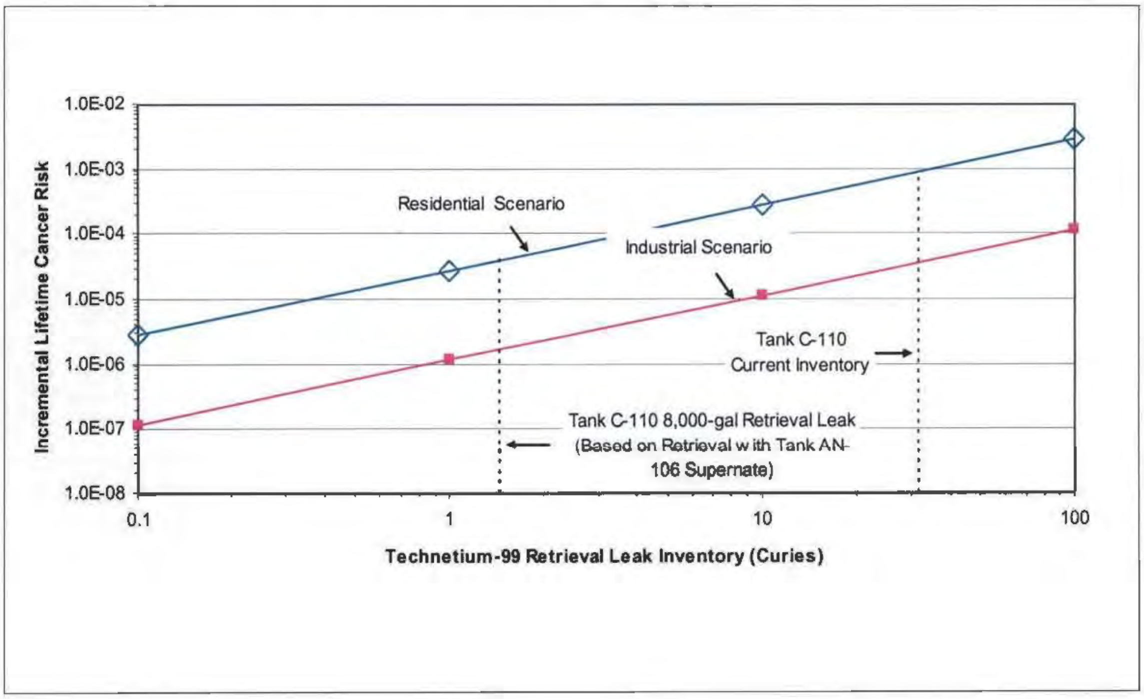


Figure B-2. Tank C-110 Hexavalent Chromium Hazard Quotient Plot.

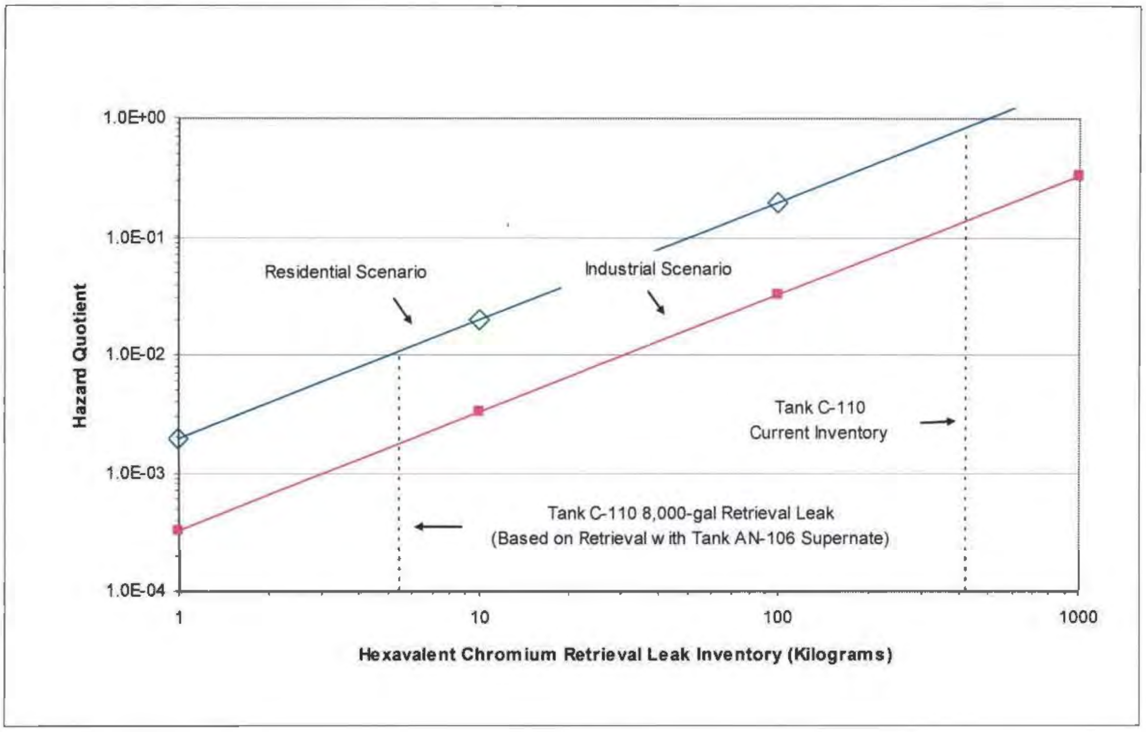
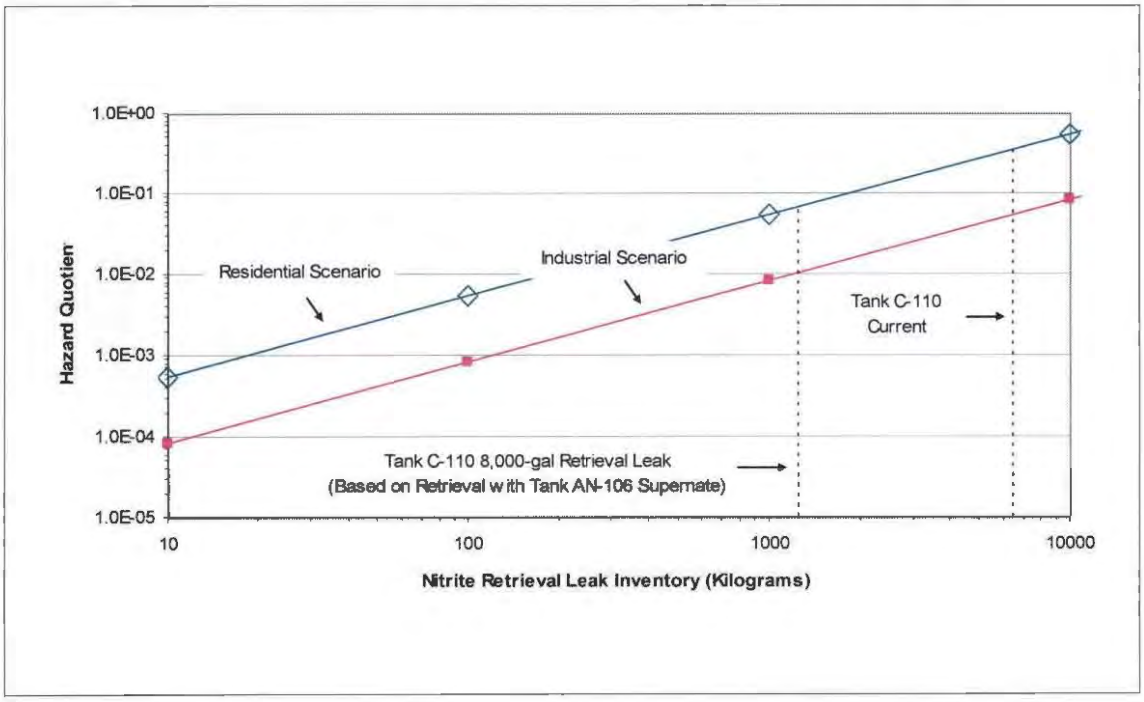


Figure B-3. Tank C-110 Nitrite Hazard Quotient Plot.



Vertical dashed lines were added to each graph as points of reference to show the estimated current C-110 inventory and the inventory associated with a potential 8,000-gal retrieval leak. The 8,000-gal volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for C-110.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures B-1 through B-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

B2.2 INVENTORY

The reference lines shown in Figures B-1 through B-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory (BBI) by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal) by a conservative estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from C-110 with tank AN-106 supernate. The retrieval leak fluid concentrations and retrieval leak inventories based on these concentrations are calculated in RPP-22521 (Table B-1).

Table B-1. Tank C-110 Retrieval Leak Inventory Estimate.

Contaminant	Leak Fluid Concentration*	Inventory in 8,000-gal Retrieval Leak
Technetium-99	4.77E-05 Ci/L	1.44E+00 Ci
Hexavalent Chromium	1.81E-04 kg/L	5.48E+00 kg
Nitrite	4.16E-02 kg/L	1.26E+03 kg

* RPP-22521, 2008, *Tanks C-101, C-105, C-110, and C-111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev 3.

B2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The ^{99}Tc inventory associated with a hypothetical 8,000-gal retrieval leak from C-110 was estimated to be approximately 1.44 Ci (RPP-22521). As shown in Figure B-1, this corresponds to an ILCR of approximately 1.67×10^{-6} for the industrial scenario and 4.07×10^{-5} for the residential scenario. The peak ^{99}Tc groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 121 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal retrieval leak from C-110 was estimated to be approximately 5.48 kg (RPP-22521). As shown in Figure B-2, this corresponds to an HQ of approximately 1.79×10^{-3} for the industrial scenario and 1.08×10^{-2} for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 4.60×10^{-4} mg/L.

The nitrite inventory associated with an 8,000-gal retrieval leak from C-110 was estimated to be approximately 1,260 kg (RPP-22521). As shown in Figure B-3, this corresponds to an HQ of approximately 1.05×10^{-2} for the industrial scenario and 6.73×10^{-2} for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 1.06×10^{-1} mg/L.

B2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of 1.18×10^{-6}. Using Equation 7-1 from Section 7.1, the industrial scenario ILCR was calculated as the product of the ^{99}Tc inventory (Table B-1), the ^{99}Tc retrieval leak unit groundwater concentration factor (Table 7-2), and the ^{99}Tc industrial scenario unit risk factor (Table 7-3), as follows:

$$\text{ILCR} = (1.44\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.18 \times 10^{-6}$$

Complete calculation details are provided in RPP-22521.

B3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the C-110 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 (2,700 gal) of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the BBI are provided in RPP-15317 and were used in the calculation (RPP-22521). Inventories for the subset of BBI radionuclides that were shown in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, to dominate intruder doses at 500 years after closure are shown in Table B-2.

Table B-2. Tank C-110 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste*.

Radionuclide	Units	Tank C-110
Strontium-90	Ci	5.66E+01
Technetium-99	Ci	4.84E-01
Tin-126	Ci	1.61E-04
Cesium-137	Ci	2.19E+02
Plutonium-239	Ci	1.03E+00
Plutonium-240	Ci	6.09E-02
Americium-241	Ci	5.96E-01

* Table 7-1 from RPP-15317, *241-C-Waste Management Area Inventory Data Package*.

Table B-3 summarizes the intruder analysis results for C-110. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22521. Contaminant-specific doses are shown for the subset of radionuclides that dominate the total dose. The total dose shown represents the sum of the dose contributions from all radionuclides considered.

The dose values in Table B-3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table B-3 indicates that C-110 would not exceed the performance objectives of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by ^{239}Pu, ^{240}Pu, and ^{241}Am.

Table B-3. Tank C-110 Intruder Dose.

Radionuclide	Well Driller (mrem EDE)	Suburban Resident with a Garden (mrem/yr EDE)	Rural Farmer with a Dairy Cow (mrem/yr EDE)
Strontium-90	0.000	0.000	0.000
Technetium-99	0.000	0.013	0.000
Tin-126	0.000	0.000	0.000
Cesium-137	0.000	0.000	0.000
Plutonium-239	0.007	0.037	0.002
Plutonium-240	0.000	0.002	0.000
Americium-241	0.003	0.011	0.001
Other radionuclides	0.000	0.000	0.000
TOTAL	0.010	0.063	0.003

Note: The number of significant digits shown is not intended to imply a level of accuracy greater than the input values.

EDE = effective dose equivalent.

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