CH2M HILL ENGINEERING CHANGE NOTICE

☒ DM ☐ FM ☐ TM

1a. ECN 722369 R 0

1b. Proj. ECN N/A - - 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 9-27-04

5. Originator's Name, Organization, MSIN, & Phone No. R.S. Robinson, Projects, S7-70, 373-1236	6. USQ Number No. - - - R- ☒ N/A	7. Related ECNs N/A

8. Title 241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan	9. Bldg. / Facility No. C-100/241-C	10. Equipment / Component ID C-100-Series Tanks	11. Approval Designator EQ

12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.) RPP-22393 Revision 0	13. Safety Designation ☐ SC ☐ SS ☐ GS ☒ N/A	14. Expedited/Off-Shift ECN? ☐ Yes ☒ No

15a. Work Package Number N/A	15b. Modification Work Completed N/A Responsible Engineer / Date	15c. Restored to Original Status (TM) N/A Responsible Engineer / Date	16. Fabrication Support ECN? ☐ Yes ☒ No

17. Description of the Change (Use ECN Continuation pages as needed)
Revision based on revised leak detection and monitoring strategy.

18. Justification of the Change (Use ECN Continuation pages as needed)
Complete revision required based on revised leak detection and monitoring strategy.

This document does not implement any temporary or permanent changes to the facility. The USQ process is not applicable. DJ Minteer DJ Minteer 9-29-04

19. ECN Category

☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type

☐ Supercedure
☐ Revision

20. Distribution

Name	MSIN	Name	MSIN
E.W. Girgis	S7-12	D.B. Parkman	S7-12
R.S. Robinson	S7-70	R.D. Smith	S7-90
W.T. Thompson	S7-70	C. Henderson	B2-60
J.F. Bores	S7-07	K.J. Anderson	S7-01
R.E. Butler	S7-83	M.N. Jarayssi	H6-03
D.S. Doss	S7-03	G.W. Reddick	S7-70
K.E. Carpenter	S7-20	Central Files	B1-07

Release Stamp

SEP 30 2004
DATE: HANFORD RELEASE
STA: 3 ID: 18

CH2M HILL ENGINEERING CHANGE NOTICE

 ☒ DM ☐ FM ☐ TM

1a. **ECN** 722369 **R** 0

1b. **Proj. ECN** N/A - - R

21. **Revisions Planned** (Include a brief description of the contents of each revision)
Complete revision based on revised leak detection and monitoring strategy.

Note: All revisions shall have the approvals of the affected organizations as identified in block 11 "Approval Designator," on page 1 of this ECN.

22. **Design Basis Documents**
☒ Yes ☒ No
RS Robinson 9/28/04

23. **Commercial Grade Item Dedication Numbers** (associated with this design change)
N/A

24. **Engineering Data Transmittal Numbers** (associated with this design change, e.g., new drawings, new documents)
N/A

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

Type of Document	Document Number	Type of Document	Document Number
N/A	N/A	N/A	N/A

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 17, 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	A/E Signatures		Date
Design Authority	E.W. Girgis [signature]	9/29/04	Originator/Design Agent	C. Henderson [signature]	9/28/04
Resp. Engineer	R.S. Robinson [signature]	9-28-04	Professional Engineer		
Resp. Manager	W.T. Thompson [signature]	9/28/04	Project Engineer		
Quality Assurance	J.F. Bores [signature]	9/29/04	Quality Assurance		
IS&H Engineer			Safety		
NS&L Engineer	RD Smith [signature]	9/28/04	Designer		
Environ. Engineer	S.S. Doss [signature]	9-29-04	Environ. Engineer		
Engineering Checker	Checking Completed by A/E		Other		
Other	Safety R.E. Butler [signature]	9/28/04	Other		
Other	Project Manager K.E. Carpenter CA Barker for [signature]	9/28/04	DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION		
Other	System Engineer D.B. Parkman D.B. Parkman	9/28/04	Signature or a Control Number that tracks the Approval Signature		
Other	Operations K.J. Anderson [signature]	9/29/04			
Other	M.N. Jarayssi [signature] for MNJ	9/28/04	ADDITIONAL SIGNATURES		
Other	G.W. Reddick [signature]	9/28/04			
Other	[signature]	9/28/04			

241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan

R.S. Robinson
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: ECN-722369 UC:
Cost Center: BA00 Charge Code: 501679
B&R Code: Total Pages: 164

Key Words: 241-C-102, 241-C-104, 241-C-107, 241-C-108, 241-C-112 TWRWP, Sluicing

Abstract: This document establishes the C-102, C-104, C-107, C-108, and C-112 Tanks Waste Retrieval Work Plan required by Hanford Federal Facility Agreement and Consent Order.

Barbara Wolski 9/30/04

Release Approval Date

SEP 30 2004
DATE: HANFORD RELEASE
STA: 3
ID: 18

Release Stamp

Approved For Public Release

RECORD OF REVISION

(1) Document Number: RPP-22393

Page 1

(2) Title

241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) EDT-821231, Initial Release	RS Robinson	WT Thompson
1 RS	Complete rewrite due to revised leak detection and monitoring strategy. Revision per ECN-722369	RS Robinson RS Robinson 9-28-04	WT Thompson W.T. Thompson 9/28/04

241-C-102, 241-C-104, 241-C-107, 241-C-108, AND 241-C-112 TANKS WASTE RETRIEVAL WORK PLAN

September 27, 2004

Prepared By
CH2M HILL Hanford Group, Inc.
Richland, Washington

This page intentionally left blank.

CONTENTS

APPENDICES

FIGURES

TABLES

LIST OF TERMS

AEA	*Atomic Energy Act of 1954*
BBI	best-basis inventory
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HRR	high-resolution resistivity
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
PUREX	plutonium-uranium extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
WMA	waste management area
WRS	waste retrieval system

This page intentionally left blank.

1.0 INTRODUCTION

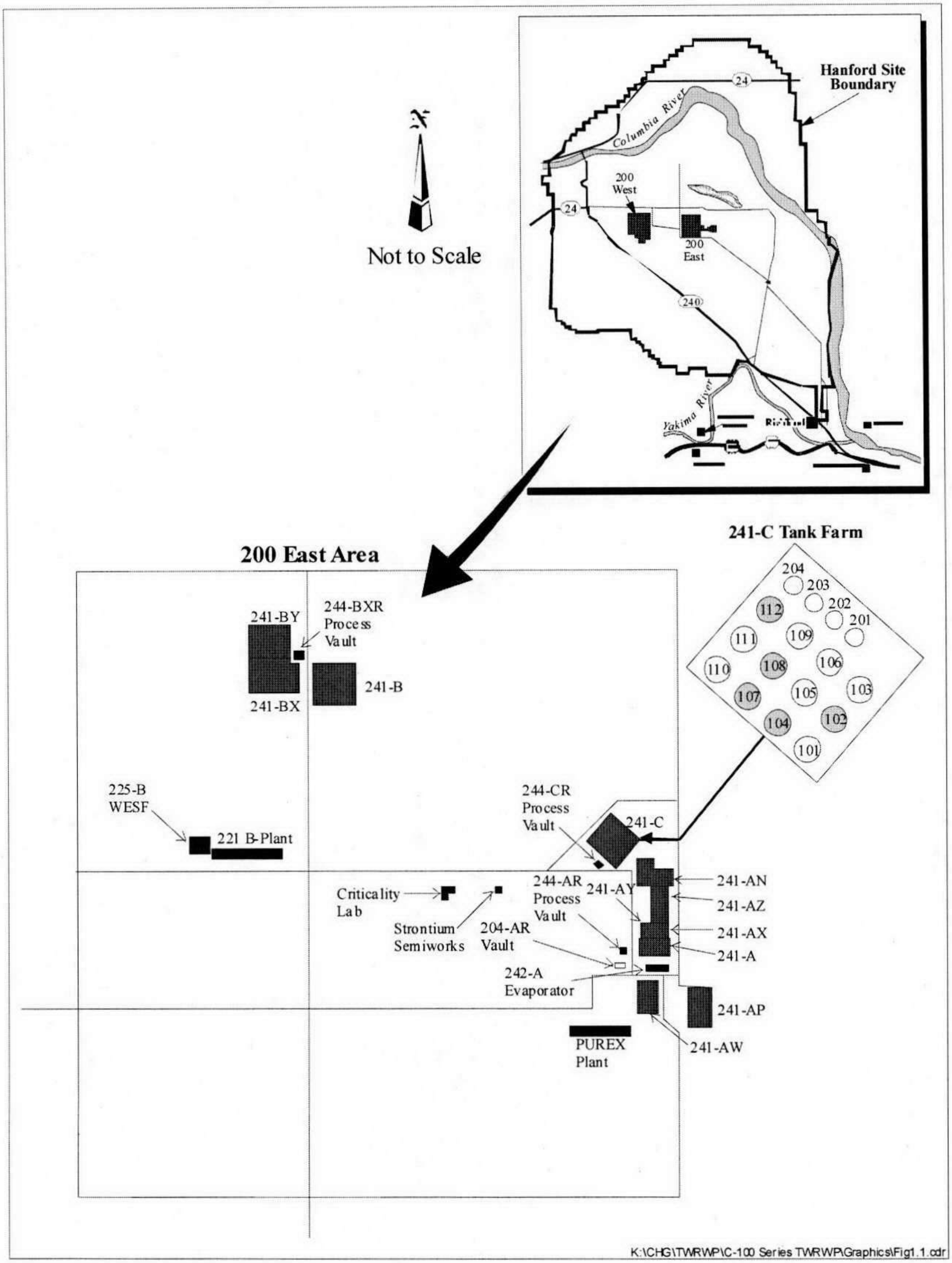
The River Protection Project mission includes storage, retrieval, immobilization, and disposal of radioactive mixed waste presently stored in underground tanks located in the 200 East and 200 West Areas of the U.S. Department of Energy (DOE) Hanford Site. Single-shell tanks (SSTs) 241-C-102 (C-102), 241-C-104 (C-104), 241-C-107 (C-107), 241-C-108 (C-108), and 241-C-112 (C-112), located in the 200 East Area (Figure 1.1), are scheduled for waste retrieval using the modified sluicing waste retrieval technology. These tanks were identified for waste retrieval with modified because they are classified as sound tanks and are suitable for deployment of existing modified sluicing waste retrieval technology

This is a primary document developed to meet the requirements identified in the *Hanford Federal Facility Agreement and Consent Order* (HFFACO; Ecology et al. 1989).
The relationship of the tank waste retrieval work plans to the overall SST waste retrieval and closure process is described in Appendix I of the 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 tanks C-102, C-104, C-107, C-108, and C-112 to allow Ecology to approve the waste retrieval action.

Tank Waste Retrieval Work Plans have been developed for the other 100-series tanks in the C farm including *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan* (RPP-21895) and *241-C-101, 241-C-105, 241-C-110, and 241-C-111 Tanks Waste Retrieval Work Plan* (under development). Additionally a similar document was prepared for the C-200-series tanks, *C-200-Series Tanks Retrieval Functions and Requirements* (RPP-16525).

Source, special nuclear, and byproduct materials, as defined in the *Atomic Energy Act of 1954* (AEA) are regulated at DOE facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that, under AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. Information in this document about the data or discussions about materials regulated by the AEA is provided for informational purposes only.

Figure 1.1. Location Map of C Tank Farm and Surrounding Facilities in the 200 East Area



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

2.1 WASTE RETRIEVAL START DATES

A summary of the current schedule baseline for waste retrieval from the five tanks addressed in this document is provided in Figure 2.1. Current plans include initiating waste retrieval from tank C-102 in June 2005, tank C-112 in September 2005, tank C-108 in December 2005, tank C-107 in February 2006, and tank C-104 in April 2006. The schedule information provided in this document is current as of the time of document preparation and is subject to change. Schedule changes will not require modification of this document. As shown in Figure 2.1, waste retrieval operations are planned to be completed within 12 months of the waste retrieval start date.

2.2 TANK HISTORY

Tanks C-102, C-104, C-107, C-108, and C-112, are located in the C tank farm in the 200 East Area as depicted in Figure 2.2. Summary data for the tanks' current conditions are provided in Table 2.1.

Table 2.1. Summary Tank Data

Tank	C-102	C-104	C-107	C-108	C-112
Constructed	1943-44	1943-44	1943-44	1943-44	1943-44
In service	1946	1946	1946	1947	1946
Diameter (ft)	75	75	75	75	75
Operating depth (ft)	16	16	16	16	16
Design capacity (gal)	530,000	530,000	530,000	530,000	530,000
Bottom shape	Dish	Dish	Dish	Dish	Dish
Ventilation	Passive	Passive	Passive	Passive	Passive
Nominal burial depth (ft)	6	6	6	6	6
Declared inactive	1977	1980	1978	1977	1976
Integrity	Sound	Sound	Sound	Sound	Sound
Interim stabilized	9/95	9/89	9/95	3/84	9/90

The C farm 100-series tanks are 75 feet in diameter and 32 feet tall. The tanks have a 16-foot operating depth and an operating capacity of 530,000 gallons each. The tanks sit below grade with at least 6 feet of soil cover to provide shielding from radiation exposure to operating personnel.

Figure 2.1. Waste Retrieval Schedule

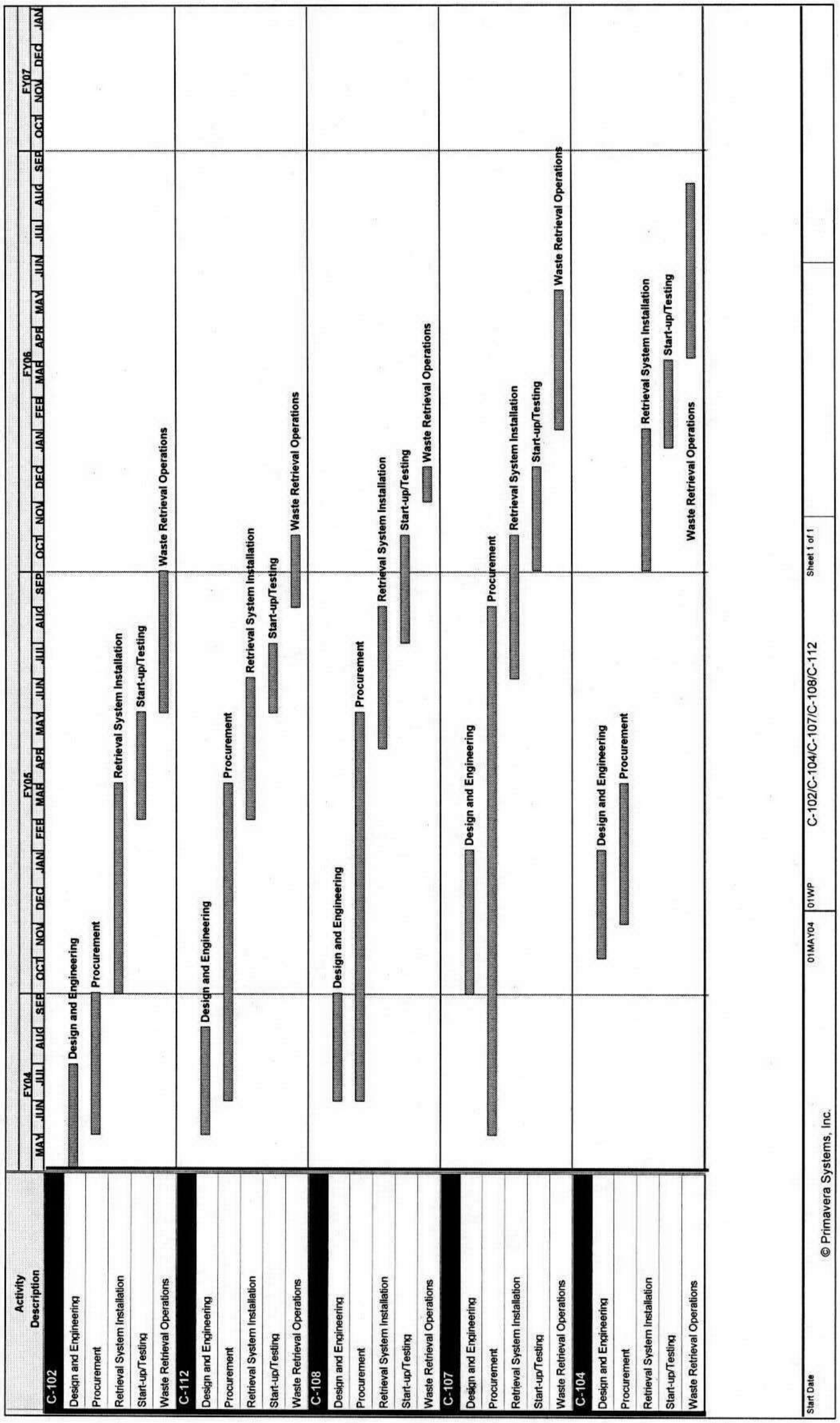
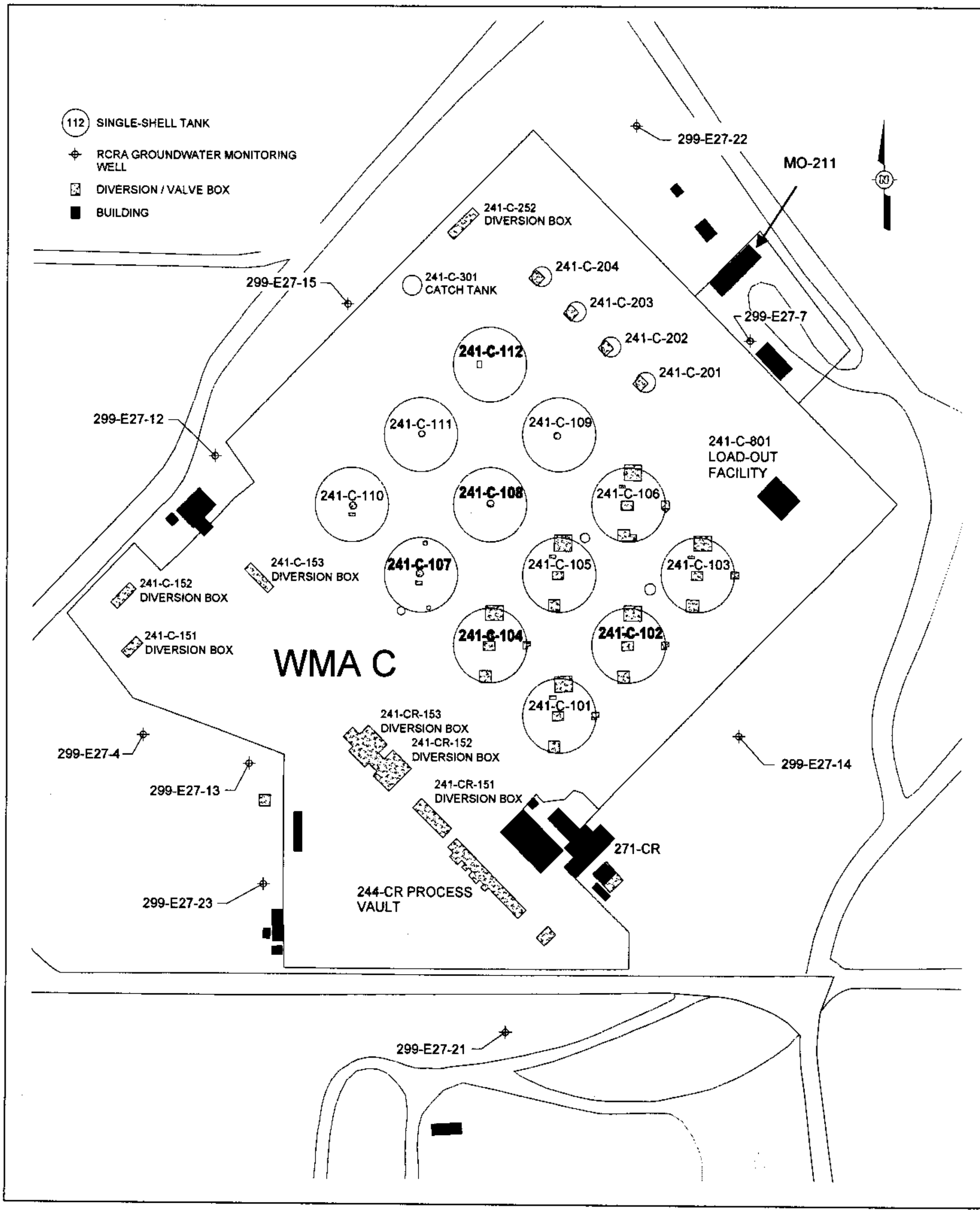


Figure 2.2. Location of Tanks C-102, C-104, C-107, C-108, and C-112



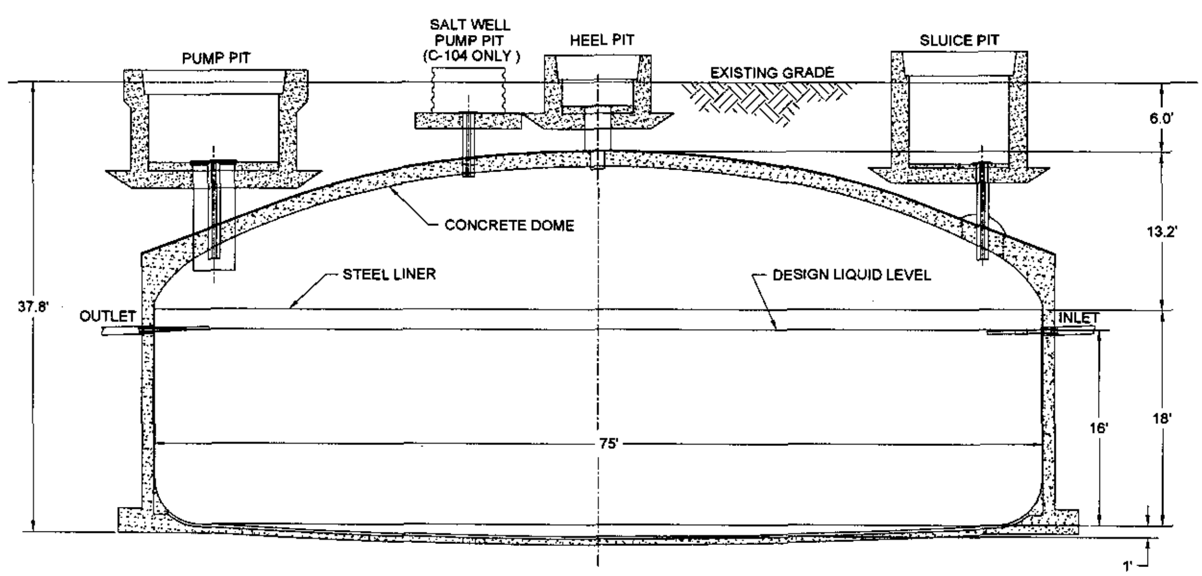
The SSTs were constructed in-place with a carbon steel lining on the bottom and sides, and a reinforced-concrete shell. The welded liners are independent of the reinforced-concrete tanks and were designed to provide leak-tight containment of the liquid radioactive wastes and to protect the reinforced-concrete 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 tanks have dished bottoms (center of tanks lower than the perimeter) and a curving intersection of the sides and bottom. Inlet and outlet lines are located near the top of the liners. These lines are also referred to as 'cascade' lines because they allowed transfer of fluids between tanks using gravity flow to support the transfer and storage of waste within a series of three 100-series SSTs.

Tanks C-101 through C-106 were modified after initial tank construction to add pits at the tank farm surface. Because of these modifications the configuration of tanks C-102 and C-104 is different than tanks C-107, C-108, and C-112 as described in the following sections.

2.2.1 Tank C-102 and C-104 Configuration

The configurations of tanks C-102 and C-104 are similar and are shown in Figure 2.3 as a cross-section view.

Figure 2.3. Tanks C-102 and C-104 Cross-Section View



C-102/-104 Cross-Section View
530,000-Gallon Capacity

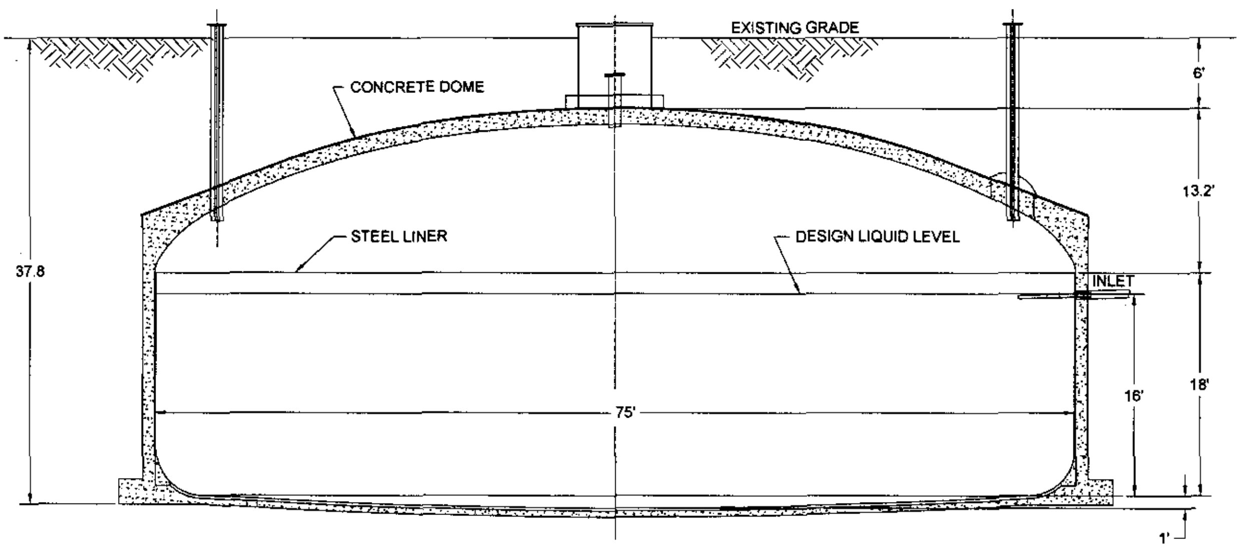
Tanks C-102 and C-104 both have three reinforced-concrete process pits that were installed after initial tank construction to facilitate uranium recovery waste retrieval. These pits extend above grade to prevent flooding by surface water. The pits provide secondary containment for the primary transfer piping within, and have removable cover blocks or plates that allow entry for work. The pit floors were constructed with drains that direct any liquid back into the tank through a tank riser located in the pit. The condenser hatchway (shown in Figure 2.5) located above the outside edge of the tank provides an indirect access path into the tank below through a 24-inch vitrified clay pipe with a 90° bend.

In addition, tank C-104 has a fourth process pit made from a corrugated steel pipe with a concrete floor. This pit and the associated 12-inch riser were added to the tank to support saltwell pumping.

2.2.2 Tank C-107, C-108, and C-112 Configuration

The configuration of tanks C-107, C-108, and C-112 is shown in Figure 2.4 as a cross-section view.

Figure 2.4. Tanks C-107, C-108, and C-112 Cross-Section View



C-107, C-108, C-112 Cross-Section View
530,000-Gallon Capacity

Note: The cascade line configuration in these three tanks varies. Tank C-107 has only an outlet line. Tank C-108 has both an inlet and an outlet and tank C-112 has only an inlet.

Tanks C-107, C-108, and C-112 do not have concrete pits, but do have pits that were installed over the center riser after initial tank construction to facilitate waste retrieval. The pits were constructed using a section of corrugated pipe with a concrete floor and drain. These pits use a metal cover plate and extends above grade to prevent flooding by surface water.

2.3 TANK RISER INFORMATION

Table 2.2 provides the size and current use/contents of tank C-102 and C-104 risers. Figure 2.5 provides the tank C-102 and C-104 riser plan view. Table 2.3 provides the size and current use/contents of tanks C-107, C-108, and C-112 risers, and Figure 2.6 provides the tanks C-107, C-108, and C-112 riser plan view.

Table 2.2. Tanks G-102 and C-104 Riser, Fill/Cascade Line Use Descriptions

Riser Number	Diameter (in.)	Use Description	
		Tank C-102	Tank C-104
R1	4	Unused temperature probe	Liquid level well, below grade
R2	12	ENRAF	Breather filter and bench mark
R3	12	Observation port/breather filter in weather covered pit (02-C pit)	Observation port in weather covered pit (04-C pit)
R4	4	Recirculating dip leg in weather covered pit (02-C pit)	Recirculating dip leg in weather covered pit (04-C pit)
R5	4	Recirculating dip leg in weather covered pit (02-A pit)	Recirculating dip leg in weather covered pit (04-A pit)
R6	12	Sluicing access riser in weather covered pit	Sluicing access riser in weather covered pit
R7	12	Temperature probe in riser through pit wall, flange weather covered (02-A pit)	Temperature probe in riser through pit wall (02-A pit)
R8	4	blind flange (obstruction)	Level gauge, ENRAF
R9	36	sludge pump access riser in weather covered pit (02-A pit)	Sludge pump access riser in weather covered pit (02-A pit)
R13	12	Saltwell screen in weather covered pit (02-B pit)	Heel jet in 02-B pit
R14	4	NA	Blind flange
R15	12	NA	Empty
A	3	Cascade overflow line to tank C-103	Cascade overflow line to tank C-105
B	3	Cascade inlet line from tank C-101	NA
C1	3	Spare inlet, capped	Fill line V150
C2	3	Spare inlet, capped	Fill line V149, sealed in diversion box 241-C-153
C3	3	Spare inlet, capped	Fill line V148, sealed in diversion box 241-C-153
C4	3	Spare inlet, capped	Spare, capped

Sources: Reference documents from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm. RPP-16194 and H-14-010613 (with ECNs)

NA = not applicable

Figure 2.5. Tanks C-102 and C-104 Riser Plan View

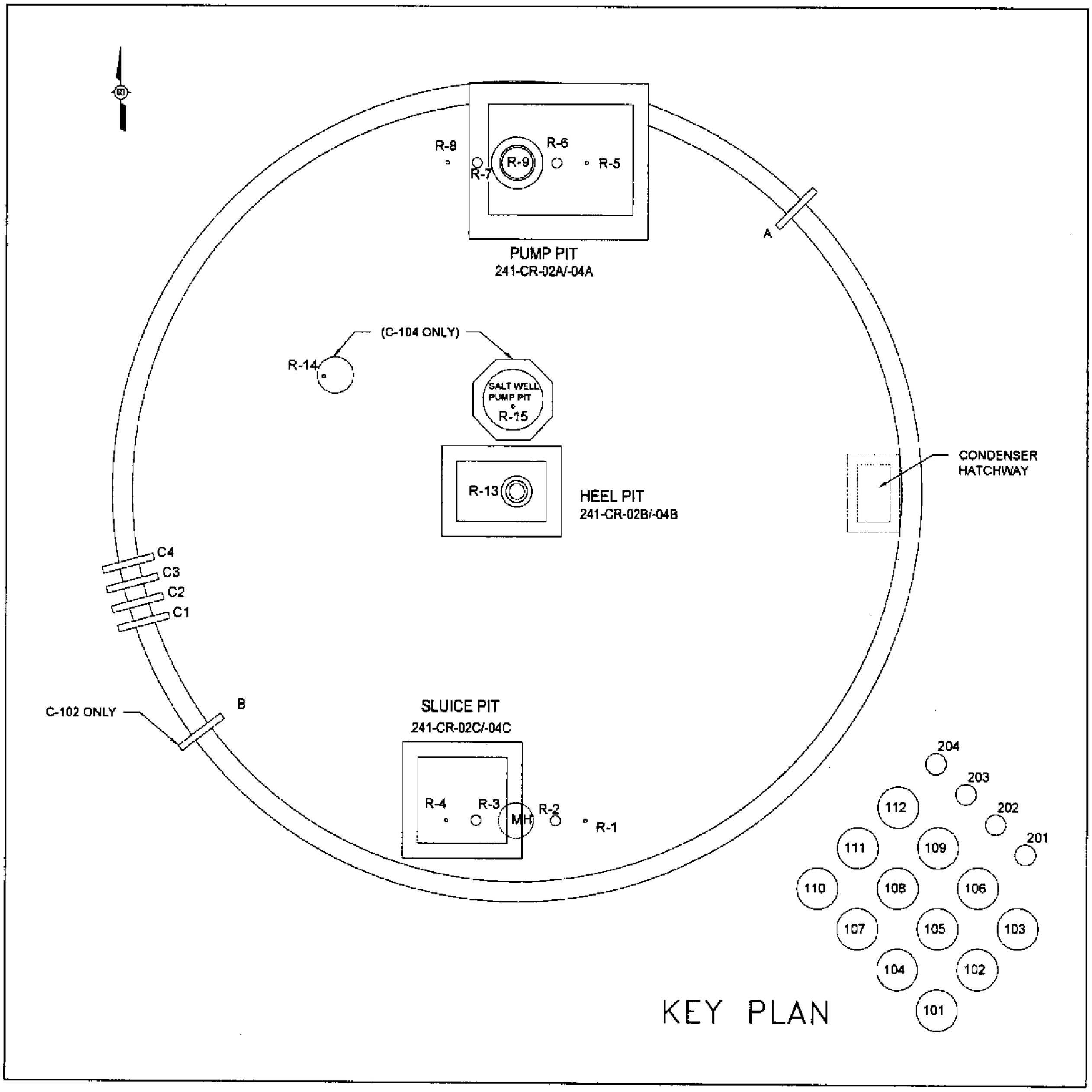


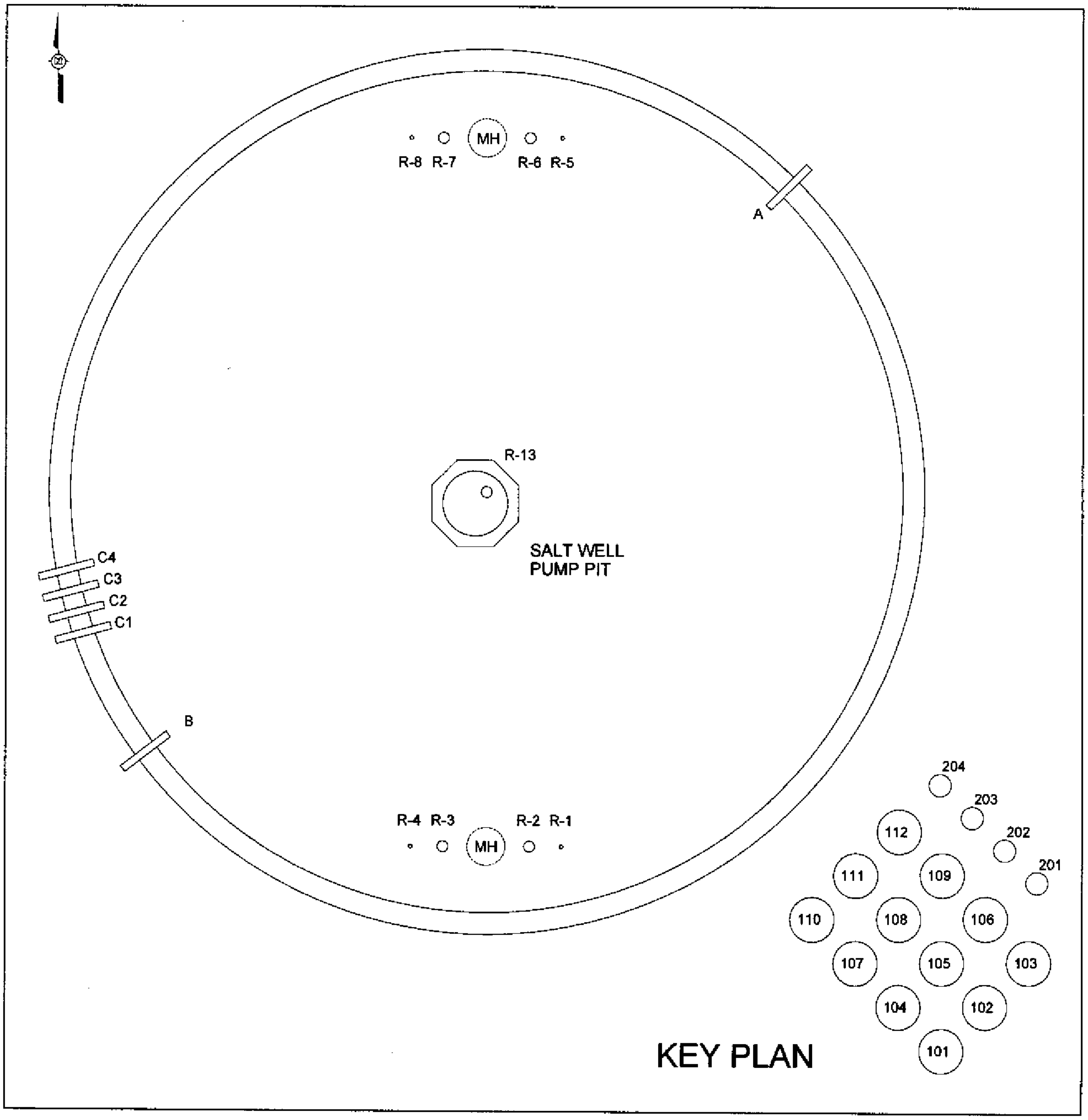
Table 2.3. Tanks C-107, C-108, and C-112 Riser Fill/ Cascade Line Use Descriptions

Number	Diameter (in.)	Use Descriptions and Comments		
		Tank C-107	Tank C-108	Tank C-112
R1	4	Spare	Thermocouple	Temperature probe
R2	12	Spare	Multi-port adapter with bench mark	Blind flange with bench mark
R3	12	Multi-port adapter / standard hydrogen monitoring system vapor probe (on 4-in. adapter)	Spare	Spare
R4	4	Breather filter	Breather filter with offset adapter	Breather filter with offset adapter
R5	4	Temperature probe	Temperature probe	Level gauge (ENRAF) with thermocouple (ECN-169038)
R6	12	Spare	Spare	Spare
R7	12	Spare	Observation port	Observation port
R8	4	Level gauge (ENRAF)	ENRAF with bench mark	Multi-function instrument tree (MIT)
R13	12	Saltwell pump	Saltwell screen in weather covered pit	Saltwell pump pit weather covered
A	3	Cascade line overflow to tank C-108	Cascade overflow line to tank C-109	NA
B	3	NA	Cascade inlet line from tank C-107	Cascade inlet line from tank C-111
C1	3	Fill line, sealed in diversion box 241-C-153	Spare, capped	Spare, capped
C2	3	Fill line, sealed in diversion box 241	Spare, capped	Spare, capped
C3	3	Fill line, sealed in diversion box 241	Spare, capped	Spare, capped
C4	3	Spare, plugged	Spare, capped	Spare, capped

Source: Best-basis inventory documents from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm.

NA = not applicable.

Figure 2.6. Tanks C-107, C-108, and C-112 Riser Plan View



2.4 CLASSIFICATION

Tanks C-102, C-104, C-107, C-108, and C-112 are classified as 'sound' in the waste tank summary report (*Waste Tank Summary Report for Month Ending April 30, 2004* [HNF-EP-0182]). 'Sound' classification is assigned to a tank when surveillance data indicates no loss of liquid attributed to a breach of integrity. A description of the 100-series tanks is provided in Appendix C, Section C2.0, of *Single-Shell Tank System Closure Plan* (RPP-13774).

2.5 TANK WASTE VOLUME/CHARACTERISTICS

The waste volume and inventories currently stored and awaiting retrieval in tanks C-102, C-104, C-107, C-108, and C-112 are summarized in Table 2.4.

There are varying degrees of uncertainty associated with the waste inventory. The inventory uncertainty is a combination of the (1) uncertainty associated with measurements of waste volume and (2) concentration. Inventory uncertainty estimates have been completed for some but not all constituents and for some but not all waste types. As an example, the relative standard deviation for technetium-99 in tanks C-102, C-104, C-107, C-108, and C-112 is presented in Table 2.5. The standard deviation can then be calculated by multiplying the inventory by the relative standard deviation. Details on the methodology used for developing inventory uncertainty values reported in the best-basis inventory (BBI) are provided in *Best Basis Inventory Process Requirements* (RPP-7625). The inventory uncertainty data associated with the contaminants that drive the long-term risk (e.g., technetium-99) can be used to provide insight to the uncertainty in the long-term human health risks presented in Section 7.0.

Although there are uncertainties associated with contaminant inventories in the tanks, 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. There are currently no plans to perform additional characterization (e.g., sampling and analyses) of the waste in tanks C-102, C-104, C-107, C-108, or C-112 to support waste retrieval and transfer. Sampling and analysis will be performed as needed to meet waste retrieval and storage requirements. Sampling and analyses of the waste from each of the tanks will be performed at or near the end of waste retrieval activities in support of component closure actions. Sampling and analysis activities associated with component closure actions will be defined in the component closure data quality objective and associated waste sampling and analysis plans.

2.5.1 Tank C-102 Waste Characteristics

Tank C-102 began receiving waste from tank C-101 through the cascade line in 1946 and stored metal waste until the second quarter of 1953. Tank C-102 cascaded waste into tank C-103 from 1946 until 1953. In 1953, the metal waste in the tank was sluiced to a sludge heel in an effort to recover uranium. The tank received uranium recovery waste from the third quarter of 1953 until the fourth quarter of 1954. During the second quarter of 1957, the tank was scavenged.

Table 2.4. Waste Volume/Inventory Summary

Waste Property	Unit	Tank C-102	Tank C-104	Tank C-107	Tank C-108	Tank C-112
Solids volume	gal	316,000	259,000	248,000	66,000	104,000
Supernate volume	gal	0	0	0	0	0
Total Volume	Gal	316,000	259,000	248,000	66,000	104,000
Cesium-137	Ci	2.59E+04	8.86E+04	5.89E+04	7.77E+04	2.66E+05
Strontium-90	Ci	2.80E+04	4.47E+05	2.08E+06	8.00E+03	6.02E+05
Technetium-99	Ci	8.87E-01	5.76E+01	3.77E+01	5.61E+00	6.11E+01
Carbon-14	Ci	1.44E+00	1.84E+00	5.56E-01	8.18E-02	3.61E+00
Iodine-129	Ci	2.32E-01	7.49E-01	7.15E-01	9.75E-04	2.74E-02
Plutonium-238, -239, -240, -241	Ci	9.81E+03	1.92E+04	4.36E+03	4.06E+00	1.27E+02
Total Curies	Ci	6.37E+04	5.55E+05	2.14E+06	8.57E+04	8.68E+-5
Sodium	lb	2.34E+05	3.90E+05	2.09E+05	7.67E+04	1.10E+05
Nitrate/Nitrite	lb	1.86E+05	1.23E+05	1.82E+05	5.52E+04	1.43E+05
Chromium	lb	1.42E+03	3.20E+03	2.04E+03	4.98E+02	3.06E+02
Total Chemicals	lb	4.21E+05	5.16E+05	3.93E+05	1.32E+05	2.53E+05

Sources: Reference download from http://twinsweb.pnl.gov/twins.htm dated 8/11/04, and RPP-21753.

Table 2.5. Technetium-99 Inventory Uncertainty

Tank	Waste Phase	Waste Type	Inventory (Ci)	Relative Standard Deviation
C-102	Total	NA	8.87E-01	Not reported
	Sludge	CWP1 (solid)	5.50E-02	Not reported
	Sludge	CWP2 (solid)	1.90E-01	Not reported
	Sludge	CWZr1 (solid)	3.37E-01	Not reported
	Sludge	MW1 (solid)	3.52E-02	Not reported
	Sludge	TBP (solid)	8.83E-02	Not reported
	Sludge	TH1 (solid)	1.81E-01	Not reported
C-104	Total	NA	5.76E+01	Not reported
	Sludge	CWP1 (solid)	1.92E+01	0.099
	Sludge	CWP2 (solid)	1.35E+01	0.099
	Sludge	CWZr1 (solid)	5.29E+00	0.099
	Sludge	NA	8.94E+00	0.099
	Sludge	OWW3 (solid)	6.06E+00	0.099
	Sludge	TH2 (solid)	4.70E+00	0.099
C-107	Total	NA	3.77E+01	Not reported
	Sludge	1C (solid)	2.04E+01	0.098
	Sludge	CWP2 (solid)	3.59E+00	0.098
	Sludge	SRR (solid)	1.37E+01	0.098
C-108	Total	NA	5.61E+00	Not reported
	Sludge	1C (solid)	5.14E+00	3.82
	Sludge	TBP (solid)	1.72E-01	Not reported
	Sludge	TFeCN (solid)	2.94E-01	Not reported
C-112	Total	NA	6.11E+01	Not reported
	Sludge	1C (solid)	8.86E+00	0.140
	Sludge	CWP1 (solid)	9.94E+00	0.140
	Sludge	TFeCN (solid)	4.23E+01	0.140
Total Ci			1.63E+02	

Source: download from http://twinsweb.pnl.gov/twins.htm dated 8/11/04
1C = first cycle decontamination.
CWP1 = PUREX coating waste generated from 1956 through 1960.
CWP2 = PUREX coating waste generated from 1961 through 1972.
CWZr1 = Zirflex coating waste.
MW1 = residual metal waste ($BiPO_4$ metal waste) from 1944-1949.
NA = not applicable.
OWW3 = PUREX organic wash waste.
PUREX = plutonium-uranium extraction.
SRR = strontium recovery supernate waste.
TBP = tributyl phosphate waste.
TFeCN = ferrocyanide scavenging waste.
TH1 = high level thorium waste 1.
TH2 = high level thorium waste 2.

During the third quarter of 1960, tank C-102 received waste water, and from the third quarter of 1960 until the fourth quarter of 1969, the tank received plutonium-uranium extraction (PUREX) cladding waste. The tank received waste from the 1966 thorium campaign during the second quarter of 1966 and PUREX organic wash waste from the second quarter of 1968 until the first quarter of 1969.

A maximum waste volume of approximately 530,000 gallons of waste in tank C-102 was reached in the first quarter of 1952 and remained at that level until the third quarter of 1952. The same amount of 530,000 gallons was reached in the first quarter of 1954 and remained at that level until the fourth quarter of 1956 (*Historical Characterization* [WHC-SD-WM-ER-313]).

A saltwell pump was installed in tank C-102 in November 1975; saltwell pumping was completed in June 1978. The tank was declared inactive in 1977 and was partially isolated in December 1982. In November 1991, the tank was saltwell pumped again (*Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-102* [GJ-HAN-86]). The tank contains an estimated 62,000 gallons of interstitial liquid.

2.5.2 Tank C-104 Waste Characteristics

Tank C-104 went into service in 1946 when it began to receive metal waste from B Plant (*Waste Status and Transaction Records Summary (WSTRS)* [LA-UR-97-311]). The metal waste began to cascade to tank C-105 in the first quarter of 1947. Waste additions continued until November 1947, when the tank and the cascade series were full. The tank remained full until 1953, when waste retrieval actions were initiated for uranium recovery. The tank was effectively emptied in early 1955. The tank remained empty until the fourth quarter of 1955 when it received tributyl phosphate waste (TBP) supernate and metal waste from tank C-112. Cladding waste was received from PUREX and was transferred to tanks C-101 and C-105 in 1956, and PUREX cladding waste was received again and cascaded to tank C-105 in 1957.

Tank C-104 received numerous transfers of different waste types. The tank currently contains only sludge consisting primarily of five waste types:

- Zirconium cladding waste (CWZr1)
- Organic wash waste (OWW3)
- Cladding waste (CWP2)
- Thorium high-level waste (TH2)
- Cladding waste (CWP1).

From 1976 to 1980, tank C-104 exchanged supernate with tank A-102. Supernate was sent to tanks AZ-101 and AX-102 in 1978. The tank received supernate waste from tank C-103 in 1979. Tank C-104 was removed from service in 1980 and was declared interim stabilized in 1989.

2.5.3 Tank C-107 Waste Characteristics

Tank C-107 was placed into service in 1946 when it began receiving waste through diversion box 241-C-153. From the second quarter of 1946 until the third quarter of 1948, tank C-107 received first-cycle waste from the B and/or T Plants. This waste was produced by separation of fission products from plutonium using the bismuth phosphate process; therefore, the waste contained a relatively high level of fission products, phosphate, and nitrate. In September 1947, tank C-107 was declared full and began cascading to tank C-108. Between 1947 and 1978, when it was declared inactive, numerous waste transfers were made into and out of tank C-107. Tank C-107 received first-cycle decontamination waste (1C) generated from the bismuth phosphate process, tributyl phosphate (UR/TBP) liquid waste, PUREX cladding removal waste (CWP2), hot semiworks waste, waste from the CR vault and Site laboratories, and strontium-rich sludge (SRR).

Two liquid-pumping campaigns have taken place since 1976. The tank was saltwell pumped from the third quarter of 1976 until the second quarter of 1977. Approximately 18,000 gallons were removed by jet pumping from November 1991 to January 1992 (*Tank Characterization Report for Single-Shell Tank 241-C-107* [WHC-SD-WM-ER-474]).

The tank currently contains sludge consisting of three waste types: first-cycle decontamination waste, PUREX cladding removal waste, and strontium-rich sludge. In general, first-cycle decontamination waste exhibits high concentrations of aluminum, bismuth, fluorine, iron, silicon, phosphate, and sulfate; PUREX cladding removal waste exhibits high concentrations of aluminum; and strontium-rich sludge exhibits high concentrations of sodium, iron, and strontium.

2.5.4 Tank C-108 Waste Characteristics

Tank C-108 was placed into service in 1947 when it began receiving waste via the cascade line from tank C-107. Tank C-108 received first-cycle decontamination waste (1C) from the bismuth phosphate process, uranium recovery waste (UR), in-farm ferrocyanide scavenging waste (TFeCN); and PUREX cladding waste (CWP). During the same period, supernate was transferred from tank C-108 to tanks BY-101 and BY-105. Other wastes received include Hot Semiworks Plant waste, PUREX organic wash waste, ion exchange waste, reduction oxidation waste, N Reactor waste, decontamination waste, and laboratory waste.

Between 1952 and 1976, when it was removed from service, numerous waste transfers were made into and out of tank C-108. The tank currently contains sludge consisting primarily of three waste types: first-cycle decontamination waste, TBP, and in-farm ferrocyanide scavenging waste. In general, first-cycle decontamination waste sludge exhibits high concentrations of aluminum, bismuth, fluorine, iron, silicon, phosphate, and sulfate; TBP sludge exhibits high concentrations of chromium, iron, sodium, phosphate, and sulfate; and in-farm ferrocyanide scavenging waste exhibits high concentrations of calcium, iron, nickel, phosphate, and cesium-137.

Saltwell pumping was completed in 1978, and intrusion prevention was completed on December 15, 1982 (*Waste Storage Tank Status and Leak Detection Criteria* [WHC-SD-WM-TI-356]). The tank was designated as interim stabilized on March 9, 1984. This tank was added to the Ferrocyanide Watch List in January 1991 and was removed June 1996 (*Waste Tank Summary Report for Month Ending November 30, 1996* [HNF-EP-0182-104]).

2.5.5 Tank C-112 Waste Characteristics

Tank C-112 was placed into service in 1946 when it began receiving metal waste from the other two tanks in the cascade (tanks C-110 and C-111). The metal waste originated from the bismuth phosphate separations process used at B Plant. Because tank C-112 is the final tank in a cascade series, most of the metal waste solids would have settled in the first two tanks. Supernate from tank C-112 was transferred to tank B-106 in 1952, leaving a 17,000-gallon heel in the tank. Tank C-112 was refilled with unscavenged uranium recovery waste in 1954. From late 1955 until 1958, the tank was used for settling scavenged ferrocyanide waste.

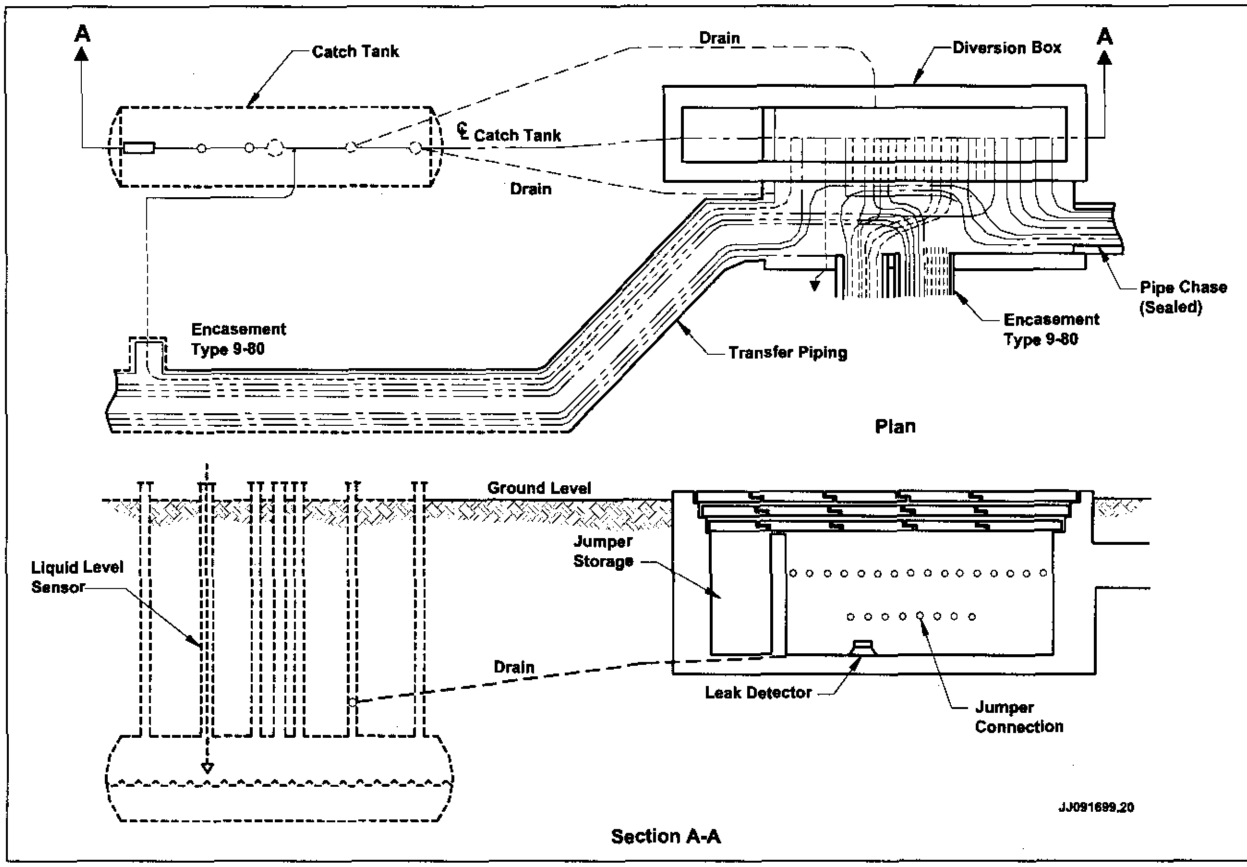
Between 1961 and 1976, when it was removed from service, numerous waste transfers were made into and out of tank C-112. The tank was saltwell pumped in 1983 resulting in the transfer of 5,000 gallons of waste from tank C-112 to DST 241-AN-103 (*Tank Characterization Report for Single-Shell Tank 241-C-112* [HNF-SD-WM-ER-541]).

The tank currently contains sludge consisting primarily of three waste types: first-cycle decontamination waste, in-farm ferrocyanide scavenging waste, and CWP1. In general, first-cycle decontamination waste sludge exhibits high concentrations of aluminum, bismuth, fluorine, iron, silicon, phosphate, and sulfate; in-farm ferrocyanide scavenging waste exhibits high concentrations of calcium, iron, nickel, phosphate, and cesium-137; and CWP1 exhibits high concentration of aluminum.

2.6 TANK ANCILLARY EQUIPMENT

Tank farms contain a complex waste transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, and other miscellaneous structures that are collectively referred to as ancillary equipment. The routing of liquid waste to and from the tanks was accomplished using this transfer system. The diversion boxes provide the means for routing waste from one transfer line to another via jumper assemblies. The diversion boxes are below ground, reinforced-concrete boxes that were designed to contain any waste that leaked from the waste transfer line connections. Diversion boxes generally drained by gravity to nearby catch tanks where any spilled waste was stored and then pumped to SSTs (*PUREX Source Aggregate Area Management Study Report* [DOE/RL-92-04]). Figure 2.7 shows a schematic of a typical diversion box.

Figure 2.7. Typical Diversion Box Schematic



One valve pit, 241-C (a corrugated steel structure with a concrete floor), also served the C tank farm and is located southwest of tank C-103. This pit was installed as part of the saltwell pumping program to allow multiple saltwells to pump to the CR vault receiver tank, 003, through a single transfer line, SN-275.

Table 2.6 provides a summary of the C tank farm ancillary equipment connected to tanks C-102, C-104, C-107, C-108, and C-112.

There is no available information on the current condition of the pipes and ancillary equipment associated with the tanks. Additionally, there is no available information on the volume/characteristics of waste associated with the pipes and ancillary equipment. The impacts of tank waste retrieval on future pipeline/ancillary equipment disposition are discussed in Section 3.7.

2.6.1 Tank C-102 Ancillary Equipment

Tank C-102 is connected to tank C-101 and tank C-103 by 3-inch-diameter cascade lines. Tank C-102 has 10 risers of varying diameters that penetrate into the tank. The risers provide access to various in-tank equipment. Table 2.2 identifies the purpose of each riser.
A cross-section view of tank C-102 is shown in Figure 2.3. Figure 2.8 illustrates the line and riser locations into and around tank C-102 along with their current uses.

Table 2.6. C Tank Farm Components Associated with Tanks C-102, C-104, C-107, C-108, and C-112 (2 Sheets)

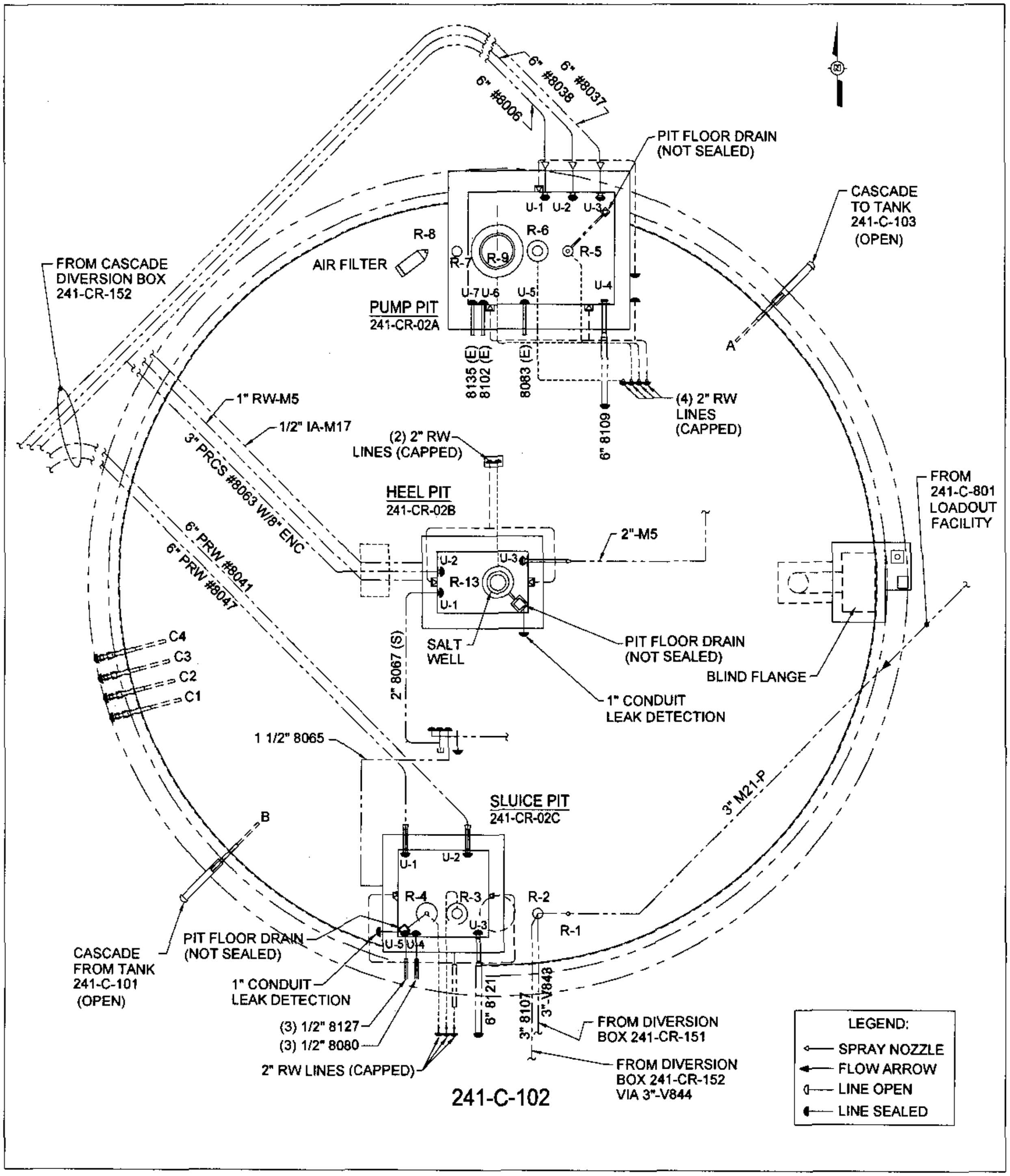
Diversion Boxes			
Unit 241-	**Constructed**	**Removed from Service**	**Description**
C-151	1946	1985	Interconnected 241-C-152, -153, and CR-151 diversion boxes
C-153	1946	1985	Interconnected 241-C-151 and -152 diversion boxes
CR-152	1946	1985	Interconnected 241-C-151 diversion box and C farm
CR-153	1946	1985	Interconnected 241-CR-151 and -152 diversion boxes and C farm
C-252	1946	1985	Interconnected 241-C-151 diversion box and C farm
Valve Pits			
Facility Number		**Description**	
241-C		Valve pit	
Tank Pits			
Facility Number		**Description**	
241-C-02A		Pump pit	
241-C-02B		Heel pit	
241-C-02C		Sluice pit	
241-C-04A		Pump pit	
241-C-04B		Heel pit	
241-C-04C		Sluice pit	
241-C-07		No pit, covered saltwell caisson	
241-C-08		No pit, covered saltwell caisson	
241-C-012		No pit, covered saltwell caisson	
Transfer Lines			
Line Number	**Connecting Facilities**		
8006	241-C-102-02A-U1	241-CR-152-L12	
8038	241-C-102-02A-U2	241-CR-152-U4	
8037	241-C-102-02A-U3	241-CR-152-L15	
8063	241-C-102-02B-U2	Line 8006	
Unknown	241-C-102-02B-U3	241-C-Valve Pit-L1	
8017	241-C-102-02C-U1	241-CR-152-L7	

Table 2.6. C Tank Farm Components Associated with Tanks C-102, C-104, C-107, C-108, and C-112 (2 Sheets)

Transfer Lines (Cont'd)		
Line Number	**Connecting Facilities**	
8041	241-C-102-02C-U2	241-CR-152-U3
V843	241-C-102	241-CR-151-L9
V844	241-C-102	241-CR-151-L8/241-CR-152-L8 via 8107
8210	241-C104-04A-U1	241-CR-153-L11
8244	241-C-104-04A-U2	241-CR-153-U2
8231	241-C-104-04A-U3	241-CR-153-L14
V101	241-C-104-04A-U4	241-C-151-L2
8270	241-C-104-04B-U2	Line 8210
Unknown	241-C-104-04B-U3	241-C-Valve Pit-L2
8220	241-C-104-04C-U1	241-CR-153-L9
8247	241-C-104-04C-U2	241-CR-153-U1
8253	241-C-104-04C-U6	241-CR-153
V050	241-C-104	241-A-152-L7
V051	241-C-104	241-A-152-L8
V148	241-C-104	241-C-153-L13
V149	241-C-104	241-C-153-L14
V150	241-C-104	241-C-153-L15
Drain Line	241-C-107-U1	241-C Valve Pit-L3
V142	241-C-153-L7	Capped
V143	214-C-107	241-C-153-L8
V144	214-C-107	241-C-153-L9
V145	214-C-107	241-C-153-L10
V172	214-C-252-U1	241-C-109/241-C-112
Unknown	241-C-108	241-C-Valve Enclosure
M5	241-C-108 Saltwell Pump Pit	241-C Valve Pit
M5	241-C-112	241-C Valve Pit-L5

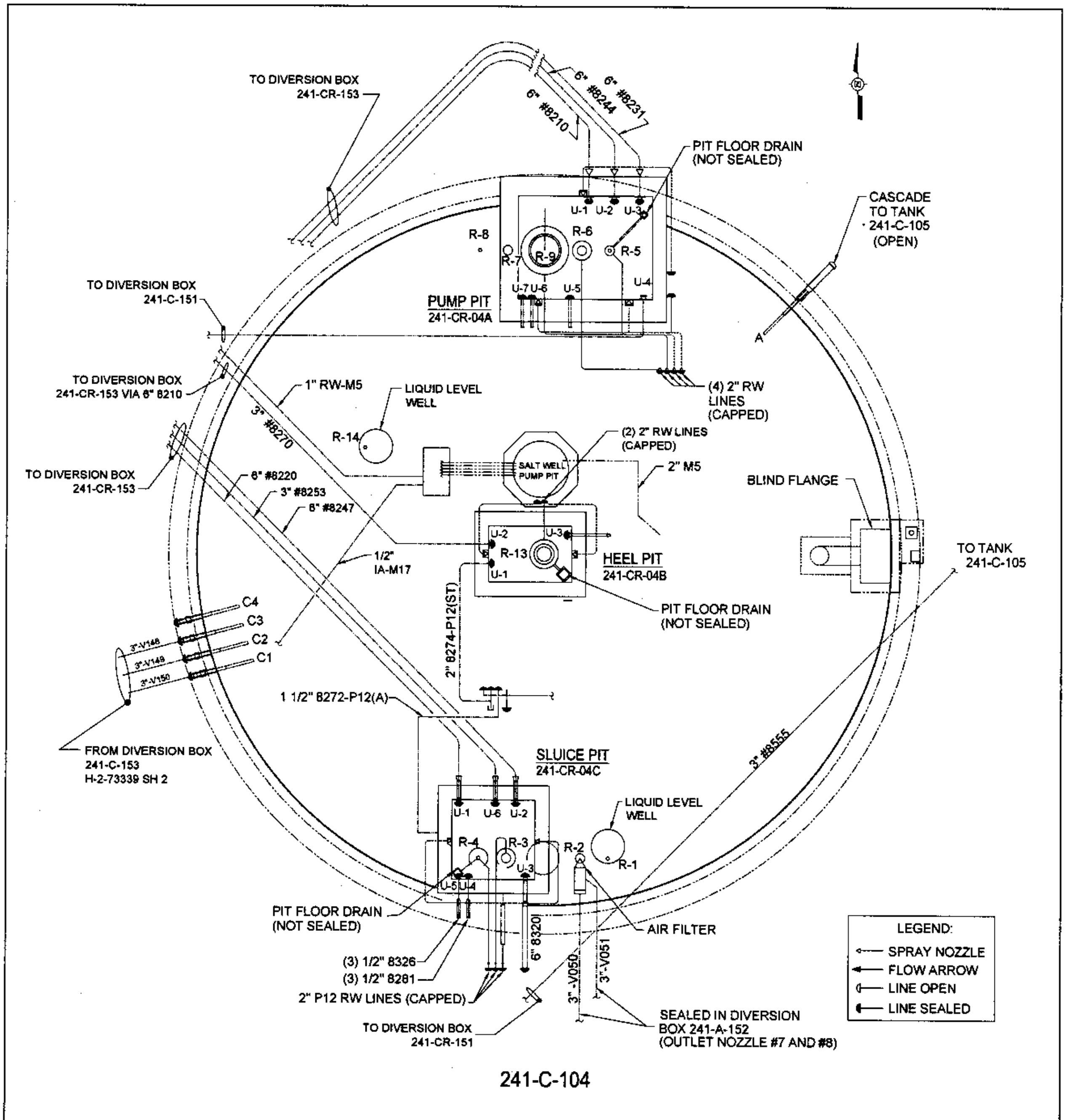
Source: RPP-13774.

Figure 2.8. Tank C-102 Plan View



Source: RPP-21609.

Figure 2.9. Tank C-104 Plan View



Twenty-seven pathways enter tank C-102 or its associated pits. The pathways include lines, nozzles, conduits, and pit drains. Twenty-two pathways into tank C-102 have already been isolated, as shown on Table 2.7. Isolation of all remaining pathways will be performed as shown on Table 2.8 as part of the tank closure to prevent introduction of new wastes or the intrusion of other liquids into the tank.

2.6.2 Tank C-104 Ancillary Equipment

Tank C-104 tank is connected to tank C-105 by a 3-inch-diameter cascade line. Tank C-104 has 11 risers of varying diameters and lengths that protrude into the tank. The risers provide access to various in-tank equipment. Table 2.2 identifies the purpose of each riser. A cross-section view of tank C-104 is shown in Figure 2.3. Figure 2.9 illustrates the line and riser locations into and around tank C-104 along with their current uses.

Twenty six pathways enter tank C-104 or its associated pit. The pathways include lines, nozzles, a pit, a valve enclosure, and a valve manifold. Twenty three pathways into tank C-104 have already been isolated, as shown on Table 2.9. Isolation of all remaining pathways will be performed as shown on Table 2.10 as part of the tank closure to prevent introduction of new wastes or the intrusion of other liquids into the tank after completion of waste retrieval.

2.6.3 Tank C-107 Ancillary Equipment

Tank C-107 tank is connected to tank C-108 by a 3-inch-diameter cascade line. Tank C-107 has nine risers of varying diameters and lengths that penetrate into the tank. The risers provide access to various in-tank equipment. Table 2.3 identifies the purpose of each riser. A cross-section view of tank C-107 is shown in Figure 2.4. Figure 2.10 illustrates the line and riser locations into and around tank C-107 along with their current uses.

Nine pathways enter tank C-107 or its associated pit. The pathways include lines, nozzles, a pit, and a weight factor enclosure. Eight pathways into tank C-107 have already been isolated, as shown on Table 2.11. Isolation of all remaining pathways will be performed as shown on Table 12 to prevent introduction of new wastes or the intrusion of other liquids into the tank after completion of waste retrieval.

2.6.4 Tank C-108 Ancillary Equipment

Tank C-108 tank is connected to tanks C-107 and C-109 by a 3-inch-diameter cascade line. Tank C-108 has nine risers of varying diameters and lengths that penetrate into the tank. The risers provide access to various in-tank equipment. Table 2.13 identifies the purpose of each riser. A cross-section view of tank C-108 is shown in Figure 2.4. Figure 2.11 illustrates the line and riser locations into and around tank C-108 along with their current uses.

Nine pathways enter tank C-108 or its associated pit. The pathways include lines, nozzles, a pit, a valve enclosure, and a valve manifold. Six pathways into tank C-108 have already been isolated, as shown on Table 2.13. Isolation of all remaining pathways will be performed as shown on Table 2.14 to prevent introduction of new wastes or the intrusion of other liquids into the tank after completion of waste retrieval.

Table 2.7. Tank C-102 Previously Isolated Lines (2 Sheets)

Intrusion path	Description	Tank waste transfer line?	Isolation technique and status	Verification
C1	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C2	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C3	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C4	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
8006	Transfer line	Yes	Isolation blank at 241-CR-152, L12	H-2-73342 and H-14-104175
8038	Transfer line	Yes	Isolation blank at 241-CR-152, U4	H-2-73342 and H-14-104175
8037	Transfer line	Yes	Isolation blank at 241-CR-152, L15	H-2-73342 and H-14-104175
8109	Spare transfer line	No	Capped outside pit during tank construction, never used	H-2-73342
8083	Electrical conduit	No	Conduit sealed	Detail 6, H-2-73450
8102	Electrical conduit	No	Conduit sealed	Detail 6, H-2-73450
8135	Electrical conduit	No	Conduit sealed	Detail 6, H-2-73450
8067	Steam line from gang valve	No	Line cut and capped when gang valve was removed	H-2-73342 and H-2-71842
8063	Transfer line	Yes	Line T's into 8006 which has isolation blank at 241-CR-152, L12	H-2-73338, H-2-73342 and H-14-104175
M5	Saltwell Transfer line	Yes	Isolation blank at 241-C, L1	H-2-73338, H-2-73342 and H-14-104175
8047	Transfer line	Yes	Isolation blank at 241-CR-152, L7	H-2-73342 and H-14-104175
8041	Transfer line	Yes	Isolation blank at 241-CR-152, U3	H-2-73342 and H-14-104175
8121	Spare transfer line	No	Capped outside pit during tank construction, never used	H-2-73342
8080	Air line	No	Cut and capped outside pit	H-2-73342 and H-2-73453

Table 2.7. Tank C-102 Previously Isolated Lines (2 Sheets)

Intrusion path	Description	Tank waste transfer line?	Isolation technique and status	Verification
8127	Spare air line	No	Capped outside pit during tank construction, never used	H-2-73342
V843	Transfer line	Yes	Isolation blank at 241-CR-151, L9	H-14-104175
V844/8107	Transfer line	Yes	Isolation blank at 241-CR-151, L8	H-14-104175
M-21-P	Transfer line to valve on tank C-103, then to loadout building	Yes	Valve has been disabled; lines to Loadout building have been cut and capped	H-2-73338, H-2-73342, and H-2-73343
Undesignated	Raw Water	No	(5) 2" lines capped above grade	H-2-73342
Undesignated	Conduit	No	Sealed	H-2-73342

Note: Raw water, steam, and air lines have been cut and capped.

Table 2.8. Tank C-102 Currently Open Lines

Line	Description	Tank waste transfer line?	Planned isolation technique
B	Cascade line from tank C-101	Yes	No action until closure fill in tank C-101 or C-102 blocks this line
A	Cascade line to tank C-103	Yes	No action until closure fill in tank C-102 or C-103 blocks this line
--	02A Pit drain	No	To be left open
--	02B Pit drain	No	To be left open
--	02C Pit drain	No	To be left open

Table 2.9. Tank C-104 Previously Isolated Lines

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification
C1(V150)	Fill line	No	Sealed in diversion box 241-C-153	H-2-73344/ H-2-73339
C2 (V149)	Fill line	No	Sealed in diversion box 241-C-153	H-2-73344/ H-2-73339
C3 (V148)	Fill line	No	Sealed in diversion box 241-C-153	H-2-73344/ H-2-73339
C4	Spare	No	Capped during tank construction, never used	H-2-73344
8210	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8231	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8244	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8270	Transfer line	Yes	Connected to line 8210 – Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8220	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8253	Drain line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8247	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73338
8326	Raw water	No	Sealed in 241-CR-04C at U5	H-2-73344
8281	Raw water	No	Sealed in 241-CR-04C at U4	H-2-73344
8320	Raw water	No	Sealed in 241-CR-04C at U3	H-2-73344
8274	Steam line	No	Capped below grade per H-2-71842	H-2-73344
8272	Air line	No	Capped per H-2-73344	H-2-73344
V050	Transfer line	Yes	Sealed in diversion box 241-A-152	H-2-73344
V051	Transfer line	Yes	Sealed in diversion box 241-A-152	H-2-73344
V101	Transfer line	Yes	Capped in diversion box 241-CR-152	H-2-73338
Unknown	Raw water	No	(9) 2" lines capped above grade	H-2-73344
M5	Saltwell pump line	Yes	Capped	H-2-73973
--	04B Pit drain	No	Plugged based on pit viper entry	RPP-13194

Table 2.10. Tank C-104 Currently Open Lines

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
A	Cascade line to tank C-105	Yes	No action until closure fill in tank C-104 or C-105 blocks this line
--	04A Pit drain	No	To be left open
--	04C Pit drain	No	To be left open

Figure 2.10. Tank C-107 Plan View

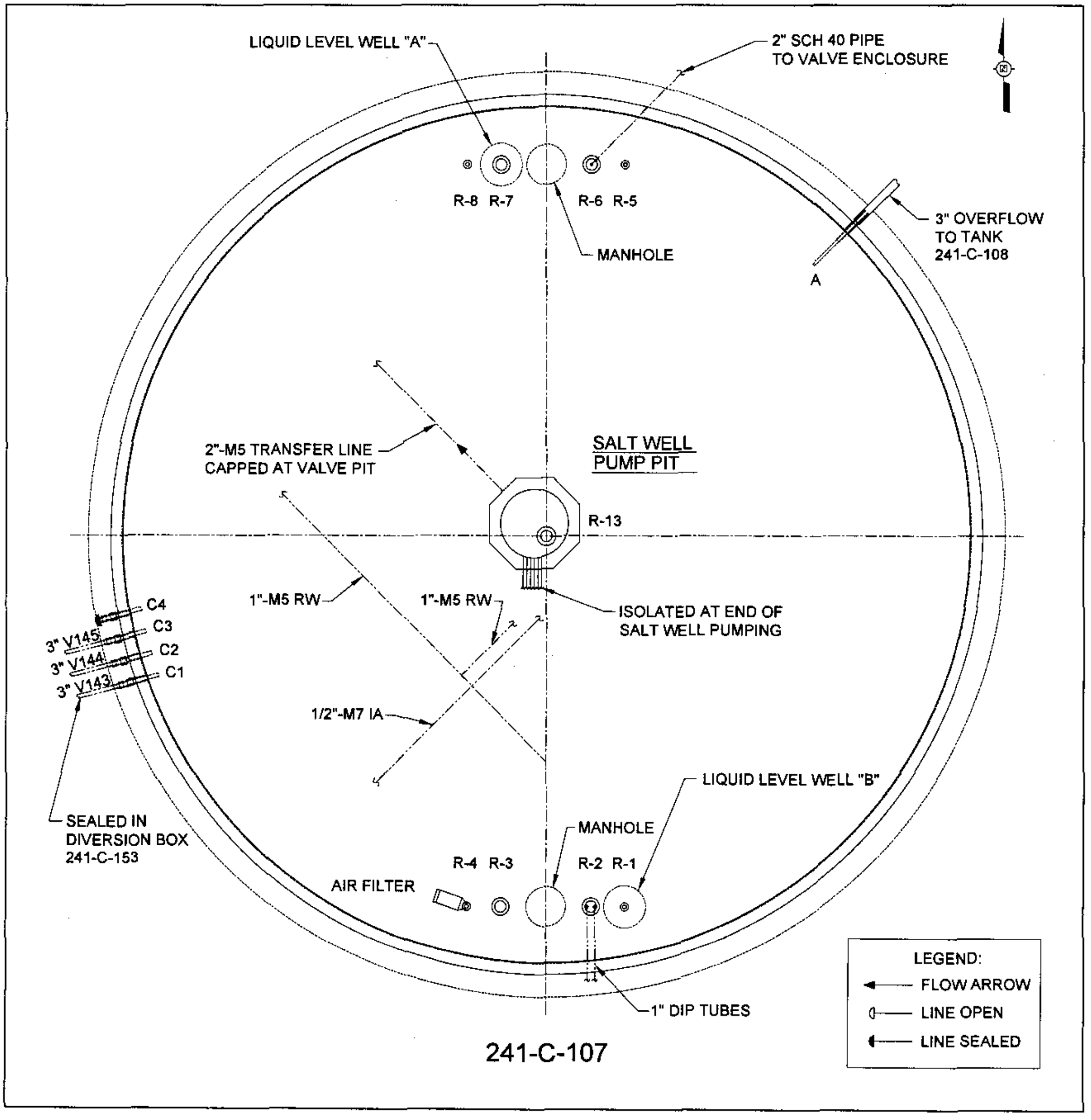


Table 2.11. Single-Shell Tank C-107 Previously Isolated Lines

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification
C1 (V145)	Transfer line on tank nozzle C1	Yes	Isolated in diversion box 241-C-153, L10	H-2-73347, H-2-73339, and H-14-104175
C2 (V144)	Transfer line on tank nozzle C2	Yes	Isolated in diversion box 241-C-153, L9	H-2-73347, H-2-73339, and H-14-104175
C3 (V143)	Transfer line on tank nozzle C3	Yes	Isolated in diversion box 241-C-153, L8	H-2-73347, H-2-73339, and H-14-104175
C4	Spare tank nozzle on C4	No	Line capped outside tank during construction. Never used.	HW-72745
Undesignated	Transfer line. First cycle waste scavenging. 2" line in R-6.	Yes	Valve manifold removed; blind flange on lines	H-2-73350 and H-2-73450
2" M5	Transfer line – saltwell	Yes	Isolated in valve pit 241-C, L3	H-2- 73338 and H-14-104175
--	Saltwell pump pit	No	Saltwell pump pit lines isolated and weather covered	H-2-73634
--	Weight factor enclosure off of saltwell pump pit	No	Lines isolated and weather enclosed	H-2- 73347, H-2-73451, and H-2-73634

Table 2.12. Single-Shell Tank C-107 Currently Open Lines

Line	Description	Tank waste transfer line?	Planned isolation technique
A	Cascade line to tank C-108	Yes	No action until final closure fill in tank C-108 blocks this line

Table 2.13. Tank C-108 Previously Isolated Lines

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification
C1	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C2	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C3	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C4	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
M5	Saltwell transfer line	Yes	Capped outside Valve Pit	H-2-73348/ H-2-73877
Unknown	Waste scavenging line in R-6	Yes	Capped	H-2-73348

Figure 2.11. Tank C-108 Plan View

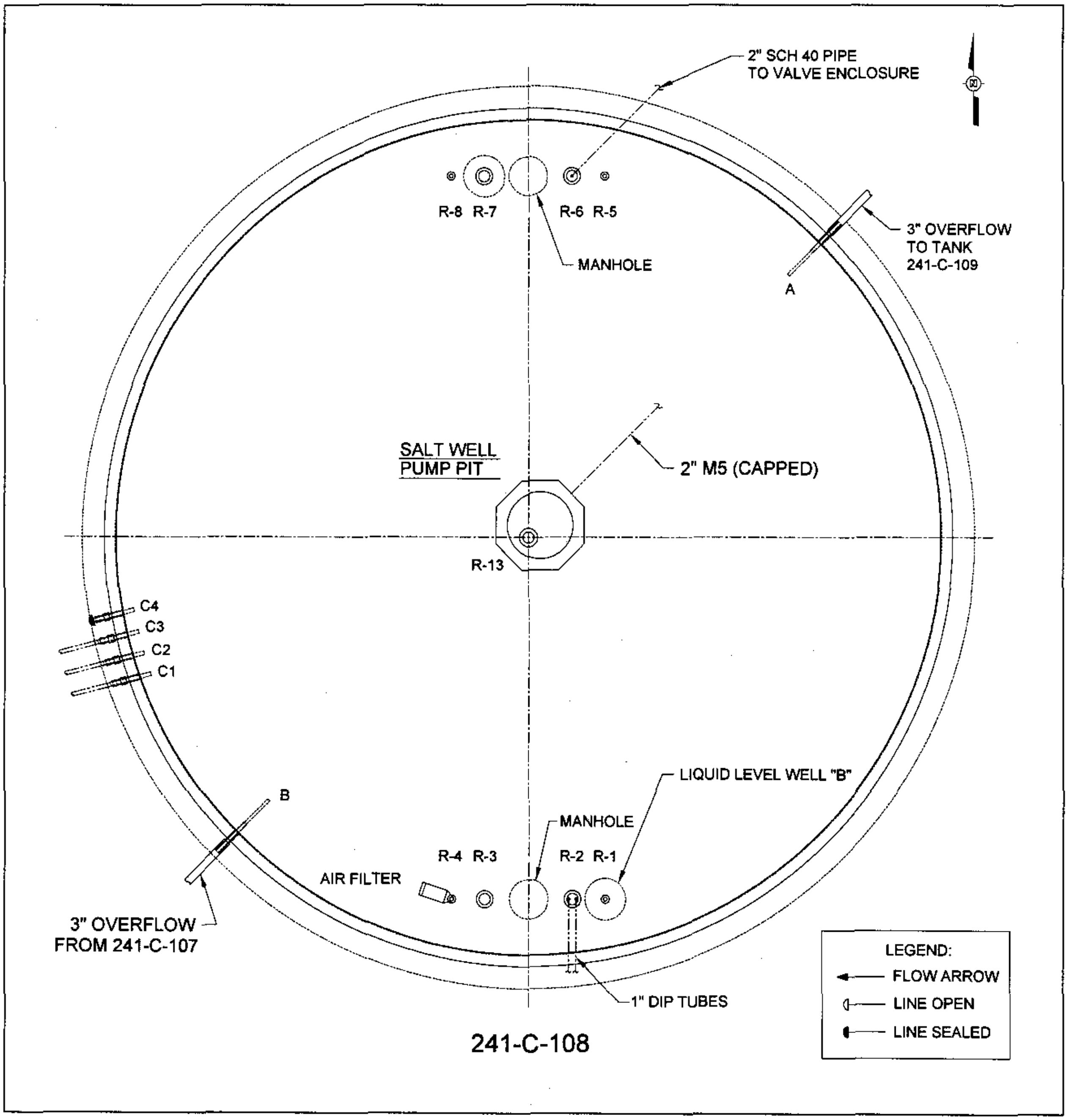


Table 2.14. Tank C-108 Currently Open Lines

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
A	Cascade line to tank C-109	Yes	No action until closure fill in tank C-108 or C-109
B	Cascade line from tank C-107	Yes	No action until closure fill in tank C-107 or C-108 blocks this line
--	02C pit drain	No	To be left open

2.6.5 Tank C-112 Ancillary Equipment

Tank C-112 tank is connected to SST 241-C-111 by a 3-inch-diameter cascade line. Tank C-112 has nine risers of varying diameters and lengths of protrusion into the tank. The risers provide access to various in-tank equipment. Table 2.3 identifies the purpose of each riser.
A cross-section view of tank C-112 is shown in Figure 2.4. Figure 2.12 illustrates the line and riser locations into and around tank C-112 along with their current uses.

Eleven pathways enter tank C-112 or its associated pit. The pathways include lines, nozzles, a pit, a valve enclosure, and a valve manifold. Nine pathways into tank C-112 have already been isolated, as shown on Table 2.15. Isolation of all remaining pathways will be performed as shown on Table 2.16 to prevent introduction of new wastes or the intrusion of other liquids into the tank after completion of waste retrieval.

Figure 2.12. Tank C-112 Plan View

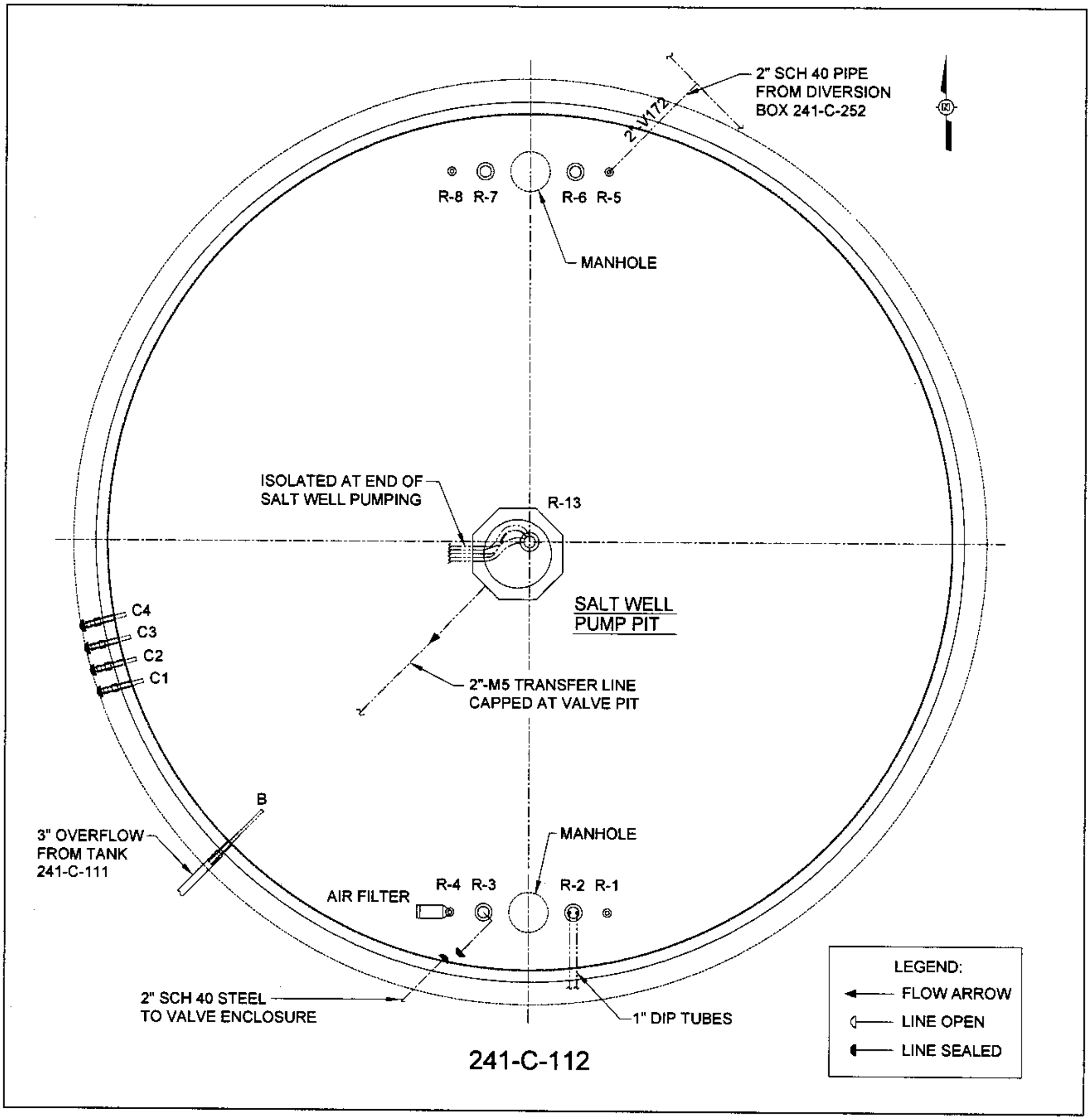


Table 2.15. Tank C-112 Previously Isolated Lines

Line	Description	Tank waste transfer line?	Isolation technique and status	Verification
C1	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
C2	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
C3	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
C4	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
V172	Waste transfer line. Line is common with tank C-109	Yes	Valves disabled in closed position; Isolation blank on nozzle in 241-C-252, U1	H-2-73339, H-2-73351, and H-14-104175
Undesignated	Saltwell transfer line (2" –M5)	Yes	Isolated at valve pit 241-C, L5	H-14-104175
Undesignated	Valve manifold (first-cycle waste scavenging) (R-3)	Yes	Valve manifold removed and both ends of line blanked	H-2-73450
Undesignated	Weight factor enclosure lines off of Saltwell Pump Pit	No	Lines isolated and enclosure is weather covered	H-2-73351, H-2-73451, and H-2-73634

Table 2.16. Tank C-112 Currently Open Lines

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
B	3-inch cascade line from tank C-111	Yes	No action until final closure fill in tank C-112 blocks this line

This page intentionally left blank.

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the planned waste retrieval technology for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112.

3.1 SYSTEM DESCRIPTION

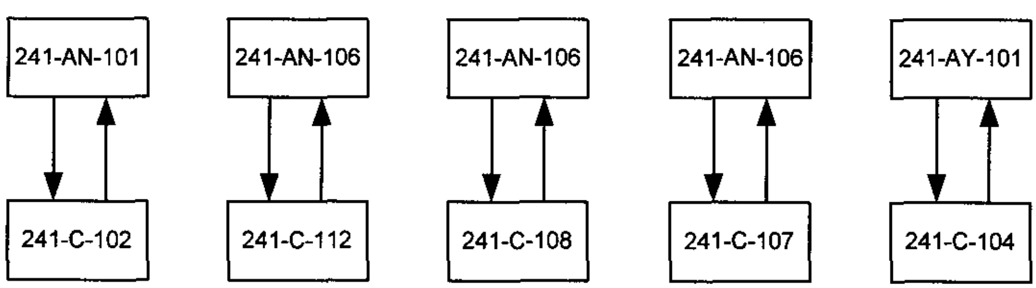
This section provides a description of the waste retrieval system (WRS) and how it will be operated.

3.1.1 Physical System Description

The WRS will consist of a sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-107, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing or new tank risers located around the perimeter of the tank. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. As a waste minimization effort the WRS will include transfer lines from the DST receiver tank back to the C farm so that DST supernate can be used as the primary sluice liquid (see Section 3.1.2 for operating description). This will minimize the overall volume of waste requiring storage in the DST system.
The systems will also have the capability to use raw water for sluicing with minor modifications.

The current waste retrieval sequence and plan for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3.1. The DSTs tanks were selected based on their location, available space, and existing or planned equipment upgrades. The waste retrieval sequence is shown left to right. There will be some overlap in waste retrieval operations. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

Figure 3.1. Waste Retrieval Liquid Supply and Double-Shell Tank Receiver Tank Designation



Monitoring instruments will be used to collect data to support operation of the WRS and perform environmental monitoring. A camera will be installed in each of the tanks to provide the capability to visually monitor and control waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flowrates), and in-tank instruments will be monitored for liquid level when in contact with the waste. This information will be used to support material balance calculations. Section 4.0 provides details on the material balance calculations to be performed during waste retrieval operations.

Before initiating waste retrieval, a formal waste compatibility assessment will be performed in accordance with *Tank Farm Waste Transfer Compatibility Program* (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. Because of the number and schedule for waste transfers associated with tanks C-102, C-104, C-107, C-108, and C-112 an automated compatibility assessment automation tool has been developed and is in the final stages of verification and validation testing. The automated tool will be used to perform waste compatibility assessments in accordance with the waste transfer compatibility program.

During waste retrieval operations, the tank(s) will be actively ventilated. Project plans include the installation of a new ventilation system to support waste retrieval operations for the C farm tanks. The new ventilation system is planned to be completed in time to be used to ventilate the tanks during waste retrieval operations. The new ventilation system consists of two exhausters along with ventilation ducting routed to each of the C farm tanks that will be subject to waste retrieval, as well as other C farm tanks containing waste (for vapor control). If the new ventilation system will not be available in time to support the initial waste retrievals, then an existing portable exhauster will be used. Details on the portable exhauster are provided in the following Notice of Construction applications (these NOC applications will be revised and submitted for approval at a future date. The revised NOCs will provide details on the new ventilation system):

- Future revision to the *Radioactive Air Emission Notice of Construction for Categorical Tank Farm Facility Waste Retrieval and Closure, Phase II, Waste Retrieval*, approval pending
- *Non-Radioactive Air Emission Notice of Construction for Categorical Tank Farm Facility Waste Retrieval and Closure, Phase II, Waste Retrieval*, approval pending.

The WRS for C-102 and C-104 will include the installation of new pumps in the center riser located in the heel pit of each tank. Each pump may be mounted on a winch system that will allow the pump to be lowered as waste retrieval progresses. The system will be designed to allow the pump suction to be lowered as low as possible in each tank to facilitate maximum waste removal. Existing equipment installed in the tanks will be removed as necessary for installation of new equipment. The sluice nozzles will be installed within the existing pump and sluice pits.

The WRS for C-107, C-108, and C-112 will require design and construction of new aboveground pits for installation of the sluice nozzles and potential modifications to the saltwell pits to accommodate installation of a slurry pump in the center of the tanks. Each pump may be mounted on a winch system that will allow the pump to be lowered as waste retrieval progresses. The system will be designed to allow the pump suction to be lowered as low as possible in each tank to facilitate maximum waste removal. The configuration of tanks C-107, C-108, and C-112 is different in that there are no concrete pits and only a single central corrugated metal saltwell pump pit. In-tank cameras will be installed to support retrieval.

There are no planned changes to tank AN-106 to support waste retrieval from tanks C-107, C-108, and C-112. The supernate pump and slurry distributor installed in tank AN-106 in support of tank C-103 waste retrieval will continue to be used to pump supernate back to the C farm and distribute the sludge as received from tanks C-107, C-108, and C-112. There are no planned changes to tank AN-101 to support waste retrieval from tank C-102. The pump installed in tank AN-101 under project W-211 will be used to pump supernate to C-102. A new slurry distributor will be installed in AN-101 to distribute the sludge received from tank C-102. A new supernate pump and a new slurry distributor are planned for tank AY-101 to support waste retrieval from tank C-104.

Because the elevation of the AN farm is approximately 22 feet higher than the C farm and the elevation of the AY tank farm is approximately 32 feet higher than the C farm, the slurry distributor and the supernate pump incorporate anti-siphon devices to prevent unintentional flow from the DST to the SST. Some transfer line drain back into the tank of origin (C-102, C-104, C-107, C-108, or C-112) will occur each time the WRS is shut down. The volume associated transfer line drain back is approximately 200 gallons per line. Any transfer line drain back that occurs prior to the end of waste retrieval operations will subsequently retrieved. The final transfer line flush will result in drainback that will not be retrieved. Condensate drain lines from the ventilation system are planned to be routed to the last sound tank scheduled to be retrieved (e.g., tank C-104).

The tanks WRS is depicted in Figure 3.2, and a potential equipment layout in the tank farm is provided in Figure 3.3.

Figure 3.2. Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System

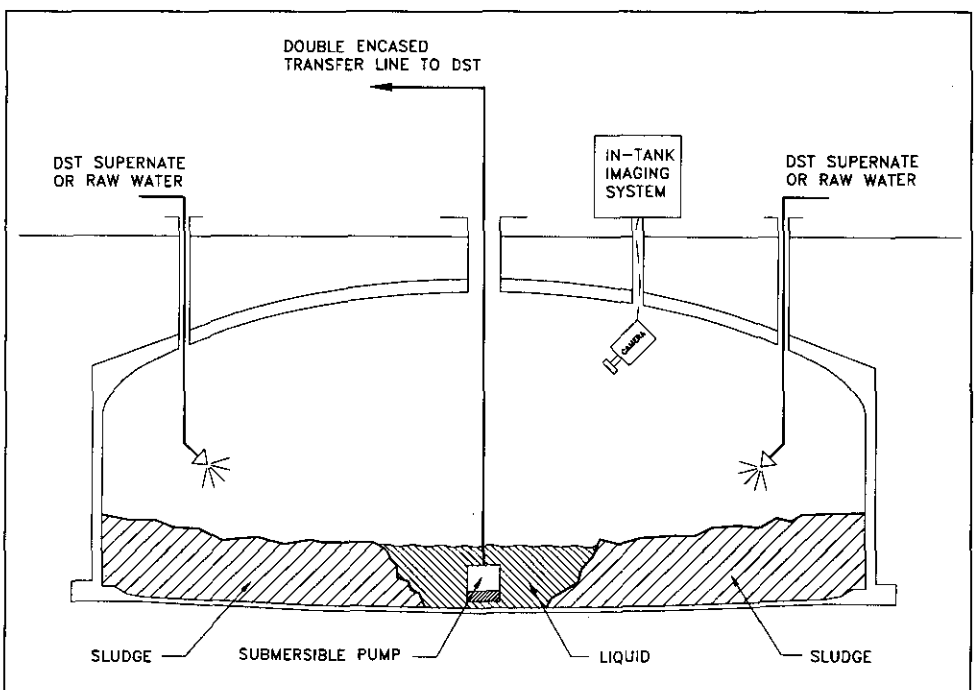
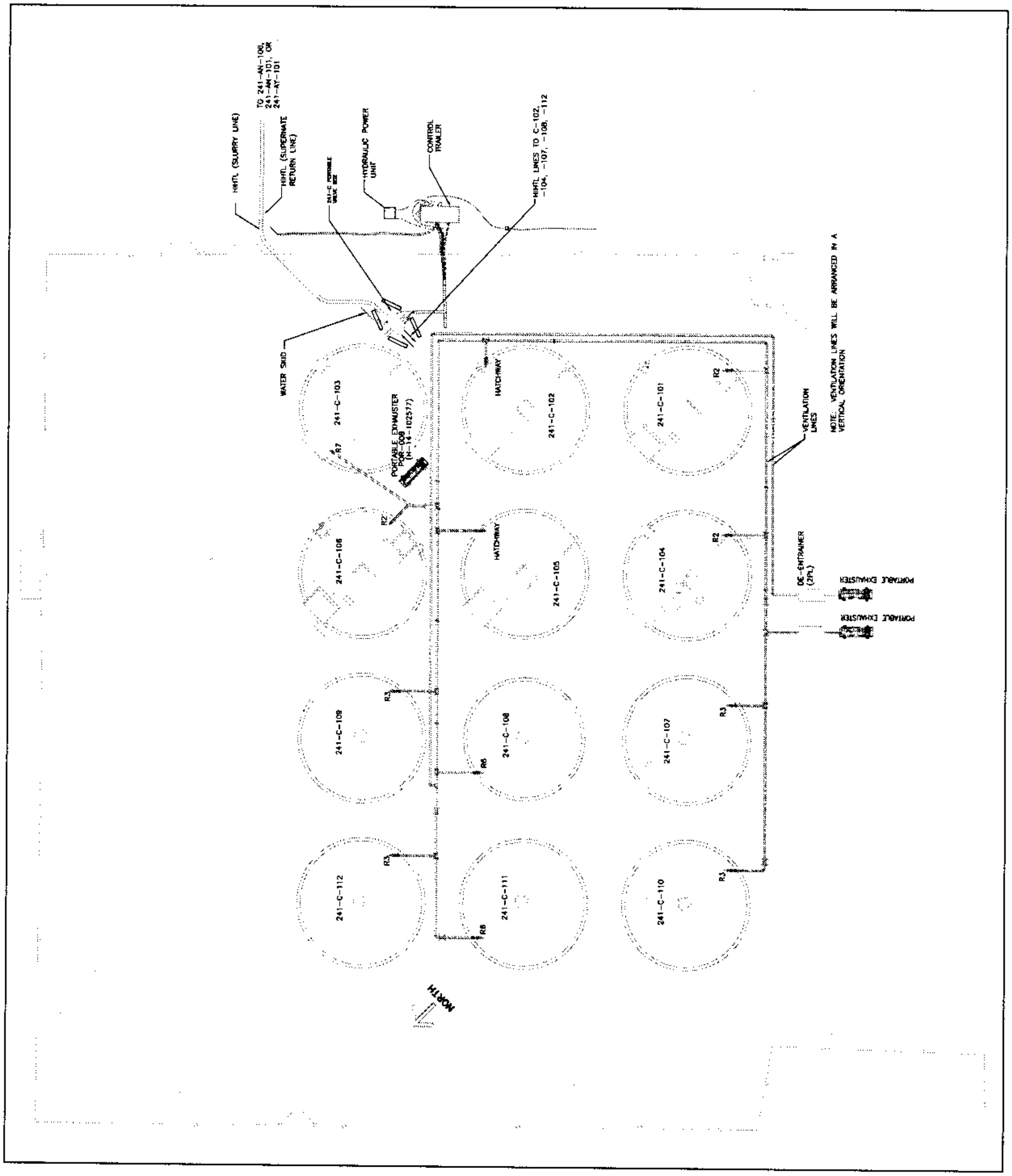


Figure 3.3. Potential Waste Retrieval Equipment Layout



All waste transfers, including transfer of waste from the C farm tanks to the DSTs and the transfer of supernate from DSTs back to C farm tanks, will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to utilize hose-in-hose overground transfer lines.

The 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 the C farm tanks and in the 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.

3.1.2 Waste Retrieval System Operating Description

The overall WRS operating strategy will consist of reducing the tank waste inventories. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tanks. Supernate will be used as the primary retrieval liquid. Raw water will be used in limited quantities as necessary for waste conveyance and transfer line flushing.

Waste retrieval operations will normally be initiated by starting the supernate pump in the DST source tank (AN-101, AN-106, or AY-101) and using the pumped supernate to provide sluicing fluid to the selected sluice nozzle. Recognizing that the tanks have been sitting in an interim stabilized condition for a number of years, sufficient liquid may need to be added to the tanks and allowed to sit for a period of time to soften the solid waste and get it moving toward the pump suction. The in-tank camera will be used to provide visual input for directing the sluice nozzle. The slurry pump in tanks C-102, C-104, C-107, C-108, or C-112 will be started as soon as liquid from the sluicer operation reaches the area of the pump inlet and there is enough liquid present to operate the pump. During waste retrieval the flow of liquid into the tanks through the sluice nozzles will be controlled to maximize waste retrieval efficiency and limit the accumulation of liquid in the tank. The composite material removed will consist of both mobilized tank waste and supernate used for mobilization.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gallons per minute.

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 and approved monitoring plans, health physics and industrial health technicians will monitor conditions within the tank farm.

During waste retrieval operations, the waste retrieval project plans to estimate the residual waste volume remaining in the tank using volume displacement where liquid is metered into the tank until the residual waste is covered, the level is measured, and volume calculated based on tank geometry. The residual waste volume is then calculated as the difference between the measured tank volume and the volume of liquid added or the volume of the liquid pumped out. Liquid would only be added to the tanks as a part of waste retrieval, final flushing of the tank and/or equipment, and/or measuring residual waste volumes. Approval of this document allows for adding raw water for measuring residual waste volumes in these tanks. The liquid added to the tank would then be pumped out of the tank to the extent possible with the slurry pump. Following completion of waste retrieval, tank closure projects will measure residual waste volume using the video/computer-aided mapping system, in accordance with an approved DQO and SAP.

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

Supernate from DSTs AN-101, AN-106, or AY-101 will be pumped into tanks C-102, C-104, C-107, C-108, and C-112 to mobilize sludge. Supernate will be added at a rate of approximately 60 to 120 gallons per minute. The waste slurry made up of the retrieval liquid along with tank solids will be removed from these tanks at approximately the same rate it is introduced. Utilizing recycled supernate to retrieve the waste from the tanks minimizes the overall volume of waste generated during the waste retrieval process. The modified sludge sluicing process will also minimize the volume of liquid in the tank during waste retrieval operations. Since the waste in these tanks has been sitting in an interim stabilized condition (e.g., nearly dry) for a number of years, portions of the waste may be resistant to sluicing. If this condition is observed, it may be necessary to add liquid to the tanks to cover the solids and allow the solids to soak for a period of time to soften the waste up so that it can be mobilized to the central pump.

A flowsheet document for the C farm 100-series tanks (*C Farm 100-Series Tanks, Retrieval Process Flowsheet Description* [RPP-21753]) shows all of the waste transfers needed to support C tank farm waste retrievals. The flowsheet document is based on simulations performed with the Hanford Tank Waste Operations Simulator (HTWOS) model. The flowsheet uses HTWOS to simulate the waste storage, retrieval, transfer, and treatment processes to provide an operating strategy for C farm waste retrieval. Table 3.1 shows the waste volumes to be retrieved from each of the five tanks addressed by this document. The flowsheet document addresses the impact from C farm waste retrievals on the DST space and what actions are required to accommodate the C farm waste (as retrieved) in the DST system. The as retrieved waste volume represents a short-term or transient impact on DST space as any excess water can be removed through evaporation within tank farm operating limits. The impact of C farm waste on the DST system with respect to long-term storage will be addressed in future revisions to the SST retrieval sequence and DST space evaluation document prepared in response to HFFACO milestone M-45-02. A number of DST to DST transfers are identified to make room for the waste retrieved from the C farm tanks. These transfers are described in the flowsheet document. Table 3.1 also shows the planned receiver tank, the total transfer volume required to accomplish the waste retrieval, and the anticipated duration of the waste retrieval operations.

Table 3.1. Tank C-102, C-104, C-107, C-108, and C-112 Waste Retrieval Summary Data

Tank Number[a]	Initial Tank Waste Volume prior to Retrieval (kgal)[b]	Retrieval Flush Volume (kgal)[b]	Receipt Tank	DST Supernate Recycle(kgal)	Estimated Operating Duration, days[c]
C-102	316	100	AN-101	10,210	164
C-112	104	100	AN-106	3,360	55
C-108	66	100	AN-106	2,130	35
C-107	248	100	AN-106	8,020	136
C-104	259	100	AY-101	8,370	134

Source: RPP-21753.

[a] Indicated in chronological order for start of retrieval.

[b] Flushing volume allocation from RPP-21753.

[c] Durations estimated based on the general operating assumptions of 3 shifts operating 7 days/week with 60% operating efficiency. Sluicing durations assume 3 volume percent solids loading in slurry and an average transfer rate of 75 gal/min.

DST = double-shell tank.

The calculations performed in support of the flow sheet assume that the retrieved solids are about 3 volume percent in the slurry transferred to the DSTs. The waste retrieval process flow sheet estimate of the total liquid volume transferred during the sluicing of each tank is provided in Table 3.1. In addition, the flowsheet allocates a nominal 100,000 gallons of water for tank and equipment flushing during each tank's waste retrieval operations. Because the supernate is recycled, the net liquid addition to double-shelled receiver tanks will be the 100,000 gallons of flush water per tank. Following completion of C farm waste retrievals the DST receipt tanks will be at or near their storage capacity.

The timing for waste transfers is dependent upon personnel resource availability, equipment availability, and DST tank conditions. Once waste retrieval operations are started they should follow the general pattern described in this section. The specific schedule for liquid additions to the tanks or waste transfers to the DSTs cannot be predicted more than a day or two in advance, so a detailed timeline for liquid additions and transfers cannot be developed showing all liquid additions and removals. The addition of water/supernate may be continuous or intermittent. Ideally the retrievals will be completed in accordance with the planned schedule, but delays with tank farm work and the lack of available resources could stretch retrieval durations out to 12 months per tank.

If water were to be used for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112, the total volume of liquid required would be approximately 33.6 million gallons (33.1 million gallons for retrieval at 3 vol % waste + 5 x 100,000 gallons for flushes). If water were used for retrieving waste from five C farm tanks addressed in this document the retrieved waste volume would exceed the capacity of the DST system and would require multiple waste transfers to other DSTs and evaporation of the liquid to reduce the volume. To evaporate all of the water to retain DST operating space, approximately 100 evaporator campaigns would be required. Transfers and evaporator campaigns would induce significant delays to waste retrieval operations.

3.3 TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION

Candidate waste retrieval technologies currently available for deployment at tanks C-102, C-104, C-107, C-108, and C-112 are (1) sluicing and (2) the mobile retrieval system. Sluicing uses water or DST supernate to mobilize waste to a pump where it can be removed from a tank. Sluicing was used for waste retrieval from tank C-106 and is planned for use in retrieving waste from tanks C-103 and C-109. The mobile retrieval system 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.

Sluicing potentially uses more liquid in the tank to mobilize the waste and provides a relatively high waste retrieval rate. Addition of liquid to the tanks using the modified sluicing system is considered acceptable for tanks that are sound. The mobile retrieval system is designed to vacuum the waste from the SST up into a batch vessel while using the minimal amount of liquid necessary to mobilize the waste. Because of this difference, the mobile retrieval system is currently the preferred waste retrieval technology for tanks that are known or suspected leaking tanks. When sluicing is performed using DST supernate, the overall volume of waste requiring management (storage and/or volume reduction) in the DST system is reduced. The equipment required for sluicing is less complex than the mobile retrieval system and is, therefore, less costly to deploy, operate, and maintain.

After considering both candidate waste retrieval technologies coupled with tanks being designated as sound, sluicing using recycled DST supernate was selected as the preferred technology for deployment in tanks C-102, C-104, C-107, C-108, and C-112 because it is inherently simpler, less expensive, and faster.

3.4 ANTICIPATED PERFORMANCE GOALS

The WRS for tanks C-102, C-104, C-107, C-108, and C-112 will be designed to retrieve as much waste from the tanks as technically practical with waste residues not to exceed 360 ft^3 or the limit of technology, whichever is less (see Section 3.6).

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

A preliminary diagram of the WRS is provided in Figures 3.2 and 3.3. As noted in Section 3.1.1 the elevation in the AN tank farm is approximately 22 feet higher than the elevation in the C tank farm and the elevation in the AY tank farm is approximately 32 feet higher than the elevation in the C tank farm.

3.6 WASTE RETRIEVAL SYSTEM FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the tanks C-102, C-104, C-107, C-108, and C-112 WRS must be designed and operated. This work plan is not a system specification that defines design criteria for the WRS. However, the system specification for the tanks (*Level 2 Specification for the C-100 Series Waste Retrieval System* [RPP-18633]) will be consistent with this work plan.

Other requirements not directly applicable to the level of definition provided in this document are disseminated to CH2M HILL Hanford Group, Inc. via its contract with DOE (Contract DE-AC-27-99RL14047). Specifically, the functions and requirements included in this document are derived from the need to satisfy the HFFACO Milestone M-45-00 requirements. The functions and requirements are provided in Table 3.2 and are focused on defining the upper-level requirements for the tanks.

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

Ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is limited to waste transfer lines and equipment installed in pits and abovegrade risers. The current status of the ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is described in Section 2.6. Existing hardware and equipment installed in the tank risers will be removed and disposed of as required for installation of the WRS.

Based on the historical information presented in Sections 2.2 and 2.5, the waste retrieval project believes that the abandoned process lines used for previous waste transfers will likely be contaminated through contact with the waste but should have limited potential for containing residual liquid or solid waste. These 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 existing buried waste transfer lines routed to tanks C-102, C-104, C-107, C-108, and C-112 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tanks. If it is found that any of these lines have not been isolated during installation of the WRS, then isolation methods will be evaluated and performed by the tank closure program. All isolation methods will be reversible and will not preclude future closure actions. With these isolation measures in place, the process lines are in a stable configuration and do not represent pathways for additional waste to enter the tanks. Access to these lines would require removal of the weather cover and cover blocks at the diversion box followed by removal of the isolation blanks.

Given (1) the configuration of the waste transfer lines (isolated), (2) the low potential for residual waste to remain in the lines, and (3) the uncertain physical condition of the lines, the waste retrieval project does not plan to remove residual waste from the transfer lines. In accordance with the C tank farm closure plan (RPP-13774), disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure plan.

Table 3.2. Tanks C-102, C-104, C-107, C-108, and C-112 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 173-400 WAC 173-460 WAC 246-247 HNF-IP-0842, Volume 6, Section 1.8 and TFC-ESHQ-ENV-STD-03	Mitigate potential release to the public and the environment.
Control waste level in tanks	The WRS shall be operated to prevent waste level from exceeding 185 inches.	OSD-T-151-00013	Minimize liquid level to the extent practical. Prevent siphoning of liquid from DST receipt tank to the SST.
Remove waste from tanks	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.	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	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	Provide for safe and effective operation of the WRS.
Minimize waste generation	The WRS shall minimize waste generation to the greatest extent practical, including water introduced into the tank.	WAC 173-303	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.	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.

Table 3.2. Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System Functions and Requirements (2 Sheets)

Function	Requirement	Basis	Key Elements
Occupational safety and health	The WRS shall be designed for safe installation, operation and maintenance.	29 CFR 1910 10 CFR 835 29 CFR 1926	OSHA standards. Occupational Radiation Protection.
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

DST = double-shell tank.
Ecology = Washington State Department of Ecology.
EPA = U.S. Environmental Protection Agency.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*
OSHA = Occupational Safety and Health Administration.
SST = single-shell tank.
WAC= Washington Administrative Code.
WRS = waste retrieval system.

3.8 INFORMATION FOR NEW ABOVEGROUND TANK SYSTEMS

The tanks C-102, C-104, C-107, C-108, and C-112 WRS does not utilize any new above ground tanks, tank systems, or treatment systems.

3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING RETRIEVAL OPERATIONS

Following completion of waste retrieval, the in-tank equipment will be left in place for disposition during component closure actions. The abovegrade equipment (transfer lines, portable valve box) will be reused to the extent possible for future waste retrieval activities in the C tank farm. Transfer lines and the portable valve box will be flushed to reach acceptable exposure rates for disconnecting and relocating the equipment. Any abovegrade equipment that is not suitable for reuse will be packaged and disposed of onsite in accordance with existing waste management procedures.

4.0 LEAK DETECTION, MONITORING, AND MITIGATION

The integrated leak detection, monitoring, and mitigation (LDMM) strategy for tanks C-102, C-104, C-107, C-108, and C-112 has been developed to meet the requirements specified in the HFFACO M-45 series milestones and to manage the risk posed by potential waste leakage during waste retrieval operations. The strategy for LDMM is summarized in the following sections and is based on retrieving as much waste as technically practicable while minimizing the potential for leaks. The purpose is to ensure that the tanks waste retrieval and LDMM strategy:

- Is technically practicable and defensible
- Considers applicable regulations and requirements
- Uses LDMM technologies and strategies that are consistent with the waste retrieval technology selected for deployment in tanks C-102, C-104, C-107, C-108, and C-112
- Minimizes waste releases to the environment should a leak occur
- Provides for detecting a leak in a timely manner
- Provides for determining leak volume in a timely manner
- Provides technically defensible data to support the appropriate response action
- Minimizes the potential risks to human health and the environment.

4.1 EXISTING TANK LEAK MONITORING

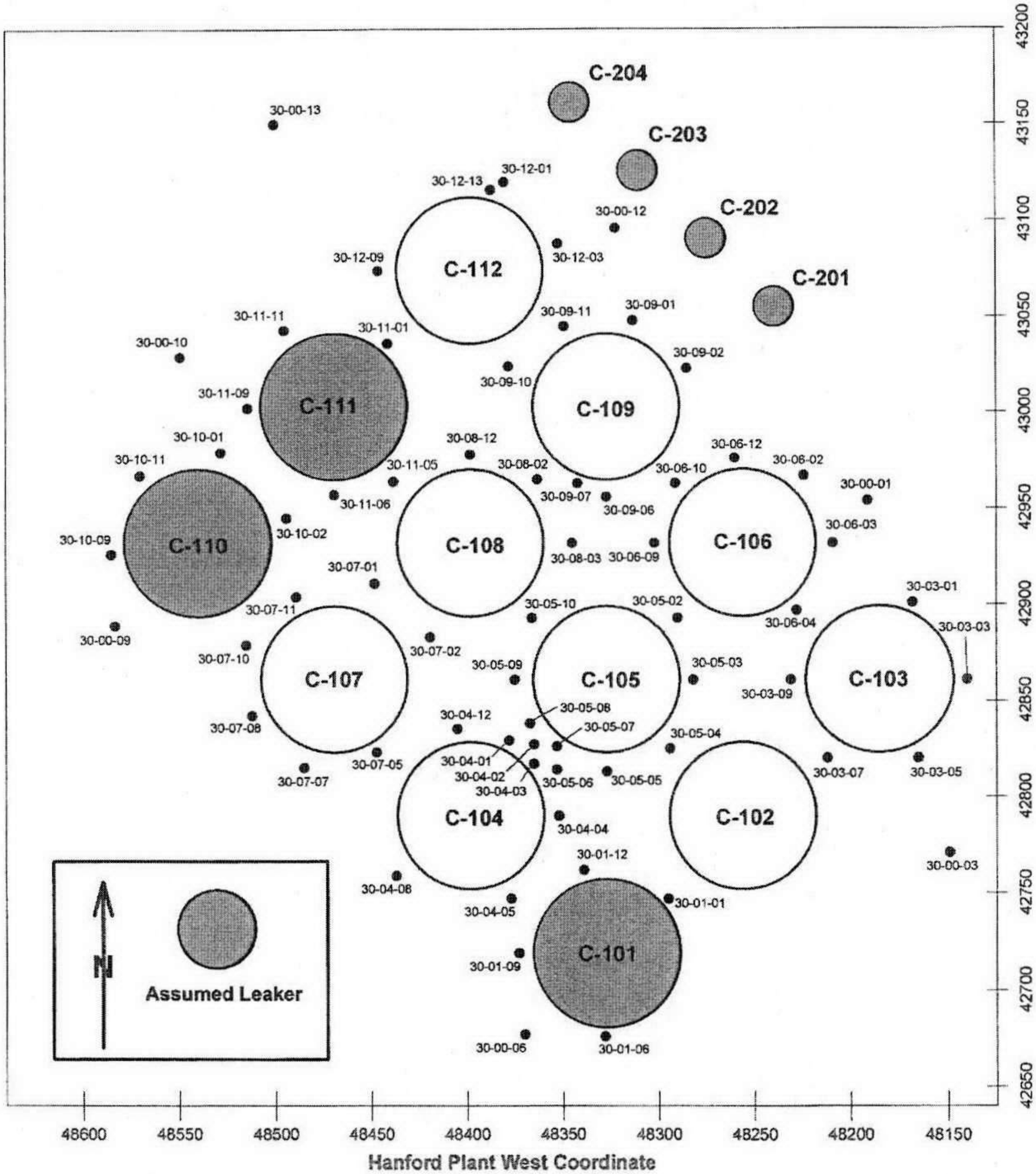
This section describes tank leak monitoring activities that have been historically performed or are currently being performed.

4.1.1 Drywell Monitoring

There are 70 drywells surrounding the 100-series tanks in the C tank farm. Under the current waste storage mode, drywell logging is not performed on a routine basis because the tanks have been interim stabilized. Recent borehole logging results performed as a part of the baseline characterization of the C tank farm, including information describing the background contamination levels present around the drywells surrounding tanks C-102, C-104, C-107, C-108, and C-112, are presented in *Vadose Zone Characterization Project at the Hanford Tank Farms, C Tank Farm Report* (GJPO-HAN-18). Evaluation of historical drywell monitoring data is provided in *Subsurface Conditions Description of the C and A-AX Waste Management Areas* (RPP-14430).

There are five drywells near tank C-102 even though the five drywells are associated with other tanks surrounding tank C-102 (Figure 4.1). The five drywells are 30-03-07, 30-00-03, 30-01-01, 30-05-05, and 30-05-04, with the closest drywell located about 12 feet from tank C-102. Three of the drywells are 100 feet deep and two are 120 feet deep (GJ-HAN-86).

Figure 4.1. Plan View of the C Tank Farm Showing Drywells



There are eight drywells spaced around C-104 that are between two and 10 feet from the edge of the tank(Figure 4.1). The eight drywells include 30-04-01, 30-04-02, 30-04-03, 30-05-06, 30-04-04, 30-04-05, 30-04-08, and 30-04-12 are (*Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-104* [GJ-HAN-87]). Three of the drywells are 50 to 60 feet deep, two drywells are 100 feet deep, and three are 135 to 145 feet deep (GJ-HAN-87).

There are seven drywells spaced around tank C-107 that are between three and 12 feet from the edge of the tank (Figure 4.1). The seven drywells include 30-07-01, 30-07-02, 30-07-05, 30-07-07, 30-07-08, 30-07-10 and 30-07-11. All seven drywells were drilled to a depth of 100 feet (*Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-107* [GJ-HAN-88]).

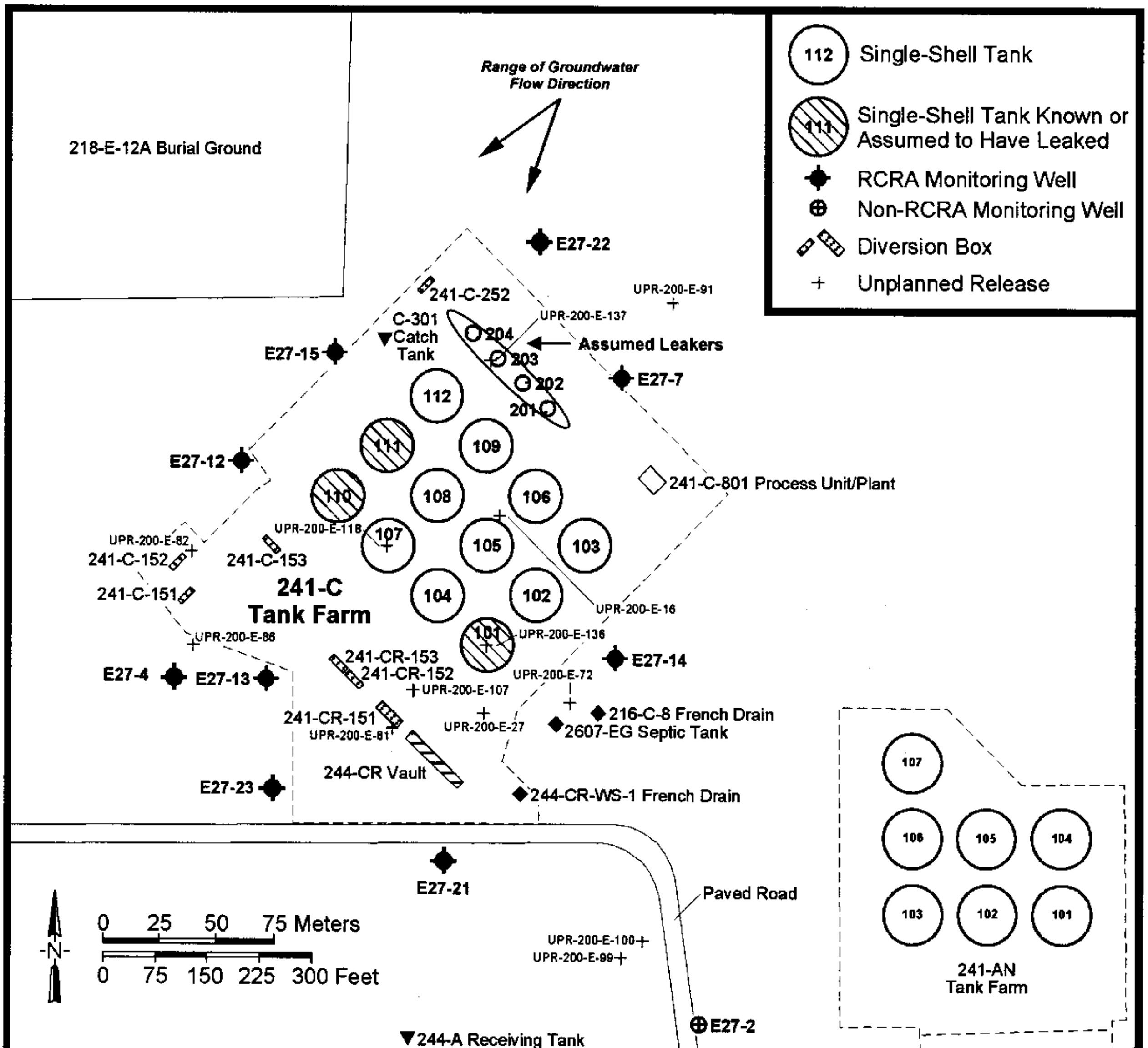
There are seven drywells spaced around tank C-108 that are between five and 13 feet from the edge of the tank. The seven drywells included 30-08-02, 30-08-03, 30-05-10, 30-07-02, 30-07-01, 30-11-05 and 30-08-12 Five of the drywells are 100 feet deep. One drywell is 50 feet deep (30-08-03) although it was drilled to 150 feet, and one drywell (30-05-10) is 135 feet deep (*Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-108* [GJ-HAN-90]).

There are seven drywells spaced around tank C-112 that are between 5 and 17 feet from the edge of the tank. The seven drywells include 30-12-13, 30-12-01, 30-12-03, 30-09-11, 30-09-10, 30-11-01, and 30-12-09. Six of the drywells are 100 feet deep and one (30-12-13) is 120 feet deep(*Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-112* [GJ-HAN-94]).

4.1.2 Groundwater Monitoring

The groundwater beneath the C tank farm has been monitored since 2001 in accordance with the *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring plan (*RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site* [PNNL-13024]). 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 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, 299-E-27-15 has been performed on a quarterly basis per request by Ecology. 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, ICP metals, gross beta, technetium and a gamma scan. Per request from Ecology in August 2004, wells 299-E27-7 or 299-E27-14 will be sampled on a monthly basis until C-200-series waste retrieval operations are complete. If the cyanide exceeds 10 µg/L in either well 299-E27-7 or 299-E27-14, wells 299-E27-15 and 299-E27-22 will also be sampled on a monthly basis. A final sample will be obtained from wells 299-E27-7 or 299-E27-14 (and wells 299-E27-15 and 299-E27-22 if the cyanide exceeds 10 µg/L in either well E27-7 or 299-E27-14) within two months of completion of C-200 retrieval.

Figure 4.2. Waste Management Area C and Regulated Structures



Modified from 2001/DCL/U/007

Source: Adapted from PNNL-14548, Figure B.18.

The quarterly groundwater monitoring that is currently performed is considered adequate for groundwater monitoring during waste retrieval. As identified in Section 7.0, the calculated time to peak concentrations in the groundwater from a leak that occurs during waste retrieval is approximately 80 years. Because the travel time for contaminants to reach the groundwater is long in comparison to waste retrieval operations, groundwater monitoring data will not be used for retrieval process control. Recent results from the groundwater monitoring at the C tank farm are reported in *Hanford Site Groundwater Monitoring for Fiscal Year 2003* (PNNL-14548).

4.1.3 In-Tank Monitoring

The waste levels in tanks C-102, C-104, C-107, C-108, and C-112 are monitored for intrusion on a quarterly basis and tank C-107 is monitored for leak detection on a weekly basis (*Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection* [OSD-T-151-00031]). Although C-107 is classified as interim stabilized, leak detection monitoring is performed because the flowrate at the end of interim stabilization exceeded 0.05 gal/min and the configuration of the tank makes leak detection monitoring technically feasible. The basis for in-tank leak detection and intrusion monitoring is provided in *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements* (RPP-9937).

4.2 LEAK DETECTION AND MONITORING SYSTEM

This section provides a description of the leak detection and monitoring (LDM) system that will be deployed at tanks C-102, C-104, C-107, C-108, and C-112 along with a description of how it will be operated.

4.2.1 Leak Detection and Monitoring for Single-Shell Tanks

The primary method for leak detection and leak monitoring for tanks C-102, C-104, C-107, C-108, and C-112 is external to the tanks and involves periodic logging of the drywells surrounding the tanks. Established drywell logging methods will be used as the primary method of leak detection. HRR will be deployed in tank C-102 in a demonstration mode. HRR will be deployed on tanks C-104, C-107, C-108, and C-112 pursuant to the requirements of Appendix I of the HFFACO, as determined by the results of the HRR deployment demonstration at tank S-102.

Additional detail on the SST leak detection approach is provided in the following sections. Leak detection in the waste transfer system and in the respective receiver DSTs will be performed using standard leak detection methods in the transfer pits and DST annulus.

4.2.1.1 Ex-Tank Leak Detection for Single-Shell Tanks

The existing truck-mounted logging system will be used along with manually deployed moisture gauges to monitor soil conditions surrounding the tanks for evidence of tank leakage.
The truck-mounted system will be deployed by qualified personnel in accordance with the existing procedures before waste retrieval operations begin by deploying calibrated gamma and neutron moisture probes over the full depth of each drywell. The pre-retrieval logging results will provide a baseline for specific depths of interest (in addition to the region near the base of the tanks).

During waste retrieval, the handheld moisture gauge will be deployed to monitor specific areas or depths of interest for increases in soil moisture content. The handheld moisture gauge will be deployed by qualified personnel in accordance with the existing procedure (*Operate Model 503DR Hydroprobe Neutron Moisture Detection* [TO-320-022]). The neutron moisture probe is used to monitor the moisture (e.g., water) content in the sediments around the drywells. Manually deployed moisture gauges will be used to monitor the drywells at specific depths of interest, including the compacted layer beneath the base of the tank that is 35 to 50 feet below grade and with fine sediments. The fine sediment layers should be the first affected by a new leak plume, potentially decreasing detection times. In the event of an unexplained increase in soil moisture content, additional monitoring with the truck-mounted systems will be used if truck access is practical to determine if there have been any changes in gamma-emitting radionuclide concentration surrounding the drywells. The target frequency for deploying the manual moisture gauges will be defined in the process control plan.

A new readily transportable drywell logging system is being developed for use in the tank farms. The new system will have calibrated neutron moisture and gross gamma probes that will provide dual data logs over preselected depths in the drywells. The new logging system also provides for electronic data recording. When approved for use, the new drywell logging system will be optionally substituted for the handheld moisture gauge.

The following drywells will be monitored:

- **Tank C-102** – 30-03-07, 30-00-03, 30-01-01, 30-05-05, and 30-05-04.
- **Tank C-104** – 30-04-01, 30-04-02, 30-04-03, 30-05-06, 30-04-04, 30-04-05, 30-04-08, and 30-04-12.
- **Tank C-107** – 30-07-01, 30-07-02, 30-07-05, 30-07-07, 30-07-08, 30-07-10 and 30-07-11.
- **Tank C-108** – 30-08-02, 30-08-03, 30-05-10, 30-07-02, 30-07-01, 30-11-05 and 30-08-12.
- **Tank C-112** – 30-12-13, 30-12-01, 30-12-03, 30-09-10, 30-09-11, 30-11-01, and 30-12-09.

It is recognized that the use of drywell logging for external monitoring has technical limitations, however attempts to improve confidence in data obtained by the primary leak detection equipment by routinely collecting corroborating data from in-tank measurements and operating data as potential indicators of a leak will be pursued. Details of the drywell monitoring plan will be defined in tank-specific process control plans.

4.2.1.2 High-Resolution Resistivity

HRR is an external LDM technology that is currently undergoing evaluation for use during waste retrievals. HRR leak detection has been deployed in a demonstration mode on tank S-102 and is planned as a demonstration deployment on tanks C-103 and C-109 (or C-102). Following completion of waste retrieval at tank S-102, a leak injection test will be performed to establish how well the HRR system performs in terms of detectable leak volumes and leak monitoring as discussed in *Test Plan for SST Deployment Demonstration and Injection Leak Testing of the HRR Long Electrode LDM System* (RPP-17191). These demonstration deployments of the HRR system (tanks S-102, C-103, and C-109 [or C-102]) and the leak injection test are needed to validate and verify this method before it can be used as a baseline LDM method.

Following completion of the demonstration deployments and liquid injection test a determination will be made regarding the viability of HRR for use in the tank farms. If it is determined that HRR is viable as the primary method for LDM it may be utilized as the sole method of external leak detection for the tanks addressed in this document.

The HRR method uses geophysical resistivity measurement methods as a means to detect changes in moisture levels. The electrical resistivity of the sediments 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 lowers the sediment resistivity. The HRR method detects changes in soil moisture content by comparing a current resistivity measurement against a previously obtained baseline measurement, or a 'pre-leak' measurement. This delta processing allows the HRR method to discount existing resistivity differences in the soil caused by factors that include conductive structures or prior leaks.

The basic resistivity measurement concept utilizes the existing drywells as measurement electrodes. By applying power to each electrode pair and making resistivity measurements from all other electrode pairs, an image of the sediment resistivity can be obtained.

4.2.1.3 In-Tank Volume (Material) Balance (During Operation)

Material balances will be performed for all transfers between tanks in accordance with the process control plan. Inputs to the material balance include water additions, volume of waste transferred from tank C-102, C-104, C-107, C-108, or C-112 to its respective receiver tank; volume of supernate transferred from the respective receiver tank to tank C-102, C-104, C-107, C-108, or C-112; and the volume of waste within the respective receiver tank. Given the operational strategy to minimize liquids in tank C-102, C-104, C-107, C-108, or C-112 during waste retrieval operations there will not be a liquid level measurement available. If not removed or retracted level monitoring equipment could get damaged by the sluicers. Given the dished bottoms of the tanks and the location of the level instrumentation near the side, waste levels can not be measured below approximately 12,000 gallons. In the absence of a means to collect real-time volume measurements for the tank, estimates will be developed using the in-tank camera. At or near the end of waste retrieval residual waste volumes will be measured using volume displacement. When residual waste volume measurements are made they will be used in the material balance calculations.

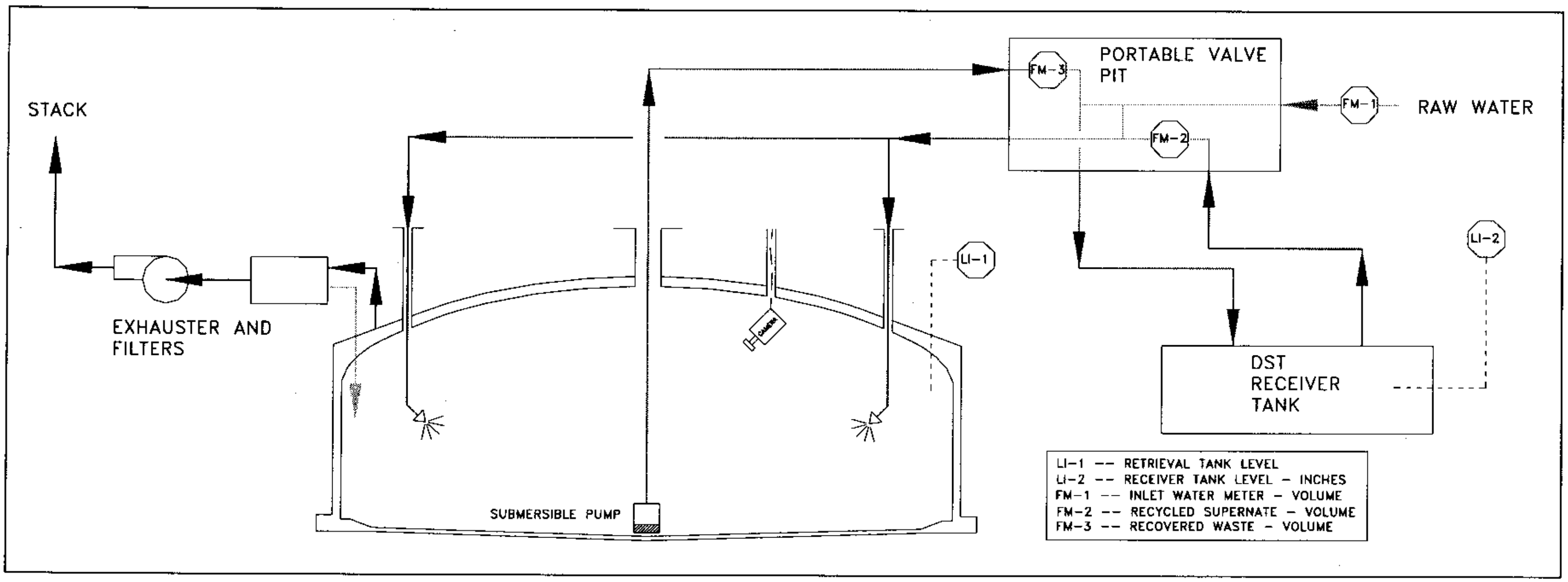
A simplified schematic flow sheet showing measurement locations is provided in Figure 4.3. The material balance can be used to identify large discrepancies in the waste retrieval process but will not be able to identify smaller leaks. Therefore, material balance calculations will only be used as a backup leak detection method.

The basic resistivity measurement concept utilizes the existing drywells as measurement electrodes. By applying power to each electrode pair and making resistivity measurements from all other electrode pairs, an 'image' of the sediment resistivity can be obtained.

4.2.2 Leak Detection in Transfer Lines and Pits

Supernate will be transferred from respective receiver tank and liquid waste and slurries will be transferred from tanks C-102, C-104, C-107, C-108, and C-112 back to their respective receiver tank using temporary hose-in-hose overground transfer lines and pits. Leak detectors located in pits and pump pits will be monitored, and will be interlocked to shut down transfer pumps if a leak is detected as required in *Operating Specifications for the Double-Shell Storage Tanks* (OSD-T-151-00007) and *Operating Specifications for Single-Shell Waste Storage Tanks* (OSD-T-151-00013). Leaks are also detected by monitoring flows and by radiation monitoring of the hose-in-hose transfer line in accordance with the requirements of *Tank Farms Documented Safety Analysis* (RPP-13033) and *Temporary Waste Transfer Line Management Program Plan* (RPP-12711). Pits associated with the receiver tank will also be monitored.

Figure 4.3. Simplified Flow Sheet Schematic Showing Measurement Locations



Leakage from the primary overground transfer hose (inner hose) will be contained by the secondary confinement system (outer hose). The secondary confinement system has been 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 shutdown the transfer pumps either automatically or manually.

4.2.3 Leak Detection in the Receiver Double-Shell Tank

The existing leak detection systems in the receiver DSTs will be utilized as required in OSD-T-151-00031. A leak from the primary vessel of receiver DST will be detected by a conductivity probe installed in the annulus or leak detection pit.

4.3 RATIONALE FOR SELECTION OF LEAK DETECTION AND MONITORING TECHNOLOGY

The LDM technology selected for deployment at tanks C-102, C-104, C-107, C-108, and C-112 represents the best available technology that is consistent with the planned approach for waste retrieval. The primary leak detection method utilizes available drywells and established technologies to monitor for liquid losses in the soils surrounding the tanks. Additionally the HRR LDM system will be deployed on each of the tanks unless it is determined through ongoing demonstration deployments that HRR is unacceptable for use as a leak detection method. Depending on the results of the ongoing demonstrations and testing, HRR may be deployed as the primary means of leak detection and monitoring (see Section 4.2.1 for additional discussion). If a determination is made that HRR is suitable for use as the primary method of leak detection, it would be deployed for any of five C farm tanks awaiting retrieval. Additionally, mass balance calculations will be performed throughout waste retrieval operations.

4.4 LEAK DETECTION FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the leak detection systems for tanks C-102, C-104, C-107, C-108, and C-112 must be designed and operated. The system specification for the C farm 100-series tanks that defines design criteria (RPP-18633) will be consistent with this work plan. The functions and requirements for LDM are detailed in Table 4.1.

4.5 ANTICIPATED TECHNOLOGY PERFORMANCE

The performance of drywell logging for leak detection is dependent on a number of variables. Based on the analysis performed in support of the tank S-112 waste retrieval, drywell monitoring can be used to detect leaks in the range of 300 to 18,000 gallons at a 95% confidence interval for a drywell located 10 feet from the edge of the tank depending on the location of the leak relative to the drywell, and the leak rate as described in *Tank S-112 Saltcake Waste Retrieval Demonstration Project Leak Detection, Monitoring, and Mitigation Strategy* (RPP-10413). The drywells identified in Section 4.1.1 are located at varying distances from the edge of the tank. Tanks C-104, C-107, C-108, and C-112 have drywells ranging from a few feet to 17 feet from the tanks. The tanks with drywells located closer than 10 feet would provide for improved leak detection (i.e., smaller volumes). The one exception is tank C-102 where there are only

5 drywells around the tank with the closest being 12 feet from the edge of the tank and the furthest being approximately 75 feet from the edge of the tank.

As noted in Section 4.2.1.1, the process control plan will define the details of the drywell monitoring to be performed during waste retrieval operations. Data collected with the handheld moisture gauge will be analyzed within a few days in order to provide timely feedback for process control. Data collected with the truck mounted logging system will be analyzed within a few weeks under normal operations. Material balance calculations will be performed on a daily basis when waste retrieval and transfers are being performed.

4.6 MITIGATION STRATEGY

The leak mitigation strategy (i.e., reduction of leak loss potential) has two aspects.
The operational strategy involves taking actions to minimize leakage potential from the onset of waste retrieval and, if a leak is detected, involves responding to minimize the overall environmental impact. The operational strategy to minimize the leak potential (initiation of a leak and leak volume) from the tank structure during waste retrieval in the absence of any indication of a leak involves the following:

- Control the in-tank liquid level during waste retrieval to levels below those present in the tanks before they were removed from service. Before being removed from service the liquid levels in the tanks were monitored providing a basis for tanks are demonstrated sound.

- Retrieve waste from an advantageous location; given the limited number of risers in the tanks, the systems will be operated to focus on retrieving waste from the center region of the tank first.

- Use the waste retrieval pump to minimize the in-tank liquid inventories between waste retrieval campaigns, in the event multiple waste retrieval campaigns are required, to further reduce any leak driving force and exposure of the tank walls.

- Minimize potential leak volume by providing a relatively high-capacity pump, capable of being located as close to tank bottom as possible, to pump down liquids if a leak is detected.

If a belowgrade leak from the tank is indicated during waste retrieval, liquid additions to the tank will be suspended and actions defined in *Tank Leak Assessment Process* (TFC-ENG-CHEM-D-42) will be implemented. Retrieval of liquid waste shall continue during the leak assessment process if possible to remove the maximum practical amount of liquid from the tank. If the leak assessment concludes that no leak is indicated, waste retrieval operations will continue under normal operating procedures. However, if a leak is validated, the operating contractor will notify the appropriate regulatory agencies in accordance with *Environmental Notification* (TFC-ESHQ-ENV_FS-C-01). This includes notification to Ecology within 24 hours of a validated leak in accordance with WAC 173-303-640 (7)(d).

Table 4.1. Tanks C-102, C-104, C-107, C-108, and C-112 Leak Detection and Monitoring Functions and Requirements

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from tanks C-102, C-104, C-107, C-108, and C-112	The LDM system shall be capable of detecting liquid waste releases during all waste removal operations.	WAC 173-303 HNF-SD-WM-TSR-006	Utilize both in-tank and external LDM technologies to detect loss of liquid from a tank; see Section 4.0
Monitor leaks from tanks C-102, C-104, C-107, C-108, and C-112 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 in-tank and external LDM technologies and operating strategies that will allow estimates of leak volumes and migration rates to be developed in the event of a leak.
Mitigate leaks during tanks C-102, C-104, C-107, C-108, and C-112 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.	HNF-SD-WM-AP-005 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, WAC 173-303-640(4), 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.
WAC=Washington Administrative Code.
WRS = waste retrieval system.

If a visible (above ground) leak or release is detected during waste retrieval operations, response actions defined in *Building Emergency Plan for Tank Farms* (HNF-IP-0263-TF) would be implemented. A visible leak or spill would only occur as a result of an accident or equipment failure. HNF-IP-0263-TF 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 in accordance with WAC 173-303-640(7)(c).

If a leak is detected in the above ground containment structures, the waste transfer pumps would be shut down and the leakage would be transferred to the tank being retrieved (tank C-102, C-104, C-107, C-108, or C-112) using the sump pump. The leaks would be repaired before resuming waste retrieval operations.

This page intentionally left blank.

5.0 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Retrieval of waste from the SSTs will be performed under the requirements of HFFACO, AEA, RCRA, "Hazardous Waste Management Act" and its implementing regulations, and "Dangerous Waste Regulations" (WAC-173-303). The SSTs are not compliant with RCRA and "Hazardous Waste Management Act" interim facility standards (i.e., "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" [40 CFR 265], Subpart J). The SSTs are currently authorized to continue operations under the "Hazardous Waste Management Act" pending closure in accordance with WAC 173-303-610 under the authority of the 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). WAC 173-303-400(3) incorporates by reference the interim status performance standards set forth by the Environmental Protection Agency in 40 CFR 265. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the AEA and various DOE directives incorporated into the contract between the Office of River Protection and CH2M HILL Hanford Group, Inc. (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 the U.S. Environmental Protection Agency 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 tanks C-102, C-104, C-107, C-108, and C-112 using supernate from the receiver DST and transferring the resulting slurry to the respective receiver tank will be obtained from the Environmental Protection Agency before initiating waste retrieval operations. DST supernate is classified as PCB remediation waste in accordance with *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste* (Ecology et al. 2000). Because the DST supernate is PCB remediation waste, the retrieval of waste from SSTs may require management of PCBs under the *Toxic Substance Control Act of 1976* (TSCA).

Table 5.1. Regulatory Requirements for Waste Retrieval (3 Sheets)

Regulatory Requirement	Waste Retrieval System Feature or Implementing Plan/Procedure
40 CFR 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 secondary containment system to rupture, leak, corrode, or otherwise fail.	A waste compatibility assessment will be completed before initiating waste retrieval operations in accordance with HNF-SD-WM-OCD-015.
40 CFR 265.194 General Operating Requirements and WAC 173-303-340 (b) The owner or operator must use appropriate controls and practices to prevent spills and overflows from tank or secondary containment systems. These include at a minimum: (1) Spill prevention controls (e.g., check valves, dry disconnect couplings); (2) Overfill prevention controls (e.g., level sensing devices, high-level alarms, automatic feed cutoff, or bypass to a standby tank); and (3) Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation.	Control of the waste retrieval process is defined in the process control plan developed for each tank. The process control plans for tanks C-102, C-104, C-107, C-108, and C-112 are being prepared: (1) The design of the waste retrieval system includes features to prevent spills including secondary containment, leak detection, and conduct of operations for nuclear facilities. (2) The DST receiver tank has an Enraf level gauge. The addition of liquid to tank C-102, C-104, C-107, C-108, or C-112 will be visually monitored and/or monitored through the use of flowmeters installed on the supply and return lines from the tank. The requirement to control the waste level is defined in Table 3.2. (3) Not applicable.
40 CFR 265.195 Inspections and WAC 173-303-320 (a) The owner or operator must inspect, where present, at least once each operating day: (1) Overfill/spill control equipment (e.g., waste-feed cutoff systems, bypass systems, and drainage systems) to ensure that it is in good working order; (2) The aboveground portions of the tank system, if any, to detect corrosion or releases of wastes; (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; and (4) The construction materials and area immediately surrounding the externally accessible portion of the tank system including secondary containment structures (e.g., dikes) to detect	Because of the radioactive nature of the tank waste, visual inspection of above-grade portions of the waste retrieval system is not possible due to shielding. Routine surveillance of tank farm conditions will be performed to monitor the general status of conditions in the tank farm: (1) Process control will be performed remotely from the control trailer and includes automatic pump shut down system with a manual backup. Additionally, instrumentation is included in the system design to monitor valve position, pressures, and flow on the waste transfer lines. (2) Aboveground portions of the tank system will be monitored on a daily basis. Radiation surveys will be performed routinely along waste transfer routes as a method of leak detection. (3) Monitoring data associated with leak detection for tanks C-102, C-104, C-107, C-108, and C-112 will be collected and assessed on a routine basis as described in Section 4.0. Monitoring data associated with the waste

Table 5.1. Regulatory Requirements for Waste Retrieval (3 Sheets)

Regulatory Requirement	Waste Retrieval System Feature or Implementing Plan/Procedure
erosion or signs of release of hazardous waste (e.g., wet spots, dead vegetation).	retrieval system (e.g., leak detectors located in portable valve box) and in pits will be continuously monitored in the control trailer. (4) During waste retrieval operations visual monitoring of the waste retrieval system and transfer line routes will be performed during daily operator rounds.
40 CFR 265.196 Response to Leaks or Spills and Disposition of Leaking or Unfit-for-Use Tank Systems	Response to leaks or spills is defined in Section 4.0 along with reference to the tank farms building emergency plan (HNF-IP-0363-TF) and the procedure for notifying regulatory agencies in TFC-ESHQ-ENV_FS-C-01.
WAC 173-303-280 General Requirements for Dangerous Waste Management Facilities	SST system has a Part A permit application, an EPA/state identification number, and complies with the special land disposal restriction for certain dangerous wastes in WAC 173-303-140.
WAC 173-303-283 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 groundwater quality (b) Degradation of air quality by open burning (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 right of ways, or public lands (g) Unstable hillsides or soils as a result of trenches, impoundments, excavations (h) The use of processes that do not treat, detoxify, recycle, reclaim, and recover waste material to the extent economically feasible (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) Investigate past leaks and spills and perform interim measures in accordance with RCRA Corrective Action process per HFFACO; Remove waste from the tanks to the limit of technology in accordance with HFFACO M-45 series milestones; continued assessment of groundwater quality through monitoring as described in the 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 CH2M HILL 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 extent economically feasible (see Section 3.0). (i) Appropriate trained employees are used to conduct the waste retrieval operation and site access controls prevent public access (see Section 5.0).

Table 5.1. Regulatory Requirements for Waste Retrieval (3 Sheets)

Regulatory Requirement	Waste Retrieval System Feature or Implementing Plan/Procedure
WAC 173-303-330 Personnel training	This information is provided in TFC-PLN-07 (Dangerous Waste Training Plan – Section 3.4 and Section 3.5).
WAC 173-303-350 Contingency Plan and Emergency Procedures	This information is provided in HNF-IP-0263 (Building Emergency Plan for Tank Farms – Section 7.0) and DOE/RL-94-02.
WAC 173-303-360 Emergencies	The information to meet this requirement is provided in HNF-IP-0263 (Building Emergency Plan for Tank Farms – Section 6, Page 26).
WAC 173-303-380 Facility Recordkeeping	The information to meet this requirement is provided in OSD-T-151-00013.
WAC 173-303-390 Facility Reporting	The information to meet this requirement is provided in HNF-IP-0263 (Building Emergency Plan for Tank Farms – Section 11, Page 47).
WAC 173-303-395 Other General Requirements	The tank farm labeling requirements are provided in TFC-ENG-FACSUP-P-19.
WAC 173-303-400 Interim Status Facility Standards	The information to meet this requirement is provided in multiple documents that have been summarized in this table.

CH2M HILL = CH2M HILL Hanford Group, Inc.
DST = double-shell tank.
EPA = U.S. Environmental Protection Agency.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*
RCRA = *Resource Conservation and Recovery Act of 1976.*
SST = single-shell tank.

6.0 PRELIMINARY ISOLATION EVALUATION

This section provides a preliminary isolation evaluation for tanks C-102, C-104, C-107, C-108, and C-112. Intrusion prevention measures were completed in the 1980's for these tanks. The identification of tank penetrations and methods used to isolate intrusion pathways is described in Section 2.0. Isolation details for intrusion measures that have been completed for the tanks are provided on the following drawings:

- "Piping Waste Tank Isolation C-Tank Farm Plot Plan" (H-2-73338, Sheet 1)
- "Piping Waste Tank Isolation TK 241-C-102" (H-2-73342, Sheet 1)
- "Piping Waste Tank Isolation TK 241-C-104" (H-2-73344, Sheet 1)
- "Piping Waste Tank Isolation TK 241-C-107" (H-2-73347, Sheet 1)
- "Piping Waste Tank Isolation TK 241-C-108" (H-2-73348, Sheet 1)
- "Piping Waste Tank Isolation TK 241-C-112" (H-2-73351, Sheet 1).

Installation of waste retrieval equipment in tanks C-102, C-104, C-107, C-108, and C-112 will involve placement of equipment through tank risers. Following completion of waste retrieval, the in-tank equipment may be removed or may be left in place for disposition during tank closure. As soon as practical following completion of waste retrieval operations isolation methods will be evaluated for potential intrusion pathways per the tank closure plan. Following evaluation of isolation methods, actions will be taken to prevent liquid intrusion before tank closure. New isolation drawings or modifications to existing drawings will be prepared to define methods for isolating potential intrusion pathways following completion of waste retrieval. The current planning baseline for component closure of tanks C-102, C-104, C-107, C-108, and C-112 includes closure of tank C-102 in 2006, tank C-104 in 2007, tank C-107 in 2007, tank C-108 in 2006, and tank C-112 in 2006.

This page intentionally left blank.

7.0 PRE-RETRIEVAL RISK ASSESSMENT

This section provides long-term human health risk information to support operational decisions in the event a leak is detected during waste retrieval operations for tanks C-102, C-104, C-107, C-108, and C-112. 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.

According to Appendix I of the HFFACO, the information provided in the work plans will include the following:

> *A pre-retrieval risk assessment of potential residuals, consideration of past leaks, and potential leaks during retrieval, based on available data and the most sophisticated analysis available at the time. The purpose of this risk assessment is to aid operational decisions during retrieval activities. This risk assessment will not be used to make final retrieval or closure decisions. Minimally it will contain the following:*
>
> - *Long-term human health risk associated with potential leaks during retrieval and potential residual waste after completion of retrieval.*
>   - *Potential impacts to groundwater, including a waste management area (WMA)-level risk assessment.*
>   - *Potential impacts based on an intruder scenario.*
> - *Process management responses to a leak during retrieval and estimated potential leak volume.*
> - *The pre-retrieval risk analysis will be based on the following criteria:*
>   - *Using the WMA fenceline for point of compliance.*
>   - *Identify the primary indicator contaminants (accounting for at least 95% of impact to groundwater risk) and provide the incremental lifetime cancer risk (ILCR) and hazard index (HI).*
>   - *Using ILCR and HI for the industrial and residential human scenarios as the risk metric.*
>   - *Calculated concentration(s) of primary indicator contaminant(s) in groundwater (mg/L and pCi/L).*

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, (2) long-term human health risk associated with inadvertent post-closure human intrusion.

Groundwater pathway impacts are discussed in Section 7.1. Inadvertent intruder impacts are discussed in Section 7.2. Calculation detail is provided in *Tanks C-102, C-104, C-107, C-108,* *and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan* (RPP-22392).

7.1 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway impacts evaluation emphasized 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 first-order approximation of potential groundwater pathway impacts for a particular retrieval leak.

The methodology used to develop the retrieval leak impact graphs is described in the Section 7.1.1. Tank-specific retrieval leak impact results are discussed in Section 7.1.2. Retrieval leak impact graphs for the individual tanks are provided in Appendix A through Appendix E. A waste management area (WMA)-level perspective on groundwater pathway impacts is provided in Section 7.1.3 to help place the potential retrieval leak impacts from the individual tanks 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:

- Focus on potential long-term groundwater pathway human health risk at the downgradient tank farm fenceline
- Use radiological incremental lifetime cancer risk (ILCR) and noncarcinogenic chemical hazard index (HI) as the primary human health impact metrics
- Use industrial and residential exposure scenarios
- Identify the significant contributors (95% of total) for each health impact metric and generate a separate graph for each significant contributor
- Derive effects of contaminant release and transport from previous studies
- 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 were calculated using the following equation.

$$R_i = I_i \times C_i \times H_i \qquad \text{Equation 1}$$

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).

Sections 7.1.1.1 through 7.1.1.4 discuss the individual terms in Equation 1, including identification of indicator contaminants, development of contaminant inventories, simulation of contaminant transport, and identification of exposure scenarios and health effects conversions factors.

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 were the contaminants estimated to dominate or drive the total impact for a particular 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 health impact metrics used were radiological ILCR and noncarcinogenic chemical HI. Nonradiological ILCR was also included for information purposes.

Indicator contaminants for each 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 technetium-99, iodine-129, 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 *Inventory and Source Term Data Package* (DOE/ORP-2003-02) for which a toxicity factor was available. Exposure scenarios and risk factors used for the RPP-13774 analysis were obtained from *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment* (HNF-SD-WM-TI-707).

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 Federal Guidance Report Number 13 (EPA-402-4-99-001) were used. For chemicals, the non-cancer toxicity reference doses and cancer induction slope factors adopted by 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 *Health Effects Assessment Summary Tables (HEAST) FY 1997 Update* (EPA-540/R-97/036) 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 total estimated impacts from all contaminants by source term for each of the health impact metrics. Table 7.1 shows the peak impacts from WMA C potential residual tank waste (including potential residual waste in the C-301 catch tank and 244-CR vault), 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-100-series tanks).

Table 7.1. Summary of Waste Management Area C Peak Groundwater Pathway Human Health Impacts at Fenceline

Source Term	Time of Peak (Yr AD)	Radiological Incremental Lifetime Cancer Risk		Nonradiological Incremental Lifetime Cancer Risk		Noncarcinogenic Chemical Hazard Index	
		Industrial	Residential	Industrial	Residential	Industrial	Residential
Residual Tank Waste[a]	5614	1.0E-06	2.3E-05	2.8E-08	6.30E-08	9.4E-03	5.7E-02
Past Leaks[b]	2117	8.1E-06	1.8E-04	1.1E-07	2.40E-07	3.3E-02	2.0E-01
Potential Retrieval Leaks[c]	2082	6.5E-06	1.4E-04	1.7E-07	3.80E-07	6.7E-02	4.2E-01

[a] Source: RPP-13774, Addendum C1, Tables 30 and 31 (based on diffusion-dominated release from 360 ft^3 and 30 ft^3 of residual tank waste in each C-100-series tank and each C-200-series tank, respectively, and from assumed post-retrieval residual waste inventories in the C-301 catch tank and 244-CR vault).

[b] Source: RPP-13774, Addendum C1, Tables 33 and 34 (based on verified vadose zone contamination associated with past unplanned releases from one tank [C-105] and three ancillary pipelines [UPR-200-E-81, UPR-200-E82, UPR-200-E-86]).

[c] Source: RPP-13774, Addendum C1, Tables 36 and 37 (based on hypothetical retrieval leak volume of 8,000 gal from each C-100-series tank [no retrieval leaks assumed for the C-200-series tanks]).

The RPP-13774 analysis results indicate the primary contributors to total WMA C radiological ILCR at the fenceline would be technetium-99 and iodine-129, with technetium-99 being the major driver. Technetium 99 was predicted to contribute approximately 85% to 99% 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.

The RPP-13774 analysis results indicate the primary contributors to the total WMA C noncarcinogenic chemical HI at the fenceline would be hexavalent chromium, nitrite, 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 75% 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.

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. 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 due to 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. Because of these uncertainties, and the fact that hexavalent chromium ILCR is generally two to three orders of magnitude lower than total radiological ILCR, radiological ILCR was selected as the cancer risk metric over nonradiological ILCR for purposes of supporting informed decision making during waste retrieval operations.

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 resuspended soil and volatilized water. The soil is assumed to be contaminated by irrigation with contaminated groundwater. 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.

7.1.1.2 Potential Retrieval Leak Inventories

The retrieval leak impact graphs provided in the appendices were generated by applying Equation 1 over a range of hypothetical retrieval leak inventories for each indicator contaminant (RPP-22392). 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-gallon retrieval leak. The 8,000-gallon volume was used only for information purposes to provide a point of reference on the graphs. Use of the 8,000-gallon value also maintains consistency and allows comparison with previous retrieval leak analyses (e.g., RPP-13774). The 8,000-gallon value was not intended to represent anticipated retrieval leak volumes or leak detection limits for tanks C-102, C-104, C-107, C-108, and C-112.

Development of the tank-specific inventories shown as points of reference on the graphs for the individual tanks is discussed in the appendices. Current inventory values were taken from the BBI by downloading from the Tank Waste Information Network System (TWINS) database. Hypothetical retrieval leak inventory values were calculated from the best available published data source.

7.1.1.3 Contaminant Transport Simulations

The RPP-13774 analysis provides the most sophisticated currently available predictions of potential long-term groundwater impacts associated with tank waste retrieval and closure activities for WMA C. The groundwater contaminant concentrations used for the retrieval leak impact graphs were derived directly from the modeling output data from the RPP-13774 analysis.

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 12,000). 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:

- Past leaks from tanks
- Past leaks from ancillary equipment (i.e., past pipe leaks)
- Potential leaks during waste retrieval
- 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., one 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 (technetium-99, 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 one curie of radionuclide or one kilogram of chemical. The retrieval leak impact graphs were generated by multiplying the simulated unit-source results by the retrieval leak inventory to obtain an estimate of peak groundwater concentration (Equation 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

* Source: RPP-13774, Addendum C1, Figure 9.
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 the HFFACO Appendix I. Both scenarios are based on scenarios described in *Hanford Site Risk Assessment Methodology* (DOE/RL-91-45). 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	HI per mg/L	3.88E+00	2.34E+01
Nitrite	HI 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 index.
ILCR = incremental lifetime cancer risk.

The conversion factors shown in Table 7.3 were taken from tables provided in HNF-SD-WM-TI-707. For technetium-99 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 HI per unit concentration in the groundwater. The factors were applied to the retrieval leak impact calculations as shown in Equation 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 generated using the methodology described above are provided in Appendix A through Appendix E for tanks C-102, C-104, C-107, C-108, and C-112, respectively. Three graphs, one for each indicator contaminant, are provided for each tank. An example calculation is also provided to illustrate how the formula given in Equation 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 the individual tanks 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 potentially reduce the uncertainties and lower the risks 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. The table shows the predicted peak groundwater concentration, radiological 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-gallon retrieval leak from each of the twelve C-100-series tanks. The four C-200-series tanks were assumed not to leak during retrieval. A sensitivity case with a larger retrieval leak volume was also included. 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.

The RPP-13774 retrieval leak assessment results shown in Table 7.4 included an 8,000-gallon retrieval leak from tank C-106. Subsequent to the completion of the RPP-13774 analysis, a waste retrieval campaign was completed for tank C-106 using modified sluicing and acid dissolution. No leakage from tank C-106 was detected during that campaign. Results of a tank C-106 post-retrieval risk assessment are reported in *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106* (RPP-20577).

7.1.3.2 Residual Waste

Potential WMA C residual waste impacts are summarized in Table 7.5 from the results of the base case analysis presented in RPP-13774. The table shows the predicted peak groundwater concentration, radiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C residual waste source term.

The RPP-13774 simulation results indicate the peak groundwater concentrations from residual waste would arrive at the fenceline approximately 3,600 years after closure (in the year 5614). The peak groundwater concentrations from residual 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 twelve 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 (sludge, supernate, etc.) during retrieval. The residual waste source term also included the estimated post-retrieval residual waste inventories remaining in the C-301 catch tank and 244-CR vault. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline.

Table 7.4. Peak Impacts at the Waste Management Area C Fenceline from Potential Retrieval Leaks

Contaminant	Time of Peak (Yr AD)	Incremental Lifetime Cancer Risk[a]		Hazard Index[b]		Groundwater Concentration[c]	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[d]
Nitrite	2082	NA	NA	2.6E-02	1.7E-01	0.26 mg/L	3.3 mg/L[e]
Total Radiological	2082	6.5E-06	1.4E-04	NA	NA	NA	NA
Total Non-Radiological	2082	1.7E-07	3.8E-07	6.7E-02	4.2E-01	NA	NA

[a] Source: RPP-13774, Addendum C1, Table 36.
[b] Source: RPP-13774, Addendum C1, Table 37.
[c] Source: RPP-13774, Addendum C1, Table 38.
[d] The MCL for chromium is for total chromium, not just hexavalent chromium.
[e] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

Table 7.5. Peak Impacts at the Waste Management Area C Fenceline from Potential Residual Waste

Contaminant	Time of Peak (Yr AD)	Incremental Lifetime Cancer Risk[a]		Hazard Index[b]		Groundwater Concentration[c]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	5614	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[d]
Nitrite	5614	NA	NA	3.4E-03	2.2E-02	0.034 mg/L	3.3 mg/L[e]
Total Radiological	5614	1.0E-06	2.3E-05	NA	NA	NA	NA
Total Non-Radiological	5614	2.8E-08	6.3E-08	9.4E-03	5.7E-02	NA	NA

[a] Source: RPP-13774, Addendum C1, Table 30.
[b] Source: RPP-13774, Addendum C1, Table 31.
[c] Source: RPP-13774, Addendum C1, Table 38.
[d] The MCL for chromium is for total chromium, not just hexavalent chromium.
[e] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

The impacts shown in Table 7.5 do not include the impacts from residual waste in WMA C ancillary piping components. The RPP-13774 analysis results indicate the peak impacts from ancillary piping components would arrive at the WMA C fenceline approximately 700 years earlier than the peak impacts from residual tank waste and would be approximately one order of magnitude lower than the peak impacts from residual tank waste and two orders of magnitude lower than the peak impacts from past leaks.

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.

Subsequent to the completion of the RPP-13774 analysis, a waste retrieval campaign was completed for tank C-106 using modified sluicing and acid dissolution. No leakage from tank C-106 was detected during that retrieval campaign. Results of a tank C-106 post-retrieval risk assessment based on samples collected from the residual waste remaining in tank C-106 following the retrieval campaign are reported in RPP-20577. The RPP-20577 analysis results indicate that the impacts from tank C-106 residual waste would be a factor of 4 to 7 lower than the corresponding impacts calculated in the RPP-13774 analysis.

7.1.3.3 Past Leaks

WMA C past leak impacts are summarized in Table 7.6 from the results of the base case analysis presented in RPP-13774. The table shows the predicted peak groundwater concentration, radiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C past leak source term.

The RPP-13774 base case simulation results indicate the 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 from one tank (C-105) and three ancillary pipelines (UPR-200-E-81, UPR-200-E82, UPR-200-E-86). 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.

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.

Table 7.6. Peak Impacts at the Waste Management Area C Fenceline from Past Leaks

Contaminant	Time of Peak (Yr AD)	Incremental Lifetime Cancer Risk[a]		Hazard Index[b]		Groundwater Concentration[c]	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[d]
Nitrite	2117	NA	NA	1.4E-02	9.1E-02	0.14 mg/L	3.3 mg/L[e]
Total Radiological	2117	8.1E-06	1.8E-04	NA	NA	NA	NA
Total Non-Radiological	2117	1.1E-07	2.4E-07	3.3E-02	2.0E-01	NA	NA

[a] Source: RPP-13774, Addendum C1, Table 33.
[b] Source: RPP-13774, Addendum C1, Table 34.
[c] Source: RPP-13774, Addendum C1, Table 38.
[d] The MCL for chromium is for total chromium, not just hexavalent chromium.
[e] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

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, *241-C Waste Management Area Inventory Data Package* (RPP-15317), GJPO-HAN-18, and *Vadose Zone Characterization Project at the Hanford Tank Farms, Addendum to the C Tank Farm Report* (GJO-98-39-TARA GJPO-HAN-18). Additional perspective on the integrity of tanks in WMA C can be found in *Single-Shell Tank System Integrity Assessment Report* (RPP-10435).

7.2 INTRUDER RISK

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 work plan to provide perspective on potential post-closure risks associated with closing tanks C-102, C-104, C-107, C-108, and C-112 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 *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington* (DOE/ORP-2003-11). 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 (*Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds* [WHC-EP-0645], *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds* [WHC-EP-0875], *Hanford Immobilized Low-Activity Tank Waste Performance Assessment* [DOE/RL-97-69], *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version* [DOE/ORP-2000-24]).

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:

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

- 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:

  - Suburban resident with a garden
  - Rural farmer with a diary cow
  - 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 feet 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 and closure 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:

- Use a time of compliance of 500 years after closure (consistent with DOE/ORP-2003-11)

- Use radiological dose as the health impact metric

- Calculate acute dose using the driller scenario

- Calculate chronic dose using the suburban resident and rural farmer scenarios

- Assume the borehole diameter is 6.5 inches for well driller and suburban resident with a garden and 10.5 inches for rural farmer with a diary cow.

- Assume the tanks each contain a volume of 360 ft^3 of residual waste at closure

- Assume the residual tank waste is embedded in a grout matrix that renders a fraction of the exhumed waste unavailable for inhalation and ingestion

- Assume intrusion occurs before contaminants have migrated from the closed facility in any significant quantity.

The commercial farmer scenario was disregarded for this analysis. Although 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, the rural farmer was used for purposes of assessing compliance with performance objectives. The rural farmer was more conservative than the commercial farmer but less conservative than the suburban resident. The DOE/ORP-2003-11 analysis considered a rural resident 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.

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 tanks C-102, C-104, C-107, C-108, and C-112 are provided in Appendix A, Appendix B, Appendix C, Appendix D, and Appendix E, respectively. Calculation detail is provided in RPP-22392.

7.2.2.1 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 gallons) 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. Tank-specific residual waste starting inventories are given in the appendices.

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 the following equations.

$$I_{EX} / V_{EX} = I_T / V_t$$

$$I_{EX} / (\pi\, r^2 h) = I_T / (\pi\, R^2 h)$$

$$I_{EX} = I_T\, (\pi\, r^2 h) / (\pi\, R^2 h)$$

$$I_{EX} = I_T\, (r / R)^2$$

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 the following equation.

$$I_{EX}(t) = I_{EX}\,Exp(-\lambda t)$$

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.

7.2.2.2 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.

Table 7.7. Unit Dose Factors for Inadvertent Intruder Scenarios[a]

Radionuclide	Driller (mrem per Ci/kg)[b]	Suburban Resident (mrem/yr per Ci exhumed)[b]	Rural Farmer (mrem/yr per Ci exhumed)[b]
Strontium-90+D	8.12E+04	3.59E+03	9.73E+01
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: HNF-SD-WM-TI-707, Tables 7, 8, and 10.
[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 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 the following equation.

$$M_{EX} = \pi r^2 h \rho$$

Where:

M_{EX} = exhumed mass (kg)
r = borehole radius (m)
h = borehole height (depth to water table) (m)
ρ = 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 and rural farmer) 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 EDE from the first year of exposure. The post-intruder dose factors were multiplied by the curies exhumed (decayed) to obtain the dose.

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 scenario and animal fodder (hay and grain) in the rural farmer 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-specific intruder impacts generated using the methodology described above are provided in the individual appendices. Intruder impacts are currently provided for tanks C-102, C-104, C-107, C-108, and C-112 in Appendix A, Appendix B, Appendix C, Appendix D, and Appendix E, respectively.

8.0 LESSONS LEARNED

A comprehensive lessons-learned effort was completed to meet the requirements of *S-102 Initial Waste Retrieval Functions and Requirements* (RPP-10901). RPP-10901 summarizes lessons learned from the Hanford Site, DOE, and general industries applicable to waste retrieval from underground storage tanks. Additionally, lessons learned from *Performance Evaluation for C-106, S-102/112 and C-200 Series Tank Retrieval Activities* (RPP-18629) were reviewed. The lessons learned identified in RPP-10901 and RPP-18629 were reviewed and the following have been incorporated into the tanks C-102, C-104, C-107, C-108, and C-112 system design:

- 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.
- Cold test all fluid connections and components before deployment to ensure leak tightness.
- 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.
- Design systems to facilitate maintenance and support functions while incorporating safety and as low as reasonably achievable features.
- Provide access to instrumentation and other components requiring servicing and maintenance that does not require breaching confinement system.
- Simplify system control screens to maximize operator efficiency and recognition of key operational parameters/data.
- Incorporate features to unplug piping systems in the event of a line blockage.
- Conduct comprehensive field walk-downs before system design to validate design assumptions and document as-found field conditions.
- Identify and specify equipment shipping, handling, and lifting requirements to facilitate safe and efficient handling and deployment of equipment.
- Conduct comprehensive post-shipping inspections to identify equipment damage and defects.
- Minimize the use of threaded joints in equipment design.
- Identify and obtain all spare parts required for system maintenance, and for equipment repairs for anticipated failures.

This page intentionally left blank.

9.0 REFERENCES

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*, as amended.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

29 CFR 1926, "Safety and Health Regulations for Construction," *Code of Federal Regulations*, as amended.

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

241-C-101, 241-C-105, 241-C-110, and 241-C-111 Tanks Waste Retrieval Work Plan, under development.

Atomic Energy Act of 1954, 42 USC 2011 et seq., as amended.

DOE O 435.1, 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

DOE/ORP-2000-24, 2001, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE/ORP-2003-02, 2003, *Inventory and Source Term Data Package*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

DOE/RL-91-45, 1995, *Hanford Site Risk Assessment Methodology*, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-92-04, 1993, *PUREX Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-97-69, 1998, *Hanford Immobilized Low-Activity Tank Waste Performance Assessment*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, March 1998.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 2000, *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA-402-R-99-001, Federal Guidance Report Number 13, 1999, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, U.S. Environmental Protection Agency, Washington, D.C.

EPA-540/R-97/036, 1997, *Health Effects Assessment Summary Tables (HEAST) FY 1997 Update*, U.S. Environmental Protection Agency, Washington, D.C.

GJ-HAN-86, 1997, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-102*, U.S. Department of Energy, Grand Junction, Colorado.

GJ-HAN-87, 1997, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-104*, U.S. Department of Energy, Grand Junction, Colorado.

GJ-HAN-88, 1997, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-107*, U.S. Department of Energy, Grand Junction, Colorado.

GJ-HAN-90, 1997, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-108*, U.S. Department of Energy, Grand Junction, Colorado.

GJ-HAN-94, 1997, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-112*, U.S. Department of Energy, Grand Junction, Colorado.

GJO-98-39-TARA GJO-HAN-18, 2000, *Vadose Zone Characterization Project at the Hanford Tank Farms, Addendum to the C Tank Farm Report*, U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

GJPO-HAN-18, 1998, *Vadose Zone Characterization Project at the Hanford Tank Farms, C Tank Farm Report*, U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

H-2-71842, 1976, "Waste Tanks Typical Isolation Details Pipe End Seals & Blanks," Rev. 1, U.S. Atomic Energy Commission, Richland Operations Office, Richland, Washington.

H-2-73338, 1988, "Piping Waste Tank Isolation C-Tank Farm Plot Plan," Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

H-2-73342, 1988, "Piping Waste Tank Isolation TK 241-C-102," Rev. 4, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-2-73343, 1988, "Piping Waste Tank Isolation TK 241-C-103," Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

H-2-73344, 1983, "Piping Waste Tank Isolation TK 241-C-104," Rev. 2, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-2-73347, 1988, "Piping Waste Tank Isolation TK 241-C-107," Rev. 3, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-2-73348, 1986, "Piping Waste Tank Isolation TK 241-C-108," Rev. 2, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-2-73351, 1986, "Piping Waste Tank Isolation TK 241-C-112," Rev. 4, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-2-73450, 2002, "Piping Isolation Details Pipe & Riser Closures," Rev. 14, U.S. Department of Energy, Office of River Protection, Richland, Washington.

H-2-73453, 1977, "SRD Isolation Blank ASSY for PUREX/Hanford Nozzles," Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

H-2-73634, 1984, "Structural Waste Tank Isolation Sched Pit Weather Covers," Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

H-2-73877, 1983, "Valve Pit and Piping Details," Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

H-14-010613, 2003, "Waste Storage Tank (WST) Riser Data," Sheet 2, Rev. 6, CH2M HILL Hanford Group, Inc., Richland, Washington.

H-14-010613, 2003, "Waste Storage Tank (WST) Riser Data," Sheet 1, Rev. 11, CH2M HILL Hanford Group, Inc., Richland, Washington.

H-14-104175, 2004, "Waste Transfer Piping Diagram, 200 East Area," Rev. 23, U.S. Department of Energy, Office of River Protection, Richland, Washington.

HNF-EP-0182, 2003, *Waste Tank Summary Report for Month Ending April 30, 2004*, Rev. 193, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-EP-0182-104, 1996, *Waste Tank Summary Report for Month Ending November 30, 1996*, Lockheed Martin Hanford Corporation, Richland, Washington.

HNF-IP-0263-TF, 2004, *Building Emergency Plan for Tank Farms*, Rev. 11, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-IP-0842, 2003, *Air Quality Program-Nonradioactive Emissions*, Volume 6, Section 1.8, Rev. 0b, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-IP-1266, 2002, *Tank Farms Operations Administrative Controls*, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-AP-005, 1999, *SST Leak Emergency Pumping Guide*, Rev. 8, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-ER-541, 1997, *Tank Characterization Report for Single-Shell Tank 241-C-112*, Rev. 1, Lockheed Martin Hanford Company, Richland, Washington.

HNF-SD-WM-OCD-015, 2003, *Tank Farm Waste Transfer Compatibility Program*, Rev. 7, CH2M HILL Hanford Group, Inc., Richland, Washington.

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.

HNF-SD-WM-TSR-006, 2003, *Tank Farms Technical Safety Requirements*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

HW-72743, NA, "Vertical Safety Rod Time Study 100B & 100D & 100F Elec. Time Delay Neutron Flux Monitors," Rev. 0, General Electric, Co.

LA-UR-97-311, 1997, *Waste Status and Transaction Records Summary (WSTRS)*, Rev. 4, Los Alamos National Laboratory, Los Alamos, New Mexico.

OSD-T-151-00007, 2003, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. I-7, CH2M HILL Hanford Group, Inc., Richland, Washington.

OSD-T-151-00013, 2003, *Operating Specifications for Single-Shell Waste Storage Tanks*, Rev. E-6, CH2M HILL Hanford Group, Inc., Richland, Washington.

OSD-T-151-00031, 2003, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, Rev. F-3, CH2M HILL Hanford Group, Inc., Richland, Washington.

PNNL-13024, 2001, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington.

Non-Radioactive Air Emission Notice of Construction for Categorical Tank Farm Facility Waste Retrieval and Closure, Phase II, Waste Retrieval, approval pending.

Radioactive Air Emission Notice of Construction for Categorical Tank Farm Facility Waste Retrieval and Closure, Phase II, Waste Retrieval, approval pending.

Resource Conservation and Recovery Act of 1976, Public Law 94 580, 90 Stat. 2795, 42 USC 901 et seq.

RPP-7625, 2003, *Best Basis Inventory Process Requirements*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-9937, 2003, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-10413, 2003, *Tank S-112 Saltcake Waste Retrieval Demonstration Project Leak Detection, Monitoring, and Mitigation Strategy*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-10435, 2002, *Single-Shell Tank System Integrity Assessment Report*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-10901, 2004, *S-102 Initial Waste Retrieval Functions and Requirements*, Rev. 1C, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-12711, 2004, *Temporary Waste Transfer Line Management Program Plan*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13033, 2003, *Tank Farms Documented Safety Analysis*, as amended, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-14430, 2003, *Subsurface Conditions Description of the C and A-AX Waste Management Areas*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-16194, 2003, *241-C-104 Waste Retrieval Project, Evaluation of Alternatives for Preparing Tank C-104 Pits and Risers*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-16525, 2004, *C-200-Series Tanks Retrieval Functions and Requirements*, Rev. 6, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-17191, 2003, *Test Plan for SST Deployment Demonstration and Injection Leak Testing of the HRR Long Electrode LDM System*, Rev. 0., CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-18629, 2003, *Performance Evaluation for C-106, S-102/112 and C-200 Series Tank Retrieval Activities*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-18633, 2004, *Level 2 Specification for the C-100 Series Waste Retrieval System*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-21609, 2004, *Single-Shell Tank 241-C-102 Component Closure Activity Plan*, Draft, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2004, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21895, 2004, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2004, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ENG-CHEM-D-42, 2003, *Tank Leak Assessment Process*, Rev. A, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ENG-FACSUP-P-19, 2004, *Issuance of Tank Farm Equipment Identification Numbers*, Rev. A, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ESHQ-ENV_FS-C-01, 2004, *Environmental Notification*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ESHQ-ENV-STD-03, 2004, *Air-Quality Radioactive Emissions*, Rev. A, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-PLN-07, 2004, *Dangerous Waste Training Plan*, Rev. A-3, CH2M HILL Hanford Group, Inc., Richland, Washington.

TO-320-022, 2003, *Operate Model 503DR Hydroprobe Neutron Moisture Detection*, Rev. A-0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

WAC 173-400, "General Regulation for Air Pollution Sources," *Washington Administrative Code*, as amended.

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended.

WAC 246-247, "Radiation Air Emissions Program," *Washington Administrative Code*, as amended.

WHC-EP-0645, 1995, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington, June 1995.

WHC-EP-0875, 1996, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington, September 1996.

WHC-SD-WM-ER-313, 1994, *Historical Characterization*, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-ER-474, 1995, *Tank Characterization Report for Single-Shell Tank 241-C-107*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-TI-356, 1988, *Waste Storage Tank Status and Leak Detection Criteria*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

This page intentionally left blank.

APPENDIX A
TANK C-102 LONG-TERM HUMAN HEALTH RISK

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

This page intentionally left blank.

A1.0 TANK C-102 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-102. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section A2.0. Inadvertent intruder impacts are presented in Section A3.0.

A2.0 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 tank C-102. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan* (RPP-22392).

A2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures A.1 through A.3 provide the tank C-102 retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure A.1. Tank C-102 Technetium-99 Risk Plot

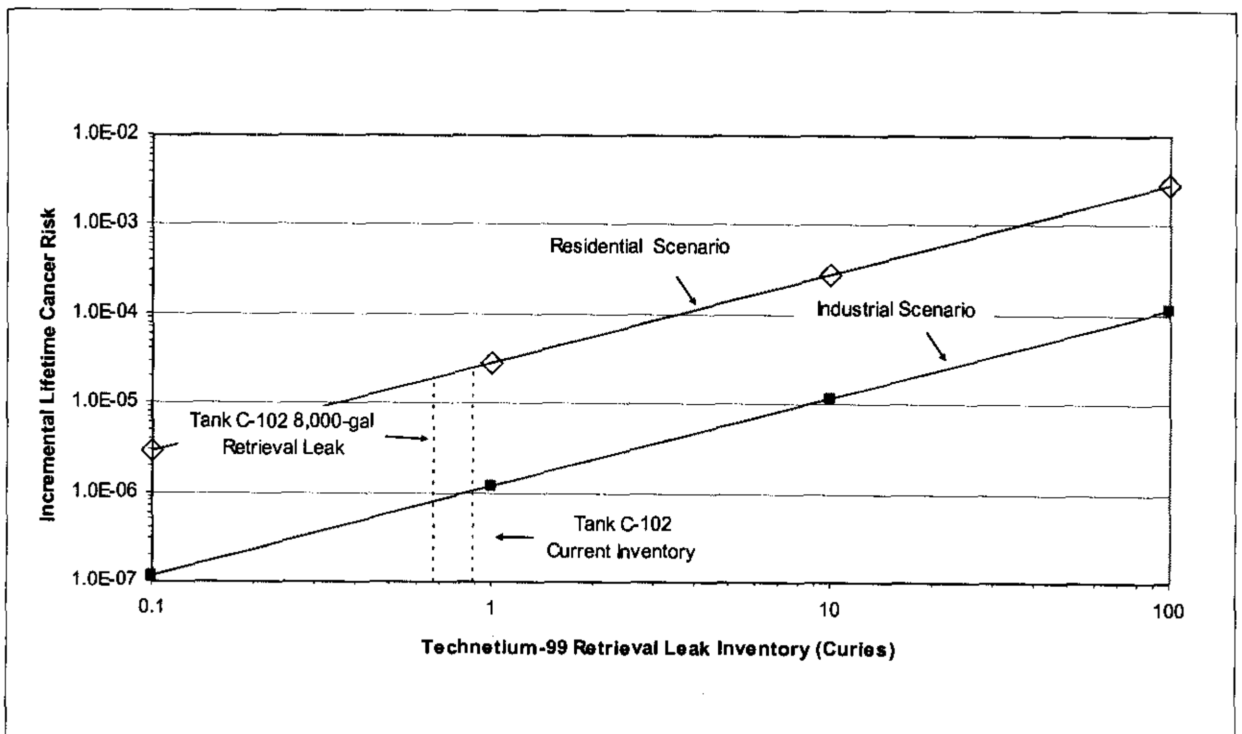


Figure A.2. Tank C-102 Hexavalent Chromium Hazard Index Plot

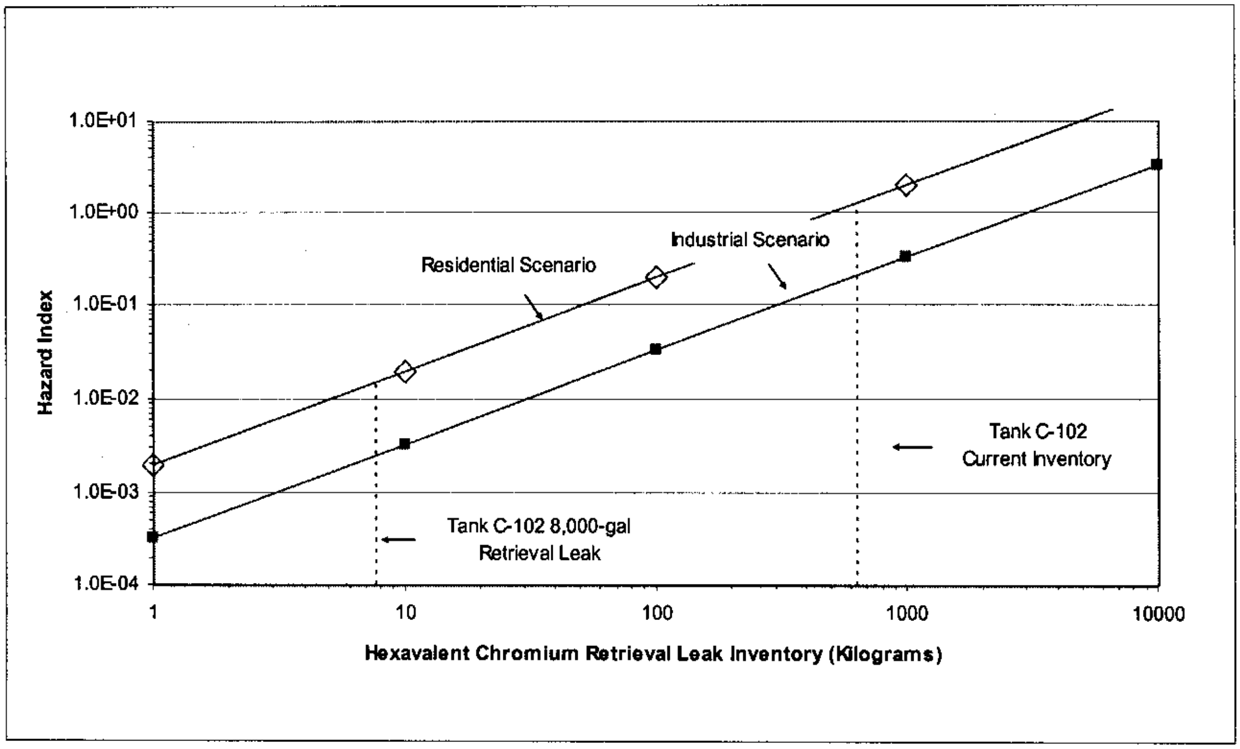


Figure A.3. Tank C-102 Nitrite Hazard Index Plot

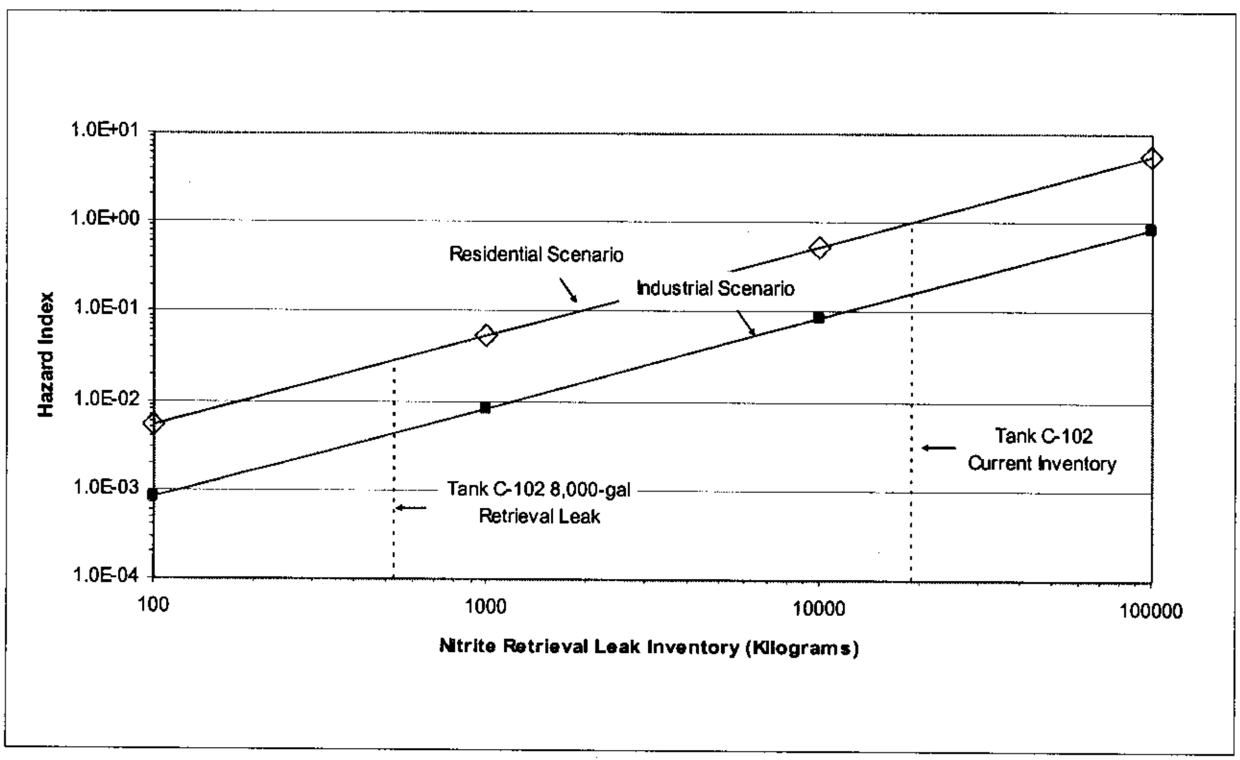


Figure A.1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-102 during retrieval. Figures A.2 and A.3 show the peak groundwater pathway hazard index (HI) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-102 during retrieval.

The ILCR and HI values shown on the graphs were based on the predicted peak groundwater concentrations at the 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 *Single-Shell Tank System Closure Plan* (RPP-13774). The graphs provide a retrieval leak risk picture for tank C-102 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 technetium-99, 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.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-102 inventory and the inventory associated with a potential 8,000 gallon 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 tank C-102.

In the event a leak is detected during 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 A.1 through A.3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gallon reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

A2.2 INVENTORY

The reference lines shown in Figures A.1 through A.3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the BBI by downloading from the TWINS database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gallons) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-102 by sluicing with recycled supernate from double-shell tank (DST) AN-101. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description* (RPP-21753).

The RPP-21753 flowsheet description provides calculated time phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a

retrieval sequence and includes DST to DST transfers necessary to maintain waste volume within overall DST space limits. The flowsheet also includes planned near term waste retrieval actions that would affect the tank inventory (e.g., C-200-series tanks waste retrieval).

The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-102 leak inventories for the tank AN-101 recycled supernate retrieval scenario are shown in Table A.1. The table also shows leak inventories for a raw water retrieval scenario.

Table A.1. Tank C-102 Retrieval Leak Inventory Comparison for Different Sluicing Fluids

Contaminant	Leak Fluid Concentration			Inventory in 8,000-Gallon Retrieval Leak		
	AN-101 Supernate[a]	Raw Water[b]	Units	AN-101 Supernate	Raw Water	Units
Technetium-99	2.25E-05	3.29E-07	Ci/L	6.80E-01	9.96E-03	Ci
Hexavalent Chromium	2.55E-04	1.83E-04	kg/L	7.73E+00	5.54E+00	kg
Nitrite	1.75E-02	4.20E-03	kg/L	5.29E+02	1.27E+02	kg

[a] Source: RPP-21753, Appendix D, Table D-1.
[b] Source: RPP-13774, Addendum C1, Table 9.

It is recognized that the retrieval sequence used in the flowsheet document may not match the current plan; however, the predicted concentrations are assumed to be representative of the predicted concentrations with minor changes in the retrieval sequence. The variation between the high and low concentrations is less than 82% for all indicator contaminants across all tanks.

Raw water retrieval leak inventories are given in Table A.1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gallon retrieval leak volume and retrieval leak fluid concentrations estimated using the HTWOS model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. The table indicates raw water leak inventories would be appreciably lower than the supernate leak inventories for technetium-99 and slightly lower for hexavalent chromium and nitrite.

A2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-102 was estimated to be approximately 0.7 curie. As shown in Figure A.1, this corresponds to an ILCR of approximately 8×10^{-7} for the industrial scenario and 2×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 57 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-102 was estimated to be approximately 8 kg. As shown in Figure A.2, this corresponds to a HI of approximately 0.003 for the industrial scenario and 0.02 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.0006 mg/L.

The nitrite inventory associated with an 8,000 gal retrieval leak from tank C-102 was estimated to be approximately 530 kg. As shown in Figure A.3, this corresponds to a HI of approximately 0.004 for the industrial scenario and 0.03 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.04 mg/L.

A2.4 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 8×10^{-7}. Using Equation 1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table A.1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7.2), and the technetium-99 industrial scenario unit risk factor (Table 7.3), as follows:

$$\text{ILCR} = (0.68\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 7.88 \times 10^{-7}$$

Complete calculation details are provided in RPP-22392.

A3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-102 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the HFFACO interim retrieval goal of 360 ft^3 (2,700 gal) of residual waste. These inventories were taken from *241-C Waste Management Area Inventory Data Package* (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 (RPP-22000). Inventories for the subset of BBI radionuclides that were shown in *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington* (DOE/ORP-2003-11) to dominate (contribute 98% of total) intruder doses at 500 years after closure are shown in Table A.2.

Table A.2. Tank C-102 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste*

Radionuclide	Units	Tank C-102
Strontium-90	Ci	5.06E+03
Tin-126	Ci	2.25E-04
Cesium-137	Ci	2.54E+02
Plutonium-239	Ci	2.88E+01
Plutonium-240	Ci	5.28E+00
Americium-241	Ci	9.87E+00

* Source: RPP-15317, Table 7-1.

Table A.3 summarizes the intruder analysis results for tank C-102. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22000. 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.

Table A.3. Tank C-102 Intruder Dose

Radionuclide	Well Driller (mrem EDE)	Suburban Resident (mrem/yr EDE)	Rural Farmer (mrem/yr EDE)
Strontium-90	0.000	0.004	0.000
Tin-126	0.000	0.000	0.000
Cesium-137	0.000	0.000	0.000
Plutonium-239	0.185	1.040	0.047
Plutonium-240	0.033	0.183	0.008
Americium-241	0.044	0.176	0.009
Other Radionuclides	0.007	0.032	0.002
TOTAL	0.269	1.435	0.065

Note: The number of significant digits shown in Table A.3 is not intended to imply a level of accuracy greater than the input values.

The dose values in Table A.3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table A.3 indicates that tank C-102 would not exceed the performance objectives of 500 mrem EDE for acute exposure and 100 mrem/yr EDE for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by plutonium-239, plutonium-240, and americium-241.

A4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2004, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2004, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

This page intentionally left blank.

APPENDIX B
TANK C-104 LONG-TERM HUMAN HEALTH RISK

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

This page intentionally left blank.

B1.0 TANK C-104 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-104. The information presented was developed using the methodology described in Section 7.0. 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 tank C-104. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan* (RPP-22392).

B2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures B.1 through B.3 provide the tank C-104 retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure B.1. Tank C-104 Technetium-99 Risk Plot

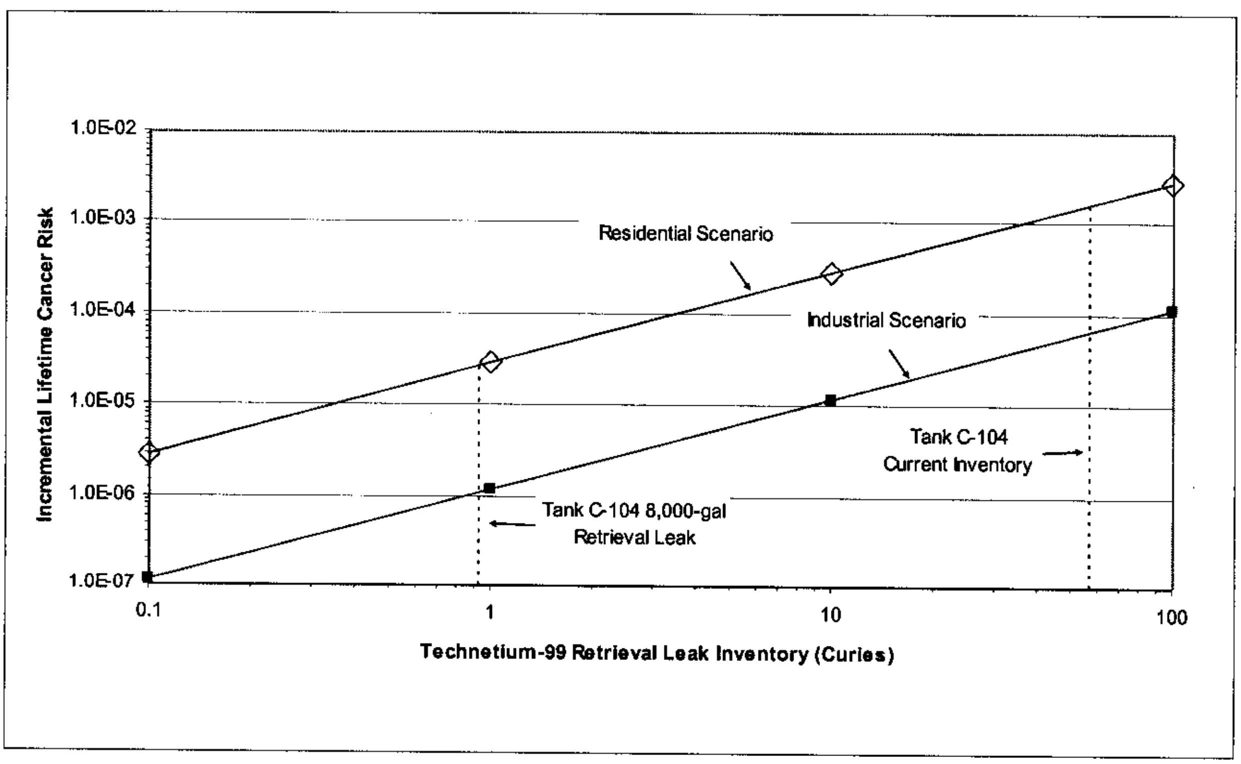


Figure B.2. Tank C-104 Hexavalent Chromium Hazard Index Plot

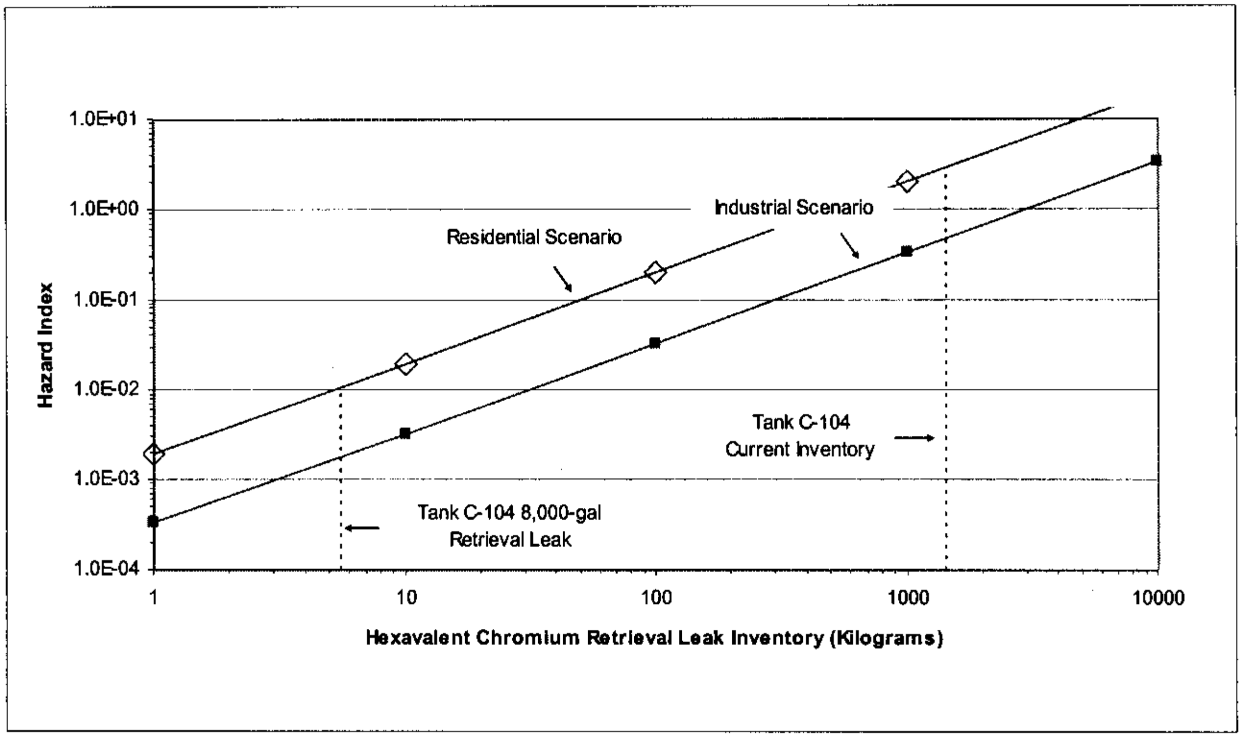


Figure B.3. Tank C-104 Nitrite Hazard Index Plot

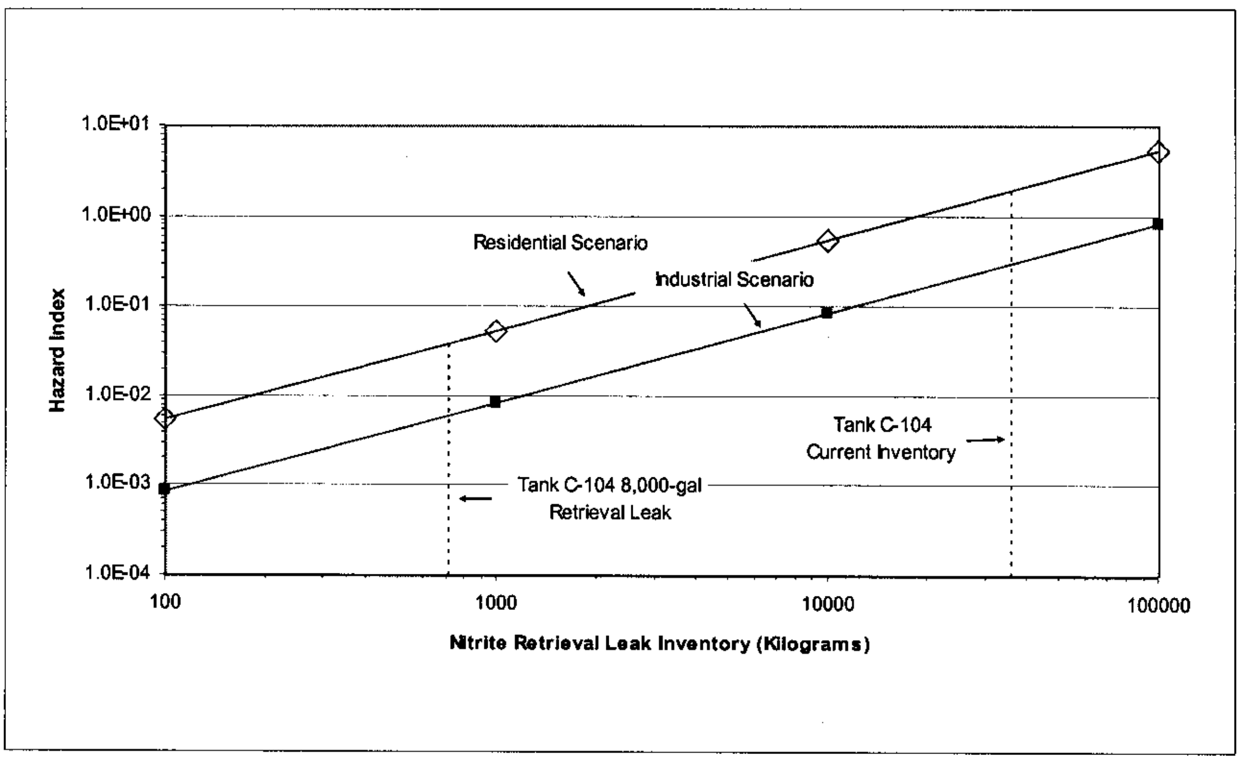


Figure B.1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-104 during retrieval. Figures B.2 and B.3 show the peak groundwater pathway hazard index (HI) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-104 during retrieval.

The ILCR and HI values shown on the graphs were based on the predicted peak groundwater concentrations at the 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 *Single-Shell Tank System Closure Plan* (RPP-13774). The graphs provide a retrieval leak risk picture for tank C-104 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 technetium-99, 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.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-104 inventory and the inventory associated with a potential 8,000 gallon 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 tank C-104.

In the event a leak is detected during 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-gallon 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 BBI by downloading from the TWINS database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gallons) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-104 by sluicing with recycled supernate from double-shell tank (DST) AY-101. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description* (RPP-21753).

The RPP-21753 flowsheet description provides calculated time phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a

retrieval sequence and includes DST to DST transfers necessary to maintain waste volume within overall DST space limits. The flowsheet also includes planned near term waste retrieval actions that would affect the tank inventory (e.g., C-200-series tanks waste retrieval).

The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-104 leak inventories for the tank AY-101 recycled supernate retrieval scenario are shown in Table B.1. The table also shows leak inventories for a raw water retrieval scenario.

Table B.1. Tank C-104 Retrieval Leak Inventory Comparison for Different Sluicing Fluids

Contaminant	Leak Fluid Concentration			Inventory in 8,000-Gallon Retrieval Leak		
	AY-101 Supernate[a]	Raw Water[b]	Units	AY-101 Supernate	Raw Water	Units
Technetium-99	3.06E-05	1.92E-05	Ci/L	9.28E-01	5.81E-01	Ci
Hexavalent Chromium	1.88E-04	4.84E-04	kg/L	5.63E+00	1.47E+01	kg
Nitrite	2.38E-02	1.21E-03	kg/L	7.22E+02	3.66E+02	kg

[a] Source: RPP-21753, Appendix D, Table D-1.
[b] Source: RPP-13774, Addendum C1, Table 9.

It is recognized that the retrieval sequence used in the flowsheet document may not match the current plan; however, the predicted concentrations are assumed to be representative of the predicted concentrations with minor changes in the retrieval sequence. The variation between the high and low concentrations is less than 82% for all indicator contaminants across all tanks.

Raw water retrieval leak inventories are given in Table B.1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gallon retrieval leak volume and retrieval leak fluid concentrations estimated using the HTWOS model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. The table indicates raw water leak inventories would be slightly lower than the supernate leak inventories for technetium-99 and nitrite and slightly higher for hexavalent chromium.

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

The technetium-99 inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-104 was estimated to be approximately 0.9 curie. As shown in Figure B.1, this corresponds to an ILCR of approximately 1×10^{-6} for the industrial scenario and 3×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 78 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-104 was estimated to be approximately 6 kg. As shown in Figure B.2, this corresponds to a HI of approximately 0.002 for the industrial scenario and 0.01 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.0005 mg/L.

The nitrite inventory associated with an 8,000 gal retrieval leak from tank C-104 was estimated to be approximately 720 kg. As shown in Figure B.3, this corresponds to a HI of approximately 0.006 for the industrial scenario and 0.04 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.06 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 1×10^{-6}. Using Equation 1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table B.1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7.2), and the technetium-99 industrial scenario unit risk factor (Table 7.3), as follows:

$$\text{ILCR} = (0.928\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.08 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

B3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-104 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the HFFACO interim retrieval goal of 360 ft^3 (2,700 gal) of residual waste. These inventories were taken from *241-C Waste Management Area Inventory Data Package* (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 (RPP-22000). Inventories for the subset of BBI radionuclides that were shown in *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington* (DOE/ORP-2003-11) to dominate (contribute 91% of total) intruder doses at 500 years after closure are shown in Table B.2.

Table B.2. Tank C-104 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste*

Radionuclide	Units	Tank C-104
Strontium-90	Ci	5.04E+03
Tin-126	Ci	1.79E-02
Cesium-137	Ci	9.93E+02
Plutonium-239	Ci	5.69E+01
Plutonium-240	Ci	1.12E+01
Americium-241	Ci	6.60E+01

* Source: RPP-15317, Table 7-1.

Table B.3 summarizes the intruder analysis results for tank C-104. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22000. 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.

Table B.3. Tank C-104 Intruder Dose

Radionuclide	Well Driller (mrem EDE)	Suburban Resident (mrem/yr EDE)	Rural Farmer (mrem/yr EDE)
Strontium-90	0.000	0.004	0.000
Tin-126	0.009	0.009	0.001
Cesium-137	0.001	0.001	0.000
Plutonium-239	0.365	2.054	0.092
Plutonium-240	0.069	0.389	0.018
Americium-241	0.291	1.171	0.057
Other Radionuclides	0.079	0.366	0.017
TOTAL	0.814	3.994	0.185

Note: The number of significant digits shown in Table B.3 is not intended to imply a level of accuracy greater than the input values.

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 tank C-104 would not exceed the performance objectives of 500 mrem EDE for acute exposure and 100 mrem/yr EDE for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by plutonium-239, plutonium-240, and americium-241.

B4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2004, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2004, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

This page intentionally left blank.

APPENDIX C
TANK C-107 LONG-TERM HUMAN HEALTH RISK

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

This page intentionally left blank.

C1.0 TANK C-107 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-107. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section C2.0. Inadvertent intruder impacts are presented in Section C3.0.

C2.0 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 tank C-107. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan* (RPP-22392).

C2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures C.1 through C.3 provide the tank C-107 retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure C.1. Tank C-107 Technetium-99 Risk Plot

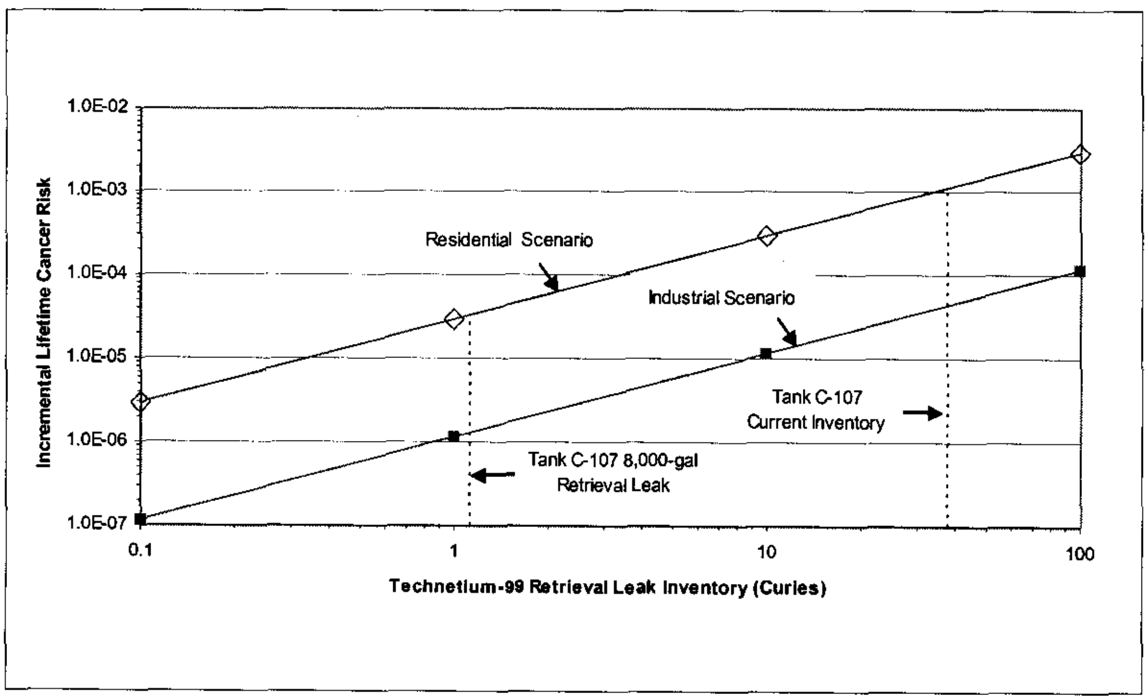


Figure C.2. Tank C-107 Hexavalent Chromium Hazard Index Plot

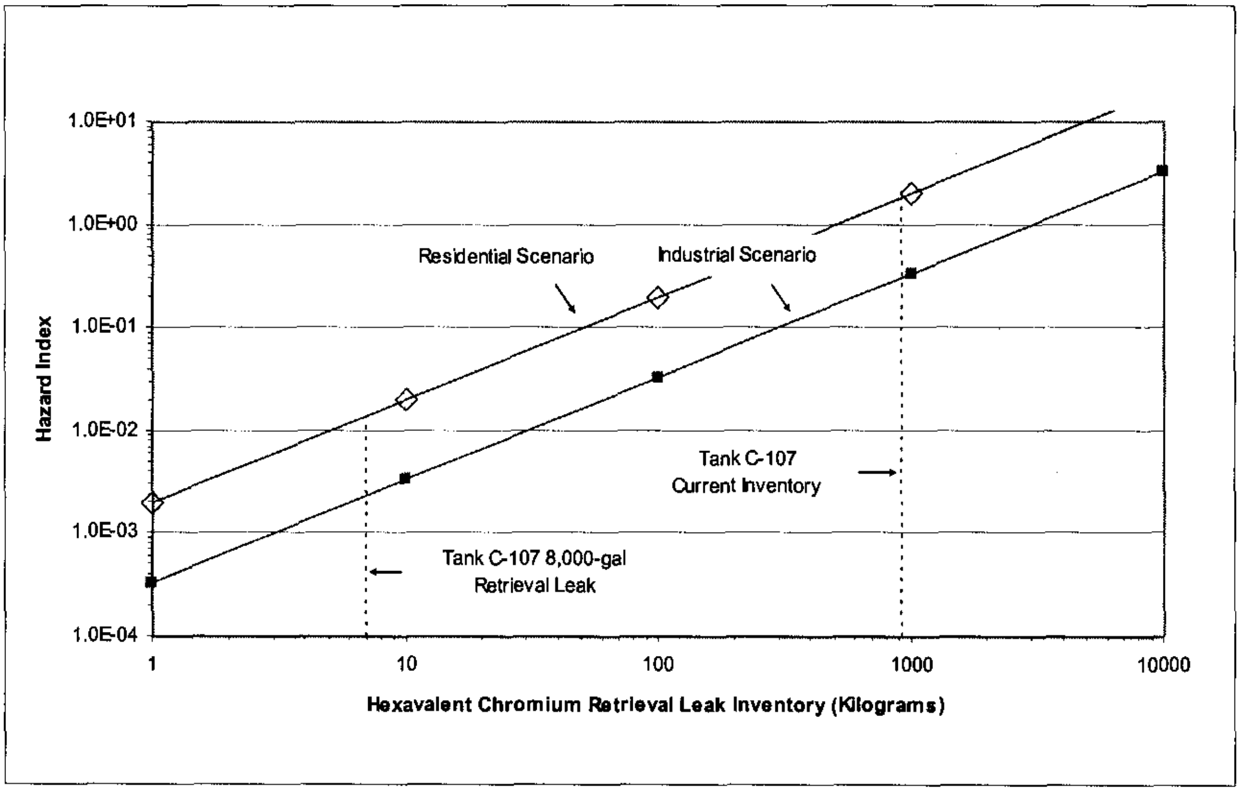


Figure C.3. Tank C-107 Nitrite Hazard Index Plot

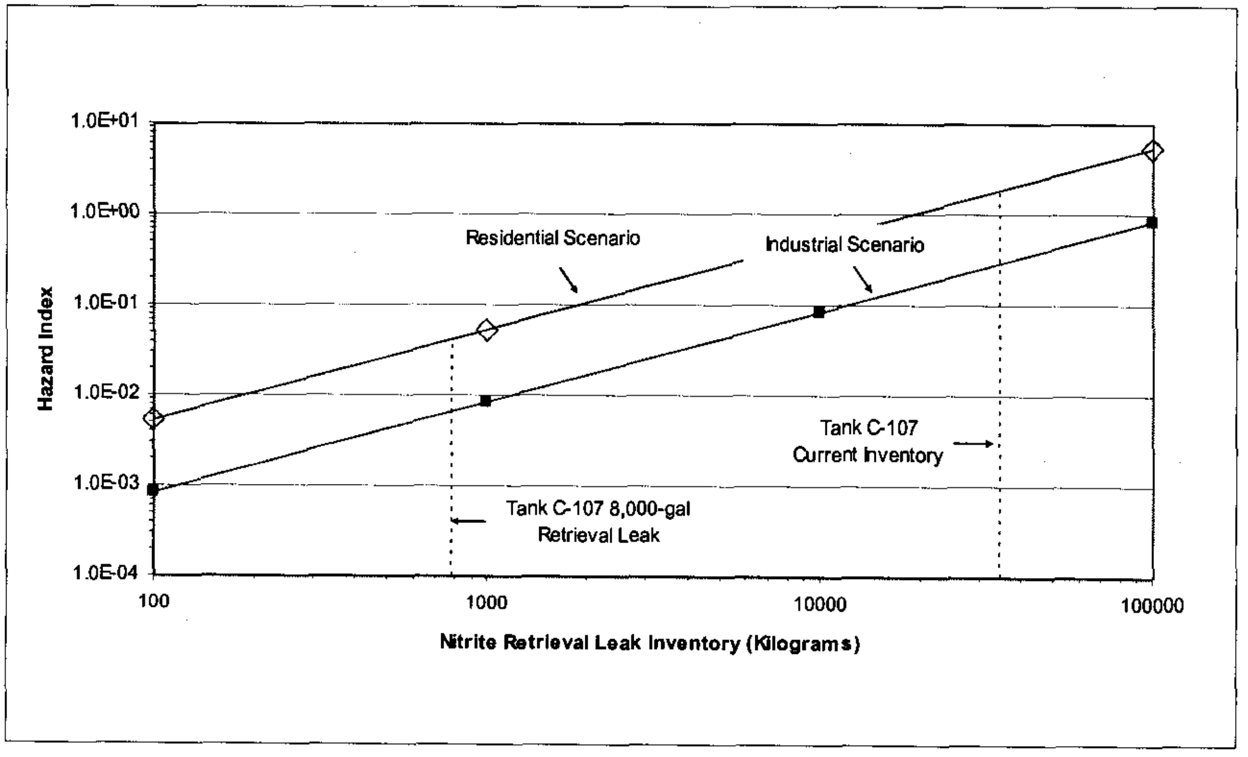


Figure C.1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-107 during retrieval. Figures C.2 and C.3 show the peak groundwater pathway hazard index (HI) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-107 during retrieval.

The ILCR and HI values shown on the graphs were based on the predicted peak groundwater concentrations at the 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 *Single-Shell Tank System Closure Plan* (RPP-13774). The graphs provide a retrieval leak risk picture for tank C-107 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 technetium-99, 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.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-107 inventory and the inventory associated with a potential 8,000 gallon 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 tank C-107.

In the event a leak is detected during 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 C.1 through C.3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gallon reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

C2.2 INVENTORY

The reference lines shown in Figures C.1 through C.3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the BBI by downloading from the TWINS database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gallons) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-107 by sluicing with recycled supernate from double-shell tank (DST) AN-106. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description* (RPP-21753).

The RPP-21753 flowsheet description provides calculated time phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a

retrieval sequence and includes DST to DST transfers necessary to maintain waste volume within overall DST space limits. The flowsheet also includes planned near term waste retrieval actions that would affect the tank inventory (e.g., C-200-series tanks waste retrieval).

The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-107 leak inventories for the tank AN-106 recycled supernate retrieval scenario are shown in Table C.1. The table also shows leak inventories for a raw water retrieval scenario.

Table C.1. Tank C-107 Retrieval Leak Inventory Comparison for Different Sluicing Fluids

Contaminant	Leak Fluid Concentration			Inventory in 8,000-Gallon Retrieval Leak		
	AN-106 Supernate[a]	Raw Water[b]	Units	AN-106 Supernate	Raw Water	Units
Technetium-99	3.71E-05	1.75E-05	Ci/L	1.12E+00	5.30E-01	Ci
Hexavalent Chromium	2.31E-04	4.29E-04	kg/L	7.00E+00	1.30E+01	kg
Nitrite	2.59E-02	1.63E-03	kg/L	7.83E+02	4.94E+02	kg

[a] Source: RPP-21753, Appendix D, Table D-1.
[b] Source: RPP-13774, Addendum C1, Table 9.

It is recognized that the retrieval sequence used in the flowsheet document may not match the current plan; however, the predicted concentrations are assumed to be representative of the predicted concentrations with minor changes in the retrieval sequence. The variation between the high and low concentrations is less than 82% for all indicator contaminants across all tanks.

Raw water retrieval leak inventories are given in Table C.1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gallon retrieval leak volume and retrieval leak fluid concentrations estimated using the HTWOS model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. The table indicates raw water leak inventories would be slightly lower than the supernate leak inventories for technetium-99 and nitrite and slightly higher for hexavalent chromium.

C2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-107 was estimated to be approximately 1 curie. As shown in Figure C.1, this corresponds to an ILCR of approximately 1×10^{-6} for the industrial scenario and 3×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 94 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-107 was estimated to be approximately 7 kg. As shown in Figure C.2, this corresponds to a HI of approximately 0.002 for the industrial scenario and 0.01 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.0006 mg/L.

The nitrite inventory associated with an 8,000 gal retrieval leak from tank C-107 was estimated to be approximately 780 kg. As shown in Figure C.3, this corresponds to a HI of approximately 0.006 for the industrial scenario and 0.04 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.07 mg/L.

C2.4 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 1×10^{-6}. Using Equation 1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table C.1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7.2), and the technetium-99 industrial scenario unit risk factor (Table 7.3), as follows:

$$\text{ILCR} = (1.12\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.30 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

C3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-107 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the HFFACO interim retrieval goal of 360 ft^3 (2,700 gal) of residual waste. These inventories were taken from *241-C Waste Management Area Inventory Data Package* (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 (RPP-22000). Inventories for the subset of BBI radionuclides that were shown in *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington* (DOE/ORP-2003-11) to dominate (contribute 100% of total) intruder doses at 500 years after closure are shown in Table C.2.

Table C.2. Tank C-107 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste*

Radionuclide	Units	Tank C-107
Strontium-90	Ci	2.43E+04
Tin-126	Ci	6.91E-01
Cesium-137	Ci	6.89E+02
Plutonium-239	Ci	2.34E+01
Plutonium-240	Ci	4.27E+00
Americium-241	Ci	7.32E+01

* Source: RPP-15317, Table 7-1.

Table C.3 summarizes the intruder analysis results for tank C-107. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22000. 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.

Table C.3. Tank C-107 Intruder Dose

Radionuclide	Well Driller (mrem EDE)	Suburban Resident (mrem/yr EDE)	Rural Farmer (mrem/yr EDE)
Strontium-90	0.000	0.020	0.001
Tin-126	0.359	0.348	0.036
Cesium-137	0.001	0.001	0.000
Plutonium-239	0.150	0.845	0.038
Plutonium-240	0.026	0.148	0.007
Americium-241	0.323	1.302	0.063
Other Radionuclides	0.001	0.016	0.001
TOTAL	0.860	2.680	0.146

Note: The number of significant digits shown in Table C.3 is not intended to imply a level of accuracy greater than the input values.

The dose values in Table C.3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table C.3 indicates that tank C-107 would not exceed the performance objectives of 500 mrem EDE for acute exposure and 100 mrem/yr EDE for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by tin-126, plutonium-239, and americium-241.

C4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2004, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2004, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

This page intentionally left blank.

APPENDIX D
TANK C-108 LONG-TERM HUMAN HEALTH RISK

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

This page intentionally left blank.

D1.0 TANK C-108 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-108. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section D2.0. Inadvertent intruder impacts are presented in Section D3.0.

D2.0 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 tank C-108. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan* (RPP-22392).

D2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures D.1 through D.3 provide the tank C-108 retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure D.1. Tank C-108 Technetium-99 Risk Plot

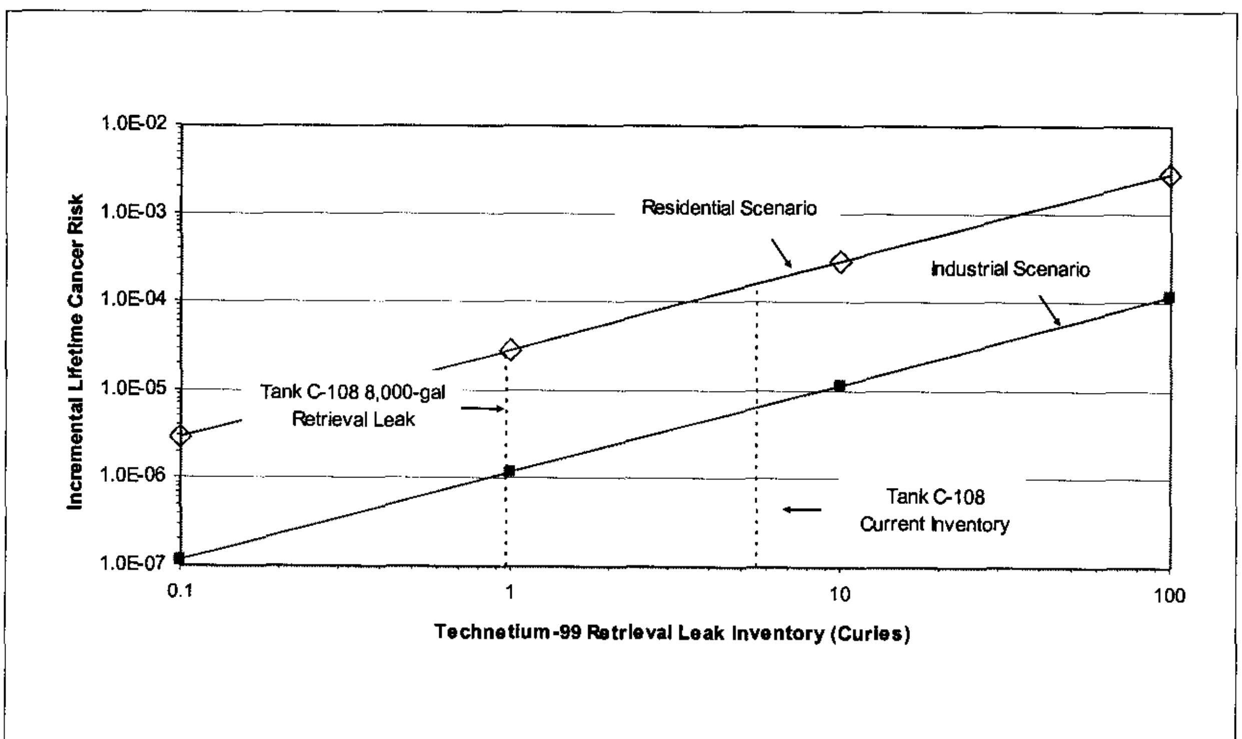


Figure D.2. Tank C-108 Hexavalent Chromium Hazard Index Plot

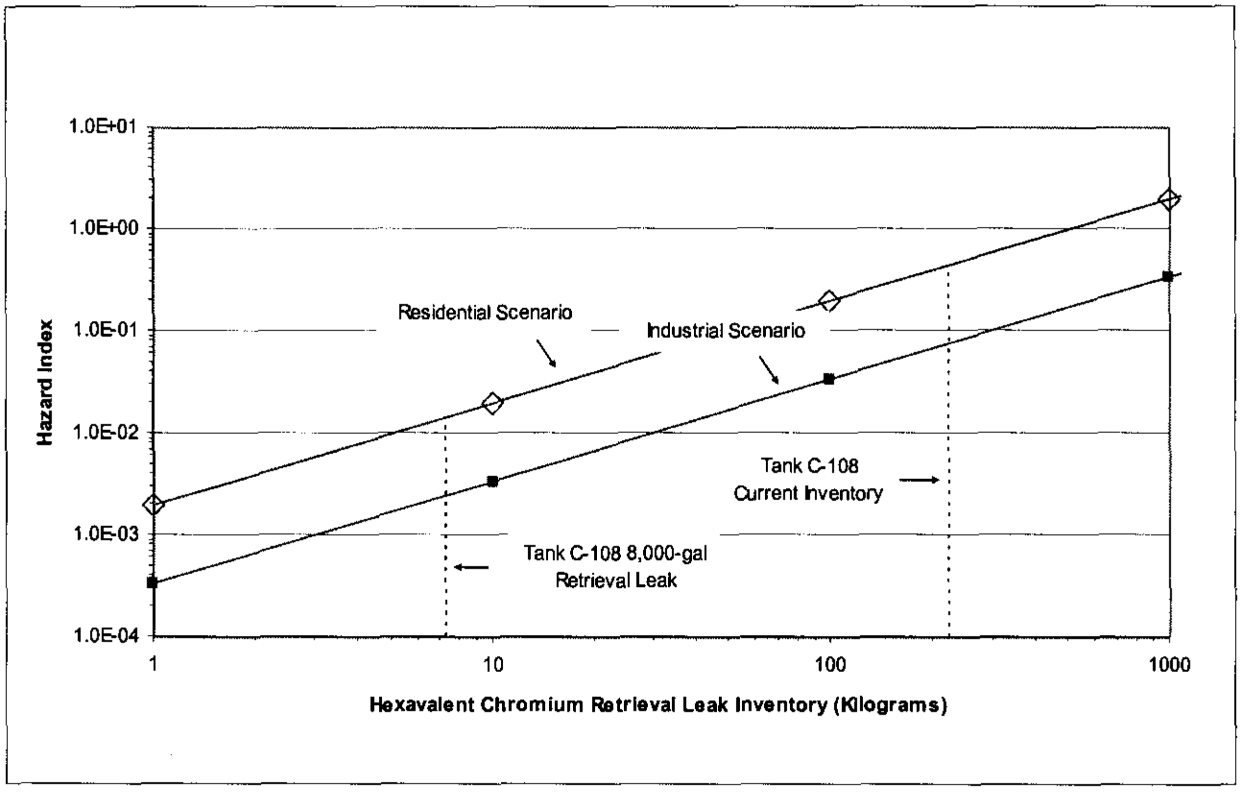


Figure D.3. Tank C-108 Nitrite Hazard Index Plot

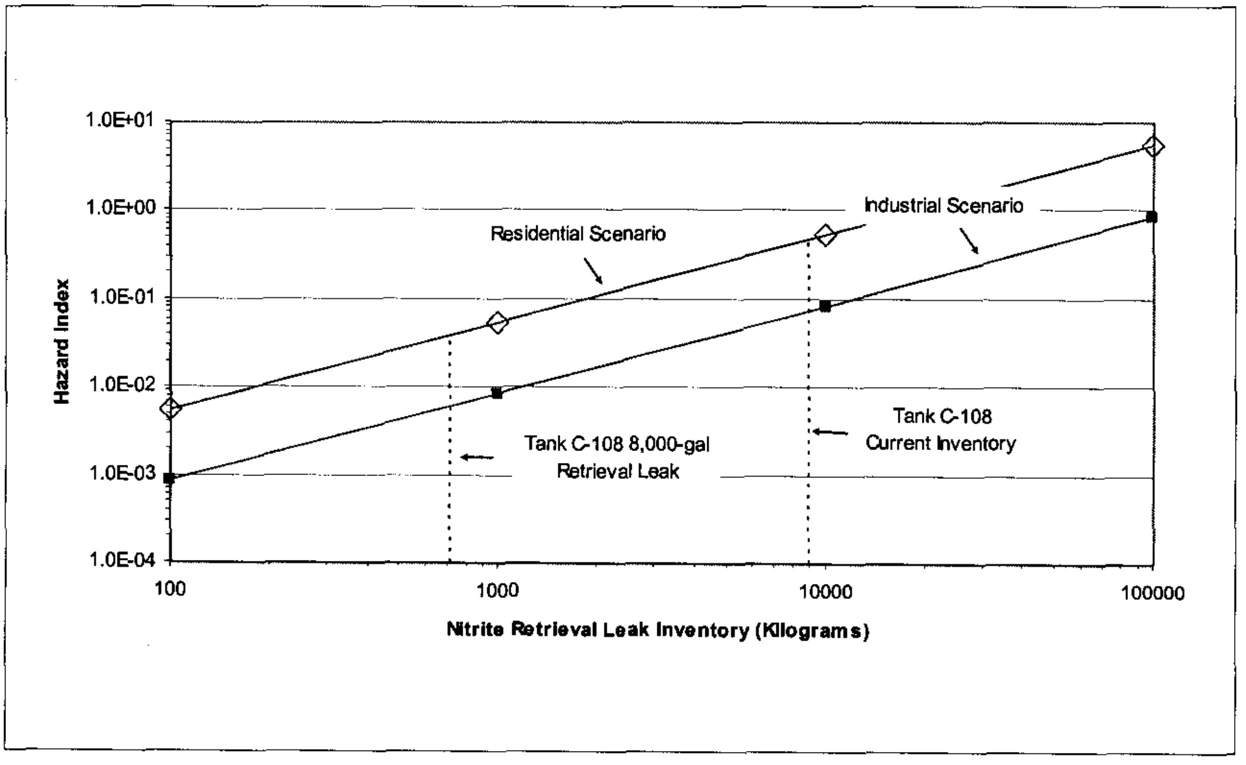


Figure D.1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-108 during retrieval. Figures D.2 and D.3 show the peak groundwater pathway hazard index (HI) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-108 during retrieval.

The ILCR and HI values shown on the graphs were based on the predicted peak groundwater concentrations at the 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 *Single-Shell Tank System Closure Plan* (RPP-13774). The graphs provide a retrieval leak risk picture for tank C-108 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 technetium-99, 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.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-108 inventory and the inventory associated with a potential 8,000 gallon 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 tank C-108.

In the event a leak is detected during 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 D.1 through D.3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gallon reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

D2.2 INVENTORY

The reference lines shown in Figures D.1 through D.3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the BBI by downloading from the TWINS database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gallons) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-108 by sluicing with recycled supernate from double-shell tank (DST) AN-106. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description* (RPP-21753).

The RPP-21753 flowsheet description provides calculated time phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a

retrieval sequence and includes DST to DST transfers necessary to maintain waste volume within overall DST space limits. The flowsheet also includes planned near term waste retrieval actions that would affect the tank inventory (e.g., C-200-series tanks waste retrieval).

The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-108 leak inventories for the tank AN-106 recycled supernate retrieval scenario are shown in Table D.1. The table also shows leak inventories for a raw water retrieval scenario.

Table D.1. Tank C-108 Retrieval Leak Inventory Comparison for Different Sluicing Fluids

Contaminant	Leak Fluid Concentration			Inventory in 8,000-Gallon Retrieval Leak		
	AN-106 Supernate[a]	Raw Water[b]	Units	AN-106 Supernate	Raw Water	Units
Technetium-99	3.22E-05	6.64E-06	Ci/L	9.75E-01	2.01E-01	Ci
Hexavalent Chromium	2.41E-04	2.49E-04	kg/L	7.30E+00	7.54E+00	kg
Nitrite	2.37E-02	9.38E-03	kg/L	7.18E+02	2.84E+02	kg

[a] Source: RPP-21753, Appendix D, Table D-1.
[b] Source: RPP-13774, Addendum C1, Table 9.

It is recognized that the retrieval sequence used in the flowsheet document may not match the current plan; however, the predicted concentrations are assumed to be representative of the predicted concentrations with minor changes in the retrieval sequence. The variation between the high and low concentrations is less than 82% for all indicator contaminants across all tanks.

Raw water retrieval leak inventories are given in Table D.1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gallon retrieval leak volume and retrieval leak fluid concentrations estimated using the HTWOS model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. The table indicates raw water leak inventories would be slightly lower than the supernate leak inventories for technetium-99 and nitrite and slightly higher for hexavalent chromium.

D2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-108 was estimated to be approximately 1 curie. As shown in Figure D.1, this corresponds to an ILCR of approximately 1×10^{-6} for the industrial scenario and 3×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 82 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-108 was estimated to be approximately 7 kg. As shown in Figure D.2, this corresponds to a HI of approximately 0.002 for the industrial scenario and 0.01 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.0006 mg/L.

The nitrite inventory associated with an 8,000 gal retrieval leak from tank C-108 was estimated to be approximately 720 kg. As shown in Figure D.3, this corresponds to a HI of approximately 0.006 for the industrial scenario and 0.04 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.06 mg/L.

D2.4 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 1×10^{-6}. Using Equation 1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table D.1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7.2), and the technetium-99 industrial scenario unit risk factor (Table 7.3), as follows:

$$\text{ILCR} = (0.975\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.13 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

D3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-108 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the HFFACO interim retrieval goal of 360 ft^3 (2,700 gal) of residual waste. These inventories were taken from *241-C Waste Management Area Inventory Data Package* (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 (RPP-22000). Inventories for the subset of BBI radionuclides that were shown in *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington* (DOE/ORP-2003-11) to dominate (contribute 68% of total) intruder doses at 500 years after closure are shown in Table D.2.

Table D.2. Tank C-108 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste*

Radionuclide	Units	Tank C-108
Strontium-90	Ci	3.44E+02
Tin-126	Ci	5.22E-04
Cesium-137	Ci	3.33E+03
Plutonium-239	Ci	1.30E-01
Plutonium-240	Ci	8.40E-03
Americium-241	Ci	2.68E-01

* Source: RPP-15317, Table 7-1.

Table D.3 summarizes the intruder analysis results for tank C-108. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22000. 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.

Table D.3. Tank C-108 Intruder Dose

Radionuclide	Well Driller (mrem EDE)	Suburban Resident (mrem/yr EDE)	Rural Farmer (mrem/yr EDE)
Strontium-90	0.000	0.000	0.000
Tin-126	0.000	0.000	0.000
Cesium-137	0.005	0.005	0.001
Plutonium-239	0.001	0.005	0.000
Plutonium-240	0.000	0.000	0.000
Americium-241	0.001	0.005	0.000
Other Radionuclides	0.000	0.007	0.000
TOTAL	0.007	0.022	0.001

Note: The number of significant digits shown in Table D.3 is not intended to imply a level of accuracy greater than the input values.

The dose values in Table D.3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table D.3 indicates that tank C-108 would not exceed the performance objectives of 500 mrem EDE for acute exposure and 100 mrem/yr EDE for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by cesium-137, plutonium-239, and americium-241.

D4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2004, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2004, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

This page intentionally left blank.

APPENDIX E
TANK C-112 LONG-TERM HUMAN HEALTH RISK

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

This page intentionally left blank.

E1.0 TANK C-112 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-112. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section E2.0. Inadvertent intruder impacts are presented in Section E3.0.

E2.0 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 tank C-112. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan* (RPP-22392).

E2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures E.1 through E.3 provide the tank C-112 retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure E.1. Tank C-112 Technetium-99 Risk Plot

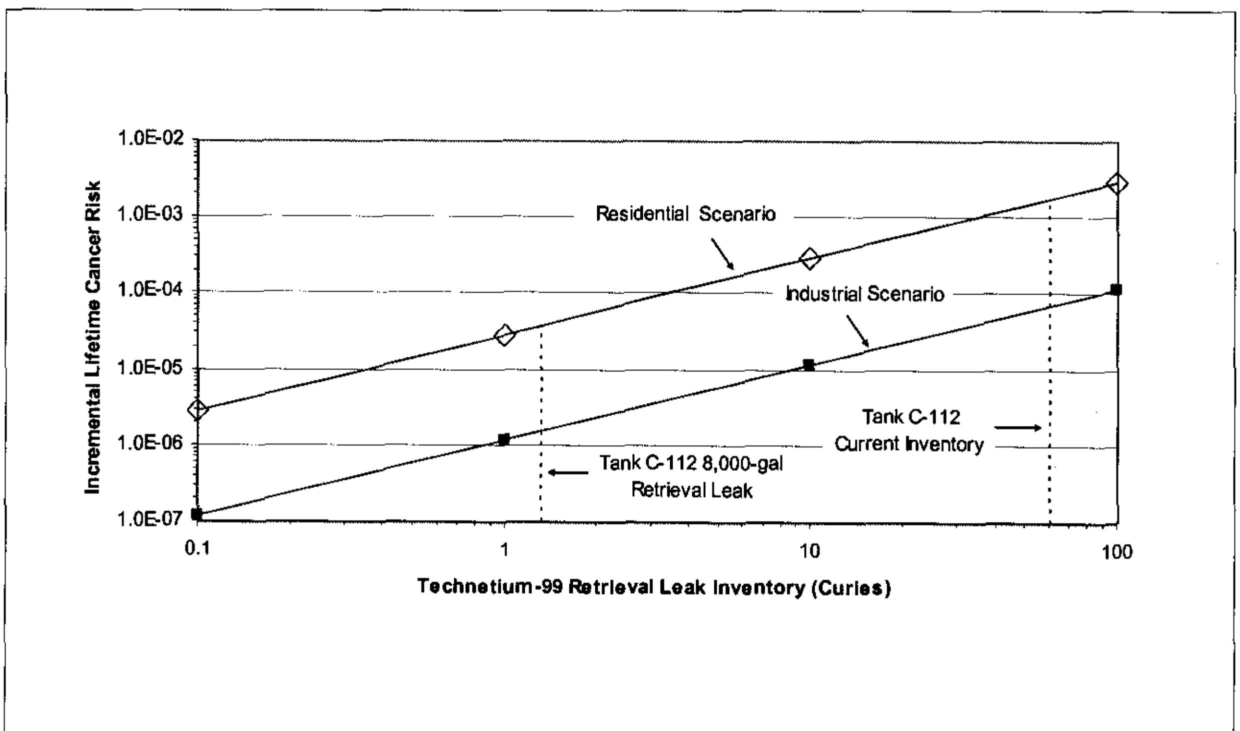


Figure E.2. Tank C-112 Hexavalent Chromium Hazard Index Plot

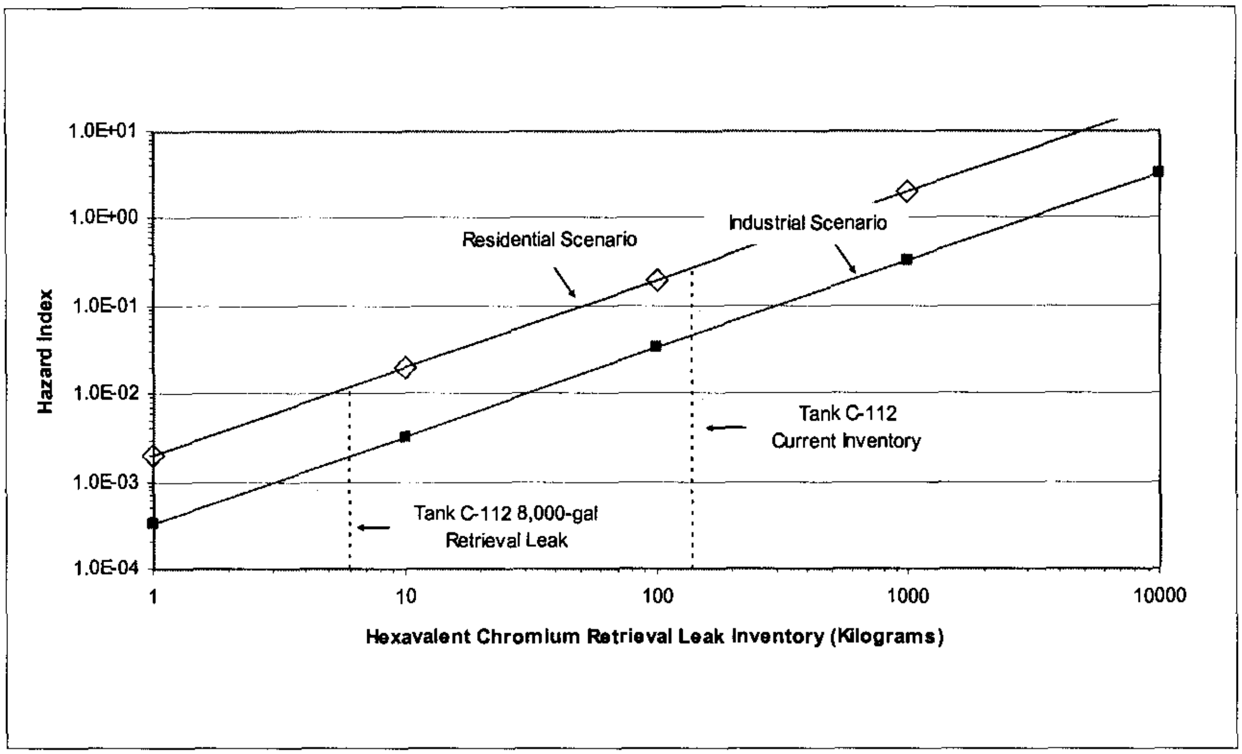


Figure E.3. Tank C-112 Nitrite Hazard Index Plot

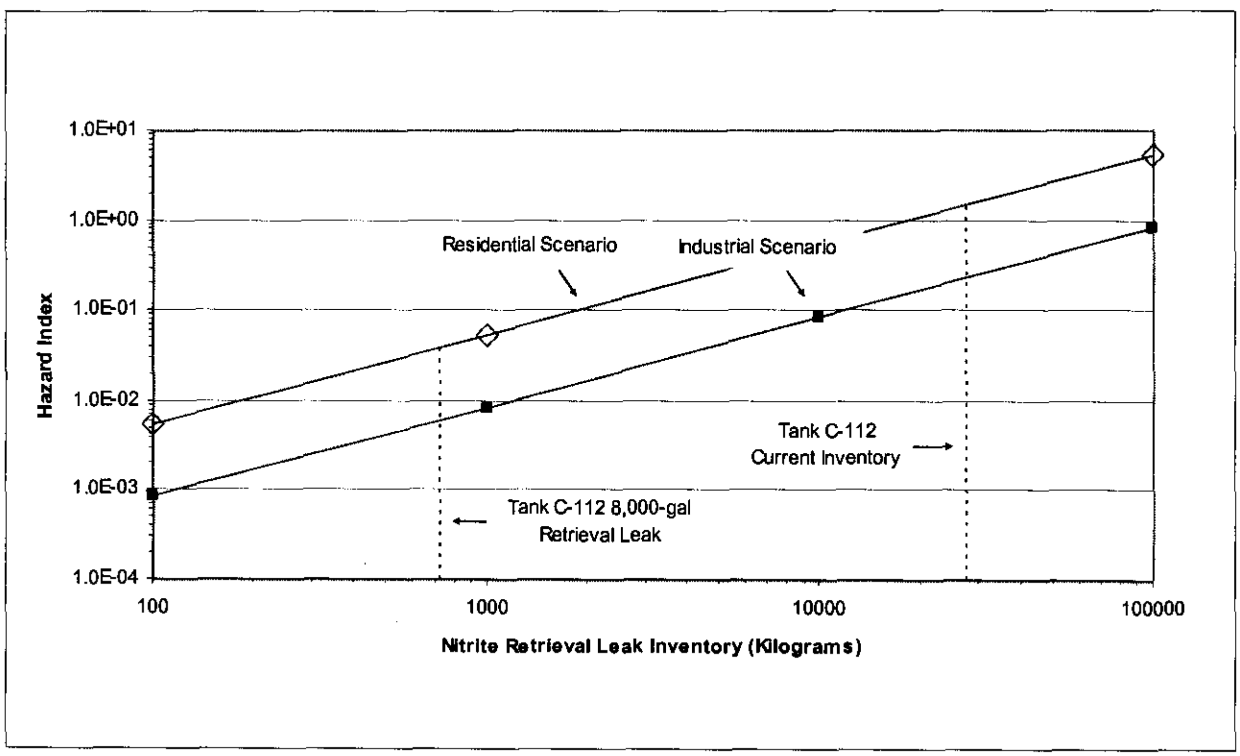


Figure E.1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-112 during retrieval. Figures E.2 and E.3 show the peak groundwater pathway hazard index (HI) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-112 during retrieval.

The ILCR and HI values shown on the graphs were based on the predicted peak groundwater concentrations at the 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 *Single-Shell Tank System Closure Plan* (RPP-13774). The graphs provide a retrieval leak risk picture for tank C-112 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 technetium-99, 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.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-112 inventory and the inventory associated with a potential 8,000 gallon 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 tank C-112.

In the event a leak is detected during 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 E.1 through E.3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gallon reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

E2.2 INVENTORY

The reference lines shown in Figures E.1 through E.3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the BBI by downloading from the TWINS database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gallons) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-112 by sluicing with recycled supernate from double-shell tank (DST) AN-106. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description* (RPP-21753).

The RPP-21753 flowsheet description provides calculated time phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a

retrieval sequence and includes DST to DST transfers necessary to maintain waste volume within overall DST space limits. The flowsheet also includes planned near term waste retrieval actions that would affect the tank inventory (e.g., C-200-series tanks waste retrieval).

The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-112 leak inventories for the tank AN-106 recycled supernate retrieval scenario are shown in Table E.1. The table also shows leak inventories for a raw water retrieval scenario.

Table E.1. Tank C-112 Retrieval Leak Inventory Comparison for Different Sluicing Fluids

Contaminant	Leak Fluid Concentration			Inventory in 8,000-Gallon Retrieval Leak		
	AN-106 Supernate[a]	Raw Water[b]	Units	AN-106 Supernate	Raw Water	Units
Technetium-99	4.38E-05	4.24E-05	Ci/L	1.33E+00	1.28E+00	Ci
Hexavalent Chromium	2.00E-04	9.67E-05	kg/L	6.05E+00	2.93E+00	kg
Nitrite	2.41E-02	1.93E-02	kg/L	7.31E+02	5.84E+02	kg

[a] Source: RPP-21753, Appendix D, Table D-1.
[b] Source: RPP-13774, Addendum C1, Table 9.

It is recognized that the retrieval sequence used in the flowsheet document may not match the current plan; however, the predicted concentrations are assumed to be representative of the predicted concentrations with minor changes in the retrieval sequence. The variation between the high and low concentrations is less than 82% for all indicator contaminants across all tanks.

Raw water retrieval leak inventories are given in Table E.1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gallon retrieval leak volume and retrieval leak fluid concentrations estimated using the HTWOS model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. The table indicates raw water leak inventories would be slightly lower than the supernate leak inventories.

E2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-112 was estimated to be approximately 1 curie. As shown in Figure E.1, this corresponds to an ILCR of approximately 1×10^{-6} for the industrial scenario and 4×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 110 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal retrieval leak from tank C-112 was estimated to be approximately 6 kg. As shown in Figure E.2, this corresponds to a HI of approximately 0.002 for the industrial scenario and 0.01 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.0005 mg/L.

The nitrite inventory associated with an 8,000 gal retrieval leak from tank C-112 was estimated to be approximately 730 kg. As shown in Figure E.3, this corresponds to a HI of approximately 0.006 for the industrial scenario and 0.04 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.06 mg/L.

E2.4 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 1×10^{-6}. Using Equation 1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table E.1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7.2), and the technetium-99 industrial scenario unit risk factor (Table 7.3), as follows:

$$\text{ILCR} = (1.33\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.54 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

E3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-112 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the HFFACO interim retrieval goal of 360 ft^3 (2,700 gal) of residual waste. These inventories were taken from *241-C Waste Management Area Inventory Data Package* (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 (RPP-22000). Inventories for the subset of BBI radionuclides that were shown in *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington* (DOE/ORP-2003-11) to dominate (contribute 87% of total) intruder doses at 500 years after closure are shown in Table E.2.

Table E.2. Tank C-112 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste*

Radionuclide	Units	Tank C-112
Strontium-90	Ci	1.68E+04

Tin-126	Ci	1.08E-03
Cesium-137	Ci	7.39E+03
Plutonium-239	Ci	2.12E+00
Plutonium-240	Ci	3.38E-01
Americium-241	Ci	1.23E+01

* Source: RPP-15317, Table 7-1.

Table E.3 summarizes the intruder analysis results for tank C-112. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22000. 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.

Table E.3. Tank C-112 Intruder Dose

Radionuclide	Well Driller (mrem EDE)	Suburban Resident (mrem/yr EDE)	Rural Farmer (mrem/yr EDE)
Strontium-90	0.001	0.013	0.001
Tin-126	0.001	0.001	0.000
Cesium-137	0.011	0.011	0.001
Plutonium-239	0.014	0.077	0.003
Plutonium-240	0.002	0.012	0.001
Americium-241	0.054	0.218	0.011
Other Radionuclides	0.001	0.051	0.001
TOTAL	0.084	0.383	0.018

Note: The number of significant digits shown in Table E.3 is not intended to imply a level of accuracy greater than the input values.

The dose values in Table E.3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table E.3 indicates that tank C-112 would not exceed the performance objectives of 500 mrem EDE for acute exposure and 100 mrem/yr EDE for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by plutonium-239 and americium-241.

E4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

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

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2004, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2004, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Waste Retrieval Work Plan*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

This page intentionally left blank.