0061800

RPP-16525, Rev. 5

C-200-Series Tanks Retrieval Functions and Requirements

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

RECEIVED
MAY 17 2004
EDMC

EDT/ECN: ECN 721711 R0 UC: 2000
Cost Center: BA00 Charge Code: 501679
B&R Code: N/A Total Pages: 45

Key Words: C-201; C-202; C-203; C-204; Tanks Retrieval Functions and Requirements

Abstract: This document establishes the C-200-Series Tanks Waste Retrieval System Functions and Requirements.

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

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

APR 13 2004
DATE:
STA: 15
HANFORD RELEASE
ID: 20

J. Aardal 4-13-04
Release Approval Date

Release Stamp

Approved For Public Release

CH2M HILL ENGINEERING CHANGE NOTICE

Page 1 of 2

☒ DM ☐ FM ☐ TM

1a. ECN 721711 R 0

1b. Proj. ECN - - R

2. Simple Modification ☒ Yes ☐ No	3. Design Inputs – For full ECNs, record information on the ECN-1 Form (not required for Simple Modifications)		4. Date 4-12-04
5. Originator's Name, Organization, MSIN, & Phone No. PM Branson, Projects, S7-12, 372-0086		6. USQ Number No. TF - - - R - ☒ N/A ☐ Refer to Work Package	7. Related ECNs N/A
8. Title C-200-Series Tanks Retrieval Functions and Requirements	9. Bldg. / Facility No. C-200/241-C	10. Equipment / Component ID C-200-Series Tanks	11. Approval Designator EQ
12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.) RPP-16525, Rev 4		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 ORP review comments.

Page 1, last paragraph was added at the direction of ORP.

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

Revision required based on comments received from, the DOE Office of River Protection.

The USQ process is N/A for this document change. No facility modifications, procedure changes, or tests/experiments are affected by this revision.

19. ECN Category

☒ Direct Revision

☐ Supplemental

☐ Void/Cancel

ECN Type

☐ Supercedure

☐ Revision

20. Distribution

Name	MSIN	Name	MSIN
JS Conrad	S7-03	WT Thompson	S7-70
JS Boettger	S7-24	C Henderson	B2-60
MC Tipps	S7-90	CH2M EQRG	
MN Jarayssi	H6-03	Central Files	B1-07
PM Branson	S7-12		
DG Baide	S7-70		
JJ Luke	H6-03		

Release Stamp

APR 13 2004

DATE:

STA: 15

HANFORD RELEASE

ID: 20

A-6003-563.1 (01/04)

CH2M HILL ENGINEERING CHANGE NOTICE

☒ DM ☐ FM ☐ TM

1a. ECN 721711 R 0

1b. Proj. ECN - - R

21. Revisions Planned (Include a brief description of the contents of each revision)

Complete revision based on comments received from, the DOE Office of River Protection.

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

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			

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	EW Girgis	4/13/04	Originator/Design Agent	C Henderson	4/13/04
Resp. Engineer	PM Branson	4/13/04	Professional Engineer		
Resp. Manager	WT Thompson C Henderson for WTT per Telecon	04/13/04	Project Engineer		
Quality Assurance	MC Tipps	04/13/04	Quality Assurance		
IS&H Engineer			Safety		
NS&L Engineer			Designer		
Environ. Engineer	~~JS Conrad~~ C. Kemp for GK per telecon	4/13/04	Environ. Engineer	JJ Luke	4/13/04
Engineering Checker			Other		
Other	Team Lead/Lead Engr. DG Banks	4/13/04	Other		
Other	Sys. Engr. JS Boettiger	4/13/04	DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION		
Other	MN Jarayssi	4/13/04	Signature or a Control Number that tracks the Approval Signature		
Other					
Other			ADDITIONAL SIGNATURES		
Other					
Other					

RECORD OF REVISION	(1) Document Number RPP-16525	Page 1

(2) Title
C-200-Series Tanks Retrieval Functions and Requirements

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
1	(7) Section 4.1.2, paragraph 2, page 19, revised	PM Branson	W.T. Thompson
2	Complete rewrite due to comments received from the Washington State Department of Ecology, per	PM Branson	W.T. Thompson
	ECN-721155, Rev. 0		
3	Section 4.2.1, paragraph 3, page 22, revised	PM Branson	W.T. Thompson
4	Complete revision based on comments received from Washington State Department of Ecology, per		
	ECN 721688, Rev. 0	D.G. Baide	W.T. Thompson
5 RS	Complete revision based on comments received from the DOE Office of River Protection (ORP) per		
	ECN 721711 Rev. 0.	D.G. Baide	W.T. Thompson

A-7320-005 (10/97)

C-200-SERIES TANKS RETRIEVAL FUNCTIONS AND REQUIREMENTS

April 8, 2004

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

EXECUTIVE SUMMARY

This document establishes the functions and requirements required by Milestone M-45-00 of the *Hanford Federal Facility Agreement and Consent Order*[1] for the retrieval of mixed waste stored in the C-200-series tanks. All four of the C-200-series tanks are designated as assumed leaking tanks and are located in the 200 East Area of the Hanford Site. The retrieval of waste from the C-200-series tanks will integrate leak detection, monitoring, and mitigation with retrieval technologies to minimize the potential for leaks to occur during retrieval and the leak volume should a leak occur.

The goals of this waste retrieval deployment are to remove waste to the limit of the technology, including the retrieval of 99% (no more than 30 cubic feet residual per tank) of tank contents by volume. Waste retrieval from the C-200-series tanks will utilize a vacuum-based retrieval process that introduces limited volumes of water to mobilize solids in the tanks that are then removed using vacuum as the motive force. Any water added would be in close proximity to the vacuum head, which will reduce the potential for liquid to pool within the tank.

This functions and requirements document establishes the C-200-series tanks waste retrieval system specifications (including leak detection, monitoring, and mitigation system specifications). The specifications are based on the use of leak detection and monitoring technologies that are consistent with the vacuum-based retrieval system and consider human health risks associated with the tank waste and potential waste volumes that could leak during retrieval.

The waste retrieval system being deployed inherently reduces the potential for leakage to occur and the resulting volumes if a leak were to occur. Therefore, the risk-based leak detection and monitoring strategy is based on preventing leakage, minimizing leak volumes if a leak should occur, and using available process control data for performing mass balance leak detection within the C-200-series tanks.

[1] 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.

CONTENTS

1.0 INTRODUCTION 1
1.1 PURPOSE 3
1.2 SCOPE 3
1.3 C-200-SERIES TANKS CONDITION 3

2.0 RISK BASIS 7
2.1 METHODOLOGY 7
2.1.1 Indicator Contaminant 8
2.1.2 Inventory 9
2.1.3 Contaminant Transport Transfer Functions 11
2.1.4 Exposure Scenarios 13
2.2 RESULTS 14
2.2.1 C-200-Series Tanks 14
2.2.2 C Tank Farm 17
2.3 INTRUDER RISK 21
2.3.1 Intruder Scenarios and Performance Objectives 21
2.3.2 Results 22

3.0 FUNCTIONS AND REQUIREMENTS 22

4.0 LEAK DETECTION, MONITORING, AND MITIGATION AND RETRIEVAL STRATEGY 26
4.1 LEAK DETECTION, MONITORING, AND MITIGATION STRATEGY 26
4.1.1 Leak Mitigation Strategy 27
4.1.2 Leak Detection Strategy 27
4.2 SYSTEM DESCRIPTION 29
4.2.1 Waste Retrieval System Description 29
4.2.2 Leak Detection and Monitoring System Description 31
4.3 OPERATING STRATEGY 34
4.3.1 Leak Detection and Monitoring Operations 34
4.3.2 Leak Mitigation Operations 34
4.3.3 Waste Retrieval Operations 35

5.0 REFERENCES 35

FIGURES

1. Location Map of C Tank Farm and Surrounding Facilities in the 200 East Area 2
2. Waste Management Area C and Regulated Structures 5
3. Plan View of the C Tank Farm Showing Drywells 6
4. C-200-Series Tanks Incremental Lifetime Cancer Risk Plot 14
5. Incremental Lifetime Cancer Risk Levels for C-200-Series Tanks Residual Waste and Leaked Waste (Industrial Scenario) 15
6. C-200-Series Tanks Hazard Index Plot 15
7. Hazard Index Levels for C-200-Series Tanks Residual Waste and Leaked Waste (Industrial Scenario) 16
8. Waste Retrieval System Diagram 30
9. C-200-Series Waste Retrieval Site Plan 32

TABLES

1. Individual Contaminant Percentage Contributions to Waste Management Area C Total Incremental Lifetime Cancer Risk and Hazard Index Values 9
2. Inventory Estimates for C-200-Series Tanks 10
3. Technetium-99 In-Tank Transport Transfer Function 12
4. Technetium-99 Ex-Tank Transport Transfer Function 12
5. Hexavalent Chromium In-Tank Transport Transfer Function 12
6. Hexavalent Chromium Ex-Tank Transport Transfer Function 13
7. Health Effects Conversion Factors for Industrial and Residential Exposure Scenarios ... 13
8. C Tank Farm Risk Evaluation Results for Industrial Scenario 18
9. C Tank Farm Risk Evaluation Results for Residential Scenario 19
10. C-200-Series Tanks Intruder Dose 22
11. C-200-Series Tanks Waste Retrieval System Functions and Requirements 23

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
F&R	functions and requirements
HI	hazard index
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
RSD	relative standard deviation
SST	single-shell tank
WRS	waste retrieval system

1.0 INTRODUCTION

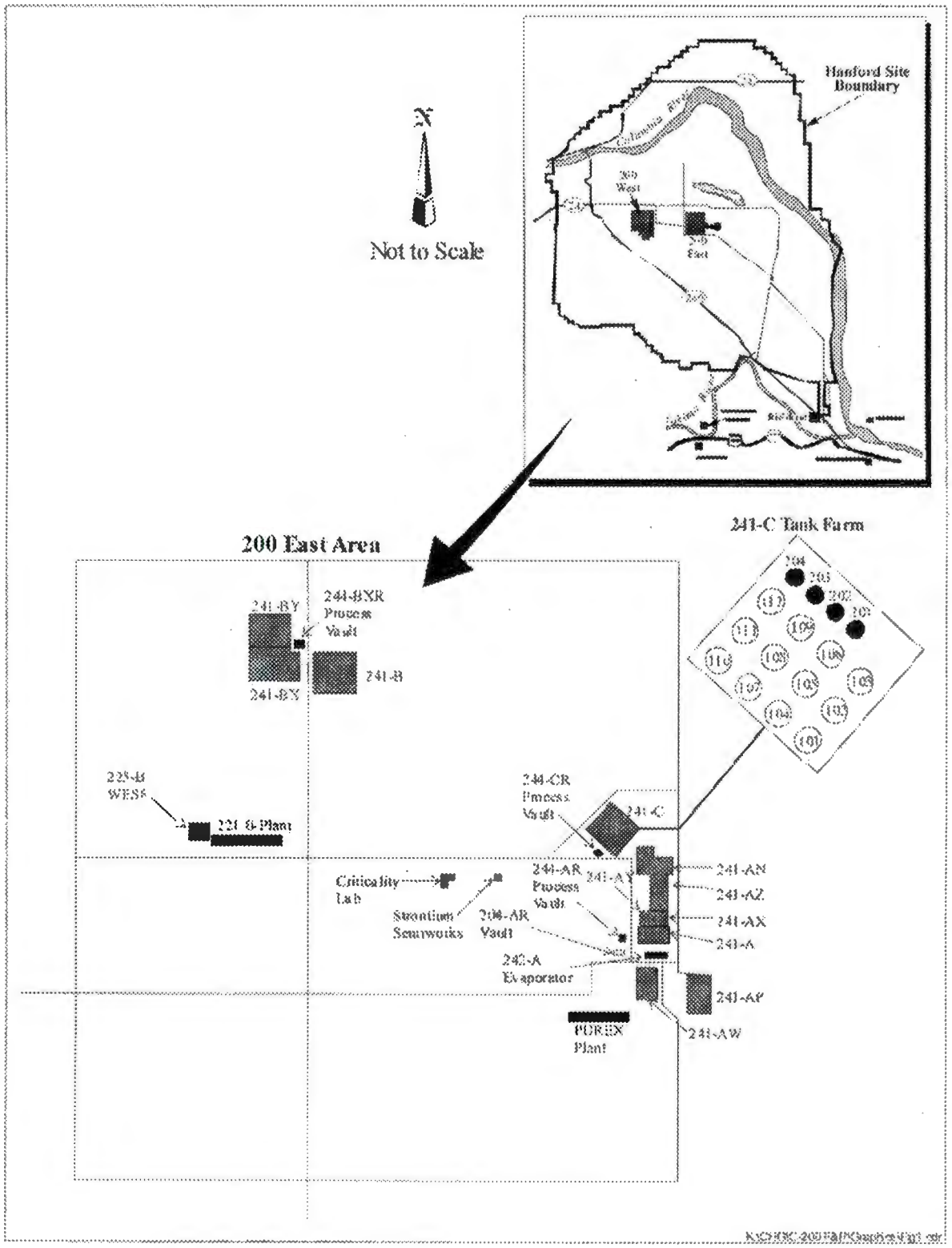
The River Protection Project mission includes storage, retrieval, immobilization, and disposal of high-level mixed radioactive waste presently stored in 177 underground tanks located in the 200 East and 200 West Areas of the U.S. Department of Energy (DOE) Hanford Site. The River Protection Project is in the process of accelerating single-shell tank (SST) waste retrievals. The C-200-series tanks (C-201, C-202, C-203, and C-204), located in the 200 East Area, are four of the tanks for which the schedule for waste retrieval has been accelerated (Figure 1). These tanks were chosen for early retrieval because they will provide high solids feed to the WTP while not further constraining available double-shell tank (DST) space; the existing waste transfer infrastructure from tank C-106 retrieval activities will be available to reduce overall retrieval costs through continuity in operations; their retrieval will contribute to closure of the C tank farm; and their retrieval will demonstrate the vacuum retrieval system in an actual waste tank for the first time and provide operational experience for future waste retrievals. Because of the recent schedule acceleration, tank-specific waste retrieval milestones have not been established in the *Hanford Federal Facility Agreement and Consent Order* (HFFACO; Ecology et al. 1989) for the C-200-series tanks. However, this functions and requirements (F&R) document has been prepared to serve as a waste retrieval F&R document. This document follows a streamlined approach to developing waste retrieval F&R documents that was developed after issuing the F&R documents for waste retrieval in tanks C-104, S-102, and S-112.

Because of concerns related to the liquid containment integrity of the older SSTs, current plans call for retrieving the SST waste and staging it in the more reliable DSTs to serve as feed material for the waste immobilization process. Although retrieval is a significant closure action, it does not constitute final closure. The C-200-series waste retrieval activities will be conducted, to the extent practical, to meet requirements that allow ultimate closure of the tanks and the tank farm. Therefore, the steps taken to retrieve waste from the C-200-series tanks will not preclude any future closure decisions.

The approach used to develop this document includes an integrated waste retrieval and leak detection, monitoring, and mitigation (LDMM) strategy that considers human health risk in the planning and development of waste retrieval system (WRS) requirements.

Please note that source, special nuclear and byproduct materials, as defined in the *Atomic Energy Act of 1954* (AEA), as amended, 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. To the extent that this F&R document provides data or discussions about materials regulated by the AEA, that information is provided for informational purposes only.

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



1.1 PURPOSE

This document provides the F&R necessary to support the design of the WRS for the C-200-series tanks. This document also provides a preliminary strategy commensurate with the F&R for waste retrieval and LDMM. The strategy combines leak detection and monitoring (LDM) methods that are consistent with the vacuum-based retrieval system along with an operational strategy designed to reduce the potential for leaks to occur and the resulting volume in the event a leak should occur. This document additionally provides risk information to establish a basis for making informed decisions in the event a leak is detected during retrieval.

1.2 SCOPE

The scope of this document is to establish the following:

- Waste retrieval F&R
- LDMM strategy
- waste retrieval strategy for the C-200-series tanks.

Approval of this document will enable the WRS design to be finalized.

The F&R identified in this document provide the foundation for the design criteria and design requirements documented in *Specification for the 241-C-200 Series Waste Retrieval System* (RPP-14075). Design specifications are used to develop the project engineering concepts, scope, and boundaries. The content of the design specifications include detailed requirements such as operating pressures, temperatures, materials of construction and control system requirements, confinement boundaries and controls, interface requirements, and similar detailed application requirements.

1.3 C-200-SERIES TANKS CONDITION

The C-200-series tanks were constructed from 1943 to 1944 and were put into service in 1947 and 1948. The tanks are first-generation tanks constructed with a dish-shaped bottom, a painted grout layer, an asphalt (waterproof) membrane, and an outer reinforced concrete shell to maintain the structural integrity of the steel liner by protecting it from soil loads. The reinforced concrete shell is cylindrical and supports the steel liner, which is constructed of mild steel. The steel liner extends up the tank wall to a height of 25 feet (*Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area* [WHC-SD-WM-ER-349]). Tie lines between the C-200-series tanks were at the same elevation, which allowed them to overflow and equalize tank volumes.

As of January 2003, tank C-201 contained approximately 1,100 gallons of waste consisting of sludge; tank C-202 contained 800 gallons of waste consisting of sludge; tank C-203 contained 2,600 gallons of waste consisting of sludge; tank C-204 contained 2,400 gallons of waste consisting of sludge (*Characteristics of Waste in the C-200 Series of Hanford Underground Waste Tanks* [RPP-14627]). The C-200-series tanks are presently passively ventilated. The C-200-series tanks are categorized as "assumed leakers" (*Waste Tank Summary Report for Month Ending January 31, 2003* [HNF-EP-0182]).

An evaluation of the historical data was performed to assess whether the observed liquid level decreases observed in the tanks during the 1980s could be attributed to normal evaporation. The results of this evaluation were inconclusive. Given the uncertainty in the estimated evaporation losses, a technical basis could not established as to whether the tanks did or did not leak. Details on the evaluation are provided in *Evaluation of Liquid Losses Noted in The 241-C-200 Series Tanks in the Early 1980s* (RPP-19918).

The first waste put into the C-200-series tanks went into tanks C-201 and C-204 in 1947 and consisted of metal waste from operation of the bismuth phosphate process in the 221-B Separations Building. Tanks C-201 and C-204 were filled with metal waste by January 1948. Metal waste was then hydraulically mined from these tanks from March 1953 through January 1955. The metal waste sludge and supernate was dissolved in acid in the 244-BXR vault and then transferred to the 221-U Building where uranium was recovered from the waste using a tributyl phosphate-based solvent extraction process. After completing the removal of metal waste, each tank was visually inspected and determined to be empty. However, given the inspection method, periscope optics, residual metal waste could have been left in each tank (*Origin of Wastes in C-200-Series Single-Shell Tanks* [RPP-15408]).

Tanks C-203 and C-204 received cold uranium (i.e., uranium that had not been irradiated in a reactor) waste from plutonium-uranium extraction (PUREX) startup testing in November 1955. The cold uranium waste was removed from tanks C-203 and C-204 in December 1955. Tanks C-201 through C-204 were then used from May 1955 through October 1956 to receive and store waste originating from research and development activities conducted at the 201-C Hot Semiworks Facility in the 200 East Area (RPP-15408).

Tanks C-201 through C-204 were not used to receive waste after being filled with waste from the 201-C Hot Semiworks Facility. The liquid in tanks C-201, C-202, C-203, and C-204 was transferred to other C farm tanks in the 1970s (RPP-15408).

Figure 2 provides a plan view of the C tank farm and the surrounding *Resource Conservation and Recovery Act of 1976* groundwater monitoring wells. Groundwater monitoring activities will be consistent with the current *Resource Conservation and Recovery Act of 1976* monitoring plan (*RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site* [PNNL-13024]) and coordinated with other environmental monitoring as appropriate. Based on PNNL-13024, groundwater is monitored either semiannually or annually for pH, specific conductivity, anions, total organic carbon, total organic halogens, alkalinity, cyanide, ICP metals, gross beta, and technetium. There are a number of drywells surrounding the 100-series tanks within the C tank farm; however, there are no drywells surrounding the 200-series tanks (Figure 3).

Figure 2. Waste Management Area C and Regulated Structures

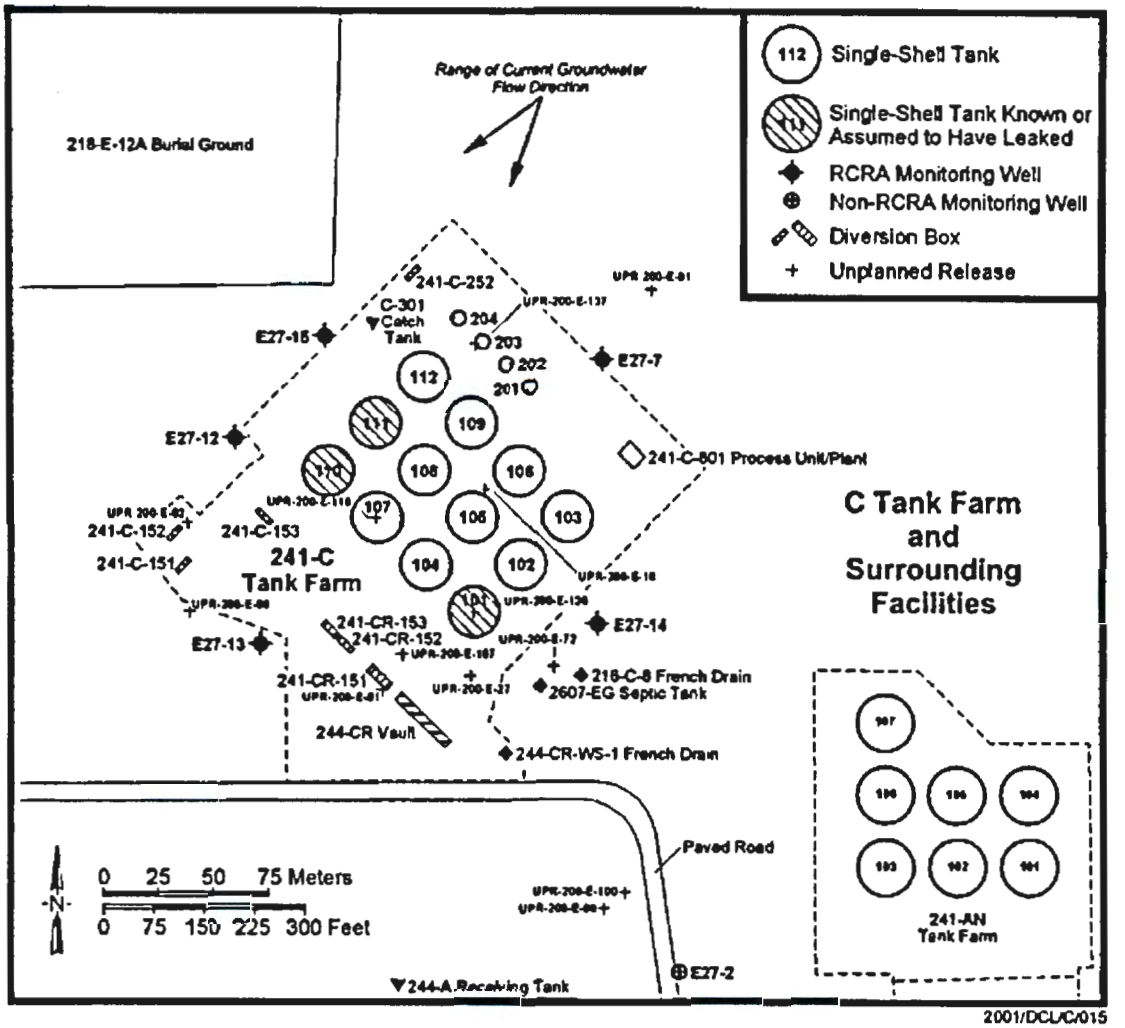
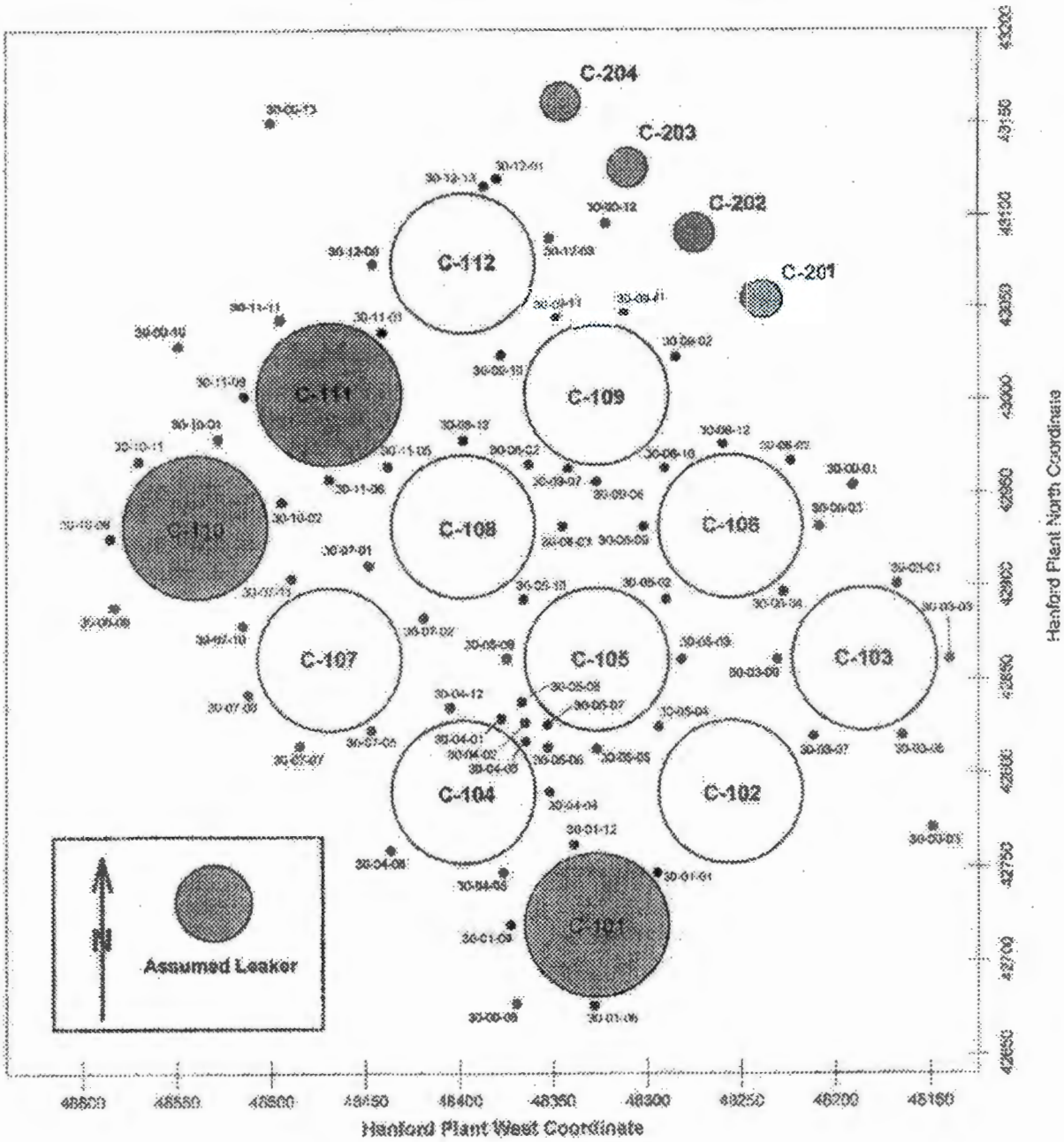


Figure 3. Plan View of the C Tank Farm Showing Drywells



Source: GJO-HAN-18.

2.0 RISK BASIS

This section presents the results of a preliminary evaluation of the long-term human health risks associated with waste in the C-200-series tanks and potential leaks that could occur during waste retrieval operations. Risk from inadvertent human intrusion into the C-200-series tanks following closure is also presented. The need to consider long-term human health risks in developing waste retrieval F&R was established in the HFFACO M-45 milestone series through Change Package M-45-00-01A. Milestones established by that change package required that a scoping-level risk assessment be prepared as part of the waste retrieval F&R documents. Scoping level is interpreted to be the same as a screening-level risk assessment that utilizes currently available data and information.

DOE and the Washington State Department of Ecology (Ecology) have recognized that there are risks associated with retrieving waste from aging SSTs, including the potential for leakage during waste retrieval. However, DOE and Ecology have also recognized that there are risks associated with continued storage of waste in the SSTs. Not retrieving the waste will result in its eventual and certain release, when the tanks ultimately fail. The C-200-series tanks are approximately 35 years beyond their design life, and continued storage will increase the potential for leakage to occur during waste retrieval. Time will make the situation worse so there is a bias for moving forward with waste retrieval and transfer of waste from the aging SSTs to the safer, more reliable DSTs as part of the overall commitment to meet the 2018 date for completing SST waste retrievals to fulfill HFFACO Milestone M-45-05 requirements.

Retrieval of all the waste from the C-200-series tanks with no leakage is the goal of the waste retrieval project. A risk evaluation was performed to provide a basis for making informed decisions during waste retrieval operations in the event a leak is detected or unexpected waste retrieval conditions arise. The risk basis was developed using estimated long-term human health risk via the groundwater pathway. The evaluation methodology is summarized in Section 2.1. Evaluation results are presented in Section 2.2. Calculation detail is provided in *C-200-Series Tanks Long-Term Human Health Risk Calculations* (RPP-20589). Risk from inadvertent human intrusion is presented in Section 2.3.

2.1 METHODOLOGY

The evaluation methodology followed a streamlined approach consistent with the goal of performing a screening-level assessment. Much of the information for the evaluation was derived from an existing waste management area C risk analysis presented in Appendix C of *Single-Shell Tank System Closure Plan* (RPP-13774). The main elements of the approach can be summarized as follows:

- Focus on potential long-term groundwater pathway human health risk at the tank farm fenceline
- Use incremental lifetime cancer risk (ILCR) and hazard index (HI) as risk metrics
- Provide radiological ILCR for one indicator contaminant

- Provide noncarcinogenic chemical HI for one indicator contaminant
- Derive effects of contaminant release and transport from previous studies; involves no new contaminant transport analysis
- Use the best available existing published data and information to the maximum extent possible, with little new data generated for the creation of the document.

Risk impacts were calculated for this evaluation using the following equation:

$$R_i = I_i \times T_i \times d_i \qquad \text{Eq. 1}$$

Where:

i = indicator contaminant
R_i = risk metric (ILCR or HI)
I_i = inventory (Ci or kg)
T_i = transport transfer function (pCi/L per Ci or mg/L per kg)
d_i = health effects conversion factor (ILCR per pCi/L or HI per mg/L).

Sections 2.1.1 through 2.1.4 provide a discussion of the individual terms in Equation 1, including selection of indicator contaminants, development of contaminant inventories, derivation of transport transfer functions, and identification of exposure scenarios and health effects conversions factors.

2.1.1 Indicator Contaminant

Technetium-99 was selected as the indicator contaminant for radiological ILCR based on the results of the long-term groundwater pathway impact analysis presented in RPP-13774. The RPP-13774 analysis included all radionuclides reported in *Inventory and Source Term Data Package* (DOE/ORP-2003-02) for which a dose factor was available. Individual radionuclide contributions are reported for technetium-99 and iodine-129. Together, technetium-99 and iodine-129 provided the majority of the total ILCR. Technetium-99 was the major driver, contributing approximately 90% of the total ILCR for the industrial scenario and approximately 96% for the residential scenario. Table 1 summarizes the individual contaminant contributions from the RPP-13774 results for the residual waste and retrieval leakage source terms. Contaminant contributions from the unplanned releases source term (past leaks and spills) as reported in RPP-13774 are very similar to those shown in Table 1.

Table 1. Individual Contaminant Percentage Contributions to Waste Management Area C Total Incremental Lifetime Cancer Risk and Hazard Index Values

Contaminant	Percentage of Total ILCR		Percentage of Total HI	
	Industrial Scenario	Residential Scenario	Industrial Scenario	Residential Scenario
Technetium-99	90.0%	95.6%	N/A	N/A
Iodine-129	9.9%	2.3%	N/A	N/A
Nitrite	N/A	N/A	35.6%	37.7%
Nitrate	N/A	N/A	4.8%	5.1%
Chromium (VI)	N/A	N/A	47.8%	43.7%
Uranium	N/A	N/A	0.1%	0.1%

Source: RPP-13774, Addendum C1, Table 28.
HI = hazard index.
ILCR = incremental lifetime cancer risk.
N/A = not applicable.

Hexavalent chromium was selected as the indicator contaminant for noncarcinogenic chemical HI based on the analysis results presented in RPP-13774. The RPP-13774 analysis included all hazardous chemicals reported in DOE/ORP-2003-02 for which a toxicity factor was available. Individual chemical contributions are reported for chromium, nitrite, nitrate, and uranium. Together, those four contaminants accounted for the majority of the total HI. For the residual waste and retrieval leakage source terms, chromium contributed approximately 48% of the total HI for the industrial scenario and approximately 44% for the residential scenario (Table 1).

For this screening-level assessment, ILCR and HI values are calculated based only on the indicator contaminants. However, total ILCR and HI values can be estimated by applying the RPP-13774 contaminant contribution percentages shown in Table 1 to the indicator contaminant ILCR and HI values. For example, an estimate of the total ILCR can be made by multiplying the technetium-99 ILCR by 1/0.90 or 1/0.96 for the industrial and residential scenarios, respectively. Likewise, an estimate of the total HI can be made by multiplying the chromium HI by 1/0.48 or 1/0.44 for the industrial and residential scenarios, respectively.

2.1.2 Inventory

The C-200-series tanks indicator contaminant inventories used for this evaluation are shown in Table 2. These inventories were developed for consistency with the inventories used in the RPP-13774 analysis.

Table 2. Inventory Estimates for C-200-Series Tanks

Tank	Current Inventory[a]		Residual Waste (30 ft³ [220 gal])[b]		Potential Retrieval Leak (100 gal)[c]		Past Leak[d]	
	Tc-99 (Ci)	Cr (VI) (kg)	Tc-99 (Ci)	Cr (VI) (kg)	Tc-99 (Ci)	Cr (VI) (kg)	Tc-99 (Ci)	Cr (VI) (kg)
C-201	1.41E-02	2.29E+00	2.99E-03	4.86E-01	1.41E-04	2.29E-02	0.00	0.00
C-202	1.47E-02	2.39E+00	3.12E-03	5.08E-01	1.47E-04	2.39E-02	0.00	0.00
C-203	2.82E-02	4.57E+00	2.40E-03	3.88E-01	9.39E-05	1.52E-02	0.00	0.00
C-204	1.81E-02	2.95E+00	1.54E-03	2.51E-01	6.06E-05	9.84E-03	0.00	0.00

[a]Source: RPP-13774, Addendum C1, Table 7.
[b]Source: RPP-13774, Addendum C1, Table 8b.
[c]Source: Calculated from retrieval fluid concentrations given in RPP-13774, Addendum C1, Table 9.
[d]Source: RPP-13774, Addendum C1, Table 6.

Current technetium-99 and hexavalent chromium inventories shown in Table 2 are the same as those used in RPP-13774 and are consistent with the best-basis inventory (BBI) estimates reported in DOE/ORP-2003-02.

The technetium-99 and hexavalent chromium inventories reported in the BBI for the C-200-series tanks are based on sample analyses rather than modeled data. The uncertainty in the reported inventories is provided in the BBI in terms of relative standard deviation (RSD). The RSD reported in the BBI for the pre-retrieval inventory of technetium-99 is 138% for tank C-201, 80% for tank C-202, and 33% for tanks C-203 and C-204. The RSD reported in the BBI for the pre-retrieval inventory of chromium is 80% for tanks C-201 and C-202 and 33% for tanks C-203 and C-204. Because the long-term risk estimates vary directly with inventory, these uncertainties would be expected to contribute to the uncertainty in the estimates for long-term risk.

Residual waste inventories shown in Table 2 are the same as those used for the RPP-13774 Base Case analysis and are based on the Selected Phase Removal data set from DOE/ORP-2003-02. The DOE/ORP-2002-02 Selected Phase Removal data set takes into account removal of selected phases of waste (e.g., sludge, supernate) during retrieval. The inventories shown are for 30 cubic feet of residual waste, which corresponds to the HFFACO Milestone M-45 interim retrieval goal for 200-series SSTs.

The waste retrieval leak inventories shown in Table 2 were calculated consistent with the approach used in RPP-13774 by multiplying the assumed retrieval leak volume by the retrieval fluid concentration as predicted by the Hanford Tank Waste Operations Simulator (HTWOS) model run described in *Hanford Tank Waste Operations Simulator (HTWOS) Model Run results for the Integrated Mission Acceleration Plan (IMAP) Unconstrained Case* (RPP-14302). A hypothetical retrieval leak volume of 100 gallons per tank was used for informational purposes only. This volume was used to provide a point of reference on the graphs and is not intended to represent anticipated waste retrieval leak volumes or leak detection limits for the C-200-series tanks.

The maximum volume of waste that could leak during waste retrieval operations is uncertain. This uncertainty is tied to the ability of the WRS to mobilize the waste from the tanks with minimal liquid volumes. The intent of deploying the vacuum-based WRS is to retrieve waste without the addition of water; however, water additions may be necessary and will vary depending on waste make-up and retrieval effectiveness. Only a small fraction of the water volume added to the tanks could leak due to the design of the WRS and the localized addition of liquids at the vacuum head.

Seven C farm tanks, including the four C-200-series tanks, are currently classified as assumed leakers in HNF-EP-0182. However, as discussed in RPP-13774 and DOE/ORP-2003-02, the preponderance of currently available data, including data from baseline spectral gamma logging of C tank farm drywells described in *Hanford Tank Farms Vadose Zone: C Tank Farm Report* (GJO-HAN-18), supports the recognition of one pre-existing source of vadose zone contamination (past leaks) in the C tank farm, in the vicinity of tank C-105. Currently available data do not support the recognition of pre-existing sources of vadose zone contamination in the vicinity of the tanks classified as leakers in HNF-EP-0182. The past leak source term used in this evaluation is consistent with that used for the RPP-13774 analysis (i.e., one measured source of vadose zone contamination in the C tank farm, in the vicinity of tank C-105).

2.1.3 Contaminant Transport Transfer Functions

For this screening-level assessment, the effects of contaminant release and transport were taken from the existing analysis that was the most relevant to the case being studied. For the C-200-series tanks, this was the waste management area C numerical vadose zone and groundwater contaminant transport modeling analysis presented in RPP-13774. Proportionality coefficients called transport transfer functions were developed from the RPP-13774 analysis results and used in lieu of performing groundwater contaminant transport modeling. Transfer functions were applied as shown in Equation 1 to represent the unit contaminant concentration in groundwater per unit inventory released at the source.

The transfer functions used for this assessment were calculated from the results of the RPP-13774 contaminant transport analysis by dividing the model-predicted 10,000-year peak technetium-99 and chromium groundwater concentrations at the tank farm fenceline by the technetium-99 and chromium inventories released at the source. Separate transfer functions were calculated for in-tank waste (residual waste) and ex-tank waste (potential retrieval leaks). Tables 3 through 6 show the derivation of the individual transfer functions used for this assessment. Note that the waste retrieval leak transfer functions were based on RPP-13774 results for the C-100-series tanks. The RPP-13774 analysis did not include retrieval leak simulations for the C-200-series tanks because it was assumed that a dry waste retrieval method would be used for these tanks.

Table 3. Technetium-99 In-Tank Transport Transfer Function

Peak Technetium-99 Groundwater Concentration at C Tank Farm Fenceline from Residual Waste in C Farm Tanks Retrieved to HFFACO Goal (pCi/L)[a]	Technetium-99 Inventory in Residual Waste in C Farm Tanks Retrieved to HFFACO Goal (Ci)[b]	In-Tank Transport Transfer Function (pCi/L per Ci)
65	7.58	8.58

[a]Source: RPP-13774, Addendum C1, Table 14.
[b]Source: RPP-13774, Addendum C1, Table 8b.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*

Table 4. Technetium-99 Ex-Tank Transport Transfer Function

Peak Technetium-99 Groundwater Concentration at C Tank Farm Fenceline from 8,000 gal Retrieval Leak From C Farm 100-Series Tanks (pCi/L)[a]	Technetium-99 Inventory in 8,000 gal Retrieval Leak from C Farm 100-Series Tanks (Ci)[b]	Ex-Tank Transport Transfer Function (pCi/L per Ci)
420	4.96	84.7

[a]Source: RPP-13774, Addendum C1, Table 14.
[b]Source: RPP-13774, Addendum C1, Table 10.

Table 5. Hexavalent Chromium In-Tank Transport Transfer Function

Peak Chromium Groundwater Concentration at C Tank Farm Fenceline from Residual Waste in C Farm Tanks Retrieved to HFFACO Goal (mg/L)[a]	Chromium Inventory in Residual Waste in C Farm Tanks Retrieved to HFFACO Goal (kg)[b]	In-Tank Transport Transfer Function (mg/L per kg)
0.001	119	8.4×10^{-6}

[a]Source: RPP-13774, Addendum C1, Table 18.
[b]Source: RPP-13774, Addendum C1, Table 8b.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*

Table 6. Hexavalent Chromium Ex-Tank Transport Transfer Function

Peak Chromium Groundwater Concentration at C Tank Farm Fenceline from 8,000 gal Retrieval Leak From C Farm 100-Series Tanks (mg/L)[a]	Chromium Inventory in 8,000 gal Retrieval Leak from C Farm 100-Series Tanks (kg)[b]	Ex-Tank Transport Transfer Function (mg/L per kg)
0.064	76.1	8.4×10^{-5}

[a]Source: RPP-13774, Addendum C1, Table 18.
[b]Source: RPP-13774, Addendum C1, Table 10.

2.1.4 Exposure Scenarios

Risks were calculated for two exposure scenarios, industrial and residential. 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 were taken from tables provided in *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment* (HNF-SD-WM-TI-707). The conversion factors provide the lifetime cancer morbidity risk per unit concentration of technetium-99 in the groundwater and the noncarcinogenic chemical HI per unit concentration of hexavalent chromium in the groundwater. The conversion factor values used for this assessment are shown in Table 7.

Table 7. Health Effects Conversion Factors for Industrial and Residential Exposure Scenarios

Scenario	Technetium-99 Groundwater Unit Risk Factor (ILCR per pCi/L)	Hexavalent Chromium Groundwater Unit Hazard Factor (HI per mg/L)
Industrial[a]	1.38×10^{-8}	4.32
Residential[b]	3.36×10^{-7}	24

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

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

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 watering livestock (ingestion of meat, poultry, and dairy products). Complete descriptions of the industrial and residential scenarios can be found in HNF-SD-WM-TI-707.

2.2 RESULTS

Evaluation results for the C-200-series tanks are provided in Section 2.2.1. The scope of this evaluation also included the development of a risk perspective for all tanks in the C tank farm. Results of a screening-level C tank farm risk assessment are provided in Section 2.2.2.

2.2.1 C-200-Series Tanks

Evaluation results for the C-200-series tanks are depicted in Figures 4 through 7. Figures 4 and 5 show the peak groundwater pathway technetium-99 ILCR at the tank farm fenceline as a function of technetium-99 inventory in the C-200-series tanks. Figures 6 and 7 show the peak groundwater pathway hexavalent chromium HI at the tank farm fenceline as a function of hexavalent chromium inventory in the C-200-series tanks. As discussed in Section 2.1.1, an estimate of the total ILCR and HI values can be calculated from the values shown on the plots by multiplying the plotted values by the reciprocal of the decimal percent of each indicator contaminant's contribution to the total ILCR or HI.

Figure 4. C-200-Series Tanks Incremental Lifetime Cancer Risk Plot

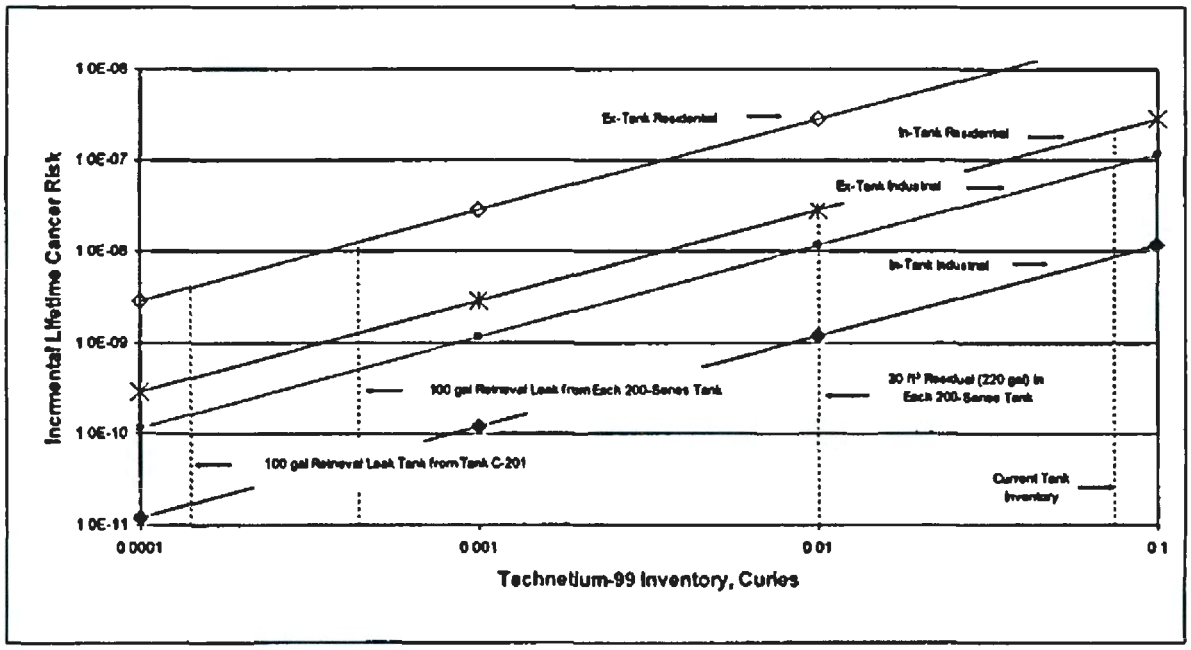


Figure 5. Incremental Lifetime Cancer Risk Levels for C-200-Series Tanks Residual Waste and Leaked Waste (Industrial Scenario)

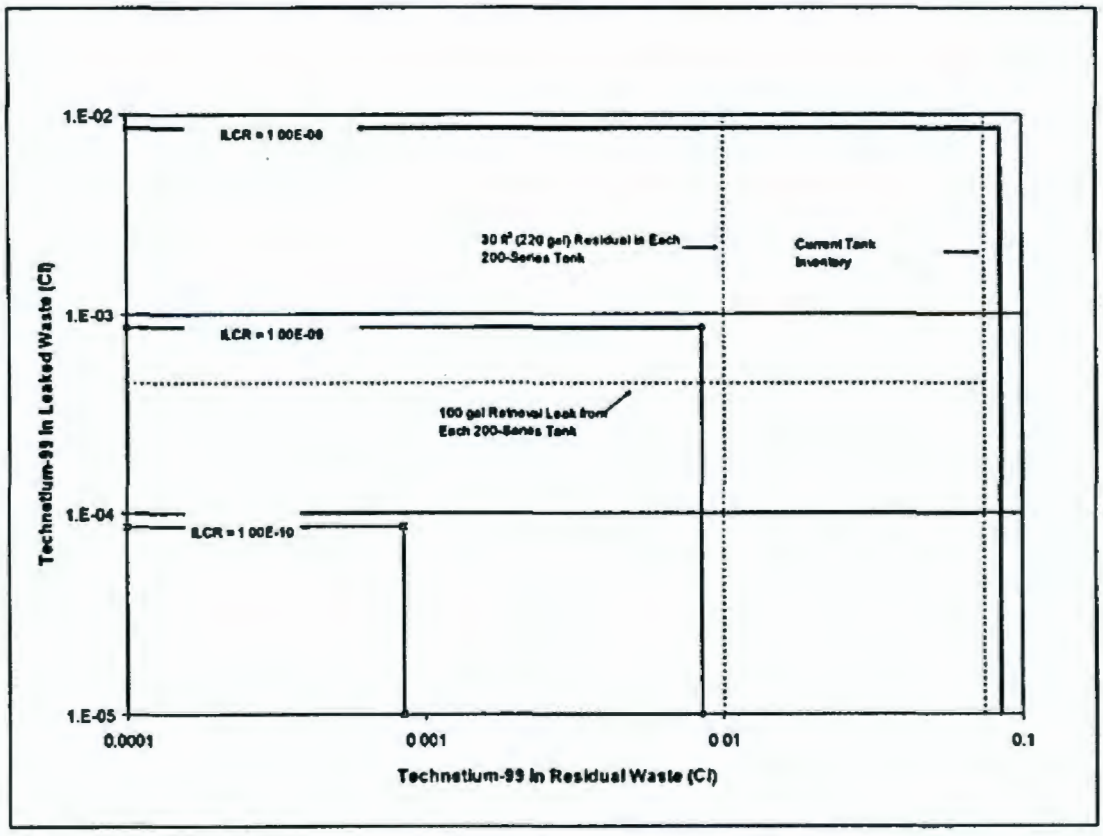


Figure 6. C-200-Series Tanks Hazard Index Plot

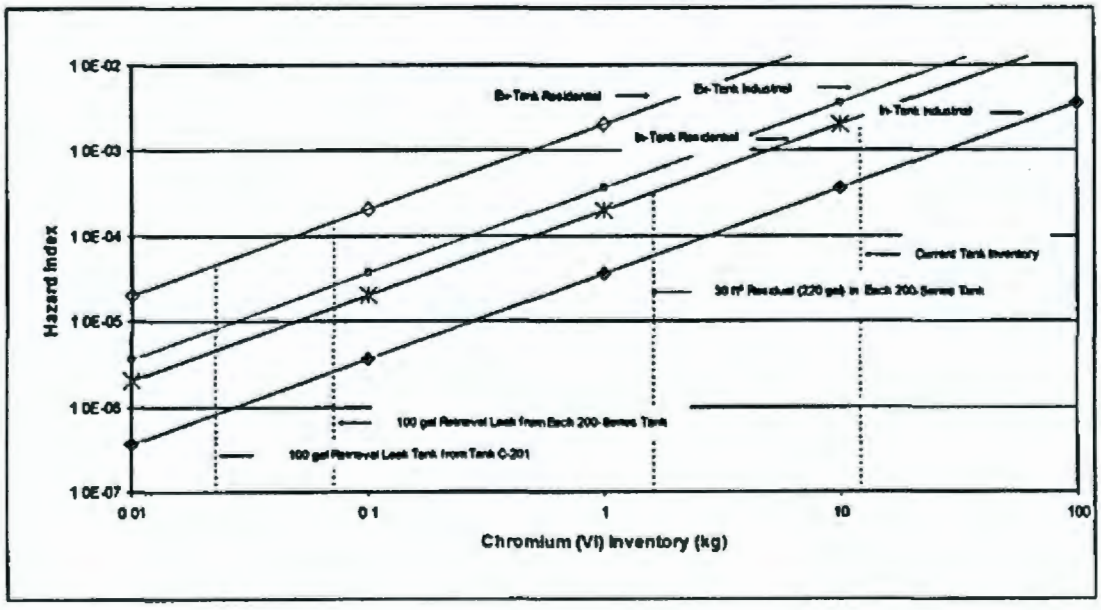
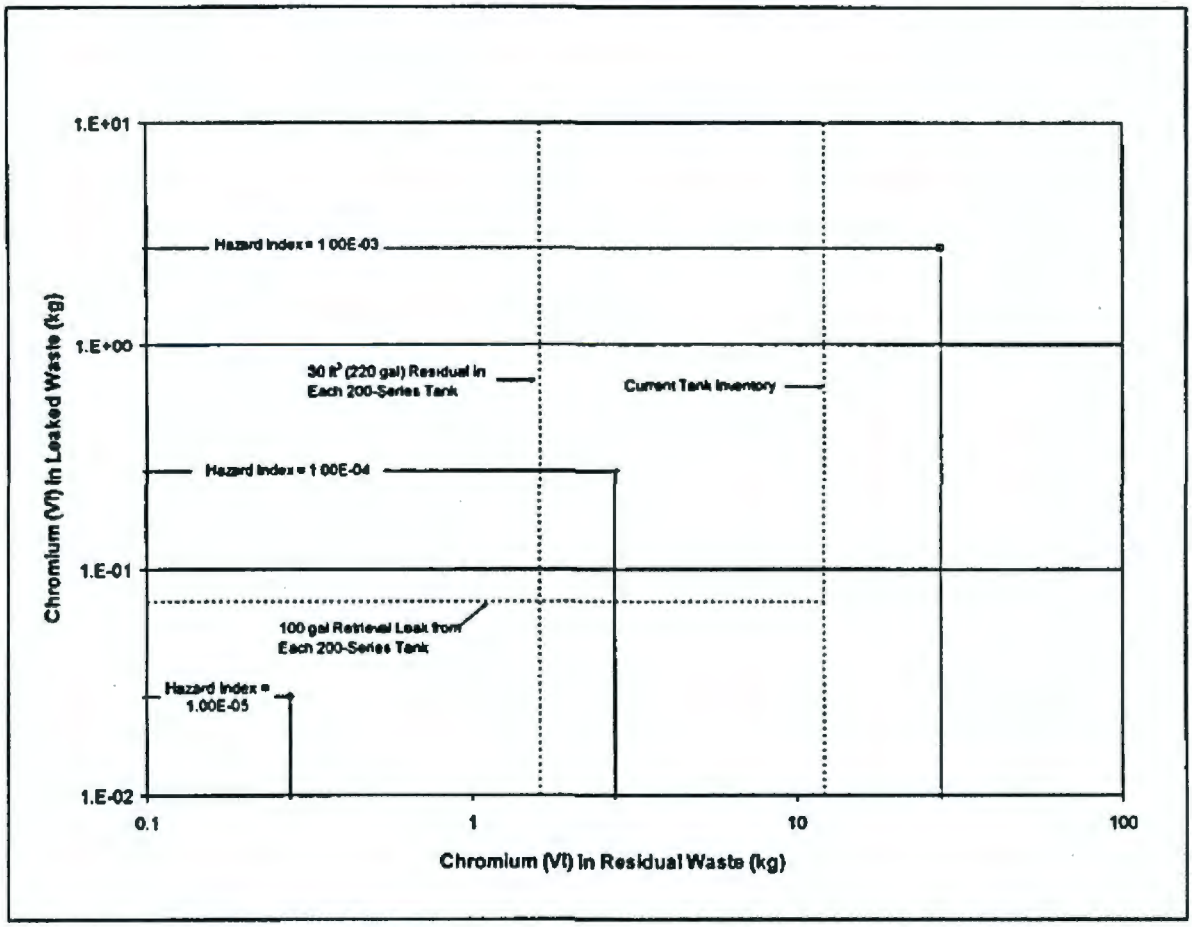


Figure 7. Hazard Index Levels for C-200-Series Tanks Residual Waste and Leaked Waste (Industrial Scenario)



Four separate sloped lines are shown in Figures 4 and 6, two for in-tank waste (residuals) for the industrial and residential scenarios and two for ex-tank waste (retrieval leakage) for the industrial and residential scenarios. The data points for these lines were calculated by applying Equation 1 over a range of technetium-99 and hexavalent chromium inventory values. Vertical lines are used to indicate the estimated inventories of technetium-99 and chromium associated with several in-tank and ex-tank volumes of interest. Estimated inventories are shown for the current C-200-series tank waste, 30 cubic feet of residual waste in each C-200-series tank, a 100-gallon retrieval leak from each C-200-series tank, and a 100-gallon leak from one of the C-200-series tanks.

Figure 4 indicates that the ILCR posed by the current technetium-99 inventory in the C-200-series tanks is approximately 9×10^{-9} for the industrial scenario and 2×10^{-7} for the residential scenario. Waste retrieval down to approximately 30 cubic feet in each C-200-series tank reduces the ILCR by approximately 1 order of magnitude. The inventory of technetium-99 associated with a potential retrieval leak (ex-tank) of 100 gallons from one of the C-200-series tanks (tank C-201) is approximately 0.0001 curies and corresponds to a risk of approximately 2×10^{-10} for the industrial scenario and 4×10^{-9} for the residential scenario. A 100-gallon leak

from each C-200-series tank increases the retrieval leak risk to approximately 5×10^{-10} for the industrial scenario and 1×10^{-8} for the residential scenario.

Figure 6 indicates that the HI posed by the current hexavalent chromium inventory in the C-200-series tanks is approximately 4×10^{-4} for the industrial scenario and 2×10^{-3} for the residential scenario. Waste retrieval down to approximately 30 cubic feet in each C-200-series tank reduces the HI by approximately 1 order of magnitude. The inventory of chromium associated with a potential retrieval leak (ex-tank) of 100 gallons from one of the C-200-series tanks (tank C-201) is approximately 0.02 kilograms and corresponds to a HI of approximately 8×10^{-6} for the industrial scenario and 5×10^{-5} for the residential scenario. A 100-gallon leak from each C-200-series tank increases the retrieval leak HI to approximately 3×10^{-5} for the industrial scenario and 1×10^{-4} for the residential scenario.

Figures 5 and 7 were plotted using the same data used in Figures 4 and 6, respectively, for the industrial scenario but depict the results from a slightly different perspective. Figure 5 shows three curves, each depicting the relationship between residual waste and retrieval leakage technetium-99 inventory for a constant ILCR level. The ILCR levels shown are 1×10^{-8}, 1×10^{-9}, and 1×10^{-10}. Figure 7 likewise shows three curves, each depicting the relationship between residual waste and retrieval leakage hexavalent chromium inventory for a constant HI level. The HI levels shown are 1×10^{-3}, 1×10^{-4}, and 1×10^{-5}. Three dashed lines are used on both Figures 5 and 7 to indicate the technetium-99 and chromium inventories associated with the current C-200-series tank waste, 30 cubic feet of residual waste in each 200-series tank, and a 100-gallon retrieval leak from each C-200-series tank.

It should be noted that plots of the type shown in Figures 5 and 7 are conservative because they assume coincident arrival times of the peak groundwater concentrations from the residual waste and retrieval leakage source terms. As discussed in Section 2.1.3, the projected arrival times for the peaks from these two source terms are actually widely separated and the peaks therefore would not be additive. The plots are included for informational purposes to provide a perspective on the relationship between residual waste and retrieval leakage impacts.

2.2.2 C Tank Farm

To provide a screening-level perspective of the C-200-series tanks relative to the other C farm tanks, the methodology used for the C-200-series tanks was applied to all tanks in the C tank farm. Results for the C tank farm evaluation are summarized in Tables 8 and 9 for the industrial and residential scenarios, respectively.

Tables 8 and 9 show the estimated technetium-99 and hexavalent chromium inventories and associated peak ILCR and HI values by tank and source term for each tank in the C farm. The ILCR and HI values shown are groundwater pathway peak values at the C tank farm fenceline and were calculated using the approach described in Section 2.1.

Table 8. C Tank Farm Risk Evaluation Results for Industrial Scenario

Tank	Current Inventory		Residual Waste (360 ft³ [2,700 gal] C-100 Tanks, 30 ft³ [220 gal] C-200 Tanks)				Assumed 8,000 gal (C-100 Tanks) or 100 gal (C-200 Tanks) Retrieval Leak				Measured Contamination in C Tank Farm Vadose Zone			
	Tc-99 (Ci)	Cr (VI) (kg)	Tc-99 (Ci)	ILCR	Cr (VI) (kg)	HI	Tc-99 (Ci)	ILCR	Cr (VI) (kg)	HI	Tc-99 (Ci)	ILCR	Cr (VI) (kg)	HI
241-C-101	6.97E-01	2.99E+02	2.13E-02	2.52E-09	9.15E+00	3.31E-04	8.66E-03	1.01E-08	3.72E+00	1.35E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-102	1.32E+00	7.35E+02	1.13E-02	1.34E-09	6.26E+00	2.27E-04	9.96E-03	1.16E-08	5.54E+00	2.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-103	1.34E+01	3.91E+02	7.02E-01	8.31E-08	3.33E+00	1.21E-04	2.08E+00	2.43E-06	9.88E+00	3.59E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-104	5.80E+01	1.46E+03	3.95E+00	4.68E-07	4.59E+01	1.66E-03	1.17E+01	1.37E-05	1.36E+02	4.94E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-105	8.14E+01	4.13E+02	1.19E+00	1.41E-07	5.82E+00	2.11E-04	3.53E+00	4.13E-06	1.73E+01	6.27E-03	1.93E+00	2.15E-06	9.82E+00	3.46E-03
241-C-106	3.14E+00	6.18E+01	4.57E-01	5.41E-08	2.53E+01	9.16E-04	8.36E-02	9.77E-08	1.65E+00	5.98E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-107	3.79E+01	9.30E+02	4.11E-01	4.86E-08	1.01E+01	3.66E-04	5.30E-01	6.19E-07	1.30E+01	4.72E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-108	6.19E+00	2.32E+02	2.52E-01	2.98E-08	9.47E+00	3.43E-04	2.01E-01	2.35E-07	7.54E+00	2.74E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-109	3.23E+01	1.18E+02	1.37E+00	1.62E-07	5.02E+00	1.82E-04	8.18E-01	9.55E-07	2.98E+00	1.08E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-110	3.18E+01	4.20E+02	4.84E-01	5.73E-08	6.38E+00	2.31E-04	7.90E-01	9.24E-07	1.04E+01	3.80E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-111	2.70E+00	8.52E+01	1.27E-01	1.50E-08	4.00E+00	1.45E-04	6.30E-02	7.36E-08	1.99E+00	7.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-112	6.11E+01	1.39E+02	1.59E+00	1.88E-07	3.61E+00	1.31E-04	1.28E+00	1.50E-06	2.93E+00	1.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-201	1.41E-02	2.29E+00	2.99E-03	3.54E-10	4.86E-01	1.76E-05	1.41E-04	1.65E-10	2.29E-02	8.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-202	1.47E-02	2.39E+00	3.12E-03	3.69E-10	5.08E-01	1.84E-05	1.47E-04	1.72E-10	2.39E-02	8.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-203	2.82E-02	4.57E+00	2.40E-03	2.84E-10	3.88E-01	1.40E-05	9.39E-05	1.10E-10	1.52E-02	5.53E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-204	1.81E-02	2.95E+00	1.54E-03	1.82E-10	2.51E-01	9.09E-06	6.06E-05	7.08E-11	9.84E-03	3.58E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.30E+02	5.30E+03	1.06E+01	1.25E-06	1.36E+02	4.92E-03	2.11E+01	2.47E-05	2.13E+02	7.74E-02	1.93E+00	2.15E-06	9.82E+00	3.46E-03

Ci = curies.
Cr (VI) = hexavalent chromium.
HI = hazard index.
ILCR = incremental lifetime cancer risk.
kg = kilograms.
Tc-99 = technetium-99.

Table 9. C Tank Farm Risk Evaluation Results for Residential Scenario

Tank	Current Inventory		Residual Waste (360 ft³ [2,700 gal] C-100 Tanks, 30 ft³ [220 gal] C-200 Tanks)				Assumed 8,000 gal (C-100 Tanks) or 100 gal (C-200 Tanks) Retrieval Leak				Measured Contamination in C Tank Farm Vadose Zone			
	Tc-99 (Ci)	Cr (VI) (kg)	Tc-99 (Ci)	ILCR	Cr (VI) (kg)	HI	Tc-99 (Ci)	ILCR	Cr (VI) (kg)	HI	Tc-99 (Ci)	ILCR	Cr (VI) (kg)	HI
241-C-101	6.97E-01	2.99E+02	2.13E-02	6.14E-08	9.15E+00	1.84E-03	8.66E-03	2.46E-07	3.72E+00	7.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-102	1.32E+00	7.35E+02	1.13E-02	3.26E-08	6.26E+00	1.26E-03	9.96E-03	2.83E-07	5.54E+00	1.12E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-103	1.34E+01	3.91E+02	7.02E-01	2.02E-06	3.33E+00	6.71E-04	2.08E+00	5.92E-05	9.88E+00	1.99E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-104	5.80E+01	1.46E+03	3.95E+00	1.14E-05	4.59E+01	9.23E-03	1.17E+01	3.33E-04	1.36E+02	2.75E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-105	8.14E+01	4.13E+02	1.19E+00	3.44E-06	5.82E+00	1.17E-03	3.53E+00	1.01E-04	1.73E+01	3.48E-02	1.93E+00	5.24E-05	9.82E+00	1.92E-02
241-C-106	3.14E+00	6.18E+01	4.57E-01	1.32E-06	2.53E+01	5.09E-03	8.36E-02	2.38E-06	1.65E+00	3.32E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-107	3.79E+01	9.30E+02	4.11E-01	1.18E-06	1.01E+01	2.03E-03	5.30E-01	1.51E-05	1.30E+01	2.62E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-108	6.19E+00	2.32E+02	2.52E-01	7.26E-07	9.47E+00	1.91E-03	2.01E-01	5.72E-06	7.54E+00	1.52E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-109	3.23E+01	1.18E+02	1.37E+00	3.95E-06	5.02E+00	1.01E-03	8.18E-01	2.33E-05	2.98E+00	6.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-110	3.18E+01	4.20E+02	4.84E-01	1.39E-06	6.38E+00	1.28E-03	7.90E-01	2.25E-05	1.04E+01	2.11E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-111	2.70E+00	6.52E+01	1.27E-01	3.66E-07	4.00E+00	8.05E-04	6.30E-02	1.79E-06	1.99E+00	4.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-112	6.11E+01	1.39E+02	1.59E+00	4.58E-06	3.61E+00	7.26E-04	1.28E+00	3.65E-05	2.93E+00	5.91E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-201	1.41E-02	2.29E+00	2.99E-03	8.62E-09	4.86E-01	9.78E-05	1.41E-04	4.02E-09	2.29E-02	4.62E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-202	1.47E-02	2.39E+00	3.12E-03	8.99E-09	5.08E-01	1.02E-04	1.47E-04	4.19E-09	2.39E-02	4.82E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-203	2.82E-02	4.57E+00	2.40E-03	6.92E-09	3.88E-01	7.81E-05	9.39E-05	2.67E-09	1.52E-02	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
241-C-204	1.81E-02	2.95E+00	1.54E-03	4.44E-09	2.51E-01	5.05E-05	6.06E-05	1.72E-09	9.84E-03	1.99E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.30E+02	5.30E+03	1.06E+01	3.05E-05	1.36E+02	2.74E-02	2.11E+01	6.01E-04	2.13E+02	4.30E-01	1.93E+00	5.24E-05	9.82E+00	1.92E-02

Ci = curies.
Cr (VI) = hexavalent chromium.
HI = hazard index.
ILCR = incremental lifetime cancer risk.
kg = kilograms.
Tc-99 = technetium-99.

Tables 8 and 9 show tank farm total ILCR and HI values for each source term but do not show a composite of the source terms because of the separation in arrival time of the source term peaks. As discussed in Section 2.1.3, the peak groundwater concentrations from the residual waste source term would arrive approximately 3,500 years after closure and would not be additive with the peaks from the retrieval leak or past leak source terms. Peak groundwater concentrations from the retrieval leak and past leak source terms would arrive within approximately the next 100 years and would be additive. The cumulative effects of residual waste, past leaks, and potential retrieval leaks in waste management area C are fully analyzed and described in RPP-13774.

The technetium-99 and hexavalent chromium inventories shown in Tables 8 and 9 for the C-100-series tanks other than tanks C-103, C-104, and C-105 were developed using the same approach used for the C-200-series tanks (Section 2.1.2) and are consistent with the inventories used in RPP-13774. The inventories shown for tanks C-103, C-104, and C-105 differ from the inventories used in RPP-13774 and are consistent with the inventories used for the risk analysis presented in *C-100-Series Tanks Waste Retrieval Functions and Requirements* (RPP-18811). The tanks C-103, C-104, and C-105 inventories used in RPP-18811 differ from the inventories used in RPP-13774 because the RPP-18811 analysis assumed that waste would be retrieved from these three tanks using recirculated DST supernate. The calculation method for the tanks C-103, C-104, and C-105 inventories shown in Tables 8 and 9 is summarized in RPP-20589 and described in detail in *Tanks C-103 and C-105 Long-Term Human Health Risk Calculations* (RPP-19071) and *Tank C-104 Long-Term Human Health Risk Calculations* (RPP-20079).

The residual waste inventories shown in Tables 8 and 9 for the C-100-series tanks were based on residual volumes of 360 cubic feet, corresponding to the HFFACO Milestone M-45 interim retrieval goal for 100-series SSTs. The retrieval leak inventories shown for the C-100-series tanks were based on a hypothetical retrieval leak volume of 8,000 gallons. This volume was used for informational purposes to provide a point of reference on the graphs and is not intended to represent anticipated retrieval leak volumes or leak detection limits for the C-100-series tanks.

The past leak inventory shown in Tables 8 and 9 is consistent with the inventory used in RPP-13774. As discussed in Section 2.1.2, this inventory reflects the fact that the preponderance of currently available data supports the recognition of one pre-existing source of vadose zone contamination (past leak) in the vicinity of tank C-105. Further discussion of C tank farm vadose zone contamination is provided in RPP-13774 and DOE/ORP-2003-02.

As shown in Tables 8 and 9, the retrieval leakage technetium-99 ILCR is approximately an order of magnitude greater than the ILCR from residual waste for the C-100-series tanks. For the C-200-series tanks, the retrieval leakage technetium-99 ILCR is slightly less than the ILCR from residual waste. These same relationships hold true for the hexavalent chromium HI values.

Tables 8 and 9 indicate that the tank farm total technetium-99 ILCR from residual waste is approximately 1×10^{-6} and 3×10^{-5} for the industrial and residential scenarios, respectively. The tank farm total technetium-99 ILCR from retrieval leaks is approximately 2×10^{-5} and 6×10^{-4} for the industrial and residential scenarios, respectively. The tank farm total technetium-99 ILCR from past leaks is approximately 2×10^{-6} and 5×10^{-5} for the industrial and residential scenarios, respectively.

Tables 8 and 9 indicate that the tank farm total hexavalent chromium HI from residual waste is approximately 5×10^{-3} and 3×10^{-2} for the industrial and residential scenarios, respectively. The tank farm total hexavalent chromium HI from retrieval leakage is approximately 8×10^{-2} and 4×10^{-1} for the industrial and residential scenarios, respectively. The tank farm total hexavalent chromium from past leaks is approximately 3×10^{-3} and 2×10^{-2} for the industrial and residential scenarios, respectively.

2.3 INTRUDER RISK

An analysis of inadvertent human intrusion impacts for waste management area C is provided 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]).

The C-200-series tanks analysis results reported in DOE/ORP-2003-11 are summarized in this section to provide additional perspective on potential post-closure risks associated with the C-200-series tanks assuming waste is retrieved to the HFFACO interim retrieval goal.

2.3.1 Intruder Scenarios and Performance Objectives

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

- An inadvertent intruder who 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 (post-intrusion residential scenarios). Three 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. The basement scenario was not considered credible in DOE/ORP-2003-11 and was not analyzed.

The performance objective for the driller scenario was 500 mrem effective dose equivalent for a one-time exposure. The performance objective for the post-intrusion residential scenarios was 100 mrem/yr effective dose equivalent for a continuous exposure. The time of compliance for the DOE/ORP-2003-11 analysis was 500 years after closure and closure was assumed to occur in the year 2050.

2.3.2 Results

Table 10 summarizes the DOE/ORP-2003-11 analysis results for the C-200-Series tanks. The values in the table give the estimated tank-specific impacts for each scenario from intrusion at 500 years after closure assuming each tank contains a volume of 30 cubic feet of residual waste at closure. The residual waste contaminant inventories used for the analysis were consistent with the Selected Phase Removal data set from DOE/ORP-2003-02.

Table 10. C-200-Series Tanks Intruder Dose[a]

Tank	Driller (mrem) EDE	Suburban Resident with a Garden (mrem/yr) EDE	Rural Farmer with a Diary Cow (mrem/yr) EDE	Commercial Farmer (mrem/yr) EDE
C-201	1.46	22.1	0.39	0.004
C-202	0.77	11.5	0.20	0.002
C-203	0.16	2.3	0.04	0.000
C-204	0.005	0.06	0.001	0.000

[a]Source = DOE/ORP-2003-11, Appendix C.
EDE = effective dose equivalent.

Table 10 indicates that none of the C-200-series tanks would exceed the performance objectives at 500 years after closure. Tank C-201 would have the highest impacts. The most significant contributors to the dose at 500 years were plutonium-239, plutonium-240 and americium-241.

3.0 FUNCTIONS AND REQUIREMENTS

This document establishes the upper-level functions and corresponding requirements to which the C-200-series tanks WRS must be designed and operated. Other requirements not directly applicable to the level of definition provided in this document are disseminated to CH2M HILL Hanford Group, Inc. via the DOE-CH2M HILL Hanford Group, Inc. Contract (Contract DE-AC-27-99RL14047). Specifically, the F&R included in this document are derived from the need to satisfy the HFFACO Milestone M-45-00 requirements to retrieve as much tank waste as technically possible, with tank waste residues not to exceed 30 cubic feet, or the limit of the waste retrieval technology, whichever is less. Additionally the F&R ensure that waste retrieval actions do not result in adverse impacts to workers, the public, or the environment. Some of these requirements are derived from the regulatory documents, such as the *Code of Federal Regulations* and the *Washington Administrative Code*, while others are based on the design limitations of the C-200-series tanks and the DST receiver tank. The F&R are provided in Table 11 and are focused on appropriately driving the design of the C-200-series WRS so that the aforementioned requirements are met. These F&R are consistent with RPP-14075.

Table 11. C-200-Series Tanks Waste Retrieval System Functions and Requirements (3 Sheets)

Function	Requirement	Basis	Key Elements
Control structure and waste temperature in C-200-series tanks	Maintain tank structure and waste temperature within limits defined in SST operating specification.	OSD-T-151-00013	Maximum 137 °C (280 °F) for waste and maximum 120 °C (250 °F) for dome
Control C-200-series tank waste level	Prevent waste overflow and limit hydrostatic head-induced stresses in the tank.	OSD-T-151-00013	Maintain waste level from exceeding 280 in. and minimize liquid level to the extent practical
Control vapor space pressure in the C-200-series tanks	Maintain vapor space pressure within limits defined in SST operating specification.	OSD-T-151-00013	Minimum = -(5.3 in. w.g. + [waste height (in.)] × [specific gravity of waste]); not to exceed -9 in. w.g.
Control gaseous discharges from the C-200-series tanks	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 1.7	Mitigate potential release to personnel, the public, and the environment
Remove waste from the C-200-series tanks	The C-200-series WRS shall be capable of removing as much waste as technically possible, with tank waste residues not to exceed 30 ft^3, or the limit of the waste retrieval technology, whichever is less. If DOE believes that waste retrieval to these levels is not possible for a tank, DOE will submit a detailed explanation to EPA and Ecology explaining why these levels cannot be achieved, and specifying the quantities of waste that DOE proposes to leave in the tank. The request will be approved or disapproved by EPA and Ecology on a case-by-case basis.	HFFACO Milestone M-45-00	The WRS shall provide the ability to retrieve waste to less than 30 ft^3
Control and monitor the waste removal process in the C-200-series tanks	The C-200-series WRS shall provide the monitor and control capability to control the waste retrieval and transfer process. This includes controlling and monitoring the following C-200-series WRS process parameters: • Pressures • Flow rates • Differential pressures across exhaust ventilation filters • Leak detection systems. The C-200-series WRS shall be operated remotely, have video monitoring capabilities, and provide instrumentation to support performing material balance calculations.	RPP-13033 HNF-SD-WM-TSR-006 WAC 173-303	Provide for safe and effective operation of the WRS

Table 11. C-200-Series Tanks Waste Retrieval System Functions and Requirements (3 Sheets)

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from the C-200-series tanks	The WRS shall be capable of detecting liquid waste releases during all waste removal operations. The system shall be designed to detect leakage from the tank using technologies consistent with waste retrieval methods to detect tank leaks during retrieval.	WAC 173-303 HNF-SD-WM-TSR-006	Utilize LDM technologies coupled with mitigation strategies to minimize the potential for retrieval leakage; see Section 4.0
Monitor leaks from the C-200-series tanks during waste removal	The WRS shall quantify liquid release volumes from the C-200-series tanks if a release is detected during waste retrieval operations.	WAC 173-303	Utilize LDM technologies coupled with mitigation strategies to minimize the potential for retrieval leakage
Measure and estimate residual waste in the C-200-series tanks	The WRS design shall allow for estimating the residual waste in the C-200-series tanks following retrieval operations.	HFFACO, Appendix H	Design feature. Residual volume will be estimated using in-tank video. Requirements for post-retrieval waste volume measurement will be documented in RPP-16616.
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
Mitigate leaks during the C-200-series 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 retrieval if they occur. The primary means of mitigation shall be through removal of free liquid as rapidly as feasible using the equipment described in this document.	HNF-SD-WM-AP-005 WAC 173-303	Leak mitigation strategy described in Section 4.0
Nuclear safety	The WRS shall be designed and operated to protect workers, public, the environment, and equipment from exposure to radioactive tank waste and emissions during the retrieval campaign.	WAC 246-247 10 CFR 830 RPP-13033 HNF-SD-WM-TSR-006 HNF-IP-1266	Ensure protection of workers and the public from routine and potential accident conditions
Maintain design and operating limits for DST used as a receiver tank	The WRS shall not adversely affect the function of the DST system or exceed the DST design and operational limits.	HNF-SD-WM-TRD-007	Ensure safe and effective receipt and storage of the C-200-series tank waste in receiver DST
Occupational safety and health	The C-200-series WRS shall be designed for safe installation, operation & maintenance.	29 CFR 1910 10 CFR 835 29 CFR 1926	OSHA standards

Table 11. C-200-Series Tanks Waste Retrieval System Functions and Requirements (3 Sheets)

Function	Requirement	Basis	Key Elements
SST and DST dome loading	The WRS shall not exceed the maximum dome loading on existing SSTs and DSTs specified in HNF-SD-WM-SAR-067.	HNF-IP-1266 RPP-13033 HNF-SD-WM-TSR-006 TFC-ENG-FACSUP-C-10	Mitigates possible structural failure of tank dome
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

CAM = continuous air monitor.
DOE = U.S. Department of Energy.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
EPA = U.S. Environmental Protection Agency.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*
LCO = Limiting Condition for Operation.
LDM = leak detection and monitoring.
OSHA = Occupational Safety and Health Administration.
SST = single-shell tank.
WRS = waste retrieval system.

4.0 LEAK DETECTION, MONITORING, AND MITIGATION AND RETRIEVAL STRATEGY

This section describes the LDMM and waste retrieval strategy for the C-200-series tanks WRS, including definitions for LDMM, uncertainties in detecting and monitoring leaks, LDMM and waste retrieval strategy, and preliminary system descriptions. LDMM activities are defined in *Annual Progress Report on the Development of Waste Tank Leak Monitoring/Detection And Mitigation Activities in Support of M-45-08 (TPA Milestone M-45-09E Fiscal Year 2000 Progress Report)* (RPP-7012). These definitions have been accepted by the Office of River Protection and Ecology and are presented here for reference:

- **Leak Detection**: Technologies, methods, or systems used to detect a leak.
- **Leak Monitoring**: Technologies, methods, or systems used to quantify liquid waste release volumes from an SST, if a release is detected during waste retrieval operations. Leak monitoring also includes assessment of leak monitoring data in an effort to estimate the rate and direction of movement through the soil.
- **Leak Mitigation**: Technologies, waste retrieval methods, or systems that can reduce the potential for a leak to occur, the volume of a leak if it were to occur, and action taken to minimize leak volumes in the event a leak is detected during waste retrieval.

4.1 LEAK DETECTION, MONITORING, AND MITIGATION STRATEGY

The integrated LDMM strategy for the C-200-series tanks has been developed to meet the requirements specified in the HFFACO M-45 series milestones and 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 C-200-series tanks waste retrieval and LDMM strategy:

- Is technically practicable and defensible
- Considers applicable regulations and requirements
- Meets the programmatic needs of the Office of River Protection to move forward with waste retrieval using available technologies
- Utilizes LDMM technologies and strategies that are consistent with the waste retrieval technology selected for deployment in the four 200-series tanks.
- 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
- Reduces the risks to human health.

4.1.1 Leak Mitigation Strategy

The primary goal of the C-200-Series Tanks Project LDMM strategy is leak mitigation (i.e., reduction of leak loss potential) and is two-fold. The operational strategy takes actions to minimize liquid available for leakage (any liquid currently in the tanks plus any water added) from the onset of retrieval and to minimize the time at risk (*C-200 Series Tanks Retrieval Leak Detection, Monitoring, and Mitigation Strategy White Paper* [RPP-15230]).

The operational strategy to minimize the leak potential (initiation of a leak and leak volume) during waste retrieval in the absence of any indication of a leak involves the following (RPP-15230):

- Limit the volume of liquid in the tank. The selected WRS uses a vacuum-based conveyance system deployed on an articulating mast to remove the waste from the tanks. No standing water is required in the tank for this system to operate. The system will vacuum up any free liquids.
- If the sludge is too stiff to be removed by the vacuum system a high-pressure, low-volume water jet will be used to dislodge/breakup the waste for removal. The waste retrieval strategy is to use the water jet for a short time then quickly vacuum up loosened waste and any free liquids so they will not be available to leak. The water jet is attached directly to the vacuum nozzle so that any water used to mobilize the sludge will immediately be removed.
- The time at risk (waste retrieval duration) will be low.

4.1.2 Leak Detection Strategy

The C-200-Series Tanks Project has evaluated both in-tank and ex-tank methods that have been used historically for leak detection. To be a suitable candidate for full-scale deployment, LDM technologies must be technically mature (i.e., ready for deployment without further development or testing) and capable of being deployed in a manner that supports the waste retrieval schedule and operational performance and reliability requirements (RPP-15230). The leak detection strategy is to: (1) detect a leak in a timely manner, (2) determine leak volumes in a timely manner, (3) provide technically defensible data to determine the response to a detected leak, and (4) implement an appropriate response.

The C-200 series tank WRSs and waste retrieval strategy have been designed to reduce the possibility of a tank waste leak and the potential environmental impact of a leak, should one occur. As previously discussed, the WRS is designed to introduce water only as needed. The rate at which water is added is controlled, and the source is located next to the vacuum system intake. The vacuum system uses the water to mobilize the waste and remove it immediately from the tank. The small amount of liquid introduced into the tank and the short duration that the liquid will remain within the tank reduces or eliminates the ability to measure

liquid levels for leak detection. Thus, static liquid observation wells cannot be employed. Also, drywell monitoring is not practical because there are currently no drywells located around the C-200 series tanks. If drywells were to be installed around the C-200 series tanks, they would have limited utility for leak detection because of the short waste retrieval durations and low water volumes. Therefore, the only viable approach that has been identified to detecting a leak is the mass balance approach. The following paragraphs present a more detailed discussion of each leak detection method considered for the C-200 series tanks. Conventional in-tank and ex-tank leak detection methods will be employed on the double-shell waste receiving tank, AN-106 (RPP-15230).

4.1.2.1 Static Liquid Level Observation

Leak detection in SSTs has historically been based on liquid level monitoring. Static liquid level monitoring works well if the tank being retrieved and the receiver tank both have a liquid surface that can be accurately measured and used to estimate waste inventory in both tanks. No free liquids will typically be available in the C-200-series tanks during waste retrieval operations (RPP-15230). The use of the vacuum retrieval system will reduce leakage potential and will not allow for liquid level monitoring during retrieval operations. Static level monitoring will be used for leak detection in receiver tank AN-106 (RPP-15230). It should be noted that the addition of the waste from any one of the C-200-series tanks would raise the level in tank AN-106 by 2 inches or less.

4.1.2.2 Mass Balance

The mass balance approach uses process control data to compare liquid added to the tank to liquid removed from the tank (i.e., liquid pumped out of the tank and potentially the water vapor losses from the tank exhauster). Flow meters will be used to track the volume of liquid added to the tank and dilution water added for transfer conditioning. This volume will then be compared to the liquid fraction of the waste pumped into the transfer line using process control data to reveal a gross deficit due to possible leakage (RPP-15230). Static level measurements will be monitored in receipt tank AN-106 to track the total volume of waste received from the WRS.

Mass balance is the only method that is a candidate for deployment in the C-200-series tanks. Mass balance will be utilized throughout the waste retrieval campaign; however, there are a number of factors that contribute to the uncertainty associated with mass balance and the ability to detect small leaks from the C-200-series tanks. The amount of water used by the system and the waste sent to the DST system will be measured; however, there are streams within the WRS that will not be measured. These streams will tend to bias the material balance.

The volume of water used by the WRS will be measured by a flowmeter. For any given batch there are liquid volumes returned to the tank that are not measured that will bias the material balance. The water vapor in the air stream and the carry over of liquid waste from the slurry tank to the vacuum pump will not be metered. Additionally, a small amount of the waste retrieved from the tank may not be removed at the slurry tank. Any waste not removed at the slurry tank will be carried over and scrubbed out the vacuum pump water separator and eventually drained back into tank C-203 while that tank is being retrieved, or into tank C-202 during retrieval of waste from tank C-201, C-202, or C-204 (*Process Control Plan for the 241-C-200 Series Waste Retrieval System* [RPP-16945]).

The uncertainties with the water balance along with the uncertainties in estimating the volume of waste remaining in the tank have not been quantified. However, for the C-200-series tanks the potential leak volumes during waste retrieval are minimized by the low waste volumes, the vacuum retrieval system design, and the short duration of the waste retrieval campaign. It is estimated that between 250 and 900 gallons of water could be added to each tank for waste retrieval. The estimated volumes of water to be added to the tanks during waste retrieval are smaller than the uncertainty in current waste volume within the tanks. The BBI currently identifies the RSD for waste volume at 79.65% for tanks C-201 and C-202 and 31.86% for tanks C-203 and C-204. This translates into an uncertainty of +/- 880 gallons for tank C-201; +/-640 gallons for tank C-202; +/-830 gallons for tank C-203; and +/- 760 gallons for tank C-204 based on one standard deviation.

4.1.2.3 Ex-Tank Leak Detection

Available ex-tank leak detection methods involve indirect measurement of subsurface conditions in the drywells surrounding the tank. Drywell monitoring has been used extensively in the past for LDM. As monitoring drywells are not installed around the C-200-series tanks, this method is not an option. Annulus leak detection will be used in receiver tank AN-106 (RPP-15230).

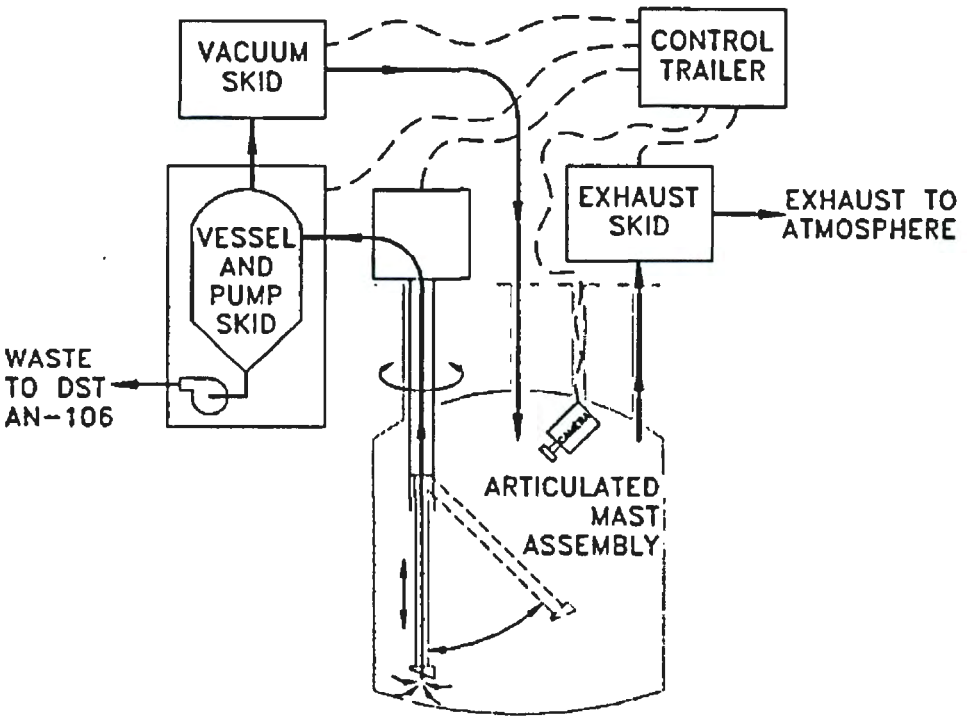
4.2 SYSTEM DESCRIPTION

The waste retrieval and LDM systems described in this section represent an overview of the system currently planned for deployment in the C-200-series tanks. Modifications during fabrication and resulting from testing and deployment may change the system configuration as it is described herein. However, the final design shall comply with the requirements established in this document.

4.2.1 Waste Retrieval System Description

The C-200-Series Tanks Project will use a vacuum retrieval system that utilizes an articulating mast to remove waste from the tank. Both air and water are injected at the vacuum head to mobilize the waste. If needed, a series of five scarifying, high-pressure, low-volume water jets located around the outside of the vacuum head can be used to dislodge waste. The waste is deposited in a batch vessel located above grade in the vessel/pump skid where load cells and a level gauge indicate the waste batch volume. The batch vessel is a slurry tank with a 290 gallon capacity and a working volume of 250 gallons. The recovered waste will be mixed and diluted as necessary for transfer through a hose-in-hose assembly to tank AN-106 (Figure 8).

Figure 8. Waste Retrieval System Diagram



Both the vessel/pump skid and the vacuum skid provide secondary containment and leak detection. Both skids provide for leak collection and drainage back to one of the C-200-series tanks. The drain lines will be routed to tank C-203 during retrieval of waste from that tank. During retrieval of waste from tanks C-201, C-202, and C-204 the drain lines will be routed to tank C-202.

The vacuum will be produced by tandem vacuum pumps installed upstream of the waste receiving vessel. The tandem vacuum pumps provide a level of redundancy in that normally only one pump would be operated. The system does have the capability to run both of the vacuum pumps simultaneously if needed for waste removal. Offgas from the vacuum system will be returned to the tank. Active ventilation on the tank, provided by an exhaust system, will filter and monitor the exhaust prior to discharge to the atmosphere.

Miscellaneous process and skid drainage will be routed back to either tank C-203 (during retrieval of waste from tank C-203) or tank C-202. During routine operations a small volume of contaminated seal water from the vacuum system and line drainage will be generated and routed back to either tank C-203 (during retrieval of tank C-203) or tank C-202. Also, under upset or emergency conditions, waste contained in the batch vessel can be drained back to the tank being retrieved as part of recovery actions.

When waste retrieval operations have been completed for all four C-200-series tanks, the pump skid and vacuum skid will be decontaminated to the extent necessary to reach acceptable exposure rates for dismantling and moving the equipment for reuse at other tanks. This involves flushing and draining equipment and piping with water. Decontamination of the waste retrieval equipment will include some unavoidable drain back of flush water into the last of the C-200-series tanks retrieved.

The system design is intended for multiple deployments and will typically be comprised of skids and modular assemblies. The major components of the system including the following:

- Articulated mast assemblies (one each for tanks C-201, C-202, C-203, and C-204)
- Vessel and pump skid
- Vacuum skid
- Hydraulic power packs
- Exhauster skid
- Compressed air skid
- Water supply skid
- Closed-circuit television camera
- Control trailer.

The modular design of the system incorporates reliability and maintainability features that allow for continued operation, repair, and/or replacement of components in the event of a component failure. Redundant slurry pumps are provided in the vessel/pump skid that provides the capability to transfer waste out of the slurry vessel in the event that one of the pumps fail. Spare parts required to support operations have been evaluated and procured to support system operations.

A possible arrangement for the equipment is shown in Figure 9.

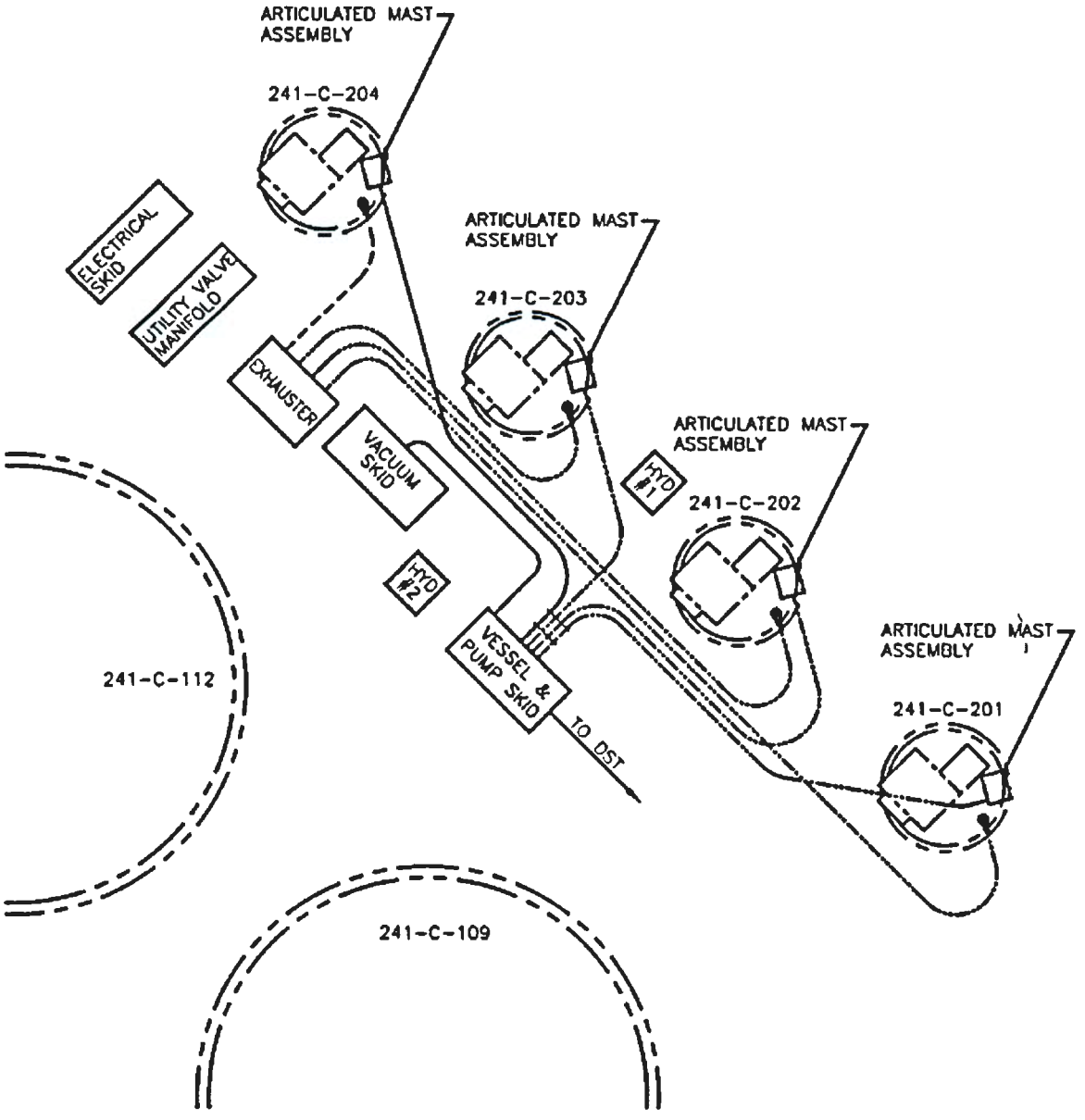
4.2.2 Leak Detection and Monitoring System Description

The C-200-series tanks WRS uses instrumentation to monitor liquids added to and removed from the tank. Figure 3 illustrates the lack of monitoring drywells adjacent to the C-200-series tanks. The absence of drywells around the C-200-series tanks eliminates the ability to deploy moisture monitoring and spectral gamma monitoring techniques for leak detection during waste retrieval.

In the absence of available ex-tank methods at the C-200-series tanks, good engineering practice dictates the observation of process control data that could indicate possible liquid loss. A running total of liquid added to the tank and dilution water added for transfer conditioning will be compared to the liquid fraction of the waste pumped into the transfer line to reveal a gross deficit due to possible leakage. Volumes of liquid added to the tank for retrieval, liquid added to slurry waste in the batch vessel, and total waste slurry volume transferred out will be measured by in-line flow meters.

The baseline LDM methods for receipt tank AN-106 include level monitoring within the tank and conductivity probes and continuous air monitoring in the DST annulus.

Figure 9. C-200-Series Waste Retrieval Site Plan



4.2.2.1 Ex-Tank Leak Detection

Available ex-tank leak detection methods involve indirect measurement of subsurface conditions in the drywells surrounding the tank. Drywell monitoring has been used extensively in the past for LDM depending on the number and proximity of drywells to the tank of interest.
No monitoring drywells are installed around the C-200-series tanks. The installation of new drywells is currently outside the scope of the C-200-Series Tanks Project. For the C-200-series tanks, drywell monitoring techniques are not an option.

4.2.2.2 In-Tank Static Liquid Level Monitoring

Due to low volumes of waste in the C-200-series tanks, estimated retrieval duration, and operational approach to minimizing free liquids, a free liquid surface will not be present for any appreciable time and no in-tank static liquid level monitoring is planned in the SSTs.

A direct Enraf™[2] level-sensing instrument will be used in tank AN-106, the receipt tank for waste retrieved from the C-200-series tanks. This instrumentation has a high degree of resolution and repeatability and is well suited for the volumetric method in tanks with a measurable air-liquid interface.

4.2.2.3 In-Tank Dynamic Mass Balance (During Operation)

As good engineering practice, process control data will be used to compare liquid added to liquid removed from the tank. A running total of volume of liquid added to the tank and dilution water added for transfer conditioning will be compared to the liquid fraction of the waste pumped into the transfer line to reveal a gross deficit due to possible leakage.

Static level detection will be used for mass balance calculations in receipt tank AN-106.
Flow meters on the vacuum retrieval system transfer piping will provide mass balance input from the C-200-series tanks.

4.2.2.4 Leak Detection In Transfer Lines and Pits

Liquid waste and slurries will be transferred from the C-200-series tanks to tank AN-106 using temporary hose-in-hose over ground transfer lines and existing valve pits. Leak detectors located in the tank AN-106 waste receipt pit will be monitored in the C-200-series waste retrieval control trailer. The WRS will shut down if a leak is detected in the transfer system.

Leakage from the primary over ground transfer hose (inner hose) will be contained by the secondary confinement system (outer hose) and detected by one of the leak detectors.
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.

4.2.2.5 Leak Detection In the Receiver Double-Shell Tank

Tank AN-106 is selected as the receiver DST for waste from the C-200-series tanks. A leak from the primary vessel is detected by either a conductivity probe leak detection system installed in the annulus or a continuous air monitor that detects airborne radionuclides entrained in the

[2] EnrafTM-Nonius Series 854 is a trademark of Enraf-Nonius, N. V. Verenigde Instrumentenfabricken Enraf-Nonius CORPORATION NETHERLANDS Rontegenweg 1 Delft NETHERLANDS

annulus ventilation exhaust stream. Detection of a leak into the annulus of the tank by either system activates an audible alarm and an annunciator panel light.

The tank annulus is designed to collect and direct waste that leaks from the primary tank to the annulus for detection and transfer. Slots cut in the insulating concrete that supports the tank at the bottom are designed to drain any leakage to the leak detection pit. Conductivity probe assemblies in the leak detection pit along with radiation monitors on the annulus ventilation system are installed to detect tank leaks.

4.3 OPERATING STRATEGY

The operating strategy for performing LDM and retrieval applies before, during, and after waste retrieval as described below. The strategy is consistent with the current level and maturity of the C-200-series tank WRS design, as well as consistent with the F&R established in this document.

4.3.1 Leak Detection and Monitoring Operations

Before initiating waste retrieval operations a visual assessment of in-tank conditions will be performed using the in-tank camera. Additionally, baseline conditions (e.g., volume) within the receipt DST will be established to support mass balance calculations.

During waste retrieval operations, process control data will be collected and dynamic mass balance performed as an indicator of a leak. If a leak is detected during waste retrieval operations, data collection activities will be continued in an effort to monitor leak rates and total leak volumes to the extent possible.

The overall waste retrieval operating strategy will consist of reducing the tank inventory and minimizing liquid additions during waste retrieval operations. Process control parameters will be monitored to track liquid inventories while waste is actively being retrieved. The strategy for leak detection at tank AN-106 involves static level monitoring for gross mass balance to assess transfer line integrity and utilizing DST annulus leak detection systems. This approach represents deployment of the best available technology in these tanks.

4.3.2 Leak Mitigation Operations

If a leak is indicated during waste retrieval operations, actions defined in operating procedures will be implemented. The first response to an indication of a potential leak will be to perform a leak assessment in accordance with the process control plan. 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 Ecology and others in accordance with *Environmental Notification* (TFC-ESHQ-ENV_FS-C-01).
Any response will consider the potential risk associated with the leak as described in Section 2.0, the estimated leak rate, and the estimated time required to complete waste retrieval. For example the response action to a small volume slow leak discovered near the end of waste retrieval may be to continue retrieving waste and finish as soon as possible. Potential response actions include the following:

- Modify leak monitoring (e.g., implementing more frequent in-tank mass balance)
- Modify waste retrieval operating conditions
- Discontinue adding liquids
- Stop all C-200-series waste retrieval operations
- Continue waste retrieval operations.

The response actions would then be implemented and, if appropriate, waste retrieval operations would continue under modified procedures through the completion of the waste retrieval activities. The requirements for implementation of leak response actions during waste retrieval operations will be established in the process control plan that will be developed concurrent with the design of the waste retrieval and LDM system.

4.3.3 Waste Retrieval Operations

The overall waste retrieval operating strategy will consist of reducing the tank waste inventory and minimizing liquid additions during waste retrieval operations. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tank. Water will be used in limited quantities as necessary for waste conveyance and transfer line flushing.

During normal operations, the composite rate of removal from the tank on average will exceed the rate of water introduction. The composite material removed will consist of both mobilized tank waste and water used to affect mobilization. Maintaining a higher pumping rate out of the tank is integral to minimizing the liquid that escapes from the area immediately local to the vacuum suction inlet. The increased leak potential associated with the addition of water will be minimized by maintaining a vacuum rate higher than the water introduction rate.

5.0 REFERENCES

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

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

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

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

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*, Revision 0, Office of River Protection, Department of Energy, Richland, Washington, August 2001.

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

GJO-HAN-18, 1998, *Hanford Tank Farms Vadose Zone: C Tank Farm Report*, U.S. Department of Energy, Grand Junction Project Office, Grand Junction, Colorado.

HNF-5183, 2000, *Tank Farms Radiological Control Manual (TFRCM)*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-EP-0182, 2003, *Waste Tank Summary Report for Month Ending June 30,, 2003*, Rev. 183, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-IP-0842, 2002, *RPP Administration*, "Environmental Air Quality," Volume 6, Section 1.7, Rev. 0b, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-IP-1266, 2000, *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-TRD-007, 2002, *System Specification for the Double-Shell Tank System*, 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.

HNF-SD-WM-TI-707, 2003, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Rev. 3, U.S. Department of Energy, Richland, Washington.

PNNL-13024, 2003, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, ICN-3, Pacific Northwest National Laboratory, Richland, Washington.

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

RPP-7012, 2000, *Annual Progress Report on the Development of Waste Tank Leak Monitoring/Detection and Mitigation Activities in Support of M-45-08 (TPA Milestone M-45-09E Fiscal Year 2000 Progress Report)*, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13033, 2003, *Tank Farms Documented Safety Analysis*, 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-14075, 2003, *Specification for the 241-C-200 Series Waste Retrieval System*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14302, 2003, *Hanford Tank Waste Operations Simulator (HTWOS) Model Run Results for the Integrated Mission Acceleration Plan (IMAP) Unconstrained Case*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14627, 2003, *Characteristics of Waste in the C-200 Series of Hanford Underground Waste Tanks*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15230, 2003, *C-200 Series Tanks Retrieval Leak Detection, Monitoring, and Mitigation Strategy White Paper*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15408, 2003, *Origin of Wastes in C-200-Series Single-Shell Tanks*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-16616, 2004, *Component Closure Action Data Quality Objectives for the C-200 Series Tanks*, Rev. 1 Draft, CH2M HILL Hanford Group, Inc., Richland Washington.

RPP-16945, 2004, *Process Control Plan for the 241-C-200 Series Waste Retrieval System*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-18811, 2004, *C-100-Series Tanks Waste Retrieval Functions and Requirements*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-19071, 2004, *Tanks C-103 and C-105 Long-Term Human Health Risk Calculations*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-19918, 2004, *Evaluation of Liquid Losses Noted in The 241-C-200 Series Tanks in the Early 1980s*, Draft, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20079, 2004, *Tank C-104 Long-Term Human Health Risk Calculations*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20589, 2004, *C-200-Series Tanks Long-Term Human Health Risk Calculations*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

OSD-T-151-00013, 2000, *Operating Specification for Single-Shell Waste Storage Tanks*, November 2000, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ENG-FACSOP-C-10, 2003, *Control of Dome Loading*, Rev. A2, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ESHQ-ENV_FS-C-01, 2003, *Environmental Notification*, Rev. A-2, 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-349, 1994, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.