S

CH2M HILL ENGINEERING CHANGE NOTICE	1a. ECN 722119 R 0
Page 1 of 2 ☒ DM ☐ FM ☐ TM	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 9-16-04
5. Originator's Name, Organization, MSIN, & Phone No. NS Cannon, COGEMA Engineering, R1-82, 376-0562		6. USQ Number No. - - - R - ☒ N/A	7. Related ECNs N/A
8. Title Tank S-109 Partial Waste Retrieval Functions and Requirements	9. Bldg. / Facility No. S-109/241-S	10. Equipment / Component ID S-109 Series Tank	11. Approval Designator EQ
12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.) RPP-18812, Rev. 1		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)

Problem: This document " Tank S-109 Partial Waste Retrieval Functions and Requirements" (RPP-18812, Rev. 1) was provided to WDOE/ORP for review and comment, as was the original intent with its production. This process resulted in comments and required changes as provided by WDOE and ORP.

Solution: This direct revision of RPP-18812, Rev. 1, "Tank S-109 Partial Waste Retrieval Functions and Requirements" to produce RPP-18812, Revision 2, will incorporate the WDOE/ORP comments and changes, as required and agreed to.

Analysis: N/A

Scope: Incorporate the WDOE/ORP comments and changes into RPP-18812, completing the primary agreement document review process.

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

This document was originally prepared for submission to ORP and the Washington Department of Ecology (WDOE) to initiate the primary agreement document review process. The WDOE/ORP review has been completed, and this revision incorporates the resulting comments from the WDOE/ORP.

USQ evaluation is not required (Block 6) as this document does not directly change field configuration or implement field operating requirements.

19. **ECN Category**

☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type

☐ Supercedure
☐ Revision

20. **Distribution**

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See Attached Distribution Sheet.			

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Page 2 of 2 ☒ DM ☐ FM ☐ TM	1b. Proj. ECN - - R

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

None

Note: All revisions shall have the approvals of the affected organizations as identified in block 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
None			

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	GP Janicek	9/22/04	Originator/Design Agent	NS Cannon	9-20-04
Resp. Engineer	~~JN Doeler~~ DH Shuford	9/23/04	Professional Engineer		
Resp. Manager	WT Thompson	9/22/04	Project Engineer		
Quality Assurance	DD Carson	9-20-04	Quality Assurance		
IS&H Engineer			Safety		
NS&L Engineer			Designer		
Environ. Engineer	FR Miera	9/22/04	Environ. Engineer		
Engineering Checker	JN Doeler	9/23/04	Other		
Other	~~DH Shuford~~ DHS		Other		
Other	Proj Manager: DW Hamilton	9/22/04	DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION		
Other	JS Schofield	9/23/04	Signature or a Control Number that tracks the Approval Signature		
Other	RE Bauer	9/23/04			
Other	CE Hanson	9/22/04	ADDITIONAL SIGNATURES		
Other	PC Miller	9/23/04			
Other					

DISTRIBUTION SHEET

To Distribution	From SST Projects	Page 1 of 1
Project Title/Work Order Tank S-109 Partial Waste Retrieval Functions and Requirements		Date September 2004 EDT No. NA ECN No. 722119 R0

Name	MSIN	Text With All Attach.	Text Only	Attach/ Appendix Only	EDT/ECN Only
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RPP-18812, Rev. 2

S-109 Partial Waste Retrieval Functions and Requirements

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Key Words: S-109, S Farm, S-109 Partial Waste Retrieval Project, S-109 Partial Waste Retrieval Functions and Requirements, Tri-Party Agreement, TPA.

Abstract: This document establishes the S-109 Tanks Waste Retrieval system specifications (including leak detection, monitoring, and mitigation system specifications), required by milestone M-45-00 of the Hanford Federal Facility Agreement and Consent Order.

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RECORD OF REVISION

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Page 1

(2) Title: Tank S-109 Partial Waste 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
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2 RS	Incorporates WDOE/ORP comments, completing the primary document review process, per ECN 721119 R0	D. Shuford ~~JN Boeler~~ DH Shuford	WT Thompson 1/22/07

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RPP-18812, Rev. 2

TANK S-109 PARTIAL WASTE RETRIEVAL FUNCTIONS AND REQUIREMENTS

July 29, 2004

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

EXECUTIVE SUMMARY

This document establishes the functions and requirements for the partial retrieval of waste stored in tank S-109 in support of a planned treatment demonstration. This tank is designated as sound and is located in the 200 West Area of the Hanford Site. The retrieval of waste from tank S-109 will integrate leak detection, monitoring, and mitigation with technologies to minimize the potential for leaks to occur during waste retrieval and the resulting leak volume should a leak occur.

The retrieval of waste from tank S-109 will occur in three separate phases:

- **Phase 1 – Salt Cake Dissolution:** 300 gallons of tank waste (dissolved in approximately 1,000 gallons of brine) will be retrieved from the tank for transfer to the Test and Demonstration Facility. A pump will be installed in the center of the tank to retrieve liquid waste. Existing saltwell brine will be mobilized and removed followed by the dissolution of salt cake waste through the controlled addition of water through the pump dilution system. Dilution water will be introduced below the waste surface at the pump intake.

- **Phase 2– Controlled Sluicing:** 200,000 to 300,000 gallons of tank waste will be retrieved using a pump and low volume sluice nozzles. Up to three remote water distribution devices will be installed to spray water onto the waste.

- **Phase 3:** The balance of the waste will be retrieved in accordance with the *Hanford Federal Facility Agreement and Consent Order*.

Waste retrieved from tank S-109 during Phase 1 and Phase 2 that meets the waste feed requirements will be sent to a permitted treatment, test, and demonstration facility. Waste retrieval from tank S-109 during Phase 1 and Phase 2 that does not meet the waste feed requirements of the treatment demonstration facility will be sent to a double-shell tank. It is estimated that as much as 30,000 gallons of waste could be sent to a double-shell tank during Phase 1. Up to 100,000 gallons of waste total could be sent to a double-shell tank during Phase 1 and Phase 2 combined. The waste acceptance criteria for the treatment demonstration facility is set at less than 0.05 Ci/L cesium-137, average solids concentration of less than 3%, and TRU concentration of less than 100 nCi/g. Based on existing waste characterization data, the cesium-137 concentration in the tank saltwell brine exceeds the waste acceptance criteria of 0.05 Ci/L for cesium-137 at the treatment demonstration facility. Following removal of the existing saltwell brine, the average cesium-137 concentration (approximately 0.006 Ci/L when normalized to 5M sodium) is expected to be well below the waste acceptance criteria. Radiation monitors along with verification sampling in the waste staging tank will be utilized to determine whether the waste is routed to the double-shell tank system or to the treatment demonstration facility.

Only Phases 1 and 2 are addressed in this document. This document will be revised or a new document prepared in the future to address retrieval of the balance of the waste in the tank during Phase 3. Partial waste retrieval during Phases 1 and 2 is a step towards tank closure; however, component closure actions for tank S-109 cannot be completed until the balance of the waste is retrieved during Phase 3.

This document establishes the functions and requirements for both the tank S-109 partial waste retrieval system and the leak detection, monitoring, and mitigation system. The specifications are based on the waste retrieval technologies best suited to the specific tank conditions and leak detection and monitoring technologies that are consistent with the waste retrieval technologies. The functions and requirements also consider human health risks associated with the tank waste and potential waste volumes that could leak during retrieval.

The waste retrieval systems planned for deployment during Phase 1and Phase 2 will control the volumes of water added and the location to limit the potential for leakage to occur and to limit the resulting volumes if a leak were to occur. Drywell monitoring will be used as the primary leak detection method during Phase 1. High-resolution resistivity will be deployed as the primary leak detection and monitoring method during Phase 2.

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LIST OF TERMS

BBI	best-basis inventory
CH2M HILL	CH2M HILL Hanford Group, Inc.
DBVS	Demonstration Bulk Vitrification System
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
F&R	functions and requirements
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HIHTL	hose-in-hose transfer line
HRR	high-resolution resistivity
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
REDOX	Reduction-Oxidation Extraction (Plant)
SST	single-shell tank
TDF	Test and Demonstration Facility
WRS	waste retrieval system
WMA	waste management area

1.0 INTRODUCTION

The River Protection Project mission includes storage, retrieval, immobilization, and disposal of 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 developing supplemental technologies that, if proven through demonstration testing, could be used to supplement low-activity waste treatment capabilities at the Waste Treatment Plant. The details of the demonstration test are provided in *Research, Development, and Demonstration Permit Application for Bulk Vitrification Test Demonstration Facility* (DOE/ORP-2003-23). Tank S-109, located in the 200 West Area (Figure 1), is a tank that has been selected for partial waste retrieval. This tank was selected for partial retrieval because a portion of the waste in the tank meets the waste feed requirements of the waste treatment technology demonstration.

The treatment of the Hanford tank waste is required under the *Hanford Federal Facility Agreement and Consent Order* (HFFACO; Ecology et al. 1989) signed by the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency, and DOE in accordance with HFFACO Milestone M-62-00, which calls for completion of pretreatment processing and vitrification of Hanford high-level and low-activity tank wastes by December 31, 2028.

Full retrieval of waste from tank S-109 will occur in three separate phases:

- **Phase 1 – Salt Cake Dissolution:** Approximately 300 gallons of tank waste (dissolved to approximately 1,000 gallons of brine) for each container that is processed will be retrieved from the tank for transfer to the Test and Demonstration Facility (TDF).
- **Phase 2 – Controlled Sluicing:** 200,000 to 300,000 gallons of tank waste will be retrieved using a pump and low volume sluice nozzles.
- **Phase 3** – The balance of the waste in tank S-109 will be retrieved in accordance with the HFFACO.

Only Phases 1 and 2 are addressed in this document. The waste retrieval systems (WRSs) planned for deployment during Phase 1 and Phase 2 are described in Section 4.2.. This document will be revised or a new document prepared in the future to address retrieval of the balance of the waste in the tank during Phase 3.

Waste retrieved from tank S-109 during Phase 1 and Phase 2 that does not meet the waste feed requirements of the treatment demonstration facility will be sent to a double-shell tank (DST). Based on current estimates, up to 100,000 gallons of waste from tank S-109 could be sent to the DST system during Phase 1 and Phase 2 combined. This value could go up or down by a factor of 2.5 based on modeling and flowsheet development efforts (*Supplemental Treatment Test and Demonstration Facility Process Flowsheet* [RPP-20528]).

Water will be added to tank S-109 during both Phase 1 and Phase 2 waste retrieval campaigns. At the completion of Phase 2 retrieval, the liquid volume remaining in the tank will be pumped

out to ensure that the tank contains less than 50,000 gallons of drainable interstitial liquid and less than 5,000 gallons of supernate.

The tank S-109 partial WRS will interface with the TDF as defined in *Demonstration Bulk Vitrification Specification* (RPP-17403). Additional information on the supplemental treatment demonstration and relationship to the tank S-109 WRS is provided in DOE/ORP-2003-23.

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 WRS requirements.

The major elements of the document consist of the following:

- Long-term human health risk from potential releases (Section 2.0)
- Upper-level functions and requirements (F&R) for the WRS (Section 3.0)
- Description of the WRS and operating strategy (Sections 4.2.1 and 4.3.3)
- Description of the planned approach for LDMM (Section 4.0).

Source, special nuclear, and byproduct materials, as defined in the *Atomic Energy Act of 1954*, are regulated at DOE facilities exclusively by DOE acting pursuant to its *Atomic Energy Act of 1954* authority. These materials are not subject to regulation by the State of Washington under the Washington State "Hazardous Waste Management Act," the federal Resource Conservation and Recovery Act, or any other relevant provision of law. Where information regarding processing, packaging, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*, as amended) has been incorporated into this F&R document, it is not incorporated for the purpose of regulating the radiation hazards of such components, but is only presented for general knowledge in support of project discussion.

1.1 PURPOSE

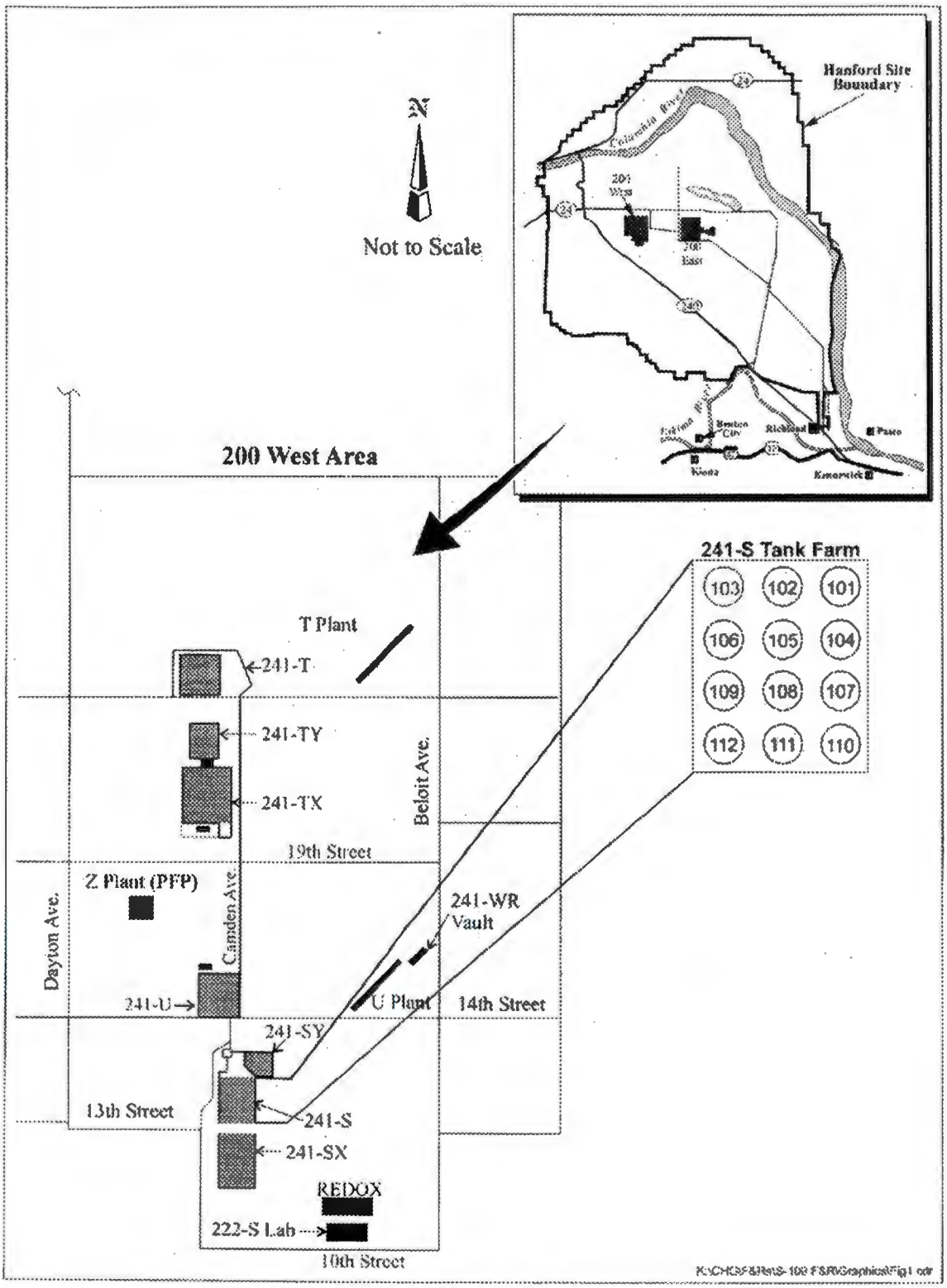
This document provides the F&R necessary to institute proper regulatory control of the design and waste retrieval implementation activities associated with the WRS for tank S-109 partial waste retrieval. This document also provides a preliminary waste retrieval and LDMM strategy compatible with the F&R. The strategy combines best available leak detection and monitoring (LDM) methods with an operational strategy designed to reduce the potential for leaks to occur during waste retrieval 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 waste retrieval.

1.2 SCOPE

This document will establish the following:

- Waste retrieval F&R
- LDMM strategy
- Waste retrieval strategy for tank S-109.

Figure 1. Location Map of S Tank Farm and Surrounding Facilities in the 200 West Area



Approval of this document will enable completion of the Phase 1and Phase 2 WRS design for tank S-109.

The F&R identified in this document provide the foundation for the design criteria and design requirements documented in *System Specification for the Tank S-109 Waste Retrieval System for Supplemental Treatment Demonstration* (RPP-18632). System specifications are used to communicate requirements that appropriately bound and constrain an item. The content of the system specifications will 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. The system specification for tank S-109 will be consistent with this F&R document.

1.3 CURRENT TANK CONDITIONS

Tank S-109 was constructed between 1950 and 1951, and was put into service in the fourth quarter of 1952. Tank S-109 is one of twelve 100-series single-shell tanks (SSTs) in the S farm. Tank S-109 is the third tank in a three-tank cascade. The tank is constructed with a dish-shaped bottom 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 carbon steel. Tank S-109 is 75 feet in diameter and has a capacity of 758,000 gallons (*Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area* [HNF-SD-WM-ER-352]).

As of June 2003, tank S-109 contained approximately 533,000 gallons of waste consisting of 520,000 gallons of salt cake including 16,000 gallons of interstitial salt cake liquid and 13,000 gallons of sludge. Specific volumes and constituents currently stored in tank S-109 are presented in Table 1. Average and action level concentrations for chemical constituents in the salt cake waste are provided in Table 2. If the waste feed is at or above the action level concentrations further evaluation would be performed before processing. Tank S-109 is presently passively ventilated. Tank S-109 tank is categorized as "sound" (*Waste Tank Summary Report for Month Ending June 30, 2003* [HNF-EP-0182]; *Supporting Document for the Historical Tank Content Estimate for S-Tank Farm* [HNF-SD-WM-ER-323]).

Figure 2 shows a plan view of tank S-109 showing the risers and their current contents.

The top of the tank dome is approximately 8 feet below grade and the tank bottom is approximately 45 feet below grade, as shown in Figure 3. The tank is 75 feet in diameter with a storage capacity of 758,000 gallons.

Tank S-109 was constructed to store waste from the Reduction-Oxidation Extraction (REDOX) Plant. Primary additions to the tank consisted of REDOX high-level waste, REDOX cladding waste, water, REDOX salt cake, and partial neutralized feed (HNF-SD-WM-ER-352).

Table 1. Tank S-109 Waste Volume and Inventory Summary

Tank S-109 Waste Type	Volume (gallons)
Salt cake	520,000 including 16,000 interstitial liquid
Sludge	13,000
Total waste	533,000
Waste Inventory	**Units as noted**
Cs-137	47,600 Ci (21,700 Ci in SC solid, 19,200 Ci in SC liquid, and 6,750 Ci in sludge)
Sr-90	60,500 Ci (15,100 Ci in SC solid, 16.4 Ci in SC liquid, and 45,400 Ci in sludge)
Tc-99	313 Ci (294 in SC solid, 19.1 Ci in SC liquid, and 0.797 Ci in sludge)
C-14	65.3 Ci (63.1 Ci in SC solid, 2.03 Ci in SC liquid, and 0.114 Ci in sludge)
I-129	0.6 Ci (0.566 Ci in SC solid, 0.0368 Ci in SC liquid, and 0.0015 Ci in sludge)
Pu-238, -239, -240, -241	147 Ci (26.8 Ci in SC solid, 0.0062 Ci in SC liquid, and 120 Ci in sludge)
Sodium	1,700,000 lb (1,650,000 in SC solid, 30,400 lb in SC liquid, and 20,000 lb in sludge)
Nitrate/Nitrite	4,279,000 lb (4,222,000 lb in SC solid, 30,100 lb in SC liquid, and 27,100 lb in sludge)

SC = salt cake.

Table 2. Chemical Constituents in Average Tank 241-S-109 Salt Cake Waste

Constituent/Contaminant	Average Salt Cake Normalized to 5 M Na* (µg/ml)	Action Level Concentration in 5 M Na** (µg/ml)
Aluminum	1,300	12,000
Calcium	49	13,000
Chloride	270	8,500
Total Chromium	770	7,600
Fluoride	110	17,000
Iron	270	13,000
Potassium	170	15,000
Manganese	8	13,000
Nickel	6	13,000
Nitrite	3,000	***
Nitrate	290,000	***
Lead	29	7,700
Phosphate	5,500	27,000
Silica	160	****
Sulfate	3,700	8,000
Total Inorganic Carbon as CO_3	11,000	***
Total Organic Carbon	320	***
Total Uranium	28	14,000

*The composition is based on the salt cake portion of the Tank 241-S-109 Best-Basis Inventory (BBI 2001; as reported in TWINS), normalized to 5 M Na (115,000 µg/ml).

**Concentrations at or above these values require further evaluation before processing.

*** No limit- destroyed or removed in the vitrification process.

**** No limit – high –Si waste will increase glass performance

Figure 2. Tank S-109 Plan View

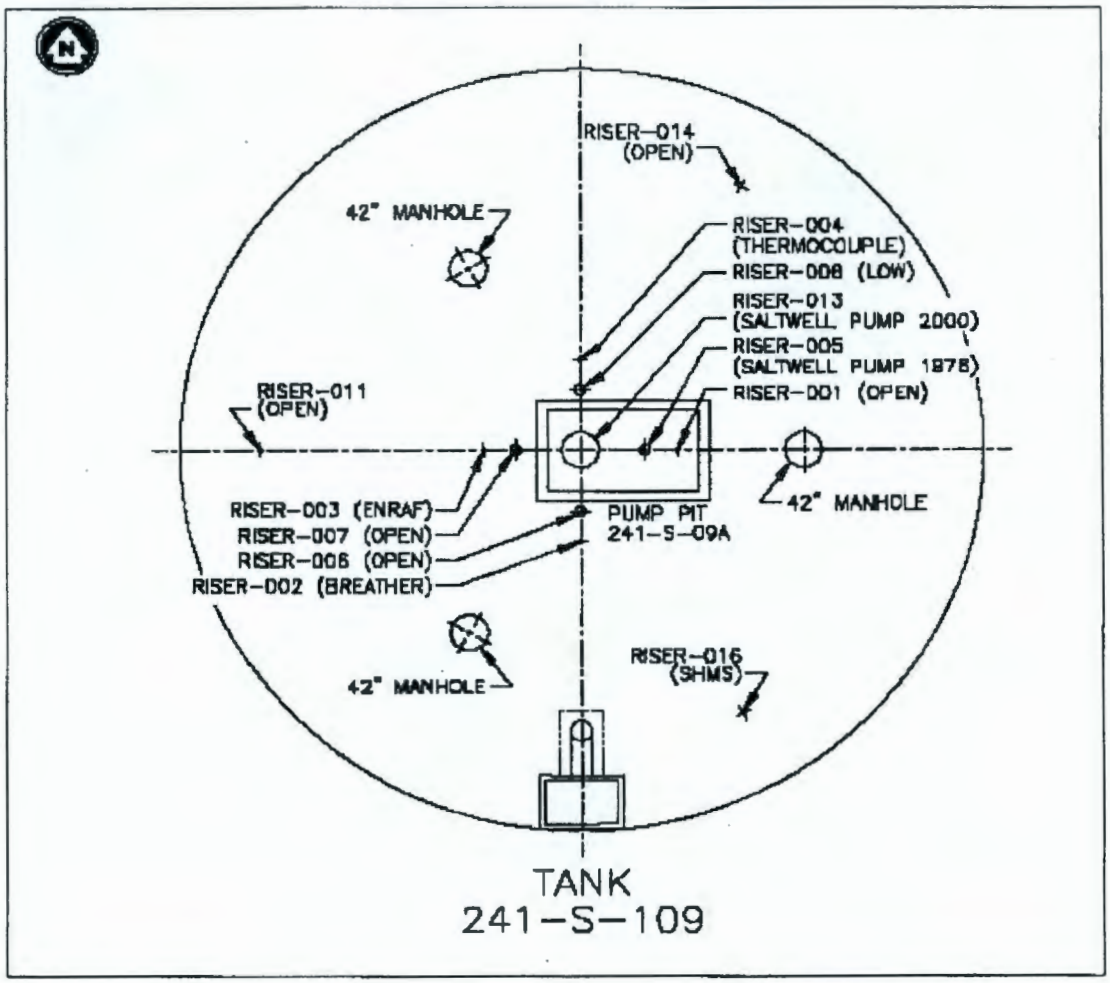


Figure 3. Tank S-109 Cross-Section Sketch

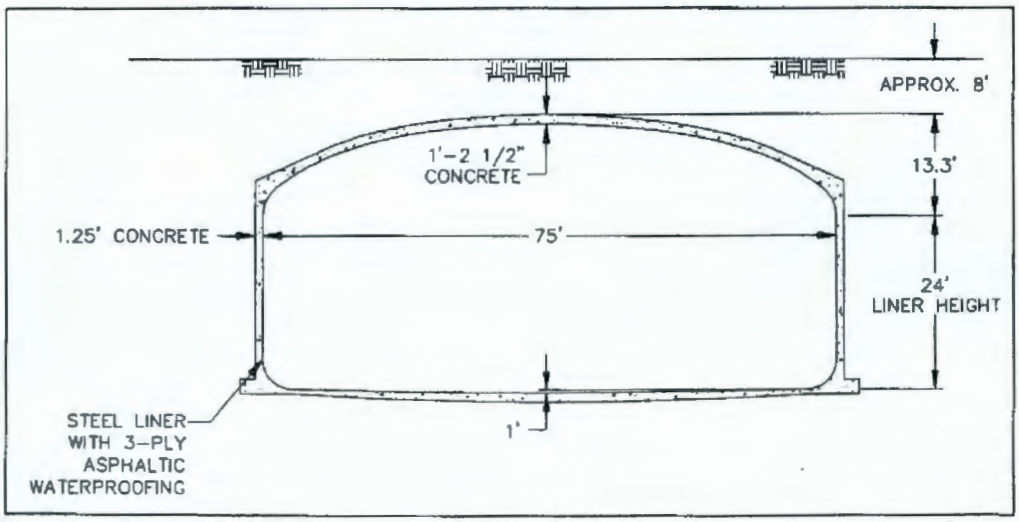


Figure 4 provides a plan view of waste management area (WMA) S-SX and the surrounding *Resource Conservation and Recovery Act of 1976* groundwater monitoring wells. Groundwater monitoring is currently performed on a quarterly basis in accordance with the *Resource Conservation and Recovery Act of 1976* monitoring plan (*RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site* [PNNL-12114-ICN-2]). There are no plans to modify the existing groundwater monitoring activities as a part of the tank S-109 waste retrieval activities. Ongoing groundwater monitoring will provide defense-in-depth to leak detection from the tanks. Groundwater monitoring will not be used as a process control parameter for leak detection during waste retrieval operations. There are a number of drywells surrounding the 100-series tanks in the S tank farm (Figure 5). Use of the drywells during tank S-109 waste retrieval is discussed in Section 4.0.

1.4 RELATED PERMITTING ACTIVITIES

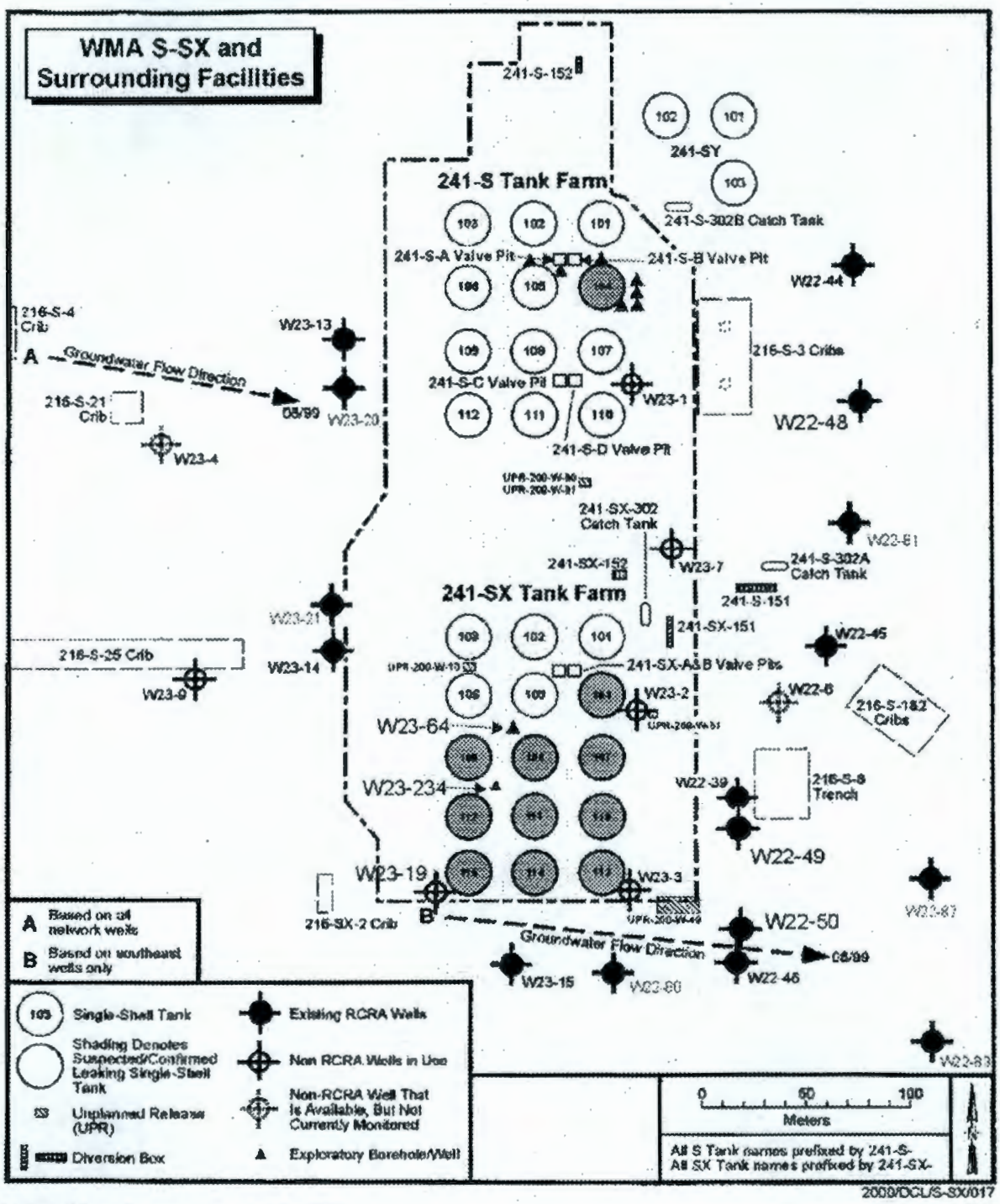
The retrieval and treatment of waste from tank S-109 requires regulatory approvals through the state of Washington departments of Health and Ecology. In addition to this F&R document, regulatory approvals for the waste retrieval, treatment demonstration, temporary storage, and disposal are being requested from the state of Washington through the following:

- *Research, Development, and Demonstration Permit Application for Supplemental Treatment and Demonstration Facility* (DOE/ORP-2003-23)
- "Radioactive Air Emissions Notice of Construction (NOC) Application for Categorical Tank Farm Facility Waste Retrieval and Closure: Phase I – Site Preparation and System Installation" (Schepens 2003a)
- "Radioactive Air Emissions Notice of Construction (NOC) Application for Categorical Tank Farm Facility Waste Retrieval and Closure: Waste Retrieval Operations" (Schepens 2003b)
- "Approval of Criteria and Toxics Air Emissions, Categorical Notice of Construction Application for Operations of Waste Retrieval Systems in Single-Shell Tank Farms" (Schepens 2004).

2.0 RISK BASIS

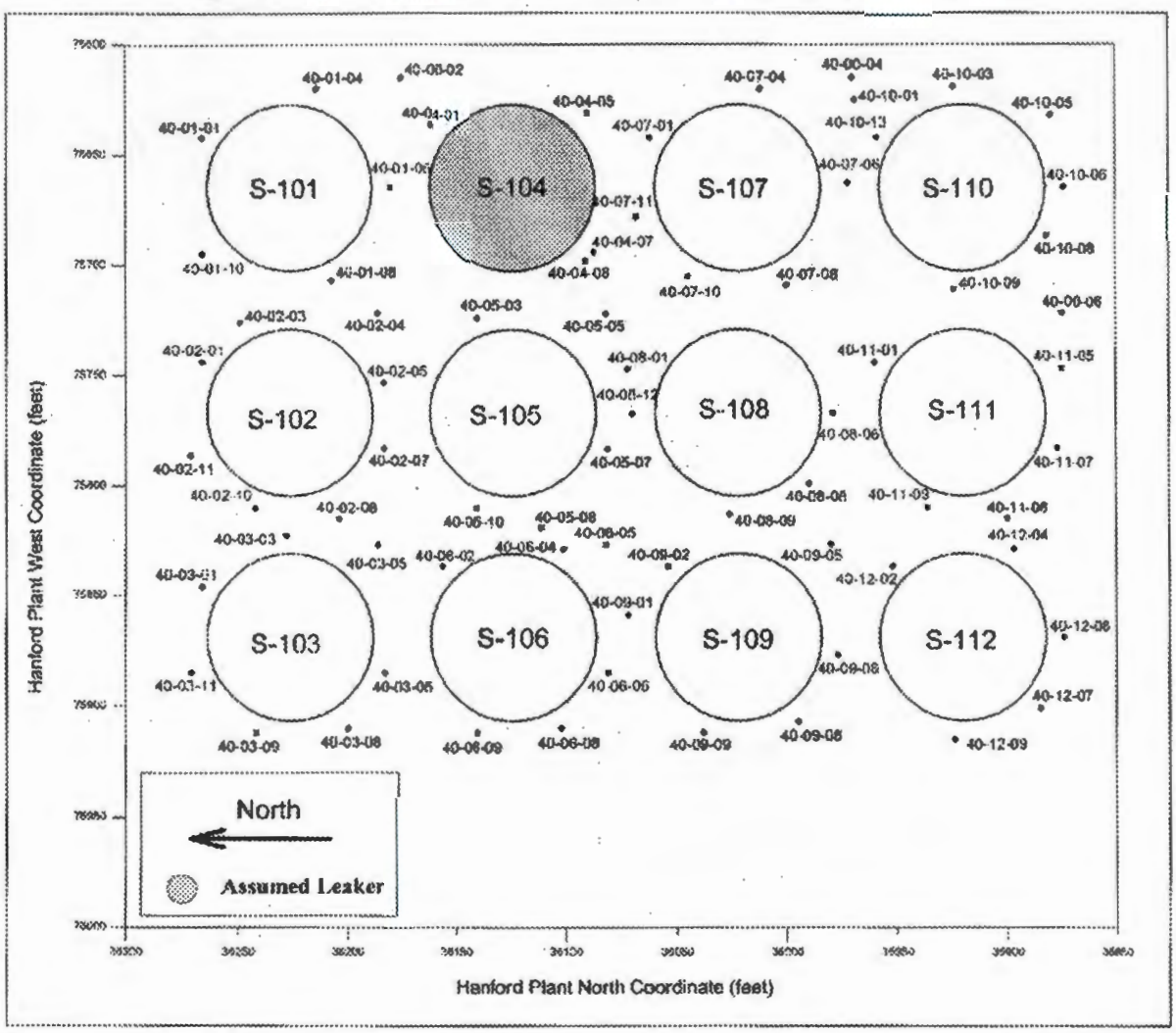
This section presents the results of a preliminary evaluation of the long-term human health risks associated with waste in tank S-109 and potential leaks that could occur during waste retrieval to support the TDF. The need to consider long-term human health risks in developing waste retrieval F&R was 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.

Figure 4. Waste Management Area S and Regulated Structures



Note: All wells are preceded by 299-.

Figure 5. Plan View of the S Tank Farm Showing Drywells



Source: GJO-HAN-17.

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 *Tank S-109 Long-Term Human Health Risk Calculations* (RPP-19136).

2.1 METHODOLOGY

The tank S-109 partial waste retrieval is intended to support technology demonstration and not tank closure. Because the scope of this F&R document is limited to partial waste retrieval associated with Phase 1 and Phase 2, only the risks associated with tank S-109 potential retrieval leakage are addressed. Evaluation of the risk associated with tank S-109 residual waste, the risk from inadvertent post-closure human intrusion into tank S-109, and the risk associated with other S farm tanks, will be provided in the documentation prepared in support of the final tank S-109 waste retrieval.

The main elements of the approach used for this evaluation 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 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.

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

Where:

i = indicator contaminant
R_i = risk metric (ILCR or HI)
I_i = inventory (Ci or kg released into the environment [e.g., retrieval leakage])
T_i = transport transfer function (pCi/L per Ci or mg/L per kg)
H_i = health effects conversion factor (ILCR per pCi/L or HI per mg/L).

Sections 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

The tank S-109 risk basis was developed using indicator contaminant impacts rather than total impacts from all tank S-109 waste contaminants. This approach was used primarily to ensure that the resulting graphical tools would be sufficiently simple to facilitate rapid decision making during waste retrieval. An indicator contaminant is the contaminant estimated to make the largest contribution to the total impact.

Two indicator contaminants, one for each of the impact metrics used (radiological ILCR and noncarcinogenic chemical HI), were selected based on the results of a screening procedure. Nonradiological ILCR was included in the screening procedure for information purposes but was not carried forward to the evaluation (i.e., was not used to develop a graphical tool). A summary of the screening procedure results is shown in Tables 3 through 5.

Table 3. Radionuclide Indicator Contaminant Screening Results

Contaminant of Concern	Inventory in 8,000 gal Retrieval Leak*		Peak ILCR		Percentage of Total ILCR	
	Units	Tank S-109	Industrial	Residential	Industrial	Residential
Carbon-14	Ci	2.96E-01	6.44E-05	4.65E-04	9.53	3.28
Selenium-79	Ci	3.96E-03	4.04E-06	2.08E-05	0.60	0.15
Technetium-99	Ci	1.42E+00	5.50E-04	1.34E-02	81.44	94.49
Iodine-129	Ci	2.74E-03	5.69E-05	2.95E-04	8.43	2.08
Total			6.75E-04	1.42E-02	100.00	100.00

* Calculated based on data and recommendations in DOE/ORP-2003-02.

ILCR = incremental lifetime cancer risk.

Table 4. Noncarcinogenic Chemical Indicator Contaminant Screening Results

Contaminant of Concern	Inventory in 8,000 gal Retrieval Leak[a]		Peak HI		Percentage of Total HI	
	Units	Tank S-109	Industrial	Residential	Industrial	Residential
Nitrate	kg	8.70E+03	2.10	13.53	17.32	17.77
Nitrite	kg	2.03E+03	7.86	50.58	64.83	66.42
Chromium VI[b]	kg	1.77E+02	2.17	12.03	17.85	15.80
Total			1.21E+01	7.61E+01	100.00	100.00

[a] Calculated based on data and recommendations in DOE/ORP-2003-02.

[b] Chromium inventory conservatively assumed to be entirely hexavalent chromium.

HI = hazard index.

Table 5. Carcinogenic Chemical Indicator Contaminant Screening Results

Contaminant of Concern	Inventory in 8,000 gal Retrieval Leak[a]		Peak ILCR		Percentage of Total ILCR	
	Units	Tank S-109	Industrial	Residential	Industrial	Residential
Chromium VI	kg	1.77E+02	1.35E-05	3.01E-05	100.00	100.00
Total			1.35E-05	3.01E-05	100.00	100.00

[a] Calculated based on data and recommendations in DOE/ORP-2003-02.
[b] Chromium inventory conservatively assumed to be entirely hexavalent chromium.
ILCR = incremental lifetime cancer risk.

Technetium-99 makes the largest contribution to the estimated total radiological ILCR and was therefore selected as the indicator contaminant for radiological ILCR. Technetium-99 contributed approximately 81% of the total radiological ILCR for the industrial scenario and approximately 94% for the residential scenario (Table 3).

Nitrite makes the largest contribution to the estimated total HI and was therefore selected as the indicator contaminant for noncarcinogenic chemical HI. Nitrite contributed approximately 65% of the total HI for the industrial scenario and approximately 66% for the residential scenario (Table 4).

Hexavalent chromium was evaluated for nonradiological ILCR (Table 5). A total of 24 nonradiological chemicals are reported in the best-basis inventory (BBI) (TWINS 2001), but of these only hexavalent chromium has a published cancer slope factor. Cancer risks from radionuclides (Table 3) and carcinogenic chemicals (Table 5) typically are not summed because of differences in how risk is estimated for these two categories of substances. Hexavalent chromium ILCR was estimated for information purposes to provide an indication of the potential magnitude of nonradiological ILCR for tank S-109 retrieval leakage. Because it is based on only one contaminant, nonradiological ILCR was not carried forward as a separate evaluation metric.

Note that hexavalent chromium is classified as both a toxicant and a carcinogen. It is toxic via ingestion and inhalation but carcinogenic only via inhalation. The inhalation intake for the groundwater pathway exposures is based on resuspended soil and volatilized water. The soil is assumed to be contaminated by irrigation with contaminated groundwater. Water volatilization is assumed to occur during showering. Detailed discussion of exposure scenario pathways and parameters is provided in *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment* (HNF-SD-WM-TI-707).

Calculation detail for the screening procedure is provided in RPP-19136. The procedure involved analysis of a hypothetical 8,000-gallon retrieval leak from tank S-109. The selection of the 8,000-gallon retrieval leak value was based on maintaining consistency between F&R documents and with previous evaluations of retrieval leakage. The 8,000-gallon value was used for informational purposes and is not intended to represent an anticipated leak volume or a leak detection limit.

The contaminants included in the screening procedure were mobile long-lived contaminants of concern that have been show to contribute significantly to peak long-term groundwater pathway human health impacts in previous tank farm studies (e.g., *Retrieval Performance Evaluation Methodology for the AX Tank Farm* [DOE/RL-98-72], *Single-Shell Tank S-112 Full Scale Saltcake Waste Retrieval Technology Demonstration Functions and Requirements* [RPP-7825], *Field Investigation Report for Waste Management Area S-SX* [RPP-7884], *Field Investigation Report for Waste Management Area B-BX-BY* [RPP-10098]).

Contaminant-specific ILCR and HI values were calculated using Equation 1. The contaminant-specific values were then summed to obtain the total ILCR and HI values. Contaminant-specific inventories, transport transfer functions, and health effects conversion factors used for the screening calculations were developed as described in Sections 2.1.2 through 2.1.4.

Although the tank S-109 risk information provided in this F&R document was developed using only the impacts from the two indicator contaminants, the total radiological ILCR and noncarcinogenic chemical HI values can be estimated from the indicator contaminant values by applying the contaminant contribution percentages shown in Tables 3 and 4. For example, an estimate of the total radiological ILCR can be made by multiplying the technetium-99 ILCR by 1/0.81 or 1/0.94 for the industrial and residential scenarios, respectively. Likewise, an estimate of the total HI can be made by multiplying the nitrite HI by 1/0.65 or 1/0.66 for the industrial and residential scenarios, respectively.

2.1.2 Inventory

Contaminant inventories (shown in Tables 3 through 5) were calculated based on the data and recommendations in *Inventory and Source Term Data Package* (DOE/ORP-2003-02). That document provides estimates of contaminant inventories associated with potential residual waste but not potential retrieval leaks. Section 6.4.2 of that document recommends that contaminant inventories associated with potential retrieval leaks be calculated by assuming that the contaminant concentrations in fluids leaked during retrieval would be the same as the contaminant concentrations in the final residuals remaining in the tank after retrieval. Accordingly, the tank S-109 retrieval leak fluid was assumed to have the same waste composition as the final tank residuals given in DOE/ORP-2003-02, Table A.2.

DOE/ORP-2003-02, Table A.2 provides estimated inventories associated with potential residual waste volumes of 360 cubic feet (2,700 gallons). Different inventory data sets are given for different assumed retrieval methods. For conservatism, the value used was taken from either the Selected Phase Retention data set (representative of dry retrieval methods) or the Hanford Tank Waste Operation Simulator modeling data set (representative of fluid-based retrieval methods), which ever was larger.

The tank S-109 retrieval leak fluid concentrations were calculated by dividing the DOE/ORP-2003-02, Table A.2 residual waste inventory values by the residual waste volume of 2,700 gallons. The retrieval leak inventories were then calculated as the product of the retrieval leak fluid concentrations and the assumed retrieval leak volume. A hypothetical retrieval leak volume of 8,000 gallons was used for informational purposes. This volume was used 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 tank S-109 partial waste retrieval.

The DOE/ORP-2003-02, Table A.2 inventories were derived from pre-retrieval inventories reported in the BBI. There is uncertainty associated with the inventories reported in the BBI. The uncertainty associated with the BBI inventories for the tank S-109 contaminants shown in Tables 3 through 5 is currently not reported in the BBI on a total inventory basis. However, for nitrate, nitrite, and chromium the uncertainty is reported by waste phase. No relative standard deviations are reported in the BBI for other tank S-109 contaminants of concern. For technetium-99 relative standard deviations are reported for the sludge (which is less than 10% of the total) but not for the salt cake.

The relative standard deviation for nitrate is reported as 11.6% for salt cake liquids, 9.7% for salt cake solids, and, 243% for sludge. The relative standard deviation for nitrite is reported as 7.9% for salt cake liquids, 11.8% for salt cake solids, and 228% for sludge. The relative standard deviation for chromium is reported as 9.8% for salt cake liquids, 19.8% for salt cake solids, and 237% for sludge. Because the long-term risk estimates vary directly with inventory, the inventory uncertainty would be expected to contribute to the uncertainty in the estimates for long-term risk.

The maximum volume of waste that could leak during the tank S-109 partial waste retrieval is uncertain. This uncertainty is tied to the ability of the WRS to dissolve sufficient salt cake to support the TDF while also limiting the volume of water added to the tank. The intent of the tank S-109 partial retrieval operational strategy is to minimize the amount of drainable liquid in the tank during waste retrieval operations. The water volumes added will vary depending on waste make-up and retrieval effectiveness. The operational strategy is to minimize the retrieval leak potential by pumping dissolved waste and released interstitial liquids from a center pool, thus minimizing the amount of liquid that comes in contact with the tank walls.

2.1.3 Contaminant Transport Transfer Functions

For this screening-level assessment, contaminant transport calculations were not performed. Rather, the effects of contaminant release and transport were taken from the results of the WMA S-SX groundwater impacts analysis presented in RPP-7884. The RPP-7884 analysis represents the most sophisticated assessment of long-term groundwater impacts currently available for the S tank farm.

The RPP-7884 analysis included a comprehensive field investigation of past tank waste loss events in WMA S-SX and a series of computer simulations of the future groundwater impacts from those past releases. Impacts from potential retrieval leaks and residual waste were not included. The simulations were performed for the vadose zone inventories associated with one waste loss event in the S tank farm (at tank S-104) and five waste loss events in the SX tank farm (at tanks SX-107, SX-108, SX-109, SX-113, and SX-115).

The RPP-7884 analysis included numerical simulations for 13 individual study cases, including the effect of an interim surface barrier, different recharge rates, and the initial distribution of contaminants in the vadose zone. Two-dimensional cross-sectional models were used to model

vadose zone flow and transport. Three mobile contaminants of concern, technetium-99, hexavalent chromium, and nitrate, were directly included in the simulations.

The RPP-7884 simulations started in the year 2000 and used initial contaminant distributions in the vadose zone derived from the results of the field investigation and an inventory data evaluation. The simulations did not attempt to simulate the actual waste loss events. A period of 1,000 years was simulated based on *Phase I RCRA Facility Investigation/Corrective Measure Study Work Plan for Single-Shell Tank Waste Management Areas* (DOE/RL-99-36). The simulations all assumed a final closure barrier was in place by 2040. The modeling focused primarily on the impacts to groundwater at the WMA S-SX boundary. Additional analysis points at the 200 West Area fence, 200 Area exclusion zone boundary, and the Columbia River were also included.

For the RPP-7884 base case, the estimated arrival time of the peak concentration for technetium-99 at the WMA S-SX boundary was 2046. Arrival times for the peak concentrations for chromium and nitrate were projected to be similar to those for technetium-99, with the differences being primarily due to the initial inventory distributions. Cesium-137 was included in the simulations but was projected not to reach the water table during the assessment period because of its retardation factor and radioactive decay.

For the tank S-109 evaluation, proportionality coefficients called transport transfer functions were developed from the RPP-7884 analysis results and used in lieu of performing additional contaminant transport calculations. Transfer functions were calculated for each of the RPP-7884 simulated contaminants (technetium-99, hexavalent chromium, and nitrate) as shown in Tables 6 through 8 by dividing the simulated peak groundwater concentrations at the tank farm fenceline by the inventories released at the source. Transfer functions derived from the RPP-7884 analysis results were considered appropriate for use in estimating groundwater impacts from ex-tank waste (past leaks, potential retrieval leaks). The transfer functions shown in Tables 6 through 8 would not be appropriate for use with in-tank waste (tank and ancillary equipment residuals).

Table 6. Technetium-99 Ex-Tank Transport Transfer Function

Peak Technetium-99 Groundwater Concentration at S Tank Farm Fenceline from Tank S-104 Past Leak (pCi/L)[a]	Technetium-99 Inventory in Tank S-104 Past Leak (Ci)[b]	Ex-Tank Transport Transfer Function (pCi/L per Ci)
1.08×10^{5}	3.87	2.80E+04

[a] Source = RPP-7884 (Table G.3).
[b] Source = RPP-7884 (Table 3.4).

Table 7. Hexavalent Chromium Ex-Tank Transport Transfer Function

Peak Hexavalent Chromium Groundwater Concentration at S Tank Farm Fenceline from Tank S-104 Past Leak (mg/L)[a]	Hexavalent Chromium Inventory in Tank S-104 Past Leak (kg)[b]	Ex-Tank Transport Transfer Function (mg/L per kg)
2.21×10^0	7.81E+02	2.83E-03

[a] Source = RPP-7884 (Table G.3).
[b] Source = RPP-7884 (Table 3.4).

Table 8. Nitrate Ex-Tank Transport Transfer Function

Peak Nitrate Groundwater Concentration at S Tank Farm Fenceline from Tank S-104 Past Leak (mg/L)[a]	Nitrate Inventory in Tank S-104 Past Leak (kg)[b]	Ex-Tank Transport Transfer Function (mg/L per kg)
6.65×10^2	1.70E+04	3.91E-02

[a] Source = RPP-7884 (Table G.3).
[b] Source = RPP-7884 (Table 3.4).

The transfer functions were used to represent the unit contaminant concentrations in groundwater per unit inventory released at the source and were applied to the ILCR and HI calculations as shown in Equation 1 (RPP-19136). Because the RPP-7884 analysis results did not allow transfer functions to be calculated for all contaminants considered, the contaminants were grouped for purposes of this evaluation based on similarities in subsurface transport behavior.

The technetium-99 transfer function was used for technetium-99 and the other radionuclides included in the screening procedure. Likewise, the nitrate transfer function was used for both nitrate and nitrite. The chromium transfer function was used only for chromium. The nitrate transfer function was used for nitrite instead of the hexavalent chromium transfer function because it is larger and therefore provides a more conservative impact estimate.

Grouping contaminants in this fashion contributes to the uncertainty in the groundwater concentrations and associated long-term human health risk. However, the approach is consistent with that used for the RPP-7884 risk assessment and is considered reasonable because the grouped contaminants are chemically similar and are all typically simulated with zero retardation (i.e., distribution coefficients equal to 0 mL/g).

Use of the transfer functions shown in Tables 6 through 8 contributes to the uncertainty in the results of this evaluation. The transfer functions were derived from an analysis of a past tank leak but were used in this evaluation to estimate the impacts from a potential retrieval leak. It is likely that the transfer functions overestimate the impacts from retrieval leaks, primarily because the RPP-7884 past leak simulations used initial vadose zone inventory distributions rather than

simulating an actual tank leak event. Retrieval leak simulations for all S farm tanks will be included in the risk assessment provided with the WMA S-SX closure plan now in preparation.

2.1.4 Exposure Scenarios

Health impacts 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 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 nitrite in the groundwater. The conversion factor values used for this assessment are shown in Table 9.

Table 9. Health Effects Conversion Factors for Industrial and Residential Exposure Scenarios

Scenario	Technetium-99 Groundwater Unit Risk Factor (ILCR per pCi/L)	Nitrite Groundwater Unit Hazard Factor (HI per mg/L)
Industrial[a]	1.38E-08	9.89E-02
Residential[b]	3.36E-07	6.36E-01

[a] Source = HNF-SD-WM-TI-707, Rev. 3, Tables 22 and 23.
[b] Source = HNF-SD-WM-TI-707, Rev. 3, 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).

Uncertainty in the exposure scenarios contributes to the overall uncertainty in long-term risk predictions. To address uncertainty, exposure scenario parameters are generally biased to yield higher exposure and risk values. Inputs to the scenario unit risk factors that could contribute to exposure scenario uncertainty include the various models used (e.g., food chain model, toxicokinetic model) and model parameters (e.g., food chain transfer factors, exposure factors,

dose factors, risk factors). Complete descriptions of the exposure scenario parameters, assumptions, and unit risk factor calculations can be found in HNF-SD-WM-TI-707.

2.2 RESULTS

Evaluation results are presented in Figures 6 and 7. Figure 6 shows the peak groundwater pathway technetium-99 ILCR at the S tank farm fenceline as a function of the amount of technetium-99 leaked from tank S-109 during retrieval. Figure 7 shows the peak groundwater pathway nitrite HI at the S tank farm fenceline as a function of the amount of nitrite leaked from tank S-109 during retrieval.

Figure 6. Tank S-109 Technetium-99 Incremental Lifetime Cancer Risk Plot

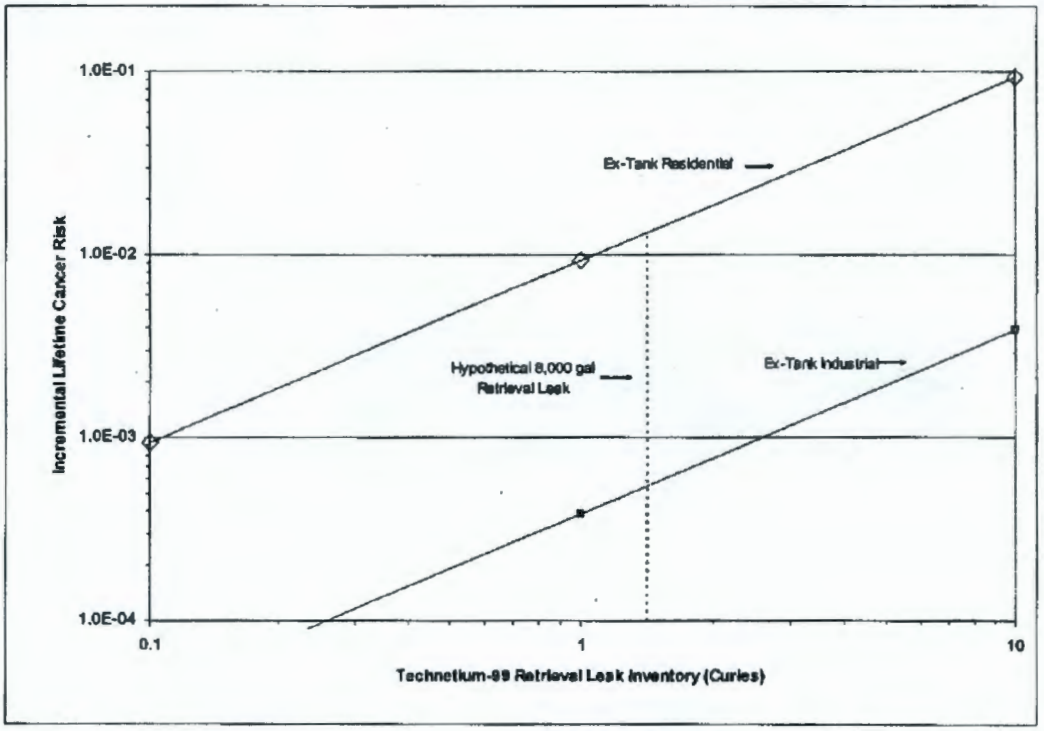
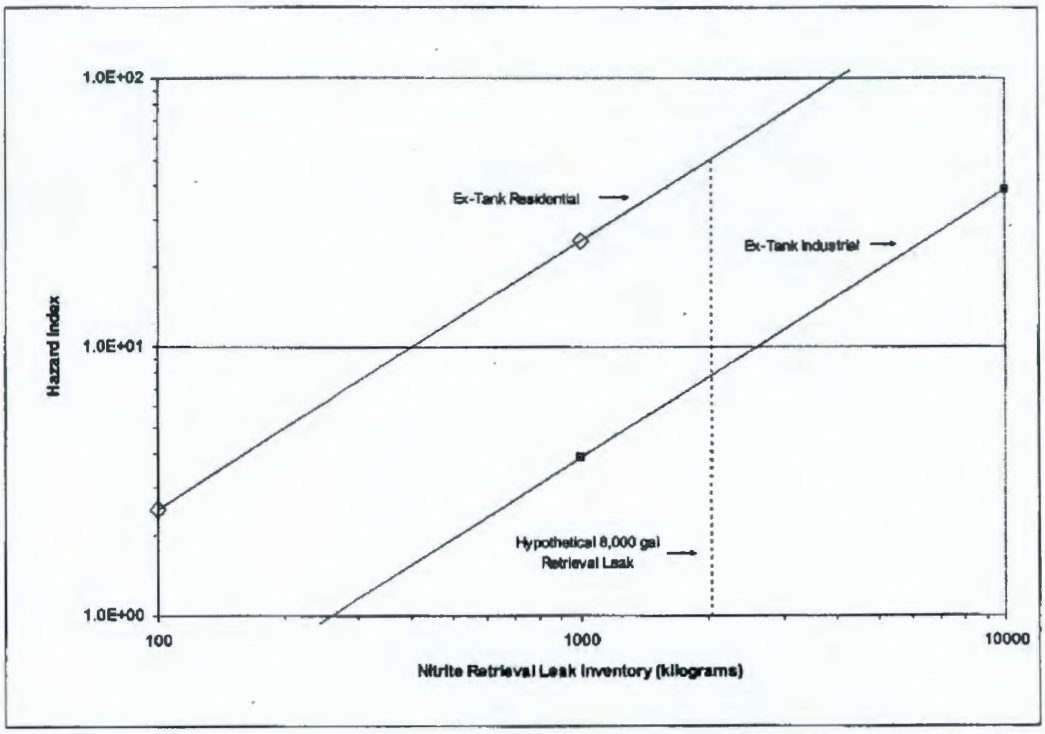


Figure 7. Tank S-109 Nitrite Hazard Index Plot



As discussed in Section 2.1.3, the projected arrival time of the peaks shown in Figures 6 and 7 is approximately 50 years after the leak event based on the supporting contaminant transport analysis (RPP-7884). Also 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 graphs by using the percent contribution information given in Tables 3 and 4.

Figures 6 and 7 provide a risk picture for tank S-109 but do not include contributions from other S tank farm sources. All sources in the S tank farm will be included in the risk assessment provided with the WMA S-SX closure plan now in preparation. Figures 6 and 7 are intended to serve as tools to aid operational decisions in the event a leak is detected or unexpected retrieval conditions arise during the tank S-109 partial waste retrieval activities.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph (Figures 6 and 7). The data points for these lines were calculated by applying Equation 1 over a range of technetium-99 and nitrite inventory values (RPP-19136). Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. A vertical dashed line was added to each graph (Figures 6 and 7) as a point of reference to show the estimated technetium-99 and nitrite inventories associated with a potential 8,000-gallon retrieval leak from tank S-109.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures 6 and 7. Using the graphs, the impacts from leak inventories greater

or lesser than those shown for the 8,000-gallon reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

The technetium-99 inventory associated with an 8,000-gallon retrieval leak from tank S-109 is approximately 1.4 curies. As shown in Figure 6, this corresponds to an ILCR of approximately 5×10^{-4} for the industrial scenario and 1×10^{-2} for the residential scenario (rounding to one significant figure).

The nitrite inventory associated with an 8,000-gallon retrieval leak from tank S-109 is approximately 2,000 kg. As shown in Figure 7, this corresponds to a HI of approximately 8 for the industrial scenario and 50 for the residential scenario.

To illustrate how these results were calculated, the following example is provided. The example uses the industrial scenario ILCR result of 5×10^{-4}. Using Equation 1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table 3), the technetium-99 transfer function (Table 6), and the technetium-99 industrial scenario unit risk factor (Table 9), as follows:

$$\text{ILCR} = (1.42\ \text{Ci}) \cdot (2.80 \times 10^{4}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 5.49 \times 10^{-4}$$

Complete calculation details are provided in RPP-19136.

For purposes of comparison, the peak impacts from the waste loss event in the S tank farm associated with tank S-104 were predicted to result in ILCR and HI values of approximately 1×10^{-3} and 12, respectively, for the industrial worker scenario (RPP-7884). The major drivers were technetium-99 for the ILCR and hexavalent chromium for the HI.

3.0 FUNCTIONS AND REQUIREMENTS

This section establishes the upper-level functions and corresponding requirements to which the tank S-109 WRS for Phase 1and Phase 2 must be designed and operated. Other requirements not directly applicable at the level of detail in this F&R are disseminated to CH2M HILL Hanford Group, Inc. (CH2M HILL) via DOE and CH2M HILL Contract (Contract DE-AC-27-99RL14047). Additionally, the F&R ensures that waste retrieval actions do not result in adverse impacts to workers, the public, or the environment. Some of these requirements are derived from regulatory documents (e.g., *Code of Federal Regulations*, *Washington Administrative Code*) while others are based on the design constraints of tank S-109. The F&R are provided in Table 10 and are focused on driving the design of tank S-109 WRS.

Waste will be retrieved from tank S-109 and transferred to a DST in the SY tank farm or to the waste receipt tanks in the TDF. This document provides the F&R for the waste retrieval and transfer functions. The requirements for the waste receipt function will be addressed in other project documentation such as RPP-17403 and DOE/ORP-2003-23 specific to the TDF.

Table 10. Tank S-109 Partial Waste Retrieval System Functions and Requirements (4 Sheets)

Function	Requirement	Basis	Key Elements
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall control the structure and waste temperature in the tanks within established limits specified in the operating specification for single-shell waste storage tanks.	OSD-T-151-00013	Maximum 137 °C (280 °F) for waste and maximum 120 °C (250 °F) for dome
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall prevent waste overflow into connected lines and limit hydrostatic head-induced stresses in the tank.	OSD-T-151-00013	Maintain waste level from exceeding 275 in. and minimize liquid level to the extent practical
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall control the vapor space pressure in the tanks during retrieval within established limits specified in the operating specification for single-shell waste storage tanks.	OSD-T-151-00013	Minimum = (2.0 in. w.g. + [waste height (in.)] × [specific gravity of waste]); not to exceed 9 in. w.g.
Retrieve waste from tank S-109	The tank S-109 WRS shall be capable of retrieving waste at the rates and volumes necessary to feed the supplemental treatment demonstration.	RPP-17403	The WRS shall provide the capability to retrieve approximately 18,000 gallons every 8 days during Phase 2
Retrieve waste from tank S-109	The WRS shall have the capability to stage waste and monitor and/or sample the waste stream for concentrations and properties in order to meet the TDF waste feed requirements.	RPP-17403	Maximum allowable radionuclide concentrations, sodium concentration, chemical concentrations
Retrieve waste from tank S-109	The tank S-109 WRS shall be capable of retrieving waste from the specified tank and transferring the waste to the TDF receipt vessel.	RPP-17403	The WRS shall meet the interface requirements as specified in RPP-17403
Retrieve waste from tank S-109	The tank S-109 WRS shall be capable of transferring feed that fails to meet the TDF waste feed acceptance criteria to a DST in SY tank farm.	RPP-17403 SSTs are not suitable for storing liquid waste	Waste retrieved from tank S-109 that does not meet waste feed requirements will be transferred to a DST for storage

Table 10. Tank S-109 Partial Waste Retrieval System Functions and Requirements (4 Sheets)

Function	Requirement	Basis	Key Elements
Retrieve waste from tank S-109	The tank S-109 WRS shall provide the monitor and control capability to control the waste retrieval and transfer process. This includes controlling and monitoring the following S-109 process parameters as necessary: • Pressures • Flow rates • Radiation levels. The tank S-109 WRS shall provide instrumentation to support performing material balance calculations.	HNF-SD-WM-TSR-006 WAC 173-303	Provide for safe and effective operation of the WRS
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall be designed for safe installation, operation, and maintenance.	29 CFR 1910 29 CFR 1926 10 CFR 835	OSHA standards Occupational Radiation Protection
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall be designed to protect personnel and equipment from fires.	ORP M 420.1-1	Ensure safe operations
Maintain safe waste storage in tank S-109	The tank S-109 WRS waste transfer line flushing systems, and other raw water connections physically connected to waste transfer or process piping shall prevent contamination of the service water. At a minimum, the tank S-109 WRS raw water backflow prevention devices shall be designed to Washington State approved models and shall be accessible for inspection by a water purveyor in a nonradiological zone.	WAC 246-290-490 HNF-SD-WM-TSR-006	Mitigation of contamination spread in existing raw water lines
Retrieve waste from tank S-109	The tank S-109 WRS hose-in-hose transfer lines shall be designed in accordance with applicable requirements.	OSD-T-151-00010 HNF-SD-WM-TSR-006 WAC 173-303	Mitigate possible failure of hose-in-hose transfer line
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall not impose loads on the tanks that exceed the dome loading limits.	HNF-IP-1266 TFC-ENG-FACSUP-C-10 RPP-11802	Mitigate possible structural failure of tank dome
Maintain safe waste storage in tank S-109	The tank S-109 WRS shall be designed to ensure proper structural strength, compatibility with the waste, and protection against corrosion.	WAC 173-303 HNF-SD-WM-TSR-006	Mitigate potential mechanical malfunction or failure of WRS components

Table 10. Tank S-109 Partial Waste Retrieval System Functions and Requirements (4 Sheets)

Function	Requirement	Basis	Key Elements
Maintain safe waste storage in tank S-109	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak detection design features.	WAC 173-303 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiving tank/facility or to a DST
Retrieve waste from tank S-109	The ventilation system exhaust shall be filtered to restrict emissions to the environment.	WAC 173-400 WAC 173-460 HNF-IP-0842, Volume 6 WAC 173-480 WAC 246-247	Mitigate potential release to personnel, the public, and the environment
Retrieve waste from tank S-109	The tank S-109 WRS shall incorporate spill prevention and control design features.	40 CFR 265 WAC 173-303 HNF-SD-WM-TSR-006	Mitigate/minimize potential for, and amount of leak
Retrieve waste from tank S-109	The tank S-109 WRS shall have emergency stop features that will shut down the waste retrieval and the waste transfer systems.	WAC 173-303	Minimize environmental impacts and personnel risks
Retrieve waste from tank S-109	The S-109 WRS shall be designed and operated to protect workers, public, and the environment from exposure to radioactive tank waste and emissions during the retrieval campaign.	10 CFR 830 HNF-SD-WM-TSR-006 HNF-IP-1266 RPP-13033 DOE O 420.1A	Ensure protection of workers, the public, and the environment from routine and potential accident conditions
Retrieve waste from tank S-109	The tank S-109 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 the best available technology to detect tank leaks during retrieval.	WAC 173-303 HNF-SD-WM-TSR-006	Utilize best available LDM technologies coupled with mitigation strategies to minimize the potential for retrieval leakage; see Section 4.0
Retrieve waste from tank S-109	The WRS shall quantify liquid release volumes from S-109 if a release is detected during waste retrieval operations.	WAC 173-303	Utilize best available LDM technologies coupled with mitigation strategies to minimize the potential for retrieval leakage
Retrieve waste from tank S-109	The S-109 WRS shall minimize waste generation to the greatest extent practical, including water introduced into the tank.	WAC 173-303	No numerical requirement
Retrieve waste from tank S-109	The integrated retrieval and LDMM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks.	HNF-SD-WM-AP-005	Leak mitigation strategy described in Section 4.0

Table 10. Tank S-109 Partial Waste Retrieval System Functions and Requirements (4 Sheets)

Function	Requirement	Basis	Key Elements
Retrieve waste from tank S-109	The WRS shall be designed for ease of decommissioning and disposal	10 CFR 835	Minimal holdup of material in waste transfer piping, piping, valves, pumps, and tanks that can be fully drained.
Retrieve waste from tank S-109	The WRS shall be designed to maintain worker exposure to radiation ALARA	10 CFR 835	Minimal holdup of material in piping, accommodation for shielding, and allowances for routine maintenance without the use of respirators.
Maintain safe storage in tank S-109	The tank shall meet established interim stabilization criteria following completion of Phase 2 waste retrieval activities.	Interim Stabilization Consent Decree (Ecology 1999)	Less than 5,000 gallons of supernate and less than 50,000 gallons of drainable interstitial liquid

CFR = *Code of Federal Regulations.*
DST = double-shell tank.
EPA = U.S. Environmental Protection Agency.
LDM = leak detection and monitoring.
LDMM = leak detection, monitoring, and mitigation.
OSHA = Occupational Safety and Health Administration.
SST = single-shell tank.
TDF = Test and Demonstration Facility.
WAC = *Washington Administrative Code.*
WRS = waste retrieval system.

4.0 LEAK DETECTION, MONITORING, AND MITIGATION, AND WASTE RETRIEVAL STRATEGY

This section describes the LDMM and waste retrieval strategy for tank S-109 WRS including definitions for LDMM, uncertainties in detecting and monitoring leaks in waste tanks, LDMM and retrieval strategy, and preliminary system descriptions. The F&R established in Section 3.0 of this document will govern the design and development of the integrated system.

LDMM terms 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, methods, or systems that can reduce the potential for a leak 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 and waste retrieval strategy for the tank S-109 WRS has been developed to support providing waste feed to the TDF while considering the requirements specified in the HFFACO M-45 series of milestones. The purpose is to ensure that the waste retrieval and LDMM strategy:

- Is technically practicable and defensible
- Considers applicable regulations and requirements
- Minimizes waste releases to the environment should a leak occur
- Reduces the risk to human health.

4.1.1 Leak Mitigation Strategy

The primary goal of the tank S-109 LDMM strategy is leak mitigation (i.e., reduction of leak loss potential). The operational strategy takes actions to minimize liquid additions during waste retrieval.

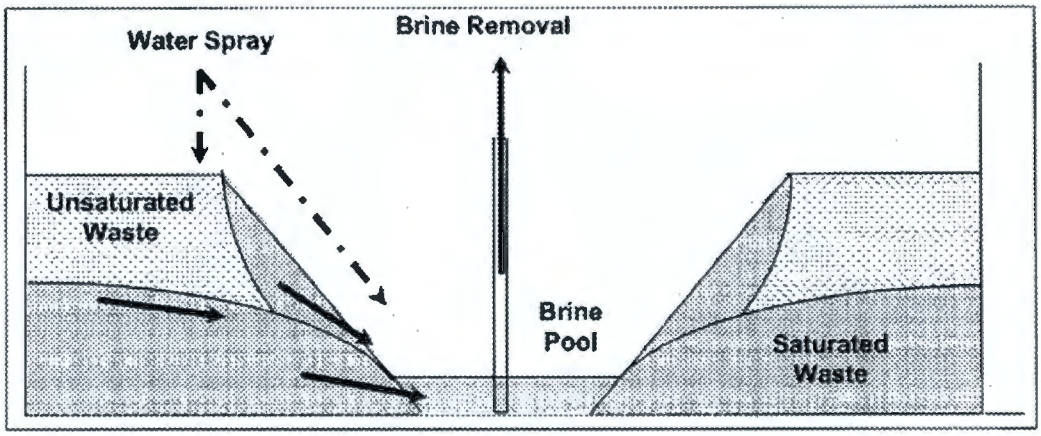
The operational strategy to minimize the leak potential (initiation of a leak and leak volume) during waste retrieval in the absence of any indication of a leak involves the following:

- Limit the addition of water to only that volume necessary to dissolve sufficient salt cake to support the TDF. The specifics of the waste retrieval process will be developed during

the design; however, the intent is to minimize the amount of drainable liquid in the tank during waste retrieval operations.

- Retrieving from advantageous location; given the limited number of risers in tank S-109, the system will be operated to focus on retrieving waste from the center region of the tank during Phase 1 and Phase 2 (Figure 8). This center-out waste retrieval strategy allows dissolved waste and released interstitial liquids to drain into a center pool, and can be pumped from the tank if a leak is detected. This strategy will minimize the amount of liquid that comes in contact with the tank walls, the location of most historical SST leaks, and will assist in the liquid collecting near the pump so the pump can operate from the lowest level in the tank consistent with the waste feed requirements of the TDF.

Figure 8. Illustration of Leak Mitigative, Center-Out Waste Retrieval Strategy



4.1.2 Leak Detection Strategy

The best practical and available leak detection methods will be used to monitor conditions in and around the tank for evidence of a tank or transfer line leak. The overall strategy for leak detection involves the following:

- During Phase 1, existing drywells will be utilized as the primary leak detection method. A baseline will be established prior to Phase 1 and after completion of Phase 1 retrieval using the existing truck mounted drywell logging tools. During waste retrieval the handheld moisture gauge will be deployed to monitor specific areas or depths of interest for increases in soil moisture content.

- During Phase 2 a high-resolution resistivity (HRR) leak detection system will be deployed for use as the primary LDM system. This technology is currently planned for demonstration deployment in the S and C tank farms prior to initiating Phase 2 activities at tank S-109. In the event that the HRR system does not prove satisfactory for use in the SST farms for leak detection, drywell monitoring will be used as the primary leak detection method.

HRR long electrode LDM is currently planned for deployment at tank S-109. The HRR method uses geophysical resistivity measurement methods as a means to detect fluid leaks.
The electrical resistivity of the sediments beneath a waste tank depends on a number of parameters, one of which is moisture content. The leakage of water or tank waste into these sediments lowers the sediment resistivity. The HRR method detects a leak by comparing a current resistivity measurement against a previously obtained baseline measurement, or a "pre-leak" measurement. This delta processing allows the HRR method to "ignore" existing resistivity differences in the soil due to conductive structures, prior leaks, etc.

The basic resistivity measurement concept is a four-pole resistivity method. With the four-pole resistivity, two poles or electrodes are connected to a power source that injects a current in the soil. The resulting voltage gradient from this current is then measured with the second pair of electrodes. This arrangement allows very small resistivity measurements to be made without impacting the measurement process (a high impedance measurement system is used with the system that has a minimum effect on the induced current field). By applying power to each electrode pair and while making resistivity measurements from all other electrode pairs, a "picture" of the sediment resistivity can be obtained that is an indicator of a leaked plume.

This technology has the potential to detect and spatially depict axial leaks as well as leaks beneath the tank, and is expected to provide an improved LDM over traditional in-tank and ex-tank leak detection methods. The viability of HRR as a leak detection method on SSTs is pending successful performance and evaluation of the planned demonstration and liquid injection leak testing (*Test Plan for SST Deployment Demonstration and Injection Leak Testing of the HRR Long Electrode LDM System* [RPP-17191]). Resistivity data from the HRR system will be collected and evaluated throughout Phase 2 waste retrieval operations. Leak detection thresholds will be established in the operating procedures.

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 tank S-109. Modifications during fabrication and changes 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 Section 3.0.

4.2.1 Partial Waste Retrieval System Description

The retrieval of waste from tank S-109 will occur in three separate phases. Partial waste retrieval will be performed in Phases 1 and 2 to support the TDF. The general approach to retrieving waste from tank S-109 during Phases 1 and 2 consists of a dissolution and pumping system (e.g., modified saltwell pumping system) to mobilize and retrieve waste. Conceptual level system descriptions are provided for only Phases 1 and 2 in this document. This document will be revised in the future to address retrieval of the balance of the waste in the tank during Phase 3.

4.2.1.1 Phase 1 Description

During Phase 1, a waste retrieval pump will be used to remove waste from tank S-109 and transfer it to a staging tank with a capacity of approximately 1,000 gallons. The waste retrieval pump for Phase 1 is currently planned to have a transfer rate of approximately 20 gallons per minute. The pump suction will be located within a screen, which will keep large-diameter solid particles out of the suction stream of the pump. To minimize retrieval of solids the pump suction will be located above the sludge layer at approximately 1 foot off of the bottom of the tank. There is approximately 13,000 gallons of sludge in tank S-109 which is expected to be in the bottom of the tank. Dilution water will be introduced near the pump inlet using the pump dilution system.

Within the tank S-109 central pump pit (09A), the pump discharge will be routed through a flow meter capable of indicating both flow rate and specific gravity of the waste, then through a hydroclone to separate the solids from the liquid. The solids removed by the hydroclone will be returned to tank S-109. Hydroclones use a tangential injection flow process, enhancing the centrifugal forces and moving solid particles outwards. The dispersed particles move downwards in a spiral path into an underflow chamber, while purified liquid moves upwards to the center of the spiral, towards a top-mounted outlet.

After passing through the hydroclone, the waste stream will then be directed through a three-way valve and routed to the 1,000-gallon staging tank or to a DST in the SY farm (probably tank SY-102). The waste transfer piping from the 09A pump pit to both the SY farm and the staging tank will be a flexible 2-inch by 4-inch hose-in-hose transfer line (HIHTL).

The HIHTLs going to both the waste staging tank and to the SY tank farm may have an optional on-line radiation monitoring system installed, which will continuously measure the quantity of cesium-137 being transferred through the HIHTL. Currently, a system like this has been installed on the HIHTL between the S-A valve pit in S tank farm and tank SY-102 to provide information on the radiation levels of the waste being transferred from the ongoing retrievals in S tank farm, such as the tank S-112 waste retrieval.

CH2M HILL Process Engineering personnel will monitor the transfer data while waste is being sent to the SY tank farm and determine when to route the waste stream to the waste staging tank.

During Phase 1, the Demonstration Bulk Vitrification System (DBVS) facility is planned to be less than a Hazard Category 3 facility. Because of this, the waste that can be sent to and received by the DBVS must be below Hazard Category 3 limits, and cannot be physically connected to a source that exceeds the Hazard Category 3 limits. To accomplish this, the waste staging tank will have only one inlet/outlet combination. While transferring waste from tank S-109 to the waste staging tank, the tank will be connected to tank S-109 via an HIHTL. With this design, the system is physically disconnected from the DBVS facility when the waste staging tank is being filled with waste. Once the waste staging tank is filled the waste batch is characterized. When it has been verified that the waste meets the DBVS waste acceptance criteria, the HIHTL connecting the waste staging tank and tank S-109 will be disconnected. The HIHTL from the DBVS facility will then be connected to the same connector on the waste staging tank. The contents of the waste staging tank will then be pumped to the DBVS receiver tank, via this

HIHTL that will exit the farm, go under Cooper Avenue, and mate up with a receiver skid at the DBVS facility.

The waste staging tank will be located on a skid that will include the following features:

- **Secondary containment and leak detection** – The skid will include secondary containment. If there are any leaks in the waste staging tank, piping, fittings, etc., within this skid, the skid will contain the leak. A leak detector will serve to detect any leakage. The skid will have drains to route any liquid back to tank S-109 or to the receiver tank in the SY tank farm.

- **Waste staging tank ventilation** – The waste staging tank and the skid will both be passively ventilated. High-efficiency particulate air filters will perform this function.

- **Waste staging tank overflow** – A tank overflow detector will be provided, with remote indication to identify if the tank level has been exceeded. A line will also be provided to direct any overflow to the floor of the skid. In the event that an overflow occurs, the waste would be collected by the secondary containment and routed back to tank S-109 or the SY farm receiver tank.

- **Sampling** – Capability will be provided to allow waste samples to be withdrawn from this tank to support waste feed verification.

- **Out-of-specification waste** – If a waste batch is found to be outside the acceptable characteristics for transfer to the DBVS facility following sampling and analysis, the batch will be transferred to the receiver tank in the SY tank farm. The transfer pump located on the waste staging tank skid can be valved to send out-of-specification waste via the three-way valve in the 09A pump pit to the SY farm receiver tank. Note: This is why the HIHTL from tank S-109 to the waste receiver tank is not removed until after confirming that the waste batch meets the DBVS facility acceptance criteria.

The Enraf gauge installed in riser 003 will be removed, a stilling well installed, and the Enraf gauge installed within the stilling well. The stilling well allows for measurement of a liquid surface and protection of the Enraf gauge from any jet action from the water distributors during Phase 2. This concept is successfully being used for the tank S-112 waste retrieval project to measure liquid levels.

The portable exhauster that is currently being used for the tank S-112 waste retrieval (POR 004), or a comparable unit, will be used to ventilate tank S-109. A similar installation design to that employed on tanks S-112 and S-102 may be used for tank S-109. In addition to the exhauster, a demister like the one deployed on tank S-112 (possibly the same unit) will be used, if required as a part of the tank S-109 ventilation system.

USDOE is addressing worker safety during retrieval through the use of engineered controls on airborne emissions and by handling the waste in accordance with all applicable regulations under the authority of the Atomic Energy Act, including Department of Energy (DOE) Orders. An example Order is DOE O 440.1a, "Worker Protection Management for DOE Federal and Contractor Employees". This order requires the development of a Health and Safety Plan

(HASP). The HASP describes how workers are protected while in and around Tank Farms. Though the HASP and other such documents, DOE orders, and actions under the Atomic Energy Act do not fall under the authority of Ecology, those orders and actions meet the requirements of WAC 173-303-283 (3) (i) relative to protection of the worker.

4.2.1.2 Phase 2 Description

During Phase 2, the DBVS facility will be a Hazard Category 2 facility, so the waste tank (S-109) can and will be directly connected to the DBVS facility. The HIHTL that comes from the DBVS facility to the waste staging tank will be disconnected and coupled to the HIHTL that comes from tank S-109. Once the HIHTL route is established between tank S-109 and the DBVS facility, the waste staging tank and skid will no longer be needed.

The waste retrieval rate during Phase 2 will be the same as Phase 1, approximately 20 gallons per minute. The hydroclone, flow meter, and online radiation monitoring system will also be used during Phase 2. CH2M HILL Process Engineering will monitor the transfer data and determine whether the retrieved waste should be routed to the SY tank farm or the DBVS facility. However, the final process control will be based on the results of waste sampling and analysis.

From the hydroclone, the filtered waste will flow through several instruments, which will provide information. The instruments that may be included in this system and housed in the 09A pump pit include the following:

- **Chemical speciation probe** – This is an optional experimental device, being developed by Pacific Northwest National Laboratory that will use Raman technology to provide information on the chemical speciation of the waste. Because of the experimental nature of this device, it will not be counted on to provide necessary process parameters, only informational process parameters.

- **Conductivity probe** – This device will provide information on the waste conductivity. The conductivity probe is planned to be a process control device.

These are in addition to the process control instruments put in place to support Phase 1.

Up to three remote water distribution devices will be installed to spray water onto the waste through risers 011, 014, and 016. These devices will be similar to the remote water distribution devices installed in tanks S-112 and S-102 for waste retrieval. The water supply system for the remote water distribution devices is capable of providing water up to approximately 180 °F, at pressures up to 175 psig, and flows up to 100 gallons per minute. For Phase 1 and Phase 2, the flow rates and pressures will likely be maintained well below these values.

HFFACO Milestone M-62-00 requires that tank waste must be pretreated before treatment and disposal as immobilized low-activity waste. Pretreatment will be performed in the WTP pretreatment facility. However, since the WTP pretreatment facility will not be available to pretreat waste for the TDF, alternate methods of pretreatment will be utilized during waste retrieval for the demonstration project. Historical waste management activities that have reduced the cesium-137 concentrations of the waste in tank S-109 include the following:

- Selection of a feed tank (S-109) containing waste that has been previously processed to reduce cesium-137 and strontium-90 concentrations.
- Reduction of the cesium-137 in tank S-109 through crystallization of the salt solution in the tank which concentrated the cesium-137 in the liquid phase for subsequent removal during interim stabilization.
- In tank liquid/solids separation, after initial placement of the waste in tank S-109 the sludge settled to the bottom of the tank and will not be retrieved during Phases 1 and 2.

During Phases 1 and 2, the following processes, as described in Section 4.3.1, will provide pretreatment of the tank S-109 waste prior to transfer to the TDF:

- Reduction in cesium-137 concentration through removal of brine with high concentrations of cesium-137 and selective dissolution during the waste retrieval process.
- Liquid/solids separation process to minimize carryover of high-activity sludge inadvertently retrieved from the tank will be included as a part of the Phase 1 and Phase 2 WRSs. The separations process will allow solids to be returned to the tank pending final retrieval.

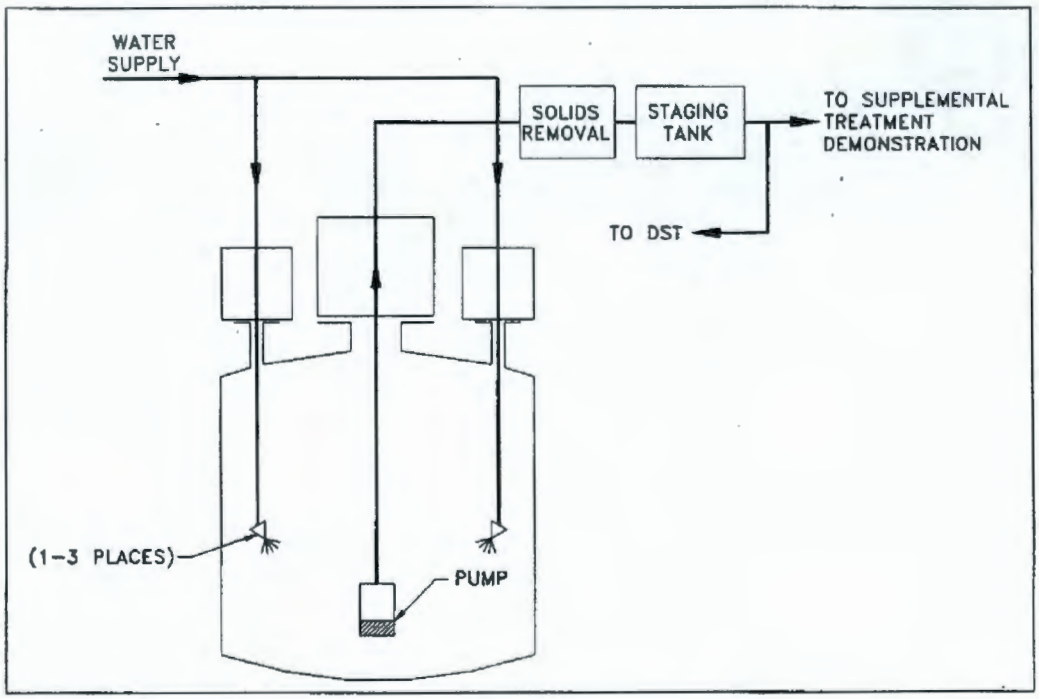
Because the TDF has specific limits on the waste feed the WRS will include provisions for waste sampling. Transfer routes will also be established to the SY tank farm for transferring waste from tank S-109 that does not meet the waste feed requirements of the TDF. The specifics of the system are under development and depend in part on the conditions of the existing system.

Following Phase 1 the WRS will be modified to support Phase 2 where a controlled sluicing process will be used to retrieve between 200,000 to 300,000 gallons of salt cake from the tank. The WRS envisioned for Phase 2 will include a pumping system, monitoring and control system, ventilation system, and water distribution system. The water distribution system will be installed in existing tank risers and will have the capability to direct water at various locations in the tank. The staging tank and solids removal equipment installed to support waste retrieval during Phase 1 will also be used during Phase 2.

Water used to calibrate instruments, check line connections, do leak tests, and flush back retrieved waste under an equipment failure scenario will not be defined as a retrieval fluid if returned back to tank S-109. While any liquid added will contribute to the overall waste volume, liquid additions under these scenarios will not constitute introduction of new waste into an SST.

A concept for the tank S-109 WRS during Phase 2 is depicted in Figure 9.

Figure 9. Phase 2-Controlled Sluicing Waste Retrieval System



4.2.2 Leak Detection and Monitoring System Description

During Phase 1 waste retrieval the existing truck-mounted system or systems will be used along with manually deployed moisture gauges to monitor soil conditions surrounding the tank for evidence of waste leakage. At a minimum one of the truck mounted systems will be used to establish a baseline before waste retrieval operations begin and for comparison purposes following completion of waste retrieval. The current schedule baseline includes initiating Phase 1 waste retrieval in March 2005 and is estimated to last approximately six weeks.

Two separate truck mounted systems are available that could be deployed, including the baseline Spectral Gamma Logging System and the Radiation Assessment System. The Spectral Gamma Logging System uses a calibrated high-purity germanium tool capable of detecting gamma emitting radionuclides in the soil at concentrations above approximately 0.2 pico curies/gram. The Radiation Assessment System uses a calibrated sodium-iodide based detector designed to detect gamma emissions from cesium-137, cobalt-60, and europium at concentrations above approximately 0.8 pico curies/gram for cesium-137 and 0.5 pico curies/gram cobalt-60. Since cobalt-60 and europium are mobile, the Radiation Assessment System can be used to monitor contaminant migration. Both of the truck mounted systems can be used to collect soil moisture measurements using an americium-beryllium based neutron generator with an appropriate detector. The truck mounted soil moisture tools can be used to detect a fraction of a percent increase in soil moisture.

Hand held moisture gauges are manually operated versions of the truck mounted soil moisture tools. The hand held gauges can readily be deployed by tank farm operations personnel with the appropriate training. The use of manually deployed moisture gauges represents an enhancement

to the truck-mounted system by providing more frequent moisture measurements in areas of interest without having to continually deploy the trucks into the farm.

Gamma detectors are calibrated on an annual basis against known activity sources. Moisture gauges are calibrated on an annual basis against three known moisture contents in two well casing diameters (6-inch and 8-inch) which are common to the Hanford Site.

Tank S-109 has eight drywells that will be monitored if accessible. In clockwise rotation around the tank they are 40-09-01, 40-09-02, 40-08-09, 40-09-05, 40-09-06, 40-09-08, 40-09-09, and 40-06-06. Drywell 40-08-09 is associated with tank S-108 and drywell 40-06-06 is associated with tank S-106, but both of these drywells are close enough to tank S-109 to be useful for leak monitoring purposes. Historical data and information associated with monitoring activities in these drywells are provided in *Analyses and Summary of Historical Drywell Gamma Logs for S-Tank Farm – 200 West* (HNF-4220) and *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank S-109* (GJ-HAN-78). The historical data presented in HNF-4220 categorizes the drywells surrounding S-109 as being "clean" meaning that contamination was not detected above background levels.

The HRR system installed prior to Phase 2 will utilize the existing drywells around tank S-109 as the primary electrodes. The HRR system that will be deployed during Phase 2 will be similar to the system currently installed at tank S-102. The HRR system is not expected to require the addition of any new drywells. Cabling will be connected to a number of selected drywells. The cabling will then be routed to a single control station housing the resistivity instrumentation.

4.3 OPERATING STRATEGY

The operating strategy for performing LDMM and waste retrieval applies before, during, and after retrieval as described in the following sections. The strategy is consistent with the current level and maturity of the tank S-109 WRS design for Phase 1 and Phase 2, as well as the F&R established in Section 3.0.

The S-109 tank waste retrieval equipment shall be operated, maintained, and managed by qualified personnel trained to the levels described in *RPP Administration* (HNF-IP-0842), Volume 3, Section 10, "Training," and *Dangerous Waste Training Plan* (TFC-PLN-07), for hazardous waste, and WRS-specific training to be developed following completion of the WRS design.

4.3.1 Partial Waste Retrieval Operations

The overall retrieval operating strategy will consist of reducing the tank S-109 inventory of salt cake by up to 400,000 gallons while minimizing liquid hydrostatic head during waste retrieval operations, and monitoring for loss of liquid inventories while waste is actively being retrieved.

Phase 1 waste retrieval operations will consist of the controlled addition of dissolution water near the center of the tank through the pump. Prior to the addition of water, the pump will be operated to locally reduce the liquid level and create a cone of depression or gradient. The initial liquid removed from the tank is anticipated to exceed the waste feed limits for the TDF and will be transferred to the SY tank farm. Once the liquid level around the saltwell is lowered, water

will be added to dissolve the salt cake and the resulting brine will be pumped to the staging tank. During Phase 1, approximately one staging tank volume (approximately 1,000 gallons) will be pretreated and staged in the staging tank. After accumulation in the staging tank, the waste will be sampled for verification against the TDF waste feed requirements, then transferred to the TDF feed tank.

Prior to Phase 1 the ^{137}Cs content around the saltwell will be reduced by pumping the interstitial liquor (IL) in the vicinity of the saltwell pump (approximately 300 gallons) to the DST system (currently it is planned to use SY-102). At the completion of Interim Stabilization of tank S-109, interstitial liquor flowed into the saltwell at a rate of 0.028 gallons per minute. Based on this rate of re-fill, within a week, approximately 300 gallons of IL will have flowed into the reservoir and can be pumped out to tank SY-102. If this is repeated 6 times, 10 percent of the IL can be removed from the tank before tank retrieval and the cesium content of the saltcake in the vicinity of the saltwell will be reduced. The IL will be diluted to ~1.35 specific gravity (spg) before transfer to tank SY-102.

During Phase 1, tank S-109 will be modified with an above grade 1000 gallons staging tank and an in-pit solids/liquid separation system. Approximately 3,000 gallons of hot water will be back-flushed through the saltwell screen. Within a few minutes the water should become saturated. Then approximately 2,000 gallons of brine will be pumped to tank SY-102, the next 555 gallons of brine (diluted with 445 gallons of water) will be sent to the staging tank through the solids/liquid separation system, and the remainder of the brine will be sent to tank SY-102. Solids must be removed from the brine before it is transferred to the staging tank, but not necessarily before transfer to SY-102. The brine will be diluted to ~1.35 spg before transfer to tank SY-102 and to 5M Na (1.25 spg) before transfer to DBVS. During retrieval, gamma monitors on the HIHTL from tank S-109 to tank SY-102 and from tank S-109 to the staging tank will provide process information about the cesium content.

After the staging tank contents are sampled and analyzed, and the results are acceptable, the staging tank will be segmented from tank S-109. The sample results will be used to verify that the DBVS will remain a below Hazard Category 3 facility before the waste is transferred to the DBVS waste receipt tank.

Phase 2 waste retrieval operations will consist of the controlled addition of dissolution water using water distribution nozzles. The waste retrieval operation will be oriented at retrieving waste from the center of the tank out. Approximately 3 gallons of water will be used to dissolve 1 gallon of tank waste. As the water penetrates the salt cake, the waste will be dissolved and mobilized toward the center of the tank where it will be pumped out. Once the waste is out of the tank it will undergo a liquids/solids separation step. Following the liquids/solids separation step the waste will undergo sampling and/or monitoring to verify acceptability at the TDF. Waste that does not meet the TDF waste feed requirements will be routed to the SY tank farm for storage.

Prior to Phase 2, water distribution nozzles will be added to tank S-109 in the one or more of the 4 inch risers located near the periphery of the tank (Risers 11, 14, & 16). Approximately 12,000 gallons of cold water will be sprayed on the surface of the salt in a ring around the periphery of the tank. This will push cesium laden interstitial liquor to the center of the tank for

removal. After the water has had time to migrate to the saltwell (about 2 days), the brine will be pumped to tank SY-102. Solids/liquid separation for this process is not required. Cold water is used because the goal is to remove cesium (which is highly soluble even in cold water) but not the salt cake. This process will be repeated a total of 3 times to flush cesium laden liquids out of the tank. For Phase 2, tank S-109 will also use a solids/liquid separation system. The HIHTL from tank S-109 to the staging tank and the HIHTL from the staging tank to DBVS will be disconnected from the staging tank and the HIHTLs will be joined. This will isolate the staging tank and connect tank S-109 directly to the DBVS making the DBVS a Hazard Category 2 facility.

During Phase 2, multiple batches of hot water (approximately 7,500 gallons each) will be broadcast on the saltcake and allowed to migrate to the pump inside the saltwell screen. The first seven batches are anticipated to contain elevated levels of cesium and will be transferred to the DST system. The remaining batches (one per DBVS campaign) will be sent to the DBVS. The first 500 gallons of brine from each batch will be transferred to tank SY-102 and the balance will be transferred to the DBVS waste receipt tanks. The first 500 gallons of brine will contain elevated concentration of cesium and are best routed to the DST system. Dilution water will be added to the brine sent to DBVS to maintain the sodium concentration at approximately 5 molar. Conservative flow sheet calculations estimate that up to 250,000 gallons of waste will be sent to the DST system.

4.3.2 Leak Detection and Monitoring Operations

During Phase 1 waste retrieval, LDM operations will consist of monitoring the drywells surrounding tank S-109. It is anticipated that the truck mounted system will be deployed no more than 60 days prior to initiating waste retrieval to establish a baseline. The truck-mounted systems will deploy calibrated gamma and neutron moisture probes over the full depth of each drywell in accordance with the current operating procedures. The truck mounted system will also be deployed in the event that waste retrieval operations are shut down for an extended period of time.

During waste retrieval operations a handheld moisture gauge will be deployed by qualified operators in accordance with the current version of Tank Farm plant operating procedure *Operate Model 503DR Hydroprobe Neutron Moisture Detection* (TO-320-022). The operating procedure defines parameters for data collection with the moisture gauge, including count times. The handheld moisture gauge will be used to monitor the moisture (e.g., water) content in the sediments around the drywells just above and below the base of the tank (45-60 feet below grade) at 1-foot increments. Additional areas or depths of interest may be identified following deployment of the truck mounted system. In the event of an unexplained increase in soil moisture content, additional monitoring with the truck-mounted system will be used, if truck access is practical, to determine if there have been any changes in gamma emitting radionuclide concentration surrounding the drywells.

The frequency for deploying the manual moisture gauges will be defined in the process control plan. A target frequency for deployment would be approximately every two weeks subject to work controls and tank farm access limitations.

Following completion of Phase 1 the truck mounted system will be deployed using the same suite of logging tools used to establish the preretrieval baseline. Deployment of the truck mounted system is planned within 60 days following completion of Phase 1 waste retrieval operations. The logging results obtained following Phase 1 can then be used for comparison against the baseline established prior to initiating waste retrieval.

During Phase 2 operations, resistivity data will be collected and analyzed for changes in conditions that may provide indications of a leak. Analysis of the data collected by the HRR system will include comparison of the resistivity data against baseline data collected before the start of waste retrieval operations. Changes or trends that may indicate a leak will be closely monitored. Resistivity change thresholds will be established in operating procedures.

4.3.3 Leak Mitigation Operations

If a leak is indicated during waste retrieval water additions to the tank will be suspended and actions defined in *Tank Leak Assessment Process* (TFC-ENG-CHEM-D-42) will be implemented. Retrieval of liquid waste shall continue during the leak assessment process if possible to remove the maximum practical amount of liquid from the tank. If the leak assessment concludes that no leak is indicated, waste retrieval operations will continue under normal operating procedures. However, if a leak is validated, the operating contractor will notify Ecology and others in accordance with environmental notification *Environmental Notification* (TFC-ESHQ-ENV_FS-C-01).

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.

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