RPP-RPT-58935, Rev. 0

241-AX-104 Tank Waste Retrieval Work Plan

Author Name:
A.R. Olander
A.K. Wahi
M. Rahman
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-08RV14800

EDT/ECN:	N/A	UC:	
Cost Center:	2FH	Charge Code:	201773
B&R Code:	N/A	Total Pages:	134 mw 9/28/2015

Key Words: 241-AX-104, Retrieval, Tank Waste Retrieval Work Plan, TWRWP

Abstract: This document establishes the 241-AX-104 Tank Waste Retrieval Work Plan required by the Consent Decree.

DATE:
Sep 28, 2015
HANFORD RELEASE

APPROVED
By Julia Raymer at 1:09 pm, Sep 28, 2015

Release Approval Date Release Stamp

Approved For Public Release

131

58935 mw 9/28/2015
RPP-RPT-~~58395~~
Revision 0

241-AX-104 Tank Waste Retrieval Work Plan

Prepared by

A. R. Olander, Washington River Protection Solutions, LLC

A. K. Wahi, INTERA, Inc.

M. Rahman, INTERA, Inc.

Date Published
September 2015

washington river protection solutions

Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-08RV14800

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Abbreviations, Acronyms, and Initialisms

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

™ High-Resolution Resistivity (HRR) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona
™ Leak Detection and Monitoring (LDM) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona

RMS	radionuclide monitoring system
SGLS	spectral gamma system
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases
TSD	treatment, storage, and disposal
TWINS	Tank Waste Information Network System
TWRWP	Tank Waste Retrieval Work Plan
UPR	unplanned release
WMA	waste management area
WRPS	Washington River Protection Solutions
WRS	waste retrieval system
WTP	Waste Treatment and Immobilization Plant

Units

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

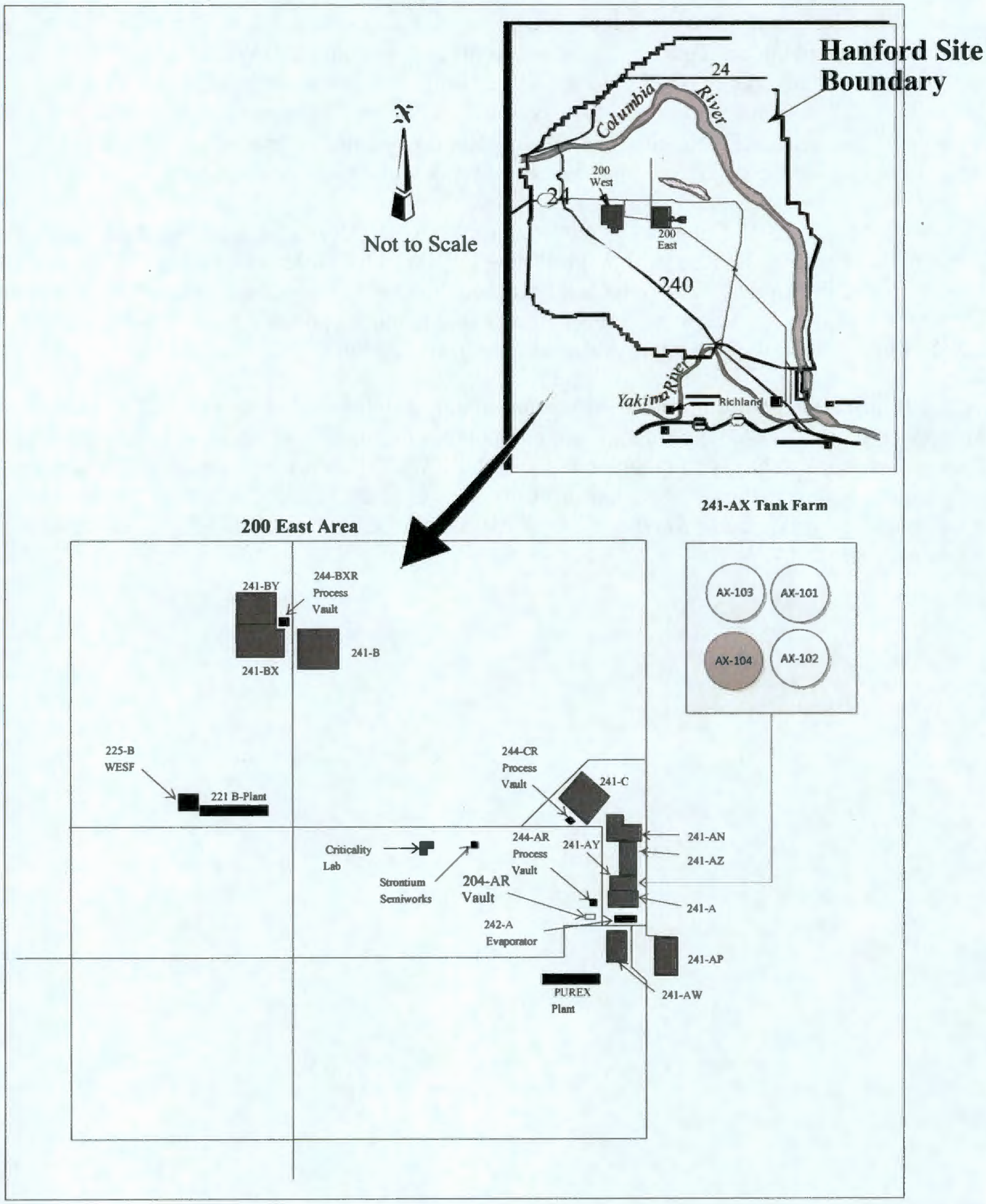
1.0 INTRODUCTION

The U.S. Department of Energy, Office of River Protection (DOE-ORP) River Protection Project mission includes storage, retrieval, immobilization, and disposal of radioactive mixed waste presently stored in underground tanks located in the 200 East and 200 West Areas of the U.S. Department of Energy (DOE) Hanford Site. Single-shell tank 241-AX-104 (AX-104) located in the 200 East Area (Figure 1-1), is scheduled for waste retrieval using a modified sluicing system retrieval technology. Tank AX-104 is classified as "sound" as specified in HNF-EP-0182, Rev. 328, *Waste Tank Summary Report for Month Ending April 30, 2015.*

As of October 25, 2010, Consent Decree No. 08-5085-FVS (Decree) has provided the regulating direction for Tank Waste Retrieval Work Plans (TWRWP) for tanks retrieved as Project B-1 and Project B-4 of the Decree. The purpose of this document is to provide the State of Washington, Department of Ecology (Ecology) information on the planned approach for retrieving waste from AX-104 to allow Ecology to approve the waste retrieval action.

Where information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*) has been incorporated into this TWRWP, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of this tank waste retrieval work plan or *Revised Code of Washington,* Chapter 70.105 RCW, "Hazardous waste management."

Figure 1-1. Location Map of Tank 241-AX-104, AX Tank Farm, and Surrounding Facilities in the 200 East Area.



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

2.1 TANK

Tank(s) *and/or ancillary equipment condition and Configuration*

Tank 241-AX-104 is the subject of this TWRWP.

2.1.1 Start Date

Submittal of the TWRWP shall be accompanied by a schedule provided for informational purposes only

The planned start date for tank AX-104 waste retrieval operations is April 2017 but is subject to change depending on priorities and availability of resources. The forecast completion date for tank AX-104 is September 2017.

2.1.2 History of Tank

Tank(s) and/or ***ancillary equipment condition and Configuration***

Summary-level historical data related to the configuration and operating history for tank AX-104 is provided in Table 2-1.

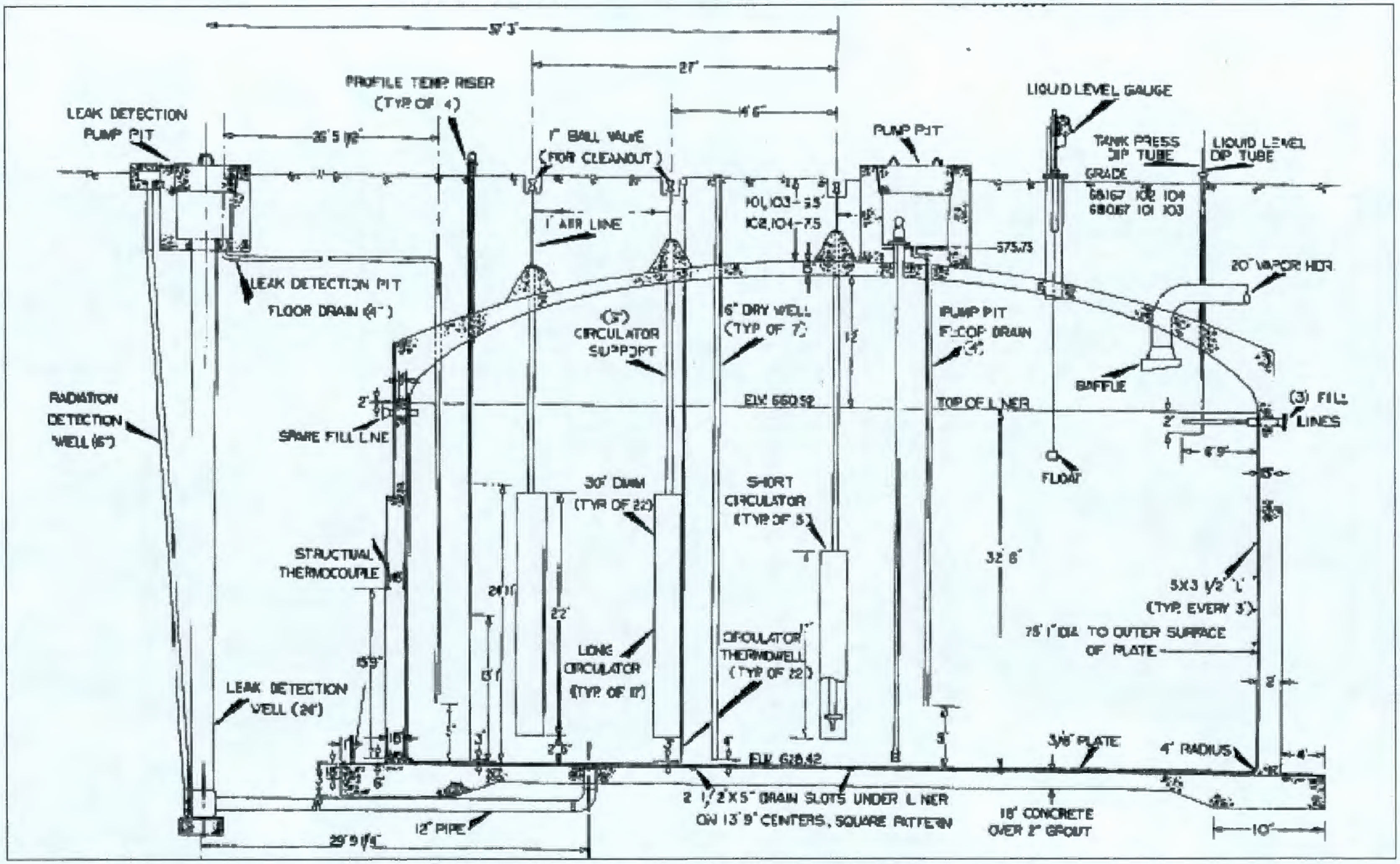
Table 2-1. Summary-Level Data for Tank AX-104.

Constructed	1963-64
In service	1966
Diameter (ft)	75
Operating depth (in.)	360
Design capacity (gal.)	≈1,000,000
Bottom shape	Flat
Ventilation	Active*
Nominal burial depth (ft)	6
Declared inactive	1978
Interim stabilized	08/81

**While in Operation*

The 241-AX tanks consist of a 75-ft diameter, carbon steel liner inside a concrete tank. The tank steel bottoms intersected the sidewalls orthogonally rather than the dished bottoms of earlier designed tank farms. The concrete thickness is 1.5-ft on the tank bottom, 2-ft to 1.25-ft on the side walls, and 1.25-ft for the tank dome. The concrete tank dome thickness increases to approximately 5-ft along the sidewalls. Figure 2-1 shows a composite of AX Farm tanks.

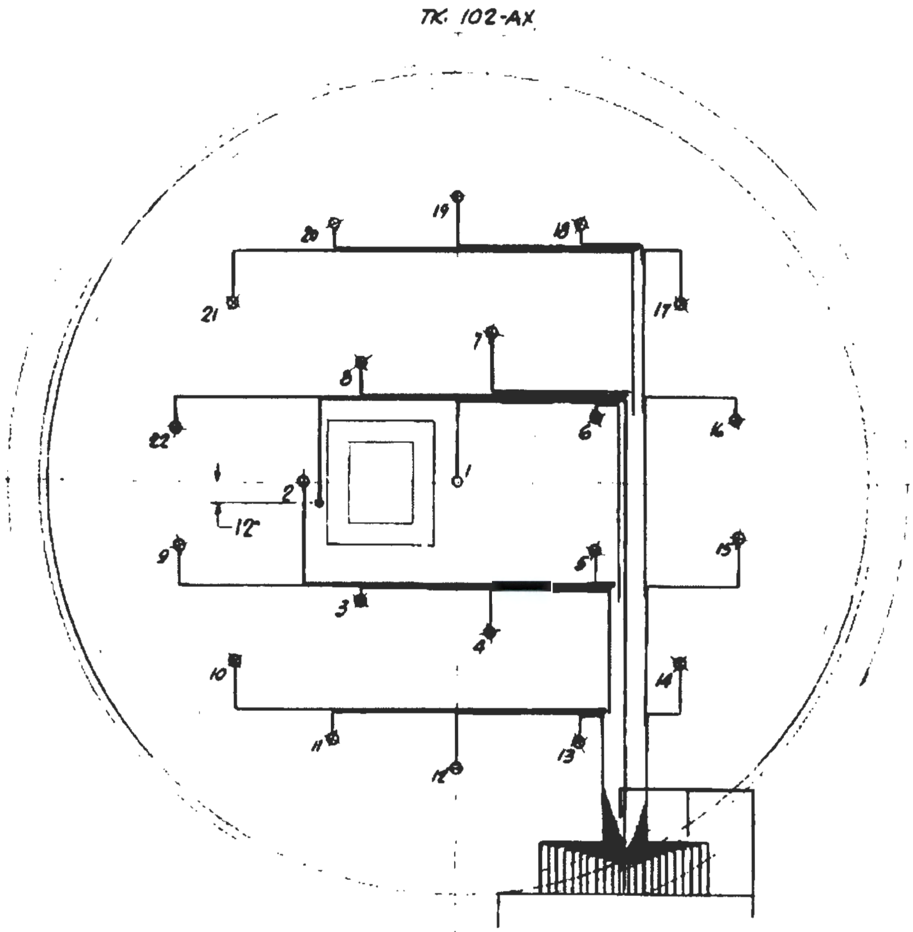
Figure 2-1. AX Tank Composite



Source: SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*

Each tank was originally equipped with 54 risers that penetrated the tank dome and 22 airlift circulators that were operators to suspend solids, mix the tank contents, and dissipate heat. The airlift circulators positions are shown in Figure 2-2. The airlift circulators are welded to the bottom of risers and end about 2.5-ft from the bottom of the tank. The airlift circulator draft tubes are in two lengths; 17 and 22-ft.

Figure 2-3. Tank AX-104 Airlift Circulator Position.*



*** From drawing H-2-44676, *Air Lift Circulator***

The 241-AX tanks were originally designed to contain liquid and solid wastes at a maximum temperature of 350°F (RPP-10435 *Single-Shell Tank Integrity Assessment Report*, page A-43).

The tank design includes a leak detection pit. A system of drain channels in the concrete base slab immediately below the carbon steel liner direct any leaked material to drain collection point. A 12 in. carbon steel pipe connects the drain network with a leak detection well. The sixty-foot deep well consists of a 24 in., schedule 20 carbon steel pipe, surmounted by a concrete pump pit. A waste transfer line connects the leak detection pit with a pump pit atop the 241-AX tank. A radiation detection well is located adjacent to the leak detection well.

Table 2-2 provides the size and use of tank AX-104 risers, fill/cascade lines, and any equipment installed in or on the risers prior to modification for retrieval. There are many risers of varying diameters and lengths of protrusion into the tank. Figure 2-2 provides the tank AX-104 riser plan view. Planned use of the risers for waste retrieval is described in Section 3.1.1.

Table 2-2. Tank AX-104 Riser Configuration[a] (2 Pages)

Component Identification Number	Diameter (in.)	Use Descriptions and Comments
		Tank AX-104
1A	34	Sludge Sluice, Weather Covered
1B	34	Pump Pit, Weather Covered
2A-2Y	6	Airlift Circulator
3A	14	B-222 Observation Port, Bench Mark
4	20	Vapor Outlet, Below Grade
5A	12	Pump Mount, Weather Covered
5B	12	Pump Mount, Weather Covered
6	4	Tank Pressure, Below Grade
7A	4	Temperature Probe
7B	4	Temperature Probe
7C	4	Below Grade
7D	4	Drain
8A	6	Drywell
8B	6	Drywell
8C	6	Drywell
8D	6	Drywell
8E	6	Drywell
8F	6	Drywell
8G	6	Drywell
9A	6	Spare
9B	6	Enraf
9C	6	Temperature Probe
9D	6	Drain, Below Grade
9E	6	Air Filter
9F	6	Flange
9G	6	Blind Flange
10	4	Drain, Weather Covered
11A	0.75	Structural Thermocouple-Below Grade
11B	0.75	Structural Thermocouple-Below Grade
11C	0.75	Structural Thermocouple-Below Grade
12	4	Leak Detection Pit Drain-Below Grade

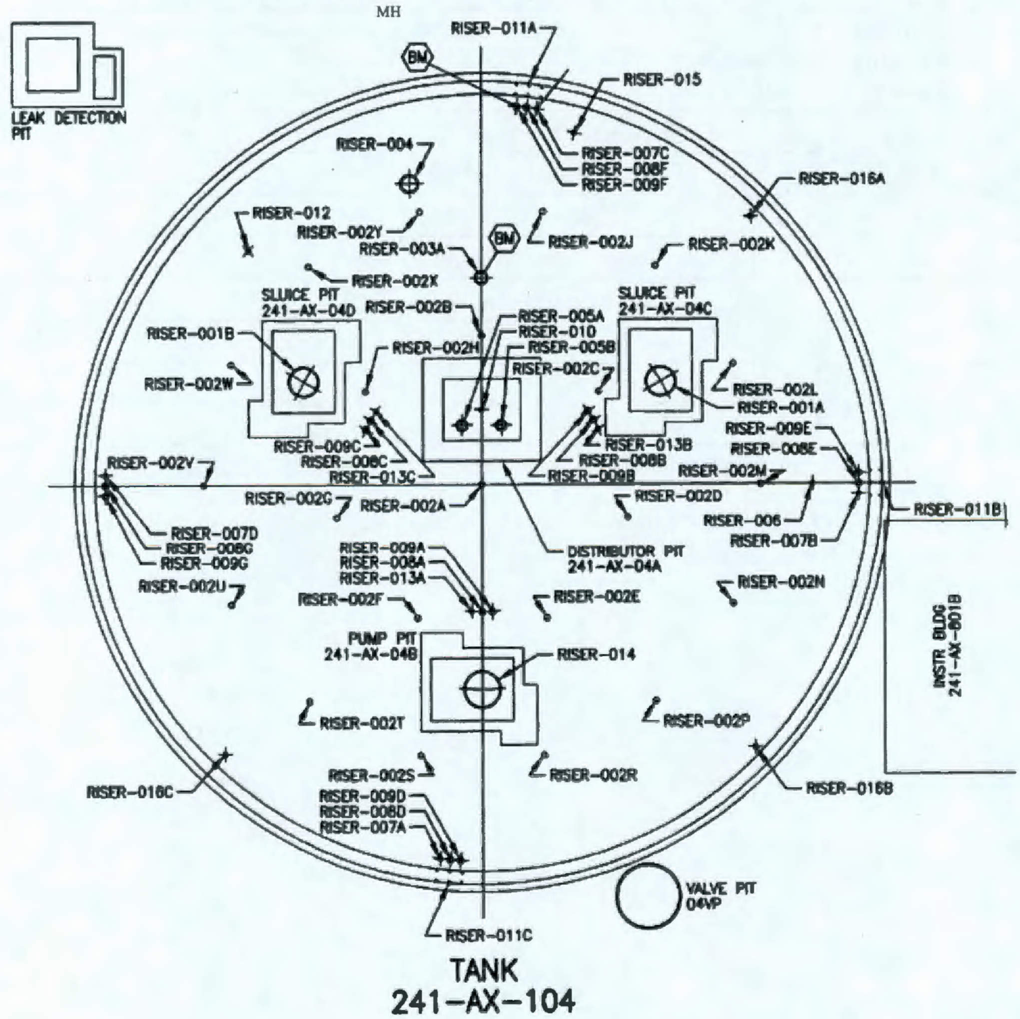
Table 2-2. Tank AX-104 Riser Configuration[a] (2 Pages)

Component Identification Number	Diameter (in.)	Use Descriptions and Comments
		Tank AX-104
13A	4	Temperature Probe, Weather Covered
13B	4	Temperature Probe, Weather Covered
13C	4	Temperature Probe, Weather Covered
14	42	Sludge Sluice, Weather Covered
15	4	Future Condensate-Below Grade
16A	4	Flange
16B	4	Flange
16C	4	Flange

[a] Best-basis inventory documents from TWINS, Web Site – http://twinsweb.pnl.gov/twins.htm and H-14-010609

[b] Enraf is the supplier of the identified level gauges; ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

Figure 2-3. Tank AX-104 Riser and Fill/Cascade Line Plan View.

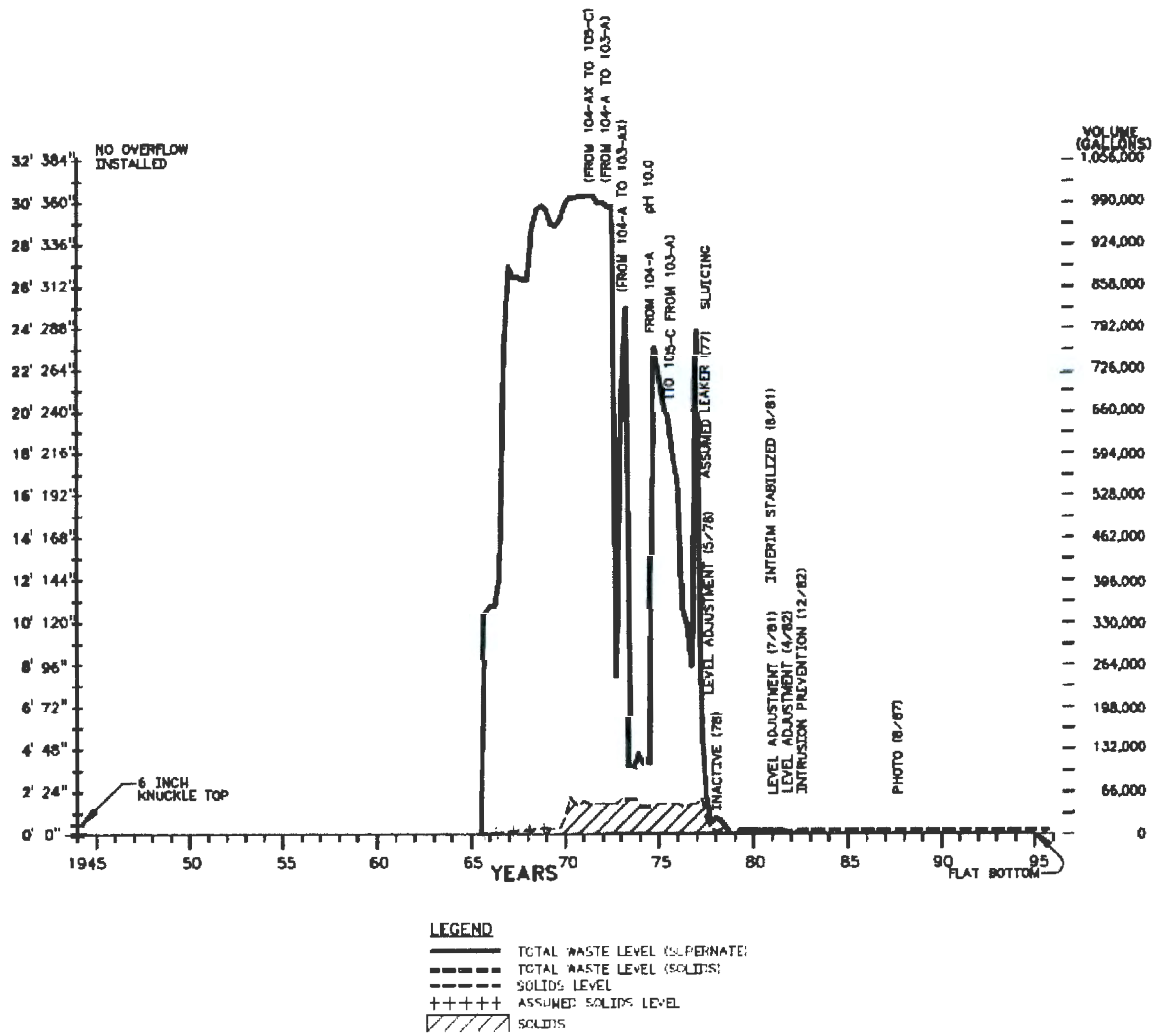


2.1.3 Tank Classification and Level History

Tank(s) and/or ancillary equipment ***condition*** *and Configuration*

Tank AX-104 is classified as sound in HNF-EP-0182. Figure 2-4 shows the waste level history in the tank and some information on the waste stored in the tank.

Figure 2-4. Tank AX-104 Surface Level History



2.1.4 Tank Waste Volume/Characteristics

Tank(s) and/or ancillary equipment condition and Configuration

Tank AX-104 entered service in the third quarter of 1965 when it received water from miscellaneous sources. From the fourth quarter of 1965 through the first quarter of 1969, intermittent transfers were made to and from tank 241-A-102. Beginning in the third quarter of 1966 and continuing through the second quarter of 1969, the tank received plutonium-uranium extraction (PUREX) high- and low-level waste. Organic wash waste (containing low solids) from PUREX was received in the first two quarters of 1968. During the second quarter of 1968 and the first quarter of 1969, several small amounts of B-Plant waste (from which strontium had been extracted) were transferred into the tank. From 1970 until the end of the tank's active service life, transfers of PUREX sludge supernatant waste (PSS) were made both to and from a variety of other SSTs. The last supernatant transfer occurred in the fourth quarter of 1977. The majority of the tank solids were removed during a sluicing campaign in the second and third quarters of 1977. The intent of the campaign was to remove the high-heat-generating strontium and cesium isotopes. A volume assessment following the sluicing campaign revealed that additional waste removal was needed because the volume and thickness of the waste remaining in the tank could still potentially produce thermal hot spots. A second sluicing campaign was initiated in the beginning of 1978 and continued until mid-April of that year. Upon conclusion of this campaign, no further waste removal was required.

The tank was declared inactive in 1978. The tank was declared an assumed leaker in 1977, with an estimated leakage volume of 30 kL (8 kgal). The tank was administratively interim stabilized in 1981, and intrusion prevention was completed in 1982.

The waste volume and physical properties of the waste stored in tank AX-104 are summarized in Table 2-3.

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

Waste Property	Unit	Tank AX-104
Sludge volume[a]	gal	7,400
Saltcake volume[a]	gal	0
Supernate volume[a]	gal	0
Interstitial liquid volume[b]	gal	0
Sludge density[a]	kg/L	1.8
Sludge percent water[a]	%	8.2
Saltcake density[a]	kg/L	NA
Saltcake percent water[a]	%	NA

[a] Source: Best-basis inventory download from http://twinsweb.pnl.gov/twins.htm dated January 16, 2014 and May 12, 2014

[b] HNF-EP-0182, *Waste Tank Summary Report for Month Ending April 30, 2015*

Rev. 328, Washington River Protection Solutions, LLC., Richland, Washington.

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

Although there are uncertainties associated with contaminant inventories in tank AX-104 (Appendix A), the following items show that there is sufficient information on the characteristics that affect waste retrieval, transfer, and storage in the double-shell tanks (DSTs) to proceed with waste retrieval. The information used for waste volumes and constituents is the best available and is deemed sufficient based on knowledge of those attributes necessary for planning and design purposes to proceed with the retrieval.

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

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

Currently there are no plans to perform additional pre-retrieval characterization (e.g., sampling and analyses) of the waste in tank AX-104.

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

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

2.2 PIPELINES AND ANCILLARY EQUIPMENT

Tank(s) and/or ***ancillary equipment*** *condition and Configuration*

Table 2-4 provides a summary of the AX Tank Farm ancillary equipment connected to tank AX-104. Pathways into the tank include lines, pit drains, and risers. Table 2-5 summarizes the status of the pathways that have already been isolated. There are no other known pathways into the tank; should any be discovered, they will be isolated during retrieval system installation or in accordance with the tank closure plan.

The existing buried waste transfer lines routed to tank AX-104 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tank following retrieval. With these isolation measures in place, the process lines are in a stable configuration and do not represent pathways for water or additional waste to enter the tanks.

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

Information on the current condition or on the volume/characteristics of any waste associated with piping and other ancillary equipment is not available. An ancillary equipment source term was defined to include the residual waste in the AX farm piping for the purpose of assessing the long-term human health risk for the overall waste management area (WMA) as described in Section 7.1.3.4.

Unplanned releases (UPR) from the ancillary equipment that are attributed to ancillary equipment leaks include the following excerpts from operational reports (RPP-ENV-37956, *Hanford 241-A/AX Farm Leak Assessments Report*):

a. **Ground Near Tank 241-AX-104.** An employee mistakenly pulled a contaminated electrode cable out of tank AX-104 and set it on the ground; he then removed his contaminated gloves and set them on the ground. Due to the high dose rate on the electrode, the employee received a whole body and extremity dose.

b. **702-A Building.** One of the Number 1 filters in the 702-A Building was breached, causing a contamination spread in an area of 100 × 400 ft north-northwest of the stack and another area of 100 × 100 ft southwest of the stack. Contamination levels were 20-30,000 dpm with white pasty material adjacent to the building at 80-300,000 dpm, and a weep-hole in the stack reading 35 mrad/hr.

c. **241-AX Offgas Header Dresser Coupling**. Release of condensate from 241-AX offgas header Dresser couplings. Dresser couplings were installed on the 241-A and 241-AX vapor header system. The investigation determined that the exhaust vapor header system to the AX Farm tanks was the source of several sizeable radiation releases to the soil. Test probing suggested that the Dresser couplings in the vapor header system had suffered degradation with a resulting loss of service integrity.

d. **Vapor Header Release.** Both Boeing and Battelle Northwest systems demonstrated a salt contamination area north of tank AX-102. Using the tank farm total gamma profiling (NaI) and direction Ge(Li) profiling, the leak was determined to be from the 20-in. vapor header connecting tank AX-101 and tank AX-102. The Dresser couplings which connect several sections of the header have been found to be leaking, and auger drilling in the immediate vicinity of the couplings was used to confirm the leak source and support the belief that the tank itself is sound. A similar condition was found over tank AX-104 which is also the apparent cause of recent radiation increases at the 42-ft depth in a tank dry well. Other peaks in the same well at 23- and 60-ft depths have decreased during this period.

e. **Vapor Header Release.** The "hot" test to seal a subsurface vent header and stabilize the surrounding radioactive sediments was completed in AX Farm near tank AX-102. Isotopic directional readings were taken in the five 4-meter deep wells that were drilled for monitoring purposes and for injecting the asphalt emulsion around a suspected leaking Dresser coupling. Readings were also taken in the 11 and 12 o'clock 102-AX dry wells. Readings in the injection wells were taken twice before the injection at a three-week interval. Important results were (1) the activity was primarily cesium, (2) the count rate was as high as 14 × 106 c/m, (3) where direction could be ascertained (difficult because of the high activity) the highest activity was coming from the direction of the Dresser coupling, (4) the activity peaked at the 2.5- to 3.5-meter depth, and (5) diffusion upward toward the surface was evident, readings at the 0.6-meter level being as high as 5 × 106 c/m. Readings in the deeper wells indicated cesium at the top and changing over to ruthenium at the lower depths (below about 9 meters). Six hundred and fifty gallons of a 2:1 mixture of 65% asphaltic emulsion were added to the four injection wells surround the Dresser coupling. An estimated volume of about three cubic meters was injected into sediments around the coupling. Radionuclide concentrations monitored before and after the injection did not indicate any significant change, and the volume added did not move the other radionuclides downward. This test was not planned for this fiscal year. The results indicate that this technique is beneficial in sealing leaking pipes and stabilizing radioactivity in sediments.

f. **102-AX-02A Pit.** During a hairpin jumper removal from the 102-AX-02A Pit, a dark-colored process solution ran from an open nozzle to the pit floor. Due to the high dose rates, it was agreed that an operator flush the pit floor with water. The temperature of the pit and process solution was higher than the air and flush water and the water unexpectedly flash vaporized and a vapor formed carrying contamination up out of the pit in a fan shaped plume for about 75 ft in a southerly direction from the 02A pit with levels from 30-50,000 dpm.

g. **Riser #9 AX-104.** Operator removing a sludge weight from Riser #9 on tank AX-104 for disposal contaminated skin to 200,000 dpm, clothing to 20,000 dpm, and several spots on the ground to 500 mrad/hr. Also contaminated sluicer shack and change room floor to 500,000 and 300,000 dpm, respectively.

h. **702-A Vent Station.** During a flush of the de-entrainer pads at the 702-A Vent Station, there was an apparent carry over of flush solution to the stack. Contamination levels ranged from 50 mrad/hr at an exhauster drain line to general ground contamination within farm zoned areas to 40,000 dpm, and spotty contamination to 10,000 dpm at the 200-E exclusion fence. An additional contamination spread within the farm occurred when the second 702-A exhaust fan was started: levels were 2,000-40,000 dpm. An Operator received hair contamination of 5,000 dpm.

Additional details about past releases can be found in RPP-ENV-37956. Additional release information gained during installation of retrieval systems are not accounted for in this document.

Table 2-4. AX Tank Farm Components Associated with Tank AX-104.*

Single-Shell Tanks			
Tank	**Constructed**	**Declared Inactive**	**Constructed Operating Capacity (gal)**
241-AX-104	1963 – 1964	1978	1,000,000
Diversion Boxes			
Unit	**Constructed**	**Removed from Service**	**Description**
241-AX-152	1962^	2001	Routed waste between 244-AR Vault, A, AX, and AZ Farms
Valve Pits			
241-AXA		Valve pit	
241-AXB		Valve pit	
Tank Pits			
241-AX-04A		Distributor Pit	
241-AX-04B		Pump Pit	
241-AX-04C		Sluice Pit	
241-AX-04D		Sluice Pit	
Other Pits			
241-AX-04E		Leak Detection Pit	

Transfer Lines		
Line Number	**Connecting Facilities**	
A-104	241-AX-104-A	241-AX-152
B-104	241-AX-104-B	241-AX-152
C-104	241-AX-104-C	241-AY-501
SL-112	241-AX-04A	241-AX-B
4026	241-AX-04A	244-AR-Vault
8061	241-AX-04A	241-AY-152
8032	241-AX-04B	241-AX-04D
8033	241-AX-04B	241-AX-04A
SN-212	241-AX-04B	241-AX-B
8027	241-AX-04C	241-AY-152
8034	241-AX-04C	241-AX-04A
8044	241-AX-04C	241-AX-04A
8028	241-AX-02D	241-AY-152

*H-14-104175 and WIDS
^RPP-14430

Table 2-5. Tank AX-104 Previously Isolated Lines.

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification*
Nozzle A	A-104	Yes	Cement plug in funnel at 241-AX-152	H-14-104175 H-2-73382
Nozzle B	B-104	Yes	Cement plug in funnel at 241-AX-152	H-14-104175 H-2-73382
Nozzle C	C-104	Yes	Process blank installed at 241-AY-501	H-14-104175
Distributor Pit	SL-112	Yes	A process blank is installed in 241-AX-04A and an isolation blank is installed in 241-AX-B. Both pits are weather sealed and isolated.	H-14-104175
Distributor Pit	4026	Yes	Isolation blank installed at 244-AR-Vault	H-14-104175
Distributor Pit	8061	Yes	Isolation blank installed at 241-AY-152	H-14-104175
Pump Pit	SN-212	Yes	Process blank installed at 241-AX-04B and an isolation blank is installed at 241-AX-B	H-14-104175
Sluice Pit	8027	Yes	Isolation blank installed at 241-AY-152	H-14-104175
Sluice Pit	8028	Yes	Isolation blank installed at 241-AY-152	H-14-104175

*Verification documents reference information is provided in Section 8.0 of this document.

Currently, there are no open transfer lines into tank AX-104. The isolation details listed in Table 2-5 may change when retrieval systems are installed.

3.0 PLANNED RETRIEVAL TECHNOLOGY

...describe the retrieval technology or technologies to be implemented...

This section provides a description of the waste retrieval technologies that will be used, if needed, in tank AX-104. The first technology is sluicing using an extended reach sluicing system (ERSS). The second technology is high pressure water using the ERSS. The rationale for selection technologies is provided in Section 3.3. However, in accordance with Appendix C, Part 1 of the Decree:

> "If 360 cubic feet is reached with the first retrieval technology, the first retrieval technology shall be used to the "limits of technology" and a second retrieval technology shall not be required."

Retrieval activities will switch from one technology to the other as required in an attempt to reach the Consent Decree residual waste goal.

In accordance with the Decree, Appendix C, Part 1:

> If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP shall be deployed to the "limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above [in Appendix C, Part 1 of the Decree].

3.1 SYSTEM DESCRIPTION

...describe the retrieval technology or technologies to be implemented... and *system description*

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

3.1.1 Physical Description

The in-tank WRS equipment will consist of an ERSS sluicing system to mobilize and retrieve waste from tank AX-104. The sluicing system will include three ERSS's, one more than C farm tanks, with a centrally positioned slurry pump. The ERSS's will be positioned in the tank so that the nozzles can be moved in close proximity to the waste on the tank floor while still being high enough to be able to spray down into most of the airlift circulators. The ERSS's will be controlled from a control trailer located outside the tank farm fence. The ERSS's will be installed in existing tank risers located roughly midway between the center of the tank and the tank wall (see Figure 2-3 and Table 3-1 for locations) . The sluice nozzles will have the capability to direct liquid at various locations in the tank. The WRS will have the capability to use high pressure water to break apart hard agglomerations of waste. The WRS will also have the capacity to use hot or cold water for sluicing.

The configuration of tank AX-104 includes four concrete pits; the central pump pit contains two risers. The drains in the pits will be covered so that a buildup of liquid can reach the leak detector. A sump pump will be used to pump accumulated liquid in the tank. The WRS for tank AX-104 may require design and construction of riser extensions to support the installation of the sluice nozzles and a slurry pump. Table 3-1 provides the planned riser use for tank AX-104. This riser use may change.

Table 3-1. Planned Riser Use for Tank AX-104 Waste Retrieval System.

Riser Number	Tank AX-104
001A	Sluicer/ERSS
001B	Sluicer/ERSS
003A	Exhauster Connection/Camera
005A	Spare
005B	Slurry Pump
007A	Camera
007C	Camera
007D	Sample Sleeve/Chemical Addition Port
009B	ENRAF
009C	Camera
009D	Exhauster Inlet/Vacuum Controller
009E	Camera
009F	Exhaust
009G	Camera
014	Sluicer/ERSS

Source: RPP-RPT-57187 and H-14-020109

The new slurry pump will be installed in a riser located in the center pit. The slurry pump design for AX-104 will allow the pump installation height to be adjusted to facilitate maximum waste removal. The slurry pump can be lowered to an elevation that allows liquid to be pumped to less than 1 inch of the bottom floor. The pumps used in C Farm could only achieve a liquid level of 2.5 inches above the bottom floor. The AX-104 pump will be installed in the retracted position using a crane. The pump will be lowered into added liquid during retrieval startup. The pump will be lowered to the bottom of the tank as waste retrieval progresses. Other designs or arrangements may be used to optimize the pump installation or operation..

A mass flowmeter will be installed on the slurry pump discharge line in the center pit. The mass flowmeter will be able to measure, flowrate, density, and temperature. A sample sleeve will be installed in riser 007D so that liquid/slurry waste samples can be collected from ERSS recirculation if needed.

Camera(s) will be installed in tank AX-104 to provide the capability to visually monitor and aid in control of waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flow rates). Flowrates will be used to support material balance calculations. The existing ENRAF[1] level gauge in tank AX-104 will be retracted during waste retrieval operations and will be used periodically to monitor waste levels.

During waste retrieval operations, tank AX-104 will be actively ventilated. The ventilation system will consist of skid-mounted high-efficiency particulate air filtered portable exhauster(s). Two portable exhausters, POR126 and POR127, will be installed in AX Farm. POR127 will also serve as a backup exhauster to tank AY-102. POR127 ductwork and condensate drain line will not be connected to the AX tanks until tank AY-102 retrieval is complete. After tank AY-102 retrieval is complete, both exhausters will be able to draw air from all four AX Farm tanks.

Condensate drainage from the exhauster(s) from AX tanks will be routed back to an SST being retrieved or an SST undergoing equipment installation in preparation for retrieval or to AY Farm. POR126 will have the capability to drain condensate to any of the four AX farm tanks. Condensate from POR127 will drain back to the tank AY-102 while AY retrieval is ongoing. After tank AY-102 retrieval is completed the POR127 condensate lines will be connected to the AX tanks so that condensate can be routed to any of the four AX farm tanks. Any change to this drainage routing will be covered by a change to this TWRWP.

A diversion box serves to control the routing and flow of liquid to the sluice nozzles, tank AZ-102, and to control water additions to the waste retrieval process. The diversion box provides secondary containment and the collection/detection of any leakage in a sump. The diversion box will have a leak detector that is connected to the pump shutdown system in the control trailer. In the event that a leak is detected in the diversion box, the slurry pump in tank AX-104 would be shut down. The diversion valve box has a sump and a sump pump that can be configured to transfer any leakage to the SST being retrieved or to tank AZ-102.

A splitter box will be used to route waste from one or more of the AX tanks being retrieved to tank AZ-102. The splitter box will have a leak detector that is connected to the pump shutdown system in the control trailer. Leak detectors may be a conductivity probe, a thermal leak detector, or another type of leak detector as appropriate. The splitter box has a sump and a sump pump that can be configured to transfer any leakage to the SST being retrieved or to tank AZ-102.

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

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

DST 241-AZ-102 (AZ-102) is planned to be used for waste receipt. Tank AZ-102 was selected based on its location, available space, and existing equipment.

Transfer of waste from tank AX-104 to tank AZ-102 will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use over-ground hose-in-hose transfer lines (HIHTL) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

The receiver tank AZ-102 will have a slurry drop leg to receive the sludge and liquid from tank AX-104. The tank AZ-102 ENRAF will be used to monitor the waste level in that tank.

3.1.2 Operating Description

...operational requirements during retrieval...

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

Waste compatibility assessments require evaluations to determine whether or not controls are necessary to prevent the formation of gels and line plugging. The identified control requirements are called out in the process control plan.

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

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

a. RPP-29002, *Double-Shell Tank System Waste Analysis Plan.* SST transfers into the DSTs for any reason must meet the waste acceptance criteria presented in this plan. This plan is written pursuant to WAC 173-303-300(5) and the Environmental Protection Agency (EPA) guidance document OSWER 9938.4-03, *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste.*

b. Waste Stream Profile Sheet (RPP-29002). The sheet addresses the applicable sections of WAC 173-303-300; Title 40, *Code of Federal Regulations*, Part 761, "Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761); 40 CFR 268, "Land Disposal Restrictions;" and WAC 173-303-140, "Land Disposal Restrictions," and also requires a waste compatibility assessment pursuant to HNF-SD-WM-DQO-001, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, to meet WAC 173-303-395(1).

During normal routine operations, waste retrieval will be initiated by adding water, if necessary, to the tank by backflowing water through the pump and adding water through in-line water nozzles near the pump screen to create an operating well for the pump. Tanks with saltcake often form structured columns in the waste that can fill with silt (even though AX-104 is not expected to have a significant amount of salt, precautions will be taken to prevent plugging). The silt can plug the pump so adding water clears the silt and may dissolve the saltcake, which opens an operating cavity for the pump. While the pump is starting water will be added, if needed, through the ERSS sluice or high pressure nozzles. The specific gravity of the waste will be monitored as described in the process control plan to minimize the risk of plugging waste retrieval system hoses and transfer lines and to minimize impacts to DST space.

Due to the small volume of solids, initial sluicing will likely target waste piles or obstructions that might interfere with slurry flowing towards the pump. To maximize the saturation of added water, unsaturated water will be sprayed towards the outer edge of the tanks so that contact time between the salts and water can be maximized. The in-tank camera will be used to provide visual input for directing the sluice nozzles. Typically, one sluicer motion controls will be operated at a time at a flow rate of approximately 60 to 120 gal/min; however, when water is added for dissolution it may be added through more than one sluicer simultaneously.

If the pump suction is too shallow when waste retrieval is started, the sluice nozzle discharges can be aimed at the pump inlet to enable the pump to be inserted a little deeper. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that when additional water is being added to the tank, the rate of water introduction will approximately equal the rate of solution removal. The waste removed will consist of the mobilized solids, dissolved solids, and added water. Maintaining a balanced pumping rate into and out of the tank is integral to minimizing the liquid volume in tank AX-104 and reducing the potential for leakage.

An additional technology provided by the ERSS is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure recycled liquor stream. High pressure water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

If initial sluicing efforts show the tank AX-104 sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank to cover the waste and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. Liquid can break down bonds in dried waste or dissolve salt crystals holding the waste together if they are present. The water used will not be saturated and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval. The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. The time needed to soften the waste is unknown but would likely not be more than a few days.

The retrieval process will be monitored using closed-circuit television to facilitate waste retrieval and aid in efficiently retrieving the tanks. Raw water will be used for waste mobilization and conveyance, transfer line flushing, equipment flushing, heel flushing, or as required for miscellaneous use. The liquid in the tank AX-104 will be recycled and used to sluice waste reducing the amount of water needed for retrieval. During all retrieval activities the tank liquid level will be maintained below the maximum waste level designated in the process control plan.

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

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank or per unit of time or transfer will be tracked. The units used will be selected by engineering personnel.

The project will determine when a tank retrieval is complete by following the Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

There is no limit of technology definition for an ERSS waste retrieval process. A limit of technology definition will not be developed until sufficient ERSS retrieval operations have been performed to enable development of a justifiable definition. Until an ERSS limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to ERSS retrieval operations.

The limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing,* as when the concentration of SST waste in the retrieved slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent. This limit of technology is used to gauge whether or not other retrieval technologies have reached their limit of technology.

The evaluation of limit of technology will consider all the requirements stated in the Decree. Evaluation of risk reduction will include application of an AX risk decision assessment tool approved for use by both ORP and Ecology. The evaluation will be based on the estimate of remaining volume and projected concentrations of waste constituents.

Experience has shown that unexpected waste forms and tank conditions may be encountered and that equipment performance can degrade with time. The ORP will inform Ecology at least every two weeks, through normally scheduled meetings, about unexpected waste forms, behavior, and tank conditions, along with retrieval equipment performance changes that would impact overall retrieval rates and retrieval volume. If a normally scheduled meeting does not occur, Ecology will initiate a meeting for this information exchange.

At these meetings, ORP will provide to Ecology the basis and rationale for continuing retrieval when it is suspected that waste form behavior, tank condition and/or equipment performance has diminished significantly or performance impacted the ability of the deployed equipment to operate in order to meet the waste residual goal of 360 ft^3.

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

a. System performance and efficiency data.

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

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

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

e. Presentation and discussion of residual sample location.

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

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

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

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

   1. Examination of in-tank images to observe/record waste contours and characteristics.

2. Estimation of waste retrieval performance efficiency and remaining waste volume.
3. Using performance data to demonstrate that a consistent pattern is present indicating limits of technology have been reached.
4. Evaluation of waste retrieval performance against system limitations.

Status reports are continued until waste retrieval operations cease. An SST completion of retrieval certification and a retrieval data report are then prepared and issued in accordance with the Decree and the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) respectively.

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

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

...operational requirements during retrieval...

The pump adjustment features described previously should allow the tank AX-104 pump to be installed with little or no water addition. However, if tank conditions require water additions to successfully install the pump (e.g., debris under the pump installation riser), water additions would be controlled in accordance with OSD-T-151-00013, *Operating Specifications for Single-Shell Waste Storage Tanks*, Section 3.1). This water would be added through the sluicers, by lancing, or by back flushing through the pump.

Water could also be added to the tank as needed to flush equipment removed from the tank or for a number of operational reasons. The use of water is minimized to avoid taking up DST storage space.

The estimated water volume used for the retrieval and the estimated retrieval time is provided in Table 3-2.

Table 3-2. Tank AX-104 Waste Retrieval Summary Data.

Tank	Initial Tank Waste Volume prior to Retrieval (kgal)	Projected Water Use Volume (kgal)	Other Additions (kgal)	Estimated Operating Duration (days) [d]
AX-104	7.4[a]	141.9[b]	57.0[c]	46

[a] From Table 2-3.
[b] SVF-1647 Rev. 5
[c] The retrieval plan includes volume of chemicals and time allotted for chemical dissolution.
[d] Duration estimate based on the general operating assumptions of four shifts operating 7 days/week with 41% operating efficiency.

When adding liquid to the SST for the sole purpose of obtaining a waste level measurement, the following conditions apply:

1. The high resolution resistivity (HRR)™ leak detection system for the tank described in Section 4.2.1 must be continuously operable for at least 48 hours prior to the liquid addition.

2. The benchmark level described in Section 4.6.1 will not be exceeded during the liquid addition.

3. Excess liquid will be removed from the tank as soon as practical once a usable waste level measurement is obtained.

The timing for transfers out of tank AX-104 is dependent on personnel resource availability, equipment availability, and DST conditions. Once waste retrieval is started, it should follow the general pattern described, but no liquid additions or removals to/from tank AX-104 can be predicted for more than a day or two in advance; therefore, no detailed timeline can be developed showing all liquid additions and removals. The water addition/removal may be intermittent or continuous. Based on experience with other modified sluicing and saltcake dissolution retrievals, it will likely last for an 8- to 16-hr period, then be followed by a one shift to several day wait, then continue. Work continuity will be dependent on resource availability. Ideally the retrieval will be completed within a few months, but delays with tank farm work and lack of available resources could increase retrieval duration.

3.2.1 Basis for Using Water

By using water as the waste retrieval liquid, some of the waste in tank AX-104 will be simultaneously dissolved and mobilized. As the agglomerates and structure are disturbed, silt and sludge will be mobilized and can be removed from the tank. The addition of water means no soluble radionuclides are added to the AX-104 inventory, so there is reduced risk. At the end of retrieval waste residual flushing to remove water soluble radionuclides will not be needed. Also, no supernate transfer line is needed between tanks AX-104 and AZ-102 reducing the amount of pressurized waste conveyed above ground.

3.3 TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION

...rationale for selecting these technologies to meet the requirements of this Decree...

Waste retrieval technologies currently available for deployment at tank AX-104 are (1) sluicing with water or (2) modified sluicing with supernate. Due to the large number of obstructions in the tank an in-tank vehicle and mobile-arm retrieval system were not considered feasible. Vacuum technologies were not considered because the tank leak status is "sound" and vacuum systems are less efficient than other technologies.

Modified sluicing with supernate would be performed using DST supernate that is saturated or nearly saturated with the salts that might be in tank AX-104. Even though saltcake is not listed

™ High-Resolution Resistivity (HRR) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona in the AX-104 inventory, some dried salts are likely to exist and will be more readily dissolved with water.

If a modified sluicing system similar to previously used systems was installed, there would be only one supernate pump. The water retrieval sluicing system would have an installed spare sluicing water pump that is not in a DST so very little down time from pump failure is expected. Also, if water conservation is needed, the water slurry can be recycled through ERSS's rather than using fresh water. The combination of directed sluicing with little downtime is expected to provide better sluicing than past supernate based sluicing operations. Modified sluicing doubles the required transfer infrastructure and increases the number of monitored leak detection points that can slow retrieval with false alarms. The retrieval duration would be expected to be significantly longer than sluicing with water.

After considering both candidate waste retrieval technologies and evaluation of the tank as discussed in Section 2.1.3.2, sluicing using water was selected as the preferred first technology for deployment in tank AX-104.

The second technology alternatives, if necessary, are (1) high pressure water, and (2) chemical dissolution. High pressure water can be deployed with an ERSS or an in-tank vehicle; an in-tank vehicle is not considered feasible due to the obstructions in the tank.

High pressure water is preferred with large heel volume because a chemical dissolution may take up too much DST space and, for caustic or acid dissolutions, will have proportionally more impact to the DST space. A chemical retrieval process is preferable for heels where the volume is relatively low so the impact on DST space and the Waste Treatment Plant (WTP) throughput volume is less. A chemical retrieval process may also be preferable if the waste solid particles are already small because the surface area for dissolution is greater and an in-tank vehicle may just push the fine particles around the tank.

High pressure water was selected as the second technology for tank AX-104 as it can be deployed easily when the first technology is no longer effective and the tank residual waste volume in the Decree is exceeded or it can be used in conjunction with sluicing. High pressure water prepares the waste solids for chemical dissolution by decreasing particle size and increasing surface area and should be used prior to chemical dissolution. High pressure water introduces no chemicals into the DST system that may have an impact on the WTP. Chemical dissolution compliments the mechanical technologies and has shown to be effective for waste forms resistant to size reduction by mechanical methods, but, normally, should only be used after the heel volume has been reduced by all the feasible mechanical technologies available.

The technologies selected are the technologies which should be deployed first, to their limits of technology, in an effort to achieve the 360 ft^3 target volume goal specified in the Decree.

3.4 ANTICIPATED PERFORMANCE COMPARED TO AGREEMENT CRITERIA

....two retrieval technologies that shall be deployed to each of their "limits of technology" in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank."

The WRS for tank AX-104 will be designed to retrieve as much waste from the tank as possible with the technologies selected in an effort to obtain a waste residue goal of 360 ft^3 or the limit of technology, whichever is less in accordance with the requirements of the Decree.

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

General arrangement diagrams

Figure 3-1 is a proposed installation of ventilation system(s) equipment to support waste retrieval operations. Alternate layouts may also be used. A sketch of the WRS installation planned for tank AX-104 is provided in Figure 3-2. A potential HIHTL flow path routing and equipment layout in the tank farm is provided in Figure 3-3. The elevation in the AZ tank farm is approximately 10 ft lower than the elevation in the AX tank farm.

Additional system information such as general arrangement diagrams, system description, piping and instrumentation drawings (P&ID), process flow diagrams, are included in the Independent Qualified Registered Professional Engineer (IQRPE) package provided to Ecology.

Figure 3-1. Potential New Ventilation Equipment Layout.

Figure 3-2. Tank AX-104 Waste Retrieval System In-Tank Components.

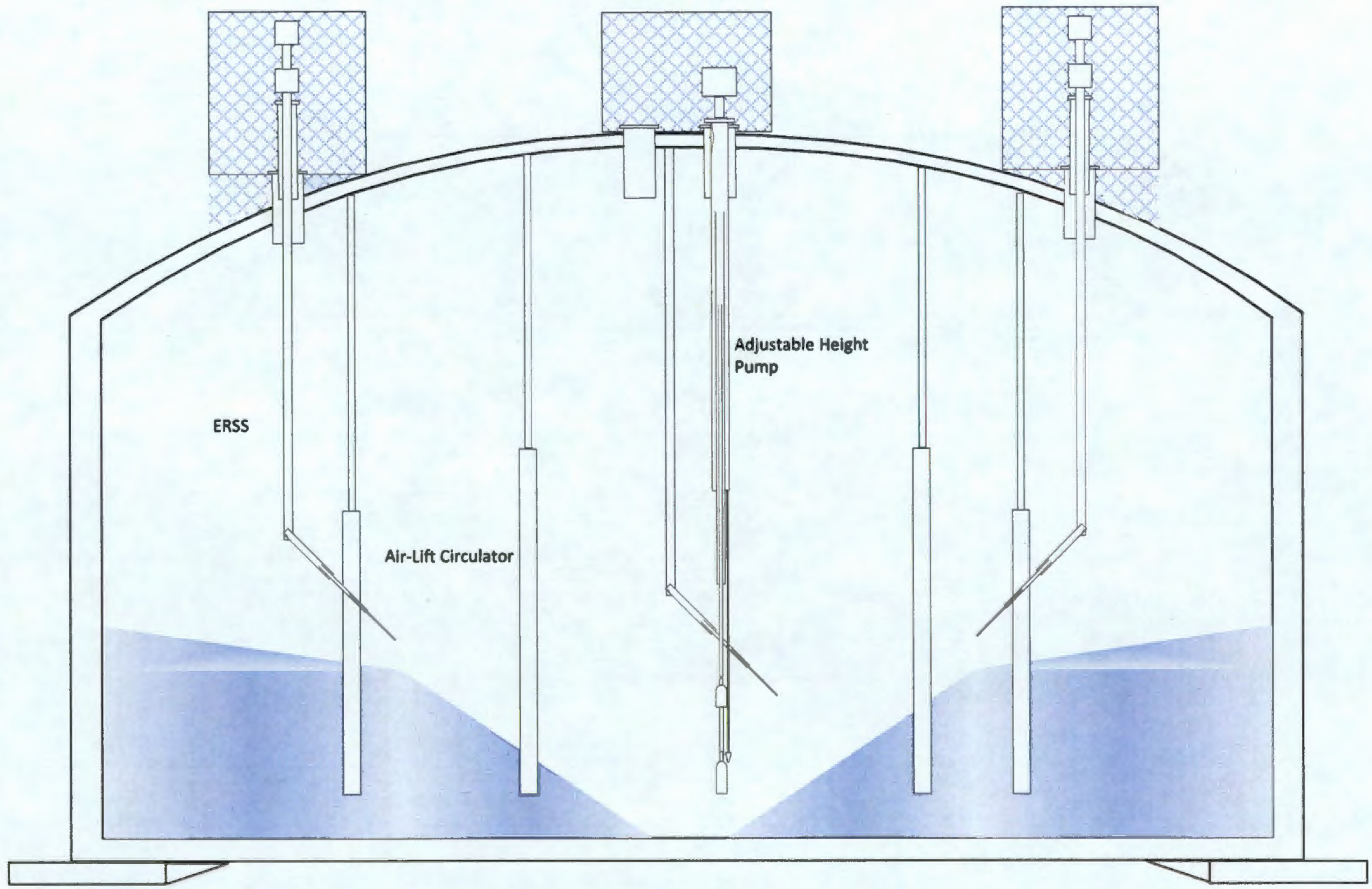


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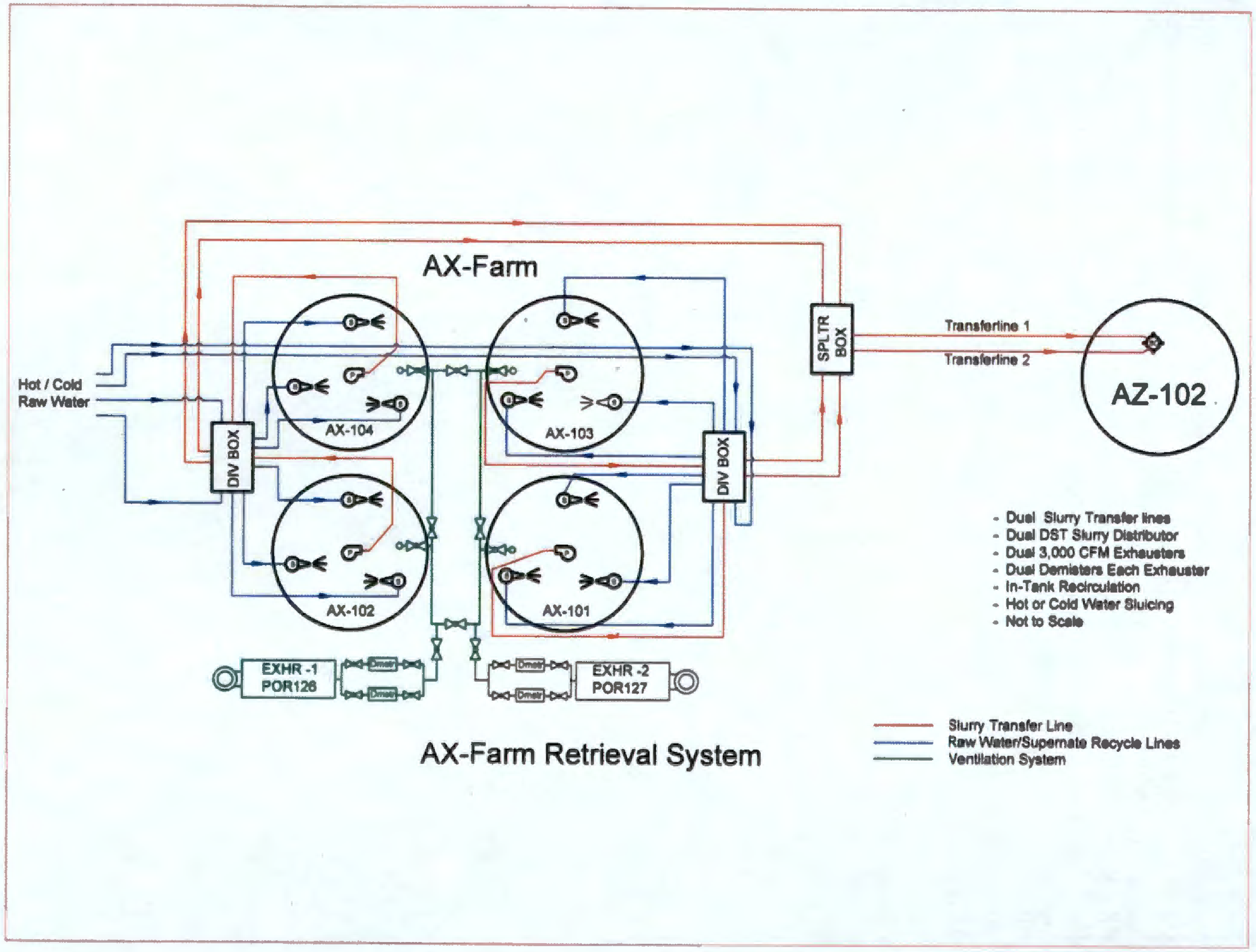
Figure 3-3. Tank AX-104 Waste Retrieval System In-Tank Components.



3.6 FUNCTIONS AND REQUIREMENTS FOR WRS DESIGN

Functions and associated requirements necessary to support design of proposed waste retrieval... system.

This section defines the upper-level functions and corresponding requirements to which the tank AX-104 WRS must be designed and operated. This TWRWP is not a system specification that defines design criteria for the WRS. However, the system specification for the tank AX-104 WRS will be consistent with this TWRWP. The functions and requirements are provided in Table 3-3 and are focused on defining the upper-level requirements for the tanks.

Table 3-3. Tank AX-104 Waste Retrieval System Functions and Requirements.

Function	Requirement	Basis*	Key Elements
Control gaseous and particulate discharges	The ventilation system exhaust shall be filtered to restrict emissions to the environment.	WAC 173-303-283(3)(b) WAC 173-400 WAC 173-460 WAC 246-247 TFC-ESHQ-ENV-STD-03 TFC-ESHQ-ENV-STD-04	Mitigate potential release to the public and the environment.
Mitigate potential for leaks to occur during waste retrieval	Prevent inadvertent release from tank AX-104 to the environment.	RPP-13033, Section 3.3.2.3.4	Do not raise waste level above benchmark level. (Benchmark level is discussed in Section 4.6).
Control waste level in DST receiver tank	The WRS shall be operated to maintain waste level within specified allowable maximum and minimum values.	OSD-T-151-00007	Provide for safe waste storage in DSTs.
Remove waste from tank AX-104	The retrieval technologies will be designed, deployed, and operated to each of their "limits of technology" in an effort to achieve the waste residue goal of 360 ft^3 of waste or less for each tank. The limit of technology is defined in the Decree.	WAC 173-303 Consent Decree CV-08-05085-FVS	The WRS shall provide the ability to retrieve as much waste as technically possible.
Control and monitor the waste removal process in tank AX-104	The WRS shall provide the monitor and control capability to control the waste retrieval and transfer process. This includes controlling and monitoring the following WRS process parameters: • Pressures • Flow rates • Differential pressures across exhaust ventilation filters • Leak detection systems.	RPP-13033 HNF-SD-WM-TSR-006 WAC 173-303 WAC 246-247 TFC-ENG-STD-26 Consent Decree No. CV-08-5085-FVS	Provide for safe and effective operation of the WRS.
Minimize waste generation	The WRS shall minimize waste generation to the greatest extent practical.	WAC 173-303	No numerical requirement.
Nuclear safety	The WRS shall be designed and operated to protect workers, public, the environment, and equipment from exposure to radioactive tank waste and emissions during the retrieval campaign.	WAC 246-247 10 CFR 830 RPP-13033 HNF-SD-WM-TSR-006 HNF-IP-1266	Ensure protection of workers and the public from routine operations and potential accident conditions.
Occupational safety and health	The WRS shall be designed for safe installation, operation and maintenance.	WAC 173-303-2 83(3)(i) 29 CFR 1910 10 CFR 835 29 CFR 1926	OSHA standards. Occupational Radiation Protection.
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features.	WAC 173-303-400 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver DST.

* Basis documents reference information is provided in Chapter 8

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

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

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

The existing buried waste transfer lines routed to tank AX-104 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tanks. Following waste retrieval activities, new transfer lines and auxiliary equipment will be flushed as needed and the equipment reused or disposed of as discussed in Section 3.9.

Should the situation arise where a structure needs to be flushed following retrieval, it is estimated that the flush volume would be in the 100- to 200-gal range. This solution would go to tank AX-104 unless a valve change was made to direct the solution to another SST that had not yet completed retrieval.

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

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

Existing risers and pits associated with tank AX-104 will be isolated following retrieval activities, when agreement has been reached with Ecology on tank AX-104 closure. These isolation methods are designed to minimize water intrusion to the tank. However, by the general design and nature of the equipment, intrusion of rainwater or snowmelt cannot be precluded.

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

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

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

3.8 INFORMATION FOR NEW ABOVEGROUND TANK SYSTEMS

...identifies the use of new aboveground tanks, tank systems or treatment systems (not otherwise permitted, and to be operated only during the retrieval duration) shall include the following additional information:

- *General arrangement diagrams*
- *System description*
- *Piping and instrumentation drawings (P&ID) for the retrieval system*
- *Process flow diagrams*
- *Information to demonstrate compliance with WAC 173-303-640*
- *Describe the disposition of the system at completion of the retrieval*

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

A written integrity assessment, reviewed and certified by an IQRPE, attesting that the transfer-related equipment and associated transfer lines are suitable for use during waste retrieval operations will be prepared in accordance with 40 CFR 265.192, "Design and Installation of New Tank Systems or Components," and submitted to Ecology following completion of the design and field installation of the WRS. This includes verification that the subject equipment meets the requirements set forth in 40 CFR 265.193, "Containment and Detection of Releases." If additional systems or additional transfer line systems are used, each system will be evaluated by an IQRPE. The design provided to the IQRPE for review will include all new or existing transfer systems, structures or components, including secondary containment (e.g., central caisson) and leak detection equipment, used for tank AX-104 waste retrieval.

The requirements for an IQRPE assessment need and the permitting decision logic for new equipment or repairs/upgrades to equipment will be performed in compliance with TFC-ESHQ-ENV-PP-C-11, *Independent Qualified Registered Professional Engineer*.

The IQRPE assessment will include P&ID, process flow diagrams, and information to demonstrate compliance with WAC-173-303-640. These engineering documents are normally not final until construction is complete and are not available when the TWRWP is submitted to Ecology. The engineering documents will be provided separate from the TWRWP.

General arrangement diagrams are provided in Section 3.5. The system is described in Section 3.1. Disposition of the system is described in Sections 3.7 and 3.9.

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

3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING WASTE RETRIEVAL

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

3.9.1 Disposition of New Waste Retrieval System Components

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

3.9.2 Disposition of Existing Ancillary Equipment

Ancillary equipment associated with tank AX-104 is limited to waste transfer lines and equipment installed in pits and above-grade risers. The current status of the ancillary equipment associated with tank AX-104 is described in Section 2.2. Any existing contaminated ancillary equipment located within risers that needs to be removed following waste retrieval will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds or controlled as specified in TFC-OPS-WM-C-10.

In accordance with the current plans for development and submittal of the SST System Closure Plan under HFFACO milestone series M-45-00 and HFFACO Appendix I, disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Closure plans will be incorporated into the Hanford Facility RCRA Permit Revision 8C, or the renewed permit referred to as the Hanford Facility Dangerous Waste Permit, Revision 9, as appropriate.

3.10 AIR MONITORING PLAN

Operational requirements during retrieval

ORP and the Tank Farm Contractor, pursuant to federal requirements for protection of their workers, will develop and implement industrial hygiene (IH) monitoring plans for exhauster stack emissions for the retrieval of tank AX-104. The plans will be developed and implemented pursuant to the requirements of TFC-PLN-34, *Industrial Hygiene Exposure Assessment Strategy*. The chemicals of potential concern (COPC), for which exhauster stack sampling and analysis will be conducted, will be identified in the IH monitoring plan for the retrieval. The COPC identified in the IH monitoring plans, as determined to be appropriate by the tank farm contractor IH, will be all or a subset of those constituents listed in RPP-20949, *Data Quality Objectives for the Evaluation of Tank Chemical Emissions for Industrial Hygiene Technical Basis*, Table 4-1, developed with input from Ecology and RPP-22491, *Industrial Hygiene Vapor Technical Basis*. No COPC shall be dropped from the Tank Vapor Information Sheet (TVIS) list developed for AX Farm without 90 days prior notification to and approval from Ecology. If ORP notifies Ecology of its desire to cease exhauster stack sampling for a COPC initially identified and listed in an IH monitoring plan and no response is received from Ecology within 90 days, the COPC will be deleted from the IH monitoring plan and sample and analysis activities for that COPC will cease. New COPCs may be added to an IH monitoring plan without notification to or approval from Ecology and without modifying or revising this TWRWP.

The sampling and analysis methods shall be EPA, National Institute for Occupational Safety and Health, or Occupational Safety and Health Administration approved methods or an equivalent tank farm contractor approved method, as identified in RPP-20949. The exhauster stack samples will be analyzed at the 222-S Laboratory, or an equivalent laboratory consistent with the quality assurance/quality control procedures for that laboratory. Further, laboratory analysis data will be kept on file at the laboratory consistent with the laboratory record keeping procedures for a period of not less than five years and will be available to Ecology within 24 hours on request.

Ecology and ORP understand and agree that the activities discussed above do not restrict ORP and the Tank Farm Contractor from taking any and/or all steps necessary as ORP and the Tank Farm Contractor deem appropriate to protect its workforce in response to data and information generated by an IH monitoring plan or incidents as they might arise during waste retrieval. Ecology and ORP also understand and agree that the preceding sampling and analysis discussion is presented to ensure ORP is achieving the agreed to sampling and analysis for the protection of the public and its workers and does not modify the exemption from the requirements of 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart CC, granted to ORP under 40 CFR 265.1080(b)(6) incorporated by reference in WAC 173-303-400(3)(a). Therefore, this discussion does not imply any change to the respective authority of either Ecology or ORP regarding the sampling, analysis, monitoring, and control of airborne emissions from Hanford Site tanks.

4.0 DESCRIPTION OF PLANNED LEAK DETECTION AND MONITORING TECHNOLOGIES

Leak detection monitoring and mitigation plan, including technology description, rationale for selection, configuration, inspection and monitoring requirements, mitigation response, and anticipated performance goals

4.1 EXISTING TANK LEAK MONITORING

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

Prior to beginning retrieval operations, SSTs are in waste storage mode. The requirements for leak detection while in waste storage mode are provided in OSD-T-151-00031. When retrieval operations are ready to commence for AX-104 the tank enters retrieval mode as described in 4.2.

4.1.1 Drywell Monitoring

Seven drywells that are in the vicinity of tank AX-104 will be used for leak detection monitoring. The monitoring drywells are between 3 and 8 ft from the edge of the tank (Figure 4.1). The seven drywells are 11-04-01, 11-02-10, 11-04-05, 11-04-19, 11-04-08, 11-04-10, and 11-04-11. The drywells are from approximately 100 ft to 125 ft deep (GJ-HAN-52, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank AX-104*).

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

4.1.2 Existing Tank Level Monitoring Equipment and Activities

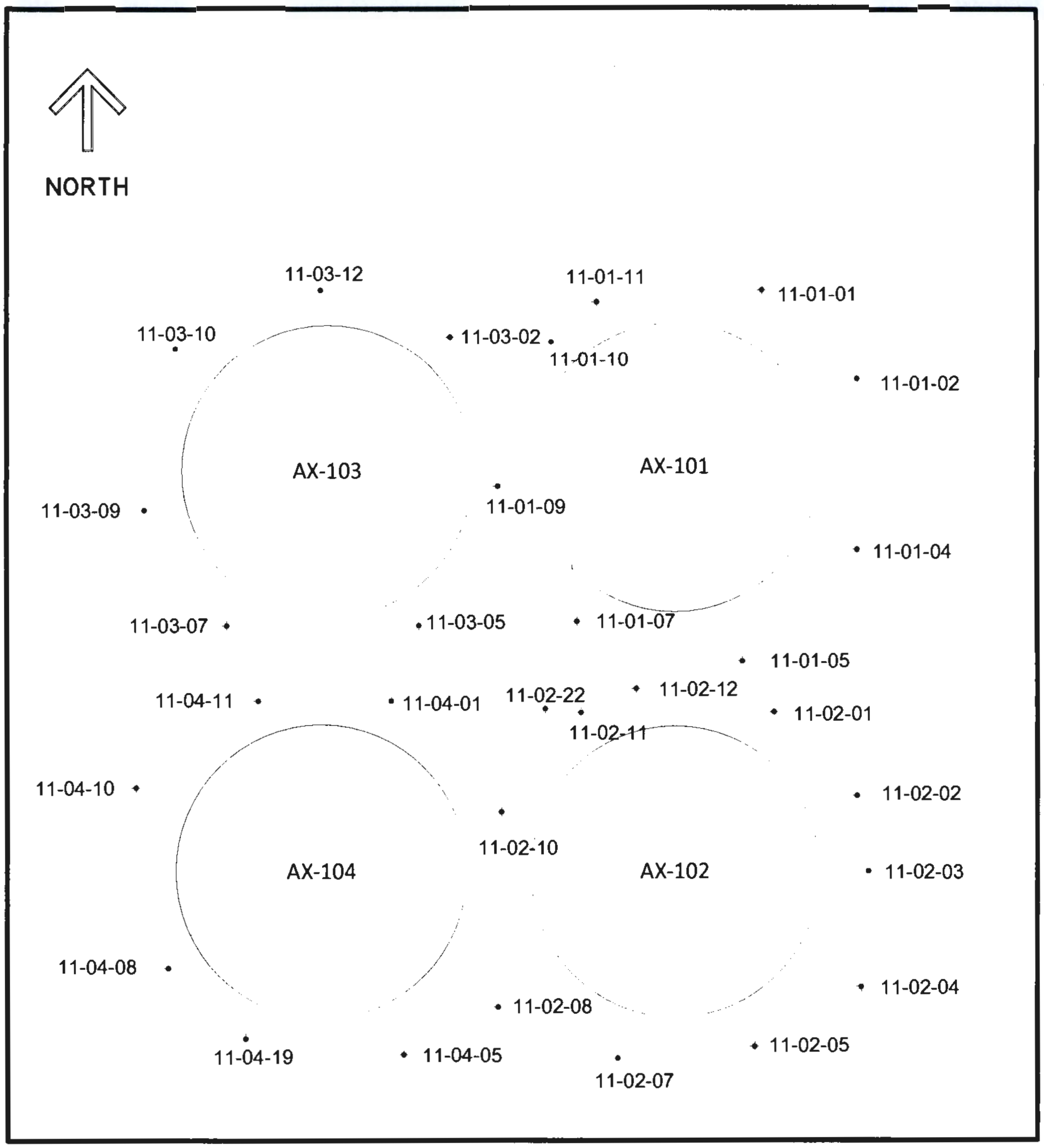
In tank AX-104 liquid observation wells (LOW) are used for intrusion/leak detection monitoring. The receiver DST has the same type of level gauge installed. The receiver DST annulus has three leak detection devices installed such as ENRAF level gauges or similar instruments and continuous air monitors for detection of leaks from the tank primary tank liner.

The waste level in tank AX-104, while in storage mode, is monitored for intrusion only on a quarterly basis (OSD-T-151-00031). The basis for in-tank leak detection and intrusion monitoring while in storage mode is provided in RPP-9937, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements Document.*

The primary level monitoring in the receiver DST is performed as described in OSD-T-151-00031, Section 3.0. The three annulus leak detector instruments provide indication of tank leaks as described in OSD-T-151-00031, Section 4.0.

Level monitoring for the tank receiving the exhauster condensate, if not AX-104, will be performed as specified in the applicable Ecology approved TWRWP for that tank or estimated on a quarterly basis when requested by Ecology.

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



4.2 PROPOSED LEAK DETECTION MONITORING SYSTEM DESCRIPTION

Leak detection monitoring and mitigation plan, including ***technology description****, rationale for selection, configuration, inspection and monitoring requirements, mitigation response, and anticipated performance goals.*

This section provides a description of the leak detection and monitoring (LDM)™ system that will be deployed at tank AX-104 during waste retrieval along with a description of how it will be operated.

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

When all waste removal operations have been completed, a final waste volume measurement is obtained, and all post-retrieval monitoring required by this document is completed, the tank retrieval status is maintained but retrieval leak detection is complete and the tank is monitored for intrusion as specified in Section 6.

4.2.1 Description of Proposed LDM System Configuration Used During Waste Retrieval

The LDM method for tank AX-104 during retrieval is an HRR LDM system with drywells and the tank thermocouple as electrodes. The HRR system will be fully implemented administratively as well as physically implemented in the field when used.

Established drywell logging methods will be used to survey the drywells surrounding tank AX-104 prior to the start of retrieval, and will be used as a backup means of leak detection if the HRR system becomes inoperable. The use of drywell logging as a backup is specified in 4.2.1.1.

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

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

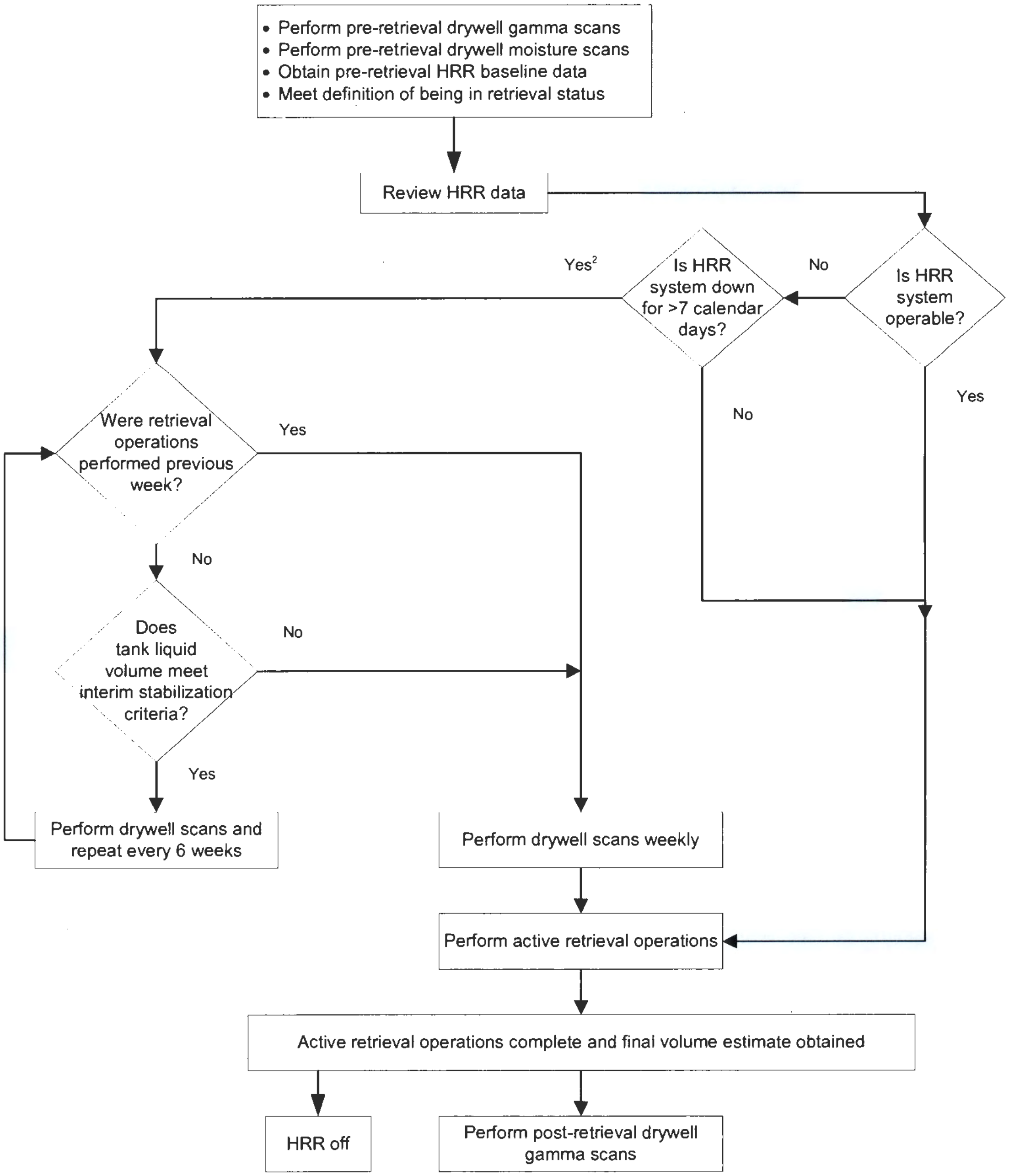
LDM systems consisting of standard leak detection arrangements are used for transfer lines and pits.

The LDM system used for the receiver DST is the same one described in Section 4.1.3.

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

™ Leak Detection and Monitoring (LDM) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona

Figure 4-2. Leak Detection Methodology for SST Retrieval.[1]



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

4.2.1.1 Drywell Monitoring

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

- Gamma scans will be obtained for each listed drywell prior to initiation of retrieval operations in the tank
- Moisture scans will be obtained for each listed drywell prior to initiation of retrieval operations in the tank
- After retrieval operations have been initiated, drywell logging will only be performed if needed as a backup leak detection method or when active retrieval will be discontinued for an extended period (typically 2 months or longer). .
- Gamma scans will be obtained for each listed drywell following completion of active retrieval operations in the tank

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

Current plans include monitoring of the following drywells prior to waste retrieval from tank AX-104:

11-04-01, 11-02-10, 11-04-05, 11-04-19, 11-04-08, 11-04-10, and 11-04-11.

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

The pre- and post-retrieval gamma scans will be obtained from near the ground surface to near the bottom of each drywell. Pre-retrieval gamma scans will preferably be obtained within a year of retrieval start but may, with approval from Ecology, be within two years.

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

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

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

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

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

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

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

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

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

The SGLS truck can also be used to operate a neutron moisture logging system, which measures in situ vadose zone moisture over the range of 0 to about 25 vol% moisture content. The neutron

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

moisture logging system uses a similar source-detector relationship as the handheld moisture gauge.

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

The handheld moisture gauge will be deployed by qualified personnel in accordance with TO-320-022, *Operate Model 503DR M1 HP-2 or M1HP-3 Hydroprobe Neutron Moisture Detection* or TO-320-060 *Operate Model 503DR M1 HP-4 Hydroprobe Neutron Moisture Gauge.*

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

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

4.2.1.2 Leak Detection Using SST Liquid Level Measurement

Should conditions exist where a continuous liquid surface measurement is available (e.g., a pump fail prior to removing as much liquid as practical from the tank and replacement of the pump cannot occur immediately) this measurement could provide an additional means of leak detection superior to either drywell monitoring or HRR. SST Liquid level measurement can be used for leak detection during waste retrieval under the following conditions:

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

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

c. There are no active retrieval operations being performed.

d. The tank is not being actively exhausted except as required to meet air permit requirements.*

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

*If the exhaust is applied to the tank for > 7 days and causes a significant level decrease rate, moisture logging will be evaluated as an alternative leak detection method.

Material balance will not be credited for SST leak detection during the retrieval of tank AX-104.

4.2.1.3 High-Resolution Resistivity.

HRR will be used for leak detection during the retrieval of the waste in tank AX-104. The equipment operates continuously except when down for repairs, calibrations, electrical outages, or similar reasons. Should a problem occur which renders the HRR leak detection system inoperable, drywell monitoring would be used as a backup means of leak detection, within the conditions specified in Figure 4-2 and section 4.2.1.

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

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

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

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

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

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

4.2.1.4 Leak Detection in Transfer Lines and Pits during Waste Retrieval.

Liquid waste and slurry will be transferred from tank AX-104 to the receiver DST using temporary over-ground HIHTLs and pits. Leak detectors located in pits will be monitored during waste transfers. Leaks may also be detected by monitoring flows and by radiation monitoring of the HIHTL in accordance with the requirements of RPP-13033, *Tank Farms Documented Safety Analysis,* and RPP-12711. The AZ-102 dual drop leg assembly will also be monitored.

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

4.2.1.5 Leak Detection in Receiver DST during Waste Retrieval.

The existing leak detection systems in the receiver DST will be utilized as required in OSD-T-151-00031. Leak detection instruments are installed in the annulus to detect a leak from the primary tank.

4.2.1.6 Use of Drywells During and After Waste Retrieval

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

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

4.3 RATIONALE FOR SELECTION OF LEAK DETECTION MONITORING TECHNOLOGY

> *Rationale for selection of LDM technology Leak detection monitoring and mitigation plan, including technology description,* ***rationale for selection****, configuration, inspection and monitoring requirements, mitigation response, and anticipated performance goals.*

The LDM technology selected for deployment at tank AX-104 represents the best available technology. The HRR system, as described in Section 4.2.1.3 is believed to provide improved leak detection monitoring over that provided by drywell monitoring.

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

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

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

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

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

4.4 LEAK DETECTION FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the leak detection systems for tank AX-104 must be designed and operated. The system specification for the AX tank farm will be consistent with this TWRWP. The functions and requirements for LDM are given in Table 4-1.

Table 4-1. Tank AX-104 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from tank AX-104	The LDM system shall be capable of detecting liquid waste releases during all waste removal operations.	WAC 173-303	Utilize LDM technologies to detect loss of liquid from a tank; see Section 4.2.1.
Monitor leaks from tank AX-104 during waste removal	The WRS shall be capable of providing data to support quantifying leak volumes from the tanks in the event a release is detected during waste retrieval operations.	WAC 173-303	Utilize both ex-tank LDM technologies and process data that will allow estimate of leak volume and migration rate to be developed to the extent practical in the event of a leak.
Mitigate leaks during tank AX-104 waste retrieval	The integrated retrieval and LDM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks during waste retrieval if they occur.	WAC 173-303	Leak mitigation strategy described in Section 4.6.
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features in accordance with 40 CFR 265.193 and DOE O 435.1.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver DST.

DST = double-shell tank.
LDM = leak detection and monitoring.
WRS = waste retrieval system.
40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."
DOE O 435.1, 2001, *Radioactive Waste Management.*
HNF-SD-WM-TSR-006, 2005, *Tank Farms Technical Safety Requirements.*
RPP-13033, 2005, *Tank Farms Documented Safety Analysis.*
WAC 173-303, "Dangerous Waste Regulations."

4.5 ANTICIPATED TECHNOLOGY PERFORMANCE

Rationale for selection of LDM technology Leak detection monitoring and mitigation plan, including technology description, rationale for selection, configuration, inspection and monitoring requirements, mitigation response, and ***anticipated performance goals****.*

4.5.1 Drywell Monitoring

There is no single value that can be stated as the maximum leak that could go undetected by drywell monitoring for tank AX-104.

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

100,000 combinations were analyzed. The following wording on drywell monitoring performance in italics is extracted from RPP-10413.

From Section 5.3 of RPP-10413:

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

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

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

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

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

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

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

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

From Attachment B3 of RPP-10413:

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

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

Table B3.1. Summary of Stochastic Results

Parameter	*One*	*Two*	*Three*
Mean travel time	*2,670 d*	*650 d*	*234 d*
Median travel time	*716 d*	*144 d*	*54 d*
5th percentile time	*6.6 d*	*3.4 d*	*2.5 d*
95th percentile time	*10,500 d*	*2,590 d*	*924 d*
Mean volume leaked	*23,100 gal*	*5,620 gal*	*2,030 gal*
Median volume leaked	*11,200gal*	*2,160 gal*	*795 gal*
5th percentile volume	*105 gal*	*59 gal*	*46 gal*
95th percentile volume	*87,700 gal*	*22,400 gal*	*7,980 gal*

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

Drywell logging is a currently deployed technology and has been used for a number of years within the tank farms. It normally requires about one shift to perform handheld moisture logging on all the drywells around a tank, assuming a 15- to 30-ft logging range with data taken every foot. Approximately one shift is required to do a gamma scan with the RAS truck on one drywell, based on a full 75- to 100-ft scan. If the RAS was used only over the same range as the hand-held moisture logging, more than one drywell could possibly be logged in a shift. A full SGLS scan of a single drywell will take one shift. If the SGLS scan was limited to the same depth range as the hand-held moisture monitoring, more than one drywell might be logged in a shift.

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

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

Moisture logging data sheets are normally given to data analysis personnel the same or following day from when the logging was performed. In instances such as when logging is done on a day when personnel are normally off, it may be several days before the sheets are reviewed. Following review, operations personnel are notified by data analysis personnel of out of the ordinary readings. This notification will thus usually be 1 to 2 days after the data are taken, but in limited instances may be up to 4 days.

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

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

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

4.5.2 SST Liquid Level Monitoring

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

4.5.3 HRR Leak Detection

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

It is reasonable to assume that the response for an HRR system deployed around an SST in AX Farm may be somewhat less than that reported in RPP-30121 for the leak injection test setup due to the differences in geometry between the test setup and a 100 Series SST in AX Farm, including the presence of concrete around the steel SST body which may diffuse or hold up leakage. Based on past tank leak experience, the rate of an actual tank leak would also likely be less than the range of leak rates tested in the leak injection test. Due to these differences and other limitations preventing direct extrapolation of test results to field deployment for AX-104, a quantitative value cannot be stated for the leak detection capability of an HRR system deployed in AX Farm. However, it can be qualitatively stated that based upon experience at the Mock Test Site, the S-102 leak injection test, observation of the response of surface electrodes tested both at S-102 and C-103, and general HRR system operation both in S Farm and C Farm it is believed an HRR system deployed in AX Farm should provide leak detection capability better than the calculated drywell monitoring leak detection capability in Section 4.5.1.

HRR interrogates the soil around and under a tank. The system sensitivity may decrease somewhat with the distance of an electrode (drywell) from the tank, but resistivity changes were still seen with drywells 100 ft. away from the injection point during the injection testing. With drywell logging, waste liquid likely needs to be less than a foot from the drywell to be detected by moisture monitoring. Gamma monitoring could potentially detect a leak when the liquid was two to three feet from the drywell, depending upon conditions. HRR is expected to have a much better sensitivity for leak detection with the much larger area interrogated by HRR when using the drywell-to-tank electrode data upon which the leak injection test conclusions were based. Sensitivity for HRR leak detection using drywell-to-drywell data; however, it still expected to be better than drywell monitoring due to the larger soil volume interrogated by HRR.

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

No instantaneous method to measure leak migration rates is available due to the inherent uncertainty and variance in the performance of the technology.

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

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

4.6 LEAK MITIGATION AND RESPONSE

Leak detection monitoring and mitigation plan, including technology description, rationale for selection, configuration, inspection and monitoring requirements, ***mitigation response****, and anticipated performance goals.*

4.6.1 Waste Retrieval Tank Leak

4.6.1.1 Waste Retrieval Tank Leak Mitigation

Leak mitigation strategy for an SST leak during waste retrieval refers to both reducing the potential for a leak to occur and to minimizing the volume of waste that could leak to the ground if there were a tank leak. Leak minimization for a waste retrieval tank leak is provided by actions taken before and during waste retrieval. These include the following:

- The in-tank liquid inventory during waste retrieval will be less than liquid level present in the tank before interim stabilization activities were undertaken.

- Addition of liquid to the retrieval tank is minimized and liquid pools that form are removed as practical.
- Liquid inventories will be removed between waste retrieval campaigns.
- Waste is retrieved to the extent practical by working from the center of the tank outwards.
- The HRR system data is evaluated as specified in Section 4.2.1.3.
- Equipment handling controls are used to minimize the potential for dropping equipment into the tank, which could penetrate the tank bottom during installation.
- A benchmark level is maintained in the tank. The waste level shall not exceed this benchmark. The benchmark level shall be defined in the process control plan. The benchmark shall be based upon minimizing free liquid in the tank.

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

4.6.1.2 Waste Retrieval Tank Leak Response

There is no tank specific response plan for an SST leak during waste retrieval. The generic leak response reactions in this subsection are applicable to any tank undergoing sluicing waste retrieval. There may be further actions specified by Corrective Actions or in a WMA A/AX closure plan when implemented.

The 'timeliness' of any leak response action is dictated in part by how often the HRR data (or drywell monitoring data when used as a backup means of leak detection), are reviewed. No leak response is initiated until a potential leak is noted. The steps enumerated in section 4.6.1.1 are used to minimize the leak potential and leak volume. Anomalies noted during HRR data review are evaluated for leak potential. The following actions will occur when this data review indicates an unexplained anomaly exists that may be caused by a potential tank leak:

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

2. Implement the TFC-ENG-CHEM-D-42 leak assessment procedure. No specific completion times are stated for the referenced steps in the leak assessment process. Leak assessment steps in TFC-ENG-CHEM-D-42 include:

   - **Review available information and identify additional information needs.** Available information includes in-tank and ex-tank measured data (e.g., surface level, flow rate, barometric pressure); tank process history; historical drywell logs; photographs; etc.

- **Develop specific leak and non-leak hypotheses.** Analysts and subject matter experts develop leak and non-leak hypotheses through a concurrence approach.
- **Assess leak probability.** The probability for each leak and non-leak hypothesis is calculated. The probability assessment is reviewed and concurred with by the analysts.
- **Prepare leak assessment report.** The leak assessment report includes the information reviewed, discussion of hypotheses considered, summary of analysts' assessments, summary of mathematical probabilities, and final determination.

3. In form Ecology within 72 hours that the evaluation process in TFC-ENG-CHEM-D-42 was initiated and that liquid additions to the tank have been suspended to validate if a leak has occurred.

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

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

Waste retrieval operations will resume under normal operating procedures if the leak assessment concludes that no leak is indicated.

The operating contractor will notify the appropriate regulatory agencies in accordance with TFC-ESHQ-ENV_FS-C-01, *Environmental Notification*, should a leak be validated. This includes notification to Ecology pursuant to the requirements of WAC 173-303.

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

- Notify Tank Farm Contractor Environmental personnel of the leak.
- Determine if the spill or release exceeds 40 CFR 302, "Designation, Reportable Quantities, and Notification," reportable quantity for the material.
- Determine if a RCRA contingency plan needs to be implemented.
- Notify Ecology and the Washington State Department of Health if the reportable quantity has been exceeded and/or the RCRA contingency plan has

been implemented. (Note: These notifications are performed per specific requirements on a checklist.)

- Specific actions to mitigate the impact of an SST leak, including spill response, interim measures, remedial actions, and closure activities, will require consultation with Ecology and DOE-ORP. Specific response(s) to a confirmed release are contingent on the specifics of the release, including time to closure of farm, size of release, relation of release to previous releases, retrieval processes and equipment in farm.

4.6.2 Receiving Tank Leak

4.6.2.1 Receiving Tank Leak Mitigation

The only receiver tank for tank AX-104 waste is tank AZ-102. Since any DST leak would be into the annulus surrounding the primary containment tank there is no release to the environment to mitigate, but timely response to a leak should minimize the volume of waste that enters the tank annulus. The primary mitigation strategy for a DST leak is to maintain operable leak detection systems and respond as specified in procedures to potential or confirmed leaks.

4.6.2.2 Receiving Tank Leak Response

A generic leak response plan is provided in HNF-3484, *Double-Shell Tank Emergency Pumping Guide*, and RPP-5842, *Time Deployment Study for Annulus Pumping*.

Actions taken in the event of a leak of waste from primary tank piping into the secondary containment system of the DST system or other receiver tank during a waste transfer from an SST to a DST include:

1. Stopping the flow of waste into the tank system (stopping the transfer),

2. Pumping waste in the primary tank to another DST until the liquid level in the secondary containment is no longer increasing, and,

3. Removing the waste from the secondary containment system as soon as practicable. Tanks that develop leaks at or near the tank bottom may also require salt well jet pumping to remove trapped liquids from between solid layers in the tank.

Pumping out waste from the primary tank and from the annulus would require tank specific response plans in the form of procedures or work packages.

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

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

- Leak detection equipment preventive maintenance or functional testing that will exceed 24 hours downtime.
- Leak detection equipment repair that will require more than 90 days to complete.
- Annulus leak detection probe elevations that are outside the elevation band prescribed by the operator round sheets.
- Operating annulus continuous air monitor readings that equal or exceed the continuous air monitor alarm setpoint, and are not due to atmospheric radon or its decay products, or not due to operational activities (e.g., annulus contamination due to vacuum imbalance between annulus and primary tank ventilation system or other operational activity).

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

4.6.3 Transfer Line Leak

Transfer line leakage occurring near the DST would likely drain to the DST receiver tank. All other transfer line leakage will drain back to either the SST being retrieved or a containment structure on the transfer line. Leakage to the containment structure is transferred to the SST being retrieved or to the DST.

4.6.3.1 Transfer Line Leak Mitigation

Leak mitigation is provided by the design of equipment that channels all leakage into an outer encasement that drains to an alarmed location and a collection tank. The transfer is shut down when the alarm occurs.

4.6.3.2 Transfer Line Leak Response

Responses to transfer leak detection alarms are performed per procedure (procedures for waste transfer are developed before waste retrieval operations). Transfer line leak detection is performed in a similar manner to, and response is similar to that for, existing tank farm transfers. There is nothing unique to the tank waste retrieval transfer line leak detection system logic when compared to existing tank farms transfer line leak detection. Should a leak be detected in the aboveground diversion/splitter boxes or pits, the waste transfer pumps would be shut down and the leakage would be transferred to the SST being retrieved or the receiver DST (the AZ Farm is at a lower elevation than AX Farm) using the sump pump. Leaks within one of the sluicer pits will result in pump shutdown with leakage draining to the SST. Waste leaked to the secondary containment of the transfer line will be returned to the SST being retrieved or the DST receiver tank. The leaks would be repaired or the leak location bypassed before resuming waste retrieval operations.

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

5.0 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Functions and associated requirements necessary to support design of proposed waste retrieval and leak detection monitoring and mitigation system(s).

Retrieval of waste from the SSTs will be performed under the requirements of the Decree, the *Atomic Energy Act of 1954*, and RCRA, RCW 70.105, "Hazardous Waste Management Act" and their implementing regulations. The SSTs do not provide secondary containment and are not compliant with RCRA, RCW 70.105 and some interim facility standards of Subpart J of 40 CFR 265. The SSTs are currently authorized to continue operations under the interim status standards pending closure in accordance with WAC 173-303-610, "Closure and Post-Closure," under the authority of HFFACO Action Plan Section 5.3, and Milestones series M-45-00. Interim status standards are authorized pursuant to the Hanford Facility RCRA Permit, Condition I.A. In addition to the regulatory requirements for interim status, the Hanford Facility RCRA Permit also imposes requirements on interim status Treatment, Storage, and /or Disposal Units based on those requirements identified in the Permit Applicability Matrix (Hanford Facility RCRA Permit Attachment 9). DOE conducts day-to-day operations of the SSTs in accordance with the interim status standards established in WAC-173-303-400(3), "Interim Status Facility Standards," to the extent practicable as documented in various compliance agreements. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the *Atomic Energy Act of 1954* and various DOE directives incorporated into the contract between ORP and the tank farm contractor (DE-AC27-08RV14800). These requirements are implemented through operating plans and procedures by the tank farm contractor.

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

The ventilation system(s) used during waste retrieval operations are designed to pass air through the tank, thereby reducing condensation and fog within the tank. The ventilation systems required by the Washington State Department of Health include a heater, prefilter, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Details of the ventilation systems are provided in 00-05-006, *Hanford Site Air Operating Permit*, as amended and succeeded.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
WAC 173-303-320, General Inspection Requirements	(a) The owner or operator must inspect his facility for malfunctions and deterioration, operator errors, and discharges (b) The owner or operator must develop and follow a written schedule for inspecting all monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment that are important to preventing, detecting, or responding to environmental or human health hazards. (c) The owner or operator must remedy any deterioration or malfunction of equipment or structures which the inspection reveals on a schedule which ensures that the problem does not lead to an environmental health hazard. (d) The owner or operator must record inspections in an inspection log or summary.	See Section 4.2 for the tank waste monitoring inspection schedule to meet the requirements of 40 CFR 265.195(a) during retrieval. RPP-16922 contains the inspection schedule for both the SST and DST systems that meet the requirements of 40 CFR 265.195(b). The inspection requirements are implemented through Operator Rounds and Shift Office tickle files. Deficiencies discovered by operators are entered into a tracking system and resolved.
WAC 173-303-330, Personnel Training	(a) Facility personnel must successfully complete a program of classroom instruction or on-the-job training that teaches them to perform their duties in a way that ensures the facility's compliance with the requirements of this part. (b) Facility personnel must successfully complete the program required in paragraph (a) of this section within six months after the date of their employment or assignment to a facility, or to a new position at a facility, whichever is later. Employees hired after the effective date of these regulations must not work in unsupervised positions until they have completed the training requirements of paragraph (a) of this section. (c) Facility personnel must take part in an annual review of the initial training required in paragraph (a) of this section (d) The owner or operator must maintain records at the facility (e) Training records must be kept until closure of the facility	TFC-PLN-07 contains the Dangerous Waste training requirements for tank farm workers. Completion of the training requirements is recorded in electronic records. Electronic records are used to support regulatory agency inquiry during compliance inspections. Tank farm employees who enter the TSD portion of the facility are subject to the HAZWOPER training requirements of 29 CFR 1910.120 as well as other health and safety training requirements. These additional health and safety training requirements are not part of the Dangerous Waste Training plan. Employees entering the TSD portion of the facility, at a minimum, receive 24-hr hazardous waste worker training. Employees who may come in contact with tank waste complete the 40-hr hazardous waste worker training. Both groups complete annual 8-hr hazardous waste worker refresher training.
Hanford Facility RCRA Permit Condition II.A and WAC 173-303-350, WAC 173-303-360, Contingency Plan and Emergency Procedures	WAC 173-303-350 (1): Each owner or operator must have a contingency plan. WAC 173-303-350 (2) and (3): (a) The contingency plan must describe the actions facility personnel must take in response to fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water (b) If the owner or operator has already prepared a Spill Prevention, Control, and Countermeasures (SPCC) Plan or some other emergency or contingency plan, he need only amend that plan to incorporate hazardous waste management provisions. (c) The plan must describe arrangements agreed to by local police departments, fire departments, hospitals, contractors, and State and local emergency response teams.	The Hanford Emergency Management Plan (DOE/RL-94-02) as attachment 4 to the Hanford Facility RCRA Permit and the Tank Farm Building Emergency Plan (RPP-27869), serve as the RCRA contingency plan for both the SST and DST Systems. Facility-wide requirements which are not the responsibility of the SST System are addressed in Hanford Facility RCRA permit Condition II.A and DOE/RL-94-02. Required notifications are contained in TFC-ESHQ-ENV_FS-C-01. The Building Emergency Plan is maintained and updated as required. Supporting the contingency plan are the abnormal operating procedures and the emergency response procedures. Required

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
	(d) The plan must list names, addresses, and phone numbers of all persons qualified to act as emergency coordinator (e) The plan must include a list of all emergency equipment at the facility (f) The plan must include an evacuation plan for facility personnel WAC 173-303-350 (4): A copy of the contingency plan must be maintained at the facility. WAC 173-303-350 (5): A contingency plan must be reviewed, and immediately amended, if necessary, whenever: (a) Applicable regulations are revised (b) The plan fails in an emergency (c) The facility changes (d) The list of emergency coordinators changes (e) The list of emergency equipment changes WAC 173-303-360 (1): At all times, there must be at least one employee either on the facility premises or on call with the responsibility for coordinating all emergency response measures. WAC 173-303-360 (2): (a) Whenever there is an imminent or actual emergency situation, the emergency coordinator must immediately: (1) Activate internal facility alarms or communication systems (2) Notify appropriate State or local agencies (b) Whenever there is a release, fire or explosion, the emergency coordinator must immediately identify the character, exact source, amount, and real extent of any released hazard. (c) The emergency coordinator must assess possible hazards to human health or the environment (d) If the emergency coordinator determines that the facility has had a release, fire, or explosion which could threaten human health, or the environment, outside the facility, he must report his findings. (e) The emergency coordinator must take all reasonable measure necessary to ensure that fire, explosions, and releases do not occur, recur, or spread to other hazardous waste at the facility (f) If the facility stops operations in response to a fire, explosion or release, the emergency coordinator must monitor for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment, wherever this is appropriate	notifications are contained in TFC-ESHQ-ENV_FS-C-01. The contingency plans are maintained in the Production Operations shift office. The on-duty Shift Manager serves as the Building Emergency Director. Emergency pumping of the DST is guided by emergency pumping guide HNF-3484. The Building Emergency Plan is maintained and updated as required by the Production Operations group.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
	(g) Immediately after an emergency, the emergency coordinator must provide for treating, storing, or disposing of recovered waste, contaminated soil or surface water, or any other material that results from a release, fire, or explosion (h) The emergency coordinator must ensure that no waste that may be incompatible with the released material is treated, stored, or disposed of until cleanup procedures are completed and all emergency equipment listed in the contingency plan is cleaned and fit for its intended use before operation is resumed (i) The owner or operator must notify the Regional Administrator, and appropriate State and local authorities, that the facility is in compliance with paragraph (h) before operations are resumed (j) The owner or operator must note in the operating record the time, date, and details of any incident that requires implementing the contingency plan. Within 15 days after the incident, submit a written report on the incident to the Regional Administrator.	
WAC 173-303-380, Facility Recordkeeping	(a) The owner or operator must keep a written operating record	The written operating record for the SST System includes but is not limited to the following: • Completed operator rounds • Shift Manager log books • Completed corrective maintenance and preventative maintenance procedures and packages
265.191, Assessment of existing tank systems integrity	(a) For each existing tank system that does not have secondary containment meeting the requirements of 265.193, the owner or operator must determine that the tank system is not leaking or is unfit for use. (b) This assessment must determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture, or fail. (d) If, as a result of the assessment conducted in accordance with paragraph (a) of this section, a tank system is found to be leaking or unfit for use, the owner or operator must comply with the requirement of §265.196.	(a) and (b): RPP-10435 prepared and submitted under HFFACO Milestone M-23-24. (d) Because the SSTs are not compliant with RCRA 40 CFR 265.191, the SSTs are currently authorized to continue operations pending closure under the authority of the HFFACO milestone series M-45-00.
265-192, Design and Installation of New Tank Systems or Components	(a) Owners or operators of new tank systems or components must ensure that the foundation, structural support, seams, connections, and pressure control (if applicable) are adequately designed and that the tank system has sufficient structural strength, compatibility with the waste to be stored or treated, and corrosion protection so that it will not collapse, rupture, or fail. The owner or operator must obtain a written assessment, reviewed and certified by an independent, qualified, registered professional engineer attesting that the system has sufficient structural integrity and is acceptable for the storing and treating of hazardous (dangerous) waste. (b) The owner or operator of a new tank systems must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation.	The HIHTL design and installation is verified and certified by an IQRPE. Aboveground retrieval tank systems are verified and certified by an IQRPE. System design and IQRPE certification ensure that parts (a), (b), (c), (d), and (e) are met. Cathodic protection is not installed on the HIHTL. **Note:** The 241-AX-104 concrete pits are not fully compliant with 40 CFR 265.193 and WAC 173-303-640 secondary containment standards and cannot be certified by an IQRPE pursuant to 40 CFR 265.192 or

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
	Prior to covering, enclosing, or placing a new tank system or component in use, an independent, qualified installation inspector or an independent, qualified, registered professional engineer, either of whom is trained and experienced in the proper installation of tank systems, must inspect the system or component. (c) New tank systems or components and piping that are placed underground and that are backfilled must be provided with a backfill material that is a noncorrosive, porous, homogeneous substance that is carefully installed so that the backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported. (d) All new tanks and ancillary equipment must be tested for tightness prior to being covered, enclosed, or placed in use. (e) Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement vibration, expansion or contraction (f) The owner or operator must provide the type and degree of corrosion protection necessary to ensure the integrity of the tank system during use of the tank system. The installation of a corrosion protection system that is field fabricated must be supervised by an independent corrosion expert to ensure proper installation (g) The owner or operator must obtain and keep on file at the facility a written statement by those persons required to certify the design of the tank system and supervise the installation of the tank system in accordance with the requirements of this section to attest that the tank system was properly designed and installed and that repairs were performed. These written statements must also include the certification statement.	WAC 173-303-640. The alternative design and operating practices, together with location characteristics are as effective as secondary containment because the concrete pits have installed leak detection systems that will terminate a waste transfer upon detection of a leak, have a method for removal of any waste or liquid that enters the pit, and have sufficient volume such that they will contain, without overflowing the pit, any leaked waste resulting from transfer line hold-up drainage and pump operation from the time of detection to time of automatic or operator induced shutdown. The pits will not be upgraded to meet the secondary containment standards and will not be inspected by, or certified by, an IQRPE. An IQRPE will certify the leak detection operability criteria have been met before retrieval begins (RPP-RPT-58466).
265.193, Containment and Detection of Releases	(a) In order to prevent the release of hazardous (dangerous) waste or hazardous (dangerous) constituents to the environment, secondary containment must be provided (b) Secondary containment must be: (1) Designed, installed, and operated to prevent any migration of waste or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system (2) Capable of detecting and colleting releases and accumulated liquids until the collected liquid can be removed. (c) To meet the requirements of paragraph (b) of this section, secondary containment must be at a minimum: (1) Constructed of or lined with materials that are compatible with the waste(s) to be placed in the tank system and must have sufficient strength and thickness to prevent failure due to pressure gradients, physical contact with the waste to which it is exposed, climatic conditions, the stress of installation, and the stress of daily operation.	The above ground retrieval system equipment is designed with compliant secondary containment. Design documentation is available for inspection.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
	(2) Placed on a foundation or base capable of providing support to the secondary containment system and resistance to pressure gradients above and below the system and capable of preventing failure due to settlement, compression, or uplift. (3) Provided with a leak-detection system that is designed and operated so that it will detect the failure of either the primary and secondary containment structure or any release if hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the existing detection technology or site conditions will not allow detection of a release within 24 hours. (4) Sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system with 24 hours, or in as timely a manner as is possible to prevent harm to human health or the environment, if removal of the released waste or accumulated precipitation cannot be accomplished within 24 hours. (d) Secondary containment for tanks must include one or more of the following devices; (1) A line (external to the tank) (2) A vault (3) A double-walled tank (4) An equivalent device as approved by the Regional Administrator. (e) [Applies to the design of external liners, vaults, and double-walled tanks.] (f) Ancillary equipment must be provided with full secondary containment except for: (1) Aboveground piping (exclusive of flanges, joints, valves, and connections) that are visually inspected for leaks on a daily basis (2) Welded flanges, welded joints, and welded connections that are visually inspected for leaks on a daily basis (3) Sealless or magnetic coupling pumps and sealless valves that are visually inspected for leaks on a daily basis (4) Pressurized aboveground piping systems with automatic shutoff devices that are visually inspected for leaks on a daily basis.	
265.194, General Operating Requirements	(a) Hazardous (dangerous) wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail. (b) The owner or operator must use appropriate controls and practices to prevent spills and overflows from tank or containment systems. They include at a minimum: (1) Spill prevention controls (e.g., check valves, dry disconnect couplings); (2) Overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank); and	(a) The waste compatibility assessment ensures solutions and materials are compatible prior to addition. (b) Control of the waste retrieval process is defined in the process control plan for each retrieval: (1) System design. (2) The receiving DST has primary tank level instrumentation which is monitored during transfers.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
	(3) Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation (c) The owner or operator must comply with the requirements of § 265.196 if a leak or spill occurs in the tank system.	(3) Not applicable. (c) Because the SSTs are not compliant with RCRA 40 CFR 265.191, the SSTs are currently authorized to continue operations pending closure under the authority of the HFFACO milestone series M-45-00.
265.195 (a) and (b), Inspections	(a) The owner or operator must inspect, where present, at least once each operating day, data gathered from monitoring and leak detection equipment (e.g., pressure or temperature gauges, monitoring wells) to ensure that the tank system is being operated according to its design. (b) Except as noted under the paragraph (c) of this section, the owner or operator must inspect at least once each operating day: (1) Overfill/spill control equipment (e.g., waste-feed cutoff systems, bypass systems, and drainage systems) to ensure that it is in good working order; (2) Above ground portions of the tank system, if any, to detect corrosion or releases of waste; and (3) The construction materials and the area immediately surrounding the externally accessible portion of the tank system, including the secondary containment system (e.g., dikes) to detect erosion or signs of releases of dangerous waste (e.g., wet spots, dead vegetation).	See Row for WAC 173-303-320 above. Cathodic protection is not installed on HIHTLs.
265.196 Response to leaks or spills and disposition of leaking or unfit-for-use tank systems	A tank system or secondary containment system from which there has been a leak or spill, or which is unfit for use, must be removed from service immediately, and the owner or operator must satisfy the following requirements; (a) Cessation of use; prevent flow or addition of wastes (b) Removal of waste from tank system or secondary containment system (c) Containment of visible releases to the environment (d) Notifications, reports	Responses to leak or spills applicable to requirement are defined in Sections 4.6.2 and 4.6.3.
WAC 173-303-283 (3), Performance standards	The owner/operator must design, construct, operate, or maintain a dangerous waste facility that to the maximum extent practical given the limits of technology prevents: (a) Degradation of ground water quality; (b) Degradation of air quality by open burning or other activities; (c) Degradation of surface water quality; (d) Destruction or impairment of flora and fauna outside the active portion of the facility; (e) Excessive noise (f) Conditions that constitute a negative aesthetic impact for the public using rights of ways, or public lands, or for landowners of adjacent properties; (g) Unstable hillsides or soils as a result of trenches, impoundments, excavations, etc.;	The following plans and procedures and their implementation provide the preventative measures required: (a) The current groundwater monitoring plan for the waste management area(s). (b) No open burning is allowed. (c) Berms and gutters are in place to prevent surface runoff and surface run-on. (d) No destruction or impairment of flora and fauna occur outside of the tank farms.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval.* (7 Sheets)

Regulation	Requirement	Compliance Method
	(h) The use of processes that do not treat, detoxify, recycle, reclaim, and recover waste material to the extent economically feasible; and (i) Endangerment of the health of employees, or the public near the facility.	(e) Noise is monitored based on applicable health and safety requirements. (f) The tank farms are within the dangerous waste facility (i.e., Hanford site). (g) Appropriate permits are obtained before excavation work is started. No excavation work is associated with tank waste retrieval. (h) The waste retrieval process is designed, constructed and will be operated to treat and recover waste to the limits of technology in accordance with Decree. (i) The public is protected by the NOC per WAC 173-303-400 & 460. Workers are protected per TFC-PLN-43.
WAC 173-303-400, Interim Status Facility Standards	WAC 173-303-400(3)(a) incorporates by reference 40 CFR 265 Subpart J. WAC 173-303-400(3)(b) replaces federal terms in 40 CFR 265 (i.e., regional administrator, hazardous) with state terms (i.e., department, dangerous). WAC 173-303-400(3)(c)(ix) replaces/modifies certain requirements for tank systems.	Applicable operating plans and procedures are referenced throughout the document; too numerous to appropriately reference herein.

* Document reference information is provided in Chapter 8 of this document.

DST = double-shell tank.

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

HIHTL = hose-in-hose transfer line.

IQRPE = independent, qualified, registered professional engineer.

NOC = notice of construction.

SST = single-shell tank.

TSD = treatment, storage, and/or disposal.

6.0 PRELIMINARY ISOLATION EVALUATION

Preliminary isolation evaluation including a list of ancillary equipment associated with the specific component, plans for ancillary equipment removal or waste retrieval, available characterization information for waste contained within ancillary equipment, and anticipated interrelated impacts of various retrieval actions

This section provides a preliminary isolation evaluation for tank AX-104. Intrusion prevention measures were completed in the 1980s for this tank. The identification of tank penetrations and methods used to isolate intrusion pathways are described in Section 2.2. Isolation details for intrusion measures completed for tank AX-104 are provided on drawing H-2-73382, *Piping Waste Tank Isolation 241-AX-104 Tank Farm Plot Plan*, Sheet 1.

Following completion of waste retrieval, the in-tank equipment may be removed or may be left in place for disposition during tank closure activity actions. Isolation of pipelines and ancillary equipment will be performed in accordance with an Ecology-approved closure plan. Tank and/or ancillary equipment component closure will not begin until there is an approved component closure plan for WMA A-AX.

Isolation of intrusion routes into the tank will be done within the closest diversion box to the tank when AX-104 waste retrieval has been completed. Additional isolation of any other tank and/or ancillary equipment, excluding HIHTLs, once tank AX-104 waste retrieval has been completed will be performed as needed for operational purposes related to future tank waste retrievals. HIHTLs will be handled as described in 3.9.1. Once the final closure plan has been agreed to the intrusion prevention will proceed per the schedule for final tank closure at that time.

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

7.0 PRE-RETRIEVAL RISK ASSESSMENT

This section provides long-term human health risk information to support operational decisions in the event a leak is detected during waste retrieval operations for tank AX-104. Context information is provided regarding potential future impacts of residual tank waste and leaks for all tanks in WMA A/AX. The requirement to consider long-term human health impacts in developing tank waste retrieval work plans is described in Appendix C, Part 2, of the Decree.

According to the Consent Decree, Appendix C, Part 2, Item 4, the information provided in the work plans will include the following:

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

The risk information provided in this section was developed to meet the requirements identified in the Decree. Information is provided for two main categories of impacts: (1) long-term human health risk associated with use of groundwater, and (2) long-term human health risk associated with inadvertent post-closure human intrusion. Uncertainty or sensitivity evaluations of the impact of constituent concentration variability will be provided in the closure plan risk assessment and the retrieval data report.

Groundwater pathway impacts are discussed in Section 7.1. Inadvertent intruder impacts are discussed in Section 7.2.

7.1 GROUNDWATER PATHWAY IMPACTS

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

The methodology used to develop the retrieval leak impact graphs is described in Section 7.1.1. Tank-specific retrieval leak impact results are discussed in Section 7.1.2. Retrieval leak impact graphs for tank AX-104 are provided in Appendix B. A WMA-level perspective on groundwater pathway impacts is provided in Section 7.1.3 to help place the potential retrieval leak impacts from the individual tank into the context of the potential impacts for WMA A/AX as a whole.

The methodology developed for evaluating impacts for the groundwater pathway is largely based on local-scale modeling tools (with some modification) that were developed for the A and AX tank farms to support DOE/EIS-0391, Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington, hereinafter TC&WM EIS. As such, reviewers of the results that follow should be cognizant of the following assumptions and aspects of the methodology developed to support this TWRWP, especially if comparing results of past or future modeling efforts:

- **Points of Analysis** – Per requirements outlined in the Decree, results summarized here are provided at the WMA fenceline which is hundreds of meters closer to the source areas (e.g., only 10 m from tanks AX-101 and AX-102) than the A Barrier Boundary where groundwater impacts from the WMA A/AX and other tank farm areas were evaluated in the TC&WM EIS. The WMA fenceline is also closer to the source areas than points of analysis (i.e., 100 m downgradient of the WMA fenceline) that will eventually be considered in the long-term performance assessment of a closed WMA A/AX. The TWRWP relies on the present day fenceline rather than assume a location for a future fenceline encompassing a closed WMA A/AX with a surface barrier. It is probable a future fenceline would be further from the tanks than the present fenceline. The location of the point of analysis affects the amount of dilution and dispersion that occur along the transport pathway.
- **Model Resolution –** To facilitate the calculation of contaminant impacts at the WMA fenceline the Subsurface Transport Over Multiple Phases (STOMP)-based local-scale models of the A and AX tank farm areas were extended into the underlying unconfined aquifer system. The grid resolution of this part of the local-scale models is highly discretized so that impacts can be examined at the WMA fenceline, i.e., concentrations are typically determined in 5 m × 5 m × 5 m volumes, in contrast to

the coarser resolution in the regional-scale model used to simulate transport of groundwater impacts from source areas to the A Barrier Boundary in the TC&WM EIS.

- **Past Leak Inventories** – This analysis uses estimates of past leak inventories used in the TC&WM EIS. Recently updated estimates of past releases documented in RPP-RPT-58291, *Hanford Waste Management Area A-AX Soil Contamination Inventory Estimates*, provide information for consideration in the WMA A/AX performance assessment that may produce changes in the location, timing, and magnitude of predicted past releases impacts.
- **Retrieval Leak Inventories** – This analysis includes updated information on potential retrieval leak inventories for the AX farm tanks (RPP-RPT-58867, *AX Farm Groundwater Risk Constituent Concentration Determination*) while using existing estimates from the TC & WM EIS for retrieval leak inventories for the A Farm tanks. The A Farm tanks are expected to be retrieved in accordance with a future TWRWP(s) in which assumptions may be updated (for instance, tanks A-104 and A-105 are unlikely to be sluiced). The approach for estimating retrieval leak inventories for the AX Farm tanks as documented in RPP-RPT-58867 differs from previous assessments.
- **Residual Inventories** – This analysis uses estimates of residual waste inventories in tanks and ancillary equipment used in the TC&WM EIS. Recently updated estimates of residual inventories documented in RPP-RPT-58293, *Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*, provide information for consideration in the WMA A/AX performance assessment that may produce changes in the location, timing, and magnitude of predicted residual inventory impacts. Residual inventories used in a final closure performance assessment will eventually be developed based on laboratory analysis of tank waste retrieval samples collected after the retrieval process at the WMA A/AX is completed.
- **Contaminant Release Models for Residual Wastes** – This analysis makes use of contaminant release models used for tank waste residuals in the TC&WM EIS. Release of source terms for residual waste from tanks and ancillary equipment were each based on the use of a partitioning-limited, convective-flow release model assumed for grout-stabilized waste (DOE/EIS-0391 Appendix M). Other recent tank farm assessments are evaluating the potential effects of the tank structure, grout in-filling of tanks, and the tank residuals in controlling the release of contaminants after closure. These assessments are considering diffusion-controlled and/or solubility-controlled release models for tank residuals that will generally limit contaminant releases from residual wastes and predict lower peak concentrations that would arrive later in time.

7.1.1 Retrieval Leak Evaluation Methodology

The retrieval leak graphs were developed using the following methodology:

- Focus on potential long-term groundwater pathway human health risk at the downgradient tank farm fenceline
- Use radiological incremental lifetime cancer risk (ILCR) and noncarcinogenic chemical hazard index (HI) as the primary human health impact metrics
- Use industrial and residential exposure scenarios
- Identify the significant contributors (95% of total) for each health impact metric and generate a separate graph for each significant contributor (note that in risk terminology, the HI for all chemicals is the sum of the hazard quotient, or HQ, for each chemical)
- Derive effects of contaminant release and transport from previous studies
- Use the best available published data and information to the maximum extent possible.

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

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

Where:

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

Sections 7.1.1.1 through 7.1.1.4 discuss the individual terms in Equation 7-1, including identification of indicator contaminants, development of contaminant inventories, simulation of contaminant transport, and identification of exposure scenarios and health effects conversions factors.

7.1.1.1 Indicator Contaminants

Retrieval leak impact graphs were generated for a subset of significant contaminants rather than for all contaminants. Significant contaminants were the contaminants estimated to dominate or drive the total impact for a particular human health impact metric, also known as "risk drivers." Significant contaminants serve as indicators of the magnitude of total impacts from all contaminants.

An indicator contaminant approach was used to ensure that the resulting graphical tools would provide a reasonable estimate of total impacts but at the same time be sufficiently simple to facilitate rapid decision making without requiring a lot of additional calculation in the event a leak is detected during waste retrieval. The primary human health impact metrics used were radiological ILCR and noncarcinogenic chemical HI. Nonradiological ILCR was also included for information purposes. Exposure scenarios and unit factors used in the calculation of ILCR and HI are discussed in Section 7.1.1.4.

Indicator contaminants for each human health impact metric were identified based on the results of the TC&WM EIS. TC&WM EIS provides results of a site-specific model developed for sources across the Hanford Site, including WMA A/AX. DOE/EIS-0391 Appendix Q provides contaminant-specific impact contributions at the "A Barrier Boundary" by source term for contaminants for which a toxicity factor was available. The A Barrier Boundary is a hypothetical line of analysis encompassing an area much larger than WMA A/AX and including multiple other source areas. Whereas the existing TC&WM EIS model cannot be used to predict groundwater impacts from WMA A/AX sources at the WMA fenceline, the TC&WM EIS does identify contaminants not predicted to be significant for any source within the A Barrier Boundary, and the model provides a basis to determine which remaining contaminants probably account for 95% of ILCR and HI for each source term and exposure scenario at the time of peak impact. The indicator contaminants thus identified were Tc-99, I-129, chromium (Cr), and nitrate (NO_3). Nitrite (NO_2) was added to this list per the discussion that follows.

The determination of indicator contaminants also considered that similar risk drivers are obtained from the analysis in DOE/ORP-2005-01, Initial Single-Shell Tank System Performance Assessment at the Hanford Site, and the use of the associated Decision Management Tool (DMT) (RPP-39234, *Decision Management Tool, Version 5, User's Manual*). DOE/ORP-2005-01 provides results of a site-specific model developed for WMA C, and extrapolated to other WMAs in the 200 East Area, including WMA A/AX. DOE/ORP-2005-01 provides contaminant-specific impact contributions at the WMA A/AX downgradient fenceline by source term for contaminants for which a toxicity factor was available.

One difference between the TC&WM EIS and previous assessment tools such as DMT is the assumption in the TC&WM EIS that nitrite inventory for all source terms would be converted to nitrate prior to transport to the point of calculation. Thus, the TC&WM EIS model did not specifically evaluate nitrite independently and its results identified nitrate as a significant hazard contributor, whereas previous assessments of tank farm sources routinely identified nitrite as a significant hazard contributor and not necessarily nitrate. Because analyzing the validity of the assumption for all relevant source terms is non-trivial, and because nitrite has higher toxicity than nitrate, source terms were recalculated to separately simulate both nitrite and nitrate.

Table 7-1 summarizes the contaminant contributions by source term for each of the human health impact metrics using results from the present modeling as described briefly in Sections 7.1.1.3 and 7.1.1.4. Details of the methodology and resulting modeling and associated calculations of risk, dose, and hazard impacts are more fully described in RPP-CALC-60497, *Peak Groundwater Concentrations for Tank Farm 241-AX TWRWP Risk Assessment* and RPP-CALC-60498, *Tank Waste Pre-Retrieval Assessment of Dose and Risk*. Table 7-1 shows the peak impacts from the following WMA A/AX source terms: 1) past leaks and other waste loss events involving tanks A-103, A-104, A-105, AX-102, and AX-104; 2) potential retrieval leaks from AX-104; 3) potential retrieval leaks from all AX-100-series tanks; 4) potential retrieval leaks from all A-100-series tanks; 5) tank residual waste; and 6) residual waste in ancillary equipment. Retrieval leak volumes are discussed in Section 7.1.1.2. Peak impacts from sources in the A Farm occur at locations along the fenceline that are distant from peak impacts from sources in the AX Farm. Table 7-1 reports the maximum impacts between the two tank farms for each contaminant from each source except retrieval leaks, with total ILCR or HI for all indicator contaminants assumed to be additive (i.e., only one tank farm contributes to the value reported for each contaminant, but differences in location along the fenceline and in timing are ignored in the totals for all indicator contaminants). Peak impacts from potential retrieval leaks from each of the remaining AX-100-series tanks are reported in separate TWRWP documents that were developed concurrently with this document. Table 7-1 assumes peak impacts from all AX-100-series tank retrieval leaks are additive, i.e., differences in location along the fenceline and in timing are ignored.

Results of the TC&WM EIS, the DMT, and preliminary runs of the present TWRWP model indicate the only contributors to total WMA A/AX radiological ILCR at the fenceline at the time of peak concentration would be the long-lived and highly mobile radionuclides, technetium-99 and iodine-129, with technetium-99 being the major contributor. Technetium-99 was predicted to contribute greater than 90% of the total radiological ILCR for every source term and receptor scenario, and technetium-99 and iodine-129 combined contribute greater than 98%. For modeling purposes, highly mobile contaminants are those with distribution coefficient (K_d) values of 0 mL/g in the vadose zone and saturated zone sediments, as assumed in the TC&WM EIS. The contribution from iodine-129 and absence of carbon-14 at the time of peak are likely to be a consequence of the updated K_d values assumed in the TC&WM EIS (0 and 4.0 mL/g, respectively) versus the older values in the DMT (0.2 and 0 mL/g, respectively). Even with the treatment of carbon-14 as both non-reactive (except for radioactive decay) and non-sorbing in the DMT, it contributes less than 2% for every source term and receptor scenario. Tritium is too short-lived to contribute at the time of peak impact. Technetium-99 and iodine-129 were therefore selected as the radiological ILCR indicator contaminants for this evaluation.

Percentage contributions shown in Table 7-1 are based on total impacts of the indicator contaminants only, because only indicator contaminants were simulated. Impacts from other long-lived, highly mobile contaminants could be estimated by scaling impacts from one of the indicator contaminants by the ratio of the contaminant inventories. From simulations with the present TWRWP model, percentage contributions shown in Table 7-1 indicate technetium-99 accounted for 93 to >99% of the radiological ILCR and iodine-129 accounted for <1 to 7%.

The analysis results indicate the only contributors to the total WMA A/AX noncarcinogenic chemical HI at the fenceline at the time of peak would be the following highly mobile ($K_d = 0$ mL/g) chemicals: chromium, nitrite, and nitrate, with chromium and nitrite being the major drivers. From the TC&WM EIS results, these three chemicals combined were predicted to contribute at least 98% of the total HI for every source term and receptor scenario. Relative contaminant contributions could not be accurately predicted from the TC&WM EIS results prior to recalculating separate nitrate and nitrite source terms, but since no chemical dominated the HI in every case, each was potentially significant. The analysis conservatively assumed that all chromium inventory was hexavalent chromium. The DMT indicated a contribution in past leaks scenarios from 1-butanol (n-butyl alcohol), however the TC&WM EIS updated K_d value of 3.0 mL/g eliminated the impact that arose from the DMT using a value of 0 mL/g. Chromium, nitrite, and nitrate were therefore selected as the noncarcinogenic chemical HI indicator contaminants for this evaluation.

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area A/AX Fenceline. (3 Sheets)

Source Term	Time of Peak by Indicator Contaminant (Calendar Year)	Radiological Incremental Lifetime Cancer Risk by Indicator Contaminant		Nonradiological Incremental Lifetime Cancer Risk by Indicator Contaminant		Noncarcinogenic Chemical Hazard Index by Indicator Contaminant	
		Industrial	Residential	Industrial	Residential	Industrial	Residential
Past leaks [a]	Tc-99 2029 I-129 2054 Cr 2051 NO_2 2042 NO_3 2051	Tc-99 6.8E-05 (95%) I-129 3.8E-06 (5%) Total 7.2E-05 (100%)	Tc-99 1.6E-03 (99%) I-129 1.8E-05 (1%) Total 1.6E-03 (100%)	Cr 4.2E-07 (100%) Total 4.2E-07 (100%)	Cr 9.9E-07 (100%) Total 9.9E-07 (100%)	Cr 1.3E-01 (58%) NO_2 8.7E-02 (40%) NO_3 3.7E-03 (2%) Total 2.2E-01 (100%)	Cr 6.9E-01 (54%) NO_2 5.6E-01 (44%) NO_3 2.3E-02 (2%) Total 1.3 (100%)
AX-104 Retrieval leak [b]	Tc-99 2672 I-129 2673 Cr 2673 NO_2 2672 NO_3 2672	Tc-99 6.9E-05 (>99%) I-129 6.7E-08 (<1%) Total 6.9E-05 (100%)	Tc-99 1.6E-03 (>99%) I-129 3.1E-07 (<1%) Total 1.6E-03 (100%)	Cr 1.1E-07 (100%) Total 1.1E-07 (100%)	Cr 2.5E-07 (100%) Total 2.5E-07 (100%)	Cr 3.1E-02 (84%) NO_2 2.7E-03 (7%) NO_3 3.4E-03 (9%) Total 3.7E-02 (100%)	Cr 1.7E-01 (81%) NO_2 1.7E-02 (8%) NO_3 2.2E-02 (10%) Total 2.1E-01 (100%)
A Farm Retrieval leaks [c]	Tc-99 2068 I-129 2068 Cr 2068	Tc-99 6.3E-05 (93%) I-129 5.0E-06 (7%)	Tc-99 1.5E-03 (99%) I-129 2.3E-05 (1%) Total 1.5E-03 (100%)	Cr 1.6E-06 (100%) Total 1.6E-06 (100%)	Cr 3.8E-06 (100%) Total 3.8E-06 (100%)	Cr 4.8E-01 (72%) NO_2 1.7E-01 (25%) NO_3 1.7E-02 (3%)	Cr 2.6E+00 (69%) NO_2 1.1E+00 (29%) NO_3 1.1E-01 (3%)

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area A/AX Fenceline. (3 Sheets)

Source Term	Time of Peak by Indicator Contaminant (Calendar Year)	Radiological Incremental Lifetime Cancer Risk by Indicator Contaminant		Nonradiological Incremental Lifetime Cancer Risk by Indicator Contaminant		Noncarcinogenic Chemical Hazard Index by Indicator Contaminant	
		Industrial	Residential	Industrial	Residential	Industrial	Residential
	NO_2 2068 NO_3 2068	Total 6.8E-05 (100%)				Total 6.6E-01 (100%)	Total 3.8E+00 (100%)
AX Farm Retrieval leaks [d]	Tc-99 2671-2743 I-129 2672-2745 Cr 2672-2745 NO_2 2672-2739 NO_3 2672-2741	Tc-99 1.5E-04 (97%) I-129 5.2E-06 (3%) Total 1.6E-04 (100%)	Tc-99 3.6E-03 (>99%) I-129 2.4E-05 (<1%) Total 3.6E-03 (100%)	Cr 2.2E-06 (100%) Total 2.2E-06 (100%)	Cr 5.2E-06 (100%) Total 5.2E-06 (100%)	Cr 6.5E-01 (60%) NO_2 3.8E-01 (35%) NO_3 5.2E-02 (5%) Total 1.1E+00 (100%)	Cr 3.5E+00 (56%) NO_2 2.4E+00 (39%) NO_3 3.4E-01 (5%) Total 6.3E+00 (100%)
Residual tank waste [e]	Tc-99 3236 I-129 3559 Cr 3327 NO_2 3327 NO_3 3327	Tc-99 6.1E-05 (96%) I-129 2.7E-06 (4%) Total 6.3E-05 (100%)	Tc-99 1.4E-03 (>99%) I-129 1.2E-05 (<1%) Total 1.5E-03 (100%)	Cr 1.6E-06 (100%) Total 1.6E-06 (100%)	Cr 3.7E-06 (100%) Total 3.7E-06 (100%)	Cr 4.7E-01 (58%) NO_2 3.1E-01 (38%) NO_3 3.1E-02 (4%) Total 8.0E-01 (100%)	Cr 2.5E+00 (54%) NO_2 2.0E+00 (42%) NO_3 2.0E-01 (4%) Total 4.7E+00 (100%)

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area A/AX Fenceline. (3 Sheets)

Source Term	Time of Peak by Indicator Contaminant (Calendar Year)	Radiological Incremental Lifetime Cancer Risk by Indicator Contaminant		Nonradiological Incremental Lifetime Cancer Risk by Indicator Contaminant		Noncarcinogenic Chemical Hazard Index by Indicator Contaminant	
		Industrial	Residential	Industrial	Residential	Industrial	Residential
Residual ancillary equipment waste [f]	Tc-99 3391 I-129 3708 Cr 3476 NO_2 3475 NO_3 3357	Tc-99 3.2E-05 (95%) I-129 1.7E-06 (5%) Total 3.3E-05 (100%)	Tc-99 7.5E-04 (99%) I-129 7.7E-06 (1%) Total 7.6E-04 (100%)	Cr 7.4E-07 (100%) Total 7.4E-07 (100%)	Cr 1.7E-06 (100%) Total 1.7E-06 (100%)	Cr 2.2E-01 (58%) NO_2 1.4E-01 (38%) NO_3 1.5E-02 (4%) Total 3.8E-01 (100%)	Cr 1.2E+00 (54%) NO_2 9.3E-01 (42%) NO_3 9.7E-02 (4%) Total 2.2E+00 (100%)

Source: RPP-CALC-60497 and RPP-CALC-60498

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

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 2007 Model Toxics Control Act risk-based criteria are based on a target risk level of 10^{-5} for carcinogens and a hazard quotient of 1 for noncarcinogens.

[a]Basis: Source-term releases of selected indicator contaminant inventories contained within WMA A/AX past waste losses associated with tanks A-103, A-104, A-105, AX-102, and AX-104

[b] Basis: Source-term releases of selected indicator contaminant inventories contained within an assumed 4,000-gal retrieval leak from AX-Farm tank AX-104, using OLI Stream Analyzer concentrations.

[c]Basis: Source-term releases of selected indicator contaminant inventories contained within retrieval leaks from A-Farm tanks (A-101, A-102, A-103, A-104, A-105, and A-106), using inventory and assumptions from the TC&WM EIS, i.e., each tank has one 4,000-gal retrieval leak simultaneously

[d] Basis: Source-term releases of selected indicator contaminant inventories contained within retrieval leaks from AX-Farm tanks (AX-101, AX-102, AX-103, and AX-104) assuming maximum impacts are additive, using OLI Stream Analyzer concentrations and assuming each tank has one 4,000 gal retrieval leak.

[e]Basis: Source-term releases of selected indicator contaminant inventories contained within WMA A/AX residual tank waste, using TC&WM EIS inventories and assumptions.

[f] Basis: Source-term releases of selected indicator contaminant inventories contained within WMA A/AX residual ancillary equipment waste, using TC&WM EIS inventories and assumptions.

From simulations with the present TWRWP model, percentage contributions shown in Table 7-1 (based on total impacts of the indicator contaminants only) indicate chromium accounted for 54 to 72% of the HI, nitrite for 25 to 44%, and nitrate for 2 to 5%. Chromium and nitrite together account for the vast majority of the HI in all scenarios. However, it is safest to retain nitrate as an indicator since the percentage contributions are sensitive to assumptions about chromium and nitrogen speciation that could change given additional information.

Uranium was simulated as a moderately mobile (K_d = 0.6 mL/g) contaminant in the TC&WM EIS, and the results indicated uranium became the dominant radiological and chemical dose after calendar year 5000, but did not exceed the ILCR or HI of the mobile contaminants during the modeling period. A limited number of simulations of additional contaminants, including uranium, with the TWRWP model produced similar results. A potential retrieval leak from AX-102, which was estimated to have the highest uranium inventory of potential retrieval leaks from AX-100-series tanks and was nearest to the fence, produced a peak concentration of about 3×10^{-3} mg/L. Assuming essentially all of the mass was uranium-238, the resulting peak concentration would correspond to a radiological ILCR of about 2×10^{-6} and to a HQ of about 0.3, less than the peak values for mobile contaminants. Contaminants with K_d values of 2.5 mL/g and higher did not break through to the water table during the 10,000-yr modeling period. Tritium peaked early at levels well below those of the other mobile contaminants and decayed to insignificant levels at the time of peak. The results confirmed the expectation based on the TC&WM EIS, and therefore most simulations included only the indicator contaminants as described.

Peak human health impacts from all contaminants were projected to occur in the following time ranges: 1) from before closure to within 20 years after closure for past leaks and A-100-series tank retrieval leaks, 2) within 700 years after closure for AX-100-series tank retrieval leaks, and 3) within 1,700 years after closure for residual waste in tanks and ancillary equipment. The difference in peak arrival times for retrieval leaks in the A Farm versus the AX Farm is attributed to the hydraulic properties assigned in the TC&WM EIS AX farm model for a fine layer just above the water table. Sediments at a similar depth within the A Farm model are coarser across most of the horizontal domain. The peak values in all cases were driven by contributions from the highly mobile (K_d = 0 mL/g) contaminants. Uranium and less mobile contaminants had not yet broken through to the water table at the time of peak for any source term and therefore made no contribution to the peak impacts. Tritium had decayed to insignificant levels at the time of peak impacts. Uranium exhibited increasing concentrations at the end of the 10,000 year simulation and was a primary contributor to the impacts calculated at the end of the simulation. The impacts at the end of the simulation were lower than the peak impacts by an order of magnitude or more.

The analysis also included an assessment of nonradiological cancer risk. Cancer risks from radionuclides and carcinogenic chemicals are typically reported as separate metrics rather than being summed because of differences in how risk is estimated for these two categories of substances. Of the nonradiological indicator contaminants, only chromium has a published cancer slope factor. For purposes of this analysis, chromium was assumed to be hexavalent chromium. The TC&WM EIS evaluated a longer list of nonradiological contaminants in the BBI or in sample results and found chromium to be the only significant contributor to nonradiological ILCR within the A Barrier Boundary for the groundwater pathway.

The nonradiological ILCR results are shown in Table 7-1 for information purposes to provide an indication of the potential magnitude of nonradiological ILCR. The results indicate that nonradiological ILCR peaks would be on the order of 10^{-7} to 10^{-6} depending on source term and exposure scenario. However, because it is based on only one contaminant, nonradiological ILCR was not carried forward as a separate evaluation metric (i.e., was not used to generate a separate set of retrieval leak impact graphs). The degree to which the chromium ILCR provides an indication of total ILCR is uncertain because of the limited number of chemical analytes reported in the BBI. Hexavalent chromium toxicity values are applied to chromium concentration for this analysis. There is additional uncertainty regarding chromium speciation and the degree of conservatism introduced by assuming that all chromium is hexavalent chromium.

7.1.1.2 Potential Retrieval Leak Inventories

This analysis presents much of the risk data assuming a 4,000-gal. retrieval leak volume, the same volume assumed in the TC&WM EIS. This quantity is used only as a point of reference. The choice of the reference volume is arbitrary and does not affect how the risk values would be used in the event of a retrieval leak. The 4,000 gal. is a hypothetical volume that represents neither an anticipated leak volume nor a leak detection limit. Tank AX-104 is classified as sound and is not anticipated to leak during waste retrieval. If a leak is detected, however, the risk graphs for tank AX-104 provided in Appendix A will allow the leak impacts to be evaluated regardless of leak volume.

Inventories developed from thermodynamic modeling using the OLI Systems Inc. Stream Analyzer (RPP-RPT-58867) represent the most sophisticated analysis available for the AX Farm tank retrieval leaks. In lieu of thermodynamic modeling results, the A Farm tank retrieval leaks retain the inventory assumptions used in the TC&WM EIS which involve simple dilution (DOE/EIS-0391 Appendix D). The TC&WM EIS used a single source term for retrieval leaks from all six tanks in the A Farm occurring simultaneously. The A Farm tanks are expected to be retrieved in accordance with a future TWRWP(s) in which assumptions may be updated (for instance, tanks A-104 and A-105 are unlikely to be sluiced). Pending that assessment, the TC&WM EIS assumptions for the A Farm potential retrieval leaks source term are retained as the most sophisticated analysis available for the A Farm at this time.

The retrieval leak impact graphs provided in the appendix were generated by applying Equation 7-1 over a range of hypothetical retrieval leak inventories for each indicator contaminant. 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. For information purposes only, a point of reference corresponding to the estimated inventory for a hypothetical 4,000-gal. retrieval leak from tank AX-104, summarized in Table 7-2, was provided on the graphs.

Table 7-2. Inventory for a Potential Retrieval Leak from Tank AX-104.

Contaminant	Units	Inventory [a]
Technetium-99	Ci	4.75E+00
Iodine-129	Ci	8.59E-05
Chromium	kg	6.72E+00
Nitrite	kg	2.60E+01
Nitrate	kg	5.30E+02
Total Uranium	kg	3.82E+01

Assumes a hypothetical retrieval leak volume of 4,000 gal.
Mass of nitrite as the ion.
Mass of nitrate as the ion.
[a] Source: RPP-RPT-58867

7.1.1.3 Contaminant Transport Simulations

To provide the most sophisticated currently available predictions of potential long-term groundwater impacts associated with tank waste retrieval and closure activities for WMA A/AX, flow and transport were simulated using three-dimensional models in the most current approved build of the STOMP simulator (PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases, Version 4.0 User's Guide*), based predominantly on STOMP input files developed for the TC&WM EIS (DOE/EIS-0391). Detailed methodology for the contaminant transport simulations is reported in RPP-CALC-60497. The groundwater contaminant concentrations used for the retrieval leak impact graphs were derived directly from the modeling results summarized in RPP-CALC-60497.

As explained in RPP-CALC-60497, STOMP vadose zone models for the A Farm and AX Farm from the TC&WM EIS were each extended to include the upper portion of the saturated zone at sufficient resolution to report concentrations at the WMA fenceline. Local-scale saturated zone properties used in the modeling were developed from an evaluation of hydraulic properties used in the Central Plateau Groundwater Model (CPGWM) Calibration Version 3.3 (CP-47631, Rev. 2, Version 6.3.3) in conjunction with up-to-date hydrogeologic observations and local groundwater elevation trends as summarized in RPP-ENV-58578, *Summary of the Natural System at Waste Management Area A/AX*; SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*; and CHPRC-02485-VA, *Groundwater Flow Beneath Waste Management Area A-AX*. The transport simulations were performed for the following types of contaminant sources within WMA A/AX:

- Past leaks and other waste loss events associated with tanks
- Potential leaks during waste retrieval
- Residual waste remaining in tanks
- Residual waste remaining in ancillary equipment.

Releases of inventories for the majority of these sources were modeled as implemented in the TC&WM EIS STOMP A and AX farm models as detailed in RPP-CALC-60497. The exception was for inventories developed for potential retrieval leaks from the AX-100-series tanks that were evaluated as unit source (i.e., 1 Ci or kg) releases in 4,000-gallon volumes of water from individual tanks. To predict potential groundwater concentrations, the unit source results were scaled by updated retrieval leak inventory estimates determined from thermodynamic modeling with the OLI Systems Inc. Stream Analyzer (RPP-RPT-58867).

The TC&WM EIS past leaks source terms included large waste losses associated with Tanks A-104 and A-105, and much smaller losses associated with Tanks A-103, AX-102, and AX-104. Tanks A-103, AX-102, and AX-104 have historically been classified as assumed leakers. However, formal re-assessments of these three tanks in accordance with TFC-ENG-CHEM-D-42 determined they did not leak and should be reclassified as sound (RPP-ASMT-42278, *Tank 241-A-103 Leak Assessment Report*; RPP-ASMT-42628, *Tank 241-AX-102 Integrity Assessment Report;* RPP-ASMT-57574, *Tank 241-AX-104 Integrity Assessment Report*). Conversely, ongoing updates to the Soil Inventory Model (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*) based on the recent tank farm leak assessment (RPP-ENV-37956, Rev. 2) may include some small unplanned releases in WMA A/AX that were not modeled in the TC&WM EIS or that were approximated as part of the tank past leaks terms. Since the TC&WM EIS past leaks source terms are the most sophisticated analysis of past releases in WMA A/AX currently completed, they are retained with the existing basis.

Release of source terms for residual waste from tanks and from ancillary equipment were each based on a partitioning-limited, convective-flow release model assumed for grout-stabilized waste (DOE/EIS-0391). These source terms are implemented in the STOMP-based models as gradual releases of contaminant mass that are implicitly related to the recharge conditions discussed later in this section. K_d values applicable to the grouted waste in the release model were 1) 0 mL/g for the nonradiological indicator contaminants, 2) 1 mL/g for technetium-99, and 3) 50 mL/g for iodine-129 (DOE/EIS-0391 Tables M-7 and M-8). (These Kd values apply only to transport within the residual waste and not to the vadose zone or aquifer). Note that other recent tank farm assessments have alternatively considered diffusion-controlled and/or solubility-controlled release models for tank residuals that generally predict lower peak concentrations and later arrival times.

In the TC&WM EIS implementation for ancillary equipment residual waste releases, the elevation of releases was several meters deeper than the typical elevation for ancillary equipment in WMA A/AX. Any underestimation of peak arrival times for this source term was assumed to be small and to not warrant a full re-evaluation of the release implementation for the TWRWP model.

Nitrite and nitrate source terms were recalculated from the TC&WM EIS nitrate source terms for all affected sources by using the raw inventory data in the TC&WM EIS references to determine the fraction of each species as nitrate and then converting the mass of nitrite by stoichiometry.

The STOMP models have overlapping domains alternately centered on the AX Farm tanks or the A Farm tanks as appropriate for a given source term, with each domain extending laterally a short distance beyond the relevant sections of the tank farm fenceline and vertically downward through the vadose zone into the upper portion of the underlying aquifer. Properties and boundary conditions of the vadose zone are unchanged from the TC&WM EIS. The simulations all assumed a final closure barrier was in place by 2050. Recharge was assumed to occur initially at a rate of 3.5 mm/yr until the year each tank farm became operational, then at a rate of 100 mm/yr over the footprint of the tanks until placement of the barrier. The barrier was assumed to function at its design estimate recharge rate (0.5 mm/yr) for 500 years, after which recharge was assumed to increase to 3.5 mm/yr. The analysis in RPP-CALC-60497 indicated the upper 11 m of the saturated zone below the steady-state water table elevation of 119.5 m resides within a gravel stratum with a local effective horizontal hydraulic conductivity value of 1,750 m/d for the domain. Boundary conditions for the saturated zone assumed steady-state flow to the southeast at a hydraulic gradient of 1×10^{-5} (RPP-CALC-60497).

Following a simulated historical 3,000-year period to initialize conditions in the vadose zone, predictive simulations were carried out for a 10,000-year assessment period over the calendar years 1940 to 11940. Predictive simulation times in units of years were output by STOMP using the average length of a year on the Julian calendar and are reported as approximate Gregorian calendar years by adding 1,940 (i.e., leap years are not tracked precisely). It should be emphasized that model predictions into future centuries and millennia have uncertainties larger than a few years.

The upper 11 m of the saturated zone was adequate to simulate groundwater concentrations in the 5-m interval below the water table, which is the interval used for comparison with groundwater protection standards. Within the resolution of each STOMP model grid, groundwater concentrations of each indicator contaminant were calculated at every point along the downgradient fenceline and reported for the time and location of maximum concentration for each source.

Table 7-3 shows the unit source simulation results for the indicator contaminants in the AX-104 retrieval leak source term. The results indicated the peak groundwater concentrations from a potential retrieval leak at AX-104 would arrive at the WMA A/AX downgradient fenceline around calendar year 2672. The values shown are the predicted peak contaminant concentrations in groundwater at the downgradient WMA A/AX fenceline from release of 1 Ci of radionuclide or 1 kg of chemical. The number of digits shown exceeds the number of significant digits because the values are used in subsequent calculations. The retrieval leak impact graphs were generated by multiplying the simulated unit source results by the retrieval leak inventory to obtain an estimate of peak groundwater concentration (Equation 7-1).

Table 7-3. Indicator Contaminants Unit Inventory Simulation Results for AX-104 Retrieval Leak Source Term.

Contaminant	Peak Groundwater Concentration at WMA A/AX Fenceline*	Units	Time of Peak (Calendar Year)
Techetium-99	1.05E+03	pCi/L per Ci	2672
Iodine-129	1.05E+03	pCi/L per Ci	2673
Chromium	1.05E-03	mg/L per kg	2673
Nitrite	1.04E-03	mg/L per kg	2672
Nitrate	1.05E-03	mg/L per kg	2672

Source: RPP-CALC-60497
WMA = waste management area.

A lag of several hundred years is predicted between peak arrival times for retrieval leaks in the A Farm and those in the AX Farm. The lag is attributed primarily to the hydraulic properties assigned in the TC&WM EIS AX farm model for a layer of fine sediments just above the water table. Sediments at a similar depth within the A Farm tank model are generally coarser. Differences in peak concentrations and arrival times between tanks within the AX Farm are attributable both to different distances upgradient from the fenceline and variability in the thickness and elevation of the layer of fine sediments from tank to tank.

Releases from residual waste in tanks and from ancillary equipment are modeled to occur at the same time over similar footprints with a vertical separation of 6 m between the tank bottoms and the depth assumed for ancillary equipment releases, and therefore the peak impacts tend to occur at similar times. In WMA A/AX, the vertical separation is likely somewhat greater, but the effect on arrival times is probably small given the control exerted by the layer of fine sediments deeper in the vadose zone.

7.1.1.4 Exposure Scenarios

Human health impacts were generated and displayed on the retrieval leak impact graphs for an industrial and a residential exposure scenario, consistent with the requirements in the Decree. Both scenarios are based on scenarios described in HNF-SD-WM-TI-707 Revision 5, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*. The health effects conversion factors for both scenarios are shown in Table 7-4 for the indicator contaminants. Human health impact calculations are presented in RPP-CALC-60498.

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

Table 7-4. Groundwater Unit Health Effects Factors for Industrial and Residential Exposure Scenarios.

Contaminant	Units	Industrial [a]	Residential [b]
Technetium-99	ILCR per pCi/L	1.38E-08	3.27E-07
Iodine-129	ILCR per pCi/L	7.42E-07	3.39E-06
Chromium	HQ per mg/L	4.43E+00	2.42E+01
Nitrite	HQ per mg/L	9.88E-02	6.36E-01
Nitrate	HQ per mg/L	6.18E-03	3.97E-02
Chromium	ILCR per mg/L	1.50E-05	3.51E-05

HQ = hazard quotient.

ILCR = incremental lifetime cancer risk.

[a] Source: HNF-SD-WM-TI-707, Tables 19 and 20.

[b] Source: HNF-SD-WM-TI-707, Tables 23 and 24.

HNF-SD-WM-TI-707, 2007, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*, Rev. 5, Fluor Government Group, Richland, Washington.

Assumes all chromium inventory is hexavalent chromium.

The conversion factors shown in Table 7-4 were taken from tables provided in HNF-SD-WM-TI-707. For technetium-99, iodine-129, and chromium, the conversion factors provide the ILCR per unit concentration in the groundwater. For nonradiological chemicals, the conversion factors provide the noncarcinogenic chemical HQ per unit concentration in the groundwater. Hexavalent chromium toxicity values are applied to chromium concentration for this analysis. The factors were applied to the retrieval leak impact calculations as shown in Equation 7-1.

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

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

Note that chromium is classified as both a chemical toxicant (evaluated using HQ) and a carcinogen (evaluated using ILCR). It is classified as toxic via both ingestion and inhalation but carcinogenic only via inhalation. The inhalation intake for the groundwater pathway exposures is based on re-suspended soil and volatilized water. The soil is assumed to be contaminated by irrigation with contaminated groundwater for both the industrial and residential scenarios. Water volatilization is assumed to occur during showering with contaminated groundwater.

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). There is additional uncertainty regarding chromium and nitrogen speciation and the degree of conservatism introduced by assuming that all chromium is hexavalent chromium. Complete descriptions of the exposure scenario parameters, assumptions, and unit risk factor calculations can be found in HNF-SD-WM-TI-707.

7.1.2 Retrieval Leak Impact Analysis Results

Tank-specific retrieval leak impact graphs generated using the methodology described above are provided in Appendix A for tank AX-104. One graph for each indicator contaminant is provided. An example calculation is also provided to illustrate how the formula given in Equation 7-1 was applied in generating the graphs.

Peak impacts from a hypothetical 4,000-gal. retrieval leak from tank AX-104 are summarized in Table 7-5. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the AX-104 retrieval leak unit source term scaled by the inventory in Table 7-2.

The peak fenceline concentrations of the indicator contaminants from a tank AX-104 retrieval leak were projected to arrive around calendar year 2672. The long transport time is influenced by the layer of fine sediments noted in section 7.1.1.3. Differences between simulated retrieval leak impacts for tank AX-104 and for other AX-100-series tanks reported in other TWRWPs are attributable primarily to differences in inventory and proximity to the fenceline.

Table 7-5. Peak Impacts at the Waste Management Area A/AX Fenceline from a Potential Retrieval Leak at Tank AX-104.

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk		Hazard Index		Groundwater Concentration (pCi/L or mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
		Industrial	Residential	Industrial	Residential		
AX-104							
Technetium-99	2672	7E-05	2E-03	No Rfd	No Rfd	5,000	900
Iodine-129	2673	7E-08	3E-07	No Rfd	No Rfd	0.090	1
Chromium	2673	1E-07	3E-07	0.03	0.2	0.0070	0.1 [a]
Nitrite	2672	No CPF	No CPF	0.003	0.02	0.027 [b]	3.3 [b]
Nitrate	2672	No CPF	No CPF	0.003	0.02	0.55 [c]	45 [c]
Total radiological	--	**7E-05**	**2E-03**	--	--	--	--
Total nonradiological	--	**1E-07**	**3E-07**	**0.04**	**0.2**	--	--

Source: RPP-CALC-60498

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No Rfd= no reference dose available

Assumes one 4,000 gallon retrieval leak.

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 2007 Model Toxics Control Act risk-based criteria are based on a target risk level of 10^{-5} for carcinogens and a hazard quotient of 1 for noncarcinogens.

[a] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[b] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[c] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.1.3 Waste Management Area A/AX Risk Assessment

This section provides information to allow the potential retrieval leak impacts from the individual tanks to be placed in the context of the potential impacts from WMA A/AX as a whole.

Sections 7.1.3.1 through 7.1.3.4 summarize the analysis results in terms of the projected peak impacts at the WMA A/AX downgradient fenceline from past leaks, potential retrieval leaks, residual waste remaining in tanks, and residual waste remaining in ancillary equipment.

7.1.3.1 Past Leaks

WMA A/AX past leak impacts are summarized in Table 7-6. The results show the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA A/AX past leak source releases.

The results indicate the peak groundwater concentrations from past leaks would arrive at the WMA A/AX downgradient fenceline around calendar years 2029 to 2054. The past leaks source terms were based on past unplanned releases modeled in the TC &WM EIS at tanks A-103, A-104, A-105, AX-102, and AX-104. Past releases at tanks A-103, A-104 and A-105 were simulated separately from those at tanks AX-102 and AX-104, and the maximum impacts between the simulations were reported since significant interaction between the two groups of releases is not predicted. That is, the overall maximum concentrations are attributable to larger, earlier releases from tanks A-104 and A-105 that cause maximum concentrations at a point along the southern portion of the fenceline, whereas concentrations due to smaller, later releases from tanks AX-102 and AX-104 peak around calendar year 2061 at a point on the eastern fenceline

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

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk		Hazard Index		Groundwater Concentration (pCi/L or mg/L)	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	2029	7E-05	2E-03	No Rfd	No Rfd	4,900	900 pCi/L
Iodine-129	2054	4E-06	2E-05	No Rfd	No Rfd	5.2	1 pCi/L
Chromium	2051	4E-07	1E-06	0.1	0.7	0.028	0.1 mg/L [a]
Nitrite	2042	No CPF	No CPF	0.09	0.6	0.88 [b]	3.3 mg/L [b]
Nitrate	2051	No CPF	No CPF	0.004	0.02	0.59 [c]	45 mg/L [c]
Total radiological	--	**7E-05**	**2E-03**	--	--	--	--
Total nonradiological	--	**4E-07**	**1E-06**	**0.2**	**1**	--	--

RPP-CALC-60498

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No Rfd= no reference dose available

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 2007 Model Toxics Control Act risk-based criteria are based on a target risk level of 10^{-5} for carcinogens and a hazard quotient of 1 for noncarcinogens.

[a] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[b] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[c] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

Groundwater concentrations were calculated as cumulative fenceline maximum concentrations over the entire downgradient length of the WMA A/AX fenceline. The peak groundwater concentrations from past leaks were projected to overlap in time and be additive with the peak groundwater concentrations from potential retrieval leaks from the A Farm tanks but were not projected to be additive with the peaks from potential retrieval leaks from the AX Farm tanks or from residual waste remaining in tanks and ancillary equipment. The peak from A Farm retrieval leaks was projected to arrive around calendar year 2068 compared with 2029 to 2054 for the past leaks.

Transport of contaminants from past releases was based on water flow from the original releases and natural recharge only (i.e., surface infiltration of meteoric water). The effect on existing contamination of artificial recharge, such as a retrieval leak or water line leak, was not explicitly simulated. Generally speaking, should the fluid released in a retrieval leak intercept an existing vadose zone plume in WMA A/AX, there is a potential for the contamination to be flushed more quickly to the water table. The effect of the flushing on peak groundwater concentration and arrival time would depend on a number of factors, including initial plume depth and the rate, volume, and location of the retrieval leak. If this were to occur, the WMA A/AX past leak impacts could differ from the projected impacts shown in Table 7-6, which were calculated assuming meteoric infiltration. However, until the assumed time of final closure in calendar year 2050, an enhanced average rate of infiltration is assumed based on disturbance of soil and vegetation (DOE/EIS-0391), and the enhanced meteoric infiltration rate likely exceeds any artificial recharge.

7.1.3.2 Potential Retrieval Leaks

Potential WMA A/AX retrieval leak impacts are summarized in Table 7-7. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the A-Farm retrieval leak source term as well as total impacts from all the AX-100-series tank retrieval leak source terms.

The retrieval leak source terms were based on a hypothetical 4,000-gal. retrieval leak from each of the AX-100-series tanks and A-100-series tanks all occurring in calendar year 2018. The contaminant concentrations in the retrieval leaks from the AX-100-series tanks were estimated by a different method than that used for the A-100-series tanks (see Section 7.1.1.2).

The peak from A Farm retrieval leaks was projected to arrive around calendar year 2068, and the peak from AX Farm retrieval leaks was projected to arrive from calendar years 2671 to 2745. As noted in Section 7.1.1.3, the difference is attributed primarily to the hydraulic properties of a layer of fine sediments occurring only below the AX tanks in the model. Ongoing evaluation of the hydrogeology in WMA A/AX suggests the layer may be both more widespread and less resistant to flow than the currently available analysis in the model indicates. If so, the peak concentrations from retrieval leaks in A Farm and AX Farm may arrive closer together in time, but still at different locations on the fenceline. The currently simulated peak from A Farm retrieval leaks was projected to overlap in time and be additive with the peak groundwater concentrations from past leaks. Neither peak concentrations from A Farm retrieval leaks nor those from AX Farm retrieval leaks were projected to be additive with peak concentrations from residual waste remaining in tanks and ancillary equipment. Declining concentrations from AX Farm retrieval leaks following the peak were projected to overlap increasing concentrations from residual waste source terms prior to their peak, but at any given time between peaks, the impacts from one source term or the other are an order of magnitude lower than at the peak. If the fine sediment layer has higher hydraulic conductivities than modeled, the separation between peaks would likely be even greater, because even though all arrival times would be earlier, the breakthrough curves would be sharper.

Table 7-7. Peak Impacts at the Waste Management Area A/AX Fenceline from Potential Retrieval Leaks for All WMA A/AX Tanks. (2 pages)

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk		Hazard Index		Groundwater Concentration (pCi/L or mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
		Industrial	Residential	Industrial	Residential		
A Farm Total[d]							
Technetium-99	2068	6E-05	2E-03	No Rfd	No Rfd	4,600	900
Iodine-129	2068	5E-06	2E-05	No Rfd	No Rfd	6.7	1
Chromium	2068	2E-06	4E-06	0.5	3	0.11	0.1 [a]
Nitrite	2068	No CPF	No CPF	0.2	1	1.7 [b]	3.3 [b]
Nitrate	2068	No CPF	No CPF	0.02	0.1	2.7 [c]	45 [c]
Total radiological	--	**7E-05**	**2E-03**	--	--	--	--
Total nonradiological	--	**2E-06**	**4E-06**	**0.7**	**4**	--	--
AX Farm Total[e]							
Technetium-99	2670-2739	2E-04	4E-03	No Rfd	No Rfd	11,000	900
Iodine-129	2671-2742	5E-06	2E-05	No Rfd	No Rfd	7.0	1
Chromium	2671-2742	2E-06	5E-06	0.6	4	0.15	0.1 [a]
Nitrite	2672-2736	No CPF	No CPF	0.4	2	3.8 [b]	3.3 [b]
Nitrate	2672-2738	No CPF	No CPF	0.05	0.3	8.4 [c]	45 [c]
Total radiological	--	**2E-04**	**4E-03**	--	--	--	--
Total nonradiological	--	**2E-06**	**5E-06**	**1**	**6**	--	--

Source: RPP-CALC-60498

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

Table 7-7. Peak Impacts at the Waste Management Area A/AX Fenceline from Potential Retrieval Leaks for All WMA A/AX Tanks. (2 pages)

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk		Hazard Index		Groundwater Concentration (pCi/L or mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
		Industrial	Residential	Industrial	Residential		

No Rfd = no reference dose available

Assumes one 4,000 gallon retrieval leak for each tank.

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 2007 Model Toxics Control Act risk-based criteria are based on a target risk level of 10^{-5} for carcinogens and a hazard quotient of 1 for noncarcinogens.

[a] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[b] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[c] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

[d] Based on the cumulative retrieval leak impacts for A-Farm 100-series tanks assuming all tanks leak simultaneously.

[e] Based on the cumulative retrieval leak impacts for AX-Farm 100-series tanks assuming maximum impacts are additive.

7.1.3.3 Residual Waste Remaining in Tanks

Potential WMA A/AX residual tank waste impacts are summarized in Table 7-8. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA A/AX residual tank waste source terms.

Source terms for residual waste potentially remaining in tanks after closure were based on assumptions from the TC&WM EIS Alternative 2B analysis that waste containing 1% of the current BBI of each contaminant would remain.

The results indicate the peak groundwater concentrations from residual tank waste would arrive at the fenceline approximately from calendar years 3236 to 3559. The different grouted waste K_d values for the indicator contaminants are responsible for the separation in peak arrival times of the different contaminants. If a diffusion-limited release model were additionally assumed for the contaminant releases from the tank residuals, resulting peak concentrations would likely be lower and occur later in time. Results reported for the WMA-wide maximum impacts also blend impacts from differing tank residual inventories transported along different subsurface pathways such that radiological contaminant impacts to the eastern fenceline from the AX Farm are reported together with nonradiological contaminant impacts to the southern fenceline from the A Farm. The range of contaminant peak arrival times is somewhat broader when each source area is considered separately.

The peak groundwater concentrations from residual tank waste were projected to overlap in time and be additive with the peak groundwater concentrations from residual ancillary equipment waste but were not projected to be additive with the peaks from past leaks or potential retrieval leaks as discussed in Sections 7.1.3.1 and 7.1.3.2.

Table 7-8. Peak Impacts at the Waste Management Area A/AX Fenceline from Potential Residual Tank Waste.

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk		Hazard Index		Groundwater Concentration	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	3236	6E-05	1E-03	No Rfd	No Rfd	4,400 pCi/L	900 pCi/L
Iodine-129	3559	3E-06	1E-05	No Rfd	No Rfd	3.6 pCi/L	1 pCi/L
Chromium	3327	2E-06	4E-06	0.5	3	0.11 mg/L	0.1 mg/L [a]
Nitrite	3327	No CPF	No CPF	0.3	2	3.1 mg/L [b]	3.3 mg/L [b]
Nitrate	3327	No CPF	No CPF	0.03	0.2	5.0 mg/L [c]	45 mg/L [c]
Total radiological	--	**6E-05**	**1E-03**	--	--	--	--
Total nonradiological	--	**2E-06**	**4E-06**	**0.8**	**5**	--	--

Source: RPP-CALC-60498

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No Rfd= no reference dose available

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 2007 Model Toxics Control Act risk-based criteria are based on a target risk level of 10^{-5} for carcinogens and a hazard quotient of 1 for noncarcinogens.

[a] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[b] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[c] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.1.3.4 Residual Waste Remaining in Ancillary Equipment

Potential WMA A/AX residual ancillary equipment waste impacts are summarized in Table 7-9. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA A/AX residual ancillary equipment waste source terms.

Source terms for residual waste potentially remaining in ancillary equipment after closure were based on assumptions from the TC&WM EIS Alternative 2B analysis that residual ancillary equipment concentrations will be proportional to average tank residual concentrations for the tank farm, which in turn will be proportional to current BBI (see DOE/EIS-0391). In A Farm the simulated residual waste inventory released from ancillary equipment was approximately 0.49 times the residual waste inventory released from the tanks; in AX Farm the ratio was approximately 0.67. Therefore impacts from ancillary equipment were projected to be of about the same order of magnitude and somewhat lower than impacts from tank residuals.

The results indicate the peak groundwater concentrations from residual ancillary equipment waste would arrive at the fenceline approximately from calendar years 3357 to 3708. The different grouted waste K_d values for the indicator contaminants are responsible for the separation in peak arrival times of the different contaminants. If a diffusion-limited release model were additionally assumed for the contaminant releases from residuals for some of the ancillary equipment that will be grouted, resulting peak concentrations would likely be lower and occur later in time. Results reported for the WMA-wide maximum impacts also blend impacts from differing ancillary equipment residual inventories transported along different subsurface pathways such that impacts to the eastern fenceline from the AX Farm and impacts to the southern fenceline from the A Farm by different contaminants are reported together and are assumed to be additive for a given metric.

The peak groundwater concentrations from residual ancillary equipment waste were projected to overlap in time and be additive with the peak groundwater concentrations from residual tank waste but were not projected to be additive with the peaks from past leaks or potential retrieval leaks as discussed in Sections 7.1.3.1 and 7.1.3.2. With a diffusion-limited release model for residual tank waste, impacts from ancillary equipment residuals and tank residuals would likely not be additive.

Table 7-9. Peak Impacts at the Waste Management Area A/AX Fenceline from Potential Residual Ancillary Equipment Waste.

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk		Hazard Index		Groundwater Concentration	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	3391	3E-05	7E-04	No Rfd	No Rfd	2,300 pCi/L	900 pCi/L
Iodine-129	3708	2E-06	8E-06	No Rfd	No Rfd	2.3 pCi/L	1 pCi/L
Chromium	3476	7E-07	2E-06	0.2	1	0.050 mg/L	0.1 mg/L [a]
Nitrite	3475	No CPF	No CPF	0.1	0.9	1.5 mg/L [b]	3.3 mg/L [b]
Nitrate	3357	No CPF	No CPF	0.03	0.1	2.4 mg/L [c]	45 mg/L [c]
Total radiological	--	**3E-05**	**8E-04**	--	--	--	--
Total nonradiological	--	**7E-07**	**2E-06**	**0.4**	**2**	--	--

Source: RPP-CALC-60498

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No Rfd= no reference dose available

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 2007 Model Toxics Control Act risk-based criteria are based on a target risk level of 10^{-5} for carcinogens and a hazard quotient of 1 for noncarcinogens.

[a] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[b] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[c] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.2 INADVERTENT INTRUDER RISK

Inadvertent waste site intrusion risk is an assessment of the health impacts from unknowingly intruding into a waste site at some point in the future following closure. Inadvertent intruder impact estimates are included in this work plan to provide perspective on potential post-closure risks associated with closing tank AX-104 assuming waste is retrieved to residual inventories identified in the TC&WM EIS analysis of Alternative 2B (see DOE/ORP-2003-02, *Inventory and Source Term Data Package,* Appendix D, Table D.1) and the residuals are closed in place. Exposure scenarios are defined in HNF-SD-WM-TI-707 Revision 5 and complete human health impact calculations are presented in RPP-CALC-60498.

7.2.1 Inadvertent Intruder Scenarios and Performance Measures

The HNF-SD-WM-TI-707 evaluation of inadvertent intrusion includes several types of intrusion scenarios, all of which assume that no institutional memory of the closed facility remains following closure. The credible post-closure intrusion scenarios identified were:

- An intruder who inadvertently drills into the closed site and brings some of the waste to the surface, receiving an acute dose (well driller scenario).
- A post-drilling resident who lives where waste has been exhumed and scattered over the surface, receiving a chronic dose (post-intrusion residential scenarios). Three such residential scenarios were included:
  - Suburban garden
  - Rural pasture
  - Commercial farm

Detailed descriptions of the scenarios are presented in HNF-SD-WM-TI-707. A basement scenario, in which exposure occurs during excavation for a basement or building foundation, is not considered credible and is not analyzed. This is because the top of the residual waste in each of the AX Farm tanks would be about 59 ft (18 m) below the current ground surface, and would be covered with an additional surface barrier. Neither basements for home residences nor foundations for commercial structures are likely to extend this far below the surface.

Although the HNF-SD-WM-TI-707 analysis identified scenarios involving intrusion into grouted tanks as credible, this does not imply anything about the probability of such scenarios. Each would require a driller to mobilize equipment on top of the barrier to the small fraction of the land surface directly overlying a tank and drill through the tank dome and several meters of grout to the depth of the waste without noticing that anything was unusual. The coincident combination of drilling rig power and durability, unlucky placement, and operator judgment required for these scenarios at a given Hanford SST presents an even higher threshold at WMA A/AX where the tanks are deeper and would require even greater grout thickness. Nevertheless, this set of scenarios in common with other Hanford assessments is analyzed for the sake of quantifying/bounding the potential risk to a representative range of hypothetical receptors.

The performance measure for acute exposure identified for the well driller scenario is 500 mrem effective dose equivalent for a one-time exposure. The performance measure for chronic exposure identified in post-intrusion residential scenarios is 100 mrem/yr effective dose equivalent. Doses are calculated at 100-year intervals from 100 to 1,000 years after closure. The dose at 500 years after closure is reported since that is the soonest time when the intrusion was assumed to occur. Closure is assumed to occur in the calendar year 2050.

7.2.2 Methodology

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

- Report calculations for 500 years after closure
- Use radiological dose as the health impact metric
- Calculate acute dose using the well driller scenario
- Calculate chronic dose using the suburban garden, rural pasture, and commercial farm scenarios
- For the well driller scenario, assume the borehole extends a distance equal to that from the current land surface to the predicted steady-state water table elevation (89 m), and that the driller is exposed to the average concentration of exhumed waste mixed with the cuttings
- Assume the borehole diameter in the scenario is 6.5 in. (0.1651 m) for the suburban garden, 10.5 in. (0.2667 m) for the rural pasture, and 16.5 in. (0.4191 m) for the commercial farm
- Assume the 75.08-ft (22.88-m) diameter tanks each contain a volume of 360 ft^3 (10.19 m^3) of residual waste at closure
- Assume the residual tank waste is embedded in a grout matrix that renders 90% of the exhumed waste unavailable for inhalation and ingestion
- Assume intrusion occurs before contaminants have migrated from the closed facility in any significant quantity
- Calculate radioactive decay of parent nuclide concentrations in the soil to the time of exposure using standard equations, and apply the unit dose factors from HNF-SD-WM-TI-707 Revision 5 to account for decay chains and all other exposure parameters and assumptions

Sections 7.2.2.1 and 7.2.2.2 discuss the calculation methodology for the two primary components of the inadvertent intruder calculation, inventory and dose. Tank-specific results for tank AX-104 are provided in Appendix A.

7.2.2.1 Inventory

The starting inventories for the inadvertent intruder calculation were the estimated radionuclide inventories remaining in the tanks in the TC&WM EIS analysis of Alterntaive 2B. Current inventories for all 46 radionuclides reported in the BBI (DOE/ORP-2003-02, Rev. 0, Appendix D, Table D.1) were assumed to be 99% retrieved at closure and were initially decayed from the referenced basis date of January 1, 2001 to the assumed closure date of January 1, 2050 for use in the calculation (except 3 short-lived radionuclides controlled by parent inventories). Tank-specific residual waste starting inventories are given in the appendix.

Under the well driller scenario, the un-decayed exhumed concentration in the drill cuttings is calculated by dividing the activity at closure by the total mass of the cuttings as shown in Equation 7-2 (derived in HNF-SD-WM-TI-707 Revision 5):

$$Q_{exhumed} \cong \frac{Q_{closure}}{A_{tank} L_{borehole}\, \rho_{cuttings}} \quad (7\text{-}2)$$

where,

$Q_{exhumed}$	=	Un-decayed exhumed concentration (Ci/kg) of the radionuclide in drill cuttings
$Q_{closure}$	=	Activity (Ci) of a radionuclide at assumed closure date (January 1, 2050)
A_{tank}	=	Cross-sectional area of the tank (m^2)
$L_{borehole}$	=	Borehole depth to water table (m)
$\rho_{cuttings}$	=	Average *in-situ* bulk density of the borehole cuttings (kg/m^3)

The borehole depth to the water table is assumed to equal the distance from the current land surface to the steady-state water table determined in RPP-CALC-60497. At AX-104 this distance is about 89 m.

For the post-intrusion residential scenarios, the un-decayed exhumed activity was calculated using Equation 7-3:

$$Q_{exhumed} = Q_{closure} \frac{A_{borehole}}{A_{tank}} \quad (7\text{-}3)$$

where,

$Q_{exhumed}$	=	Un-decayed exhumed activity (Ci) of the radionuclide from the borehole
$Q_{closure}$	=	Activity (Ci) of a radionuclide at assumed closure date (January 1, 2050)
$A_{borehole}$	=	Cross-sectional area of the borehole (m^2)
A_{tank}	=	Cross-sectional area of the tank (m^2)

Equation 7-4 was used to convert pre-retrieval activities of all radionuclides to activities at closure:

$$Q_{closure} = Q_{pre-retrieval} \times (1 - PR) \times exp(-\lambda t) \quad (7\text{-}4)$$

where,

$Q_{closure}$	=	Activity (Ci) of a radionuclide at assumed closure date (January 1, 2050)
$Q_{pre-retrieval}$	=	Pre-retrieval activity (Ci) of a radionuclide on January 1, 2001
PR	=	Percentage retrieval (99% = 0.99)
Exp	=	Exponential function (natural log base e raised to a power)

λ	=	Radioactive decay constant, per year
t	=	Time between pre-retrieval inventory basis date and closure in years (49 years)

Equation 7-5 accounts for radioactive decay since closure:

$$Q_{exhumed}(t) = Q_{exhumed} \times exp(-\lambda t) \quad (7\text{-}5)$$

where,

$Q_{exhumed}(t)$	=	Exhumed concentration or activity of a radionuclide decayed as a function of time (Ci/kg or Ci)
$Q_{exhumed}$	=	Un-decayed exhumed concentration or activity of a radionuclide (Ci/kg or Ci)
exp	=	Exponential function (natural log base e raised to a power)
λ	=	Radioactive decay constant, per year, calculated as $\ln(2) \cong 0.6931$ divided by the radionuclide half-life in years
t	=	Elapsed time since closure in years

7.2.2.2 Inadvertent Intruder Dose

For each intruder scenario considered, the dose contribution from each radionuclide was calculated by multiplying the exhumed inventory (decayed) by a unit dose factor. The total dose for each scenario was then calculated as the sum of the dose contributions from all radionuclide decay chains with parent nuclides included in the starting inventory. Unit dose factors for each radionuclide under each intruder scenario were taken from HNF-SD-WM-TI-707. Unit dose factors for the subset of radionuclides that drive intruder doses are shown in Table 7-10. Complete intruder scenario descriptions and unit dose factor calculations are provided in HNF-SD-WM-TI-707.

Table 7-10. Unit Dose Factors for Inadvertent Intruder Scenarios. [a]

Radionuclide	Well Driller (mrem per Ci/kg) [b]	Suburban Garden (mrem/yr per Ci exhumed) [b]	Rural Pasture (mrem/yr per Ci exhumed) [b]	Commercial Farm (mrem/yr per Ci exhumed) [b]
Strontium-90+D	8.12E+04	3.60E+03	9.75E+01	1.49E-02
Technetium-99	5.66E+02	5.06E+02	2.55E+00	8.60E-05
Tin-126+D	3.09E+07	9.66E+03	3.86E+02	5.96E+00
Cesium-137+D	8.78E+06	3.13E+03	1.25E+02	1.69E+00
Plutonium-239	3.86E+05	7.02E+02	1.21E+01	1.38E-01
Plutonium-240+D	3.86E+05	7.02E+02	1.21E+01	1.38E-01
Americium-241	5.83E+05	7.60E+02	1.41E+01	1.68E-01

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

[a] Tables 7, 8, 10, and 11 of HNF-SD-WM-TI-707, 2007, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*, Rev. 5, Fluor Government Group, Richland, Washington.

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

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

The well driller scenario unit dose factors are given in terms of the dose per unit contaminant concentration in the drill cuttings (mrem per Ci/kg) (Table 7-10). The radiation dose to this individual is the dose (effective dose equivalent) from acute exposure over a 40-hour drilling operation. The well driller dose factors were multiplied by the average radionuclide concentration in the drill cuttings (Ci/kg) to obtain the dose. The post-intruder resident scenario unit dose factors are given in terms of the dose received during the first year per curie exhumed (mrem/yr per Ci) (Table 7-10). The radiation dose to this individual is the 50-year committed effective dose equivalent from the first year of exposure. The post-intruder dose factors were multiplied by the curies exhumed (decayed) to obtain the dose.

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

7.2.3 Inadvertent Intruder Analysis Results

Tank-specific intruder impacts generated using the methodology described above are provided in Appendix A for tank AX-104. This appendix provides total dose values for the well driller, suburban garden, rural pasture, and commercial farm intrusion scenarios, along with the radionuclide-specific dose contributions from the radionuclides that dominate the total dose. Table A-3 indicates that tank AX-104 would not exceed the performance measures of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure.

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

APPENDIX A – BEST BASIS INVENTORY

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Table A-1. Tank AX-104 Inventory (4 Pages)

Analyte	Waste Phase	Waste Type	Inventory	Units
^{106}Ru	Sludge Solid	P2 (Solid)	2.83E-06	Ci
	Total		2.83E-06	Ci
^{113m}Cd	Sludge Solid	P2 (Solid)	9.52E-01	Ci
	Total		9.52E-01	Ci
^{125}Sb	Sludge Solid	P2 (Solid)	8.73E+00	Ci
	Total		8.73E+00	Ci
^{126}Sn	Sludge Solid	P2 (Solid)	8.85E-02	Ci
	Total		8.85E-02	Ci
^{129}I	Sludge Solid	P2 (Solid)	3.66E-04	Ci
	Total		3.66E-04	Ci
^{134}Cs	Sludge Solid	P2 (Solid)	1.58E-02	Ci
	Total		1.58E-02	Ci
^{137}Cs	Sludge Solid	P2 (Solid)	4.53E+04	Ci
	Total		4.53E+04	Ci
^{137m}Ba	Sludge Solid	P2 (Solid)	4.27E+04	Ci
	Total		4.27E+04	Ci
^{14}C	Sludge Solid	P2 (Solid)	1.07E-01	Ci
	Total		1.07E-01	Ci
^{151}Sm	Sludge Solid	P2 (Solid)	2.99E+04	Ci
	Total		2.99E+04	Ci
^{152}Eu	Sludge Solid	P2 (Solid)	2.20E+01	Ci
	Total		2.20E+01	Ci
^{154}Eu	Sludge Solid	P2 (Solid)	6.34E+02	Ci
	Total		6.34E+02	Ci
^{155}Eu	Sludge Solid	P2 (Solid)	2.47E+02	Ci
	Total		2.47E+02	Ci
^{226}Ra	Sludge Solid	P2 (Solid)	8.60E-07	Ci
	Total		8.60E-07	Ci
^{227}Ac	Sludge Solid	P2 (Solid)	4.40E-06	Ci
	Total		4.40E-06	Ci
^{228}Ra	Sludge Solid	P2 (Solid)	7.33E-12	Ci
	Total		7.33E-12	Ci
^{229}Th	Sludge Solid	P2 (Solid)	5.22E-09	Ci
	Total		5.22E-09	Ci
^{231}Pa	Sludge Solid	P2 (Solid)	6.09E-06	Ci
	Total		6.09E-06	Ci
^{232}Th	Sludge Solid	P2 (Solid)	7.33E-12	Ci
	Total		7.33E-12	Ci

Table A-1. Tank AX-104 Inventory (4 Pages)

Analyte	Waste Phase	Waste Type	Inventory	Units
^{232}U	Sludge Solid	P2 (Solid)	4.11E-06	Ci
	Total		4.11E-06	Ci
^{233}U	Sludge Solid	P2 (Solid)	7.97E-06	Ci
	Total		7.97E-06	Ci
^{234}U	Sludge Solid	P2 (Solid)	5.65E-02	Ci
	Total		5.65E-02	Ci
^{235}U	Sludge Solid	P2 (Solid)	2.36E-03	Ci
	Total		2.36E-03	Ci
^{236}U	Sludge Solid	P2 (Solid)	1.45E-03	Ci
	Total		1.45E-03	Ci
^{237}Np	Sludge Solid	P2 (Solid)	1.64E-02	Ci
	Total		1.64E-02	Ci
^{238}Pu	Sludge Solid	P2 (Solid)	1.23E+01	Ci
	Total		1.23E+01	Ci
^{238}U	Sludge Solid	P2 (Solid)	5.52E-02	Ci
	Total		5.52E-02	Ci
^{239}Pu	Sludge Solid	P2 (Solid)	2.69E+02	Ci
	Total		2.69E+02	Ci
^{240}Pu	Sludge Solid	P2 (Solid)	6.61E+01	Ci
	Total		6.61E+01	Ci
^{241}Am	Sludge Solid	P2 (Solid)	9.45E+02	Ci
	Total		9.45E+02	Ci
^{241}Pu	Sludge Solid	P2 (Solid)	4.20E+02	Ci
	Total		4.20E+02	Ci
^{242}Cm	Sludge Solid	P2 (Solid)	8.23E-01	Ci
	Total		8.23E-01	Ci
^{242}Pu	Sludge Solid	P2 (Solid)	4.79E-03	Ci
	Total		4.79E-03	Ci
^{243}Am	Sludge Solid	P2 (Solid)	5.05E-01	Ci
	Total		5.05E-01	Ci
^{243}Cm	Sludge Solid	P2 (Solid)	4.32E-02	Ci
	Total		4.32E-02	Ci
^{244}Cm	Sludge Solid	P2 (Solid)	9.13E-01	Ci
	Total		9.13E-01	Ci
^{3}H	Sludge Solid	P2 (Solid)	2.86E-01	Ci
	Total		2.86E-01	Ci
^{59}Ni	Sludge Solid	P2 (Solid)	2.79E+00	Ci
	Total		2.79E+00	Ci

Table A-1. Tank AX-104 Inventory (4 Pages)

Analyte	Waste Phase	Waste Type	Inventory	Units
^{60}Co	Sludge Solid	P2 (Solid)	8.74E+01	Ci
	Total		8.74E+01	Ci
^{63}Ni	Sludge Solid	P2 (Solid)	2.55E+02	Ci
	Total		2.55E+02	Ci
^{79}Se	Sludge Solid	P2 (Solid)	4.39E-02	Ci
	Total		4.39E-02	Ci
^{90}Sr	Sludge Solid	P2 (Solid)	1.87E+06	Ci
	Total		1.87E+06	Ci
^{90}Y	Sludge Solid	P2 (Solid)	1.87E+06	Ci
	Total		1.87E+06	Ci
^{93m}Nb	Sludge Solid	P2 (Solid)	9.83E-01	Ci
	Total		9.83E-01	Ci
^{93}Zr	Sludge Solid	P2 (Solid)	1.16E+00	Ci
	Total		1.16E+00	Ci
^{99}Tc	Sludge Solid	P2 (Solid)	2.06E+01	Ci
	Total		2.06E+01	Ci
Al	Sludge Solid	P2 (Solid)	2.67E+03	kg
	Total		2.67E+03	kg
Bi	Sludge Solid	P2 (Solid)	0.00E+00	kg
	Total		0.00E+00	kg
Ca	Sludge Solid	P2 (Solid)	6.10E+02	kg
	Total		6.10E+02	kg
Cl	Sludge Solid	P2 (Solid)	1.58E+01	kg
	Total		1.58E+01	kg
Cr	Sludge Solid	P2 (Solid)	2.91E+01	kg
	Total		2.91E+01	kg
F	Sludge Solid	P2 (Solid)	5.09E+00	kg
	Total		5.09E+00	kg
Fe	Sludge Solid	P2 (Solid)	1.36E+04	kg
	Total		1.36E+04	kg
Hg	Sludge Solid	P2 (Solid)	8.27E+00	kg
	Total		8.27E+00	kg
K	Sludge Solid	P2 (Solid)	8.07E+00	kg
	Total		8.07E+00	kg
La	Sludge Solid	P2 (Solid)	7.41E+01	kg
	Total		7.41E+01	kg
Mn	Sludge Solid	P2 (Solid)	2.36E+02	kg
	Total		2.36E+02	kg

Table A-1. Tank AX-104 Inventory (4 Pages)

Analyte	Waste Phase	Waste Type	Inventory	Units
Na	Sludge Solid	P2 (Solid)	2.17E+03	kg
	Total		2.17E+03	kg
Ni	Sludge Solid	P2 (Solid)	7.35E+02	kg
	Total		7.35E+02	kg
NO_2	Sludge Solid	P2 (Solid)	1.13E+02	kg
	Total		1.13E+02	kg
NO_3	Sludge Solid	P2 (Solid)	2.30E+03	kg
	Total		2.30E+03	kg
Oxalate	Sludge Solid	P2 (Solid)	5.25E+01	kg
	Total		5.25E+01	kg
Pb	Sludge Solid	P2 (Solid)	4.67E+02	kg
	Total		4.67E+02	kg
PO_4	Sludge Solid	P2 (Solid)	1.26E+02	kg
	Total		1.26E+02	kg
Si	Sludge Solid	P2 (Solid)	4.38E+01	kg
	Total		4.38E+01	kg
SO_4	Sludge Solid	P2 (Solid)	2.39E+02	kg
	Total		2.39E+02	kg
Sr	Sludge Solid	P2 (Solid)	4.80E+01	kg
	Total		4.80E+01	kg
TIC as CO_3	Sludge Solid	P2 (Solid)	4.51E+03	kg
	Total		4.51E+03	kg
TOC	Sludge Solid	P2 (Solid)	1.46E+01	kg
	Total		1.46E+01	kg
UTOTAL	Sludge Solid	P2 (Solid)	1.65E+02	kg
	Total		1.65E+02	kg
Zr	Sludge Solid	P2 (Solid)	1.99E+02	kg
	Total		1.99E+02	kg

P2 (Solid) = PUREX waste also called inorganic wash waste and fission product waste (from aluminum and zirconium clad fuel)

[a] Reference download from http://twinsweb.pnl.gov/data dated 2/17/15.

APPENDIX B – TANK AX-104 LONG-TERM HUMAN HEALTH RISK

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Abbreviations and Acronyms

HQ	Hazard Quotient
ILCR	Lifetime Cancer Risk
WMA	Waste Management Area

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

This appendix provides tank-specific pre-retrieval risk assessment results for tank AX-104. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section B2.0. Inadvertent intruder impacts are presented in Section B3.0.

B2.0 GROUNDWATER PATHWAY IMPACTS

This section provides and discusses the retrieval leak impact generated for tank AX-104. The methodology used to generate the graphs is described in Section 7.1.1.

B2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures B-1 through B-5 provide the tank AX-104 waste retrieval leak impact graphs for the five indicator contaminants (technetium-99, iodine-129, chromium, nitrite, and nitrate) identified in Section 7.1.1.1.

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

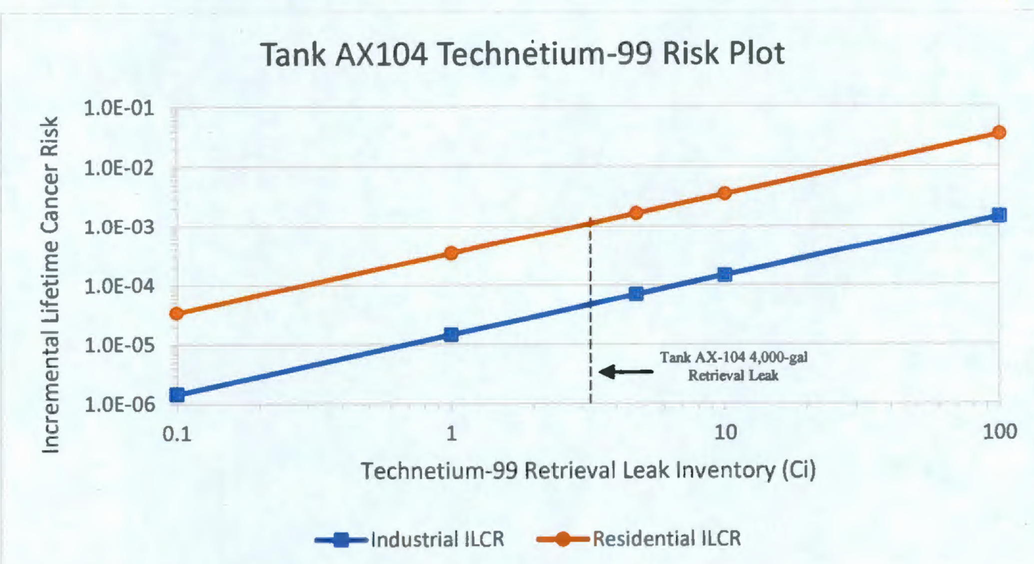


Figure B-2. Tank AX-104 Iodine-129 Risk Plot

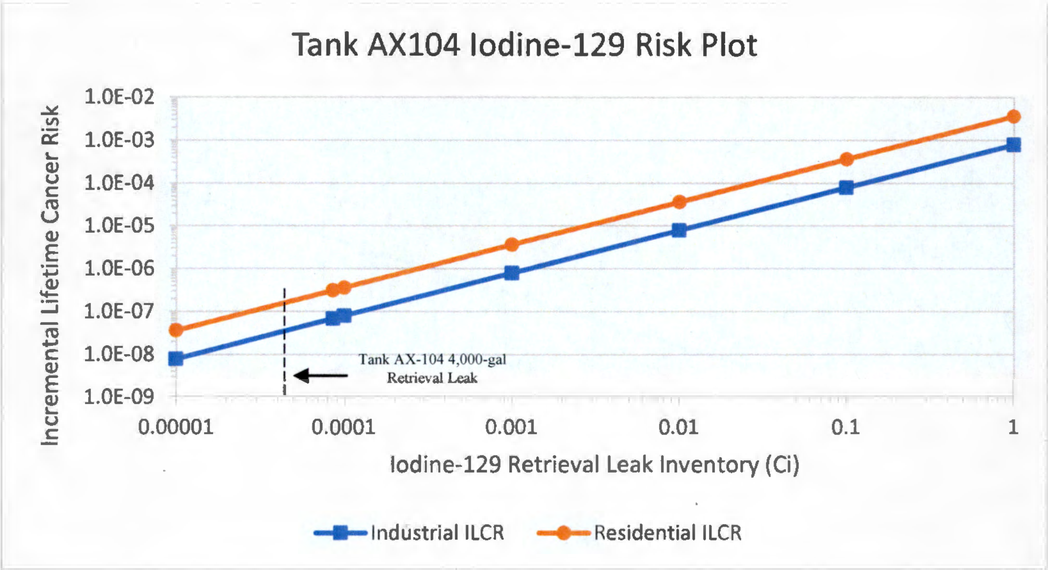


Figure B-3. Tank AX-104 Chromium Hazard Quotient Plot

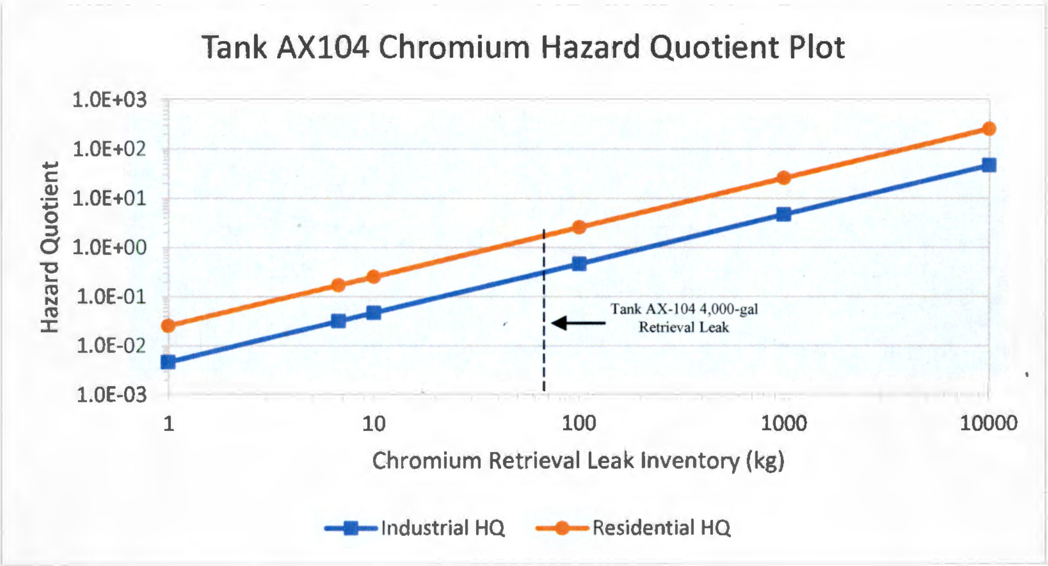


Figure B-4. Tank AX-104 Nitrite Hazard Quotient Plot

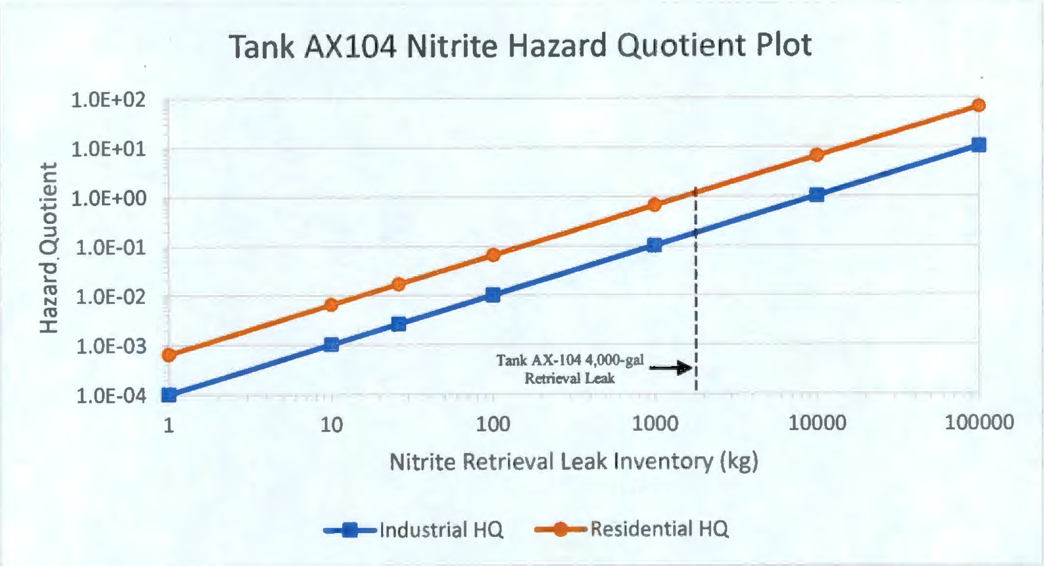
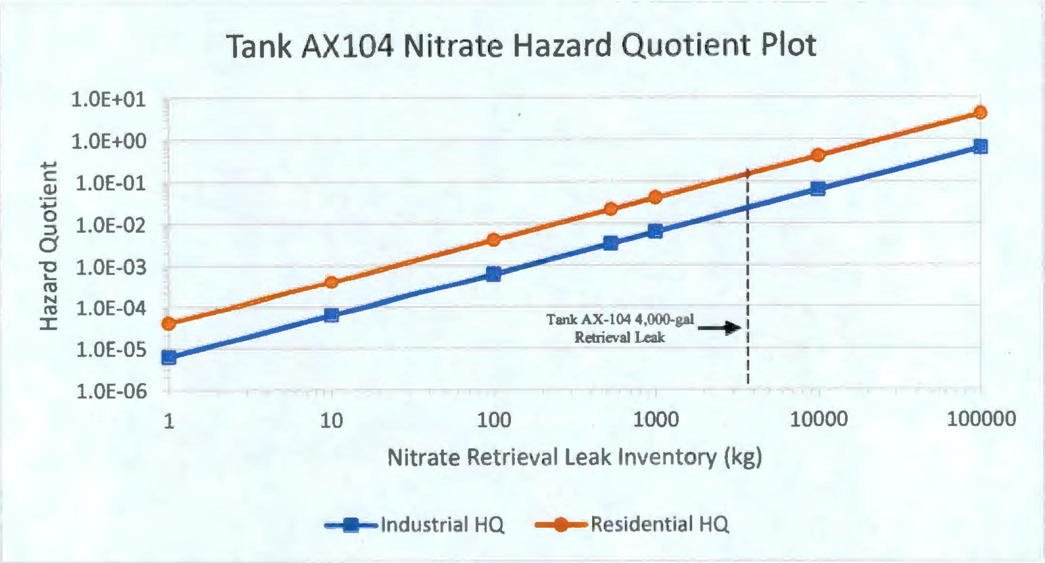


Figure B-5. Tank AX-104 Nitrate Hazard Quotient Plot



Figures B-1 and B-2 show the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 and iodine-129, respectively, as a function of the amount of contaminant leaked from tank AX-104 during waste retrieval. Figures B-3 through B-5 show the peak groundwater pathway hazard quotient (HQ) from chromium, nitrite, and nitrate, respectively, as a function of the amount of contaminant leaked from tank AX-104 during waste retrieval.

The ILCR and HQ values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) A/AX downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is in the approximate calendar year 2672 based on the supporting contaminant transport analysis in RPP-CALC-60497. The graphs provide a retrieval leak risk picture for tank AX-104 but do not include contributions from other WMA A/AX sources. Projected impacts from other WMA A/AX sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential exposure scenarios described in Section 7.1.1.4 were plotted on each graph. The lines were calculated as described in Section 7.1.1 over a range of hypothetical retrieval leak inventory values spanning multiple orders of magnitude. 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. Selection of the inventory range was arbitrary and independent of any assumption regarding the type of retrieval fluid used (raw water or supernate).

A vertical dashed line was added to each graph as a point of reference to show the estimated inventory associated with a potential 4,000-gal. retrieval leak from tank AX-104 (see Section B2.2). The 4,000-gal. volume was a hypothetical volume used only as a point of reference. It was not intended to represent an anticipated retrieval leak volume or leak detection limits for tank AX-104. Using the graphs, the impacts from leak inventories greater than or less than the reference inventory estimated for the 4,000-gal. volume can be estimated rapidly by extrapolating along the sloped lines from the impacts shown for the reference inventory.

B2.2 INVENTORY

The vertical reference lines shown in Figures B-1 through B-5 to indicate retrieval leak inventory for a 4,000-gal. leak were developed from the best available data and information. Retrieval leak inventories were calculated by multiplying the hypothetical 4,000-gal. leak volume by the retrieval leak fluid concentration estimated from thermodynamic modeling using the OLI Systems Inc. Stream Analyzer (RPP-RPT-58867). To convert curies per liter to curies per gallon, multiply by 3.78541. The retrieval leak fluid concentrations for this retrieval scenario are shown in Table B-1.

Table B-1. Tank AX-104 Retrieval Leak Inventory Estimate.

Contaminant	Leak Fluid Concentration (Ci/L or kg/L)	Inventory in 4,000-gal. Retrieval Leak (Ci or kg)
Technetium-99	3.14E-04	4.75E+00
Iodine-129	5.67E-09	8.59E-05
Chromium	4.44E-04	6.72E+00
Nitrite (as NO_2)	1.72E-03	2.60E+01
Nitrate (as NO_3)	3.50E-02	5.30E+02

B2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 4,000-gal retrieval leak from tank AX-104 was estimated to be approximately 4.75 Ci. As shown in Figure B-1, this corresponds to an ILCR of approximately 7×10^{-5} for the industrial scenario and 2×10^{-3} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA A/AX fenceline from this retrieval leak would be approximately 5,000 pCi/L.

The iodine-129 inventory associated with a hypothetical 4,000-gal retrieval leak from tank AX-104 was estimated to be approximately 8.59×10^{-5} Ci. As shown in Figure B-2, this corresponds to an ILCR of approximately 7×10^{-8} for the industrial scenario and 3×10^{-7} for the residential scenario. The peak iodine-129 groundwater concentration at the WMA A/AX fenceline from this retrieval leak would be approximately 0.090 pCi/L.

The chromium inventory associated with a hypothetical 4,000-gal retrieval leak from tank AX-104 was estimated to be approximately 6.72 kg. As shown in Figure B-3, this corresponds to an ILCR of approximately 1×10^{-7} and an HQ of 0.03 for the industrial scenario, and it corresponds to an ILCR of 3×10^{-7} and an HQ of 0.2 for the residential scenario. These impacts assume all chromium inventory is hexavalent chromium. The peak chromium groundwater concentration at the WMA A/AX fenceline from this retrieval leak would be approximately 7.0×10^{-3} mg/L, also assuming all chromium is hexavalent chromium.

The nitrite inventory associated with a hypothetical 4,000-gal retrieval leak from tank AX-104 was estimated to be approximately 26.0 kg. As shown in Figure B-4, this corresponds to a hazard quotient of approximately 0.003 for the industrial scenario and 0.02 for the residential scenario. The peak nitrite groundwater concentration at the WMA A/AX fenceline from this retrieval leak would be approximately 2.7×10^{-2} mg/L as NO_2, assuming no reactions.

The nitrate inventory associated with a hypothetical 4,000-gal retrieval leak from tank AX-104 was estimated to be approximately 530 kg. As shown in Figure B-5, this corresponds to a hazard quotient of approximately 0.003 for the industrial scenario and 0.02 for the residential scenario. The peak nitrate groundwater concentration at the WMA A/AX fenceline from this retrieval leak would be approximately 0.55 mg/L as NO_3, assuming no reactions.

B2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided using the industrial scenario ILCR result for technetium-99 of 7×10^{-5}. Following Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table B-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-3), and the technetium-99 industrial scenario unit risk factor (Table 7-4), as follows:

$$\text{ILCR} = (4.75 \text{ Ci}) \cdot (1.04 \times 10^{3} \text{ pCi/L per Ci}) \cdot (1.38 \times 10^{-8} \text{ ILCR per pCi/L}) = 7 \times 10^{-5}$$

B3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank AX-104 inadvertent intruder dose assessment were the estimated radionuclide inventories remaining in the tanks following retrieval assumed in the TC&WM EIS analysis of Alternative 2B. As per the TC&WM EIS Alternative 2B analysis, the current inventory for each of 46 radionuclides reported in the Best Basis Inventory (DOE/ORP-2003-02, Rev. 0, Appendix D, Table D.1) were assumed to be 99% retrieved at closure. Radionuclides were initially decayed from the referenced basis date of January 1, 2001 to an assumed closure date of January 1, 2050 for use in the dose assessment. Inventories for a subset of parent radionuclides that dominate intruder doses at 500 years after closure are shown in Table B-2.

Table B-2. Tank AX-104 Inventory of Dose-Driving Contaminants Assumed in TC&WM EIS for Residual Waste in the Analysis of Alternative 2B.

Radionuclide	Units	Tank AX-104
Technetium-99	Ci	9.37E-01
Tin-126	Ci	6.22E-02
Plutonium-239	Ci	2.82E+00
Plutonium-240	Ci	5.35E-01
Americium-241	Ci	8.79E+00

Source: DOE/ORP-2003-02

Table B-3 summarizes the inadvertent intruder dose assessment results for tank AX-104. These results were generated using the methodology described in Section 7.2 and RPP-CALC-60498. Contaminant-specific doses are shown for the subset of radionuclide decay chains that dominate the total dose 500 years after closure. The total dose shown represents the sum of the dose contributions from all radionuclide decay chains considered.

Table B-3. Tank AX-104 Inadvertent Intruder Dose.

Radionuclide Decay Chain	Well Driller (mrem EDE)	Suburban Garden (mrem/yr EDE)	Rural Pasture (mrem/yr EDE)	Commercial Farm (mrem/yr EDE)
Technetium-99	7.1E-06	2.5E-02	3.3E-04	2.7E-08
Tin-126 and daughters	2.6E-02	3.1E-02	3.3E-03	1.2E-04
Plutonium-239	1.4E-02	1.0E-01	4.6E-03	1.3E-04
Plutonium-240	2.6E-03	1.9E-02	8.7E-04	2.5E-05
Americium-241	3.1E-02	3.0E-01	1.4E-02	4.2E-04
Other radionuclides	2.9E-04	1E+02	8E+00	1E-02
TOTAL	**7E-02**	**1E+02**	**8E+00**	**1E-02**

Source: RPP-CALC-60498, Attachment C, Tables C-6-1 to C-6-4.

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

EDE = effective dose equivalent, 500 mrem/yr dose for Well Driller and 100 mrem/yr dose for other scenarios.

Table B-3 indicates that tank AX-104 would not exceed the performance measures of 500 mrem/yr effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure beginning 500 years after closure.

B4.0 REFERENCES

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

RPP-RPT-58867, 2015, *AX Farm Groundwater Risk Constituent Concentration Determination*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-CALC-60497, *Peak Groundwater Concentrations for Tank Farm 241-AX TWRWP Risk Assessment,* Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-CALC-60498, *Tank Waste Pre-Retrieval Assessment of Dose and Risk,* Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.