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Revision 0

Data Quality Objectives for Vadose Zone Characterization at Waste Management Area A-AX

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ACRONYMS

A Farm	241-A Tank Farm
AX Farm	241-AX Tank Farm
BGO	bismuth-germanium oxide
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
CMS	corrective measures study
COPC	contaminant of potential concern
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQO	data quality objective
DWS	drinking water standards
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
GM	Geiger Mueller detector
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HFFACO	*Hanford Federal Facility and Consent Order*
ICP	inductively coupled plasma
IPA	HFFACO Appendix I Performance Assessment
LaBr	lanthanum bromide
MS	mass spectroscopy
NaI	sodium iodide
OU	operable unit
OWW	organic wash waste
PCB	polychloride biphenyls
PSQ	principal study question
PUREX	Plutonium Uranium Extraction Plant
QAPjP	Quality Assurance Project Plan
QC	quality control
RAS	radionuclide assessment system
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA Facility Investigation
SGE	surface geophysical exploration
SST	single-shell tank
SVOC	semi-volatile organic compound
TIC	tentatively identifiable compound
TSD	treatment, storage, and disposal
UPR	unplanned release
VOC	volatile organic compound
WAC	Washington Administrative Code
WMA	Waste Management Area
WRPS	Washington River Protection Solutions

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1.0 INTRODUCTION

The purpose of defining the data quality objectives (DQO) for Waste Management Area (WMA) A-AX is to ensure that the data collected from the vadose zone will support the regulatory requirements and data needs described in Section 1.1.1. To ensure requirements and needs are well defined, a multi-agency DQO process was conducted with the Washington State Department of Ecology (Ecology), U.S. Department of Energy (DOE) (Richland Operations Office [DOE-RL] and Office of River Protection [DOE-ORP]), Washington River Protection Solutions (WPRS), and CH2M HILL Plateau Remediation Company (CHPRC).

The DQO process was initiated in 2011 but suspended prior to completion. In 2017, the process was re-initiated through meetings with the multiple agencies. Meeting notes were prepared and are available in the Hanford Site Administrative Record[1]. The information agreed to during the 2017 meetings and subsequent discussions is provided in Appendix A along with open action items.

This DQO process was implemented in accordance with the U.S. Environmental Protection Agency's (EPA) EPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, and EPA QA/G-4HW, *Data Quality Objectives Process for Hazardous Waste Site Investigations*, and Hanford Site documents (DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* [HASQARD], and TFC-ENG-CHEM-C-16, *Data Quality Objectives for Sampling and Analysis*), with some modifications to accommodate project-specific requirements and constraints. Development of the DQO is a seven-step process. Each of the seven steps undertaken for the WMA A-AX DQO process is discussed in a separate section of this DQO summary report, as identified below:

1. Define the Problem (Section 2.0)
2. Identify the Goals of the Study (Section 3.0)
3. Identify Information Inputs (Section 4.0)
4. Define the Boundaries of the Study (Section 5.0)
5. Develop the Analytical Approach (Section 6.0)
6. Specify Performance or Acceptance Criteria (Section 7.0)
7. Develop the Plan for Obtaining Data (Section 8.0).

This section of the report provides relevant background information used to support the DQO process and is organized as follows:

- Scope, Approach, and Team (Section 1.1)
- WMA A-AX Background Information (Section 1.2).

[1] The Hanford Site Administrative Record is available at: http://pdw.hanford.gov/arpir/.

1.1 SCOPE, APPROACH, AND TEAM

WMA A-AX is part of the Hanford Site single-shell tank (SST) system and is comprised of 241-A Tank Farm (A Farm) and 241-AX Tank Farm (AX Farm). WMA A-AX is located in the Hanford Site Central Plateau, near the eastern edge of the 200 East Area (Figure 1-1). To support the transfer and storage of waste within WMA A-AX SSTs, there is a complex waste transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, and other miscellaneous structures. Near-by process facilities include the 242-A Evaporator, 204-AR Unloading Facility, 244-AR Vault, and 241-A-431 Ventilation Facility.

In general, A Farm consists of the following:

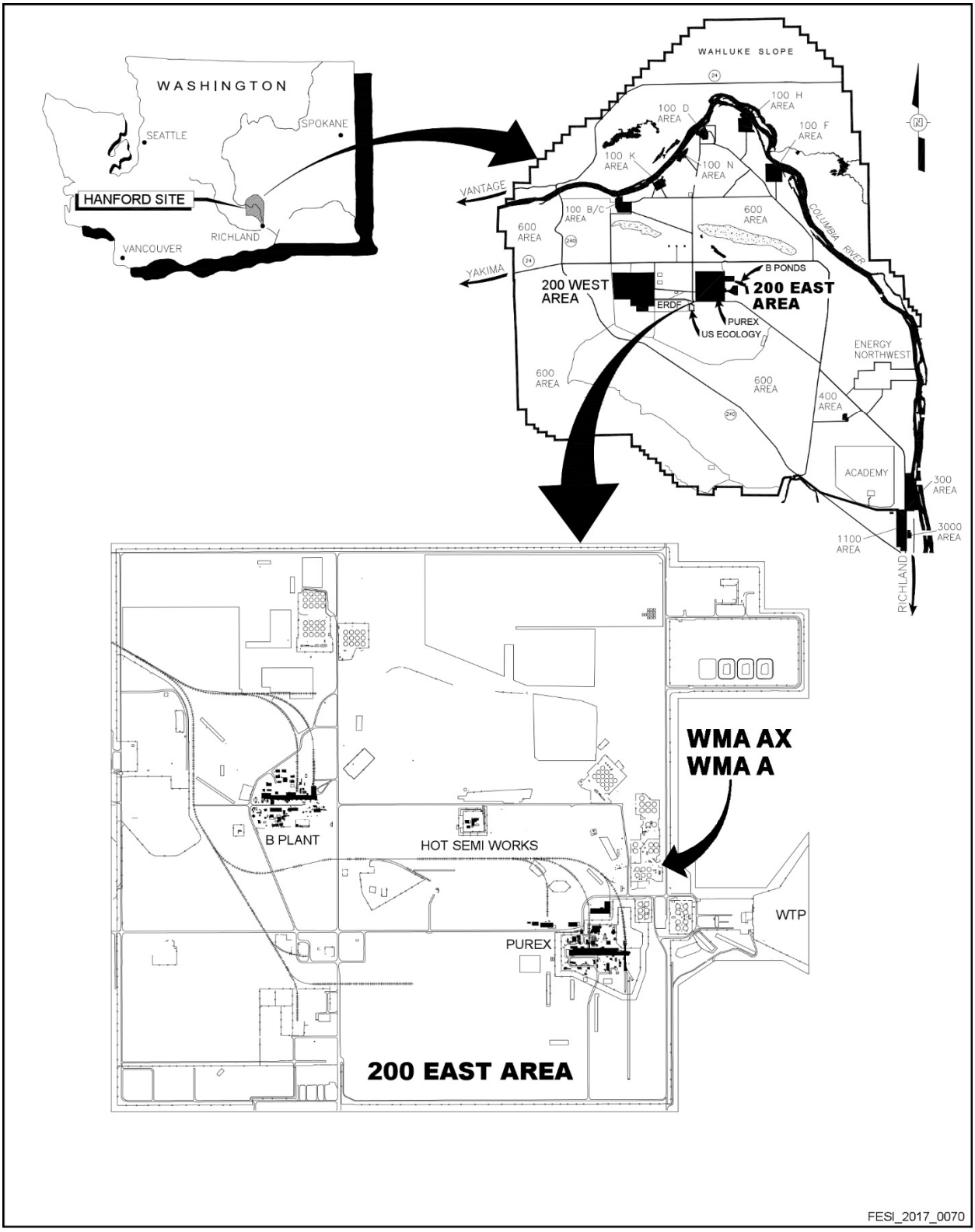
- Six 100-series SSTs, each with 1,000,000 gallons capacity
- Waste transfer lines
- Multiple drywells around each 100-series SST used as leak detection systems
- Laterals under the tanks used as leak detection systems
- Tank ancillary equipment.

In general, AX Farm consists of the following:

- Four 100-series SSTs, each with 1,000,000 gallons capacity
- Waste transfer lines
- Multiple drywells around each 100-series SST used as leak detection systems
- Tank ancillary equipment.

Figure 1-2 shows WMA A-AX and associated features, such as the fenceline.

Figure 1-1. Location Map of WMA A-AX in the 200 East Area of the Hanford Site



ERDF = Environmental Restoration Disposal Facility
PUREX = Plutonium Uranium Extraction (Plant)
WTP = Waste Treatment and Immobilization Plant

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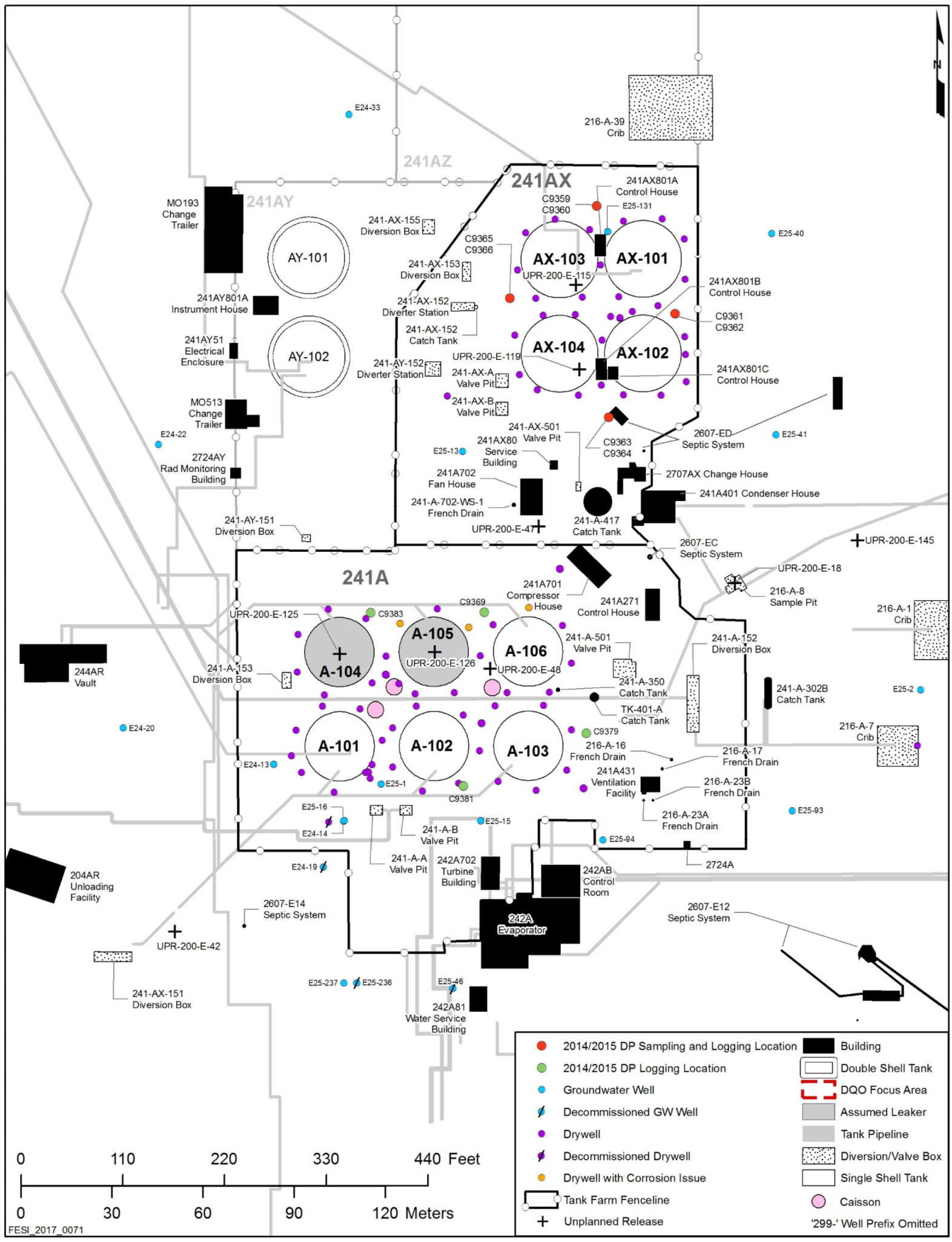

Figure 1-2. WMA A-AX Location and Surrounding Area

DP = direct push

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1.1.1 Scope and Approach

The overall scope of this DQO is as follows:

- The DQO process will address vadose zone contamination in and around WMA A-AX to support the *Resource Conservation and Recovery Act of 1976* (RCRA) Facility Investigation (RFI).

- Data will be used to develop and refine the conceptual site model and assess risk to human health and the environment, including the future risk to groundwater to support the RFI and the Ecology et al. 1989, *Hanford Federal Facility and Consent Order* (HFFACO) Appendix I Performance Assessment (IPA).

- If the risk assessment indicates a need to reduce risk to human health or the environment, the data will be used to evaluate alternatives in a corrective measures study (CMS).

- The corrective action decisions supported by the data collected under this DQO will be consistent with and support final closure of WMA A-AX.

- This DQO will not address data requirements of SST residual waste sampling and analysis or other data required to address closure associated with ancillary equipment in the tank farm. These data requirements will be addressed in a separate DQO for the closure of the SST system.

- This DQO will not address data requirements for groundwater characterization. These data requirements will be addressed through the groundwater operable units (OUs) associated with WMA A-AX; however, it is recognized that there is a need to integrate characterization and closure actions with ongoing and nearby operations and waste site/groundwater remedial actions.

Data obtained as a result of this DQO process will also be used to support the risk-informed retrieval process.

The approach to address the overall scope of the WMA A-AX DQO will be iterative, with revisions being prepared to address “focus areas,” as needed. Focus areas will be identified by the decision makers and are those areas within WMA A-AX where it has been determined that more information is needed (Table 1-1). Steps 1 through 3 and Steps 5 and 6 of the DQO process are associated with the overall area of WMA A-AX to ensure that data collected for the focus areas will meet the long-term scope and objectives to support WMA A-AX closure. Steps 4 and 7 reflect information on WMA A-AX as well as more specific information for the focus area of interest.

The scope of Revision 0 will be to support vadose zone data collection around the focus area of Tanks 241-A-104 (A-104) and 241-A-105 (A-105). If other focus area(s) need to be investigated, then an addendum or revision will be written to provide additional information with

respect to the focus area. Delineation of the overall boundary of WMA A-AX will be deferred until later.

The DQO steps and the manner in which they will be applied at WMA A-AX are identified in Table 1-1. As identified in the introductory text of this section of the WMA A-AX DQO summary report, each of these steps will be discussed in more detail in subsequent sections (e.g., Step 1 in Section 2.0 of this report).

Table 1-1. WMA A-AX DQO Approach

Step	Purpose of Step	WMA A-AX DQO Document Information
1	**State the Problem** *Define the problem that necessitates the study, identify the planning team, examine budget, and schedule.*	The problem statement will be the same for each revision of the DQO. It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
2	**Identify the Goal of the Study** *State how environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes.*	The goal of the study will be the same for each revision of the DQO. It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
3	**Identify Information Inputs** *Identify data and information needed to answer study questions.*	The information inputs will be the same for each revision of the DQO. It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
4	**Define the Boundaries of the Study** *Specify the target population and characteristics of interest, define spatial and temporal limits, scale of inference.*	Each revision will be specific to a focus area.
5	**Develop the Analytical Approach** *Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions and findings.*	The analytical approach will be the same for each revision of the DQO. It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
6	**Specify Performance or Acceptance Criteria** *Specify probability limits for false acceptance decision errors.*	Performance/Acceptance Criteria will be the same for each revision of the DQO. It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
7	**Develop the Plan for Obtaining Data** *Select the resource-effective sampling and analysis plan that meets the performance criteria*	Each revision will be specific to a focus area.

Note: Steps that reflect the "overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS" will be reviewed to determine if any specifics are needed for Focus Area Evaluation.

1.1.2 Team

This DQO was developed using input from the DQO Team, which directly involved representatives from Ecology, DOE-RL and DOE-ORP, WPRS, and CHPRC. The DQO Team consisted of decision makers, facilitators, data users, supporting function providers, observers, and interested personnel from the represented groups. The team developed the DQO process steps and compiled information from the requirements source documents along with inputs from subject matter experts. The team reviewed decisions made in the 2011 DQO workshops as part of the process, identified the data needed to support corrective measures and final closure decision-making for WMA A-AX, identified project and global technical challenges in executing the WMA A-AX characterization, and helped identify solutions for overcoming those technical challenges. Table 1-2 identifies DQO team members and their DQO functions.

Table 1-2. DQO Team Members

Organization	Name	Function/Decision Authority
DOE-ORP	Jan Bovier	DOE-ORP Project Lead[a]
DOE-RL	Doug Hildebrand	DOE-RL Lead - Integration with 200-EA-1 and Groundwater Operable Units
Ecology	Mike Barnes	Lead WMA A-AX DQO
	Jeff Lyon	Tank Farms Project Manager[a]
	Joe Caggiano[b]	Technical Support
	Elizabeth Rochette	Technical Support
	Marysia Skorska	Technical Support
	Jim Alzheimer	Technical Support
WRPS	Scott Luke	DQO Facilitator
	Paul Rutland	Vadose Zone Project Director
	Cindy Tabor	Project Lead
	Ryan Childress	Sampling Lead
	Jim Field	Leak Assessments and Process Knowledge
	Robin Varljen	Regulatory Compliance
	Kristin Singleton/Marcel Bergeron	Risk Assessment
	Harold Sydnor	Field Characterization/Sampling and Analysis
	Kathi Dunbar/Cris Lungu	Quality Assurance
	Steve McKinney/Paul Gassman	Laboratory Interface
	Bob Hiergesell	WMA A-AX Performance Assessment Integration
	Duc Nguyen	DQO Oversight

Table 1-2. DQO Team Members

Organization	Name	Function/Decision Authority
CHPRC	Bert Day	200-EA-1 and 200-IS-1 OUs
	Mark Byrnes/Phil Burke	200-DV-1 OU
	Lee Brouilland/Jeremy Lynn	200-PO-1 OU
	Greg Thomas	200-BP-5 OU
	Curt Wittreich	Groundwater OU Integration
Freestone Environmental Services, Inc.	Julie Robertson	Regulatory Support
	Kim Schuyler	Regulatory Support
INTERA	Mahmudur Rahman	Risk Assessment/Regulatory Support

a. Decision maker
b. Team member through October 2017

1.2 WMA A-AX BACKGROUND INFORMATION

To provide context for this DQO, the following background material is provided:

- Tank Features, Waste Types, and Release Information (Section 1.2.1)
- Soil Investigation Summary (Section 1.2.2)
- Conceptual Site Model (Section 1.2.3)
- Groundwater Information (Section 1.2.4).

Summary regulatory background information is provided in Section 4.0 (i.e., Step 3, identify information inputs).

1.2.1 Tank Features, Waste Types, and Release Information

Tanks in both A Farm and AX Farm received the majority of their waste from the Plutonium Uranium Extraction Plant (PUREX). Operations at PUREX went through two phases: the first phase began in 1956 and continued until 1972, and the second phase occurred from 1983 to 1985. During these phases, waste discharges to the environment (to cribs and other facilities) located around WMA A-AX were large and frequent. One set of facilities was constructed mostly on the east side of WMA A-AX, and another set was constructed ~0.5 mile south to support PUREX operations. Additionally, significantly larger quantities of dilute waste (primarily cooling water and steam condensate from various facilities) were disposed of at B Pond, located ~1 mile to the east of WMAs C and A-AX, and at Gable Mountain Pond several miles to the northwest. Together, these discharges have affected water table levels, groundwater flow direction, and groundwater chemistry underlying these WMAs (RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*).

Each tank in WMA A-AX consists of a 75 ft diameter, carbon steel liner, inside a cylindrical reinforced concrete shell. Each tank is approximately 44 ft deep with an operating depth of approximately 30 ft and operating capacity of approximately 1,000,000 gallons. The tanks have

flat bottoms that intersect the sidewalls orthogonally, rather than the dished bottoms of earlier designed tank farms. The tanks were connected by overflow lines but did not cascade. Table 1-3 identifies the waste types associated with WMA A-AX. The tanks in WMA A-AX have unique design features for the handling of high temperature waste, including airlift circulators for cooling boiling wastes and underground vessel ventilation headers for removing off-gas and water vapor.

The six 1,000,000 gallons capacity SSTs that are in A Farm were designed for the storage of boiling waste generated from irradiated fuel reprocessing at the PUREX Plant. A Farm tanks were constructed from 1954 through 1955, and operations began in 1956. The A Farm was designed with two external leak detection methods; in addition to drywells located throughout the A Farm, the tanks were underlain by laterals connected to caissons as a leak detection system. A Farm tanks were originally designed to contain liquid and solid wastes at a maximum temperature of 280°F (RPP-10435, *Single-Shell Tank System Integrity Assessment Report*). The thickness of the A Farm tanks' concrete shells is 0.5 ft on the tank bottoms, 2 to 1.25 ft on the side walls, and 1.25 ft for the tank dome. The concrete tank dome thickness increases to approximately 3.5 ft along the side walls. Each tank was equipped with risers, a vapor exhaust pipeline that penetrated the tank dome, and airlift circulators that were operated to suspend solids, mix the tank contents, and dissipate heat. After installation of airlift circulators, the operating temperature limit was revised to a maximum of 300°F at the tank bottom (RPP-10435). Waste at higher temperatures could cause buckling of the steel liner and/or structural damage to the concrete shell. Refer to Figure 1-3 for a schematic diagram of an A Farm tank.

The four 1,000,000 gallons capacity tanks that are in AX Farm were also designed for the storage of boiling waste generated from the PUREX Plant. AX Farm tanks were constructed between 1963 and 1964, and operations began in 1965. The thickness of the AX Farm tanks' concrete shells is 1.5 ft on the tank bottoms, 2 to 1.25 ft on the side walls, and 1.25 ft for the tank dome. The concrete tank dome thickness increases to 5 ft along the side walls. The AX Farm was designed with two external leak detection methods; in addition to drywells located throughout the AX Farm, tanks in the AX Farm include a grid of drain slots beneath the shell liner bottom and a leak detection well that could collect potential leakage. The tanks were equipped with risers that penetrated the tank domes, and airlift circulators that were operated to suspend solids, mix the tank contents, and dissipate heat. These tanks were designed to contain liquid and solid wastes at a maximum temperature of 350°F. Waste at higher temperatures could cause buckling of the steel liner and/or structural damage to the concrete shell. Refer to Figure 1-4 for a schematic diagram of an AX Farm tank.

Table 1-3. Waste Types Received into WMA A-AX 100-Series Tanks (1956 through 1981)

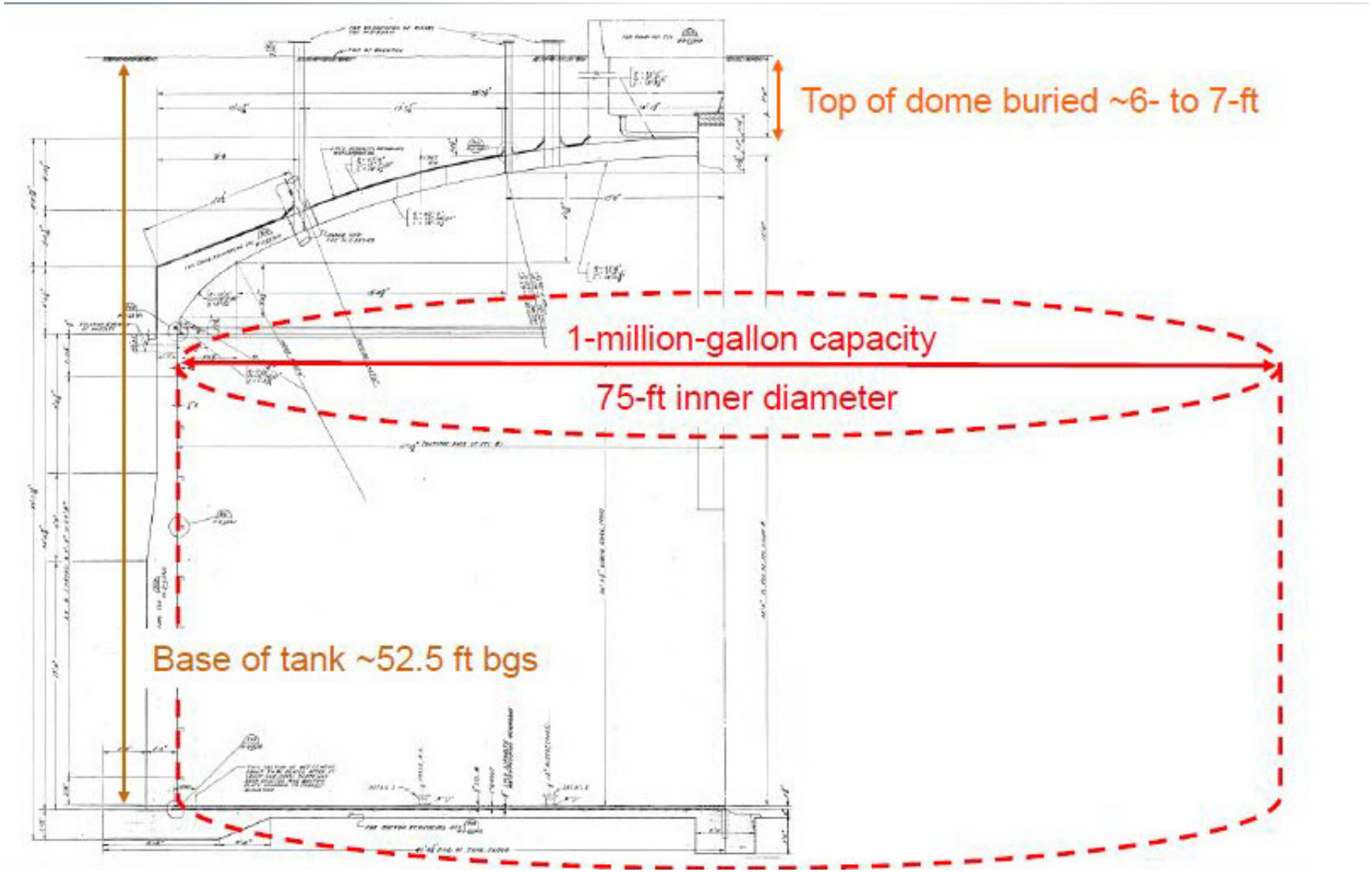
Year	A-101	A-102	A-103	A-104	A-105	A-106	AX-101	AX-102	AX-103	AX-104
1956	P OWW	OWW P	P OWW							
1957						P OWW				
1958				P OWW						
1959										
1960										
1961										
1962					P					
1963										
1964			Sluiced							
1965			OWW				P OWW FP	OWW	OWW/P	P
1966			Sluiced							
1967										
1968			CSR		Sluiced CSR				SRR B	
1969	Sluiced			Sluiced				B		
1970	P			Water		Sluiced			P	
1971					Water	P				
1972				AR/CSR/ SRR					SRR	
1973	SRR	Sluiced							PSS AR	PSS
1974		AR/SRR/ B	Sluiced			AR/B				
1975	Sluiced		AR/PSS	Sluiced				Sluiced		
1976	A-SltCk	Sluiced	Sluiced			Sluiced	Sluiced		Sluiced	
1977		A-SltCk	A-SltCk			A-SltCk	A-SltCk		A-SltCk	Sluiced
1978								A-SltCk		
1979										
1980										
1981										

Colors in table are used to highlight each waste type

AR = Water washed Plutonium Uranium Extraction (PUREX) sludge
A-SltCk = Saltcake from the 242-A Evaporator
B = 221-B Plant high-activity waste
CSR = B-Plant Cesium Recovery ion exchange waste
FP = Fission product waste
OWW = Organic Wash Waste from PUREX Plant
P = PUREX high-level waste
PSS = PUREX Sludge Supernate
SRR = Strontium recovery waste

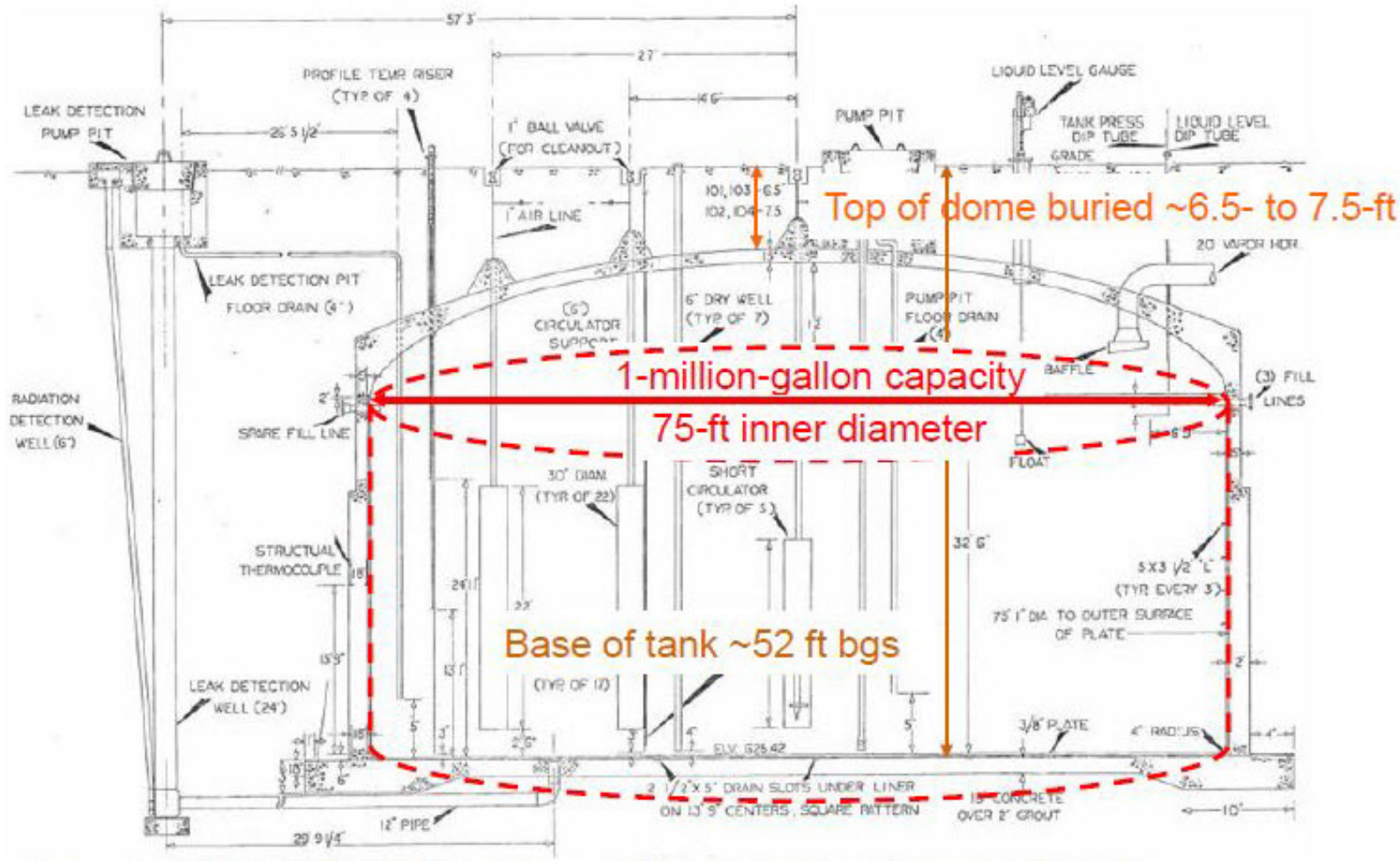
Reference: RPP-RPT-58291, *Hanford Waste Management Area A-AX Soil Contamination Inventory Estimates*

Figure 1-3. A Farm Tank Schematic



Reference: H-2-55911, *Waste Storage Tanks Composite Section.*

Figure 1-4. AX Farm Tank Schematic



Reference: RL-SEP-9, *PUREX 241-AX Tank Farm and Waste Routing System Information Manual.*

The A-AX Farm tanks were vented to an underground vessel ventilation header that connected to the two tank farms and later to the 241-AY Tank Farm. The tanks were often operated with the wastes at boiling conditions, and the purpose of the ventilation header was to remove off-gas and water vapor. The A-AX Farm tanks were isolated from this ventilation header in the early 1980s. Additionally, all of the tanks in WMA A-AX were declared inactive in the late 1970s to early 1980s and were subsequently interim stabilized by removing pumpable fluids. The A-AX Farm tanks have been saltwell-pumped to mitigate leaks/releases from tanks, and water lines within WMA A-AX are closed. However, the pipelines for the 242-A Evaporator and double-shell tanks, which are near WMA A-AX, are still active.

Based on RPP-ENV-37956, *Hanford 241-A and 241-AX Tank Farms Leak Inventory Assessment Report*, Tanks A-103, A-104, A-105, AX-102, and AX-104 were assumed to have leaked in the A and AX Farms. Tanks A-103, AX-102, and AX-104 have been reassessed and re-designated as sound. Tanks A-104 and A-105 remain classified as assumed/confirmed leakers. It appears the Tank A-104 liner leaked at or near the tank footing and below the 31 in. waste level. It is estimated that 2,000 gallons of PUREX sludge supernate leaked from Tank A-104.

Available information, including video observation of a bulged and ripped liner, indicate Tank A-105 likely leaked from around the tank perimeter at the tank base. It is estimated that 2,000 to 40,000 gallons of waste may have leaked from Tank A-105. The waste type believed to have leaked from Tank A-105 was a combination of PUREX supernatant waste and B Plant ion exchange waste. As per RPP-ENV-37956, this tank was sluiced twice after it was initially suspected to have leaked. Cesium-denuded supernate was used as the sluicing agent. A 1-Molar solution of sulfuric acid and an inhibitor, Rhodine A[2], was sprayed on the top, hard layer of sludge to soften it prior to the second sluicing with cesium-denuded supernate. Following the second sluice, water was periodically added to Tank A-105 for evaporative cooling of the remaining sludge. Of the estimated 610,000 gallons of cooling water added, approximately 200,000 to 232,000 gallons are unaccounted for and may have leaked. This cooling water does not add to the total inventory of constituents released, but does increase the total mixed waste volume.

Table 1-4, which is from RPP-ENV-37956, identifies releases associated with A-AX Farm tank loss events, including those from Tanks A-104 and A-105. In addition to tank releases, waste releases have occurred and are associated with 241-A-01B Sluice Pit (associated with Tank A-101); inside A Farm complex 200-E-131 (includes unplanned releases [UPRs] 200-E-47, 200-E-48, 200-E-115, and 200-E-119); close to but outside the fenceline (UPRs 200-E-18 and 200-E-42); cribs, trenches, drains, and basins (~800,000,000 gallons released, mostly condensate/cooling water).

[2] Rhodine A is a registered trademark of Amchem Incorporated, Longview, Texas.

Table 1-4. Summary of Tank Waste Loss Events

Tank	Description	HNF-EP-0182 Waste Loss Estimate (gal)	Revised Estimate[a]
241-A-103 (A-103)	From October 8, 1981 to March 5, 1987, the liquid level in Tank A-103 was observed to have decreased an estimated 5,500 gallons. However, the liquid waste level in Tank A-103 would also slowly rise over a period of 9 to 12 months, then drop rapidly over a 1 to 2 day period. The liquid level decrease was likely due to release of retained gas and not a loss of waste from a liner leak. No increase in radioactivity was detected in drywells or laterals beneath this tank during these events.	5,500	0 gal Tank integrity assessment (RPP-ASMT-42278) reclassified tank as "sound"
241-A-104 (A-104)	The Hanford Site tank farm contractor in correspondence with the U.S. Energy Research and Development Administration reported an estimated waste loss of 700 to 1,500 gallons in July 1975. In September 1975, the Hanford Site tank farm contractor conducted a study at Tank A-104 to reevaluate the liner leak size and revised the estimated leak loss to ~2,000 gallons. The waste type leaked from Tank A-104 is PUREX HLW supernate (P1 waste) with 0.56 Ci/g cesium-137.	500 to 2,500	~2,000 gal ~1,300 Ci of ^{137}Cs Liner leak
241-A-105 (A-105)	At least three leak events occurred with Tank A-105. PUREX HLW supernate (P1 waste) leaked from this tank in late 1963 and again in 1965. During sluicing in 1968 to 1970, 221-B Plant cesium ion exchange waste (waste type BIX) may have also leaked from this tank. In an effort to better quantify the inventory of waste leaked from Tank A-105, a new conceptual site model was devised to describe the leak. Based on this conceptual site model, the range of waste volume leaked from Tank A-105 was estimated to be between 2,000 gallons (if all P1waste) or 40,000 gallons (if all BIX waste). The actual volume of P1 and BIX waste is unknown.	10,000 to 277,000	~2,000 to 40,000 gal 25,000 Ci of ^{137}Cs plus cooling water[b] Liner leak
241-AX-102	An estimated waste loss of 3,400 gallons from Tank AX-102 is inconsistent with the relatively low level of radiation detected in the leak detection pit and drywells associated with this tank. The likely source of radioactivity detected historically in drywells 11-02-11 and 11-02-12 is the leaking Dresser[3] coupling associated with the tank off-gas piping and releases from the ventilation system.	3,000	0 gallons Tank appears sound Tank integrity assessment (RPP-ASMT-42628) concluded tank is sound

[3] Dresser is a trademark of Dresser-Rand, Houston, Texas.

Table 1-4. Summary of Tank Waste Loss Events

Tank	Description	HNF-EP-0182 Waste Loss Estimate (gal)	Revised Estimate[a]
241-AX-104	The likely source of radioactivity detected historically in drywells 11-04-01 and 11-04-11 is the leaking Dresser coupling associated with the tank off-gas piping and releases from the ventilation system.	---	0 gallons Tank appears sound Tank integrity assessment (RPP-ASMT-57574) concluded tank is sound
Other 241-A and AX Farm SSTs		0	0

a. Except as noted, ^{137}Cs inventories are decayed to January 1, 2001.

b. HNF-EP-0182 estimates 610,000 gallons of cooling water were added to Tank A-105 from November 1970 to December 1978 to aid in evaporative cooling. Approximately 232,000 gallons of added cooling water are potentially unaccounted for in the estimate of evaporative water and may have leaked from the tank. In accordance with Dangerous Waste Regulations (WAC 173-303-070, "Designation of Dangerous Waste," subsection (2)(a)(ii), as amended), any of this cooling water that has been added and subsequently leaked from the tank must be classified as a waste and should be included in the total leak volume.

HLW = high-level waste

References:

HNF-EP-0182, *Waste Tank Summary Report for Month Ending January 31, 2014*

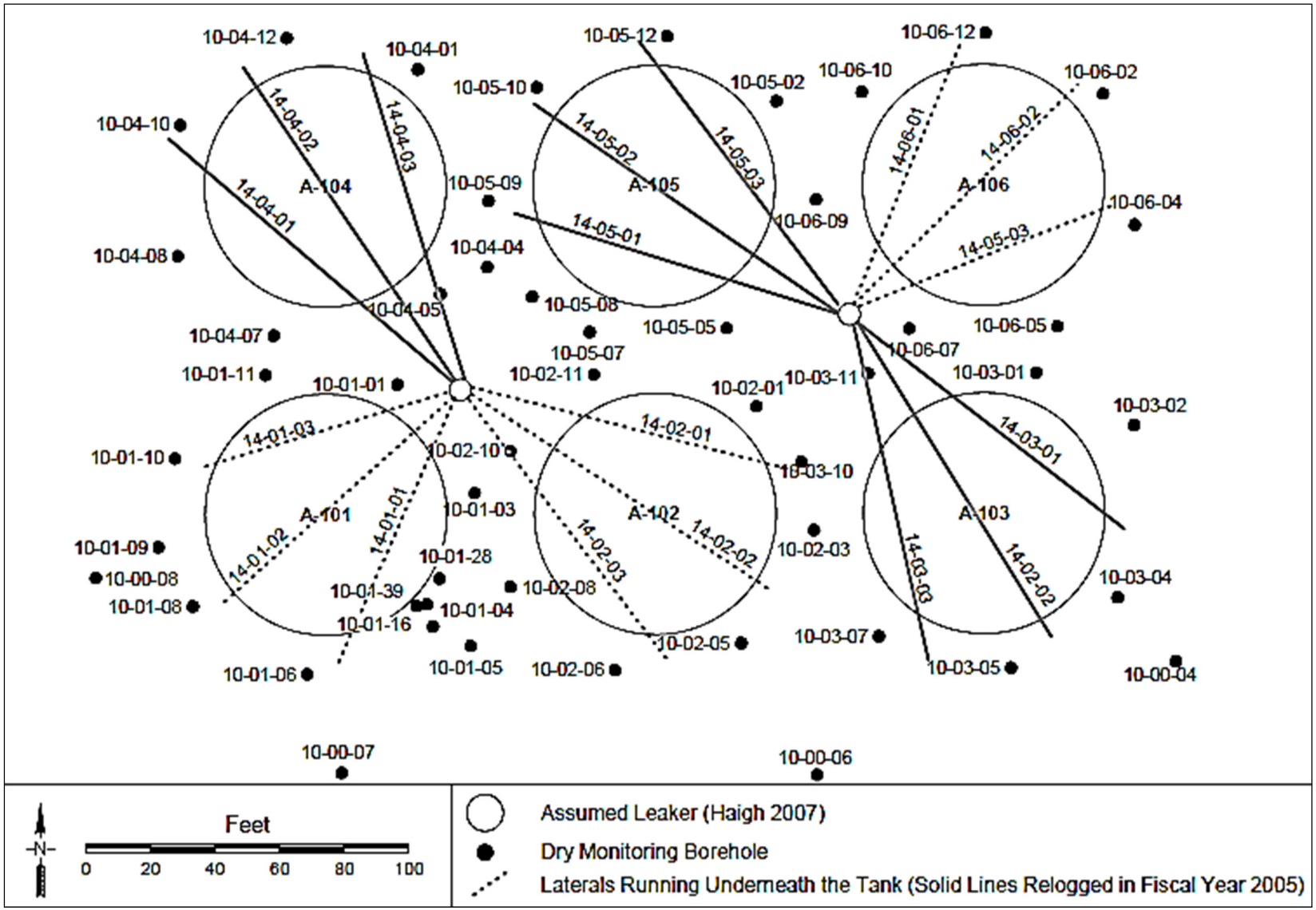
RPP-ASMT-42278, *Tank 241-A-103 Leak Assessment Report*

TFC-ENG-CHEM-D-42, Rev. B-7, *Tank Leak Assessment Process*

1.2.2 Soil Investigation Summary

Soil investigations at WMA A-AX have been ongoing from the time of the construction of A and AX Farms. The majority of the leak detection drywells at WMA A-AX were drilled in the 1960s and 1970s. Over the years, geophysical data were obtained from these drywells to investigate suspected releases of tank waste to the soil. In addition to drywells, beneath each of the tanks in A Farm, three horizontal lateral pipes were installed in 1962 and 1963. Figure 1-5 provides a visual depiction of the A Farm laterals and the location of the various drywells. The resulting geophysical data is summarized and evaluated in the following reports: HNF-2603, *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination,* and RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Areas*.

Figure 1-5. A Farm Lateral Locations



Source: RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX.*

In 2000, DOE-RL issued DOE/RL-99-36, *Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas*, as a "master" planning document that provided the framework for subsequent Phase 1 RFI characterization activities at the SST WMAs. In 2003, DOE-ORP prepared RPP-16608, *Site-Specific Single-Shell Tank Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan Addendum for Waste Management Areas C, A-AX, and U*, which guided the Phase 1 investigation of the vadose zone in a limited number of specific locations of concern at WMA A-AX, based on data gaps identified in HNF-2630 and RPP-14430.

A summary of the Phase 1 investigation data was documented in individual field investigation reports; the field investigation report for WMAs C and A-AX was released as RPP-35484. Information from multiple field investigation reports was then summarized and evaluated in DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management*. The field investigation report for WMAs C and A-AX was appended to DOE/ORP-2008-01 as Appendix L and identified for WMA A-AX that additional characterization data should focus on collecting soil samples on the north side of Tank A-105 based on the laterals data.

Additional field work was performed in 2014 and 2015. This field work consisted of logging drywells and performing a direct push investigation under RPP-PLAN-57332, *Field Sampling and Analysis Plan for Soil Samples at Waste Management Area A-AX*. More information on these activities is provided in Appendix B of this report.

1.2.3 Conceptual Site Model

Site environmental conditions, site characteristics, and contaminant nature, extent, and behavior are described by the conceptual site model. Development of the conceptual site model is a fundamental phase in the numerical model selection process (EPA/540/R-92/003, *Guidance for Data Useability in Risk Assessment (Part A) Final*; EPA/402/R-94/012, *A Technical Guide to Ground-Water Model Selection at Sites Contaminated with Radioactive Substances*; ASTM, 1999, *RBCA Fate and Transport Models: Compendium and Selection Guidance*; and CREM, 2003, *Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models*). The conceptual site model is the set of hypotheses and assumptions that postulate the characteristics and behavior of the actual site system(s) (EPA/402/R-94/012). The conceptual site model serves as the basis for determining the processes, mechanisms, and phenomena to be considered in the selection and use of *mathematical models* that are used as tools during risk assessment (DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*).

There are many potential pathways of contaminant fate and transport at WMA A-AX. A number of these potential pathways should be evaluated to inform a comprehensive conceptual site model. The development of the conceptual site model for WMA A-AX includes the preparation of illustrations needed to understand the model, as well as the numerical evaluation of risks associated with the contaminant fate and transport, which will be documented through the IPA process.

Graphical illustrations of potential contaminant fate and transport pathways depict the basis for the problem, assist in determining the type of data required, and help identify how the data would be used to solve the problem. These illustrations of potential contaminant fate and transport pathways aid in:

- Conceptualizing the nature and extent of contamination by defining the location and expected level of contamination
- Identifying analytical or numerical methods to predict water flow and transport of constituents of interest
- Quantifying fate and migration of contaminants in the environment.

The conceptual site model provides an organized description of waste migration. The conceptual site model is initially developed using historic process information and input from prior studies. As additional information about the interactions of contaminants and the environment becomes available, that information can be compared to model results. Such comparisons can enhance confidence in the validity of the model, disprove aspects of the model, or result in model refinement. The conceptual site model provides the framework for the performance and risk assessments used to inform corrective action and closure decisions.

Development of the conceptual site model supports the following functions:

- Identifies the processes and conditions that are believed to be common to all leak events.
- Guides the formulation of input parameters to, and application of, the numerical flow and transport models used to project contaminant migration from the source through the vadose zone and groundwater.
- Aids in defining and prioritizing future data collection and analysis.

The general conceptual site model for the Hanford Site Central Plateau vadose zone system postulates the basic nature, characteristics, and behavior of the vadose zone system. The model focuses on the characteristics, conditions, and associated features, events, and processes that are largely common to vadose zone conceptual site models across the Central Plateau, including at WMA A-AX. The conceptual site model framework for the Central Plateau vadose zone system can be divided into key conceptual site model components, which include descriptions of the subsystems and associated features, events, and processes that are important for description of the vadose system as a whole. The following list of key conceptual site model components incorporated into the model for WMA A-AX is derived from the basic Central Plateau vadose zone conceptual site model identified in DOE/RL-2011-50:

- Model domain and boundary conditions
- Geologic setting
- Source term
- Vadose zone hydrogeology and contaminant transport

- Infiltration and recharge
- Geochemistry and sorption
- Groundwater domain.

These conceptual site model components are consistent with those identified in EPA guidelines for the evaluation of the protection of groundwater pathway (EPA/540/R-99/008*;* OSWER No. 9200.4-18, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," and HNF-5294, *Computer Code Selection Criteria for Flow and Transport Code(s) To Be Used in Vadose Zone Calculations for Environmental Analyses in the Hanford Site's Central Plateau*).

DOE/RL-2011-50 identifies and describes the features, events, and processes applicable to most vadose zone modeling applications in the 200 Areas and provides the "basic" Central Plateau-specific vadose zone conceptual site model. The principal features, events, and processes associated with these conceptual site model components include the following:

- Relatively thick vadose zone composed of sedimentary deposits (geologic setting conceptual site model component)

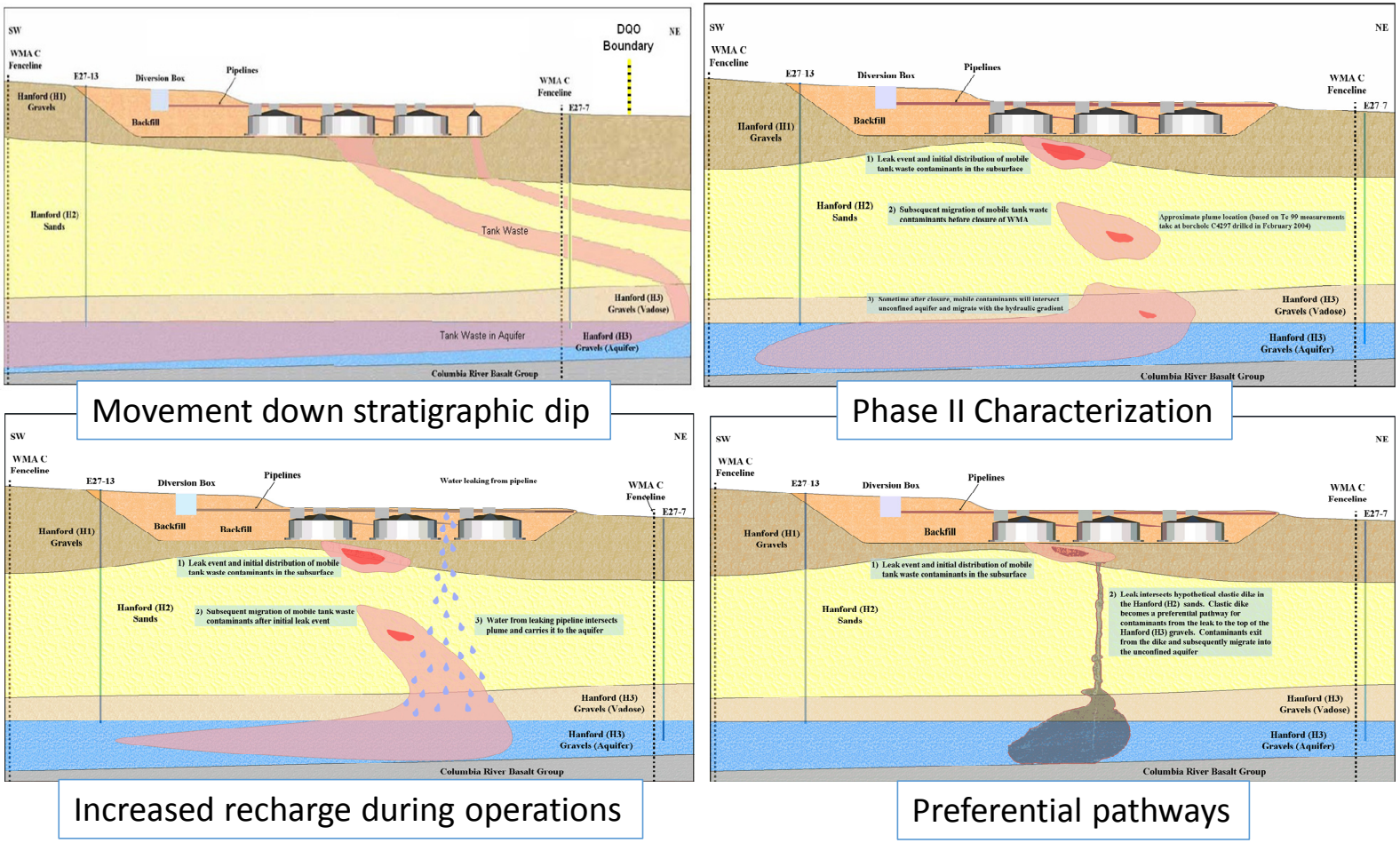
- Semi-arid region (infiltration/recharge conceptual site model component)

- Underlying unconfined aquifer (groundwater domain conceptual site model component)

- Relatively limited number of contaminants of concern in the vadose zone soils (source term) that have potential impacts to groundwater.

At the time that Revision 0 of this report was being developed, the potential contaminant fate and transport pathways to be incorporated into the WMA A-AX conceptual site model were also being developed, using an approach similar to that used for WMA C. Simplified graphical presentations of the potential contaminant fate and transport pathways considered in the WMA C conceptual site model are presented in Figure 1-6 and were presented in TOC-PRES-17-0187, *WMA A-AX RFI/CMS Data Quality Objectives Meeting 1, January, 2017*. It is expected that similar pathways of potential contaminant fate and transport will be evaluated for WMA A-AX.

Figure 1-6. Example Contaminant Fate and Transport Pathways



Source: TOC-PRES-17-0187, *WMA A-AX RFI/CMS Data Quality Objectives Meeting 1, January, 2017*

The potential contaminant fate and transport pathways that are expected to be incorporated into the WMA A-AX conceptual site model will be used to

- Identify the potential for vadose zone chemical and radiological soil contamination from past releases of tank waste
- Identify the need for soil and tank waste chemical, radiological, and physical property data to make decisions on soil contamination levels
- Evaluate mobility of constituents of interest in soil
- Evaluate potential impacts of waste releases and soil contamination on groundwater.

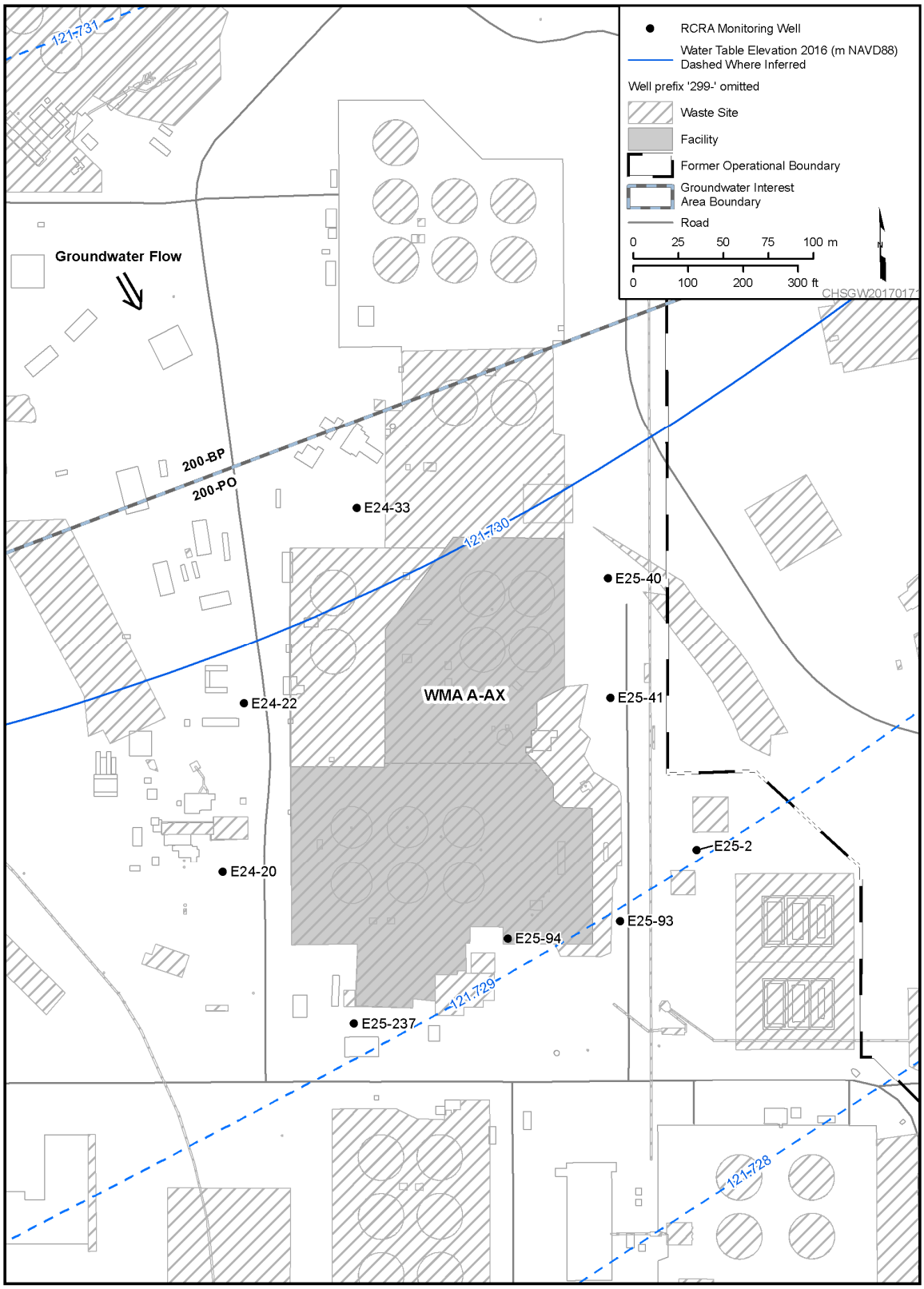
The geological setting information for WMA A-AX is provided in RPP-ENV-58578, *Summary of the Natural System at Waste Management Area A/AX*. As shown in Figure 1-1, WMA A-AX is located near the eastern edge of the 200 East Area on the Hanford Site on what is known colloquially as the Central Plateau. The vadose zone is ~262.4 to 328.1 ft thick, and there are ~223 ft between the base of the WMA A-AX 100-series tanks and the present-day water table. WMA A-AX lies within the gravel-dominated Hanford formation unit 1 in the vadose zone. Between the base of the unconfined aquifer (i.e., the Columbia River Basalt) and ground surface, this area of the Hanford Site has the following lithologic units from the bottom of the aquifer to land surface:

- Columbia River Basalt
- Ringold Formation member of Wooded Island - unit A*
- Ringold Formation member of Wooded Island - lower mud unit*
- Ringold Formation member of Wooded Island - unit E*
- Cold Creek unit gravels*
- Cold Creek unit silt
- Hanford formation unit 3
- Hanford formation unit 2
- Hanford formation unit 1
- Eolian sediments
- Backfill.
  (*indicates this formation occurs below and above the water table)

1.2.4 Groundwater Information

Groundwater flow under current conditions is generally in a southeastern direction as shown in Figure 1-7. At WMA A-AX, the approximate depth from the ground surface to the Hanford formation unit 3 is 270 ft below ground surface (bgs) and to groundwater is 290 ft bgs.

Figure 1-7. Groundwater Flow Direction in Vicinity of WMA A-AX



Source: DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*.

The groundwater in the vicinity of WMA A-AX has been significantly impacted by Hanford Site operations over the decades. During PUREX operational phases (1956-1972 and 1983-1985), waste discharges to the environment (to cribs and other discharge sites located around WMA A-AX) were large and frequent. Even larger quantities of dilute waste were disposed of at B Pond and Gable Mountain Pond. Together, these discharges have affected water table levels, groundwater flow direction, and groundwater chemistry underlying WMA A-AX (RPP-35484).

The primary contaminants observed in groundwater monitoring wells at WMA A-AX are nitrate and technetium-99. Technetium-99 exceeded the drinking water standard (DWS) in well 299-E25-236 starting in 2012. In 2013, nitrate exceeded the DWS in 299-E24-20 and 299-E25-93. Since RCRA assessment monitoring began in 2006, these are the only two wells that have exhibited nitrate concentrations above the DWS. In 2013, technetium-99 was detected above the DWS in three WMA A-AX wells: 299-E24-22, 299-E25-236, and 299-E25-93. Technetium-99 in well 299-E24-22, an upgradient WMA A-AX well, has been detected above the DWS since June 2013. The technetium-99 at well 299-E24-22 appears to be associated with sources to the north because of the regional southeast groundwater flow direction and location of this well with respect to WMA A-AX. However, technetium-99 activity at well 299-E25-93, located downgradient of WMA A-AX, has historically greater activity as compared to the upgradient wells including well 299-E24-22, indicating a source in the vicinity of WMA A-AX.

A summary of results for other constituents monitored for RCRA, *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and *Atomic Energy Act of 1954* in the WMA A-AX network during 2013 are shown in Tables 1-5 and 1-6.

Table 1-5. 2013 RCRA Assessment Parameter Summary

2013 Assessment Parameter Summary	
Parameter	**Range**
Alkalinity	84,000 to 110,000 µg/L
Chromium (filtered)	<5 to 47.9 µg/L
Lead (filtered)	<0.05 to 0.799 µg/L
Nitrate	11,600 to 52,200 µg/L
pH Measurement	7.44 to 8.44
Sodium (filtered)	17,300 to 28,300 µg/L
Specific Conductance	435 to 722 µS/cm
Sulfate	81,600 to 213,000 µg/L
Technetium-99	18 to 4,200 pCi/L
Temperature	17.0 to 21.3 °C
Total Organic Carbon	<100 to 1,010 µg/L
Turbidity	0.06 to 7.61 NTU

NTU = nephelometric turbidity unit

Reference: RPP-ENV-37956, *Hanford 241-A and 241-AX Tank Farms Leak Inventory Assessment Report.*

Table 1-6. 2013 CERCLA/*Atomic Energy Act of 1954* Groundwater Monitoring Summary

Parameter	Range
Arsenic (filtered)	3.94 to 6.63 µg/L
Arsenic (unfiltered)	5.09 to 9.06 µg/L
Chromium (filtered)	<5 to 14.2 µg/L
Chromium (unfiltered)	<5 to 81.6 µg/L
Gross Alpha	<0.12 to 3.6 pCi/L
Gross Beta	16 to 680 pCi/L
Iodine-129	2.36 to 7.02 pCi/L
Manganese (filtered)	<4 to 20.7 µg/L
Manganese (unfiltered)	<4 to 27.8 µg/L
Nitrate	10,600 to 34,100 µg/L
Specific Conductance	429 to 627 µS/cm
Strontium-90	< -0.93 to < 1.3 pCi/L
Technetium-99	12 to 1,000 pCi/L
Temperature	12.3* to 18.7 °C
Tritium	1,400 to 7,000 pCi/L
Turbidity	0.15 to 7.61 NTU
Vanadium (filtered)	11.2 to 23 µg/L
Vanadium (unfiltered)	16.2 to 24 µg/L

*Value suspect. Next lowest measured temperature was 17.2 °C.

NTU = nephelometric turbidity unit

Reference: RPP-ENV-37956, *Hanford 241-A and 241-AX Tank Farms Leak Inventory Assessment Report.*

DOE/RL-2009-85-ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit Addendum 1*, identified that iodine-129, nitrate, technetium-99, and tritium were retained as contaminants of potential concern (COPCs) in 200-PO-1 OU for WMA A-AX and the 216-A-29 Ditch. DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, identified that cyanide, iodine-129, nitrate, sulfate (exceeding secondary DWS), and technetium-99 were retained as COPCs for WMA C, which is upgradient of WMA A-AX.

Although the groundwater beneath WMA A-AX will not be investigated under the WMA A-AX DQO process, information about the groundwater will be needed to fully understand the nature and extent of contamination associated with WMA A-AX. The groundwater potentially impacted by WMA A-AX is being investigated under the Hanford Site 200-PO-1 and 200-BP-5 OUs. It is anticipated that relevant information from the remedial investigation report(s) will be incorporated into the WMA A-AX RFI Report in a manner similar to how groundwater

information about the groundwater beneath WMA C was incorporated into the WMA C Phase 2 RFI Report.

It is DOE-ORP's intent to provide a brief summary in the WMA A-AX RFI Report about groundwater monitoring results for constituents of interest. For each constituent of interest, groundwater-related information will be provided: 1) if the constituent is a groundwater COPC and 2) if upgradient sources are believed to have contributed to contamination in the groundwater under WMA A-AX. Depictions of groundwater plumes will be provided in the WMA A-AX RFI Report along with general information on the wells in the WMA A-AX area (e.g., construction diagrams, screen intervals). Additionally, information about impacts to groundwater from contamination in the vadose zone will be provided.

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2.0 STEP 1 – DEFINE THE PROBLEM

Step 1 of the seven-step DQO process is to provide a clear definition of the problem (the reason data are required) so that the focus of the project is clear. The environmental problem is defined by development of a concise problem statement.

Per EPA QA/G-4, the relevant major outputs of Step 1 are as follows:

- *A concise description of the problem*
- *A conceptual site model of the environmental problem to be investigated with a preliminary determination of the type of data needed and how it will be used (Section 1.2.3).*
- *A list of the planning team members and identification of decision makers or principal data users within the planning team (Section 1.1.2).*

With the objective of defining a problem statement in mind, the WMA A-AX Vadose Zone Characterization DQO scope was outlined in Section 1.1.1 as follows:

- *The DQO process will address vadose zone contamination in and around WMA A-AX to support the RFI.*
- *Data will be used to develop and refine the conceptual site model and assess risk to human health and the environment, including the future risk to groundwater to support the RFI and IPA.*
- *If the risk assessment indicates a need to reduce risk to human health or the environment, the data will be used to evaluate alternatives in a CMS.*
- *The corrective action decisions supported by the data collected under this DQO will be consistent with and support final closure of WMA A-AX.*
- *This DQO will not address data requirements of SST residual waste sampling and analysis or other data required to address closure associated with ancillary equipment in the tank farm. These data requirements will be addressed in a separate DQO for the closure of the SST system.*
- *This DQO will not address data requirements for groundwater characterization. These data requirements will be addressed through the groundwater OUs associated with WMA A-AX; however, it is recognized that there is a need to integrate characterization and closure actions with ongoing and nearby operations and waste site/groundwater remedial actions.*

Note that Revision 0 of this document is associated with the focus area around Tanks A-104 and A-105.

Considering the DQO scope, and after review of available information, the concise statement of the problem was identified as follows:

> *Vadose zone contamination in and adjacent to the A-AX Tank Farm may pose a current and future risk to human health and the environment, including groundwater, which requires corrective action to support closure.*

3.0 STEP 2 - IDENTIFY THE GOALS OF THE STUDY

The purpose of Step 2 is to state how environmental data will be used in meeting objectives and solving the problem, identify study questions, and define alternative outcomes.

Per EPA QA/G-4 the major outputs of Step 2 are:

- Well-defined principal study questions (PSQs)
- A listing of alternative outcomes or actions that are a result of addressing the PSQ
- For decision problems, a list of decision statements that address the study questions
- For estimation problems, a list of estimation statements that address the study questions.

3.1 GOAL OF THE STUDY

The goal of the WMA A-AX DQO process was defined as follows:

> *The goal is to ensure the appropriate vadose zone soil characterization data needs are identified to support corrective measure decisions for WMA A-AX.*

3.2 PSQS AND DECISION AND ESTIMATION STATEMENTS

Step 2 of the DQO process identifies the decisions or estimates that require new environmental data to solve the "problems" identified in Step 1. For a decision problem, the decision statement links a PSQ with a range of alternative actions that can occur upon answering the question. For an estimation problem, the estimation statement identifies what needs to be estimated or studied and possible study outcomes and key assumptions.

For WMA A-AX, one decision problem and three estimation problems were identified. Resolution of the decision problem requires collection of vadose zone soil chemical, radiological, and physical property data. The estimation problem key information needs and assumptions are as follows.

- Data on vadose zone soil and tank waste radiological, chemical, and physical properties are needed to evaluate contaminant mobility in soil.

- Data are needed on (1) naturally occurring vadose zone soil constituents that could potentially be altered by contact with tank waste and (2) tank waste constituents that may remain in soil at detectable levels after the bulk of the waste has passed through portions of the soil. These data could provide information about where tank waste may have passed through portions of the soil.

The PSQs, alternative actions, and decision/estimation statements for the WMA A-AX DQO process are shown in Table 3-1.

Table 3-1. PSQs, Alternative Actions, and Decision/Estimation Statements

Principal Study Question (PSQ)	Proposed Alternative Actions (AA)	Decision/Estimation Statements (DS/ES)
#1— Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	If contamination exceeds acceptable levels, evaluate the need for corrective measures; otherwise, document that corrective action is not required.	**#DS 1** — Determine whether contamination exceeds acceptable levels and, therefore, whether there is a need to evaluate corrective measures.
#2 – Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 2** – The chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. It is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil.
#3 – Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 3** – The chemical/physical properties of WMA A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. It is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil.
#4 – Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 4** – Chemicals and radionuclides in tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated. It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through those portions of the soil. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through those portions of the soil.

Note: Estimation Statements for the Tanks A-104/105 Focus Area support the continued development of the conceptual site model, support risk informed retrieval, and evaluate leak assessment interpretation.

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4.0 STEP 3 – IDENTIFY INFORMATION INPUTS

The purpose of Step 3 is to identify the types and sources of information needed to resolve the PSQs identified in Step 2 (Section 3.0).

Per EPA QA/G-4 the major outputs of Step 3 are as follows:

- Identification of the types (e.g., chemical/physical properties), as well as sources of information needed to resolve the decision or estimates

- Identification of the basis of information (e.g., regulations, guidance, and permits) that will guide or support choices to be made in later steps of the DQO process; information on the number of variables (constituents) that will need to be collected; and types of information (e.g., acceptable levels, uncertainty requirements) needed to meet performance or acceptance criteria

- Selection of, and information on the performance of, appropriate sampling and analysis methods for generating the information.

This section of the report provides relevant information pertaining to Step 3 and is organized as follows:

- Data Types and Sources (Section 4.1)
- Acceptable Levels (Section 4.2)
- Field Methods (Section 4.3)
- Laboratory Methods (Section 4.4)
- Constituent List for WMA A-AX (Section 4.5).

4.1 DATA TYPES AND SOURCES

Step 2 (Section 3.0) indicates that there is one decision problem (PSQ #1), and three estimation problems (PSQ #s 2 through 4). The types of data and sources of information that may be used to address PSQ #s 1 through 4 are summarized in Table 4-1. The table also identifies bases for identification and setting of acceptable levels for the WMA A-AX decision and estimation statements. Note that the type of problem can impact the types of data needed.

PSQ #1: Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?

Resolving PSQ #1 requires evaluating analytical results (chemical and radiological), geophysical data, and physical properties. Data collected to address PSQ #1 will also be used to address PSQ #s 2 through 4.

Table 4-1. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data		Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
#1 Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	Radiological (Analytical and geophysical)	Shallow zone (≤15 ft bgs)	• Previously reported analytical data • Previously reported geophysical data • Collect additional soil samples for laboratory analysis • Perform additional geophysical logging • Field screening with radiological detection equipment	CERCLA • Ecological protection • Residential[a] • Tribal[a] • Outdoor worker
		Deep zone (>15 ft bgs)	• Previously reported analytical data • Previously reported geophysical data • Collect additional soil samples for laboratory analysis • Perform additional geophysical logging • Field screening with radiological detection equipment	CERCLA • Construction worker
		Ground surface to water table	• Previously reported analytical data • Collect additional soil samples for laboratory analysis	CERCLA • Groundwater protection[b]

Table 4-1. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data		Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
#1 Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	Chemical and Physical properties (Analytical and geophysical)	Shallow zone (≤15 ft bgs)	• Previously reported analytical data • Collect additional soil samples for laboratory analysis	CERCLA • Ecological protection • Residential[a] • Tribal[a] • Outdoor worker WAC • Direct contact o Unrestricted Land Use (WAC 173-340-740 and 750[c], Method B) o Industrial Properties (WAC 173-340-745 and 750[c], Method C)
		Ground surface to water table	• Previously reported analytical data • Collect additional soil samples for laboratory analysis	WAC • Groundwater protection[b]

Table 4-1. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data	Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
	Estimation		
#2 — Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	• Technical evaluation: Physical properties (e.g., bulk density, pH, and hydraulic properties)	• Information from previous investigations • Collect additional soil samples • Batch and column leach tests • Sequential extraction tests	Acceptable levels do not apply for preliminary conceptual site model evaluation. This is a judgmental assessment.
#3 — Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	• Technical Evaluation: Leaching characteristics of tank waste based on batch and column leaching tests • Technical Evaluation: Sequential extraction to estimate the labile fraction (readily leachable fraction) of constituents • Technical Evaluation: Mineral phase identification within the tank waste residuals • Technical Evaluation: Physical properties (e.g., bulk density and pH)	• Process history • Residual waste inventory • Batch leaching kinetics and partitioning behavior of tank waste • Leaching kinetics of tank waste	Acceptable levels do not apply for preliminary conceptual site model evaluation. This is a judgmental assessment.

Table 4-1. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data	Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
#4 — Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?	Fate and transport inputs: • Technical Evaluation: Mineralogical changes due to waste-sediment interaction and mineral phase identification • Chemical and Radiological - Pore water and sediment tests (sequential extraction such as water extraction, bicarbonate extraction, acetic acid extraction, oxalic acid extraction, and total digestion) • Technical Evaluation: pH variations	• Documentation and history of releases from SSTs • Documentation of Unplanned Releases • Documentation and history of other releases • Previous investigations: o RPP-14430 o RPP-35484 • Conduct additional surface geophysical exploration • Results and conclusions resulting from any new geophysical logging or soil sample collection	Acceptable levels do not apply for preliminary conceptual site model evaluation. This is a judgmental assessment.

Note: Relevant background level information is contained in the following documents:

- DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*
- DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*
- ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*

a. Residential and tribal scenarios will be evaluated to assist interested parties in providing input on the remedial alternatives as part of the CERCLA modifying criteria.

b. Groundwater protection evaluations will be consistent with WAC 173-340-747. Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

c. The acceptable levels for inhalation exposure, protective of human health, and the environment, have not been developed at this time. During the total risk determination, chronic daily intake, individual excess lifetime cancer risk, and non-cancer hazard index from inhalation of dust and vapors in ambient air will be calculated. Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

WAC = *Washington Administrative Code*

References*:*

RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area*

RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*

WAC 173-340, “Model Toxics Control Act—Cleanup”

PSQ #2: Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?

The type of data needed for PSQ #2 involves evaluating chemical and physical properties of soil that can affect contaminant movement WMA A-AX vadose zone. Sources of information may include reviewing previous investigations, collecting and analyzing new soil samples, or performing batch, column leach, and/or sequential extraction tests.

PSQ #3: Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?

The type of data needed for PSQ #3 involves evaluating tank waste characteristics that may impact the movement of contaminants through the WMA A-AX vadose zone. Note that PSQ #3 will not involve collecting tank waste samples, since this DQO pertains to vadose zone soil. Sources of information may include reviewing process history information, residual waste inventory, existing analytical data, and previous investigations.

PSQ #4: Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?

The type of data needed for PSQ #4 includes fate and transport model inputs such as a porewater chemistry and pH variations. Sources of information may include existing data or new data generated as a result of PSQ #s 1 through 3.

4.2 ACCEPTABLE LEVELS

In addition to the types of data and sources of information needed to resolve PSQs, Table 4-1 identifies the basis for setting acceptable levels. Acceptable levels, also commonly referred to as action limits, are levels that data are compared to in order to determine environmental conditions (e.g., acceptable conditions or unacceptable conditions). As identified in Table 4-1, resolution of PSQ #s 2 through 4 will involve assessments or evaluations primarily based on professional judgment; therefore, acceptable levels do not apply.

Acceptable levels for PSQ #1 are based on regulatory requirements (e.g., CERCLA and the *Washington Administrative Codes*). Overall, data, gathered for the WMA A-AX DQO, will be used to support closure of the WMA A-AX in accordance with the requirements of the HFFACO (Ecology et al. 1989) and WA7 89000 8967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as revised (Hanford Site Wide Permit). The SST system is regulated under RCRA as amended by the *Hazardous and Solid Waste Amendments of 1984* as a treatment, storage, and disposal tank system, and will be closed as a RCRA treatment, storage, and disposal unit. Final decisions concerning the vadose zone contaminated by releases from the WMA A-AX SSTs will be addressed during closure. As described in the IPA, vadose zone closure decisions must meet the requirements of RCRA, the *Hazardous and Solid Waste*

Amendments of 1984, CERCLA, the *Atomic Energy Act of 1954* as implemented through DOE O 435.1, *Radioactive Waste Management*, and other environmental laws that may affect closure decisions.

Acceptable levels are presented in Step 5 (Section 6.0) this report. Note that use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

4.3 FIELD METHODS

To accurately address PSQs, it is important to use appropriate field and laboratory methods to generate data. This section identifies the technologies that may be used to obtain data via field and analysis methods in order to address the PSQs.

Table 4-2 summarizes the various field methods that may be used to characterize the vadose zone soil along with their limitations. The table also identifies the various parameters obtained by field methods. The primary methods identified in the table pertain to borehole installation (small and large diameter hole technologies) and geophysical technologies (e.g., ground penetrating radar, geophysical logging, and surface geophysical exploration). Constraints limiting the type of technology that could be deployed at WMA A-AX are discussed in Step 4 (Section 5.0).

Table 4-2. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
Ground Penetrating Radar: Radar-reflection surface geophysical survey technique that detects contrasts in di-electric constants in the below-grade environments from the surface.	Underground structures or interferences	Requires subjective interpretation of the reflected signals. Lack of reflective below-grade surfaces or the presence of interfering matrices can complicate or invalidate the findings. The presence of nearby buildings and utilities can interfere with reflected signals. Fines (e.g., clay and heavy fly ash) can act as a reflector to the radar signal.
Electromagnetic Induction: Surface geophysical survey technique that measures electrical conductivity in below-grade soils based on detected changes in electrical fields. Generally used to support the interpretation of ground penetrating radar surveys.		The presence of nearby buildings and utilities can interfere with reflected signals.

Table 4-2. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
Surface Geophysical Exploration: Electrical Resistivity Imaging can be acquired to develop shallow and deep, two-dimensional and three-dimensional images.	Resistivity (conductivity)	Results are impacted by interference from infrastructure such as pipelines, tanks, buildings, and other large features.
LDH Conventional Drilling (e.g., cable tool):	Geophysical Logging and Laboratory Analysis	Most drilling methods have difficulty in cobbles and boulders. Waste/tailings are brought to the surface and need to be properly contained and disposed, increasing cost and risk of exposure to workers. Not viable for new exploration in the tank farms due to waste generation and logistics (e.g., dome loading and access).
LDH Geophysical Logging	Gross and isotopic gamma emissions	Larger size instrument has lower detection limits (more sensitive) but does not fit into a SDH (<3 in.); therefore, is not a compatible technology for use with direct push methods. The count rate can effect accuracy and precision of measurements.
	Gamma emissions from fission products, americium-241, plutonium-239, neptunium-237. It is considered by some to be more accurate than sampling and laboratory assay because the assay is performed in situ with less disturbance of the sample, there is higher vertical spatial resolution, and the sample size is much larger. This method may also be more economical than traditional sampling and analysis.	This method does not assess radionuclides or daughter products that do not emit gamma rays. The gamma energies from these isotopes are at the low end of the spectrum, which results in high numerical minimum detectable activities and possible matrix effects from other isotopes. This technique requires the use of a single casing (installed by drilling or driving) in contact with the soil formation. The detector is too large to fit in a SDH (<3 in.); therefore, is not a compatible technology for use with direct push methods.
	Neutron emissions from plutonium	Because of the very low incidence of spontaneous plutonium fission and alpha-N reactions, the passive neutron profile is orders of magnitude lower than the gamma emission. The detector is too large to fit in a SDH (<3 in.); therefore, is not a compatible technology for use with direct push methods.
	Active neutron emissions from transuranics	Although neutron activation methods have been developed, they are not expected to be

Table 4-2. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
		useful for this initial characterization effort. At present, these techniques are too expensive and time consuming, and logistical problems are associated with the handling of intense sources or generators. The detector is too large to fit in a SDH (<3 in.); therefore, is not a compatible technology for use with direct push methods.
	Beta emissions	Not a fully developed technology.
	Neutron moisture	Moisture zones can be very thin and can be missed based on data collection intervals (distance and time).
	Temperature	Difficult differentiating/determining source and extent of high temperatures (e.g., soil versus infrastructure).
Laboratory Analysis for LDH	Chemical and radiological constituents and physical properties	Highly contaminated samples may require use of on-site laboratories, with associated impacts (e.g., high cost, reduced analyte lists, matrix effects, degraded detection limits, and long turnaround times). Lower contamination levels may allow use of offsite laboratories, avoiding these limitations.
SDH Direct Push	Geophysical Logging and Laboratory Analysis	Direct-push methods may be ineffective in cobbly or rocky soils.
SDH Geophysical Logging	Gross and isotopic gamma emissions	The smaller diameter detectors are not as sensitive as those used in LDH (Detection limits are not as low from instruments used in LDH.)
	Beta emissions	Not a fully developed technology.
	Neutron moisture	Moisture zones can be very thin and can be missed based on data collection intervals (distance and time).
	Temperature	Difficult differentiating/determining source and extent of high temperatures (e.g., soil versus infrastructure).
Laboratory Analysis for SDH	Chemical and radiological constituents and physical properties	Small sample size leads to difficulty to with large analysis list and low detection limits.

Note: Reinterpreting available data (e.g., surface geophysical exploration data) and/or determine if analysis on existing cores could be performed

LDH = large diameter hole SDH = small diameter hole

4.3.1 Borehole Installation

Boreholes are holes created by pushing or drilling into the vadose zone, groundwater, and bedrock to access soil for characterization. The vadose zone, which consists of unconsolidated sands and gravels, requires the installation of casing (steel, fiberglass, polyvinyl chloride) to prevent boreholes from collapsing. Often, multiple strings of casing are required to be installed in the same borehole to allow target depths to be reached, or to properly isolate zones of contamination. Depending on the equipment used, the completed borehole diameters vary from about 2.5 to 14 in.

Boreholes are constructed as either temporary or permanent structures. Temporary boreholes are usually installed to obtain soil, vapor, or groundwater samples for laboratory analysis or as access for geophysical logging tools, and are then decommissioned. Permanent boreholes are completed as wells for long term monitoring of the vadose or groundwater zones or for remedial purposes such as extraction of contaminant vapors and groundwater for treatment.

Because of the different type of soils and levels of contamination, different types of drilling technologies have been used at the Hanford Site. They can be divided into two major categories:

- Conventional drilling, which brings soils to the surface while advancing the borehole
- Direct push, which displaces the soils to advance the borehole bringing no soils to the surface.

In both categories, metal pipe is either rotated and drilled, or driven into the ground to advance the borehole.

Conventional drilling uses air/mud rotary, cable, auger, or sonic tools. These methods use a rotary drill bit, hammering action, or sonic vibration to advance the drill pipe and bring drilled cuttings to the surface through circulating air, water or a drilling mud, or by mechanical means through drive barrels, tubing, or auger flights.

Conventional drilling is best used in locations where contamination is not present to avoid the generation of large volumes of waste material removed through the drilling actions and to minimize the spread of contamination. Typically only the cable tool method is used in areas of contamination; however, this method still generates a considerable volume of waste.

Soil samples can be obtained in a variety of methods and result in either a disturbed or undisturbed sample. The undisturbed sample is normally considered a grab sample and is fairly quick, easy, and less expensive to collect. The disturbed sample is collected from drill cuttings brought to the surface through the air/water circulation method, drive barrel method from cable tool drilling, or off the auger flights from auger drilling. The soil is mixed and homogenized from the drilling action and actual depth of the sample is not known, only a general depth range. Additionally, the ability to determine soil structure and moisture content is impacted.

The undisturbed soil samples are obtained by a soil core method. In conventional drilling, undisturbed samples can be collected by using split spoon samplers. These are devices that are driven ahead of the advanced borehole into the undisturbed soils, driving the sample up into the sampler device. These usually measure approximately 2 to 5 ft in length and 2 to 6 in. in diameter. The split spoon sampler is driven its length then removed from the borehole and the samples extracted. The samples are generally collected in liners that are removed from the sampler, capped, and shipped to a laboratory. Because such sampling interrupts the drilling, it is relatively expensive.

A different method of installing a borehole is using the direct push technology. In this method, a pipe is advanced in the soils by pushing, driving, or a combination of both. No cuttings are brought to the surface; the soil around the borehole is displaced as the pipe is pushed. Various systems for direct push technology exist. The cone penetrometer system uses hydraulic rams to push pipe into the soils. The system is mounted in a large weighted truck to provide the force or weight to allow the pipe to be pushed. This method has limitations for advancing the pipe due to soil friction.

Another method involves the use of a drive hammer to drive the pipe into the soils. Both of these methods have been used at the Hanford Site with mixed results. The composition of the vadose zone, gravels and sand, and the presence of cemented zones limit penetration depths. Also, the weight and size of the cone penetrometer units restrict its use in the tank farms due to infrastructure interferences.

To meet the site specific challenges presented with respect to drilling in the tank farms, and in order to characterize the vadose zone, unique direct push rigs and tooling were developed. This rig and tooling combine the hydraulic push and hammer driving method. The hydraulic hammer unit has high-energy impact (450 to 650 ft/lbs. per cycle at 2,000 cycles per minute) and rotates the pipe while driving.

This allows the pipe to be driven and rotated at the same time, allowing for deeper target depths. The hydraulic hammers used to drive the pipe provide larger driving forces than the conventional direct push hammers utilized on commercially available direct push rigs. A 2.5 in. closed end probe is driven for borehole installation and log data collection. The direct push drill casing is heavy wall and small diameter, ranging from 2.5 in. to 2.62 in. outside diameter and 1.12 to 1.75 in. inside diameter. This system is capable of reaching depths greater than 200 ft in soil.

The initial version of the hydraulic hammer unit used a single point sampler that allowed only one sample per borehole. The sampler was driven to top of the sample interval, a locking key was unlatched, the sampler was driven through the interval, and the drive rods and sampler were removed from the borehole. This method collected an 18 in. by 1.5 in. soil core plus approximately 5 in. of soil in the drive shoe. The major limitations with this method were that only one sample could be collected per borehole and that soils containing high gamma-emitting contamination could not be sampled because there was not a safe way to isolate the sample from the worker.

A dual-wall percussion system (also referred to as dual-string sampling system) provides for multiple sampling opportunities in each borehole. Driving is conducted with the dual-wall system that consists of:

- An outer push tubing having an outer diameter of 2.625 in. and an inner diameter of 1.875 in.
- An inner tubing having an out diameter of 1.25 in. and an inner diameter of 1.08 in.

The dual-wall system with a “dummy” tip is advanced to the pre-determined sample depth. The tubing is then back-pulled approximately 2 to 5 in. to relieve tip pressure and reduce drive shoe and tip contact with formation materials. When sampling depth is achieved and the rods have been back-pulled for sampling, the removable tip is removed by extracting the inner rods. On removal of the inner string of tubing, a sampler is attached to the inner string and returned to the bottom of the outer casing/push tubing and positioned against the inner receiver face of the drive shoe. The inner and outer tubing strings are “locked” together by use of a proprietary method, and the entire assembly is advanced through the targeted sample interval.

The sampler body holds three stainless steel liners that are 1.25 in. outside diameter by 1.08 in. inside diameter. After the sampler is advanced approximately 2 ft, the inner string is released and retrieved to the surface. The liners are removed from the sampler body and surveyed. Trained sample-handling technicians document the sample condition, and the volume percent recovery, and then package and transport the sample to the laboratory for analysis. The dummy tip is reattached to the inner string and returned to the bottom and placed in the casing shoe. The entire assembly is advanced to the next designated sample depth, and the process is repeated until all samples are collected. The sampling method via direct push does not interrupt the drilling process and allows for a relatively undisturbed sample from a known depth to be collected, thus allowing for more representative analytical results.

The maximum physical sample yield is based on the dimensions of the three interior stainless steel liners and the sample shoe. Each stainless steel liner is 6 in. long, and the sampler shoe is 4 in. long and also has an inner diameter of 1.08in.. This leads to a maximum volume of 20.15 in^3 if 100% recovery is accomplished. Assuming the average density of Hanford Site soils (1.8 g/cc), the total sample yield will be 594 g.

Benefits of using the direct push technology include it being both mobile and deployable in locations difficult to access. This allows many more locations in a tank farm to be investigated as compared to conventional drilling. Direct push technology is less expensive and much easier to deploy at multiple locations inside a tank farm.

Unlike a drill rig, a direct push unit may sit on top of an underground storage tank. The direct push technology does not require the use of circulating medium (air, water, and drilling fluids) for advancement; therefore, it does not generate waste by bringing contaminated materials to surface during the drilling process. Using the direct push technology, tubing can be advanced quicker than conventional drilling, thus allowing samples to be collected in a timely manner.

In suitable materials, the units are capable of advancing tubing at a rate often exceeding 1 ft per minute. This rate of advancement varies depending upon soil consistency and density.

This technology can be deployed only in materials that can be displaced. It will not penetrate cemented materials. The drive point has been specifically designed to take advantage of the unique ability of the hydraulic hammer to drive and rotate simultaneously. It is the combination of the tooling design and this hammer that makes this technology so successful in driving tubing rapidly and to depths exceeding the capabilities of similar technologies.

4.3.2 Geophysical Technologies

Geophysical logging, as with most technologies, has evolved since its first deployment at the Hanford Site (i.e., various tools and detection limits). In general, logging is performed by a "stop and acquire" data acquisition technique (i.e., withdrawal rate). The speed of the withdrawal rate (count rates for an interval) impacts the spatial resolution and data quality (precision) of the logging data. For example, the faster the withdrawal rate, the lower the spatial resolution; in-turn, the slower the withdrawal, the higher the spatial resolution (P-GJPO-1786, *Spectral Gamma-Ray Borehole Geophysical Logging Characterization and Baseline Monitoring Plan for the Hanford Single-Shell Tanks*).

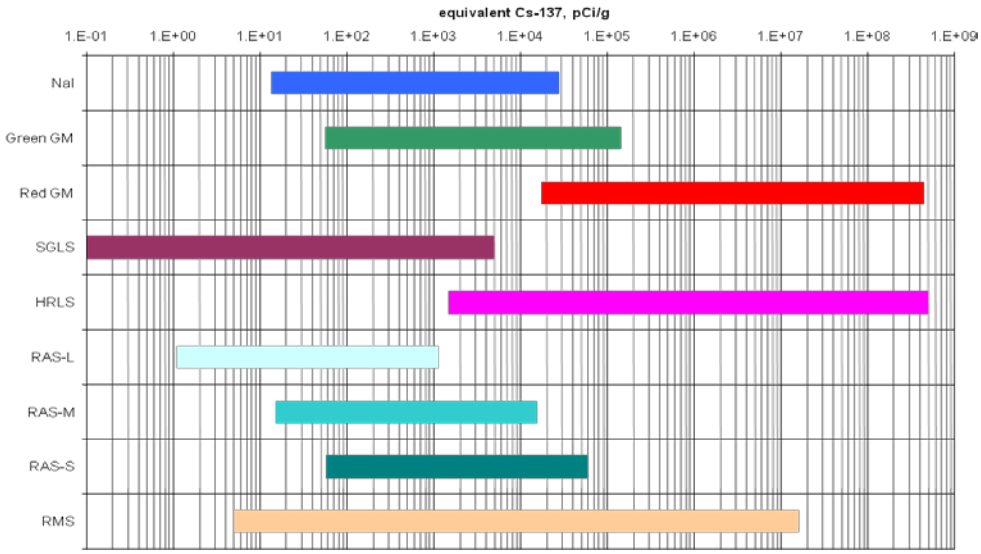
Gross gamma logging has been conducted in drywells since the 1940s; however, little data is available before 1974. Gross gamma logging for drywell logging, which used sodium iodide (NaI) and Green and Red gamma monitoring detectors (Geiger Mueller [GM] detectors), was often conducted well after leak events, sometimes by as much as several years. Comparing data collected using different probe types (i.e., NaI and GM detectors) is difficult.

Baseline spectral gamma logging, using high-purity germanium detectors, was initiated in drywells in the later 1990s to assess the distribution of the gamma-emitting radionuclides in the soil surrounding tanks. Drywell logging included measurements using spectral gamma (high-purity germanium), neutron moisture logging systems, radionuclide assessment system (RAS), and handheld neutron moisture logging. RAS and hand-held neutron moisture logging have been more recently used to support retrieval efforts.

Spectral gamma logging, using a high-purity germanium detector, provides isotope-specific gamma measurements (e.g., cesium, europium, cobalt, and uranium isotopes). Detection and quantification of low specific activity radionuclides such as uranium-238/235, and other transuranic or radionuclides that have experienced significant decay such as cobalt-60, generally require spectral gamma logging tools. For areas of higher activity (>2,000 pCi/g), a high rate logging system is used to quantify activity levels as high as 1E+08 pCi/g.

The RAS truck was designed for routine gamma monitoring against the baseline established from spectral gamma logging data. The RAS uses a series of three interchangeable NaI-based scintillation detectors (RAS-L, RAS-M, and RAS-S) for measurement over the range from background levels to about 105 pCi/g cesium-137. Figure 4-1 shows approximate measurement ranges of different types of gamma radiation detectors.

Figure 4-1. Measurement Ranges of Tank Farm Gamma Detectors



Notes:

NaI:	Sodium iodide or scintillation detector used to measure total gamma in lower activity wells.
Green GM:	Geiger Mueller tube used to measure moderate gamma activity.
Red GM:	Geiger Mueller tube used to measure high gamma activity.
SGLS:	Spectral gamma logging system, uses a high purity germanium detector to measure gamma energy spectra for separate gamma radionuclides (i.e., cesium-137, cobalt-60, europium-154, uranium-238).
HRLS:	High rate logging system, uses shielding to investigate gamma activity too intense for the spectral gamma logging system.
RAS-L:	Radionuclide Assessment System – large sodium iodide detector.
RAS-M:	Radionuclide Assessment System – medium sodium iodide detector.
RAS-S:	Radionuclide Assessment System – small sodium iodide detector.
RMS:	Radionuclide monitoring system (not used at Hanford).

Source: Appendix G from RPP-RPT-58339, 2014, *Phase 2 RCRA Facility Investigation Report for Waste Management Area C*

Groundwater monitoring wells were also logged for spectral gamma using high-purity germanium detectors. Thus, the detection limits in Figure 4-1 pertain to groundwater logging events.

Geophysical logging for direct push consists of gross gamma and spectral gamma logging, neutron moisture logging, and gyroscope logging. These logging tools are specifically calibrated to the probe hole tubing conditions under which they are deployed.

Gross gamma logging provides a measure of the concentration of gamma emitting radionuclides in the direct vicinity of the borehole location. Spectral gamma logging allows for better determination of individual gamma-emitting radionuclides. Neutron moisture logging provides an estimate of moisture content in the soil directly adjacent to the borehole. Gyroscope logging was used for angle pushes for quality control (QC).

After the year 2000, two or three different detectors were used to provide overlapping gross gamma detection ranges. A NaI scintillator was deployed to detect gross gamma at concentrations as low as 10 pCi/g and as high as approximately 90,000 pCi/g. High count rate

Geiger-Mueller detectors were used for determination of total gamma flux in zones with greater than 1E+05 to 1E+08 equivalent cesium-137 concentrations of gamma emitting nuclides. Accurate count rates in excess of 1E+08 equivalent could be obtained. Neutron-neutron detectors accurately detected moisture concentrations from saturation (17 to 25%) to less than 2 to 5% by volume.

In mid-2008, a bismuth-germanium oxide (BGO) tool for spectral gamma was deployed. This tool provided a total count gross gamma log that could be processed for naturally occurring potassium, uranium, and thorium ratios to determine if man-made gamma radiation was present. The BGO tool provided detection of cesium-137 as low as approximately 2 pCi/g.

In 2011, a combination gamma tool with dual detectors (lanthanum bromide [LaBr] and BGO) was introduced. This increased the efficiency for log data collection and improved data quality, resolution, and detection limits (cesium-137 detection of 1 to 1.5 piC/g and cobalt-60 detection of 0.5 to 1 piC/g). The new system operates with a state-of-the-art digital interface signal. Figure 4-2 shows the BGO and LaBr spectral gamma ranges.

Figure 4-2. Detector Ranges for Spectral Gamma Logging Tools Used With Direct Push

BGO: Bismuth-Germainium Oxide tool used for spectral gamma measurement.
LaBr: Lanthanum Bromide tool used simultaneously with the BGO tool for increased detection limits.

Source: Figure G-2 from RPP-RPT-58339, 2014, *Phase 2 RCRA Facility Investigation Report for Waste Management Area C*

Temperature monitoring during logging was initiated during the 2014/2015 campaign at WMA A-AX in both drywells and direct push locations. The borehole temperature logging system for drywells was deployed using an infrared sensor to measure casing temperature, with measurements made at discrete 1 ft depth intervals. This same infrared sensor technology was also included in the slim hole logging system used at direct push locations, and is planned to be used for drywell and direct push logging efforts to obtain temperature profiles of soil within the study boundary.

A dual gyroscope logging tool provides x, y, and z coordinates of the probe angle path to within 0.001 m accuracy. The gyroscope logging tool was used when angle pushes were being driven to ensure the borehole was still on target.

Surface geophysical exploration (SGE) is a term used to refer to the field of subsurface geophysical imaging. At the Hanford Site within the tank farms, SGE has been used to assist in identifying areas of unknown releases. In turn, this information along with other available farm information has been used to help identify where sampling should be conducted. The SGE method employed at the Hanford Site is called electrical resistivity imaging, also known as Electrical Resistance Tomography. It should be noted that there are limitations with this technology, like with all technologies. SGE results are impacted by interference from infrastructure such as pipelines, tanks, buildings, and other large features and additionally from the composition of the waste release.

There are multiple configurations of the electrodes used in electrical resistivity imaging survey that result in different levels of investigation depth and details. There are three types of electrodes: surface, depth, and long (drywell). Three dimensional surveying using surface electrodes and depth electrodes results in higher resolution imaging in both the lateral and vertical directions. By incorporating the depth electrodes the vertical resolution increases and the negative effects from the subsurface infrastructure are lessened. Three dimensional surveying using only drywells, results in a lesser resolution laterally, and very little resolution vertically, but provides a bulk estimate of the subsurface and is relatively more economical to deploy.

Surface electrodes are typically a temporary installation of stainless steel rods no greater length than 11 in. The depth electrodes are single or multiple electrodes placed vertically within a borehole and are implemented permanently as part of the borehole decommissioning process. Long electrodes opportunistically use the pre-existing drywells and groundwater well casings located throughout the survey area.

In general, there have been two methods for acquiring resistance imagery.

- Well-to-well survey utilizes only the existing drywells as electrodes. This differs from the other surveys that use an array of surface electrodes and depth electrodes to perform the measurements. The well-to-well survey results are typically presented in a two-dimensional plane view because the depth resolution is dependent on the length of the drywells. Well-to-well surveys began at the Hanford Site in 2005.

- Three-dimensional electrical resistivity images are created using both surface electrodes and depth electrodes. The data is collected based on a three-dimensional data acquisition method that utilizes numerous electrode arrangements. Three-dimensional surveys require significantly larger amounts of data than two-dimensional surveys, which makes an optimized geometry crucial to reduce modeling run times and analysis. The three-dimensional resistivity data acquisition uses the 180 channel resistivity system. Work began on the three-dimensional electrical resistivity images in 2013.

Use of wells as long electrodes has yielded resistivity imaging, but the results still have an amount of uncertainty due to interference of infrastructure such as pipelines, tanks, buildings, and other large features. Electrical interference can also affect resistivity measurements by providing preferential current pathways and electrical noise (voltage/current) sources from

electrical systems. The age of release, volume, and relative anion concentrations are also factors that contribute to the uncertainty of Electrical Resistance Tomography results.

SGE efforts have been to obtain electrical resistivity data while minimizing the influence of buried metal objects. Toward that goal, two significant advances have occurred: (1) use of the infrastructure directly in the acquisition campaign, and (2) placement of electrodes beneath the infrastructure. The direct use of infrastructure was demonstrated at T Farm by using wells as long electrodes ("Electrical-Resistivity Characterization of an Industrial Site Using Long Electrodes" [Rucker et al. 2010]). Burying of electrodes below the infrastructure helped to increase the vertical resolution, as long as a sufficient number of electrodes are available for the acquisition campaign.

The most notable improvements with respect to SGE are the implementation of a 180 channel resistivity system, and the improved data processing power associated with computational software and hardware advancements. All resistivity surveys completed between 2004 and 2013 at the Hanford Site used systems that were limited to 8 or 12 channels. The 180 channel system provides a greater coverage area, resulting in considerably more data, with less field effort, and resulting in a greatly reduced cost of deployment. The increase in computing capability allows these much larger data sets to be compiled and processed in a single effort rather than parsing into smaller datasets. Additionally, information such as the relative location of infrastructure and approximation of infrastructure properties can be included in the resulting models.

Data processing methodologies as outlined in RPP-RPT-50452, *Surface Geophysical Exploration – Compendium Document* have remained largely the same. This is the basis for Electrical Resistance Tomography, where a volumetric measurement of the resistance to electrical current flow within a medium is acquired. Soil free from past discharges can be expected to have high resistivity values, given the relative low natural saturation and low ionic strength of the porewater. Near contaminant discharge points, the measured resistivity will decrease depending on the transport mechanisms of the various ionic constituents.

Ground penetrating radar and electromagnetic induction are also field techniques identified in Table 4-2. These techniques are used to determine where underground structures (i.e., pipelines) exist and are typically performed to help determine where drilling can be performed.

4.4 LABORATORY METHODS

Table 4-2 also references laboratory analysis with respect to large diameter holes and small diameter holes and identified possible limitations. For large diameter holes, highly contaminated samples may require use of on-site laboratories, which will have associated impacts (e.g., high cost, reduced analyte lists, matrix effects, degraded detection limits, and long turnaround times). For small diameter holes, lower contamination levels may allow use of offsite laboratories, avoiding these limitations. Small sample size leads to difficulty to with large analysis list and low detection limits.

The preferred methods of analysis for samples are EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, or other approved standardized methods as applicable. Analytical methods are provided in Step 5 (Section 6.0).

4.5 CONSTITUENT LIST FOR WMA A-AX

Along with regulatory drivers (Table 4-1), various sources of information were reviewed to develop the list of constituents to analyze in WMA A-AX vadose zone samples:

- RPP-RPT-38152, *Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation/Corrective Measures Study* (Rev. 0)
- RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives* (Rev. 6)
- Standard Best Basis Inventory information (e.g., RPP-RPT-58857, *Derivation of Best-Basis Inventory for Tank 241-A-104 as of February 1, 2016;* RPP-RPT-58864, *Derivation of Best-Basis Inventory for Tank 241-A-105 as of January 1, 2016*)

Table 4-3 provides a list of constituents and identifies if they were evaluated per the documents above. The constituents in RPP-RPT-38152 were used as the starting point in developing the list of WMA A-AX constituents because it is more extensive than the Standard Best Basis Inventory (i.e., tank waste constituent list).

The column in Table 4-3 associated with RPP-RPT-38152 identifies if constituents were considered primary, secondary, or discontinued during the WMA C RFI field effort (with a P, S, or D in Table 4-3, respectively). Primary constituents were those for which there were specific reasons for monitoring (e.g., ecological risk assessment, underlying hazardous constituent). These reasons for constituents being identified as primary for WMA C are included in Table 4-3 as parenthetical information after the P designation.

The Standard Best Basis Inventory information was used to determine if constituents have been identified in WMA A-AX tank waste, and therefore could be present in vadose zone soil. There are quite a few similarities with the waste that was in the WMA C tanks and the waste that is in WMA A-AX tanks (e.g., both contained organic wash waste [OWW] from PUREX Plant). However as identified in Section 1.0, the tanks in WMA A-AX have unique design features for the handling of high temperature waste, including airlift circulators for cooling boiling wastes and underground vessel ventilation headers for removing off-gas and water vapor. These tanks were often operated with the wastes at boiling conditions, which would impact the organic compounds within the waste (e.g., volatization could occur).

Table 4-3 also identifies if constituents should be retained, eliminated, or be evaluated for a special study for WMA A-AX vadose zone soil analysis. The following document subsections provide information regarding why constituents were retained, considered for a special study, or

eliminated from further consideration in the WMA A-AX DQOs process. The subsections are organized as follows:

- Inorganics constituents (metals, anions, and miscellaneous [i.e., ammonium and total organic carbon]) – Section 4.5.1
- Organic constituents (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], pesticides, polychloride biphenyls (PCBs), gasoline range organics/diesel range organics, dioxins and furans) – Section 4.5.2
- Radiological constituents – Section 4.5.3
- Physical properties and evaluations – Section 4.5.4.

Dioxins and furans are not included in Table 4-3; however, they will be evaluated for analysis in the WMA A-AX area (refer to Section 4.5.2). Section 4.5.5 provides summary information on the list of WMA A-AX constituents and the location of other relevant information pertaining to constituents (e.g., analysis methods).

It should also be noted that groundwater information was also reviewed during the DQO process. The two groundwater monitoring plans guiding sampling in the area were reviewed (DOE/RL-2015-56, and DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Plan Area A-AX*). Monitoring under DOE/RL-2015-49 was initiated in 2016, and preliminary data are being evaluated as part of the RCRA process (i.e., first determination report). DOE/RL-2015-49 includes dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods for Designating Dangerous Wa*ste *WAC 173-303-090 & -100*. Some of these constituents are not associated with WMA A-AX tank waste generation and storage or operation and maintenance activities.

Additionally, information prepared for the 200-PO-1 and 200-BP-5 OUs remedial investigations were also reviewed (DOE/RL-2009-85-ADD1 and DOE/RL-2009-127).

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Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Metals					
Aluminum – Al	P (E, R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Antimony – Sb	P (E, R, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Arsenic – As	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Barium – Ba	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Beryllium – Be	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Bismuth – Bi	S	X	X	Retain	Constituent listed in WMA C and SST DQO.
Boron – B	S	X		Retain	Constituent listed in WMA C and SST DQO.
Cadmium – Cd	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Calcium - Ca	P[f]	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cerium – Ce	S	X		Retain	Retained based on tank waste and self boiling tanks. The rare earths are naturally occurring in the vadose zone.
Chromium – Cr	P (A, E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Chromium - hexavalent (CrVI)	-[g]			Retain (can be analyzed rather than estimated from total chromium)	Constituent of interest due to toxicity. The holding time for soil samples is 30 days from collection to analysis.
Cobalt – Co	P (E, R, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Copper – Cu	P (E, R, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Europium – Eu	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Iron – Fe	P (R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Lanthanum – La	S	X	X	Retain	Retain based on BBI detections. The rare earths are naturally occurring in the vadose zone.
Lead – Pb	P (A, E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Lithium - Li	P[f]	X		Retain	Constituent listed in WMA C and SST DQO. Not part of tank waste but added as part of tracer for hydrostatic head fluid (as lithium bromide).
Magnesium - Mg	P[f]	X		Retain	Constituent listed in WMA C and SST DQO.
Manganese – Mn	P (E, R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Mercury – Hg	P (A, E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Molybdenum - Mo	P[f]	X		Retain	Constituent listed in WMA C and SST DQO.
Neodymium – Nd	S	X		Retain	Retain based on tank waste and self boiling tanks. The rare earths are naturally occurring in the vadose zone.
Nickel – Ni	P (E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Niobium – Nb	S	X		Eliminate	Naturally occurring in the vadose zone.
Palladium – Pd	S	X		Eliminate	Naturally occurring in the vadose zone.

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Phosphorus - P	P[f]	X		Retain	Constituent listed in WMA C and SST DQO.
Potassium - K	P[f]	X	X	Retain	Constituent listed in WMA C and SST DQO.
Praseodymium – Pr	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Rhodium – Rh	S	X		Retain	Constituent listed in WMA C and SST DQO.
Rubidium – Rb	S	X		Eliminate	Naturally occurring in the vadose zone.
Ruthenium – Ru	S	X		Eliminate	Naturally occurring in the vadose zone.
Samarium – Sm	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Selenium – Se	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Silicon – Si	S	X	X	Retain	Retain based on BBI detections. Silicon is part of the media being analyzed (sand, gravel and silt and clay).
Silver – Ag	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Sodium - Na	P[f]	X	X	Retain	Constituent listed in WMA C and SST DQO.
Strontium – Sr	P (R)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Sulfur – S	S	X		Retain	Constituent listed in WMA C and SST DQO.
Tantalum – Ta	S	X		Retain	Constituent listed in WMA C and SST DQO.
Tellurium – Te	S	X		Eliminate	Naturally occurring in the vadose zone.
Thallium – Tl	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Thorium – Th	S	X		Retain	Retain to review isotopic thorium. Naturally occurring in the vadose zone.
Tin – Sn	S	X		Retain	Constituent listed in WMA C and SST DQO.
Titanium – Ti	S	X		Eliminate	Naturally occurring in the vadose zone.
Tungsten – W	S	X		Retain	Constituent listed in WMA C and SST DQO.
Uranium – U	P (E, R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Vanadium – V	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Yttrium – Y	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Zinc – Zn	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Zirconium – Zr	S	X	X	Retain	Constituent listed in WMA C and SST DQO.
Miscellaneous Constituents					
Ammonium – NH4+	P (W)	X		Retain	Constituent listed in WMA C and SST DQO.
TOC (total organic carbon)			X	Add	Based on BBI detections.
Anions					
Acetate – C2H3O2-	P (R)	X	X	Retain	Constituent listed in WMA C and SST DQO.

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Bromide Br-	S	X		Retain	Constituent listed in WMA C and SST DQO.
Chloride – Cl-	P	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cyanide – CN-	P (A, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Ferrocyanide – Fe(CN)64-	P (A, U, W)	X		Eliminate	No ferrocyanide waste in WMA A-AX tank waste.
Fluoride – F-	P (U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Formate – CHO2-	P (R)	X		Retain	Constituent listed in WMA C and SST DQO.
Glycolate – C2H3O3-	P (R)	X		Retain	Constituent listed in WMA C and SST DQO.
Nitrate – NO3-	P (R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Nitrite – NO2-	P (R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Oxalate – C2O42-	P (R)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Phosphate – PO4	S	X	X	Retain	Constituent listed in WMA C and SST DQO.
Sulfate – SO42-	P	X	X	Retain	Constituent listed in WMA C and SST DQO.
Sulfide – S2-	D[b, c]			Eliminate	Sulfides were not routinely used in Hanford Site processes. Limited use of sulfide may have occurred during the ferrocyanide processing of cesium-137 in the tanks. The other possible source of sulfides would be from the reduction of sulfates. However, this is unlikely in the high nitrate tank waste matrices. Soluble sulfide is not very stable and is easily oxidized by air. Any sulfide remaining in the waste is most likely present as insoluble metal sulfide. In addition, previous analyses of tank waste have not detected sulfides in the Hanford Site tanks.
Volatile Organic Compounds					WMA C, containing no self-boiling tanks, received much of the organic waste (OWW). Note that sampling for organics was discontinued at the WMA C as they were only detected a few times[b, c]. WMA A-AX, containing self-boiling tanks, received less organic waste (OWW) than WMA C (HNF-3588, RPP-21854, HNF-4240). Additionally, total organic carbon, an overall indicator of organics, is not associated with Tanks A-104 and A-105 (BBI shows 0 kg for total organic carbon).
1,1,1-Trichloroethane (TCA)	D[b, c]	X		Special Study	
1,1,2,2-Tetrachloroethane	D[b, c]	X		Special Study	
1,1,2,2-Tetrachloroethene (PCE)	D[b, c]	X		Special Study	
1,1,2-Trichloro-1,2,2-trifluoroethane	D[b, c]	X		Special Study	
1,1,2-Trichloroethane	D[b, c]	X		Special Study	
1,1,2-Trichloroethylene (TCE)	D[b, c]	X		Special Study	
1,1-Dichloroethene	D[b, c]	X		Special Study	
1,2-Dichloroethane	D[b, c]	X		Special Study	
2-Butanone (MEK, methyl ethyl ketone)	D[b, c]	X		Special Study	

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
2-Nitropropane	D[b, c]	X		Special Study	
2-Propanone (Acetone)	D[b, c]	X		Special Study	
4-Methyl-2-pentanone (MIBK, methyl isobutyl ketone))	D[b, c]	X		Special Study	
Benzene	D[b, c]	X		Special Study	
Carbon disulfide	D[b, c]	X		Special Study	
Carbon tetrachloride	D[b, c]	X		Special Study	
Chlorobenzene	D[b, c]	X		Special Study	
Chloroethene (vinyl chloride)	D[b, c]	X		Special Study	
Chloroform	D[b, c]	X		Special Study	
Dichloromethane (methylene chloride)	D[b, c]	X		Special Study	
Diethyl ether	D[b, c]	X		Special Study	
Ethyl Acetate	D[b, c]	X		Special Study	
Ethylbenzene	D[b, c]	X		Special Study	
m-Xylene	D[b, c]	X		Special Study	
n-Butyl alcohol (1-butanol)	D[b, c]	X		Special Study	
o-Xylene	D[b, c]	X		Special Study	
p-Xylene	D[b, c]	X		Special Study	
Toluene	D[b, c]	X		Special Study	
trans-1,3-dichloropropene	D[b, c]	X		Special Study	
Trichlorofluoromethane	D[b, c]	X		Special Study	
Xylenes	D[b, c]	X		Special Study	
Cis-1,2-dichloroethylene[d]	D[b, c]			Special Study	
Trans-1,2-dichloroethylene[e]	D[b, c]			Special Study	
Isobutanol (isobutyl alcohol)	D[b, c]	X		Special Study	
Semivolatile Organic Compounds					WMA C, containing no self-boiling tanks, received much of the organic waste (OWW). Note that sampling for organics was discontinued at the WMA C as they were only detected a few times. WMA A-AX, containing self-boiling tanks, received less organic waste (OWW) than WMA C (HNF-3588, RPP-21854, HNF-4240). Additionally, total organic carbon, an overall indicator of organics, is not associated with Tanks A-104 and A-105 (BBI shows 0 kg for total organic carbon).
1,1-Biphenyl	S			Eliminate	

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
1,1-Dimethylhydrazine	S	X		Eliminate	
1,2,4-Trichlorobenzene	P (E, U, W)	X		Eliminate	
1,3-Dichlorobenzene	S	X		Eliminate	
1,4-Dichlorobenzene	S	X		Eliminate	
1,4-Dinitrobenzene	S	X		Eliminate	
2,4,5-Trichlorophenol	P (A, E, U)	X		Eliminate	
2,4,6-Trichlorophenol	P (E, U)	X		Eliminate	
2,4-Dinitrotoluene	P (A)	X		Eliminate	
2,6-Bis (tert-butyl)-4-methylphenol	P (A, W)	X		Eliminate	
2-Chlorophenol	P (U)	X		Eliminate	
2-Ethoxyethanol (cellosolve solvent)	P (A)	X		Eliminate	
2-Methylphenol (o-cresol)	P(A)	X		Eliminate	
2-sec-Butyl-4,6-dinitrophenol (Dinoseb)	S	X		Eliminate	
3-Methyl-2-butanone	S	X		Eliminate	
4-Methylphenol (p-cresol, 3+4-Methylphenol (m+p-cresol))	P (A)	X		Eliminate	
Acenaphthene	P (E, U)	X		Eliminate	
Acetophenone	S	X		Eliminate	
Benzo(a) anthracene	P (in D&D-30262)			Eliminate	
Benzo(a)pyrene	P (E, in D&D-30262)	X		Eliminate	
Benzo(b)fluoranthene	P (in D&D-30262)			Eliminate	
Benzo(k)fluoranthene	P (in D&D-30262)			Eliminate	
Bis(2-ethylhexyl)phthalate	P (in WMP-28945)			Retain	Ecology requested.
Butylbenzylphthalate	P (U)	X		Eliminate	
Chrysene	P (in D&D-30262)			Eliminate	
Cresylic acid (cresol, mixed isomers) (Total Cresols)	P (A)	X		Eliminate	
Cyclohexanone	P (A, W)	X		Eliminate	
Dibenz(a,h)anthracene	P (in D&D-30262)	X		Eliminate	
Di-n-butylphthalate	P (E, U)	X		Eliminate	

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Di-n-octylphthalate	P (U)	X		Eliminate	
Fluoranthene	P (U)	X		Eliminate	
Hexachlorobutadiene	P (A, W)	X		Eliminate	
Hexachloroethane	P (A)	X		Eliminate	
Hexachloronaphthalene	S	X		Eliminate	
Hexafluoroacetone	S	X		Eliminate	
Indeno (1,2,3-cd) pyrene	P (in D&D-30262)			Eliminate	
Isodrin	S	X		Eliminate	
m-Cresol (3-Methylphenol)	P (A)	X		Eliminate	
Methylhydrazine	S	X		Eliminate	
N,N-Diphenylamine	S	X		Eliminate	
Naphthalene	P (U)	X		Eliminate	
Nitric acid, propyl ester	S	X		Eliminate	
Nitrobenzene	P (A, E, W)	X		Eliminate	
N-Nitrosodi-n-butylamine	S	X		Eliminate	
N-Nitroso-di-n-propylamine	P (U)	X		Eliminate	
N-Nitrosomethylethylamine	S	X		Eliminate	
N-Nitrosomorpholine	P (U)	X		Eliminate	
N-Nitroso-N, N-dimethylamine	S	X		Eliminate	
Octachloronaphthalene	S	X		Eliminate	
1,2-Dichlorobenzene (o-Dichlorobenzene)	P (A, W)	X		Eliminate	
2-Nitrophenol (o-Nitrophenol)	P (U)	X		Eliminate	
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	P (U)	X		Eliminate	
Pentachloronaphthalene	S	X		Eliminate	
Pentachloronitrobenzene (PCNB)	S	X		Eliminate	
Pentachlorophenol	S	X		Eliminate	
Phenol	S	X		Eliminate	
p-Nitrochlorobenzene	S	X		Eliminate	
Pyrene	P (U)	X		Eliminate	
Pyridine	P (A, W)	X		Eliminate	

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Tetrachloronaphthalene	S	X		Eliminate	
Toxaphene	S	X		Eliminate	
Tributyl phosphate	P (R, W)	X		Retain	Selected indicator organic for the occurrence of any organic contamination associated with tank waste[b]. Ecology requested.
Dibutyl phosphate	D[b, c]			Eliminate	
Ethylene glycol	D[b, c]			Eliminate	
Monobutyl phosphate	D[b, c]			Eliminate	
Pesticides					Pesticides are not associated with tank waste generation and storage but are associated with operation and maintenance activities. Specifically, these activities could have resulted in the release of potentially hazardous constituents on the ground surface. These constituents were only analyzed in the top 15 ft of soil at WMA C (RPP-PLAN-38777, Rev.0).
Aldrin	P	X		Retain	Constituent listed in WMA C and SST DQO.
alpha-BHC, beta-BHC, gamma-BHC	P	X		Retain	Constituent listed in WMA C and SST DQO.
Chlordane	P			Retain	Constituent listed in WMA C and SST DQO.
DDT/DDD/DDE (total)	P			Retain	Constituent listed in WMA C and SST DQO.
Dieldrin	P	X		Retain	Constituent listed in WMA C and SST DQO.
Endrin	P	X		Retain	Constituent listed in WMA C and SST DQO.
Heptachlor/heptachlor epoxide (total)	P			Retain	Constituent listed in WMA C and SST DQO.
Hexachlorobenzene	P	X		Retain	Constituent listed in WMA C and SST DQO.
Gasoline-Range Organics/Diesel-Range Organics					
Gasoline-Range Organics	D[b, c]			Eliminate	
Diesel-Range Organics	D[b, c]			Eliminate	
Polychlorinated Biphenyls					These constituents were only analyzed in the top 15 ft of soil at WMA C (RPP-PLAN-38777, Rev.0).
Aroclors (1016, 1221, 1232, 1242, 1248, 1254, 1260)	P	X		Retain	Constituent listed in WMA C and SST DQO.
Congeners	D[b, c]			Eliminate	
Radionuclides					
Americium-241	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Antimony-125	P (Risk assessment)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Carbon-14	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Cesium-137	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cobalt-60	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Curium-242	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Curium-243	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Curium-244	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Europium-152	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Europium-154	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Europium-155	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Iodine-129	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Neptunium-237	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Nickel-63	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-238	P (10 CFR 61.55)		X	Retain	Constituent listed in WMA C DQO.
Plutonium-239	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-240	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-241	P (10 CFR 61.55)		X	Retain Estimated from Pu-238 and Pu-239/240	Constituent listed in WMA C DQO.
Radium-226			X	Retain	Retain based on BBI detections. TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Selenium-79	P (Risk assessment)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Strontium-90	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Technetium-99	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Thorium-228	P (Possibly significant in some tanks)	X		Eliminate	TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Thorium-230	P (Possibly significant in some tanks)	X		Eliminate	TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Thorium-232	P (Possibly significant in some tanks)	X	X	Retain	Retain based on BBI detections. TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Thorium-234	P (In WMP-28945)			Eliminate	Short half-life.

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Tin-126	P (Risk assessment)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Tritium	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-233	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-234	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-235	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-236	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-238	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Physical Properties					
Bulk density	X	X		Retain	Physical property listed in WMA C and SST DQO.
pH	X	X		Retain	Physical property listed in WMA C and SST DQO.
Percent solids				Retain	Performed at WMA C, not identified in DQO.
Percent water	X	X		Retain	Physical property listed in WMA C and SST DQO.
Specific conductance				Retain	Performed at WMA C, not identified in DQO.
Particle size distribution				Retain	Particle size distribution will be performed by the laboratory if sample volume is sufficient.
Porosity				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Total alkalinity				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Redox potential				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Total inorganic carbon				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Physical Property Evaluations					
Hydraulic properties				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Iron content and iron association				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Mineral phase identification				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Leaching characteristics				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.

Table 4-3. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Sequential extraction				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.

Note:

a. P=Primary and S=Secondary as defined in RPP-PLAN-38777, *Sampling and Analysis Plan for Phase 2 Characterization of Vadose Zone Soil in Waste Management Area C*.
Discontinued (D) constituents were documented in RPP-PLAN-38777. Letters inside the parenthetical identify that reason why a constituent was categorized as primary per RPP-RPT-38152, Rev 0: A = Part A constituent, E= Ecological risk assessment, R = Risk assessment constituent, U = UHC (underlying hazardous constituent), and W = constituent in PNNL-12040, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, WMP-28945, *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process*, and D&D-30262, *Data Quality Objectives Summary Report for the 200-IS-1 Operable Unit Pipelines and Appurtenances*.

b. 11-TPD-020, "Organic Analyses Optimization for Waste Management Area (WMA) C"

c. 11-NWP-053, "Re: Organic Analyses Optimization for Waste Management Area (WMA) C"

d. Cis-1,2-dichloroethylene was incorrectly identified as Cis-1,2-dichlorobenzene (CAS Number 156-59-2) in RPP-RPT-38152.

e. Trans-1,2-dichloroethylene was incorrectly identified as Trans-1,2-dichlorobenzene (CAS number 159-60-5) in RPP-RPT-38152.

f. Moved from secondary to primary during WMA C field investigation to help in the evaluation of whether or not tank fluids have passed through the vadose zone soil.

g. Total chromium was used to estimate hexavalent chromium concentrations. Hexavalent chromium was not analyzed at WMA C and therefore did not have a "P" or "S" designation.

BBI = Best-Basis Inventory
CAS = Chemical Abstracts Service
DDD = Dichlorodiphenyldichloroethane
DDE = Dichlorodiphenyldichloroethylene
DDT = Dichlorodiphenyltrichloroethane
PCB = polychloride biphenyl
SAP = sampling and analysis plan
Tri-Party = Ecology, EPA, and DOE

References:

DV-1 SAP = DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*
SST DQO = RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*
WMA C DQO = RPP-RPT-38152, *Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation/Corrective Measures Study*

10 CFR 61.55, “Licensing Requirements for Land Disposal of Radioactive Waste,” “Waste Classification”
HNF-3588, *Organic Complexant Topical Report*
HNF-4240, *Organic Solvent Safety Issue Resolution*
RPP-21854, *Occurrence and Chemistry of Organic Compounds in Hanford Site Waste Tanks*

4.5.1 Inorganic Constituents

All metals identified as primary per RPP-RPT-38152 are recommend to be retained for analysis in WMA A-AX. Several constituents that were considered secondary per RPP-RPT-38152 are also retained for WMA A-AX because the constituents are:

- Listed in both RPP-RPT-38152 and RPP-23403 (bismuth, boron, rhodium, sulfur, tantalum, tin, tungsten, and zirconium)
- Potentially associated with tank waste (cerium, lanthanum, neodymium, and silicon).

Thorium is also recommended to be retained so that inorganic results can be compared to isotopic thorium results.

The constituents that are recommended to be eliminated from WMA A-AX vadose zone soil analysis are: europium, niobium, palladium, praseodymium, rubidium, ruthenium, samarium, tellurium, titanium, and yttrium. These constituents are identified as secondary per RPP-RPT-38152 and are considered to be rare earth elements or naturally occurring metals (RPP-RPT-38152 and RPP-23403).

Hexavalent chromium analysis was not performed on WMA C samples; instead, total chromium results were used to represent hexavalent chromium (i.e., assumption was that all of total chromium was comprised of hexavalent chromium). As identified in Table 4-3, both total chromium and hexavalent chromium analysis are recommended for WMA A-AX vadose zone soil samples.

All constituents categorized as anions in Table 4-3 and were analyzed at WMA C are recommended to be retained with the exception of sulfide and ferrocyanide. Analysis for sulfide was discontinued during the WMA C field investigation and was also removed from RPP-23403. Sulfide has not been detected in the Hanford Site tanks. Sulfide is not routinely used in Hanford Site processes and is unlikely in the high nitrate tank waste matrices. Soluble sulfide is also unstable and is easily oxidized by air. Any sulfide remaining in the waste is most likely present as insoluble metal sulfide. Ferrocyanide was associated with WMA C tank waste but not with WMA A-AX tank waste (WHC-SD-WM-SARR-038, *Assessment of the Potential for Ferrocyanide Propagating Reaction Accidents*). Although cyanide is also not associated with the waste in WMA A-AX tanks, it is recommended to be retained because the Standard BBI reports total cyanide as a supplemental constituent, and it was included in RPP-RPT-38152 and RPP-23403.

Two constituents, ammonium and total organic carbon, categorized as miscellaneous (refer to Table 4-3) are recommended for analysis at WMA A-AX. Ammonium was analyzed for at WMA C and is in RPP-23403. Total organic carbon was not analyzed for at WMA C but is listed in the Standard Best Basis Inventory and has been detected in WMA A-AX tank waste. It can also be used as an indicator for the presence of organic compounds. For these reasons, total organic carbon is recommended to be added to the constituent list for WMA A-AX vadose zone soil sampling.

4.5.2 Organic Constituents

As identified in Table 1-3, many of the WMA A-AX tanks received PUREX and OWW waste like WMA C. Most of the organic solvents (organic hydrocarbons) in WMA A-AX and WMA C tank waste are from OWW. Based on the higher temperatures maintained in the A Farm tanks (~300 °F) and AX Farm tanks (~350 °F), which did not occur at WMA C, and the lack of organic detections at WMA C, it is thought that waste released to the soil in WMA A-AX is not likely to contain organic solvents (e.g., VOCs).

Analysis of VOCs was performed at select locations at WMA C. Per RPP-PLAN-38777, *Sampling and Analysis Plan for Phase 2 Characterization of Vadose Zone Soil in the Waste Management Area C*, 5 of the 27 investigation sites were selected to evaluate potential for organic contamination. The analytical data from these sites were presented to Ecology. A letter (Letter 11-TPD-020, "Organic Analyses Optimization for Waste Management Area [WMA] C") from DOE-ORP was sent on March 29, 2011, to Ecology requesting the removal of the following from WMA C sample analysis:

- VOCs
- Ethylene glycol
- Monobutyl and dibutyl phosphate
- PCB congeners
- Gasoline range organics
- Diesel range organics.

In addition, RPP-23403 was modified to remove sulfide as a constituent associated with tank waste; therefore, discontinuing analysis for sulfide was also requested. An approval letter (Letter 11-NWP-053, "Re: Organic Analyses Optimization for Waste Management Area [WMA] C" from Ecology was received on June 1, 2011, confirming the removal of all of these constituents from the analyte list for WMA C.

It is thought that a similar approach for organics should also be implemented at WMA A-AX (i.e., that analysis of VOCs should be performed at select locations in the WMA A-AX area). For this reason, VOCs will be identified as "Special Study" in the recommendation column of Table 4-3.

For SVOCs, Table 4-3 identifies that bis(2-ethylhexyl)phthalate and tributyl phosphate are recommended to be retained for analysis at WMA A-AX. Tributyl phosphate is considered to be an indicator for organic contamination associated with tank waste. Note that tributyl phosphate was not detected in any samples from WMA C. Bis(2-ethylhexyl)phthalate was requested to be analyzed by Ecology. This constituent is often considered to be associated with laboratory contamination. It has been detected in groundwater samples in the WMA A-AX area, but those results are being evaluated. Bis(2-ethylhexyl)phthalate was not identified as a COPC in the 200-PO-1 or 200-BP-5 OUs (DOE/RL-2009-85-ADD1, DOE/RL-2009-127). The remaining SVOCs identified in Table 4-3 are recommended to be eliminated from the analysis at WMA A-AX.

Pesticides and PCBs are not considered for Standard Best Basis Inventory for tank waste. However, the tank farms, including A-AX Farm, are managed and maintained to prevent intrusion by deep-rooting vegetation and burrowing insects through the use of licensed applications of herbicides and pesticides. By preventing vegetation growth, wildlife habitat is for all practical purposes eliminated, thus discouraging use of tank farms by biota. All the constituents identified in Table 4-3 as pesticides that were analyzed in WMA C samples are also recommended to be analyzed in WMA A-AX samples. For PCBs, tank waste results indicate aroclor 1254 is the most common aroclor in Hanford Site tank waste. As identified in Table 4-3, aroclors, which were analyzed in WMA C samples, are recommended to be analyzed in WMA A-AX samples. Both pesticides and PCBs were sampled only in the top 15 ft at WMA C; however, at WMA A-AX they will be sampled at all depths in the first focus area around Tanks A-104 and A-105. The data will be reviewed from the first focus area to determine if samples should continue to be collected in the next focus areas at all depths or just within the top 15 ft. Pesticides and PCBs were included in the groundwater monitoring plan DOE/RL-2015-49, and preliminary data do not indicate pesticides or PCBs are potential groundwater contaminants. Analysis for congeners, which was discontinued at WMA C, is not recommended at WMA A-AX.

Dioxins and furans were added to groundwater monitoring per DOE/RL-2015-49. Low concentrations, near detection limits, have been detected in preliminary groundwater data and are currently being evaluated as part of the RCRA process (i.e., first determination report). No dioxins or furans were identified as COPCs in the 200-PO-1 or 200-BP-5 OUs (DOE/RL-2009-85-ADD1, DOE/RL-2009-127).

Dioxins and furans are not included in RPP-RPT-38152, RPP-23403, or the Standard Best Basis Inventory list for tank waste. They are typically degradation products of carbon compounds. Dioxins in soils, if any, are more likely from degradation of pesticides. Dioxins and furans analyses have not been performed on vadose zone soil samples from the tank farm area, and determinations will need to be made on such things as volumes needed to perform analysis, and if these volumes are achievable based on sampling methodology in the tank farms. Ecology indicated that the dioxins and furans should be considered for sampling in the southern portion of A Farm. Further discussions will continue on performing analysis of dioxins and furans in vadose zone soil samples.

4.5.3 Radiological Constituents

Table 4-3 identifies that all but three of the radionuclides analyzed at WMA C are recommended to be analyzed at WMA A-AX. Two of the three radionuclides, thorium-228, and thorium-230, are recommended for elimination because they are naturally occurring background radionuclides identified by consensus of HFFACO managers and not directly related to Hanford Operations or processes in the Central Plateau (TPA-CN-668, *Tri-Party Agreement Change Notice Form: DOE/RL-2011-104, REV. 0, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*). The third radionuclide, thorium-234, is recommended for elimination due to its short half-life. It is also not included monitored in tank waste per RPP-23403. With respect to groundwater, all radionuclides listed in DOE/RL-2015-56 are included in the list of retained constituents with the exception of chlorine-36, which is not a component of the WMA A-AX

waste stream, nor is it sampled at WMA A-AX groundwater wells. Chlorine-36 is analyzed only in the 100-K Area.

4.5.4 Physical Properties and Evaluations

Table 4-3 identifies that all of the physical properties tested in WMA C samples are recommended for testing in WMA A-AX samples. Field conditions within the tank farms typically make it necessary to use a sampling methodology (i.e., direct push) to collect samples that yields a minimal amount of soil (~ 600 grams). The priority for the soil material collected is typical to be used for chemical and radiological analyses. The standard physical property analyses at WMA C included bulk density, pH, percent water, specific conductance. Percent solids is determined from the percent of water in samples. Particle size distribution was not determined in WMA C samples; however, it is desired at WMA A-AX, and it is thought that there will be enough sample material to perform this test.

Due to sampling methodology and small sample amount, it will not be possible to perform physical property tests and evaluations other than those listed above. These additional physical property tests and evaluations will be considered for other focus areas where larger sample volumes can be collected. These additional tests are included in Table 4-3 and identified in the recommendation column as “Special Study.”

4.5.5 Summary Information

Table 4-3 identifies the constituents recommended to be analyzed in WMA A-AX samples (i.e., “Retain”). It also recommends those constituents (VOCs, and some specific physical property evaluations) that are recommended to be analyzed at select locations in the WMA A-AX area (i.e. “Special Study”). Constituents in the “Special Study” category will be reviewed for each WMA A-AX focus area to determine if they should be analyzed.

The terms primary and secondary will not be carried forward in this DQO. Separating constituents into these categories did not prove to be beneficial at WMA C and ultimately caused confusion from a data management and evaluation stand point, since secondary constituents were reported only if detected.

Additional information on constituents is provided in Step 5 (Section 6.0), which pertains to developing the DQO analytical approach. Section 6.0 identifies:

- Recommended laboratory methods
- Detection limits
- Quality assurance criteria for laboratory methods (i.e., acceptance criteria)
- Acceptable levels
- Hanford Site soil background levels, if available.

5.0 STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

The purpose of Step 4 is to identify the target population of interest and specify the spatial and temporal features pertinent for decision making or estimation.

Per EPA QA/G-4, the major outputs of this step are as follows:

- Definition of the target population with detailed descriptions of geographic limits (spatial boundaries)
- Detailed descriptions of what constitutes a sampling unit
- Time frame appropriate for collecting data and making the decision or estimate, together with those practical constraints that may interfere with data collection
- The appropriate scale for decision making or estimation.

The target population for this study is vadose zone soil (surface to groundwater). The study has vertical and horizontal spatial boundaries as well as temporal boundaries. Soil depths associated with the vertical spatial area correspond to the depths identified in Table 4-1 (Step 3 [Section 4.0]):

- ≤15 ft bgs (shallow zone)
- >15 ft bgs to groundwater (deep zone).

The vertical boundary is from the ground surface to the capillary fringe immediately above groundwater. The horizontal spatial boundary for WMA A-AX has not been defined at the time of the development of Revision 0 and is being deferred until a later revision. Refer to Appendix C for the spatial boundary associated with the focus area for Tanks A-104 and A-105.

The temporal boundary for the overall data collection in the WMA A-AX area will be the final CMS for WMA A-AX. Because the data will represent the condition of the contamination in the vadose zone between now and when the final CMS is completed, the timing of the sample collection must reflect these conditions. It is anticipated that this DQO will be in effect until the sampling and analysis for the soil remedy selection for WMA A-AX is complete. Sampling or other data collection should be integrated with similar activities whenever possible to realize efficiencies.

The smallest sampling unit is the volume of material needed to conduct analytical testing. However, there are various constraints that can impact the amount of volume that can be collected within tank farms. Table 5-1 identifies the practical constraints on data collection.

The smallest unit, for decisions or estimates, is considered to be a release site (i.e., an area in the vadose zone where there has potentially been an impact from a known or suspected release associated WMA A-AX).

Table 5-1. Practical Constraints on Data Collection

Constraint	Details
Physical access	Placing driven soil probes, borings, or excavations near tank farm system structures (i.e., SSTs, lines, diversion boxes, catch tanks) will pose additional access challenges because of the following: • Limited access to some locations because of topography. • Surface and subsurface obstructions.
Methods	The methods selected for investigations, such as excavations (e.g., trenching, test pits), driven soil probes, or borings, will influence the following: • An investigative method is selected depending on data needs (sample volume, number of samples, depth, potential radiological content, instrumentation installed, geophysical logging needs, location, groundwater well installed, etc.).
Radiological controls	Radiological issues that could influence the ability to perform the work involve the following: • Handling contaminated samples (high or very high radiation).
Field screening techniques	The ability of field screening to meet quality assurance/quality control or detection requirements may be limited as follows: • Gross gamma logging in soils may be limited by background radiation levels from adjacent structures (e.g., pipelines or diversion boxes). Small diameter gross gamma tool has a higher quantification level than the large diameter spectral tools. Therefore, very low levels of cobalt will not be detected by a small diameter logging tool. • Passive neutron logging may be limited because of lower than expected quantities of neutron-emitting isotopes.
Analytical laboratory capabilities	• Radiological controls and constraints at the sampling location (primarily high contamination levels) that delay delivery of the samples to the laboratory, causing exceedance of hold time limits. • Radiological controls and constraints at the laboratory (primarily high contamination levels) that delay analysis, causing exceedance of hold time limits. • Highly contaminated samples may require substantial dilution causing inability to analyze other contaminants effectively (e.g., reduced contaminant concentrations below detection limits).

6.0 STEP 5 – DEVELOP THE ANALYTICAL APPROACH

The purpose of Step 5 is to develop an analytic approach that will guide how to analyze the study results and draw conclusions from the data. Step 5 identifies the information necessary to determine if corrective measures should be evaluated, or if the conceptual site model needs to be revised.

The major outputs of Step 5 are as follows:

- For decision problems, choose an **acceptable level** (using information identified in Step 3 [Section 4.0]) that sets the boundary between one outcome of the decision process and an alternative. Verify that there are sampling and analysis methods with detection limits below acceptable levels. Specify the **population parameter** (e.g., maximum, mean, percentile) considered to be important to make inferences about the analytical data. Develop **decision rules** by constructing "if…then..." statements by combining the selected population parameter, the acceptable level, the scale of decision making, and the alternative actions.

- For evaluation problems, develop **specifications of the estimators** (using information identified in Step 3 [Section 4.0]) by identifying the type of data being estimated and determining the best representative measurement for this data type. Note there are no acceptable levels associated with these evaluation problems.

As identified above, there are different methods to determine the analytical approach, depending if the problem is a decision problem or evaluation problem. As identified in Step 2 (Section 3.0), this DQO has one decision problem (PSQ #1) and three evaluation problems (PSQ #2 through #4).

PSQ #1: Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?

Acceptable levels address the various risk-based standards, agreements, and requirements identified in Table 4-1 and Section 4.2 (Step 3 [Section 4.0]). Tables 6-1 and 6-2 present the acceptable levels for each of the constituents retained in Table 4-3 (Step 3 [Section 4.0]).

Table 6-1 presents acceptable levels for chemical constituents for the following evaluations:

- Direct contact unrestricted land use (≤15 ft bgs)
- Direct contact industrial land use (≤15 ft bgs)
- Outdoor worker (≤15 ft bgs)
- Ecological protection (≤15 ft bgs)
- Groundwater protection (ground surface to water table).

Table 6-2 presents acceptable levels for radiological constituents for the following evaluations:

- Outdoor worker (≤15 ft bgs)
- Construction worker (>15 ft bgs)
- Ecological protection (≤15 ft bgs).

Residential and tribal scenarios will be evaluated to assist interested parties in providing input on the remedial alternatives as a part of the CERCLA modifying criteria; thus, Tables 6-1 and 6-2 do not include acceptable levels for these scenarios. Additionally, there are no acceptable levels for groundwater protection under the site-specific model evaluation for radiological constituents; thus, there are no acceptable levels in Table 6-2 for the groundwater protection evaluation. Groundwater protection evaluations will be consistent with WAC 173-340-747. Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

In addition to acceptable levels, Tables 6-1 and 6-2 also provide the analytical methods (primary and alternative) and associated detection limits for chemical and radiological constituents, respectively. Equivalent methods may be used by the laboratory with prior approval. Ecology will be notified if such changes are necessary.

The following provides some information on the various analytical methods in Table 6-1.

Inorganic Constituents

- Metals will primarily be analyzed by inductively coupled plasma (ICP)/atomic spectroscopy and ICP/mass spectroscopy (MS).

- Hexavalent chromium will be analyzed by Method 7196. Prior to performing this analysis, the laboratory (222-S/WHL) will need to develop a preparation method.

- Mercury will be performed by Method 7471 cold vapor atomic absorption.

- Anions will primarily be analyzed by Method 9056 ion chromatography.

- Cyanide will be analyzed by Method 9014 spectrophotometric. This analytical method does not analyze for free cyanide or ferrocyanide. Note that little free cyanide is expected in the tanks because cyanide was complexed with sodium nickel as ferrocyanide.

Organic Constituents

- SVOCs will be analyzed by gas chromatography/MS.
- Pesticides/PCBs will be analyzed by gas chromatography/electron capture detector.

Table 6-1. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Metals													
Aluminum	7429-90-5	8.00E+04	3.50E+06	1.30E+06	1.18E+04[k]	4.80E+05	1.18E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	2.75	80-120	75-125	≤30
Antimony	7440-36-0	32	1,400	519	92	5.4	0.13	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.13[q]	80-120	75-125	≤30
Arsenic	7440-38-2	0.67	87.5	20[l]	127	0.034	20	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.2	80-120	75-125	≤30
Barium	7440-39-3	1.60E+04	7.00E+05	2.59E+05	358	1,648	132	6010 ICP/AES (acid)	6020 ICP/MS (acid)	10.2	80-120	75-125	≤30
Beryllium	7440-41-7	160	7,000	2,595	10	63.2	1.51	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.5	80-120	75-125	≤30
Bismuth	7440-69-9	—	—	—	—	—	—	6010 ICP/AES (acid)	—	25.8	80-120	75-125	≤30
Boron	7440-42-8	1.60E+04	7.00E+05	2.60E+05	28.6	205	3.89	6010 ICP/AES (acid)	—	6	80-120	75-125	≤30
Cadmium	7440-43-9	80	3,500	1,110	9.8	0.69	0.563	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.0202	80-120	75-125	≤30
Calcium	7440-70-2	—	—	—	—	—	1.72E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6.25	80-120	75-125	≤30
Cerium	7440-45-1	—	—	—	—	—	—	6010 ICP/AES (acid)	—	10.5	80-120	75-125	≤30
Chromium	7440-47-3	1.20E+05	5.25E+06	1.95E+06	109	2,000	18.5	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.15	80-120	75-125	≤30
Chromium-hexavalent[m]	18540-29-9	240	1.05E+04	3,893	109	0.192[v]	—	7196	—	0.09[m]	80-120	75-125	≤30
Cobalt	7440-48-4	24	1,050	389	15.7	4.3	15.7	6020 ICP/MS (acid)	6010 ICP/AES (acid)	2	80-120	75-125	≤30
Copper	7440-50-8	3,200	1.40E+05	5.19E+04	58	284	22	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Iron	7439-89-6	5.60E+04	2.45E+06	9.08E+05	—	5,645	3.26E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Lanthanum	7439-91-0	—	—	—	—	—	—	6010 ICP/AES (acid)	—	2.75	80-120	75-125	≤30
Lead	7439-92-1	250[s]	1,000[n]	—	156	3,000	10.2	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30

Table 6-1. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Lithium	7439-93-2	160	7,000	2,596	1,664	192	13.3	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.9	80-120	75-125	≤30
Magnesium	7439-95-4	—	—	—	—	—	7,060	6010 ICP/AES (acid)	6020 ICP/MS (acid)	26.3	80-120	75-125	≤30
Manganese	7439-96-5	1.12E+04	4.90E+05	1.80E+05	1,260	501	512	6010 ICP/AES(acid)	6020 ICP/MS (acid)	0.55	80-120	75-125	≤30
Mercury	7439-97-6	24	1,050	389	0.3	2.1	0.01	7471 Cold vapor atomic absorption (acid)	6020 ICP/MS (acid)	0.01[q]	80-120	75-125	≤30
Molybdenum	7439-98-7	400	1.75E+04	6,489	2	32	0.47	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.47[q]	80-120	75-125	≤30
Neodymium	7440-00-8	—	—	—	—	—	—	6010 ICP/AES (acid)	—	5.05	80-120	75-125	≤30
Nickel	7440-02-0	1,600	7.00E+04	2.59E+04	38	130	19.1	6020 ICP/MS (acid)	6010 ICP/AES (acid)	3	80-120	75-125	≤30
Phosphorus	7723-14-0	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	9.8	80-120	75-125	≤30
Potassium	7440-09-7	—	—	—	—	—	2,150	6010 ICP/AES (acid)	6020 ICP/MS (acid)	157	80-120	75-125	≤30
Rhodium	7440-16-6	—	—	—	—	—	—	6010 ICP/AES (acid)	—	25.8	80-120	75-125	≤30
Selenium	7782-49-2	400	1.75E+04	6,489	1.4	5.2	0.78	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.02[r]	80-120	75-125	≤30
Silicon	7440-21-3	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5.05	80-120	75-125	≤30
Silver	7440-22-4	400	1.75E+04	6,489	3	14	0.167	6020 ICP/MS (acid)	6010 ICP/AES (acid)	6.00E-04[r]	80-120	75-125	≤30
Sodium	7440-23-5	—	—	—	—	—	690	6010 ICP/AES (acid)	6020 ICP/MS (acid)	22.4	80-120	75-125	≤30
Strontium	7440-24-6	4.80E+04	2.10E+06	7.79E+05	4,228	6,758	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.55	80-120	75-125	≤30
Sulfur	7704-34-9	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	11.4	80-120	75-125	≤30
Tantalum	7440-25-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	25.5	80-120	75-125	≤30

Table 6-1. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Thallium	7440-28-0	0.8[y]	35[y]	—[x]	0.5	0.71	0.185	6020 ICP/MS (acid)	6010 ICP/AES (acid)	4.00E-04[r]	80-120	75-125	≤30
Thorium	7440-29-1	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	4.85	80-120	75-125	≤30
Tin	7440-31-5	4.80E+04	2.10E+06	7.79E+05	84	4.80E+04	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6	80-120	75-125	≤30
Tungsten	7440-33-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	42.9	80-120	75-125	≤30
Uranium	7440-61-1	240	1.05E+04	3,892	22	3.21[k]	3.21	6020 ICP/MS(acid)[h]	6010 ICP/AES (acid)	0.5	80-120	75-125	≤30
Vanadium	7440-62-2	400	1.75E+04	6,488	43.2	1,600	85.1	6020 ICP/MS (acid)	6010 ICP/AES (acid)	6.00E-03[r]	80-120	75-125	≤30
Zinc	7440-66-6	2.40E+04	1.05E+06	3.89E+05	621	5,971	67.8	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Zirconium	7440-67-7	—[x]	—[x]	—[x]	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1.2	80-120	75-125	≤30
Miscellaneous Constituents													
Ammonium	14798-03-9	—	—	—	—	—	9.23	300.7 IC (distillation)	—	0.5	80-120	75-125	≤30
Total organic carbon	TOC	—	—	—	—	—	—	9060	—	20	85-115	70-130	≤30
Anions													
Bromide	24959-67-9	—	—	—	—	—	—	9056 IC (water)	—	1	80-120	75-125	≤30
Chloride	16887-00-6	—	—	—	—	1,000	100	9056 IC (water)	—	0.3	80-120	75-125	≤30
Cyanide (total)	57-12-5	48	2,100	180	2.07E+04	0.97	—	9014 Spectrophotometric (distillation)	9012 Colorimetric	0.5	80-120	75-125	≤30
Fluoride	16984-48-8	4,800	2.10E+05	7.79E+04	845	2,884	2.81	9056 IC (water)	—	2.81[q]	80-120	75-125	≤30
Nitrogen in Nitrate	NO3-N	1.28E+05	5.60E+06	2.08E+06	27[o]	4.00E+01	—	9056 IC[u] (water)	—	2.5[u]	80-120	75-125	≤30
Nitrogen in Nitrite	NO2-N	8.00E+03	3.50E+05	1.30E+05	27[o]	4.00E+00	—	9056 IC[u] (water)	—	2.5[u]	80-120	75-125	≤30

Table 6-1. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Phosphate	14265-44-2	—	—	—	—	—	0.785	9056 IC (water)	—	0.785[q]	80-120	75-125	≤30
Sulfate	14808-79-8	—	—	—	—	1,000	237	9056 IC (water)	—	2.7	80-120	75-125	≤30
Acetate	71-50-1	—	—	—	—	—	—	9056 IC (water)	—	4.5	80-120	75-125	≤30
Formate	64-18-6	—	—	—	—	—	—	9056 IC (water)	—	10.0	80-120	75-125	≤30
Glycolate (2-Hydroxyacetate)	GLYCOLATE[w]	—	—	—	—	—	—	9056 IC (water)	—	3.8	80-120	75-125	≤30
Oxalate	338-70-5	—	—	—	—	—	—	9056 IC (water)	—	2	80-120	75-125	≤30
Pesticides													
Aldrin	309-00-2	0.06	7.72	0.17	0.01	2.52E-03	—	8081 GC/ECD	8270 GC/MS	0.01	70-130	70-130	≤30
alpha-BHC	319-84-6	0.16	20.83	0.41	6	5.44E-04	—	8081 GC/ECD	8270 GC/MS	—	70-130	70-130	≤30
beta-BHC	319-85-7	0.56	72.92	1.40	0.06	2.28E-03	—	8081 GC/ECD	8270 GC/MS	—	70-130	70-130	≤30
gamma-BHC	58-89-9	0.91	119.32	2.80	6	2.47E-03	—	8081 GC/ECD	8270 GC/MS	0.6	70-130	70-130	≤30
Chlordane	57-74-9	2.86	375	8.02	1	0.26	—	8081 GC/ECD	8270 GC/MS	0.1	70-130	70-130	≤30
4,4'-DDD	72-54-8	4.17	546.88	11	0.06	0.3354	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
4,4'-DDE	72-55-9	2.94	386.03	10	NC	0.4457	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
4,4'-DDT	50-29-3	2.94	386.03	9.5	0.05	3.4907	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
Dieldrin	60-57-1	0.06	8.2	0.16	1.40E-04	2.82E-03	—	8081 GC/ECD	8270 GC/MS	0.007	70-130	70-130	≤30
Endrin	72-20-8	24.0	1050	274	0.2	4.40E-01	—	8081 GC/ECD	8270 GC/MS	0.02	70-130	70-130	≤30
Heptachlor	76-44-8	0.22	29.17	0.34	0.4	0.0038	—	8081 GC/ECD	8270 GC/MS	0.04	70-130	70-130	≤30
Heptachlor epoxide	1024-57-3	0.11	14.4	0.38	0.4	0.008	—	8081 GC/ECD	8270 GC/MS	0.04	70-130	70-130	≤30
Hexachlorobenzene	118-74-1	0.63	82.03	1.42	17	8.77E-02	—	8081 GC/ECD	8270 GC/MS	1.70	70-130	70-130	≤30
Polychlorinated Biphenyls													
Aroclor 1016	12674-11-2	5.60	245	29.7	1.80	1.072	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1221	11104-28-2	0.5	65.6	0.76	1.50	0.004	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1232	11141-16-5	0.5	65.6	0.59	1.40	0.004	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1242	53469-21-9	0.5	65.6	0.97	1.50	0.069	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30

Table 6-1. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Aroclor 1248	12672-29-6	0.5	65.6	0.98	0.33	0.067	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1254	11097-69-1	0.5	65.6	1.02	1.50	0.114	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1260	11096-82-5	0.5	65.6	1.08	1.50	0.719	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Physical Properties													
Bulk Density	—	—	—	—	—	—	—	Gravimetric	—	—	—	—	≤30
pH (soil)	—	—	—	—	—	—	—	9045 (pH)	—	—	± 0.1 pH units	—	—
Percent solids	—	—	—	—	—	—	—	Gravimetric	—	—	—	—	—
Percent water	—	—	—	—	—	—	—	Gravimetric	—	—	80-120	—	≤30
Specific conductance	—	—	—	—	—	—	—	9050	—	—	—	—	—
Particle size distribution[t]	—	—	—	—	—	—	—	ASTM D 422/ ASTM D 6913	—	—	—	—	—
Semi-volatile Organic Compounds													
Bis(2-ethylhexyl)phthalate	117-81-7	71	9,375	182	0.17	13.36	—	8270 GC/MS	—	2.95	70-130	70-130	≤30
Tributyl phosphate	126-73-8	111	14,583	284	—	0.496	—	8270 GC/MS	—	3.3	70-130	70-130	≤30

a. The acceptable level (from the data quality objective process) is used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The unrestricted direct contact acceptable level is based on an excess lifetime cancer risk of 1 in 1,000,000 or hazard quotient of 1. ECF-HANFORD-10-0444, *Documentation of Standard Method B Soil Cleanup Levels for Unrestricted Land Use.*

c. The industrial direct contact acceptable level is based on an excess lifetime cancer risk of 1 in 100,000 or hazard quotient of 1. ECF-HANFORD-10-0453, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Report*.

d. The outdoor worker acceptable level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 1,000,000 or hazard quotient of 1. ECF-HANFORD-16-0134, *Calculation of Soil Nonradiological Preliminary Remediation Goals for the Outdoor Worker Scenario*.

e. CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site*.

f. ECF-HANFORD-10-0442, *Calculation of Nonradiological Soil Concentrations Protective of Groundwater Using the Fixed Parameter 3 Phase Equilibrium Partitioning Equation for the 100 Areas and 300 Area*.

g. DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*; ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

h. Isotopic uranium analysis may be substituted for total uranium as long as the required detection limit is met.

i. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and WHL-MP-1011, "Quality Assurance Project Plan for 222-S Laboratory."

j. Quality control failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are quality control failures associated with secondary analytes, reanalysis will not be required.

k. The actual value is less than its background level. Hence, it was set equal to the background concentration.

l. The outdoor worker acceptable level for arsenic is equal to the site background concentration.

m. Prior to performing this analysis, a preparation method will need to be developed; therefore, detection limit may need to be modified.

n. The acceptable level of lead is the Method A industrial land use soil cleanup level from Table 745-1 of WAC 173-340-745(3).

o. The ecological protection values for nitrate and nitrite are calculated for nitrogen in nitrate plus nitrite.

p. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

q. Detection limit listed is Hanford background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

Table 6-1. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference

r. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

s. The acceptable level of lead is the Method A unrestricted land use soil cleanup level from Table 740-1 of WAC 173-340-900.

t. Particle size distribution will be performed by the laboratory if sample volume is sufficient. Note that 222-S will need to develop protocol to perform test.

u. Detection limits and method are associated with nitrate (CAS number 14797-55-8) and nitrite (CAS number 14797-65-0). Nitrogen in nitrate and in nitrate will be determined from this analysis.

v. Groundwater protection level for hexavalent chromium was calculated using K_d = 0 mL/g as documented in PNNL-13895.

w. RPP-RPT-38152 identifies the CAS Number as 79-14-1 which is for glycolic acid. The CAS number for glycolate is 666-14-8 but the laboratory uses "GLYCOLATE" for identification.

x. Due to uncertainty associated with the documented toxicity value, the acceptable level was not calculated in referenced ECF.

y. Method B and Method C values for thallium will be used for screening purposes, not for deriving cleanup levels.

z. The acceptable levels for inhalation exposure, protective of human health and the environment, have not been developed at this time. During the total risk determination, chronic daily intake, individual excess lifetime cancer risk, and non-cancer hazard index from inhalation of dust and vapors in ambient air will be calculated.

— = no value (e.g., no toxicity value)
AES = atomic emission spectroscopy
BHC = Benzene hexachloride
DDD = Dichlorodiphenyldichloroethane
DDE = Dichlorodiphenyldichloroethylene
DDT = Dichlorodiphenyltrichloroethane
CAS = Chemical Abstracts Service
ECD = electron capture detector
GC = gas chromatography
IC = ion chromatography
K_d = distribution coefficent
NC = not calculated; toxicity information is available but a risk-based limit is not currently documented in the respective ECF document or CLARC. The NC will be replace with the acceptable level after the respective ECF is updated with the additional constituent included.

Table 6-2. Analytical Performance Requirements for Radiological Constituents

Constituent	CAS Number	Acceptable Level (pCi/g)[a]			Hanford Site Background[d] (pCi/g)	Primary Method[i]	Alternative Method[i]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[e,f]		
									Accuracy		Precision
		Outdoor Worker[b] (≤ 15 ft bgs)	Ecological Protection[c] (≤ 15 ft bgs)	Construction Worker[j] (> 15 ft bgs)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Americium-241	14596-10-2	613	4,840	2.20E+04	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	80-120	—	≤30
Antimony-125	14234-35-6	—	—	—	—	Gamma energy analysis (direct)	—	0.3	80-120	—	≤30
Carbon-14	14762-75-5	5.70E+05	32	4.80E+06	—	Liquid scintillation (acid)	—	1	80-120	75-125	≤30
Cesium-137	10045-97-3	10.8	924	1,550	1.05	Gamma energy analysis (direct)	—	0.1	80-120	—	≤30
Cobalt-60	10198-40-0	5.7	805	334	8.42E-03	Gamma energy analysis (direct)	—	0.01[g,h]	80-120	—	≤30
Curium-242	15510-73-3	—	—	—	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	—	NA
Curium-243/244	CM-243/244	64	—	7,582	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	—	NA
Europium-152	14683-23-9	6.8	1,740	739	—	Gamma energy analysis (direct)	—	0.1[g]	—	—	≤30
Europium-154	15585-10-1	8.2	1,610	691	3.34E-02	Gamma energy analysis (direct)	—	0.03[g,h]	—	—	≤30
Europium-155	14391-16-3	603	3.34E+04	3.24E+04	5.39E-02	Gamma energy analysis (direct)	—	0.05[g,h]	—	—	≤30
Iodine-129	15046-84-1	1,568	—	1.21E+05	—	Low energy gamma counting	ICP/MS (acid)	2	80-120	—	≤30
Neptunium-237	13994-20-2	24	7,880	4,193	—	ICP/MS (acid)	Alpha energy analysis (acid)	3.80E-02	80-120	75-125	≤30
Nickel-63	13981-37-8	6.00E+05	—	2.86E+07	—	Liquid scintillation (acid)	—	30	80-120	—	≤30
Plutonium-238	13981-16-3	3,438	5,980	2.98E+04	3.78E-03	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	—	≤30
Plutonium-239/240	Pu-239/240	2,971	6,270	2.80E+04	2.48E-02	Alpha energy analysis (acid)	ICP/MS (acid)	0.03[g,h]	80-120	—	≤30
Plutonium-241	14119-32-5	2.03E+04	—	1.03E+06	—	Liquid scintillation (acid)	Estimate from plutonium-238 and plutonium-239/240	1.65E+04	80-120	75-125	≤30
Radium-226	13982-63-3	—	58.3	—	0.82	Gamma energy analysis (direct)	—	0.2	80-120	75-125	≤30
Selenium-79	15758-45-9	5.68E+04	—	3.20E+06	—	Liquid scintillation (acid)	—	10	—	—	≤30
Strontium-90	10098-97-2	1190	91	1.21E+05	0.18	Beta GPC	—	0.18[g,h]	80-120	75-125	≤30
Tin-126	15832-50-5	—	—	—	—	ICP/MS (acid)	—	400	80-120	75-125	≤30
Technetium-99	14133-76-7	1.17E+05	5,360	5.80E+06	—	ICP/MS (acid)	Liquid scintillation (acid)	1	80-120	75-125	≤30

Table 6-2. Analytical Performance Requirements for Radiological Constituents

Constituent	CAS Number	Acceptable Level (pCi/g)[a]			Hanford Site Background[d] (pCi/g)	Primary Method[i]	Alternative Method[i]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[e,f]		
									Accuracy		Precision
		Outdoor Worker[b] (≤ 15 ft bgs)	Ecological Protection[c] (≤ 15 ft bgs)	Construction Worker[j] (> 15 ft bgs)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Thorium-232	7440-29-1	—	—	—	1.32	ICP/MS (acid)	—	4.40E-05	80-120	75-125	≤30
Tritium	10028-17-8	1.26E+04	420	3.26E+05	—	Liquid scintillation (acid)	—	30	80-120	75-125	≤30
Uranium-233	13968-55-3	—	—	—	—	ICP/MS (acid)	—	0.174	—	—	≤30
Uranium-234	13966-29-5	2,201	6,370	5.51E+04	1.1	ICP/MS (acid)	—	3.75E-02	—	—	≤30
Uranium-235	15117-96-1	36	4,360	5,984	0.11	ICP/MS (acid)	—	4.32E-05	80-120	75-125	≤30
Uranium-236	13982-70-2	—	—	—	—	ICP/MS (acid)	—	5.18E-04	—	—	≤30
Uranium-238	7440-61-1	170	5,150	2.11E+04	1.06	ICP/MS (acid)	—	4.37E-04	80-120	75-125	≤30

a. The acceptable level (from the DQO process) is the risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The outdoor worker acceptable level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 10,000. ECF-HANFORD-16-0133, *Calculation of Soil Radiological Preliminary Remedial Goals for the Outdoor Worker Scenario*.

c. CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site;* CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*.

d. DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*.

e. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and WHL-MP-1011, "Quality Assurance Project Plan for 222-S Laboratory."

f. Quality control failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are quality control failures associated with secondary analytes, reanalysis will not be required.

g. Detection limit listed is Hanford Site background value. The laboratory shall attempt to achieve a detection limit less than Hanford Site background.

h. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

i. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

j. The construction worker acceptable level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 10,000. ECF-HANFORD-16-0132, *Calculation of Soil Radiological Preliminary Remedial Goals for the Construction Worker Scenario*.

— = no value (e.g., no toxicity value)
CAS = Chemical Abstracts Service
GPC = gas proportional counting
GEA = gamma energy analysis
ICP = inductively coupled plasma
MS = mass spectroscopy
ft bgs = feet below ground surface

VOCs are not included in Table 6-1; however, they are in Step 3 (Section 4.0) as "Special Study." As indicated in Step 3 (Section 4.0), constituents in the "Special Study" category will be reviewed for each WMA A-AX focus area to determine if they should be analyzed. When these constituents are identified to be analyzed for a focus area, tables will be generated to identify recommended laboratory methods and acceptable levels. These new tables will be included in revisions to this DQO, as needed.

Additionally, tentatively identifiable compounds (TICs) will also be reported for relevant analysis, as necessary. Detected organic constituents that are not part of the calibration mix are reported as TICs. If a TIC is determined to be real (i.e., not an artifact of analytical methods), it will be evaluated against a gas chromatographic library. This library of compounds (called the "Hanford library") is composed of constituents that have been identified as possibly being present in Hanford Site waste in PNNL-12040, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project,* but not identified as primary constituents.

If the TIC is not found in the "Hanford library" of compounds, then the TIC will be evaluated against the standard National Institute of Standards and Technology library of compounds. This library has over 100,000 compounds. However, because they are collected on different instruments from those used for the actual analysis, the retention times and response factors will be different. Before the analyst can name or identify the TIC, the analyst must be confident that the chromatogram and mass spectra match well enough to name the compound. If the analyst cannot confidently name the compound, it is identified as an unknown and no further action is required. When a TIC is identified in the National Institute of Standards and Technology library, then the TIC will be evaluated in a similar manner as a "Hanford library" TIC.

Physical Properties

- Bulk density, percent solids, and percent water will be performed by gravimetric test.
- pH will be analyzed by Method 9045.
- Specific conductance will be analyzed by Method 9050.
- Particle size, if there is sufficient sample, will be determined by ASTM D422, *Sieve Analysis*/ASTM D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*. The 222-S Laboratory will need to develop protocol to perform this test.

Based on the methodology used to collect soil samples within tank farms, limited mass is collected. Typically the priority for analyses is to perform analyses for chemical and radiological constituents first. Therefore, limited physical property tests will be able to be performed.

Physical property tests and evaluations not included in Table 6-1 are identified in Table 4-3 (Step 3 [Section 4.0]) as "Special Study." As indicated in Step 3 (Section 4.0), constituents and/or tests in the "Special Study" category will be reviewed for each WMA A-AX focus area to

determine if they should be analyzed/performed. When these physical properties tests are identified as being needed to be performed for a focus area, tables will be generated to identify recommended laboratory methods. These new tables will be included in revisions to this DQO, as needed.

The following provides some information on the various analytical methods in Table 6-2.

Radiological Constituents

- Four primary methods will be used for analysis of radiological constituents: alpha energy, ICP/MS, gamma energy, and liquid scintillation.
- Strontium-90 will be analyzed by beta gas proportional counting.
- Plutonium-241 may be estimated using plutonium-238 and plutonium-239/240 results.
- Iodine-129 will be analyzed by low energy gamma counting.

6.1 DECISION RULES/SPECIFICATIONS OF THE ESTIMATOR

The Decision Rule for PSQ #1 and Specifications of the Estimator for PSQs #2 through #4 are defined in Table 6-3. Section 6.1.1 provides a discussion on Decision Rule 1, and Section 6.1.2 provides a discussion on Specifications of the Estimator for PSQs #2 through #4.

Table 6-3. Decision Rules and Specification of the Estimator[a]

Step 2		Step 5
Principal Study Question	**Decision/Estimation Statement (DS/ES)**	**Decision Rule/Specification of the Estimator (DR/E)**
#1— Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	**#DS 1** — Determine whether contamination exceeds acceptable levels and, therefore, whether there is a need to evaluate corrective measures.	**#DR 1** IF the maximum detected concentrations for individual constituents exceed those acceptable levels identified in Table 8, Table 9, or those that will be developed during risk evaluations, THEN further evaluation will be performed during the RFI/CMS.[b]
#2 – Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	**#ES 2** – The chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. It is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil.	**#E2** The best measurement of chemical and physical properties in WMA A-AX vadose zone soil that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated.

Table 6-3. Decision Rules and Specification of the Estimator[a]

Step 2		Step 5
Principal Study Question	**Decision/Estimation Statement (DS/ES)**	**Decision Rule/Specification of the Estimator (DR/E)**
#3 – Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	**#ES 3** – The chemical/physical properties of WMA A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. It is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil.	**#E3** The best available measurements of chemical and physical properties in WMA A-AX tank waste that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated.
#4 – Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?	**#ES 4** – Chemicals and radionuclides in tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated. It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through those portions of the soil. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through those portions of the soil.	**#E4A** The concentrations of naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment will be estimated to evaluate where waste may have passed through portions of the soil. **#E4B** The concentrations in vadose zone soil of chemicals and radionuclides that can act as tank waste markers will be estimated to evaluate where waste may have passed through portions of the soil.

[a]Data types to address PSQs are identified in Step 3 (Section 4.0, Table 4-1). Data collected to address PSQ #1 will also be used to address PSQs #2, #3, and #4. Data used to address PSQs #2, #3, and #4 will support development and refinement of the conceptual site model.

[b]Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan. Additionally, cumulative risk calculations will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

6.1.1 Decision Rule 1

The decision rule for PSQ #1 involves comparing acceptable levels to maximum detected concentrations for screening purposes to determine if there is a need for further evaluation in the RFI/CMS. As per WAC 173-340-740(7)(d)iii:

> "Direct comparison of soil sample concentrations with cleanup levels may be used to evaluate compliance with cleanup levels where selective sampling of soil can be reliably expected to find suspected soil contamination. There must be documented, reliable information that the soil samples have been taken from the appropriate locations. Persons

using this method must demonstrate that the basis used for selecting the soil sample locations provides a high probability that any existing areas of soil contamination have been found; or…….”.

Note that use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan. Additionally, cumulative risk calculations will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

6.1.2 Specification of the Estimator Statements

For evaluation problems (PSQ #2 through #4), this step involves developing a specification of the estimator by identifying the type of data being estimated and determining the best representative measurement for the data type. The estimator will provide key information and assumptions necessary to obtain data needed to make these evaluations. As identified, no acceptable levels are associated with evaluation problems. Note that Table 4-1 (Step 3, Section 4.0) identifies the type of data needed for each PSQ, and Table 6-3 identifies the specification of the estimator for each evaluation problem PSQ.

PSQ #2: Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?

The estimation statement for this PSQ is chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. The type of data being estimated/evaluated is chemical and physical properties for WMA A-AX. In WMA A-AX, it is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil. The specification of the estimator would be: The best measurements of chemical and physical properties in WMA A-AX vadose zone soil that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated. The best measurements are professional judgment.

PSQ #3: Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?

The estimation statement for this PSQ is chemical/physical properties of WMA A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. The type of data being estimated/evaluated is chemical and physical properties for WMA A-AX. In WMA A-AX, it is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil. The specification of the estimator would be: The best available measurements of chemical and physical properties in WMA A-AX tank waste that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated. The best available measurement will not include collecting samples of tank waste. Information used in the evaluation may be obtained from process history, residual waste inventory, existing

analytical data, and previous investigations. The best available measurements are professional judgment.

PSQ #4: Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?

The estimation statement for this PSQ is chemicals and radionuclides in WMA A-AX tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated.

Some examples of tank waste indicator constituents, sodium, technetium-99, molybdenum, and sulfate, are identified in PNNL-15503, *Characterization of Vadose Zone Sediments Below the C Tank Farm: Borehole C4297 and RCRA Borehole 299-E27-22*, and RPP-RPT-58339, *Phase 2 RCRA Facility Investigation Report for Waste Management Area* C. Sodium, which is naturally occurring vadose zone soil, could potentially be chemically altered by contact with tank waste. Reaction between alkaline tank fluids and native soils can form a cation exchange, whereby sodium replaces calcium and magnesium in soil, thereby elevating sodium concentrations and concurrently reducing calcium and magnesium concentrations in soil. Any detection of technetium-99 and, as indicated in PNNL-15503, elevated molybdenum or sulfate levels relative to background or natural conditions, would be significant indicators for tank waste migration. Technetium-99 is a significant tank waste marker because it is common to tank waste due to its high fission yield, is very long-lived, generally is not found in other sources of waste (e.g., cooling water), can be detected at very low concentrations using current methods, and is soluble and mobile in the environment (soil). Elevated sulfur or sulfur compounds (e.g., sulfate) in soil would likely be from Tank A-105 sluicing that used sulfuric acid as a sluicing agent. Molybdenum is a fission product generated during the operation of nuclear reactors, and molybdenum concentrations found above natural levels can be used to delineate tank waste in subsurface soil.

The type of data being estimated/evaluated are those chemical and radiological constituents, specifically indicator constituents, which can be altered as they move through the soil (e.g., ion exchange). It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through those portions of the soil. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through those portions of the soil.

Based on the above, there are two specification of the estimator statements:

- The concentrations of naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment will be estimated to evaluate where waste may have passed through portions of the soil.

- The concentrations in vadose zone soil of chemicals and radionuclides that can act as tank waste markers will be estimated to evaluate where waste may have passed through portions of the soil.

The outcome of this evaluation will be based on professional judgment.

7.0 STEP 6 – SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

The purpose of Step 6 is to examine the consequences of making incorrect decisions, and identify acceptable ranges associated with making decision errors.

The major outputs of Step 6 are:

- Performance or acceptance criteria (performance metric) to minimize errors for decision rules
- Performance or acceptance criteria (performance metric) to keep uncertainties for the specifications of the estimators within acceptable ranges.

The Step 6 outputs for WMA A-AX are:

- Quality control acceptance criteria for each constituent are identified in Tables 6-1 and 6-2.
- Where this DQO provides sample data for technical evaluations and not for direct comparison to acceptable levels, acceptance criteria for statistical uncertainty normally associated with specific performance acceptance metrics will not apply.

Decision errors are primarily due to errors that occur during field sampling and laboratory analysis. Therefore, there is a chance that an erroneous decision will be made based on the collected data or that uncertainty in the estimated result is unacceptable. To help reduce decision errors, sampling and analysis performed for WMA A-AX will be conducted with standard quality assurance/QC control practices.

Performance or acceptance criteria, which are developed to limit sampling decision error, are sometimes used to help determine sampling and analysis design. When using a probabilistic sampling approach, statistical decision error criteria are sometimes developed to estimate the minimum number of samples. Based on constraints associated with doing work within a tank farm, it is anticipated the sampling approach for WMA A-AX will be judgmental, not probabilistic. For this reason, Step 6 decision error criteria to support sample design will not be developed, and this step will have little impact on sample design.

The following identifies the logic for the performance or acceptance criteria for this DQO process.

PSQ #1: Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels? Quality control acceptance criteria for each constituent are identified in Tables 6-1 and 6-2. Note that the data generated for this decision problem (PSQ #1) will be subject to various types of errors due to such factors as how samples were collected, how measurements were made, etc. At a minimum, there are two decision error limits that should be specified:

- A false rejection decision error limit at the acceptable level
- A false acceptance decision error limit at the acceptable level.

An example of how such an error could occur involves the acid-digested technetium-99 analysis, which is subject to isobaric interference from natural ruthenium, cobalt argide, and zinc chloride ions that can skew sample results, thereby impacting the decision. Samples from WMA A-AX will be analyzed using an ICP/MS with a collision cell, which eliminates the polyatomic interferences.

Table 7-1 shows the tolerable limits on decision error for Decision Rule 1 based on the predicted consequences of making an incorrect decision under actual site conditions. The table also further defines decision error severity.

Table 7-1. Tolerable Limits on Decision Errors

Action	Possible Decision Error	Severity of Consequences of Decision Error				Decision Error that has More Severe Consequences
		Far Below the Acceptable Level	Below but Near the Acceptable Level	Above but Near the Acceptable Level	Far Above the Acceptable Level	
Conduct corrective action	Remediate an uncontaminated site	Severe[a]	Moderate	None	None	Not remediating a contaminated site
No corrective measure required	Failing to remediate a contaminated site	None	None	Moderate	Severe[b]	

Justification for severe rating:

a. Severity of decision error for remediating an uncontaminated site having contamination that is far below acceptable levels is severe based on the cost.

b. Severity of decision error for not remediating a site having contaminations far above acceptable levels is based on health and environmental risks.

PSQ #2: Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?

PSQ #3: Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?

PSQ #4: Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?

As identified previously, PSQs #2 through #4 are estimation problems. Data generated or reviewed for these technical evaluations or estimations are not compared to acceptable levels but are selected based on determining the best representative measurements. The consequence of drawing an incorrect conclusion would be that true conditions are not accurately represented.

As identified in Step 5 (Section 6.0), determining the best measurement for resolution of these estimation problems is primarily based on professional judgment and not specific performance or acceptance criteria (performance metric). Therefore, acceptance criteria for statistical uncertainty normally associated with specific performance or acceptance metrics will not apply. However, as good practice, sampling and analysis will be conducted following standard quality assurance/QC practices to minimize sampling and analysis errors and data uncertainty.

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8.0 STEP 7 – DEVELOP THE PLAN FOR OBTAINING DATA

Step 7 develops a sampling design that optimizes the data collection to meet data quality requirements specified in DQO Steps 1 through 6 and also takes into account the sampling boundaries and constraints identified in Step 4 (Section 5.0).

Per EPA QA/G-4, activities typically include:

- Gathering information needed to develop an acceptable and efficient sampling and analysis design
- Identifying constraints that will impact the sampling and analysis design
- Providing details on the sampling and analysis methods you will use to generate the data
- Identifying one or more candidate designs from which to select
- Determining an "optimal" amount of information to collect for the potential design using statistical and cost considerations
- Preparing a resource-effective information collection plan that will meet the needs and requirements.

Also per EPA QA/G-4, the major outputs of this step are documented within the Quality Assurance Project Plan (QAPjP) or within an accompanying sampling and analysis plan. These outputs include:

- Full documentation of the final sampling design, along with a discussion of the key assumptions underlying this design
- Details on how the design should be implemented together with contingency plans for unexpected events, and
- The quality assurance and QC procedures that would be performed to detect and correct problems and so ensure defensible results.

8.1 CONSTITUENTS FOR SAMPLING

This DQO process addresses the collection of data from multiple focus areas at WMA A-AX, and the entirety of WMA A-AX will be addressed through the compilation of data from these various focus areas. Overall, vadose zone soil sample material will be analyzed for the chemical, radiological, and physical properties identified in Tables 6-1 and 6-2. These tables also provide analytical methods and associated detection limits for each constituent.

Both pesticides and PCBs were sampled in only the top 15 ft at WMA C; however, at WMA A-AX they will be sampled at all depths in the first focus area around Tanks A-104 and A-105. Data from the first focus area will be reviewed to determine if samples should also be collected in subsequent focus areas at all depths or just within the top 15 ft.

Additionally, Step 3 (Section 4.0) identified some constituents, VOCs, and several physical property tests that will be evaluated for sampling at specific focus area(s) as part of special studies. The focus area(s) where these special studies will be performed will be determined through DQO discussions. The plan for obtaining data for the focus area around Tanks A-104 and A-105 is provided in Appendix C.

Information regarding contingency plans for unexpected events and quality assurance/control are provided in this section (Sections 8.2 and 8.3, respectively).

8.2 GENERAL CONTIGENCY PLANS FOR UNEXPECTED EVENTS

The rationale for selecting sample and monitoring locations is described in this DQO; however, the final locations will be established based on geophysical data obtained and facility walk downs conducted just prior to deployment to field investigation sites. Additionally, changes to field investigation site locations may be required because of unexpected field conditions, new information, health and safety concerns, or other circumstances. These issues will be reviewed on a case by case basis, and Ecology will be contacted if an event like this occurs.

8.3 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance requirements are implemented in TFC-PLN-02, *Quality Assurance Program Description* for all WRPS work processes. The HASQARD establishes the quality requirements for environmental data collection, including sampling and analysis, in support of the SST RCRA Corrective Action Program. The HASQARD provides a framework of the general requirements that apply to the RCRA Corrective Action Program characterization and remedial efforts, and applies specifically to field and laboratory activities associated with evaluating subsurface contaminant impacts involving 200 Area SST WMA releases to the environment. The HASQARD complies with the requirements of EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans EPA QA/R-5*, and also identifies technical procedural requirements that will describe field data collection and sampling and analysis requirements to be implemented during the investigation. Technical procedures will be identified in the sampling and analysis plan to address the requirements of the HASQARD.

Any laboratory performing analyses in support of this DQO shall have approved and implemented a QAPjP. The QAPjP shall meet the HASQARD minimum requirements as the baseline for laboratory quality systems. All sampling events are to be conducted using approved sampling and analysis plans. Sample analysis performed by WRPS at the 222-S Laboratory will be in accordance with ATS-MP-1032, *222-S Laboratory Facility Quality Assurance Project Plan*. Analysis by Wastren Advantage Hanford Laboratory will be in accordance with WHL-MP-1011, *WHL Quality Assurance Project Plan for 222-S Laboratory*.

The preferred methods of analysis are EPA SW-846 or other approved standardized methods as applicable. The most recent revisions are preferred. Methods used for the first time, or modified, shall be qualified before routine use. Technical procedures shall include or reference the acceptance and performance criteria for precision, accuracy, calibration, and detection limit (as appropriate) established during the qualification experiments. The laboratory performs QC analyses (e.g., blanks, matrix spikes, and laboratory control samples) at the frequency specified in the reference methods. Where such methods are not available, QC analysis is performed at the frequency specified in the laboratory analytical procedures. Where no approved regulatory methods exist, such as for radiological constituent analyses, the laboratory should use the technique suggested in Tables 6-1 and 6-2. Results of the QC samples shall meet the acceptance criteria specified in the standard methods (EPA SW-846) or laboratory QAPjP. QC results exceeding administrative limits of the governing DQO but within laboratory statistical criteria, are flagged and documented in the data summary and report narrative to prevent reoccurrence and inadvertent use. Note that the laboratory will use the least possible dilution to obtain the lowest practical detection limits for all analyses.

Samples will be collected, verified, and stored to support data completeness, data integrity, and ease of retrieval. Sample collection and field records will include field logbook or data collection sheets, chain-of-custody forms, daily QC reports, deviations, corrective action reports, and correspondence, as applicable. In addition, field records will also include equipment calibration records, drilling logs, geophysics reports, change orders/deviations, and field audit reports, as applicable.

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APPENDIX A

INFORMATION FROM WMA A-AX DQO PROCESS MEETINGS

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A1.0 INTRODUCTION

The DQO process for WMA A-AX was initiated in 2011 but suspended prior to completion. In January 2017, the process was re-initiated through meetings conducted with Ecology, DOE-RL, DOE-ORP, WPRS, and CHPRC (Table A-1). Meeting notes were prepared and are available in the Hanford Site Administrative Record[1]. This appendix incorporates the following information from the meetings, as well as updates made to reflect discussions held with Ecology through the fall of 2017:

- An updated DQO process summary handout, which documents key information to be incorporated into this DQO (Attachment A1)
- Agreements reached by the meeting attendees (Table A-2)
- Actions that remained open at the conclusion of the last meeting on August 31, 2017 (Table A-3). Note that the status of some actions has been updated since that meeting to reflect the current status.

Table A-1. Meeting Date and Number Crosswalk

Meeting Date	Meeting Number
January 26, 2017	WMA A-AX-DQO-2017-1
March 1, 2017	WMA A-AX-DQO-2017-2
March 30, 2017	WMA A-AX-DQO-2017-3
April 13, 2017	WMA A-AX-DQO-2017-4
May 25, 2017	WMA A-AX-DQO-2017-5
June 15, 2017	WMA A-AX-DQO-2017-6
July 13, 2017	WMA A-AX-DQO-2017-7
July 24, 2017	WMA A-AX-DQO-2017-8
August 7, 2017	WMA A-AX-DQO-2017-9
August 31, 2017	WMA A-AX-DQO-2017-10

[1] The Hanford Site Administrative Record is available at: http://pdw.hanford.gov/arpir/.

Table A-2. Agreements Reached at WMA A-AX DQO Process Meetings

Date	Agreements
01/26/2017	1. DOE-ORP acknowledged the need for a Phase 2 RFI at WMA A-AX.
01/26/2017	2. Available tank waste and concrete condition information will be considered for inclusion in the RFI/CMS report(s).
01/26/2017	3. **Step 1**: **Problem Statement**: "Vadose zone contamination in and adjacent to the A-AX Tank Farms may pose a current and future risk to human health and the environment, including groundwater that requires corrective action to support closure."
03/30/2017; 07/13/2017	4. The DQO will move forward with a modified scope. The DQO Revision 0 will evaluate the Tanks A-104/105 focus area. It is agreed that there is a priority to collect additional information from the release areas associated with Tanks 241-A-104 and -105 in order to assess the movement of contamination in the environment. Information from the resulting investigation will inform the development of the model being developed for the 241-A/AX performance assessment.
05/25/2017; 07/24/2017	5. **Boundaries**: The parties agreed to revise Tank A-104/105 focus area horizontal boundary as shown on the first page of Handout #1 attached to the 05/25/2017 DQO meeting notes, a vertical boundary extending from ground surface to the groundwater, and a temporal boundary driven by planned retrieval operations. **Note**: The parties agreed to revise the Tank A-104/105 focus area horizontal boundary as shown in Figure 2 of Handout #1 attached to the 07/24/17 meeting notes.
05/25/2017; 07/13/2017 08/07/2017 08/31/2017	6. The parties agreed to the **scope, objectives, and DQO approach**: as described in Handout #2 attached to the 05/25/2017 DQO meeting notes. **Note**: Scope was subsequently modified as described in Agreement 4. Bullets describing the scope were modified to clarify that the WMA A-AX DQO process will not address data requirements for groundwater modification, as shown in Handout #1 attached to the 08/07/2017 meeting notes. Table 1 (Approach) was revised to respond to an Ecology comment as shown in Handout #2 attached to the 08/31/2017 meeting notes.
05/25/2017; 07/13/2017	7. **Step 2**: The parties agreed to the **Goal of the Study** as described in Handout #2 attached to the 05/25/2017 DQO meeting notes. **Note**: The Goal of the Study was subsequently modified as documented in Handout #2 of the DQO meeting notes dated 07/13/2017 (see Agreement 12).

Table A-2. Agreements Reached at WMA A-AX DQO Process Meetings

Date	Agreements
06/15/17; 08/07/2017 08/31/2017	8. The parties agreed to use the list of **constituents** contained in Handout #1 attached to the 06/15/2017 meeting notes, except that further discussion is required regarding volatile organics, semi-volatile organics, and hexavalent chromium. **Note**: Hexavalent chromium was added to the list as shown in the DQO meeting notes dated 08/07/2017. **Note**: (1) It was agreed that the A-104/105 focus area will not include VOC analysis. VOC analysis will be identified as "special study" instead of "eliminate" in Table 6. (2) For semi-volatiles, tributyl phosphate and bis(2-ethylhexyl)phthalate will be identified in Table 6 as "retain." These constituents will be added to Table 8, and analysis will be performed on samples from WMA A-AX and the focus area around Tanks A-104 and A-105.
06/15/2017 08/31/2017	9. **Step 3**: The parties agreed to the information in Handout # 2 attached to the 06/15/2017 meeting notes, describing the **basis for identification and setting of acceptable levels for decision and estimation statements**. **Note**: Table 4 was subsequently modified as documented in Handout #2 of the DQO meeting notes dated 08/31/2017.
06/15/2017 07/13/2017 08/31/2017	10. **Step 7**: The parties agreed to the information in Handout # 3 attached to the 06/15/2017 meeting notes, describing the **number of samples** that will be taken. **Note**: Text regarding surface sample duplicates was clarified as shown in the DQO meeting notes dated 07/13/2017. **Note**: Additional discussion is needed about text in Attachment #2 to the DQO meeting notes dated 08/31/2017 regarding depths at which PCBs and pesticides will be analyzed.
06/15/2017	11. The parties agreed to the **Step 4** information on pages 10-12 of Handout # 5 attached to the 06/15/2017 meeting notes, describing the **sampling unit**, **constraints to sampling/data collection**, and **smallest decision unit**. The second bullet under **Study Boundaries** will be corrected to reflect that samples taken at depths <15 ft bgs also support the ecological assessment.
07/13/2017; 08/31/2017	12. The parties agreed on the contents of **Step 2** as modified in the 07/13/17 meeting (Handout #2) and 08/31/2017 meeting (Handout #2).
07/13/2017	13. The parties accepted Table 5 (**Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization**) as shown in Handout #2 attached to the 07/13/2017 DQO meeting notes.
07/13/2017; 07/24/2017 08/07/2017	14. The parties agreed on the contents of **Step 4** as shown in Handout #2 attached to the 07/13/2017 DQO meeting notes. **Note**: The **horizontal boundary** defined under Step 4 was subsequently modified as documented under Agreement 5. **Note**: A typographical error under "**Smallest decision unit**" was corrected as shown in Attachment #1 to the DQO meeting notes dated 08/07/2017.

Table A-2. Agreements Reached at WMA A-AX DQO Process Meetings

Date	Agreements
07/24/2017; 08/07/2017; 08/31/2017	15. **Step 7**: Sampling **Strategy, General Collection, and Design**: The parties agreed to the field methodologies (sampling and logging), direct push locations for logging and sampling, drywell logging locations, and SGE electrode installation as described in the 7/24/2017 DQO meeting notes. **Note**: Corrections and clarifications are described in the meeting notes dated 08/07/2017 and 08/31/2017.
07/24/2017	16. **Step 3**: As described in the 7/24/2017 DQO meeting notes, the parties agreed on **physical properties** to be added to Table 6 (see Handout #3 attached to the 7/13/2017 DQO meeting notes) and Table 8 (see Handout #1 attached to the 07/13/2017 DQO meeting notes).
08/31/2017	17. **Step 6**: The attendees accepted Table 12 as shown in Handout #2 of the 8/31/2017 meeting notes.

Table A-3. WMA A-AX DQO Process Meeting Actions

Action Number	Actionee	Description	August 31, 2017, Status	November 2017 Status
2017-03-30-03	Lyon/Bovier	Ecology and DOE-ORP will identify whether there are other potential WMA A/AX focus areas of interest and their level of interest in other focus areas relative to the Tanks A-104/105 focus area.	Open. Ecology identified the areas near Tanks A-103, AX-102, and AX-104 as being of interest. Retain as open item for draft DQO summary report.	Remains open.
2017-04-13-02	Bovier/Lyon	Discuss how DQO Step 4, define the boundaries of the study, will be addressed for the whole of WMA A-AX.	Open. See related Action 2017-08-07-09. Retain as open item for draft DQO summary report.	Remains open.
2017-05-25-01	Tabor	Evaluate borehole placement/configuration after getting updated GPR results.	Open. On hold until conduct GPR study. Retain as open item for draft DQO summary report.	Remains open. If locations need to be refined, adjustments will be discussed with Ecology and documented in Sampling and Analysis Plan.
2017-08-07-05	Tabor	Provide Ecology WMA C Phase 2 language regarding use of 95% UCL.	Proposed text not accepted by Ecology. Retain as open item for draft DQO summary report.	Close. Action was to email WMA C Phase 2 language, which was provided 8/9/17 to Beth Rochette. Open UCL issue is covered in action 2017-08-31-08.
2017-08-07-09	Bovier/ Hildebrand	To support Action 2017-04-13-02, DOE representatives will meet to discuss how to address areas outside the WMA A-AX fenceline that are not yet identified in the 200-IS-1 Operable Unit.	Open. Retain as open item for draft DQO summary report.	Remains open.

Table A-3. WMA A-AX DQO Process Meeting Actions

Action Number	Actionee	Description	August 31, 2017, Status	November 2017 Status
2017-08-31-01	Tabor	ORP/WRPS will look into using a VOC field screening tool at A-104/105.	New.	Remains open. VOC field screening tools will not be used at Tanks A-104/105 focus area. They are not currently being used at Hanford for detecting soil contamination, and research will need to be performed. DOE-ORP/WRPS will continue to research for use at other focus areas.
2017-08-31-02	Tabor	Pull text from page 1 of 8/31/17 Handout #1 into DQO report ("Similar WMA C analyses…requirements of new laboratory contractors.").	New.	Close. Text has been incorporated into WMA A-AX DQO summary report.
2017-08-31-03	Bovier/Lyon	Ecology, DOE-ORP, and WRPS will continue discussions on where at WMA A-AX to perform a VOC study and what VOCs to analyze.	New.	Remains open.
2017-08-31-04	Tabor	Remove color coding from Table 6 to reduce confusion.	New.	Close. The revision has been incorporated into WMA A-AX DQO summary report.
2017-08-31-05	Tabor	Add justification for not doing dioxin/furan sampling at the A-104/105 focus area to the draft DQO summary report and to the DQO meeting handout.	New.	Close. Justification has been incorporated into WMA A-AX DQO summary report and revised handout provided as Attachment A1.
2017-08-31-06	Bovier/Hildebrand/ Lyon	Ecology, DOE-ORP, and WRPS will continue discussions regarding the need to analyze WMA A-AX vadose zone soil samples for dioxins and furans.	New.	Remains open. Preliminary groundwater data are being reviewed, and discussions with DOE-ORP and DOE-RL are ongoing.

Table A-3. WMA A-AX DQO Process Meeting Actions

Action Number	Actionee	Description	August 31, 2017, Status	November 2017 Status
2017-08-31-07	Tabor	When they become available, provide issued reports to Ecology with information about VOCs found in 200-DV-1 Operable Unit boreholes.	New.	Remains open. Preliminary groundwater data are being reviewed. No reports are available at this time.
2017-08-31-08	Bovier/Hildebrand/ Lyon	Ecology, DOE-ORP, and WRPS will continue discussions about WMA A-AX Decision Rule and Performance Criteria text on data evaluation (e.g., use of 95% UCL).	New.	Remains open. Text in DQO identifies that use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan. Additionally, cumulative risk calculations will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.
2017-08-31-09	Tabor	Text about groundwater information was presented to Ecology at the 8/31/17 meeting and was accepted. Incorporate the text into draft DQO summary report.	New.	Close. Text has been incorporated into WMA A-AX DQO summary report.
2017-08-31-10	Tabor/ Rochette	Ms. Tabor will email Table 6 revisions to Ms. Rochette, who will review and respond.	New.	Close. Table 6 was emailed to Ecology on 09/07/2017. Ecology responded by email on 09/07/17 and 09/08/17.
2017-08-31-11	Tabor/ Rochette	Ms. Tabor will email Table 8 revisions to Ms. Rochette, who will review and respond.	New.	Close. Table 6 was emailed to Ecology on 09/07/2017. Ecology responded by email on 09/07/17 and 09/08/17.

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ATTACHMENT A1

WMA A-AX DATA QUALITY OBJECTIVES (DQO) PROCESS SUMMARY HANDOUT

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WMA A-AX DATA QUALITY OBJECTIVES (DQO) PROCESS SUMMARY
Revised Hand Out

BACKGROUND INFORMATION

NOTE: REVISION 0 OF THIS DQO SUMMARY REPORT IS ASSOCIATED WITH FOCUS AREA TANKS A-104 AND A-105.

DQO Process

The DQO development is a seven-step process. The DQO process for WMA A-AX will be iterative, with revisions being prepared to address focus areas, as needed. It will be setup to ensure that the data needs to support the performance assessment (PA) and risk-informed retrieval process and ultimately the Phase 2 RFI/CMS efforts are achieved. The steps and the manner in which they will be applied at WMA A-AX are identified in Table 1 (**WMA-A/AX-DQO-2017-4**).

DQO Scope and objectives

The DQO scope was outlined as follows (**WMA-A/AX-DQO-2017-1 and WMA-A/AX-DQO-2017-6**):

- The DQO process will address vadose zone contamination in and around WMA A-AX to support the RCRA Facility Investigation (RFI).
- Data will be used to develop and refine the conceptual site model and assess risk to human health and the environment, including the future risk to groundwater to support the RFI and Appendix I Performance Assessment (IPA).
- If the risk assessment indicates a need to reduce risk to human health or the environment, the data will be used to evaluate alternatives in a CMS.
- The corrective action decisions supported by the data collected under this DQO will be consistent with and support final closure of WMA A-AX.
- This DQO will not address data requirements of SST residual waste sampling and analysis or other data required to address closure associated with ancillary equipment in the tank farm. These data requirements will be addressed in a separate DQO for the closure of the SST system.
- This DQO will not address data requirements for groundwater characterization. These data requirements will be addressed through the groundwater operable units associated with WMA A-AX; however, it is recognized that there is a need to integrate characterization and closure actions with ongoing and nearby operations and waste site/groundwater remedial actions.

DQO objectives (**WMA-A-AX-DQO-2017-3** for bullets 2 and 3, and **WMA-A/AX-DQO-2017-4** for bullet 1):

- Define the WMA A-AX vadose zone characterization data necessary to guide planning to make vadose zone soil remedial decisions, support an evaluation of risks by direct contact and to ecological receptors, and support integration of vadose zone and groundwater decisions.
- Optimize a data collection program that will be used to support the Phase 2 RFI/CMS characterization of WMA A-AX and to support risk-informed retrieval efforts.
- Support refining the preliminary conceptual site model.

Table 1. WMA A-AX DQO Approach		
Step	**Purpose of Step**	**WMA A-AX DQO Document Information**
1	**State the Problem** *Define the problem that necessitates the study, identify the planning team, examine budget, and schedule.*	**The problem statement will be the <u>same for each revision</u> of the DQO.** It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
2	**Identify the Goal of the Study** *State how environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes.*	**The goal of the study will be the <u>same for each revision</u> of the DQO.** It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
3	**Identify Information Inputs** *Identify data and information needed to answer study questions.*	**The information inputs will be the <u>same for each revision</u> of the DQO.** It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
4	**Define the Boundaries of the Study** *Specify the target population and characteristics of interest, define spatial and temporal limits, scale of inference.*	**Each revision will be specific to a focus area.**
5	**Develop the Analytical Approach** *Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions and findings.*	**The analytical approach will be the <u>same for each revision</u> of the DQO.** It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
6	**Specify Performance or Acceptance Criteria** *Specify probability limits for false acceptance decision errors.*	**Performance/Acceptance Criteria will be the <u>same for each revision</u> of the DQO.** It will address the overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS.
7	**Develop the Plan for Obtaining Data** *Select the resource-effective sampling and analysis plan that meets the performance criteria*	**Each revision will be specific to a focus area.**

Note: Steps that reflect the "overall issue of collecting WMA A-AX data to support the IPA, risk-informed retrieval process, and RFI/CMS" will be reviewed to determine if any specifics are needed for Focus Area Evaluation.

STEP 1 – DEFINE THE PROBLEM

Step 1 of the seven-step DQO process is to clearly define the problem (the reason analytical data are needed) so that the focus of the project is clear.

DQO problem statement

Considering the DQO scope, and after review of available information, the concise statement of the problem was identified as follows (**WMA-A-AX-2017-1**):

> ***Vadose zone contamination in and adjacent to the A-AX Tank Farm may pose a current and future risk to human health and the environment, including groundwater, which requires corrective action to support closure.***

The DQO project team is identified as follows (**WMA-A-AX-2017-1**; modifications proposed **WMA-A-AX-2017-5**):

Table 2. DQO Planning Team Members

Organization	Name	Function/Decision Authority
U.S. Department of Energy – Office of River Protection (ORP)	Jan Bovier	ORP Project Lead[a]
U.S. Department of Energy – Operations Office (RL)	Doug Hildebrand	RL Lead - Integration with 200-EA-1 and Groundwater OUs
Washington State Department of Ecology (Ecology)	Mike Barnes Jeff Lyon Joe Caggiano[b] Elizabeth Rochette Marysia Skorska Jim Alzheimer	Lead WMA A-AX DQO Tank Farms Project Manager[a] Technical Support Technical Support Technical Support Technical Support
Washington River Protection Solutions	Scott Luke Paul Rutland Cindy Tabor Ryan Childress Jim Field Robin Varljen Kristin Singleton/Marcel Bergeron Harold Sydnor Kathi Dunbar/Cris Lungu Steve McKinney/Paul Gassman Bob Hiergesell Duc Nguyen	DQO Facilitator Vadose Zone Project Director Project Lead Sampling Lead Leak Assessments and Process Knowledge Regulatory Compliance Risk Assessment Field Characterization/Sampling and Analysis QA Laboratory Interface WMA A-AX PA Integration DQO Oversight
CHPRC	Bert Day Mark Byrnes/Phil Burke Lee Brouilland/Jeremy Lynn Greg Thomas Curt Wittreich	200-EA-1 and 200-IS-1 200-DV-1 200-PO-1 200-BP-5 Groundwater OU Integration
Freestone Environmental Services, Inc.	Julie Robertson Kim Schuyler	Regulatory Support Regulatory Support
INTERA	Mahmudur Rahman	Risk Assessment/Regulatory Support

[a]Decision maker
[b]Team member through October 2017.

STEP 2 – IDENTIFY THE GOALS OF THE STUDY

Step 2 identifies the decisions or estimates that require new environmental data to solve the "problems" identified in Step 1. For a decision problem, the decision statement links a principal study question (PSQ) with a range of alternative actions that can occur upon answering the question. For an estimation problem, the estimation statement identifies what needs to be estimated or studied and possible study outcomes and key assumptions.

Estimation problem key information needs and assumptions:

- Data on vadose zone soil and tank waste radiological, chemical, and physical properties are needed to evaluate contaminant mobility in soil.
- Data are needed on (1) naturally occurring vadose zone soil constituents that could potentially be altered by contact with tank waste and (2) tank waste constituents that may remain in soil at detectable levels after the bulk of the waste has passed through portions of the soil. These data could provide information about where tank waste may have passed through portions of the soil.

Goal of the study (**WMA-A-AX-2017-1**)

The goal is to ensure the appropriate vadose zone soil characterization data needs are identified to support corrective measure decisions for WMA A-AX.

The following note will be included in the DQO summary report: "It is recognized that there is a need to integrate characterization and closure actions with ongoing and nearby operations and waste site/groundwater remedial actions."

The Principal Study Questions, Alternative Actions, and Decision/Estimation Statements are described in Table 3. Data supporting the DQO effort (collected prior to and collected using this DQO process) will be used to develop and refine the conceptual site model.

Table 3. Principal Study Questions, Alternative Actions, and Decision/Estimation Statements

Principal Study Question (PSQ)	Proposed Alternative Actions (AA)	Decision/Estimation Statement (DS/ES)
#1— Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	If contamination exceeds acceptable levels, evaluate the need for corrective measures; otherwise, document that corrective action is not required.	**#DS 1** — Determine whether contamination exceeds acceptable levels and, therefore, whether there is a need to evaluate corrective measures.
#2 – Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 2** – The chemical/physical properties of A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. It is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil.
#3 – Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 3** – The chemical/physical properties of A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. It is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil.
#4 – Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 4** – Chemicals and radionuclides in tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated. It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through those portions of the soil. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through those portions of the soil.
Note: Estimation Statements for Focus Area Tanks A-104/105 support the continued development of the conceptual site model, support risk informed retrieval, and evaluate leak assessment interpretation.		

STEP 3 - DATA INPUTS

The purpose of Step 3 is to identify the types and sources of information needed to resolve the PSQs identified in Step 2.

Per EPA QA/G-4 the major outputs of Step 3 are:

- *Identification of the **types** (e.g., chemical/physical properties), **as well as sources** of information needed to resolve the decision or estimates*
- *Identification of the **basis** of information (e.g., regulations, guidance, and permits) that will guide or support choices to be made in later steps of the DQO process; information on the number of variables (analytes) that will need to be collected; and types of information (e.g., acceptable levels, uncertainty requirements) needed to meet performance or acceptance criteria*
- *Selection of, and information on the performance of, appropriate **sampling and analysis methods** for generating the information.*

Table 4 identifies bases for identification and setting of acceptable levels for the WMA A-AX decision and estimation statements. The contents of Table 4 were presented for discussion during DQO meeting **WMA-A-AX-DQO-2017-6** and were accepted as presented.

Table 5 identifies a range of field and analytical methods (e.g., ground penetrating radar, geophysical logging, and direct push) that could be used for vadose zone soil characterization. The contents of Table 5 were presented for discussion during DQO meeting **WMA-A-AX-DQO-2017-4**.

Table 4. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data		Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
#1 Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	Radiological (Analytical and geophysical)	Shallow zone (≤4.6m [≤15 ft] bgs)	• Previously reported analytical data • Previously reported geophysical data • Collect additional soil samples for laboratory analysis • Perform additional geophysical logging • Field screening with radiological detection equipment	CERCLA • Ecological protection • Residential[a] • Tribal[a] • Outdoor worker
		Deep zone (>4.6m [>15 ft] bgs)	• Previously reported analytical data • Previously reported geophysical data • Collect additional soil samples for laboratory analysis • Perform additional geophysical logging • Field screening with radiological detection equipment	CERCLA • Construction worker
		Ground surface to water table	• Previously reported analytical data • Collect additional soil samples for laboratory analysis	CERCLA • Groundwater Protection[b]

Table 4. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data		Potential Sources for Information Inputs	Basis for Setting Acceptable Levels

#1 Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	Chemical and Physical properties (Analytical and geophysical)	Shallow zone (≤4.6m [≤15 ft] bgs)	• Previously reported analytical data
			• Collect additional soil samples for laboratory analysis
				CERCLA
				• Ecological protection
				• Residential[a]
				• Tribal[a]
				• Outdoor worker
				WAC
				• Direct contact
				  ○ Unrestricted Land Use (WAC 173-340-740 and -750[c], Method B)
				  ○ Industrial Properties (WAC 173-340-745 and -750[c], Method C)

		Ground surface to water table	• Previously reported analytical data • Collect additional soil samples for laboratory analysis	WAC • Groundwater Protection[b]

Table 4. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data	Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
		Estimation	
#2 — Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	• Technical evaluation: Physical properties (e.g., bulk density, pH, and hydraulic properties)	• Information from previous investigations • Collect additional soil samples • Batch and column leach tests • Sequential extraction tests	Acceptable levels do not apply for preliminary conceptual site model evaluation. This is a judgmental assessment.
#3 — Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	• Technical Evaluation: Leaching characteristics of tank waste based on batch and column leaching tests • Technical Evaluation: Sequential extraction to estimate the labile fraction (readily leachable fraction) of constituents • Technical Evaluation: Mineral phase identification within the tank waste residuals • Technical Evaluation: Physical properties (e.g., bulk density and pH)	• Process history • Residual waste inventory • Batch leaching kinetics and partitioning behavior of tank waste • Leaching kinetics of tank waste	Acceptable levels do not apply for preliminary conceptual site model evaluation. This is a judgmental assessment.

Table 4. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements

PSQ	Type of Data	Potential Sources for Information Inputs	Basis for Setting Acceptable Levels
#4 — Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?	Fate and transport inputs: • Technical Evaluation: Mineralogical changes due to waste-sediment interaction and mineral phase identification • Chemical and Radiological - Pore water and sediment tests (sequential extraction such as water extraction, bicarbonate extraction, acetic acid extraction, oxalic acid extraction, and total digestion) • Technical Evaluation: pH variations	• Documentation and history of releases from SSTs • Documentation of Unplanned Releases • Documentation and history of other releases • Previous investigations: o RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area* o RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX* • Conduct additional surface geophysical exploration • Results and conclusions resulting from any new geophysical logging or soil sample collection	Acceptable levels do not apply for preliminary conceptual site model evaluation. This is a judgmental assessment.

Note: Relevant background level information is contained in the following documents:

- DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*
- DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*
- ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*

[a]Residential and tribal scenarios will be evaluated to assist interested parties in providing input on the remedial alternatives as part of the CERCLA modifying criteria.

[b]Groundwater protection evaluations will be consistent with WAC 173-340-747. Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

[c]The acceptable levels for inhalation exposure, protective of human health and the environment have not been developed at this time. During the total risk determination, chronic daily intake, individual excess lifetime cancer risk, and non-cancer hazard index from inhalation of dust and vapors in ambient air will be calculated. Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

ft bgs = feet below ground surface

Table 4. Basis for Identification and Setting of Acceptable Levels for Decision and Estimation Statements			
PSQ	**Type of Data**	**Potential Sources for Information Inputs**	**Basis for Setting Acceptable Levels**
SST = single-shell tank WAC = *Washington Administrative Code* References: RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area* RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX* WAC 173-340, "Model Toxics Control Act—Cleanup"			

Table 5. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
Ground Penetrating Radar (GPR): Radar-reflection surface geophysical survey technique that detects contrasts in di-electric constants in the below-grade environments from the surface.	Underground structures or interferences	Requires subjective interpretation of the reflected signals. Lack of reflective below-grade surfaces or the presence of interfering matrices can complicate or invalidate the findings. The presence of nearby buildings and utilities can interfere with reflected signals. Fines (e.g., clay and heavy fly ash) can act as a reflector to the radar signal.
Electromagnetic Induction (EMI): Surface geophysical survey technique that measures electrical conductivity in below-grade soils based on detected changes in electrical fields. Generally used to support the interpretation of GPR surveys.		The presence of nearby buildings and utilities can interfere with reflected signals.
Surface Geophysical Exploration: Electrical Resistivity Imaging can be acquired to develop shallow and deep, 2-dimensional and 3-dimensional images.	Resistivity (conductivity)	Results are impacted by interference from infrastructure such as pipelines, tanks, buildings, and other large features.
Large Diameter Hole (LDH) Conventional Drilling (e.g., cable tool):	Geophysical Logging and Laboratory Analysis	Most drilling methods have difficulty in cobbles and boulders. Waste/tailings are brought to the surface and need to be properly contained and disposed, increasing cost and risk of exposure to workers. Not viable for new exploration in the tank farms due to waste generation and logistics (e.g., dome loading and access).
LDH Geophysical Logging	Gross and isotopic gamma emissions	Larger size instrument has lower detection limits (more sensitive) but does not fit into a small diameter hole (SDH) (<3-inch); therefore, is not a compatible technology for use with direct push methods. The count rate can effect accuracy and precision of measurements.

Table 5. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization		
Potentially Appropriate Field Method/Analytical Method	**Parameter**	**Possible Limitations**
	Gamma emissions from fission products, Am-241, Pu-239, and Np-237 It is considered by some to be more accurate than sampling and laboratory assay because the assay is performed in situ with less disturbance of the sample, there is higher vertical spatial resolution, and the sample size is much larger. This method may also be more economical than traditional sampling and analysis.	This method does not assess radionuclides or daughter products that do not emit gamma rays. The gamma energies from these isotopes are at the low end of the spectrum, which results in high numerical minimum detectable activities and possible matrix effects from other isotopes. This technique requires the use of a single casing (installed by drilling or driving) in contact with the soil formation. The detector is too large to fit in a SDH (<3-inch); therefore, is not a compatible technology for use with direct push methods.
	Neutron emissions from plutonium	Because of the very low incidence of spontaneous plutonium fission and alpha-N reactions, the passive neutron profile is orders of magnitude lower than the gamma emission. The detector is too large to fit in a SDH (<3-inch); therefore, is not a compatible technology for use with direct push methods.
	Active neutron emissions from transuranics	Although neutron activation methods have been developed, they are not expected to be useful for this initial characterization effort. At present, these techniques are too expensive and time consuming, and logistical problems are associated with the handling of intense sources or generators. The detector is too large to fit in a SDH (<3-inch); therefore, is not a compatible technology for use with direct push methods.
	Beta emissions	Not a fully developed technology.
	Neutron moisture	Moisture zones can be very thin and can be missed based on data collection intervals (distance and time).
	Temperature	Difficult differentiating/determining source and extent of high temperatures (e.g., soil versus infrastructure).
Laboratory Analysis for LDH	Chemical and radiological constituents and physical properties	Highly contaminated samples may require use of on-site laboratories, with associated impacts (e.g., high cost, reduced analyte lists, matrix effects, degraded detection limits, and long turnaround times). Lower contamination levels may allow use of offsite laboratories, avoiding these limitations.
Small Diameter Hole (SDH) Direct Push	Geophysical Logging and Laboratory Analysis	Direct-push methods may be ineffective in cobbly or rocky soils.

Table 5. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
SDH Geophysical Logging	Gross and isotopic gamma emissions	The smaller diameter detectors are not as sensitive as those used in LDH (Detection limits are not as low from instruments used in LDH.)
	Beta emissions	Not a fully developed technology.
	Neutron moisture	Moisture zones can be very thin and can be missed based on data collection intervals (distance and time).
	Temperature	Difficult differentiating/determining source and extent of high temperatures (e.g., soil versus infrastructure).
Laboratory Analysis for SDH	Chemical and radiological constituents and physical properties	Small sample size leads to difficulty to with large analysis list and low detection limits.

Note: Reinterpreting available data (e.g., surface geophysical exploration data) and/or determine if analysis on existing cores could be performed.

GPR = ground penetrating radar

LDH = large diameter hole

SDH = small diameter hole

Table 6 provides a list of constituents and identifies which constituents will be retained, eliminated, or evaluated through a "Special Study" of WMA A-AX vadose zone soil. The contents of Table 6 were presented for discussion during DQO meeting **WMA-A-AX-DQO-2017-6**, and several changes were incorporated as a result of the discussion. Inclusion of physical properties was discussed and agreed upon in DQO meeting **WMA-A-AX-DQO-2017-8.**

Constituents in the "Special Study" study category will be reviewed for each WMA A-AX focus area to determine if they should be analyzed. Tables will be generated to identify recommended laboratory methods and acceptable levels. These new tables will be included in revisions to this DQO, as needed.

Dioxins and furans are not included in RPP-RPT-38152, RPP-23403, or Standard Best Basis Inventory list for tank waste but were added to groundwater monitoring per DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX*. Ecology indicated that the dioxins and furans should be considered for sampling in the southern portion of A Farm. Further discussions will continue on performing analysis of dioxins and furans in vadose zone soil samples. Analysis has not been performed on vadose zone soil samples from the tank farm area and determinations will need to be made on such things as volumes needed to perform analysis, and if these volumes are achievable based on sampling methodology in the tank farms.

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Metals					
Aluminum – Al	P (E, R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Antimony – Sb	P (E, R, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Arsenic – As	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Barium – Ba	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Beryllium – Be	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Bismuth – Bi	S	X	X	Retain	Constituent listed in WMA C and SST DQO.
Boron – B	S	X		Retain	Constituent listed in WMA C and SST DQO.
Cadmium – Cd	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Calcium - Ca	P[f]	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cerium – Ce	S	X		Retain	Retained based on tank waste and self boiling tanks. The rare earths are naturally occurring in the vadose zone.
Chromium – Cr	P (A, E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Chromium - hexavalent (CrVI)	-[g]			Retain (can be analyzed rather than estimated from total chromium)	Constituent of interest due to toxicity. The holding time for soil samples is 30 days from collection to analysis.
Cobalt – Co	P (E, R, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Copper – Cu	P (E, R, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Europium – Eu	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Iron – Fe	P (R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Lanthanum – La	S	X	X	Retain	Retain based on BBI detections. The rare earths are naturally occurring in the vadose zone.
Lead – Pb	P (A, E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Lithium - Li	P[f]	X		Retain	Constituent listed in WMA C and SST DQO. Not part of tank waste but added as part of tracer for hydrostatic head fluid (as lithium bromide).
Magnesium - Mg	P[f]	X		Retain	Constituent listed in WMA C and SST DQO.
Manganese – Mn	P (E, R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Mercury – Hg	P (A, E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Molybdenum - Mo	P[f]	X		Retain	Constituent listed in WMA C and SST DQO.
Neodymium – Nd	S	X		Retain	Retain based on tank waste and self boiling tanks. The rare earths are naturally occurring in the vadose zone.
Nickel – Ni	P (E, U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Niobium – Nb	S	X		Eliminate	Naturally occurring in the vadose zone.
Palladium – Pd	S	X		Eliminate	Naturally occurring in the vadose zone.

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Phosphorus - P	P[f]	X		Retain	Constituent listed in WMA C and SST DQO.
Potassium - K	P[f]	X	X	Retain	Constituent listed in WMA C and SST DQO.
Praseodymium – Pr	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Rhodium – Rh	S	X		Retain	Constituent listed in WMA C and SST DQO.
Rubidium – Rb	S	X		Eliminate	Naturally occurring in the vadose zone.
Ruthenium – Ru	S	X		Eliminate	Naturally occurring in the vadose zone.
Samarium – Sm	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Selenium – Se	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Silicon – Si	S	X	X	Retain	Retain based on BBI detections. Silicon is part of the media being analyzed (sand, gravel and silt and clay).
Silver – Ag	P (A, E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Sodium - Na	P[f]	X	X	Retain	Constituent listed in WMA C and SST DQO.
Strontium – Sr	P (R)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Sulfur – S	S	X		Retain	Constituent listed in WMA C and SST DQO.
Tantalum – Ta	S	X		Retain	Constituent listed in WMA C and SST DQO.
Tellurium – Te	S	X		Eliminate	Naturally occurring in the vadose zone.
Thallium – Tl	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Thorium – Th	S	X		Retain	Retain to review isotopic thorium. Naturally occurring in the vadose zone.
Tin – Sn	S	X		Retain	Constituent listed in WMA C and SST DQO.
Titanium – Ti	S	X		Eliminate	Naturally occurring in the vadose zone.
Tungsten – W	S	X		Retain	Constituent listed in WMA C and SST DQO.
Uranium – U	P (E, R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Vanadium – V	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Yttrium – Y	S	X		Eliminate	The rare earths are naturally occurring in the vadose zone.
Zinc – Zn	P (E, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Zirconium – Zr	S	X	X	Retain	Constituent listed in WMA C and SST DQO.
Miscellaneous Constituents					
Ammonium – NH4+	P (W)	X		Retain	Constituent listed in WMA C and SST DQO.
TOC (total organic carbon)			X	Add	Based on BBI detections.
Anions					
Acetate – C2H3O2-	P (R)	X	X	Retain	Constituent listed in WMA C and SST DQO.

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Bromide Br-	S	X		Retain	Constituent listed in WMA C and SST DQO.
Chloride – Cl-	P	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cyanide – CN-	P (A, U, W)	X		Retain	Constituent listed in WMA C and SST DQO.
Ferrocyanide – Fe(CN)64-	P (A, U, W)	X		Eliminate	No ferrocyanide waste in WMA A-AX tank waste.
Fluoride – F-	P (U, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Formate – CHO2-	P (R)	X		Retain	Constituent listed in WMA C and SST DQO.
Glycolate – C2H3O3-	P (R)	X		Retain	Constituent listed in WMA C and SST DQO.
Nitrate – NO3-	P (R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Nitrite – NO2-	P (R, W)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Oxalate – C2O42-	P (R)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Phosphate – PO4	S	X	X	Retain	Constituent listed in WMA C and SST DQO.
Sulfate – SO42-	P	X	X	Retain	Constituent listed in WMA C and SST DQO.
Sulfide – S2-	D[b, c]			Eliminate	Sulfides were not routinely used in Hanford Site processes. Limited use of sulfide may have occurred during the ferrocyanide processing of cesium-137 in the tanks. The other possible source of sulfides would be from the reduction of sulfates. However, this is unlikely in the high nitrate tank waste matrices. Soluble sulfide is not very stable and is easily oxidized by air. Any sulfide remaining in the waste is most likely present as insoluble metal sulfide. In addition, previous analyses of tank waste have not detected sulfides in the Hanford Site tanks.
Volatile Organic Compounds					WMA C, containing no self-boiling tanks, received much of the organic waste (OWW). Note that sampling for organics was discontinued at the WMA C as they were only detected a few times[b, c]. WMA A-AX, containing self-boiling tanks, received less organic waste (OWW) than WMA C (HNF-3588, RPP-21854, HNF-4240). Additionally, total organic carbon, an overall indicator of organics, is not associated with Tanks A-104 and A-105 (BBI shows 0 kg for total organic carbon).
1,1,1-Trichloroethane (TCA)	D[b, c]	X		Special Study	
1,1,2,2-Tetrachloroethane	D[b, c]	X		Special Study	
1,1,2,2-Tetrachloroethene (PCE)	D[b, c]	X		Special Study	
1,1,2-Trichloro-1,2,2-trifluoroethane	D[b, c]	X		Special Study	
1,1,2-Trichloroethane	D[b, c]	X		Special Study	
1,1,2-Trichloroethylene (TCE)	D[b, c]	X		Special Study	
1,1-Dichloroethene	D[b, c]	X		Special Study	
1,2-Dichloroethane	D[b, c]	X		Special Study	
2-Butanone (MEK, methyl ethyl ketone)	D[b, c]	X		Special Study	
2-Nitropropane	D[b, c]	X		Special Study	

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2-Propanone (Acetone)	D[b, c]	X		Special Study	
4-Methyl-2-pentanone (MIBK, methyl isobutyl ketone))	D[b, c]	X		Special Study	
Benzene	D[b, c]	X		Special Study	
Carbon disulfide	D[b, c]	X		Special Study	
Carbon tetrachloride	D[b, c]	X		Special Study	
Chlorobenzene	D[b, c]	X		Special Study	
Chloroethene (vinyl chloride)	D[b, c]	X		Special Study	
Chloroform	D[b, c]	X		Special Study	
Dichloromethane (methylene chloride)	D[b, c]	X		Special Study	
Diethyl ether	D[b, c]	X		Special Study	
Ethyl Acetate	D[b, c]	X		Special Study	
Ethylbenzene	D[b, c]	X		Special Study	
m-Xylene	D[b, c]	X		Special Study	
n-Butyl alcohol (1-butanol)	D[b, c]	X		Special Study	
o-Xylene	D[b, c]	X		Special Study	
p-Xylene	D[b, c]	X		Special Study	
Toluene	D[b, c]	X		Special Study	
trans-1,3-dichloropropene	D[b, c]	X		Special Study	
Trichlorofluoromethane	D[b, c]	X		Special Study	
Xylenes	D[b, c]	X		Special Study	
Cis-1,2-dichloroethylene[d]	D[b, c]			Special Study	
Trans-1,2-dichloroethylene[e]	D[b, c]			Special Study	
Isobutanol (isobutyl alcohol)	D[b, c]	X		Special Study	
Semivolatile Organic Compounds					WMA C, containing no self-boiling tanks, received much of the organic waste (OWW). Note that sampling for organics was discontinued at the WMA C as they were only detected a few times. WMA A-AX, containing self-boiling tanks, received less organic waste (OWW) than WMA C (HNF-3588, RPP-21854, HNF-4240). Additionally, total organic carbon, an overall indicator of organics, is not associated with Tanks A-104 and A-105 (BBI shows 0 kg for total organic carbon).
1,1-Biphenyl	S			Eliminate	
1,1-Dimethylhydrazine	S	X		Eliminate	
1,2,4-Trichlorobenzene	P (E, U, W)	X		Eliminate	

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
1,3-Dichlorobenzene	S	X		Eliminate	
1,4-Dichlorobenzene	S	X		Eliminate	
1,4-Dinitrobenzene	S	X		Eliminate	
2,4,5-Trichlorophenol	P (A, E, U)	X		Eliminate	
2,4,6-Trichlorophenol	P (E, U)	X		Eliminate	
2,4-Dinitrotoluene	P (A)	X		Eliminate	
2,6-Bis (tert-butyl)-4-methylphenol	P (A, W)	X		Eliminate	
2-Chlorophenol	P (U)	X		Eliminate	
2-Ethoxyethanol (cellosolve solvent)	P (A)	X		Eliminate	
2-Methylphenol (o-cresol)	P(A)	X		Eliminate	
2-sec-Butyl-4,6-dinitrophenol (Dinoseb)	S	X		Eliminate	
3-Methyl-2-butanone	S	X		Eliminate	
4-Methylphenol (p-cresol, 3+4-Methylphenol (m+p-cresol))	P (A)	X		Eliminate	
Acenaphthene	P (E, U)	X		Eliminate	
Acetophenone	S	X		Eliminate	
Benzo(a) anthracene	P (in D&D-30262)			Eliminate	
Benzo(a)pyrene	P (E, in D&D-30262)	X		Eliminate	
Benzo(b)fluoranthene	P (in D&D-30262)			Eliminate	
Benzo(k)fluoranthene	P (in D&D-30262)			Eliminate	
Bis(2-ethylhexyl)phthalate	P (in WMP-28945)			Retain	Ecology requested.
Butylbenzylphthalate	P (U)	X		Eliminate	
Chrysene	P (in D&D-30262)			Eliminate	
Cresylic acid (cresol, mixed isomers) (Total Cresols)	P (A)	X		Eliminate	
Cyclohexanone	P (A, W)	X		Eliminate	
Dibenz(a,h)anthracene	P (in D&D-30262)	X		Eliminate	
Di-n-butylphthalate	P (E, U)	X		Eliminate	
Di-n-octylphthalate	P (U)	X		Eliminate	
Fluoranthene	P (U)	X		Eliminate	
Hexachlorobutadiene	P (A, W)	X		Eliminate	

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Hexachloroethane	P (A)	X		Eliminate	
Hexachloronaphthalene	S	X		Eliminate	
Hexafluoroacetone	S	X		Eliminate	
Indeno (1,2,3-cd) pyrene	P (in D&D-30262)			Eliminate	
Isodrin	S	X		Eliminate	
m-Cresol (3-Methylphenol)	P (A)	X		Eliminate	
Methylhydrazine	S	X		Eliminate	
N,N-Diphenylamine	S	X		Eliminate	
Naphthalene	P (U)	X		Eliminate	
Nitric acid, propyl ester	S	X		Eliminate	
Nitrobenzene	P (A, E, W)	X		Eliminate	
N-Nitrosodi-n-butylamine	S	X		Eliminate	
N-Nitroso-di-n-propylamine	P (U)	X		Eliminate	
N-Nitrosomethylethylamine	S	X		Eliminate	
N-Nitrosomorpholine	P (U)	X		Eliminate	
N-Nitroso-N, N-dimethylamine	S	X		Eliminate	
Octachloronaphthalene	S	X		Eliminate	
1,2-Dichlorobenzene (o-Dichlorobenzene)	P (A, W)	X		Eliminate	
2-Nitrophenol (o-Nitrophenol)	P (U)	X		Eliminate	
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	P (U)	X		Eliminate	
Pentachloronaphthalene	S	X		Eliminate	
Pentachloronitrobenzene (PCNB)	S	X		Eliminate	
Pentachlorophenol	S	X		Eliminate	
Phenol	S	X		Eliminate	
p-Nitrochlorobenzene	S	X		Eliminate	
Pyrene	P (U)	X		Eliminate	
Pyridine	P (A, W)	X		Eliminate	
Tetrachloronaphthalene	S	X		Eliminate	
Toxaphene	S	X		Eliminate	

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Tributyl phosphate	P (R, W)	X		Retain	Selected indicator organic for the occurrence of any organic contamination associated with tank waste[b]. Ecology requested.
Dibutyl phosphate	D[b, c]			Eliminate	
Ethylene glycol	D[b, c]			Eliminate	
Monobutyl phosphate	D[b, c]			Eliminate	
Pesticides					Pesticides are not associated with tank waste generation and storage but are associated with operation and maintenance activities. Specifically, these activities could have resulted in the release of potentially hazardous constituents on the ground surface. These constituents were only analyzed in the top 15 ft of soil at WMA C (RPP-PLAN-38777, Rev.0).
Aldrin	P	X		Retain	Constituent listed in WMA C and SST DQO.
alpha-BHC, beta-BHC, gamma-BHC	P	X		Retain	Constituent listed in WMA C and SST DQO.
Chlordane	P			Retain	Constituent listed in WMA C and SST DQO.
DDT/DDD/DDE (total)	P			Retain	Constituent listed in WMA C and SST DQO.
Dieldrin	P	X		Retain	Constituent listed in WMA C and SST DQO.
Endrin	P	X		Retain	Constituent listed in WMA C and SST DQO.
Heptachlor/heptachlor epoxide (total)	P			Retain	Constituent listed in WMA C and SST DQO.
Hexachlorobenzene	P	X		Retain	Constituent listed in WMA C and SST DQO.
Gasoline-Range Organics/Diesel-Range Organics					
Gasoline-Range Organics	D[b, c]			Eliminate	
Diesel-Range Organics	D[b, c]			Eliminate	
Polychlorinated Biphenyls					These constituents were only analyzed in the top 15 ft of soil at WMA C (RPP-PLAN-38777, Rev.0).
Aroclors (1016, 1221, 1232, 1242, 1248, 1254, 1260)	P	X		Retain	Constituent listed in WMA C and SST DQO.
Congeners	D[b, c]			Eliminate	
Radionuclides					
Americium-241	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Antimony-125	P (Risk assessment)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Carbon-14	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cesium-137	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cobalt-60	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Curium-242	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Curium-243	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Curium-244	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Europium-152	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Europium-154	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Europium-155	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Iodine-129	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Neptunium-237	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Nickel-63	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-238	P (10 CFR 61.55)		X	Retain	Constituent listed in WMA C DQO.
Plutonium-239	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-240	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-241	P (10 CFR 61.55)		X	Retain Estimated from Pu-238 and Pu-239/240	Constituent listed in WMA C DQO.
Radium-226			X	Retain	Retain based on BBI detections. TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Selenium-79	P (Risk assessment)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Strontium-90	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Technetium-99	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Thorium-228	P (Possibly significant in some tanks)	X		Eliminate	TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Thorium-230	P (Possibly significant in some tanks)	X		Eliminate	TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Thorium-232	P (Possibly significant in some tanks)	X	X	Retain	Retain based on BBI detections. TPA-CN-668 removed radium-226 and -228 from DV-1 SAP. Potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232 are naturally occurring background radionuclides identified by consensus of Tri-Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Thorium-234	P (In WMP-28945)			Eliminate	Short half-life.
Tin-126	P (Risk assessment)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Tritium	P (10 CFR 61.55)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-233	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-234	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Uranium-235	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-236	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-238	P (Potential major activity contributor)	X	X	Retain	Constituent listed in WMA C and SST DQO.
Physical Properties					
Bulk density	X	X		Retain	Physical property listed in WMA C and SST DQO.
pH	X	X		Retain	Physical property listed in WMA C and SST DQO.
Percent solids				Retain	Performed at WMA C, not identified in DQO.
Percent water	X	X		Retain	Physical property listed in WMA C and SST DQO.
Specific conductance				Retain	Performed at WMA C, not identified in DQO.
Particle size distribution				Retain	Particle size distribution will be performed by the laboratory if sample volume is sufficient.
Porosity				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Total alkalinity				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Redox potential				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Total inorganic carbon				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Physical Property Evaluations					
Hydraulic properties				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Iron content and iron association				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Mineral phase identification				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.
Leaching characteristics				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.

Table 6. WMA A-AX Constituent Rationale

Constituent	*Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation / Corrective Measures Study* (RPP-RPT-38152, Rev 0)[a]	*Single-Shell Tank Component Closure Data Quality Objectives* (RPP-23403, Rev. 6)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Sequential extraction				Special Study	Additional physical properties will be considered for focus areas where sufficient sample volumes can be collected.

Note:

a. P=Primary and S=Secondary as defined in RPP-PLAN-38777, Rev.3, *Sampling and Analysis Plan for Phase 2 Characterization of Vadose Zone Soil in Waste Management Area C.*
Discontinued (D) constituents were documented in RPP-PLAN-38777, Rev.3. Letters inside the parenthetical identify that reason why a constituent was categorized as primary per RPP-RPT-38152, Rev 0: A = Part A constituent, E= Ecological risk assessment, R = Risk assessment constituent, U = UHC (underlying hazardous constituent), and W = constituent in PNNL-12040, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, WMP-28945, *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process*, and D&D-30262, *Data Quality Objectives Summary Report for the 200-IS-1 Operable Unit Pipelines and Appurtenances*.

b. 11-TPD-020, "Organic Analyses Optimization for Waste Management Area (WMA) C"

c. 11-NWP-053, "Re: Organic Analyses Optimization for Waste Management Area (WMA) C"

d. Cis-1,2-dichloroethylene was incorrectly identified as Cis-1,2-dichlorobenzene (CAS Number 156-59-2) in RPP-RPT-38152.

e. Trans-1,2-dichloroethylene was incorrectly identified as Trans-1,2-dichlorobenzene (CAS number 159-60-5) in RPP-RPT-38152.

f. Moved from secondary to primary during WMA C field investigation to help in the evaluation of whether or not tank fluids have passed through the vadose zone soil.

g. Total chromium was used to estimate hexavalent chromium concentrations. Hexavalent chromium was not analyzed at WMA C and therefore did not have a "P" or "S" designation.

BBI = Best-Basis Inventory
CAS = Chemical Abstracts Service
DDD = Dichlorodiphenyldichloroethane
DDE = Dichlorodiphenyldichloroethylene
DDT = Dichlorodiphenyltrichloroethane
PCB = polychloride biphenyl
SAP = sampling and analysis plan
SST = single-shell tank
Tri-Party = Ecology, EPA, and DOE
WMA C = Waste Management Area C

References:

DV-1 SAP = DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*
SST DQO = RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*
WMA C DQO = RPP-RPT-38152, *Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation/Corrective Measures Study*

10 CFR 61.55, "Licensing Requirements for Land Disposal of Radioactive Waste," "Waste Classification"
HNF-3588, *Organic Complexant Topical Report*
HNF-4240, *Organic Solvent Safety Issue Resolution*
RPP-21854, *Occurrence and Chemistry of Organic Compounds in Hanford Site Waste Tanks*

STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

Identify the target population of interest and specify the spatial and temporal features pertinent for decision making or estimation.

Per EPA QA/G-4, the major outputs of this step are as follows:

- *Definition of the target population with detailed descriptions of geographic limits (spatial boundaries)*
- *Detailed descriptions of what constitutes a sampling unit*
- *Time frame appropriate for collecting data and making the decision or estimate, together with those practical constraints that may interfere with data collection*
- *The appropriate scale for decision making or estimation.*

Focus Area

Around Tanks A-104 and A-105

Target Population

Vadose zone soil (surface to groundwater)

Study Boundaries (WMA-A/AX-DQO-2017-5; WMA-A/AX-DQO-2017-6, WMA-A/AX-DQO-2017-8)

Soil depths associated with the vertical spatial area correspond to the depths identified in Table 4:

- ≤15 ft bgs (shallow zone)
- >15 ft bgs to groundwater (deep zone).

The vertical boundary is from the ground surface to the capillary fringe immediately above groundwater. The horizontal spatial boundary for this focus area is the soil near Tanks A-104 and A-105 as shown in Figure 1 as agreed to during DQO meeting **WMA-A/AX-DQO-2017-8**.

The temporal boundary for data collection for this focus area is prior to retrieval of Tanks A-104 and A-105. The temporal boundary for the overall data collection in the WMA A-AX area will be the final CMS for WMA A-AX. Because the data will represent the condition of the contamination in the vadose zone between now and when the final CMS is completed, the timing of the sample collection must reflect these conditions. It is anticipated that this DQO will be in effect until the sampling and analysis for the soil remedy selection for WMA A-AX is complete.

Note that sampling or other data collection should be integrated with similar activities whenever possible to realize efficiencies.

Sampling Unit

The smallest sampling unit is the volume of material needed to conduct analytical testing. Note that there are various constraints that can impact the amount of volume that can be collected within tank farms. Table 7 identifies the practical constraints on data collection. The contents of Table 7 were presented for discussion during DQO meeting **WMA-A-AX-DQO-2017-6** and were accepted as presented.

Constraints to sampling/data collection (WMA-A-AX-DQO-2017-6)

The practical constraints associated with data collection are shown in Table 7.

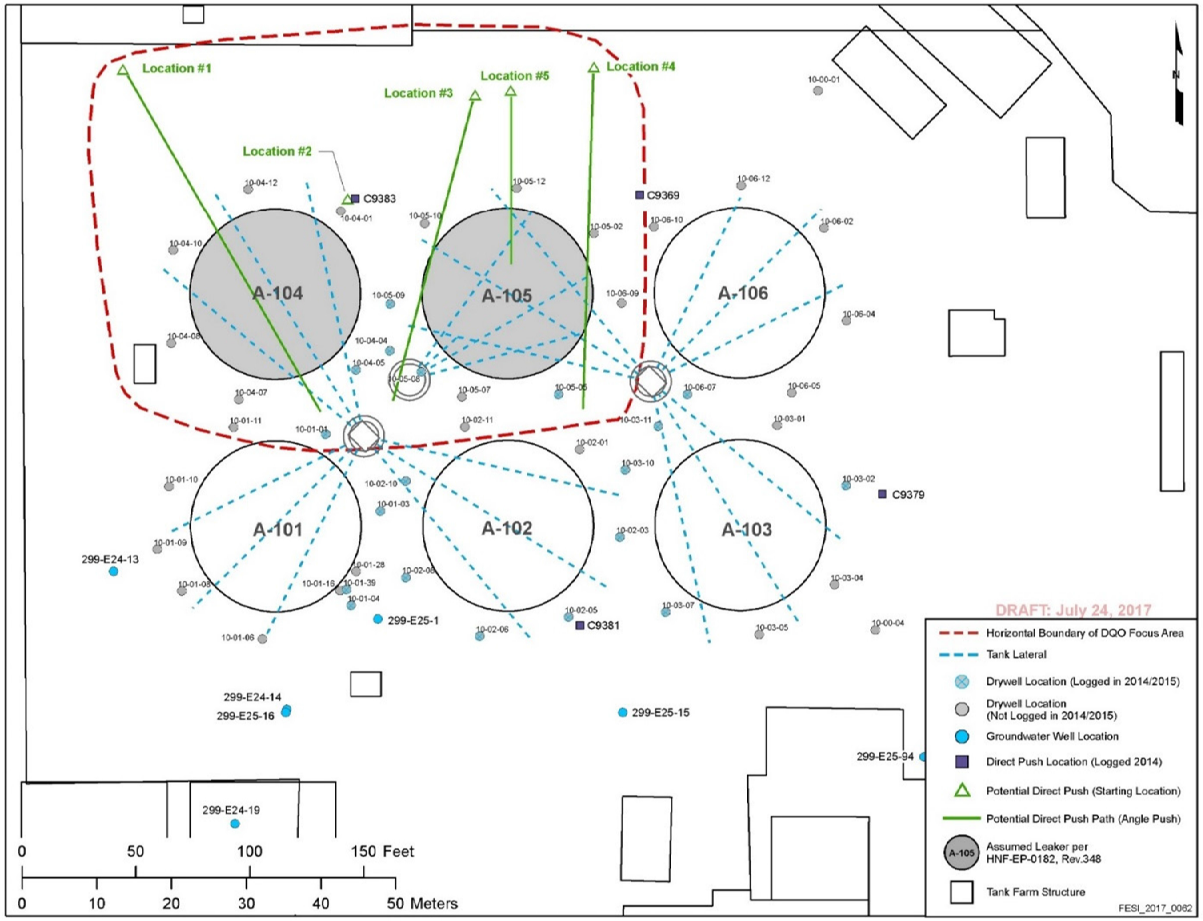
Smallest decision unit

The smallest unit, for decisions or estimates, is considered to be a release site (i.e., an area in the vadose zone where there has potentially been an impact from a known or suspected release associated WMA A-AX).

Table 7. Practical Constraints on Data Collection

Constraint	Details
Physical access	Placing driven soil probes, borings, or excavations near tank farm system structures (i.e., SSTs, lines, diversion boxes, catch tanks) will pose additional access challenges because of the following: • Limited access to some locations because of topography. • Surface and subsurface obstructions.
Methods	The methods selected for investigations, such as excavations (e.g., trenching, test pits), driven soil probes, or borings, will influence the following: • An investigative method is selected depending on data needs (sample volume, number of samples, depth, potential radiological content, instrumentation installed, geophysical logging needs, location, groundwater well installed, etc.).
Radiological controls	Radiological issues that could influence the ability to perform the work involve the following: • Handling contaminated samples (high or very high radiation).
Field screening techniques	The ability of field screening to meet quality assurance/QC or detection requirements may be limited as follows: • Gross gamma logging in soils may be limited by background radiation levels from adjacent structures (e.g., pipelines or diversion boxes). Small diameter gross gamma tool has a higher quantification level than the large diameter spectral tools. Therefore, very low levels of cobalt will not be detected by a small diameter logging tool. • Passive neutron logging may be limited because of lower than expected quantities of neutron-emitting isotopes.
Analytical laboratory capabilities	• Radiological controls and constraints at the sampling location (primarily high contamination levels) that delay delivery of the samples to the laboratory, causing exceedance of hold time limits. • Radiological controls and constraints at the laboratory (primarily high contamination levels) that delay analysis, causing exceedance of hold time limits. • Highly contaminated samples may require substantial dilution causing inability to analyze other contaminants effectively (e.g., reduced contaminant concentrations below detection limits).

Figure 1. Depiction of Horizontal Boundary of A-104/105 DQO Focus Area (WMA-A/AX-DQO-2017-8)



STEP 5 – DEVELOP THE ANALYTIC APPROACH (WMA-A-AX-DQO-2017-7)

The purpose of Step 5 is to develop an analytic approach that will guide how to analyze the study results and draw conclusions from the data.

The major outputs of Step 5 are as follows.

- *For decision problems, choose an **acceptable level** (using information identified in Step 3) that sets the boundary between one outcome of the decision process and an alternative. Verify that there are sampling and analysis methods with detection limits below acceptable levels. Specify the **population parameter** (e.g., maximum, mean, percentile) considered to be important to make inferences about the analytical data. Develop **decision rules** by constructing "if…then…" statements by combining the selected population parameter; the acceptable level, the scale of decision making, and the alternative actions.*
- *For evaluation problems, develop **specification of the estimators** (using information identified in Step 3) by identifying the type of data being estimated and determining the best representative measurement for this data type. Note there are no acceptable levels associated with these evaluation problems.*

Step 5 identifies the information necessary to determine if corrective measures should be evaluated, or if conceptual site model needs to be revised.

- Acceptable levels identified in Tables 8 and 9 are risk-based standards for individual contaminants established to meet requirements or agreements identified in Step 3, Table 4.

- In addition to acceptable levels, Tables 8 and 9 also provide the analytical methods (primary and alternative) and associated detection limits for chemical and radiological constituents, respectively.

- Decision rule for PSQ# 1 will use acceptable levels to decide if evaluation of corrective measures is required. Note that use of acceptable levels for baseline risk purposes will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

- Acceptable levels do not apply to evaluations identified in ES#2, ES#3 or ES#4. The estimator will provide key information and assumptions necessary to obtain data needed to make these evaluations. Data will support development and refinement of the conceptual site model.

- Data obtained as a result of each PSQ may be used to support the evaluation of other PSQs.

The Decision Rule for PSQ #1 and Specifications of the Estimator for PSQs #2 through #4 are defined in Table 10.

The primary decision rule for PSQ #1 involves comparing acceptable levels to maximum detected concentrations for screening purposes to determine if there is a need for further evaluation in the RFI/CMS. As per WAC 173-340-740(7)(d)iii:

> "Direct comparison of soil sample concentrations with cleanup levels may be used to evaluate compliance with cleanup levels where selective sampling of soil can be reliably expected to find suspected soil contamination. There must be documented, reliable information that the soil samples have been taken from the appropriate locations. Persons using this method must demonstrate that the basis used for selecting the soil sample locations provides a high probability that any existing areas of soil contamination have been found; or…….".

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Metals													
Aluminum	7429-90-5	8.00E+04	3.50E+06	1.30E+06	1.18E+04[k]	4.80E+05	1.18E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	2.75	80-120	75-125	≤30
Antimony	7440-36-0	32	1,400	519	92	5.4	0.13	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.13[q]	80-120	75-125	≤30
Arsenic	7440-38-2	0.67	87.5	20[l]	127	0.034	20	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.2	80-120	75-125	≤30
Barium	7440-39-3	1.60E+04	7.00E+05	2.59E+05	358	1,648	132	6010 ICP/AES (acid)	6020 ICP/MS (acid)	10.2	80-120	75-125	≤30
Beryllium	7440-41-7	160	7,000	2,595	10	63.2	1.51	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.5	80-120	75-125	≤30
Bismuth	7440-69-9	—	—	—	—	—	—	6010 ICP/AES (acid)	—	25.8	80-120	75-125	≤30
Boron	7440-42-8	1.60E+04	7.00E+05	2.60E+05	28.6	205	3.89	6010 ICP/AES (acid)	—	6	80-120	75-125	≤30
Cadmium	7440-43-9	80	3,500	1,110	9.8	0.69	0.563	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.0202	80-120	75-125	≤30
Calcium	7440-70-2	—	—	—	—	—	1.72E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6.25	80-120	75-125	≤30
Cerium	7440-45-1	—	—	—	—	—	—	6010 ICP/AES (acid)	—	10.5	80-120	75-125	≤30
Chromium	7440-47-3	1.20E+05	5.25E+06	1.95E+06	109	2,000	18.5	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.15	80-120	75-125	≤30
Chromium-hexavalent[m]	18540-29-9	240	1.05E+04	3,893	109	0.192[v]	—	7196	—	0.09[m]	80-120	75-125	≤30
Cobalt	7440-48-4	24	1,050	389	15.7	4.3	15.7	6020 ICP/MS (acid)	6010 ICP/AES (acid)	2	80-120	75-125	≤30
Copper	7440-50-8	3,200	1.40E+05	5.19E+04	58	284	22	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Iron	7439-89-6	5.60E+04	2.45E+06	9.08E+05	—	5,645	3.26E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Lanthanum	7439-91-0	—	—	—	—	—	—	6010 ICP/AES (acid)	—	2.75	80-120	75-125	≤30
Lead	7439-92-1	250[s]	1,000[n]	—	156	3,000	10.2	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Lithium	7439-93-2	160	7,000	2,596	1,664	192	13.3	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.9	80-120	75-125	≤30
Magnesium	7439-95-4	—	—	—	—	—	7,060	6010 ICP/AES (acid)	6020 ICP/MS (acid)	26.3	80-120	75-125	≤30
Manganese	7439-96-5	1.12E+04	4.90E+05	1.80E+05	1,260	501	512	6010 ICP/AES(acid)	6020 ICP/MS (acid)	0.55	80-120	75-125	≤30
Mercury	7439-97-6	24	1,050	389	0.3	2.1	0.01	7471 Cold vapor atomic absorption (acid)	6020 ICP/MS (acid)	0.01[q]	80-120	75-125	≤30
Molybdenum	7439-98-7	400	1.75E+04	6,489	2	32	0.47	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.47[q]	80-120	75-125	≤30
Neodymium	7440-00-8	—	—	—	—	—	—	6010 ICP/AES (acid)	—	5.05	80-120	75-125	≤30
Nickel	7440-02-0	1,600	7.00E+04	2.59E+04	38	130	19.1	6020 ICP/MS (acid)	6010 ICP/AES (acid)	3	80-120	75-125	≤30
Phosphorus	7723-14-0	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	9.8	80-120	75-125	≤30
Potassium	7440-09-7	—	—	—	—	—	2,150	6010 ICP/AES (acid)	6020 ICP/MS (acid)	157	80-120	75-125	≤30
Rhodium	7440-16-6	—	—	—	—	—	—	6010 ICP/AES (acid)	—	25.8	80-120	75-125	≤30
Selenium	7782-49-2	400	1.75E+04	6,489	1.4	5.2	0.78	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.02[r]	80-120	75-125	≤30
Silicon	7440-21-3	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5.05	80-120	75-125	≤30
Silver	7440-22-4	400	1.75E+04	6,489	3	14	0.167	6020 ICP/MS (acid)	6010 ICP/AES (acid)	6.00E-04[r]	80-120	75-125	≤30
Sodium	7440-23-5	—	—	—	—	—	690	6010 ICP/AES (acid)	6020 ICP/MS (acid)	22.4	80-120	75-125	≤30
Strontium	7440-24-6	4.80E+04	2.10E+06	7.79E+05	4,228	6,758	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.55	80-120	75-125	≤30
Sulfur	7704-34-9	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	11.4	80-120	75-125	≤30
Tantalum	7440-25-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	25.5	80-120	75-125	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Thallium	7440-28-0	0.8[y]	35[y]	—[x]	0.5	0.71	0.185	6020 ICP/MS (acid)	6010 ICP/AES (acid)	4.00E-04[r]	80-120	75-125	≤30
Thorium	7440-29-1	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	4.85	80-120	75-125	≤30
Tin	7440-31-5	4.80E+04	2.10E+06	7.79E+05	84	4.80E+04	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6	80-120	75-125	≤30
Tungsten	7440-33-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	42.9	80-120	75-125	≤30
Uranium	7440-61-1	240	1.05E+04	3,892	22	3.21[k]	3.21	6020 ICP/MS(acid)[h]	6010 ICP/AES (acid)	0.5	80-120	75-125	≤30
Vanadium	7440-62-2	400	1.75E+04	6,488	43.2	1,600	85.1	6020 ICP/MS (acid)	6010 ICP/AES (acid)	6.00E-03[r]	80-120	75-125	≤30
Zinc	7440-66-6	2.40E+04	1.05E+06	3.89E+05	621	5,971	67.8	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Zirconium	7440-67-7	—[x]	—[x]	—[x]	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1.2	80-120	75-125	≤30
Miscellaneous Constituents													
Ammonium	14798-03-9	—	—	—	—	—	9.23	300.7 IC (distillation)	—	0.5	80-120	75-125	≤30
Total organic carbon	TOC	—	—	—	—	—	—	9060	—	20	85-115	70-130	≤30
Anions													
Bromide	24959-67-9	—	—	—	—	—	—	9056 IC (water)	—	1	80-120	75-125	≤30
Chloride	16887-00-6	—	—	—	—	1,000	100	9056 IC (water)	—	0.3	80-120	75-125	≤30
Cyanide (total)	57-12-5	48	2,100	180	2.07E+04	0.97	—	9014 Spectrophotometric (distillation)	9012 Colorimetric	0.5	80-120	75-125	≤30
Fluoride	16984-48-8	4,800	2.10E+05	7.79E+04	845	2,884	2.81	9056 IC (water)	—	2.81[q]	80-120	75-125	≤30
Nitrogen in Nitrate	NO3-N	1.28E+05	5.60E+06	2.08E+06	27[o]	4.00E+01	—	9056 IC[u] (water)	—	2.5[u]	80-120	75-125	≤30
Nitrogen in Nitrite	NO2-N	8.00E+03	3.50E+05	1.30E+05	27[o]	4.00E+00	—	9056 IC[u] (water)	—	2.5[u]	80-120	75-125	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[l, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Phosphate	14265-44-2	—	—	—	—	—	0.785	9056 IC (water)	—	0.785[q]	80-120	75-125	≤30
Sulfate	14808-79-8	—	—	—	—	1,000	237	9056 IC (water)	—	2.7	80-120	75-125	≤30
Acetate	71-50-1	—	—	—	—	—	—	9056 IC (water)	—	4.5	80-120	75-125	≤30
Formate	64-18-6	—	—	—	—	—	—	9056 IC (water)	—	10.0	80-120	75-125	≤30
Glycolate (2-Hydroxyacetate)	GLYCOLATE[w]	—	—	—	—	—	—	9056 IC (water)	—	3.8	80-120	75-125	≤30
Oxalate	338-70-5	—	—	—	—	—	—	9056 IC (water)	—	2	80-120	75-125	≤30
Pesticides													
Aldrin	309-00-2	0.06	7.72	0.17	0.01	2.52E-03	—	8081 GC/ECD	8270 GC/MS	0.01	70-130	70-130	≤30
alpha-BHC	319-84-6	0.16	20.83	0.41	6	5.44E-04	—	8081 GC/ECD	8270 GC/MS	—	70-130	70-130	≤30
beta-BHC	319-85-7	0.56	72.92	1.40	0.06	2.28E-03	—	8081 GC/ECD	8270 GC/MS	—	70-130	70-130	≤30
gamma-BHC	58-89-9	0.91	119.32	2.80	6	2.47E-03	—	8081 GC/ECD	8270 GC/MS	0.6	70-130	70-130	≤30
Chlordane	57-74-9	2.86	375	8.02	1	0.26	—	8081 GC/ECD	8270 GC/MS	0.1	70-130	70-130	≤30
4,4'-DDD	72-54-8	4.17	546.88	11	0.06	0.3354	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
4,4'-DDE	72-55-9	2.94	386.03	10	NC	0.4457	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
4,4'-DDT	50-29-3	2.94	386.03	9.5	0.05	3.4907	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
Dieldrin	60-57-1	0.06	8.2	0.16	1.40E-04	2.82E-03	—	8081 GC/ECD	8270 GC/MS	0.007	70-130	70-130	≤30
Endrin	72-20-8	24.0	1050	274	0.2	4.40E-01	—	8081 GC/ECD	8270 GC/MS	0.02	70-130	70-130	≤30
Heptachlor	76-44-8	0.22	29.17	0.34	0.4	0.0038	—	8081 GC/ECD	8270 GC/MS	0.04	70-130	70-130	≤30
Heptachlor epoxide	1024-57-3	0.11	14.4	0.38	0.4	0.008	—	8081 GC/ECD	8270 GC/MS	0.04	70-130	70-130	≤30
Hexachlorobenzene	118-74-1	0.63	82.03	1.42	17	8.77E-02	—	8081 GC/ECD	8270 GC/MS	1.70	70-130	70-130	≤30
Polychlorinated Biphenyls													
Aroclor 1016	12674-11-2	5.60	245	29.7	1.80	1.072	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1221	11104-28-2	0.5	65.6	0.76	1.50	0.004	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1232	11141-16-5	0.5	65.6	0.59	1.40	0.004	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1242	53469-21-9	0.5	65.6	0.97	1.50	0.069	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Aroclor 1248	12672-29-6	0.5	65.6	0.98	0.33	0.067	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1254	11097-69-1	0.5	65.6	1.02	1.50	0.114	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1260	11096-82-5	0.5	65.6	1.08	1.50	0.719	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Physical Properties													
Bulk Density	—	—	—	—	—	—	—	Gravimetric	—	—	—	—	≤30
pH (soil)	—	—	—	—	—	—	—	9045 (pH)	—	—	± 0.1 pH units	—	—
Percent solids	—	—	—	—	—	—	—	Gravimetric	—	—	—	—	—
Percent water	—	—	—	—	—	—	—	Gravimetric	—	—	80-120	—	≤30
Specific conductance	—	—	—	—	—	—	—	9050	—	—	—	—	—
Particle size distribution[t]	—	—	—	—	—	—	—	ASTM D 422/ ASTM D 6913	—	—	—	—	—
Semi-volatile Organic Compounds													
Bis(2-ethylhexyl)phthalate	117-81-7	71	9,375	182	0.17	13.36	—	8270 GC/MS	—	2.95	70-130	70-130	≤30
Tributyl phosphate	126-73-8	111	14,583	284	—	0.496	—	8270 GC/MS	—	3.3	70-130	70-130	≤30

a. The acceptable level (from the data quality objective process) is used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The unrestricted direct contact acceptable level is based on an excess lifetime cancer risk of 1 in 1,000,000 or hazard quotient of 1. ECF-HANFORD-10-0444, Revision 3, *Documentation of Standard Method B Soil Cleanup Levels for Unrestricted Land Use*.

c. The industrial direct contact acceptable level is based on an excess lifetime cancer risk of 1 in 100,000 or hazard quotient of 1. ECF-HANFORD-10-0453, Revision 2, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Report*.

d. The outdoor worker acceptable level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 1,000,000 or hazard quotient of 1. ECF-HANFORD-16-0134, *Calculation of Soil Nonradiological Preliminary Remediation Goals for the Outdoor Worker Scenario*.

e. CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site*.

f. ECF-HANFORD-10-0442, *Calculation of Nonradiological Soil Concentrations Protective of Groundwater Using the Fixed Parameter 3 Phase Equilibrium Partitioning Equation for the 100 Areas and 300 Area*.

g. DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes;* ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

h. Isotopic uranium analysis may be substituted for total uranium as long as the required detection limit is met.

i. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and WHL-MP-1011, "Quality Assurance Project Plan for 222-S Laboratory."

j. Quality control failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are quality control failures associated with secondary analytes, reanalysis will not be required.

k. The actual value is less than its background level. Hence, it was set equal to the background concentration.

l. The outdoor worker acceptable level for arsenic is equal to the site background concentration.

m. Prior to performing this analysis, a preparation method will need to be developed; therefore, detection limit may need to be modified.

n. The acceptable level of lead is the Method A industrial land use soil cleanup level from Table 745-1 of WAC 173-340-745(3).

o. The ecological protection values for nitrate and nitrite are calculated for nitrogen in nitrate plus nitrite.

p. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

q. Detection limit listed is Hanford background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

r. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i, j]		
											Accuracy		Precision
		Direct Contact Soil Ingestion Unrestricted Land Use[b, z] (≤ 15 ft bgs)	Direct Contact Soil Ingestion Industrial Land Use[c, z] (≤ 15 ft bgs)	Outdoor Worker[d] (≤ 15 ft bgs)	Ecological Protection[e] (≤15 ft bgs)	Groundwater Protection[f] (ground surface to groundwater)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference

s. The acceptable level of lead is the Method A unrestricted land use soil cleanup level from Table 740-1 of WAC 173-340-900.

t. Particle size distribution will be performed by the laboratory if sample volume is sufficient. Note that 222-S will need to develop protocol to perform test.

u. Detection limits and method are associated with nitrate (CAS number 14797-55-8) and nitrite (CAS number 14797-65-0). Nitrogen in nitrate and in nitrate will be determined from this analysis.

v. Groundwater protection level for hexavalent chromium was calculated using Kd = 0 mL/g as documented in PNNL-13895.

w. RPP-RPT-38152 identifies the CAS Number as 79-14-1 which is for glycolic acid. The CAS number for glycolate is 666-14-8 but the laboratory uses "GLYCOLATE" for identification.

x. Due to uncertainty associated with the documented toxicity value, the acceptable level was not calculated in referenced ECF.

y. Method B and Method C values for thallium will be used for screening purposes, not for deriving cleanup levels.

z. The acceptable levels for inhalation exposure, protective of human health and the environment, have not been developed at this time. During the total risk determination, chronic daily intake, individual excess lifetime cancer risk, and non-cancer hazard index from inhalation of dust and vapors in ambient air will be calculated.

— = no value (e.g., no toxicity value)
AES = atomic emission spectroscopy
BHC = Benzene hexachloride
DDD = Dichlorodiphenyldichloroethane
DDE = Dichlorodiphenyldichloroethylene
DDT = Dichlorodiphenyltrichloroethane
CAS = Chemical Abstracts Service
ECD = electron capture detector
GC = gas chromatography
IC = ion chromatography
ICP = inductively coupled plasma
MS = mass spectroscopy
NC = not calculated; toxicity information is available but a risk-based limit is not currently documented in the respective ECF or CLARC. The NC will be replace with the acceptable level after the respective ECF is updated with the additional constituent included.
ft bgs = feet below ground surface

Table 9. Analytical Performance Requirements for Radiological Constituents

Constituent	CAS Number	Acceptable Level (pCi/g)[a]			Hanford Site Background[d] (pCi/g)	Primary Method[i]	Alternative Method[i]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[e,f]		
									Accuracy		Precision
		Outdoor Worker[b] (≤ 15 ft bgs)	Ecological Protection[c] (≤ 15 ft bgs)	Construction Worker[j] (> 15 ft bgs)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Americium-241	14596-10-2	613	4,840	2.20E+04	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	80-120	—	≤30
Antimony-125	14234-35-6	—	—	—	—	Gamma energy analysis (direct)	—	0.3	80-120	—	≤30
Carbon-14	14762-75-5	5.70E+05	32	4.80E+06	—	Liquid scintillation (acid)	—	1	80-120	75-125	≤30
Cesium-137	10045-97-3	10.8	924	1,550	1.05	Gamma energy analysis (direct)	—	0.1	80-120	—	≤30
Cobalt-60	10198-40-0	5.7	805	334	8.42E-03	Gamma energy analysis (direct)	—	0.01[g,h]	80-120	—	≤30
Curium-242	15510-73-3	—	—	—	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	—	NA
Curium-243/244	CM-243/244	64	—	7,582	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	—	NA
Europium-152	14683-23-9	6.8	1,740	739	—	Gamma energy analysis (direct)	—	0.1[g]	—	—	≤30
Europium-154	15585-10-1	8.2	1,610	691	3.34E-02	Gamma energy analysis (direct)	—	0.03[g,h]	—	—	≤30
Europium-155	14391-16-3	603	3.34E+04	3.24E+04	5.39E-02	Gamma energy analysis (direct)	—	0.05[g,h]	—	—	≤30
Iodine-129	15046-84-1	1,568	—	1.21E+05	—	Low energy gamma counting	ICP/MS (acid)	2	80-120	—	≤30
Neptunium-237	13994-20-2	24	7,880	4,193	—	ICP/MS (acid)	Alpha energy analysis (acid)	3.80E-02	80-120	75-125	≤30
Nickel-63	13981-37-8	6.00E+05	—	2.86E+07	—	Liquid scintillation (acid)	—	30	80-120	—	≤30
Plutonium-238	13981-16-3	3,438	5,980	2.98E+04	3.78E-03	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	—	≤30
Plutonium-239/240	Pu-239/240	2,971	6,270	2.80E+04	2.48E-02	Alpha energy analysis (acid)	ICP/MS (acid)	0.03[g,h]	80-120	—	≤30
Plutonium-241	14119-32-5	2.03E+04	—	1.03E+06	—	Liquid scintillation (acid)	Est. from Pu-238 and Pu239/240	1.65E+04	80-120	75-125	≤30
Radium-226	13982-63-3	—	58.3	—	0.82	Gamma energy analysis (direct)	—	0.2	80-120	75-125	≤30
Selenium-79	15758-45-9	5.68E+04	—	3.20E+06	—	Liquid scintillation (acid)	—	10	—	—	≤30
Strontium-90	10098-97-2	1190	91	1.21E+05	0.18	Beta GPC	—	0.18[g,h]	80-120	75-125	≤30
Tin-126	15832-50-5	—	—	—	—	ICP/MS (acid)	—	400	80-120	75-125	≤30
Technetium-99	14133-76-7	1.17E+05	5,360	5.80E+06	—	ICP/MS (acid)	Liquid scintillation (acid)	1	80-120	75-125	≤30
Thorium-232	7440-29-1	—	—	—	1.32	ICP/MS (acid)	—	4.40E-05	80-120	75-125	≤30
Tritium	10028-17-8	1.26E+04	420	3.26E+05	—	Liquid scintillation (acid)	—	30	80-120	75-125	≤30

Table 9. Analytical Performance Requirements for Radiological Constituents

Constituent	CAS Number	Acceptable Level (pCi/g)[a]			Hanford Site Background[d] (pCi/g)	Primary Method[i]	Alternative Method[i]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[e,f]		
									Accuracy		Precision
		Outdoor Worker[b] (≤ 15 ft bgs)	Ecological Protection[c] (≤ 15 ft bgs)	Construction Worker[j] (> 15 ft bgs)					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Uranium-233	13968-55-3	—	—	—	—	ICP/MS (acid)	—	0.174	—	—	≤30
Uranium-234	13966-29-5	2,201	6,370	5.51E+04	1.1	ICP/MS (acid)	—	3.75E-02	—	—	≤30
Uranium-235	15117-96-1	36	4,360	5,984	0.11	ICP/MS (acid)	—	4.32E-05	80-120	75-125	≤30
Uranium-236	13982-70-2	—	—	—	—	ICP/MS (acid)	—	5.18E-04	—	—	≤30
Uranium-238	7440-61-1	170	5,150	2.11E+04	1.06	ICP/MS (acid)	—	4.37E-04	80-120	75-125	≤30

a. The acceptable level (from the data quality objective process) is the risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The outdoor worker acceptable level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 10,000. ECF-HANFORD-16-0133, Revision 0, *Calculation of Soil Radiological Preliminary Remedial Goals for the Outdoor Worker Scenario*.

c. CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site;* CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*.

d. DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*.

e. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and WHL-MP-1011, "Quality Assurance Project Plan for 222-S Laboratory."

f. Quality control failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are quality control failures associated with secondary analytes, reanalysis will not be required.

g. Detection limit listed is Hanford background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

h. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

i. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

j. The construction worker acceptable level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 10,000. ECF-HANFORD-16-0132, Revision 0, *Calculation of Soil Radiological Preliminary Remedial Goals for the Construction Worker Scenario*.

— = no value (e.g., no toxicity value)
CAS = Chemical Abstracts Service
ft bgs = feet below ground surface
GPC = gas proportional counting
GEA = gamma energy analysis
ICP = inductively coupled plasma
MS = mass spectroscopy

Table 10. Decision Rules and Specification of the Estimator[a]

Step 2		Step 5
Principal Study Question	**Decision/Estimation Statement (DS/ES)**	**Decision Rule/Specification of the Estimator (DR/E)**
#1— Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	**#DS 1** — Determine whether contamination exceeds acceptable levels and, therefore, whether there is a need to evaluate corrective measures.	**#DR 1** IF the maximum detected concentrations for individual constituents exceed those acceptable levels identified in Table 8, Table 9, or those that will be developed during risk evaluations, THEN further evaluation will be performed during the RFI/CMS.[b]
#2 – Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	**#ES 2** – The chemical/physical properties of A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. It is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil.	**#E2** The best measurement of chemical and physical properties in WMA A-AX vadose zone soil that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated.
#3 – Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	**#ES 3** – The chemical/physical properties of A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. It is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil.	**#E3** The best available measurements of chemical and physical properties in WMA A-AX tank waste that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated.
#4 – Is information available to define whether, and where, tank waste passed through portions of the WMA A-AX vadose zone soil?	**#ES 4** – Chemicals and radionuclides in tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated. It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through those portions of the soil. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through those portions of the soil.	**#E4A** The concentrations of naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment will be estimated to evaluate where waste may have passed through portions of the soil. **#E4B** The concentrations in vadose zone soil of chemicals and radionuclides that can act as tank waste markers will be estimated to evaluate where waste may have passed through portions of the soil.

Table 10. Decision Rules and Specification of the Estimator[a]

Step 2		Step 5
Principal Study Question	**Decision/Estimation Statement (DS/ES)**	**Decision Rule/Specification of the Estimator (DR/E)**

[a]Data types to address PSQs are identified in Table 4. Data collected to address PSQ #1 will also be used to address PSQs #2, #3, and #4. Data used to address PSQs #2, #3, and #4 will support development and refinement of the conceptual site model.

[b]Use of acceptable levels will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan. Additionally, cumulative risk calculations will be documented during the development of the WMA A-AX RFI/CMS Phase 2 Work Plan.

STEP 6 – SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA (WMA-A-AX-DQO-2017-7)

Step 6 examines consequences of making incorrect decisions, and identifying acceptable ranges associated with making decision errors.

The major outputs for Step 6 are:

- *Performance criteria (performance metric) to minimize errors for decision rules*
- *Performance criteria (performance metric) to keep uncertainties for the specification of the estimators within acceptable ranges.*

The Step 6 outputs for WMA A-AX are:

- Quality control acceptance criteria for each constituent is identified in Tables 8 and 9.
- Where this DQO provides sample data for technical evaluations and not for direct comparison to acceptable levels, acceptance criteria for statistical uncertainty normally associated with specific performance acceptance metrics will not apply.

Performance or acceptance criteria, which are developed to limit sampling decision error, are sometimes used to help determine sampling and analysis design. When using a probabilistic sampling approach, statistical decision error criteria are sometimes developed to estimate the minimum number of samples. Based on constraints associated with doing work within a tank farm, it is anticipated the sampling approach for WMA A-AX will be judgmental, not probabilistic. For this reason, Step 6 decision error criteria to support sample design will not be developed, and this step will have little impact on sample design.

Note that the data generated for this decision problem (PSQ #1) will be subject to various types of errors due to such factors as how samples were collected, how measurements were made, etc. At a minimum, there are two decision error limits that should be specified:

- A false rejection decision error limit at the acceptable level
- A false acceptance decision error limit at the acceptable level.

Table 11 shows the tolerable limits on decision error for Decision Rule 1 based on the predicted consequences of making an incorrect decision under actual site conditions. The table also further defines decision error severity. Decision errors are primarily due to errors that occur during field sampling and laboratory analysis. Therefore, there is a chance that an erroneous decision will be made based on the collected data or that uncertainty in the estimated result is unacceptable.

Table 11. Tolerable Limits on Decision Errors

Action	Possible Decision Error	Severity of Consequences of Decision Error				Decision Error that has More Severe Consequences
		Far Below the Acceptable Level	Below but Near the Acceptable Level	Above but Near the Acceptable Level	Far Above the Acceptable Level	
Conduct corrective action	Remediate an uncontaminated site	Severe[a]	Moderate	None	None	Not remediating a contaminated site
No corrective measure required	Failing to remediate a contaminated site	None	None	Moderate	Severe[b]	

Justification for severe rating:

[a] Severity of decision error for remediating an uncontaminated site having contamination that is far below acceptable levels is severe based on the cost.

[b] Severity of decision error for not remediating a site having contaminations far above acceptable levels is based on health and environmental risks.

PSQs #2 through #4 are estimation problems. Data generated or reviewed for these technical evaluations or estimations are not compared to acceptable levels but are selected based on determining the best representative measurement. The consequence of making an incorrect conclusion would be that true conditions are not accurately represented. As identified in Step 5, determining the best measurement for resolution of these estimation problems is primarily based on professional judgment.

STEP 7 – DEVELOP THE PLAN FOR OBTAINING DATA FOR FOCUS AREA AROUND TANKS A-104/A-105 (WMA-A-AX-DQO-2017-5, WMA-A-AX-DQO-2017-6, WMA-A-AX-DQO-2017-8)

Step 7 develops a sampling design that optimizes the data collection to meet data quality requirements specified in DQO Steps 1 through 6 and also takes into account the sampling boundaries and constraints identified in Step 4.

Per EPA QA/G-4, the major outputs of Step 7:

- *Full documentation of the final sampling design along with key assumptions underlying the design,*
- *Details on how the design should be implemented together with contingency plan for unexpected events, and*
- *QA/QC performed to detect and correct problems and so ensure defensible results.*

Sampling Strategy and General Collection Techniques (WMA-A-AX-DQO-2017-8)

- Direct Push – collection via dual-string sampling system
- Two direct push borings per location, one for geophysical logging and second for soil sampling
- Sample depth meetings after geophysical logging

Note: Gyroscope will be used on angle pushes to confirm borehole path

Sampling Design (WMA-A-AX-DQO-2017-8)

A random sampling strategy cannot be applied in WMA A-AX because of the extensive amount of interferences caused by buried infrastructure and topographic constraints. Therefore, a non-probabilistic (or judgmental) sampling strategy that targets locations based on existing knowledge will be used. This approach provides the highest potential for confirming and characterizing known and suspected releases in and around WMA-AX and will help refine the WMA-AX conceptual site models.

Location and Number of Direct Push Boreholes (WMA-A/AX-DQO-2017-5, WMA-A/AX-DQO-2017-8)

See Figure 1 (in Step 4) and Table 12.

Table 12. Direct Push Location Strategy for Tanks 241-A-104 and 241-A-105

Location #	Approximate Location	Input Factors Associated with Location **Reason for Sampling**	Target Depth (bgs) **Angle**[1] Pipe Run *Minimum distance from Tank*
1	Northwest of Tank 241-A-104 (Angle push going southeast and directly under the tank)	• Tank A-104 designated as a leaker (~2,000 gallons) • Possible leak location area (RPP-ENV-37956, Rev. 2, Figure 4-1) • Higher temperature and gross gamma readings in laterals (14-04-01 and 14-04-02, RPP-ENV-37956, Rev. 2 [Figures B2-11 through B2-13]) • Higher temperature and gross gamma readings in drywells (10-04-04 and 10-04-05)	174 ft **45** 246 ft

Table 12. Direct Push Location Strategy for Tanks 241-A-104 and 241-A-105			
Location #	**Approximate Location**	Input Factors Associated with Location **Reason for Sampling**	Target Depth (bgs) **Angle**[1] Pipe Run *Minimum distance from Tank*
		• Higher SGE conductivity area (RPP-ENV-37956, Rev. 2, Figure 3-9) **Assess Tank A-104 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	*15.75 ft*
2	North and between Tanks 241-A-104 and 241-A-105 (Vertical push)	• Tanks A-104 and A-105 designated as a leaker (~2,000 gallons and ~2,000 to 40,000 gallons, respectively) • Direct push log at Location C9383, temperature of ~120 ºF, ~50 ft bgs • Possible location for deep push ~285 ft bgs **Assess Tanks A-104 and A-105 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	285 ft **None** 285 ft *54 ft*
3	North of Tank 241-A-105 (Angle push towards southwest-side of tank)	• Tanks A-104 and A-105 designated as a leaker (~2,000 gallons and ~2,000 to 40,000 gallons, respectively) • Possible leak location area (RPP-ENV-37956, Rev. 2, Figure 4-2) • Higher temperature and gross gamma readings in laterals (14-05-01,14-05-02, and 14-05-03, RPP-ENV-37956, Rev. 2 [Figures B3-18 through B3-19]) • Higher temperature readings in drywells (10-05-09, 10-04-04 and 10-04-05) • Drywell 10-05-10 indicated casing corrosion (~ 64 ft bgs) • Higher SGE conductivity area ((RPP-ENV-37956, Rev. 2, Figure 3-9) **Assess Tanks A-105 and A-104 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	241 ft **30** 279 ft *23 ft*
4	Northeast of Tank 241-A-105 (Angle push going south and under the east side of tank)	• Tank A-105 designated as a leaker (~2,000 to 40,000 gallons) • Possible leak location area (RPP-ENV-37956, Rev. 2, Figure 4-2) • Higher temperature and gross gamma readings in laterals (14-05-01,14-05-02, and 14-05-03, RPP-ENV-37956, Rev. 2 [Figures B3-18 through B3-19]) • Higher temperature readings in drywell (10-05-05)	127 ft **50** 197 ft

Table 12. Direct Push Location Strategy for Tanks 241-A-104 and 241-A-105			
Location #	**Approximate Location**	Input Factors Associated with Location **Reason for Sampling**	Target Depth (bgs) **Angle**[1] Pipe Run *Minimum distance from Tank*
		• Drywell 10-05-02 indicated casing corrosion (~ 64 ft bgs) **Assess Tank A-105 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	*7.5 ft*
5	North of Tank 241-A-105 (Angle push going under the north side of tank)	• Tank A-105 designated as a leaker (~2,000 to 40,000 gallons) • Higher temperature and gross gamma readings in laterals (14-05-01,14-05-02, and 14-05-03, RPP-ENV-37956, Rev. 2 [Figures B3-18 through B3-19]) • Corrosion observed at drywells 10-05-02 and 10-05-10 **Assess Tank A-105 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	285 ft **15** 295 ft *29 ft*
[1] Angle is defined as degrees from vertical (i.e., 90 degrees minus dip).			

Recommended Number of Samples Collected From WMA A-AX Per Direct Push Location (WMA-A/AX-DQO-2017-6, WMA-A/AX-DQO-2017-8)

- Each sampling location consists of one surface sample, two additional shallow (≤15 ft bgs) samples, and at least seven deep (>15 ft bgs) samples.
- A duplicate sample will be collected at 25% of the surface sample locations (i.e., a duplicate surface sample will be collected at one in four surface locations).
- Shallow samples taken from below the surface will be taken at ~7 to 9 ft bgs and ~12 to 14 ft bgs. The purpose of collecting samples in the first 15 ft is to provide data for the direct exposure pathway and to provide initial data for ecological risk.
- Deep samples will be taken down to a depth of ~240 to 285 ft bgs or refusal. The depths for sampling individual horizons will be selected by reviewing the gamma, temperature, and moisture logs of the first direct push and the following information: any leak loss inventory information pertinent to the site, geologic summary of the area, operational history, and historical characterization data at that site.

Summary:

- 3 Shallow Samples (≤15 ft bgs)
- 7 Deep Samples (>15 ft bgs to Total Depth).

Note: Proposed Vertical Total Depths for 5 boreholes are 127, 174, 241, and 285 ft bgs (two locations).

Constituents for Sampling

The available vadose zone soil sample material will be analyzed for the chemical, radiological and physical properties identified in Tables 8 and 9. These tables also provide analytical methods and associated detection limits for each constituent.

Both pesticides and PCBs were sampled in only the top 15 ft at WMA C; however, at WMA A-AX they will be sampled at all depths in the first focus area around Tanks A-104/A-105. Data from the first focus area will be reviewed to determine if samples should also be collected in subsequent focus areas at all depths or just within the top 15 ft.

It should be noted that Step 3 identified some constituents, VOCs, and several physical property tests, which will be evaluated for "Special Study" (refer to Table 6). These constituents will not be analyzed in samples collected around the focus area of Tanks A-104 and A-105. The primary reasons for these "Special Study" constituents not being analyzed at this focus area are:

- There is not enough sample material collected via direct push to perform these analysis and those identified in Tables 8 and 9.
- There are no procedures in place for handling, packaging, and analyses/testing of soil.
- There needs to be further discussion and evaluation of existing data to determine where to best perform these analyses.

Specifically for VOCs, similar WMA C analyses were last conducted around 2010, and laboratory contract and personnel changes have resulted in a loss of expertise related to sample management and analysis. Procedures for handling and analyzing the samples will have to be recreated to meet the requirements of new laboratory contractors.

Additionally, analysis for dioxins and furans will not be performed at focus area around Tanks A-104/A-105. Dioxins and furans analyses have not been performed on vadose zone soil samples from the tank farm area and determinations will need to be made on such things as volumes needed to perform analysis, and if these volumes are achievable based on sampling methodology in the tank farms. Further discussions will continue on performing analysis of dioxins and furans in vadose zone soil samples.

Physical Sample Yield

- Three 6" x 1.08" ID stainless steel liners
- One 4" x 1.08" ID sampler shoe
- 16.5 cubic inches total in liners, and 3.65 cubic inches in shoe
- Results in 20.15 cubic inches (330 cc) of material
- Using the average density of Hanford soils (1.8 g/cc) = 594 g sampled materials at 100% recovery

Logging (WMA-A/AX-DQO-2017-8)

Direct Push

- Gross Gamma
- Spectral Gamma Logging System
- Neutron Moisture
- Temperature
- Gyroscope

Drywells

- Spectral Gamma Logging System
- Neutron Moisture
- Temperature
- Borehole Camera

Refer to Figure 1 (Step 4) for Drywell Logging Locations.

> Note: There was observed corrosion in three drywells (10-05-10 [casing was pulled and replaced], 10-05-02, and 10-06-12). Two drywells are in the focus area (10-05-10 and 10-05-02). Documentation has been reviewed and it is thought that these drywell can be logged; however, they will be evaluated during the field investigation to determine if they can be logged (e.g., via field and/or camera inspection).

SGE (WMA-A/AX-DQO-2017-8)

Electrode Installment

- During decommissioning in Direct Push logging borings an electrode can be installed at low cost.

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APPENDIX B

SUMMARY INFORMATION ON 2014/2015 WMA A-AX VADOSE ZONE INVESTIGATION

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B1.0 INTRODUTION

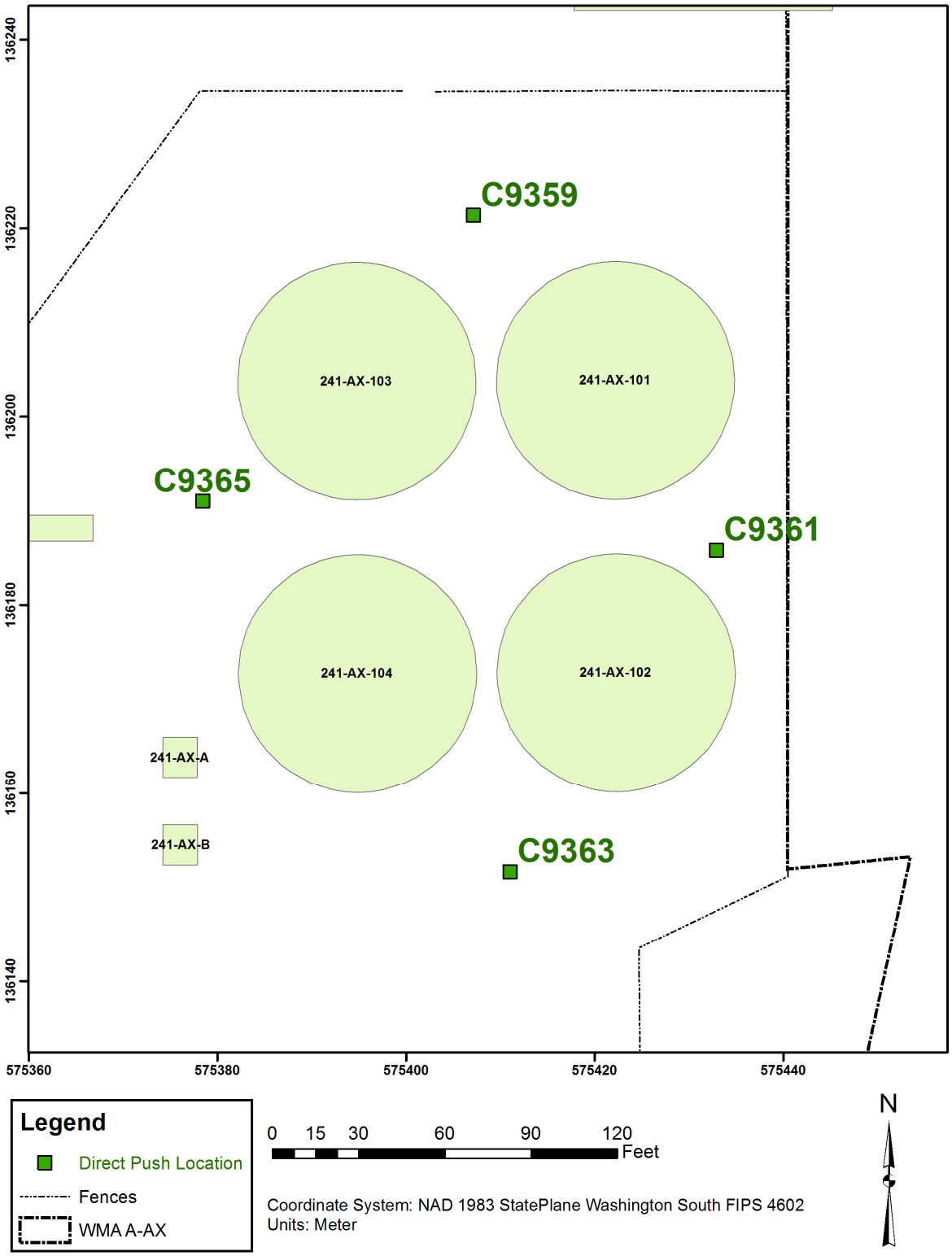
In 2014 and 2015, DOE undertook field work pursuant to RPP-PLAN-57332, *Field Sampling and Analysis Plan for Soil Samples at Waste Management Area A-AX,* to help characterize the vadose zone soil in in WMA A-AX. The field work consisted of logging drywells and performing a direct push investigation. Results from these efforts were presented during the annual meeting for the HFFACO milestone M-045-56 in 2016 and were documented in TOC-PRES-16-3310-VA*, Vadose Zone Field Characterization WMA A-AX 2014/2015*. A copy of this presentation and associated handouts are provided as an attachment to this appendix for reference purposes (Attachment B1).

Eleven locations were to be investigated under RPP-PLAN-57332, as shown in Figures B-1 and B-2. Four of the locations were in AX Farm, and seven were in A Farm. As identified in Attachment B1, 8 of the 11 locations were pushed (4 in AX Farm and 4 in A Farm). Logging was performed at all eight locations. Sampling was performed in AX Farm but not in A Farm.

Table B-1 lists the various reports associated with the 2014/2015 characterization effort. These documents were provided to Ecology as documented in meeting notes from the July 20, 2016 annual M-045-56 meeting[1] (see "Actions for FY 2016," item 2).

[1] These are available in the Hanford Facility Administrative Record at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0074960H

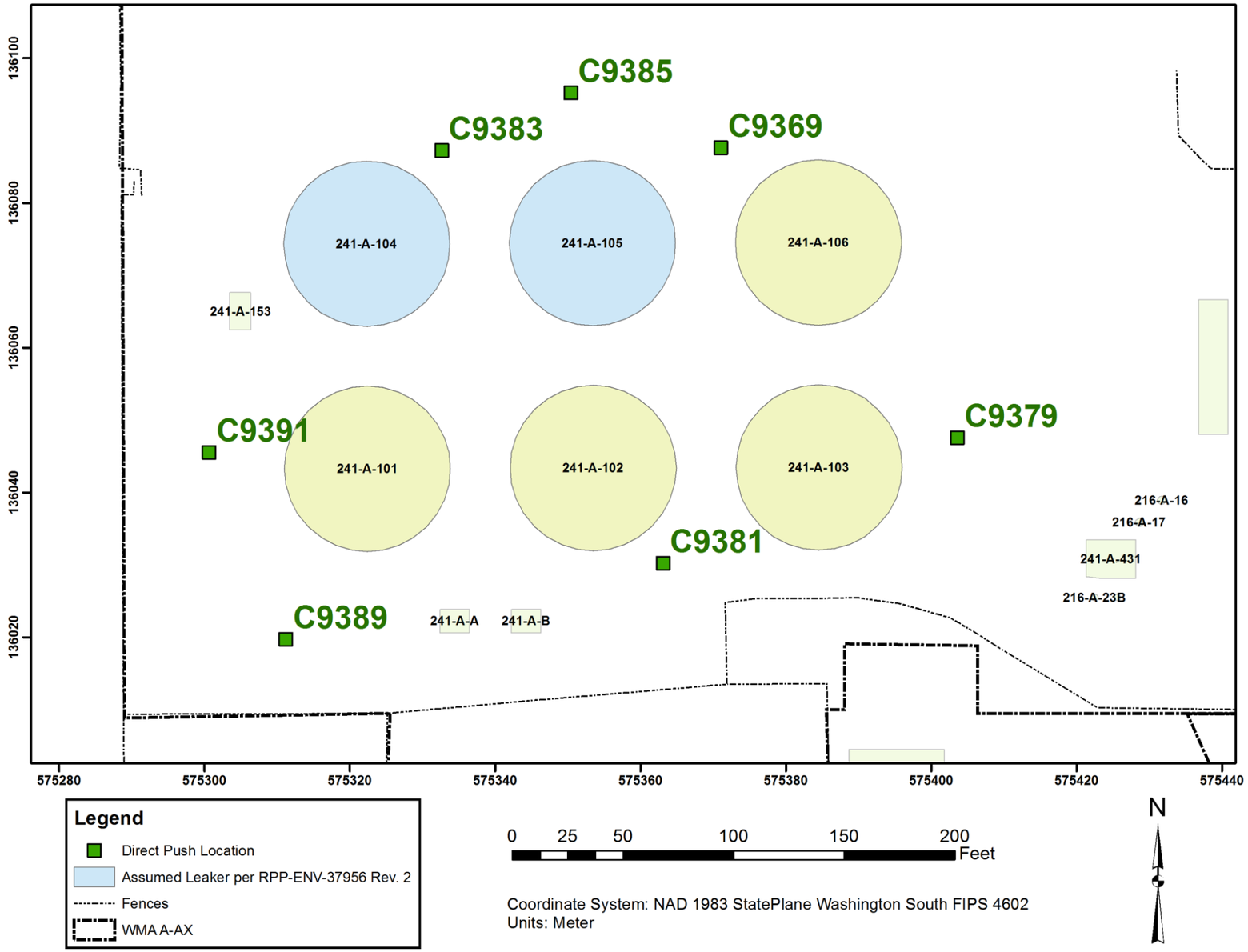
Figure B-1. AX Farm Four Direct Push Locations



WMA = Waste Management Area

Source: RPP-PLAN-57332, *Field Sampling and Analysis Plan for Soil Samples at Waste Management Area A-AX*

Figure B-2. A Farm Seven Direct Push Locations



WMA = Waste Management Area

Source: RPP-ENV-37956, *Hanford 241-A and 241-AX Tank Farms Leak Inventory Assessment Report*.

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Table B-1. Reports associated with the 2014/2015 WMA A-AX Vadose Zone Soil Characterization Efforts

Report Number	Title
Direction Push Completion Report	
RPP-ENV-58747, Rev. 0	*Fiscal Year 2014/2015 Completion Report for the 241-A and 241-AX Tank Farms Direct Push Characterization*
Analytical Report for Vadose Zone Soil Samples	
RPP-RPT-58969, Rev. 1	*Analytical Report for Soil Samples Taken at Waste Management Area AX in 2015*
Field Sampling and Analysis Plan	
RPP-PLAN-57332, Rev. 1	*Field Sampling and Analysis Plan for Soil Samples at Waste Management Area A-AX*
Drywell Logging Reports	
A Farm	
HGLP-LDR-878	10-01-01, *299-E25-97 (A6532), Log Data Report*
HGLP-LDR-853	10-01-03, *299-E25-91 (A6530), Log Data Report*
HGLP-LDR-846	10-01-04, *299-E25-92 (A6531), Log Data Report*
HGLP-LDR-854	10-01-39, *299-E25-192 (A6598), Log Data Report*
HGLP-LDR-861	10-02-03, *299-E25-83 (A6522), Log Data Report*
HGLP-LDR-862	10-02-05, *299-E25-85 (A6524), Log Data Report*
HGLP-LDR-863	10-02-06, *299-E25-86 (A6525), Log Data Report*
HGLP-LDR-864	10-02-08, *299-E25-87 (A6526), Log Data Report*
HGLP-LDR-879	10-02-10, *299-E25-88 (A6527), Log Data Report*
HGLP-LDR-874	10-03-02, *299-E25-79 (A6518), Log Data Report*
HGLP-LDR-883	10-03-07, *299-E25-82 (A6521), Log Data Report*
HGLP-LDR-880	10-03-10, *299-E25-55 (A6044), Log Data Report*
HGLP-LDR-882	10-03-11, *299-E25-84 (A6523), Log Data Report*
HGLP-LDR-881	10-04-04, *299-E25-56 (A6045), Log Data Report*
HGLP-LDR-869	10-04-05, *299-E25-63 (A6502), Log Data Report*
HGLP-LDR-871	10-05-05, *299-E25-70 (A6509), Log Data Report*
HGLP-LDR-877	10-05-08, *299-E25-98 (A6533), Log Data Report*
HGLP-LDR-873	10-05-09, *299-E25-62 (A6501), Log Data Report*
HGLP-LDR-852	10-06-07, *299-E25-77 (A6516), Log Data Report*

Table B-1. Reports associated with the 2014/2015 WMA A-AX Vadose Zone Soil Characterization Efforts

Report Number	Title
AX Farm	
HGLP-LDR-770	11-01-01, *299-E25-99 (A6534), Log Data Report*
HGLP-LDR-769	11-01-02, *299-E25-100 (A6535), Log Data Report*
HGLP-LDR-772	11-01-04, *299-E25-101 (A6537), Log Data Report*
HGLP-LDR-768	11-01-05, *299-E25-102 (A6538), Log Data Report*
HGLP-LDR-792	11-01-07, *299-E25-103 (A6539), Log Data Report*
HGLP-LDR-801	11-01-09, *299-E25-104 (A6540), Log Data Report*
HGLP-LDR-767	11-01-10, *299-E25-131 (B2896), Log Data Report*
HGLP-LDR-771	11-01-11, *299-E25-105 (A6541), Log Data Report*
HGLP-LDR-777	11-02-01, *299-E25-132 (A6563), Log Data Report*
HGLP-LDR-776	11-02-02, *299-E25-106 (A6542), Log Data Report*
HGLP-LDR-773	11-02-03, *299-E25-133 (B2898), Log Data Report*
HGLP-LDR-780	11-02-04, *299-E25-107 (A6543), Log Data Report*
HGLP-LDR-781	11-02-05, *299-E25-108 (A6544), Log Data Report*
HGLP-LDR-775	11-02-07, *299-E25-109 (A6545), Log Data Report*
HGLP-LDR-789	11-02-10, *299-E25-111 (A6547), Log Data Report*
HGLP-LDR-799	11-02-11, *299-E25-112 (A6548), Log Data Report*
HGLP-LDR-774	11-02-12, *299-E25-128 (A6562), Log Data Report*
HGLP-LDR-798	11-02-22, *299-E25-127 (A6561), Log Data Report*
HGLP-LDR-765	11-03-02, *299-E25-113 (A6549), Log Data Report*
HGLP-LDR-787	11-03-05, *299-E25-114 (A6550), Log Data Report*
HGLP-LDR-788	11-03-07, *299-E25-115 (A6551), Log Data Report*
HGLP-LDR-762	11-03-09, *299-E25-116 (A6552), Log Data Report*
HGLP-LDR-763	11-03-10, *299-E25-117 (A6553), Log Data Report*
HGLP-LDR-764	11-03-12, *299-E25-118 (A6554), Log Data Report*
HGLP-LDR-785	11-04-01, *299-E25-119 (A6555), Log Data Report*
HGLP-LDR-778	11-04-05, *299-E25-120 (A6556), Log Data Report*
HGLP-LDR-800	11-04-07, *299-E25-121 (A6557), Log Data Report*
HGLP-LDR-783	11-04-08, *299-E25-122 (A6558), Log Data Report*

Table B-1. Reports associated with the 2014/2015 WMA A-AX Vadose Zone Soil Characterization Efforts

Report Number	Title
HGLP-LDR-786	11-04-10, *299-E25-123 (A6559), Log Data Report*
HGLP-LDR-796	11-04-11, *299-E25-124 (A6560), Log Data Report*
HGLP-LDR-784	11-04-19, *299-E25-147 (A6565), Log Data Report*

B2.0 REFERENCES

HGLP-LDR-762, 2011, *299-E25-116 (A6552), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-763, 2011, *299-E25-117 (A6553), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-764, 2011, *299-E25-118 (A6554), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-765, 2011, *299-E25-113 (A6549), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-767, 2011, *299-E25-131 (B2896), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-768, 2011, *299-E25-102 (A6538), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-769, 2011, *299-E25-100 (A6535), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-770, 2011, *299-E25-99 (A6534), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-771, 2011, *299-E25-105 (A6541), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-772, 2011, *299-E25-101 (A6537), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-773, 2011, *299-E25-133 (B2898), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-774, 2011, *299-E25-128 (A6562), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-775, 2011, *299-E25-109 (A6545), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-776, 2011, *299-E25-106 (A6542), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-777, 2011, *299-E25-132 (A6563), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-778, 2011, *299-E25-120 (A6556), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-780, 2011, *299-E25-107 (A6543), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-781, 2011, *299-E25-108 (A6544), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-783, 2011, *299-E25-122 (A6558), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-784, 2011, *299-E25-147 (A6565), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-785, 2011, *299-E25-119 (A6555), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-786, 2011, *299-E25-123 (A6559), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-787, 2011, *299-E25-114 (A6550), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

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HGLP-LDR-792, 2011, *299-E25-103 (A6539), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-796, 2011, *299-E25-124 (A6560), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-798, 2011, *299-E25-127 (A6561), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-799, 2011, *299-E25-112 (A6548), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-800, 2011, *299-E25-121 (A6557), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-801, 2011, *299-E25-104 (A6540), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-846, 2010, *299-E25-92 (A6531), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-852, 2010, *299-E25-77 (A6516), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-853, 2010, *299-E25-91 (A6530), Log Data Report,* Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-854, 2010, *299-E25-192 (A6598), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-861, 2010, *299-E25-83 (A6522), Log Data Report,* Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-862, 2010, *299-E25-85 (A6524), Log Data Report,* Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-863, 2010, *299-E25-86 (A6525), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-864, 2010, *299-E25-87 (A6526), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-869, 2010, *299-E25-63 (A6502), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

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HGLP-LDR-874, 2010, *299-E25-79 (A6518), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

HGLP-LDR-877, 2010, *299-E25-98 (A6533), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

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HGLP-LDR-883, 2010, *299-E25-82 (A6521), Log Data Report*, Rev. 0, Stoller Newport News Nuclear, Richland, Washington.

RPP-ENV-58747, 2015, *Fiscal Year 2014/2015 Completion Report for the 241-A and 241-AX Tank Farms Direct Push Characterization*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-PLAN-57332, 2016, *Field Sampling and Analysis Plan for Soil Samples at Waste Management Area A-AX*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-58969, 2016, *Analytical Report for Soil Samples Taken at Waste Management Area AX in 2015*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

TOC-PRES-16-3310-VA, 2016, *Vadose Zone Field Characterization WMA A-AX,* Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

ATTACHMENT B1

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX 2014 AND 2015

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washington river protection solutions

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

2014 and 2015

TOC-PRES-16-3310-VA

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

washington river protection solutions

PURPOSE

To Collect Data to Help Develop RCRA RFI/CMS Work Plan DQO

PERFORMED

AX-Farm:

- Drywell Logging, Direct Push Logging, and Direct Push Sampling

A-Farm:

- Drywell Logging and Direct Push Logging

Collected Temperature Data via Logging

TOC-PRES-16-3310-VA

2

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

AX-Farm Summary (Handout 1ax)

Drywell Logging

Spectral Gamma and Moisture

31 Locations

Direct Push Logging

Spectral Gamma, Moisture and Temperature

4 Locations

Direct Push Sampling

96 analytes

4 Locations, 3 sample depths @ each location

TOC-PRES-16-3310-VA

3

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

AX-Farm Drywell Logging (Handout 2ax)

Total Depth ~40-125 ft

No significant changes from 1996 baseline

Cs-137

- Max. conc. Surface to ~5 ft
  - 11-01-10 and 11-02-12 have the highest concentrations (calc ~26,000* pCi/g @ 2 ft and 3,800* @ 12 ft)
- Detected in most: Surface to ~20 ft, Near tank's base (~50 ft), ~20 to 50 ft intermittently or not at all
- Detected in some: @ depths >55 ft (typically <1 pCi/g)

Co-60 and Eu-154 detected in 4 Drywells (3 same: 11-02-12, 11-04-10, 11-03-07)

Moisture: <2-43% (max. @ 11-02-22, ~5 ft), typical max. <20%, higher levels around base of tank

*calculated based on decay from 1996 reading.

TOC-PRES-16-3310-VA

4

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

AX-Farm Direct Push Logging (Handout 3ax)

Deep electrodes installed

Gamma:

- Overall and Deepest Max. C9363 (~30 pCi/g @ ~surface)

Cs-137:

- Overall Max. C9363 (~54 pCi/g @ ~5 ft)
- Deepest Max. C9365 (~9 pCi/g @ ~30 ft)

Temperature:

- Range 61-86ºF, high of 86 ºF @ C9365, surface

Moisture

- Peaks near: Base of tanks (~50 ft) and @ Intermittent Depths
- Range 2-30% (max @ C9365, ~183 ft)
- Peaks selected for sample intervals

TOC-PRES-16-3310-VA

5

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

AX-Farm Direct Push Sample Results

Detected 69 of 96 analytes

- Detected Tc-99: C9360 (180-181.5 ft bgs, ~11 pCi/g) and C9362 (202-204 ft bgs 0.16 pCi/g) (Handout 3ax)
- Detected Nitrate: All samples, 5 to 56 mg/kg (Handout 3ax)
- Not Detected Cs-137, Co-60, Eu-154

Exceeded Background 16 of 49 analytes (Handouts 4ax & 5ax)

- Constituents with Most Samples Having Exceedances: Antimony, Chromium, Molybdenum, and Silicon
- Locations with Most Exceedances: C9360, 11 analytes, other 3 locations having 7 or 8 analytes
- Location with Most Rad Exceedances: C9364, 3 analytes

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VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

AX-Farm Surface Soil Removal (Handout 1ax)

Purpose:

- To Support Retrieval Infrastructure Development – Isolating Abandoned Ventilation System

Completed:

- Based on Radioactivity Survey Information
  - Removed Soil by AX-101/102 and AX-103/104
  - Excavated Depth of ~12 to 14 ft, 20 Drums
  - Survey Results Range 120K - 998K dmp/100 cm^2
    - Highest Activity AX-101/102
    - Areas Correspond to Drywells with Higher Detected Cs-137, Co-60 and Eu-154 conc. (11-02-12, 11-04-10, and 11-03-07)

TOC-PRES-16-3310-VA

7

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

A Farm Summary (Handout 1a)

Drywell Logging

Spectral Gamma and Temperature

19 Locations

Direct Push Logging

Spectral Gamma, Moisture, and Temperature

4 Locations

TOC-PRES-16-3310-VA

8

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

A Farm Drywell Logging (Handout 2a)

Total Depth ~50-150 ft

No significant changes from 1996 baseline

Cs-137

- Max. conc. usually within the first 10 ft (calc ~632,000* pCi/g @ 10-01-03, 5ft, measured 501 pCi/g @ 10-02-08, 2.5 ft)
- Detected in most: Surface to ~20 ft, Near tank's base (~50 ft), ~20 to 50 ft intermittently or not at all
- Detected in some: @ depths >55 ft (typically <10 pCi/g)

Co-60 and Eu-154 detected: 4 and 6 drywells (3 same: 10-01-03, 10-01-39, and 10-02-08)

Temperature: 43-125 ºF (max. @ 10-05-09, 53 ft)

- Higher Temperatures 112-125 ºF around A-105 and between A-104/105, 64-75 ft

*calculated based on decay from 1996 reading.

TOC-PRES-16-3310-VA

9

VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

A-Farm Direct Push Logging (Handout 3a)

Deep electrodes installed

Gamma:

- Overall and Deepest Max. C9383 (~40 pCi/g @ ~surface [1 ft])

Cs-137:

- Overall and Deepest Max. C9383 (~67 pCi/g @ ~surface)

Temperature:

- C9369 and C39383 exhibit higher temperatures
  - 100 ºF @ C9369, 58 ft
  - 118 ºF @ C9383, 49 ft
- C9379 and C9381 exhibit similar temperatures to those in AX-Farm ~60-80 ºF

Moisture

- Peaks near: Base of tanks (~50 ft) and @ Intermittent Depths
- Range 2-30% (max @ C9379, ~127 ft)

TOC-PRES-16-3310-VA

10

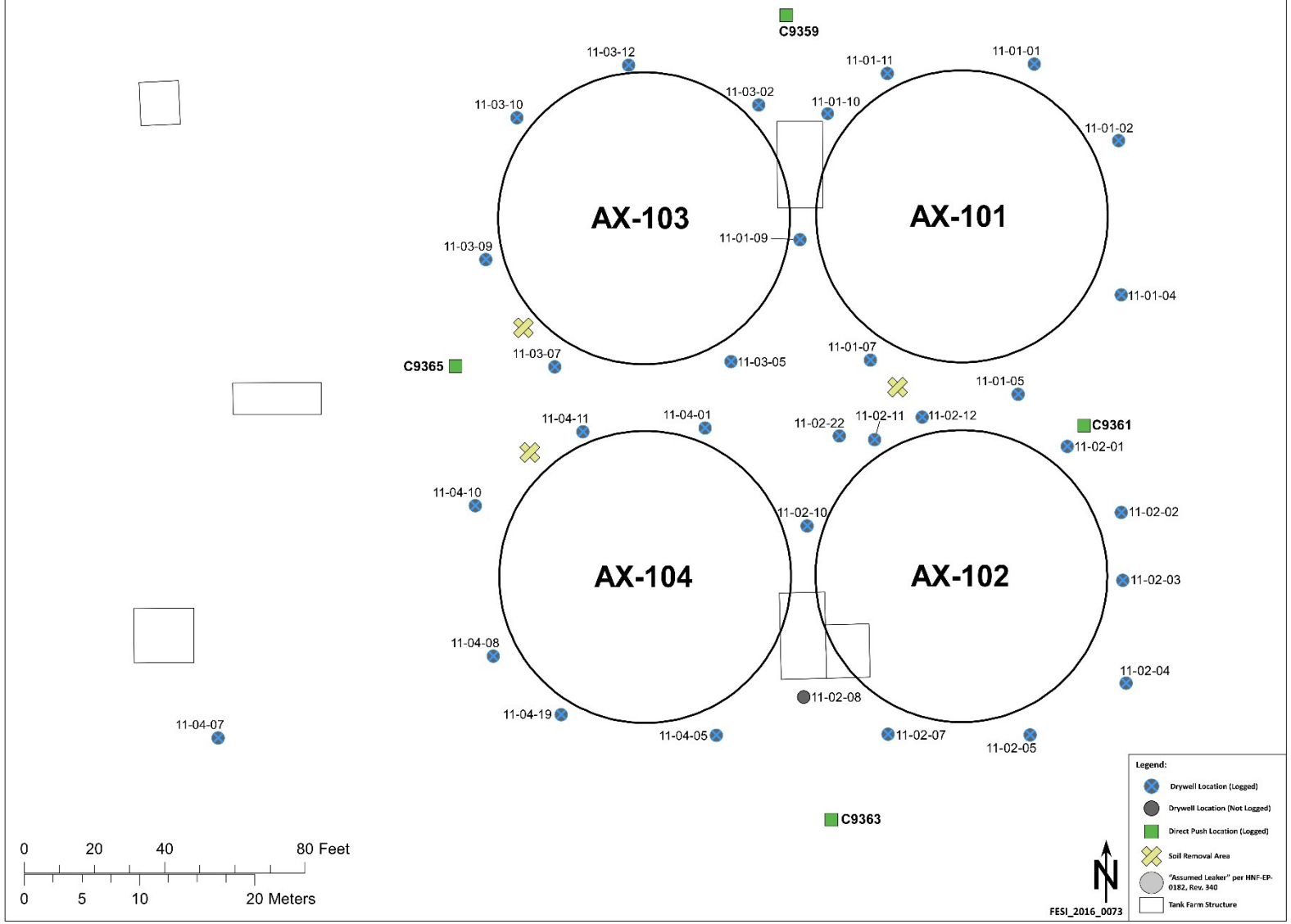
VADOSE ZONE FIELD CHARACTERIZATION WMA A-AX

Closing Remarks

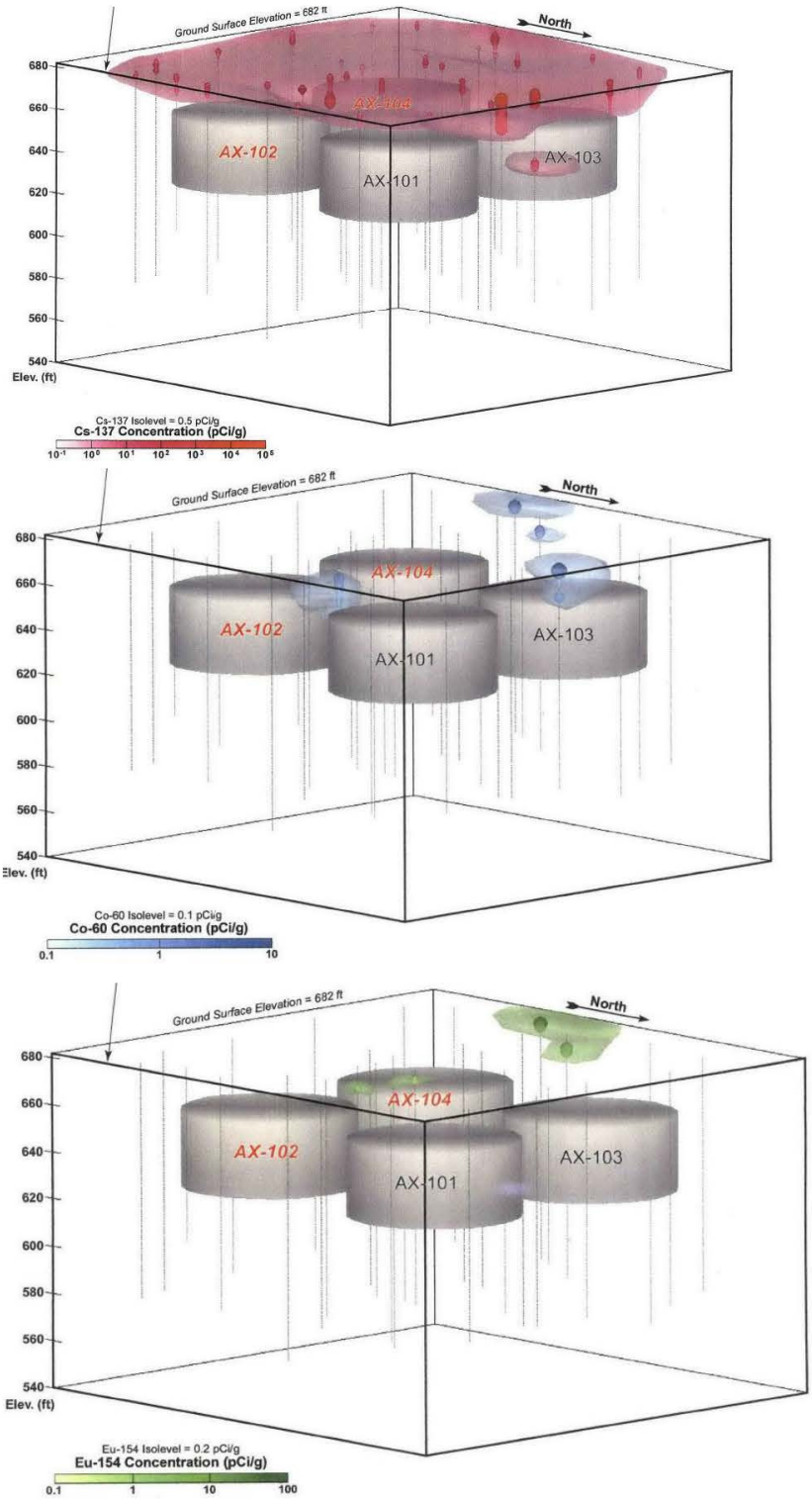
- Data will be Useful for Developing the RCRA RFI/CMS Work Plan DQO
- In General – Data Consistent with Previous Information
- Temperature Yields Useful Information

TOC-PRES-16-3310-VA

Handout 1ax : Field Characterization Locations



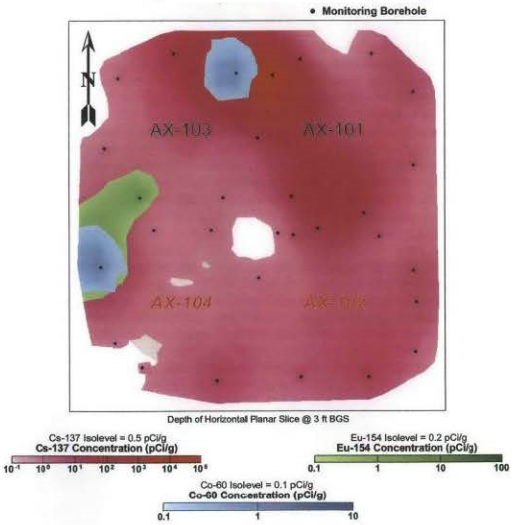
Handout 2ax1: 1996 Drywell Baseline 3D Visualizations for Cs-137, Co-60, and Eu-154



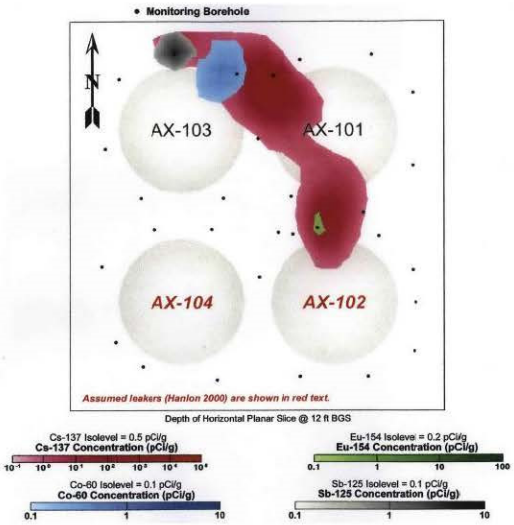
Source: Addendum to the AX Tank Farm Report GJO-97-44-TARA GJO-HAN-12, Figures D5-D12
Note: Status of assumed leakers updated to sound based on review of additional data and information (RPP-ENV-37956)

Handout 2ax2: 1996 Drywell Baseline 2D Visualizations at various depths for Cs-137, Co-60, and Eu-154

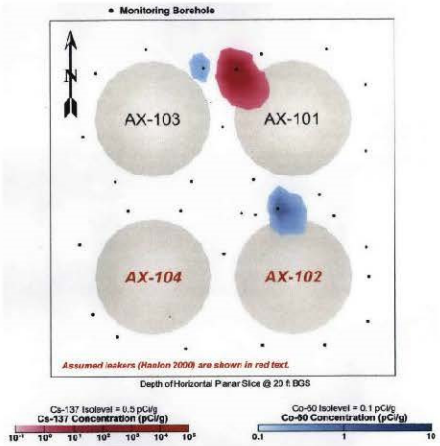
1: Depth of Horizontal Planar Slice @ 3 ft bgs



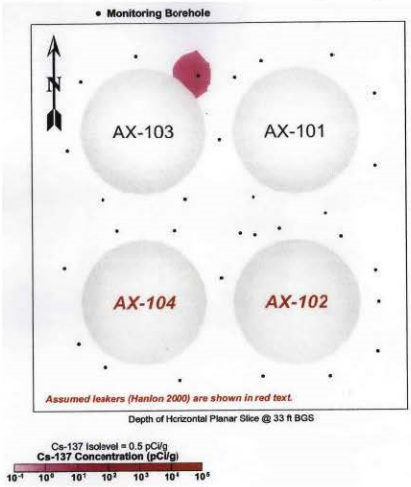
2: Depth of Horizontal Planar Slice @ 12 ft bgs



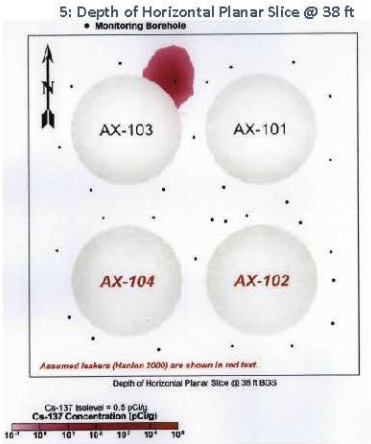
3: Depth of Horizontal Planar Slice @ 20 ft bgs



4: Depth of Horizontal Planar Slice @ 33 ft bgs



5: Depth of Horizontal Planar Slice @ 38 ft



Source: Addendum to the AX Tank Farm Report GJO-97-44-TARA GJO-HAN-12, Figures D5-D12
Note: Status of assumed leakers updated to sound based on review of additional data and information (RPP-ENV-37956)

Handout 3ax: AX-Farm Direct Push Summary Information

Location		C9359/C9360		C9361/C9362		C9363/C9364		C9365/C9366	
Date Logging Complete Total Depth ft bgs Number of Electrodes (Depth Range ft bgs)		7/2014 205.1 9 (38.25-197.25)		7/2014 205.0 9 (29.80-189.05)		7/2014 205.1 3 (15-179.8)		7/2014 205.0 9 (23.25-182.50)	
Sample Depth Meeting Date		11/25/2014		11/25/2014		11/25/2014		11/25/2014	
Sample Depth ft bgs Stratigraphic Unit		50-52 Backfill/H1		52-54 H1		45.5-47.5 Backfill (near Backfill/H1)		99.5-101.5 (H1/H2)	
Moisture Content (%)		~7.3		~7.5		~4.5		~7.4	
Nitrate* µg/g	Tc-99 pCi/g	~19	ND	~7	ND	~10	ND	~21	ND
Sample Depth ft bgs Stratigraphic Unit		115-117 Near H1/H2f		125.5-127.5 H1/H2f		121-123 H1/H2f		143-145 H2f	
Moisture Content (%)		~10.1		~5.9		~8.4		~11.6	
Nitrate* µg/g	Tc-99 pCi/g	~56	ND	~8	ND	~9	ND	~41	ND
Sample Depth ft bgs Stratigraphic Unit		180-181.5 H2c		202-204 H2c		145.5-147.5 H2f		182-184 H2c	
Moisture Content (%)		~6.5		~5.6		~7.5		~8.6	
Nitrate* µg/g	Tc-99 pCi/g	~18	~11[a,b]	~13	~0.16	~11	ND	~14	ND
Decommissioning Dates: Sample Location (Logging Location)		3/11/15 (8/11/2014)		2/24/15 (8/7/2014)		04/22/15 (7/22/2014)		4/8/15 (8/22/2014)	

Notes: ND = Not Detected (Detect limits forTc-99 ND results ranged from 0.101 to 0.114 pCi/g.), ft bgs = feet below ground surface

*Result listed is the greater of "quick turn" nitrate and nitrate by standard analysis for the sample interval. Please note, results for C9362 (125.5-127.5 ft bgs) and C9364 (all depths) are considered estimated high values based on preparation blank evaluation.

[a]Result is considered suspect and a possible false positive. The result is likely due to contamination introduced during preparation/analysis as indicated by the Tc-99 result of approximately the same level in the associated preparation blank sample.

[b]Result is from analysis of acid extract of composite sample. All other Tc-99 results are from water extract sample analysis ("quick turn" analysis). Detection limits for analysis of water extracts ~0.1 pCi/g; whereas, detection limits for analysis of acid extracts ~10 pCi/g.

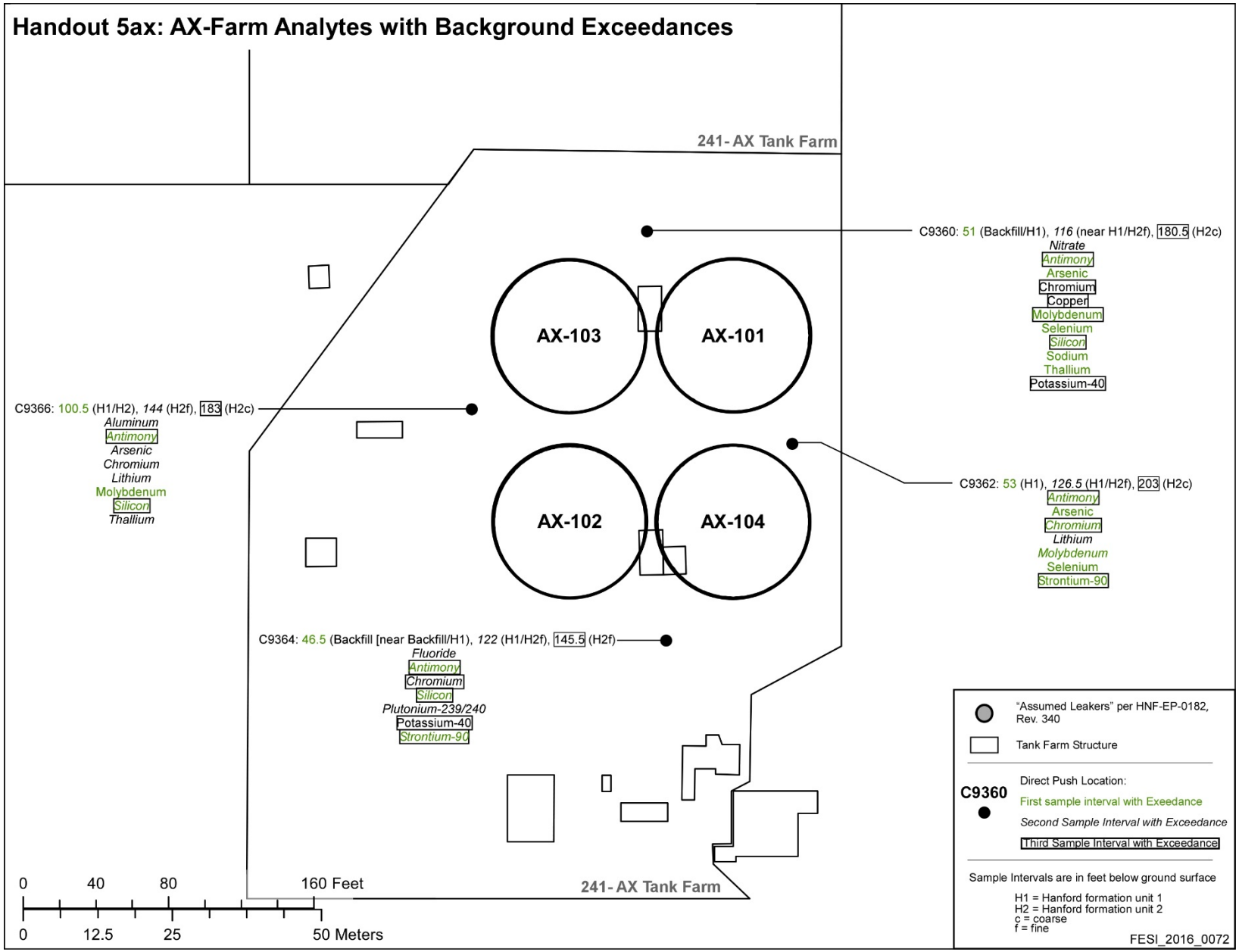
Handout 4ax: Constituents with Concentrations Above Background in 241-AX Farm

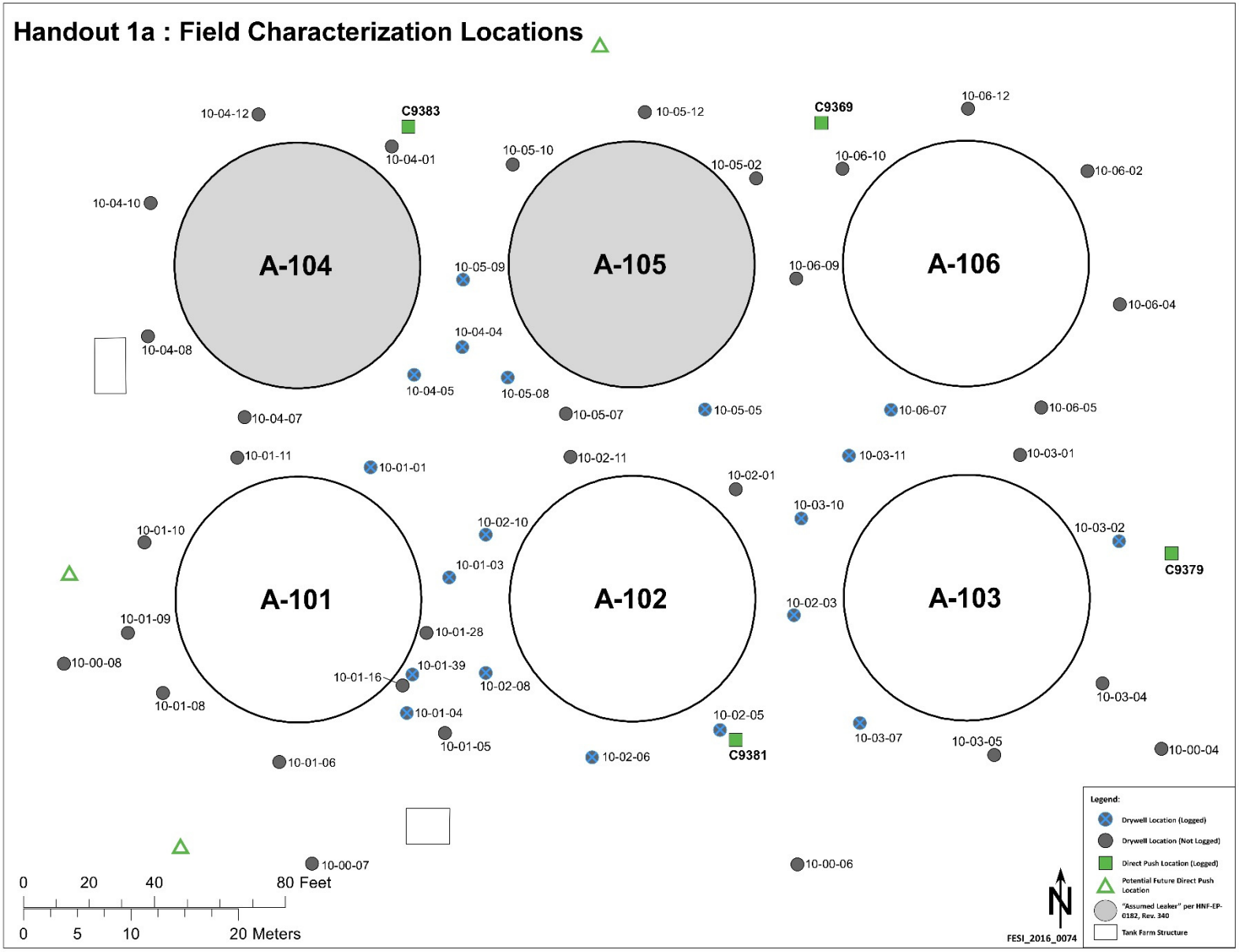
Constituent	Background Value[a]	Minimum Concentration Above Background	Maximum Concentration Above Background	Total # of Samples with background Exceedances (out of 12)	Total # of Locations with Background Exceedances (out of 12)	Location with Maximum Concentration (Depth of Maximum Concentration in ft bgs)
µg/g						
Aluminum	11800	12600	12600	1	1	C9366 (143-145)
Antimony	0.130	0.142	0.446	12	4	C9366 (143-145)
Arsenic	6.47	6.55	6.86	3	3	C9362 (52-54)
Chromium	18.5	19	29.7	7	4	C9364 (121-123)
Copper	22	25.8	25.8	1	1	C9360 (180-181.5)
Fluoride	2.81	3.12	3.12	1	1	C9364 (121-123)
Lithium	13.3	13.4	14.8	2	2	C9366 (143-145)
Molybdenum	0.470	0.798	2.83	5	3	C9362 (52-54)
Nitrate	52	55.8	55.8	1	1	C9360 (115-117)
Selenium	0.780	0.835	0.847	2	2	C9360 (50-52)
Silicon	44	51.2	66.9	9	3	C9364 (145.5-147.5)
Sodium *Essential Nutrient*	690	840	840	1	1	C9360 (50-52)
Thallium	0.185	0.197	0.215	2	2	C9366 (143-145)
pCi/g						
Plutonium-239/240[b]	0.0248	0.0677	0.0677	1	1	C9364 (121-123)
Potassium-40 *Naturally occurring background radiation*	16.6	17.1	17.9	2	2	C9364 (145.5-147.5)
Strontium-90[b]	0.178	0.188	0.328	5	2	C9364 (121-123)

[a]Background concentrations are defined in DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides* and ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

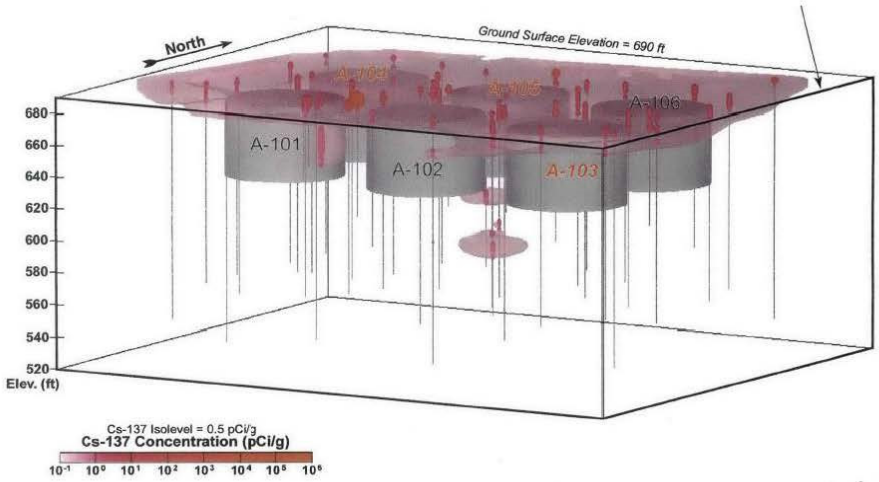
[b]Strontium-90 and Plutonium-239/240 are anthropogenic radionuclides whose background values only apply to surface soil samples.

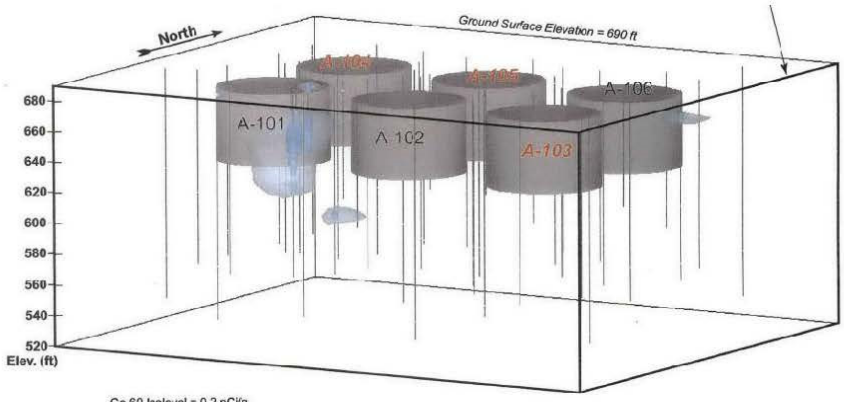
Note: ft bgs = feet below ground surface

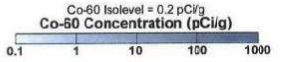

Handout 5ax: AX-Farm Analytes with Background Exceedances
241- AX Tank Farm
AX-103
AX-101
AX-102
AX-104
C9360: 51 (Backfill/H1), 116 (near H1/H2f), 180.5 (H2c)
Nitrate
Antimony
Arsenic
Chromium
Copper
Molybdenum
Selenium
Silicon
Sodium
Thallium
Potassium-40
C9366: 100.5 (H1/H2), 144 (H2f), 183 (H2c)
Aluminum
Antimony
Arsenic
Chromium
Lithium
Molybdenum
Silicon
Thallium
C9362: 53 (H1), 126.5 (H1/H2f), 203 (H2c)
Antimony
Arsenic
Chromium
Lithium
Molybdenum
Selenium
Strontium-90
C9364: 46.5 (Backfill [near Backfill/H1), 122 (H1/H2f), 145.5 (H2f)
Fluoride
Antimony
Chromium
Silicon
Plutonium-239/240
Potassium-40
Strontium-90
0 40 80 160 Feet
0 12.5 25 50 Meters
241- AX Tank Farm
"Assumed Leakers" per HNF-EP-0182, Rev. 340
Tank Farm Structure
C9360
Direct Push Location:
First sample interval with Exeedance
Second Sample Interval with Exceedance
Third Sample Interval with Exceedance
Sample Intervals are in feet below ground surface
H1 = Hanford formation unit 1
H2 = Hanford formation unit 2
c = coarse
f = fine
FESI_2016_0072

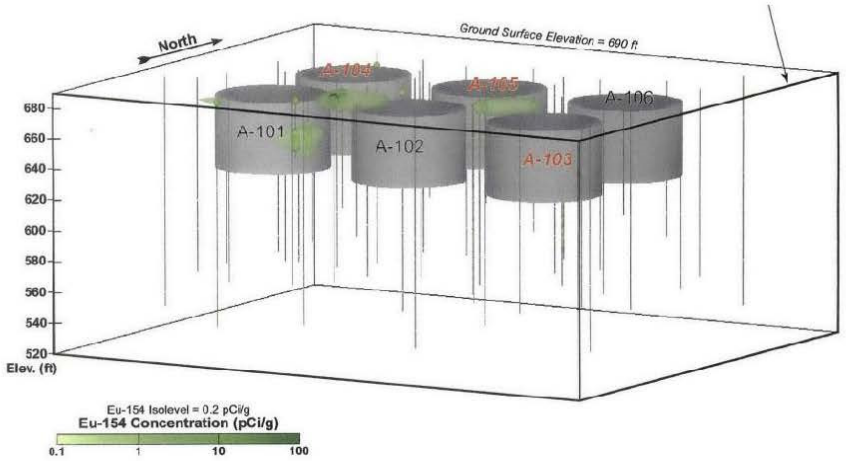

Handout 1a : Field Characterization Locations
A-104
A-105
A-106
A-101
A-102
A-103
C9383
C9369
C9379
C9381
10-04-12
10-04-01
10-04-10
10-04-08
10-04-05
10-04-04
10-04-07
10-05-12
10-05-10
10-05-02
10-05-09
10-05-08
10-05-07
10-05-05
10-06-12
10-06-10
10-06-02
10-06-09
10-06-04
10-06-07
10-06-05
10-01-11
10-01-01
10-01-10
10-01-09
10-00-08
10-01-08
10-01-16
10-01-39
10-01-28
10-01-03
10-01-04
10-01-05
10-01-06
10-00-07
10-02-11
10-02-01
10-02-10
10-02-08
10-02-05
10-02-06
10-03-11
10-03-01
10-03-10
10-03-02
10-02-03
10-03-04
10-03-07
10-03-05
10-00-04
10-00-06
0 20 40 80 Feet
0 5 10 20 Meters
FESI_2016_0074
Legend:
Drywell Location (Logged)
Drywell Location (Not Logged)
Direct Push Location (Logged)
Potential Future Direct Push Location
"Assumed Leaker" per HNF-EP-0182, Rev. 340
Tank Farm Structure

Handout 2a1: 1996 Drywell Baseline 3D Visualizations for Cs-137, Co-60, and Eu-154





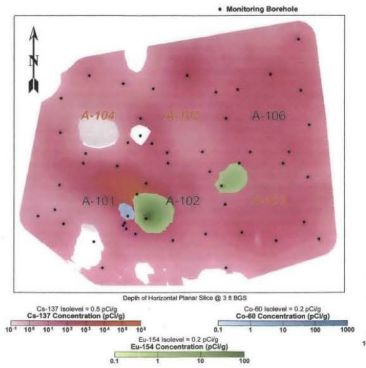




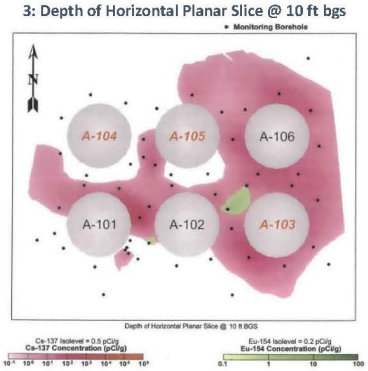
Source: GJO-98-64-TARA GJO-HAN-23, Addendum to the A Tank Farm Report, Figures D4-D16
NOTE: Status of A-103 updated to "sound" based on review of additional data and information (RPP-ENV-37956)

Handout 2a2: 1996 Drywell Baseline 2D Visualizations at various depths for Cs-137, Co-60, and Eu-154

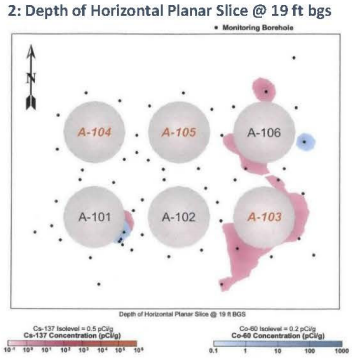
1: Depth of Horizontal Planar Slice @ 3 ft bgs



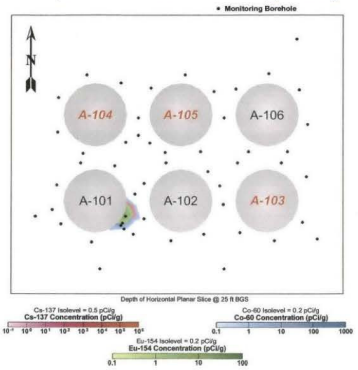
3: Depth of Horizontal Planar Slice @ 10 ft bgs



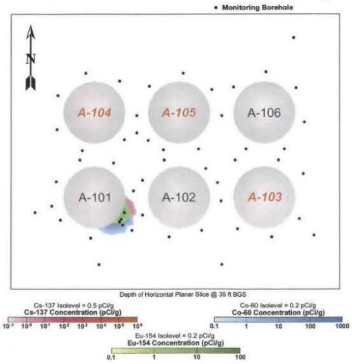
2: Depth of Horizontal Planar Slice @ 19 ft bgs



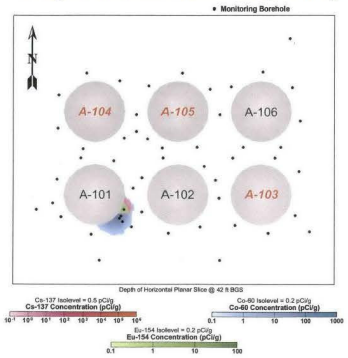
4: Depth of Horizontal Planar Slice @ 25 ft bgs



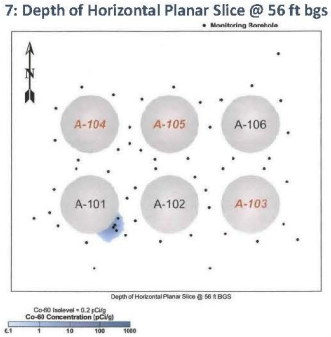
5: Depth of Horizontal Planar Slice @ 35 ft bgs



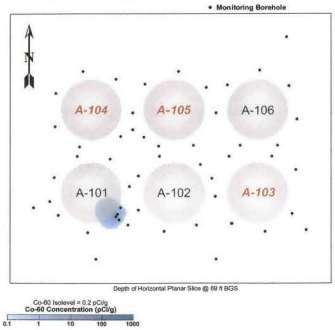
6: Depth of Horizontal Planar Slice @ 42 ft bgs



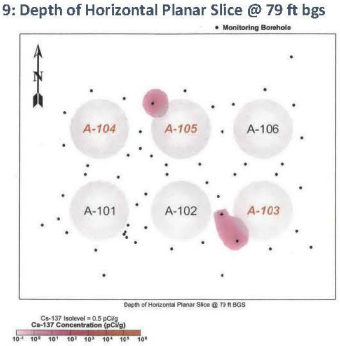
7: Depth of Horizontal Planar Slice @ 56 ft bgs



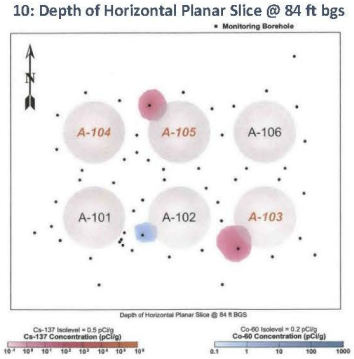
8: Depth of Horizontal Planar Slice @ 69 ft bgs



9: Depth of Horizontal Planar Slice @ 79 ft bgs



10: Depth of Horizontal Planar Slice @ 84 ft bgs



Source: GJO-98-64-TARA GJO-HAN-23, Addendum to the A Tank Farm Report, Figures D4-D16
NOTE: Status of A-103 updated to "sound" based on review of additional data and information (RPP-ENV-37956)

Handout 3a: A-Farm Direct Push Summary Information

Location	C9369/C9370	C9379/C9378	C9381/C9382	C9383/C9384
Date Logging Complete Total Depth ft bgs Number of Electrodes (Depth Range ft bgs)	8/2014 205.1 9 (20-179.25)	8/2014 205.1 9 (30-189.25)	8/2014 205.1 9 (20-179.25)	8/2014 205.0 9 (33-192.25)
Sample Depth Meeting Date	11/25/2014	11/25/2014	11/25/2014	11/25/2014
Sample Depth ft bgs Stratigraphic Unit	52-54 Backfill/H1	53-55 Backfill/H1	54-56 Backfill/H1	51-53 Backfill/H1
Sample Depth ft bgs Stratigraphic Unit	139-141 H2f	124-126 H1/H2f	99-101 H1/H2f	74-76 H1/H2f
Selected Sample Depth ft bgs Stratigraphic Unit	173-175 H2c	126-128 H2f	140-142 H2c	132-134 H2f/Hc
Decommissioning Date: (Logging Location)	(9/11/2014)	(8/29/2014)	(9/5/2014)	(8/28/2014)

Notes: ft bgs = feet below ground surface, ft amsl = feet above mean sea level

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APPENDIX C

FOCUS AREA INFORMATION FOR TANKS A-104 AND A-105 FOR STEPS 4 AND 7

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C1.0 INTRODUCTION

This appendix provides information on Step 4 (Define the Boundaries of the Study) and Step 7 (Develop the Plan for Obtaining Data) for the focus area of Tanks A-104 and A-105. Information is organized in the following manner:

- Background Information (Section C2.0)
- Boundaries for Focus Area (Section C3.0)
- Plan for Obtaining Data (Section C4.0).

C2.0 BACKGROUND INFORMATION

Section 1.2 provides general background information for WMA A-AX to facilitate the development of the DQO. This section provides some background information for the focus area around Tanks A-104 and A-105 to assist in the development of the field characterization strategy.

Both Tanks A-104 and A-105 have been identified as leakers. RPP-ENV-37956, *Hanford 241-A/AX Farm Leak Inventory Assessment Report,* provides depictions of leak locations for both Tanks A-104 and A-105 (Figures C-1 and C-2, respectively) along with lateral information. Figures C-3 and C-4 present historical radioactivity in Tanks A-104 and A-105 laterals, respectively, and Figures C-5 and C-6 present gamma and temperature surveys for Tanks A-104 and A-105 laterals, respectively.

Additionally, Figure C-7 shows the surface geophysical exploration (SGE) results for A Farm. In general, the well-to-well model for A Farm shows the lowest resistivity areas southeast of Tank A-104, southwest of Tank A-105, and south-southeast of Tank A-101.

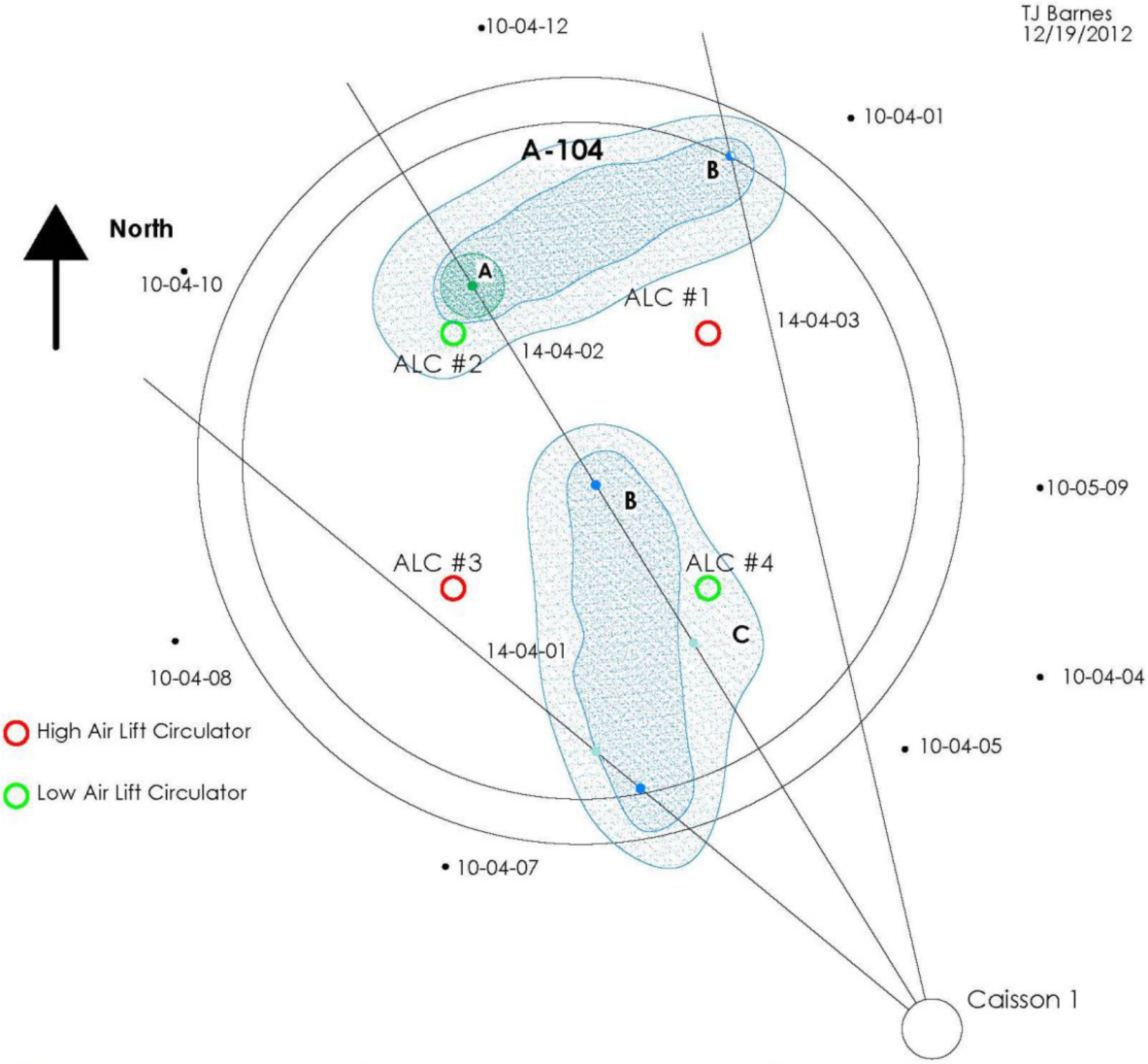
As identified in Appendix B, one direct push borehole, C9383, was logged during the 2014/2015 investigation in the vicinity of Tanks A-104 and A-105. Logging results showed a higher temperature of ~120 ºF at ~50 ft bgs.

Additional information is discussed in the following subsections:

- Tank A-104 (Section C2.1)
- Tank A-105 (Section C2.2)
- Corrosion issues (Section C2.3).

Note that numerous documents provide information about Tanks A-104 and Tank A-105. Much of this information is summarized in RPP-ENV-37956, which is the primary source for the information presented below.

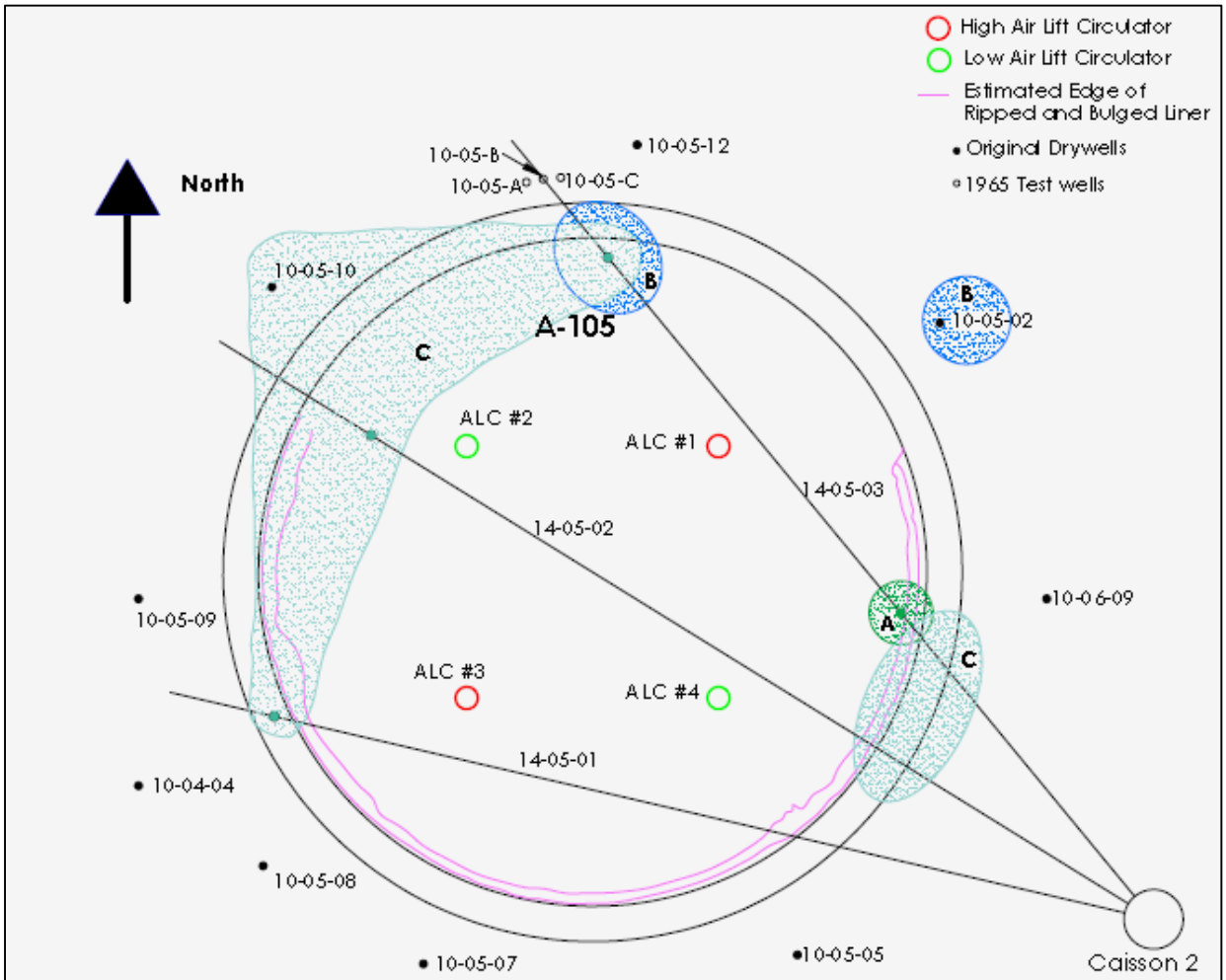
Figure C-1. Tank A-104 Possible Leak Locations and Indicators



A	B	C
March 1975	**April 1975**	**May 1975**
Radioactivity first detected in lateral 14-04-02 in March 1975 in the northern portion of tank A-104 shortly after the start of sluicing the tank in September 1974. The peak radioactivity was reported at 100 cpm in lateral 14-04-02 at approximately 94-ft from the caisson. No radioactivity was detected in the other laterals or drywells during this time.	A week after initial radioactivity was detected in lateral 14-04-02, counts continued to increase in the northern portion of the tank. Thus, sluicing was halted on April 7, 1975. On April 8, 1975, radioactivity was first detected in lateral 14-04-01 and an additional peak was recorded in lateral 14-04-02, both in the southern portion of the tank. On April 21, 1975, radioactivity was first reported in lateral 14-04-03 in the northern portion of the tank. Tank A-104 was declared a confirmed leaker and supernatant was pumped out of the tank from April 9 through April 19, 1975.	In May 1975, additional peaks were detected in lateral 14-04-02 along the southern edge of the tank. Radioactivity in site B continued to slowly increase through 1975. Radioactivity in lateral 14-04-03 slowly increased in May 1975 and then slowly declined. The tank A-104 liquid level was reported at 6.5-in at the end of April 1975 and radioactivity in the laterals appeared to stabilize by the end of 1975. No radioactivity was detected in the surrounding drywells.

Reference: RPP-RPT-54912, *Hanford Single-Shell Tank Leak Causes and Locations - 241-A Farm*.

Figure C-2. Tank A-105 Possible Leak Locations and Indicators

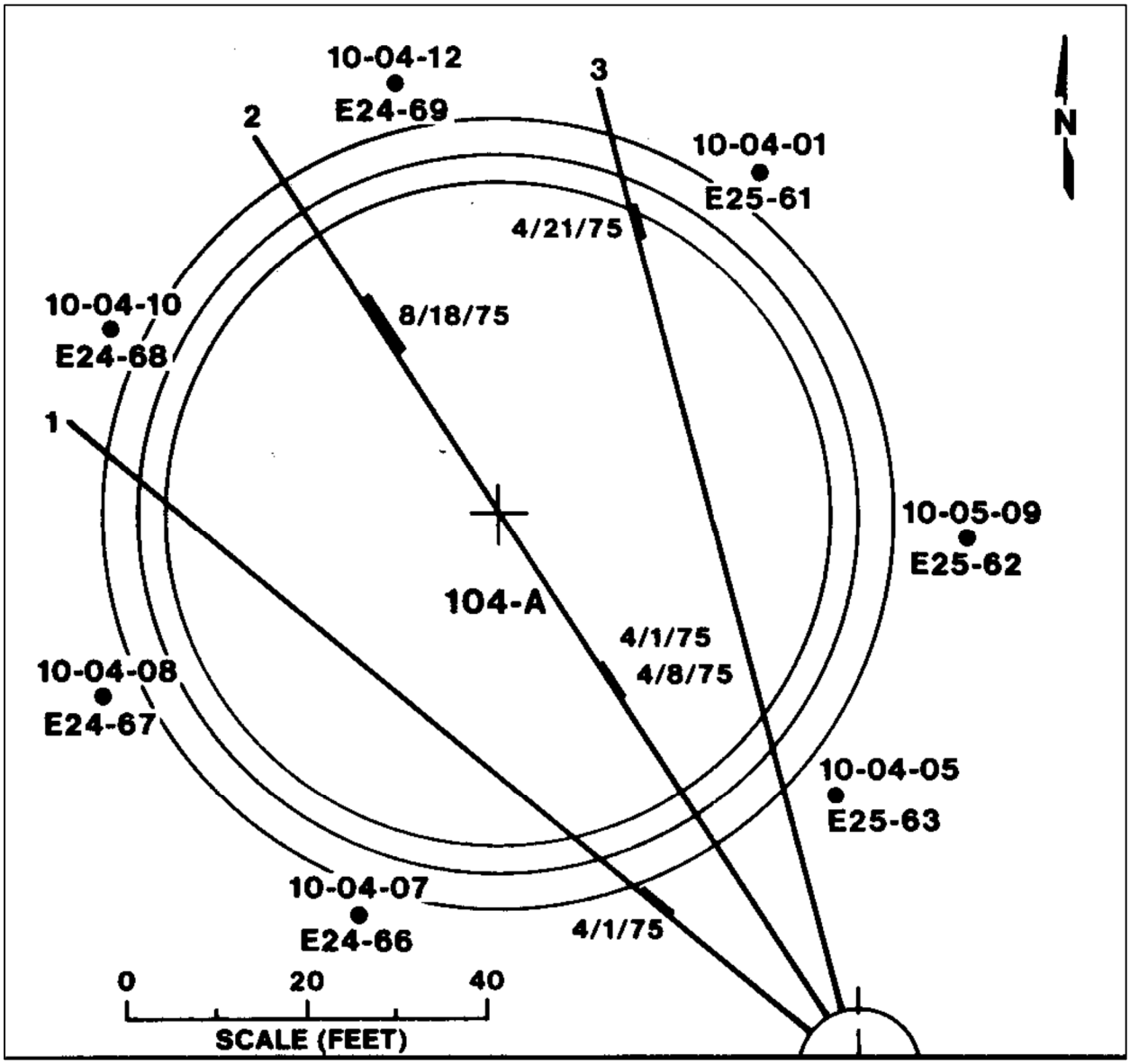


A	B	C
Nov-63	**Feb-65**	**Aug-68**
Radioactivity first detected in lateral 14-05-03 in November 1963 in the southeast portion of tank A-105. Readings remained relatively stable through March 1965. A sidewall leak was postulated during this time; however, it was not confirmed. No radioactivity was detected in the other laterals or drywells, and tank A-105 remained in service.	A steam eruption occurred in tank A-105 on January 28, 1965 causing the bottom liner to tear. One month later, radioactivity was reported in lateral 14-05-03 in the north portion of the tank. Three test wells were drilled near this lateral; however, no radioactivity or moisture was detected in these test wells. Radioactivity was detected January 1965 in drywell 10-05-02 at 74-ft BGS. The source of radioactivity may have been migration of mobile Ru-106 from a tank A-105 leak, possibly related to the November 1963 event.	In March 1968, tank A-105 was declared a confirmed leaker. Tank A-105 sluicing campaigns were conducted in 1968 and 1970. Laterals 14-05-01 and 14-05-02 began to increase in radioactivity during the first sluicing campaign August 1968 to November 1968. Sluicing became ineffective and was shut down. A second, more aggressive, sluicing campaign began August 1970 and was halted November 1970 after significant increases were detected in all the laterals underneath tank A-105. Radioactivity in drywell 10-05-10 increased between 1965 and 1972 which appears to be associated with radioactivity detected in lateral 14-05-02.

TJ Barnes
12/3/2012

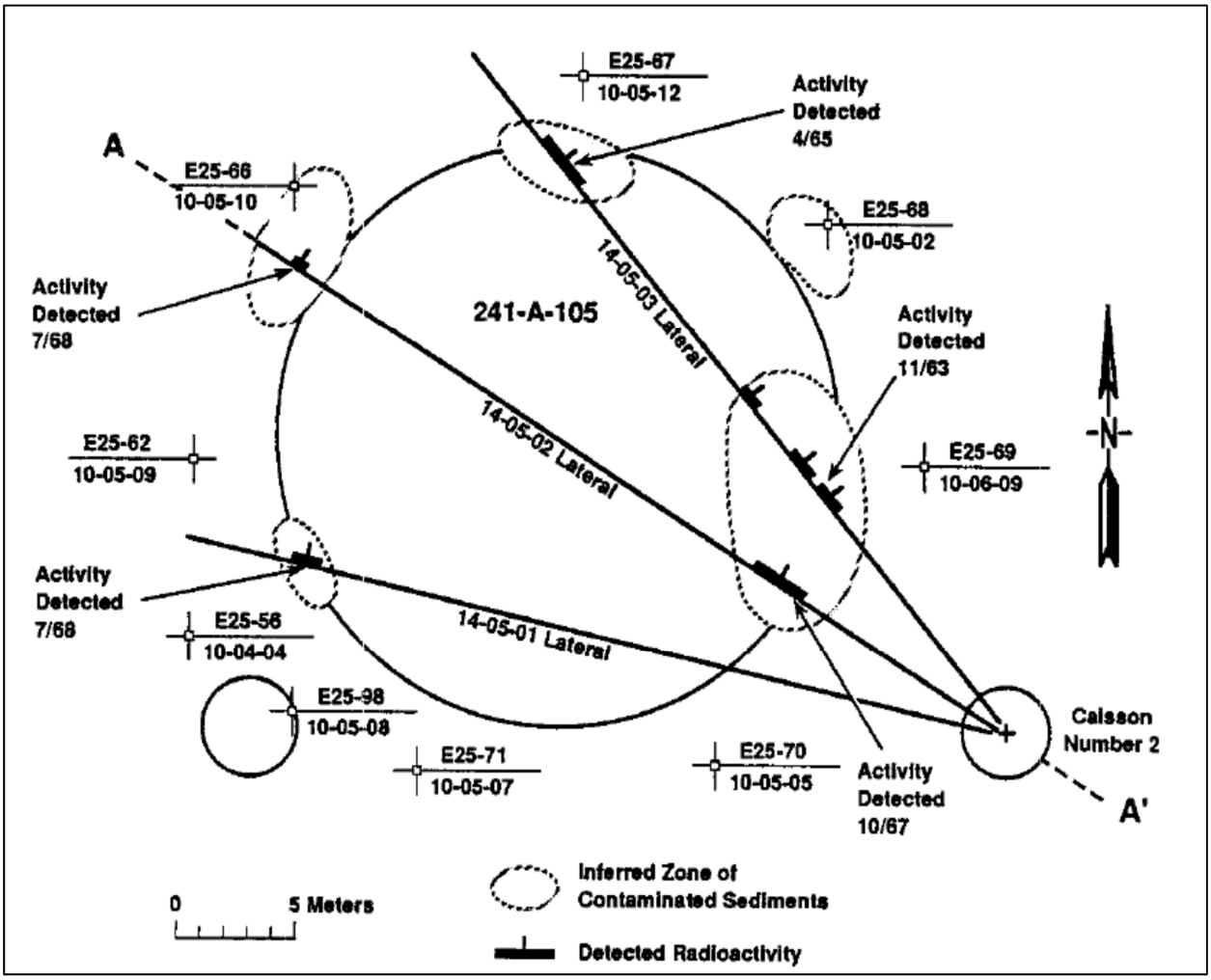
Reference: RPP-RPT-54912, *Hanford Single-Shell Tank Leak Causes and Locations - 241-A Farm*.

Figure C-3. Historical Radioactivity for Tank A-104 Laterals



Source: RPP-ENV-37956, Rev. 2, *Hanford 241-A/AX Farm Leak Inventory Assessment Report.*

Figure C-4. Location of Laterals and Gamma Activity for Tank A-105



Source: RPP-ENV-37956, Rev. 2, *Hanford 241-A/AX Farm Leak Inventory Assessment Report.*

Note: The dates of lateral radioactivity increases and stabilization during August 1968 conflict between documents WHC-MR-0264, *Tank 241-A-105 Leak Assessment*; WHC-EP-0412, *Fate and Transport of Constituents Leaked from Tank 241-A-105;* and Interoffice Memorandum 7G420-06-004, "Estimation of Tank 241-A-105 Supernatant Cesium-137 Concentration During Sluicing in August 1968."

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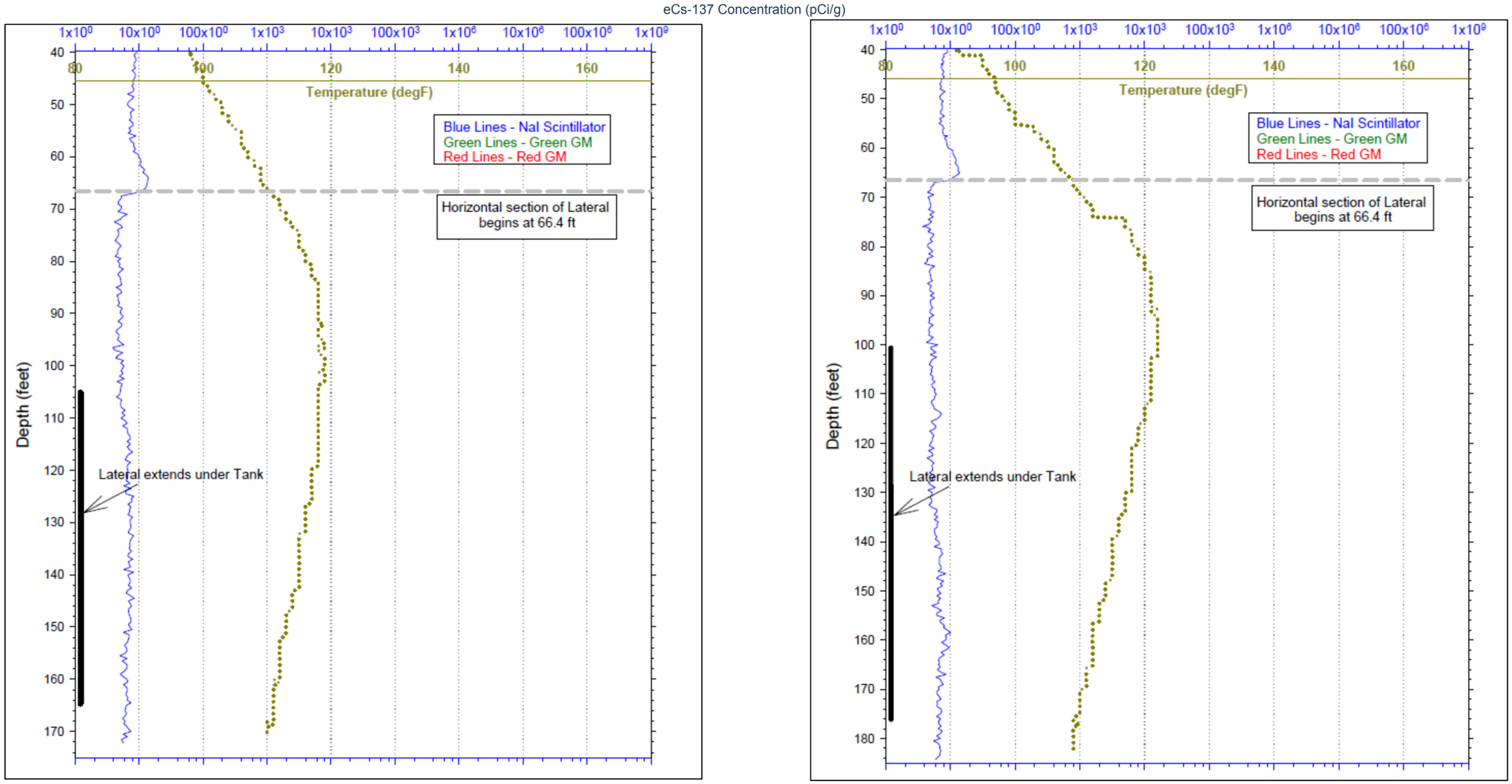
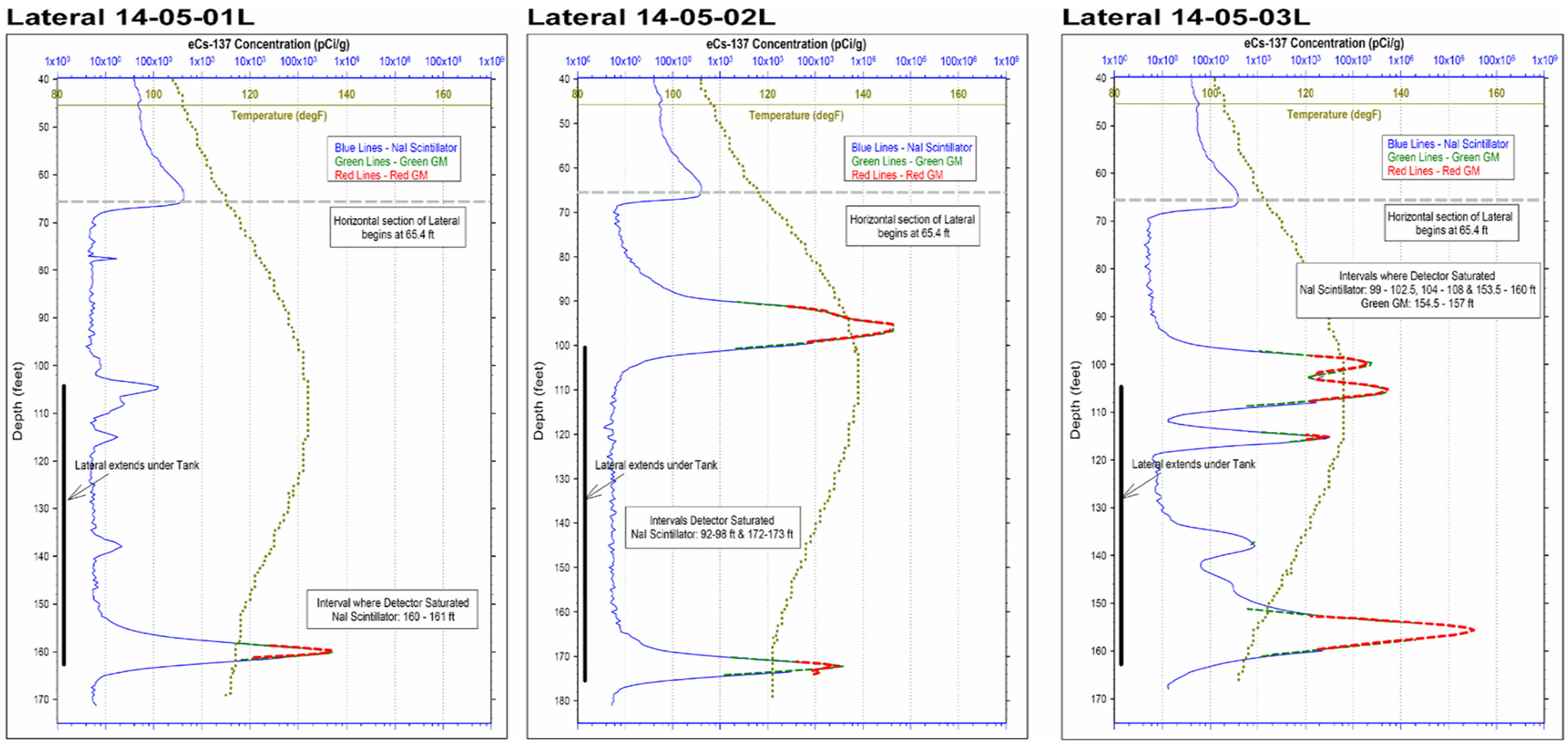
Figure C-5. Summary Gamma Survey for Laterals under Tank A-104, April 2005



Lateral 14-04-01 **Lateral 14-04-02**

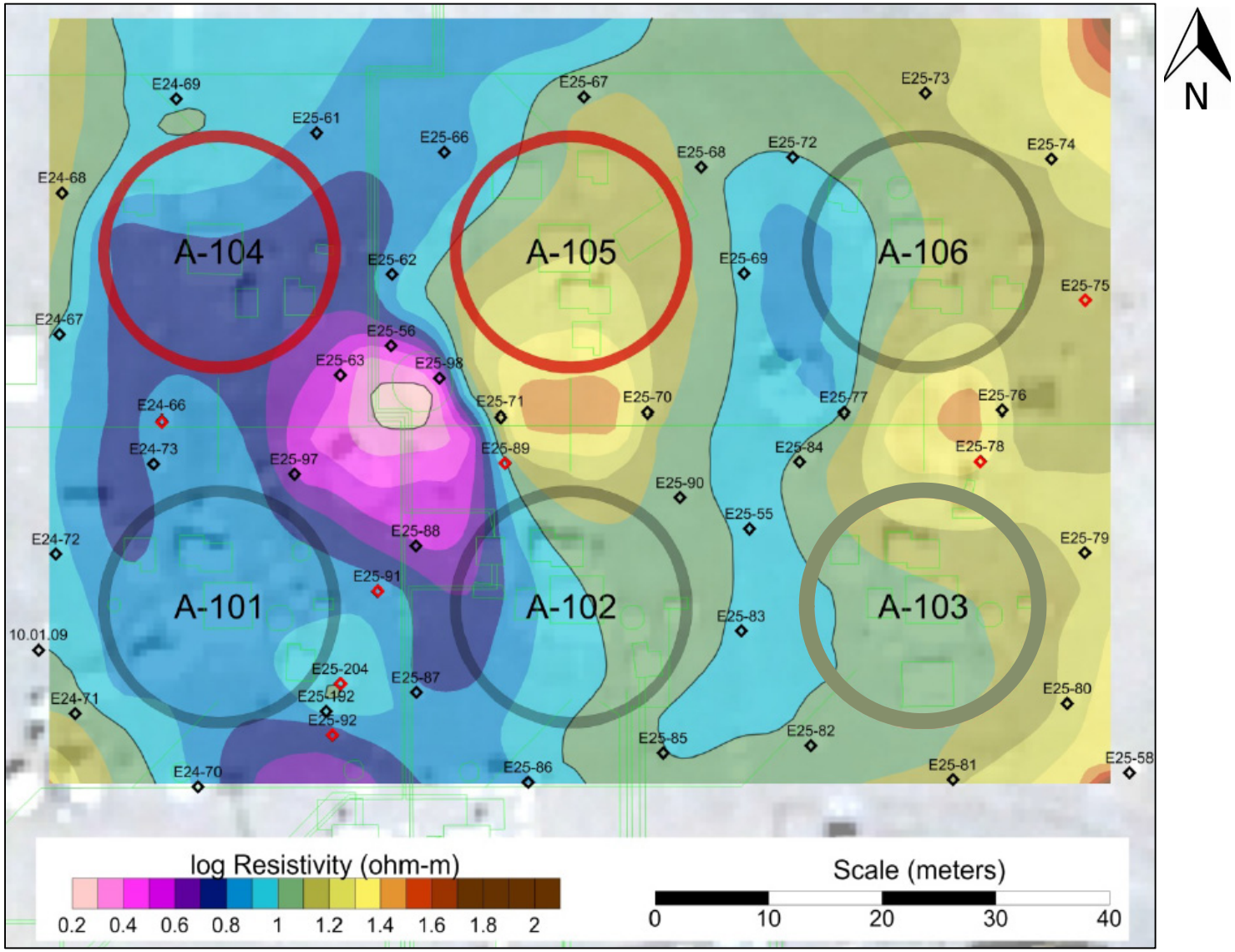
Reference: RPP-ENV-37956, Rev. 2, *Hanford 241-A/AX Farm Leak Inventory Assessment Report.*

Figure C-6. Summary Gamma Survey for the Laterals under Tank A-105, April 2005



Source: RPP-ENV-37956, Rev. 2, *Hanford 241-A/AX Farm Leak Inventory Assessment Report.*

Figure C-7. A Farm Well-to-Well Surface Geophysics Exploration Results



Source: RPP-RPT-46613, *Surface Geophysical Exploration of the A and AX Tank Farms*.

C2.1 TANK A-104

Tank A-104 was designated as a "confirmed leaker" in April 1975 based on increased radioactivity detected in laterals 14-04-01 and 14-04-02 (refer to Figure C-3). Lateral data obtained from 1975 to 1986 show elevated gamma activity below the tank that indicates the presence of a tank liner leak.

Based on the activity in the laterals under the tank and the absence of gamma activity from drywells surrounding the tank, it appears that the tank liner leaked at or near the tank footing, likely due to tank liner failure. The actual size of the leak is uncertain, and additional characterization has been recommended to better assess the volume and extent of the tank liner leak.

Leak locations depicted in Figure C-1 are based on peak readings and are a representation of possible initial and subsequent boundaries of radioactivity. It was determined that the leak site or sites are located at or near the tank footing, because the liquid level in Tank A-104 was reported at 31 in. at the end of February 1975. Several possible causes for liner leaks were examined, but the most likely cause is the Tank A-104 thermal conditions.

The level of radioactivity measured at the laterals indicates that the leak was small. Leak volume estimates range from 500 to 2,500 gal. The best estimate for the leak volume was determined to be ~2,000 gal (ARH-LD-206 B, *Atlantic Richfield Hanford Monthly Report August 1975*, pp. 10) of PSS waste containing ~0.56 Ci/gal of cesium-137 as of May 2008. The cesium-137 inventory for this release would be ~1,300 Ci decayed to January 1, 2001.

C2.2 TANK A-105

Tank A-105 was designated as a "confirmed leaker" in April 1975, based on increased radioactivity detected in laterals 14-05-01 and 14-05-02 and increased temperatures in tank laterals (refer to Figure C-4). In-tank surface level changes and video observation of a bulge and ripped liner confirm that the tank leaked.

On November 19, 1963, radioactivity detected in lateral 14-05-03 (ARH-78, *PUREX TK-105-A Waste Storage Tank Liner Instability and Its Implications on Waste Containment and Control*) indicated that Tank A-105 had leaked. On January 28, 1965, Tank A-105 experienced a rapid pressurization event that resulted in the tank liner bulging upward ~8 ft and the liner being ripped around the edges of the tank. Radioactivity (250,000 to 350,000 counts per minute [c/m]) was detected in March 1965 in lateral 14-05-03 beneath the tank. Radioactivity was also detected in laterals 14-05-02 beneath Tank A-105 in October 1967. Cooling water was added through January 1968.

From February 1968 through August 1968, the supernate in Tank A-105 was removed and the supernate heel diluted through a series of flushes using 221-B Plant cesium ion exchange supernate (CSR). In July 1968 radioactivity was detected below the west edge of the tank in laterals 14-05-01 and 14-05-02. Following the dilution and flushing of Tank A-105 supernate, two sluicing campaigns were conducted to remove the sludge from Tank A-105. The first

sluicing campaign, conducted from August through November 1968, used cesium-denuded supernate derived from operation of the cesium ion exchange process in B Plant. In the second sluicing campaign, a 1-Molar inhibited sulfuric acid was sprayed onto the sludge in Tank A-105, and waste was sluiced using cesium-denuded supernate generated in B Plant. Following the sluicing of the waste from November 1970 through December 1978, cooling water was added; based on evaporation estimates, some of the cooling water may have leaked from the tank.

Lateral data obtained from 1963 to 1986 show elevated gamma activity and high temperatures below Tank A-105 that clearly indicate the existence of a tank liner leak. In-tank surface level changes and video observation of a bulge and ripped liner confirm that the tank leaked. Based on the dates that increased gamma was detected in the laterals, the waste type leaked from Tank A-105 was determined to be a combination of PUREX supernatant waste with a cesium-137 concentration of 30.7 Ci/gal (as of May 1965 [ARH-78]) and B Plant ion exchange waste with a cesium-137 concentration of 1.38 Ci/gal (as of June 1968 [Interoffice memorandum 7G420-06-004, "Estimation of Tank 241-A-105 Supernatant Cesium-137 Concentration During Sluicing in August 1968"]).

Leak locations depicted in Figure C-2 are based on peak readings and are a representation of possible initial and subsequent boundaries of radioactivity. Based on gamma activity measured in the laterals, and the ripped liner on the tank perimeter at the base of the tank, the tank likely leaked from around the tank perimeter at the tank base. The estimated volume of waste released from Tank A-105 is ~2,000 gal from PSS waste and ~40,000 gal from B Plant liquid waste (CSR).

C2.3 CORROSION ISSUES

Well casing corrosion has been identified in several drywells near Tanks A-104 and A-105 and in groundwater wells south of A Farm. Even though the groundwater wells are a distance away from the focus area, there has been speculation that the cause of the corrosion was possibly from a Tank A-105 waste release (Ecology during WMA A-AX DQO meetings). Refer to Figure 1-2 for the locations of groundwater wells and drywells in and around A Farm that have had casing and/or corrosion issues (i.e., 299-E24-19, 299-E25-46, 200-E25-236, 10-05-02, 10-05-10, and 10-06-12).

In 2003, it was determined that two RCRA monitoring wells (299-E24-19 and 299-E25-46) in the WMA A-AX area had failed as a result of rapid corrosion of the stainless steel casing. These two wells were decommissioned, and two new replacement RCRA groundwater monitoring wells were installed in 2004 (299-E24-33 and 299-E25-95) (DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Tier 1 and 2*).

Because of the concern about the cause of the well corrosion in WMA A-AX, Pacific Northwest National Laboratory (PNNL) was asked to perform a detailed analyses of vadose zone samples collected in the vicinity of the well casings during their decommissioning in the hope of ascertaining the cause of the rapid well casing corrosion. Based on the findings of this report (PNNL-15141, *Investigation of Accelerated Casing Corrosion in Two Wells at Waste Management Area A-AX*), the use of Portland cement as an annulus sealing agent in groundwater

monitoring wells in zones with high moisture content or that have the potential to accumulate perched water was recommended.

As identified in Section 1.2.4, technetium-99 exceeded the drinking water standard in well 299-E25-236 starting in 2012. In November 2012, review of a television survey completed within well 299-E25-236 revealed accelerated corrosion between 263 and 267 ft bgs. Black staining from the corroded casing extended downward ~28 to 32 ft to groundwater at 295 ft bgs. The surface of the groundwater was covered with various particles. It was identified that the increase in technetium-99 activity at this well may have been associated with liquid seeping through the corroded casing and migrating down the inside of the casing to the groundwater within the well. Elevated technetium-99 activity also occurred at wells 299-E24-19 and 299-E25-46 (PNNL-15141). Well 299-E25-236 was decommissioned and replaced with well 299-E25-237 in 2013.

At the three corroded and decommissioned wells, the corrosion occurred above the water table at (or slightly above) a fine-grained geologic unit (the Cold Creek silt-dominated unit [CCUz]). As identified in DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX*, it is unlikely that SSTs and other liquid waste facilities in WMA A-AX leaked or discharged a large enough volume that contained the corrosive constituents necessary to corrode the three wells. The most likely source of the corrosion is chloride-bearing effluent from the 200 East Area powerhouse (284-E Powerhouse) that was discharged to an unlined ditch (200-E-286 Ditch) that traversed the southwest end of what later became the A Farm (refer to Figure C-8). This ditch was active from 1946 to 1953. The 200-E-286 Ditch likely contributed to casing corrosion in the southern part of WMA A-AX area.

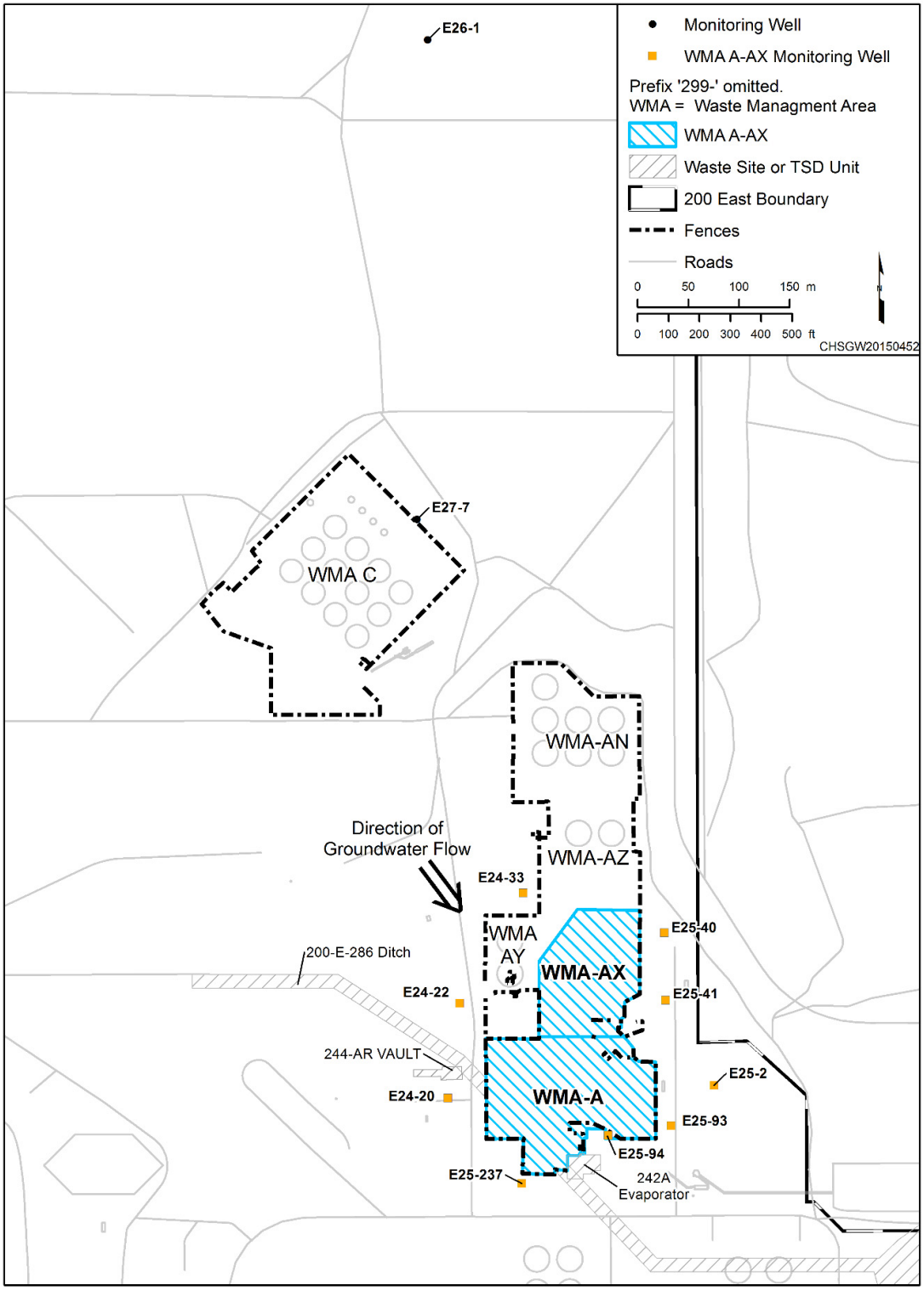
When wells 299-E24-19, 299-E25-46, and 299-E25-236 were still in service, they also showed elevated levels of nickel, a product of stainless steel well casing corrosion, along with manganese, iron, and chromium. These constituents in groundwater monitored by stainless steel wells are indicators of well corrosion. Well 299-E25-40 is also showing elevated levels of four metals indicative of stainless steel corrosion (nickel, chromium, iron, and manganese). The cause of the corrosion is unknown.

In 1978, casing issues also occurred more closely to Tanks A-104 and A-105 in drywells 10-05-02, 10-05-10, and 10-06-12. Each of these drywell's casing broke while they were being deepened:

- 10-05-02 at ~60 ft bgs
- 10-05-10 between 60 to 70 ft bgs
- 10-06-12 at ~54 ft bgs.

The casing in 10-05-10 was pulled and identified as being heavily corroded. PNNL indicated that they believed it was unlikely that there was a direct, chemical interaction between any tank leakage and the well casing (HGLP-PPS-010, *A-Farm Geophysical Logging*). Note that these drywells are still in service and continue to be logged.

Figure C-8. Location of WMA A-AX, A and AX Tank Farms, and Wells in the WMA A-AX Monitoring Network



Source: DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX.*

C3.0 BOUNDARIES FOR FOCUS AREA

As identified in Section 5.0, the purpose of DQO process Step 4 is to identify the target population of interest and specify the spatial and temporal features pertinent for decision making or estimation (i.e., boundaries). All boundaries for the focus area and WMA A-AX are the same with the exception of the horizontal spatial and temporal boundary (refer to Section 5.0). The horizontal spatial boundary for the focus area was approved in WMA A-AX DQO meeting dated July 24, 2017 (WMA A-AX-DQO-2017-8) and is shown in Figure C-9. The temporal boundary for data collection for this focus area is prior to retrieval of Tanks A-104 and A-105, whereas the temporal boundary for the overall data collection in the WMA A-AX area will be the final CMS for WMA A-AX.

C4.0 PLAN FOR OBTAINING DATA

This section provides an overview of the sampling design for characterization of the vadose zone soil within the boundary of the focus area around Tanks A-104 and A-105. Information pertaining to the plan for obtaining data at all of WMA A-AX is presented in Section 8.0 of this document. The details of conducting the focus area field characterization work will be presented in a work plan/sampling and analysis plan.

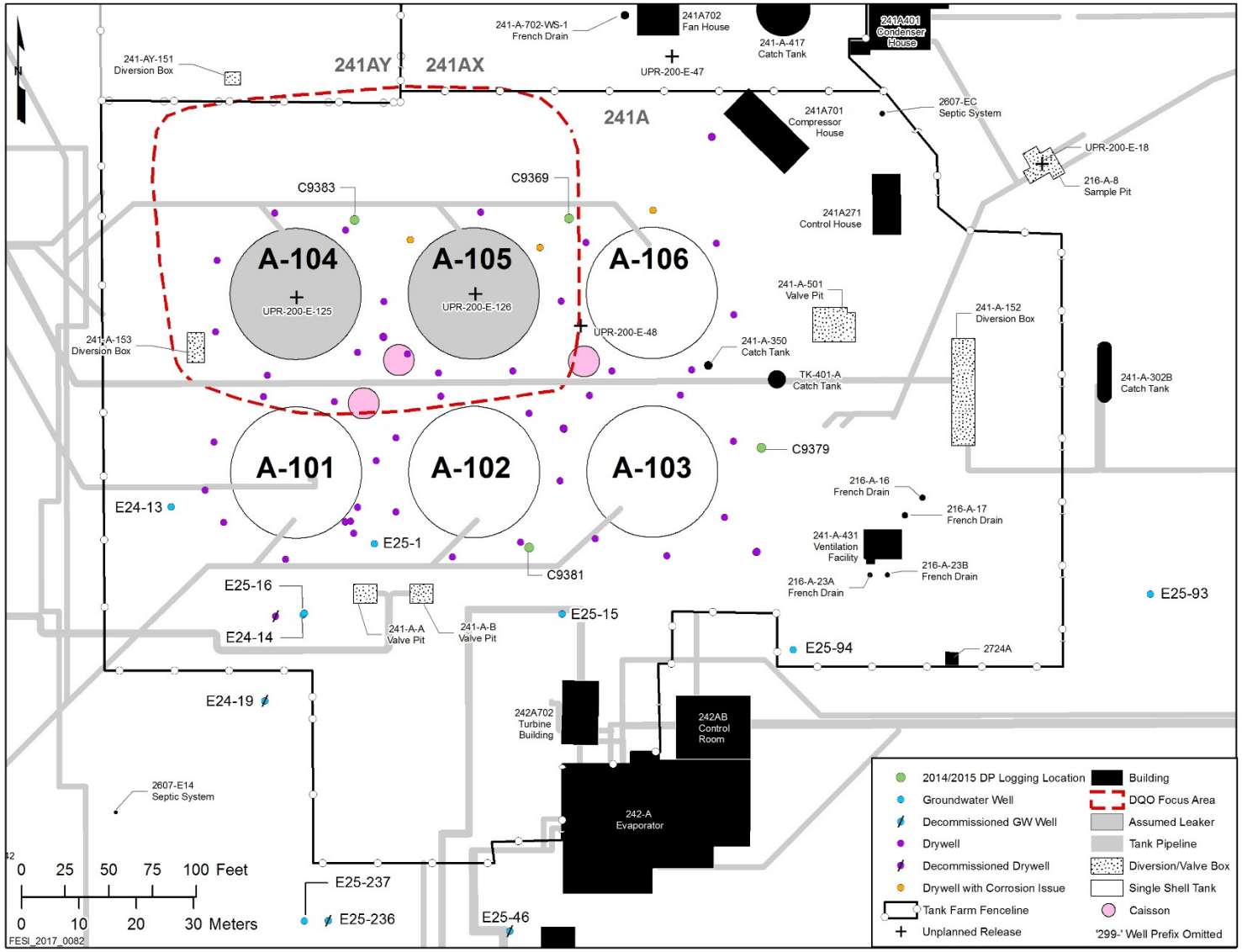
The plan for obtaining data for the focus area around Tanks A-104 and A-105 is based on discussions held among DOE-ORP, DOE-RL, Ecology, WRPS, and CHPRC in calendar year 2017. Meeting notes available through the Hanford Site Administrative Record[1] document agreements reached at these meetings. The agreements are also provided in Table A-2. A summary of the focus area characterization plan is provided in the WMA A-AX DQO meeting dated August 31, 2017 (WMA A-AX-DQO-2017-10).

The focus area sampling design overview below covers the following topics:

- Proposed field methods (Section C.4.1)
- Direct push logging and soil sampling (Section C.4.2)
- Drywell logging (Section C.4.3).

[1] The Hanford Site Administrative Record is available at: http://pdw.hanford.gov/arpir/.

Figure C-9. Study Boundary for WMA A-AX Focus Area



C4.1 PROPOSED FIELD METHODS

Step 3 of the DQO process (covered in Section 4 of this document) identifies potentially appropriate methods for performing characterization work in the vadose zone (Table 4-2) and discusses benefits and drawbacks of the methods. Based on the constraints associated with performing work in tank farms and within the focus area (Table 5-1), a subset of methods was identified for use at the Tanks A-104 and A-105 focus area:

- Use of ground penetrating radar (GPR)
- Geophysical logging of drywells and boreholes
- Collection of soil samples for laboratory analysis, using a specialized dual-string, small diameter hole, direct push method for samples taken more than 12 in. bgs.

During the initial steps of the investigation, GPR, in combination with walk downs of the study area, will be used to verify the presence and location of subsurface and surface features that would interfere with sampling activities. A GPR survey was performed in the past at A Farm, but due to the amount of time elapsed since that GPR survey, another survey must be completed in the focus area, along with field walk downs, before proposed sampling locations can be finalized.

The investigation will also use various geophysical logging tools. Gross gamma, spectral gamma, neutron moisture, temperature, and gyroscope logging will be used in direct push boreholes. Spectral gamma, neutron moisture, and temperature logging, as well as borehole cameras will be used at drywells in the focus area.

Gross gamma logging provides a measure of the concentration of gamma emitting radionuclides in the direct vicinity of the borehole location. Spectral gamma tools can indicate contamination zones and areas with increased or decreased radioactivity since prior logging efforts. Spectral gamma logging also allows for better determination of individual gamma-emitting radionuclides than gross gamma logging. Neutron moisture logging provides an estimate of moisture content in the vadose zone soil directly adjacent to the borehole. Temperature logging will aid in developing the current temperature profile in the vadose zone. Gyroscope logging will be used for angle pushes for quality control. Use of a camera will provide information on the status of the casing (e.g., whether there is corrosion). Additional information about various geophysical logging tools is provided in Section 4.3.2 of this document.

The results of geophysical logging at the Tanks A-104 and A-105 focus area will inform decisions about the locations at which vadose zone soil samples should be taken. Soil samples will be taken in the top 12 in. of the soil column using tools such as spatulas, scoops, or miniature core samplers. Vadose zone soil samples from deeper in the soil column will be taken using a modified small-diameter direct push method described in detail in Section 4.3.1 of this document.

The proposed geophysical logging and sampling activities to be conducted in the new direct push boreholes are discussed in Section C.4.2, below. Proposed drywell logging activities are discussed in Section C.4.3.

C4.2 DIRECT PUSH LOGGING AND SOIL SAMPLING

This section discusses the following sample design elements for the new boreholes proposed at the focus area around Tanks A-104 and A-105:

- Field constraints
- Borehole locations
- Borehole logging and sample depths
- Number of samples, sample size, and analytes.

C4.2.1 Field Constraints

As identified in Step 4 (Section 5.0) of this document, there are multiple constraints on data collection at WMA A-AX. Physical constraints including both subsurface and surface features that limit the locations within the focus area that can be accessed for investigation. Radiological controls must be accommodated to minimize the generation of contaminated drill cuttings and personnel exposure. Restrictions associated with planned tank waste retrieval actions must also be accommodated. Additional constraints are described in Table 5-1.

A random sampling strategy cannot be applied in WMA A-AX because of the extensive amount of interferences caused by buried infrastructure and topographic constraints. Therefore, a non-probabilistic (or judgmental) sampling strategy that targets locations based on existing knowledge will be used. This approach provides the highest potential for confirming and characterizing known and suspected releases in and around WMA-AX, and will help refine the WMA-AX conceptual site models.

C4.2.2 Borehole Locations

Direct push locations in the Tanks A-104 and A-105 focus area are limited primarily due to interferences identified by GPR surveys (Figure C-10) and planned retrieval activities.
To support selection of the optimal locations for direct push, a 3-D geologic model was built in Leapfrog® Hydro[2], incorporating known physical constraints, as well as information about tank waste releases to the soil.

As part of the WMA A-AX DQO process meeting discussions, DOE and WRPS initially proposed installing new direct push boreholes at four locations in the focus area. A fifth direct push location was subsequently proposed and other push total depths and angles were adjusted to ensure that the various reasons for sampling in the focus area (i.e., RFI characterization, leak loss estimate and modeling efforts, and performance assessment and risk-informed retrieval support) are addressed.

[2] Leapfrog® is a registered trademark of ARANZ Geo Limited, Christchurch New Zealand.

The five push locations are depicted in Figure C-11. Figures C-12 through C-16 provide vertical profile depictions of the five proposed pushes. To optimize characterization efforts, four of the five boreholes will be angle pushes to target underneath the assumed leaking tanks. In each angle borehole, a gyroscope will be used to confirm the angle of borehole path. The depth from the ground surface to the Hanford formation unit 3 is ~270 ft bgs, and the depth from ground surface to groundwater is ~290 ft bgs. The target depth for two of the five boreholes is just above groundwater; the intent is to push all of the boreholes to their target depths or refusal.

Table C-1 and the following paragraphs provide a summary of the key information about each of the five proposed push locations.

- Location #1: The reason for sampling is to assess the magnitude and pathway of contamination from Tank A-104 for modeling, risk, and nature and extent. This direct push targets the area more closely under the tank (i.e., within ~16 ft of the tank). The target depth is 174 ft bgs in the Hanford formation unit 2, above Hanford formation unit 3 and the groundwater interface (~270 ft bgs and ~290 ft bgs, respectively).

- Location #2: The reason for sampling is to assess the magnitude and pathway of contamination from Tanks A-104 and A-105 for modeling, risk, and nature and extent. The target depth of 285 ft bgs is near groundwater to gather information from the ground surface to the depth near groundwater to ensure overall vadose zone characterization (shallow to deep).

- Location #3: The reason for sampling is to assess the magnitude and pathway of contamination from Tanks A-104 and A-105 for modeling, risk, and nature and extent. The target depth is 241 ft bgs in the Hanford formation unit 2, above Hanford formation unit 3 and the groundwater interface (~270 ft bgs and ~290 ft bgs, respectively).

- Location #4: The reason for sampling is to assess the magnitude and pathway of contamination from Tank A-105 for modeling, risk, and nature and extent. This direct push targets the area more closely under the tank (i.e., within ~8 ft of the tank). The target depth is 127 ft bgs in the Hanford formation unit 2, above Hanford formation unit 3 and the groundwater interface (~270 ft bgs and ~290 ft bgs, respectively).

- Location #5: The reason for sampling is to assess the magnitude and pathway of contamination from Tank A-105 for modeling, risk, and nature and extent. The target depth of 285 ft bgs is near groundwater to gather information from the ground surface to the depth near groundwater to ensure overall vadose zone characterization (shallow to deep).

Figure C-10. Ground Penetrating Radar and Interference Map

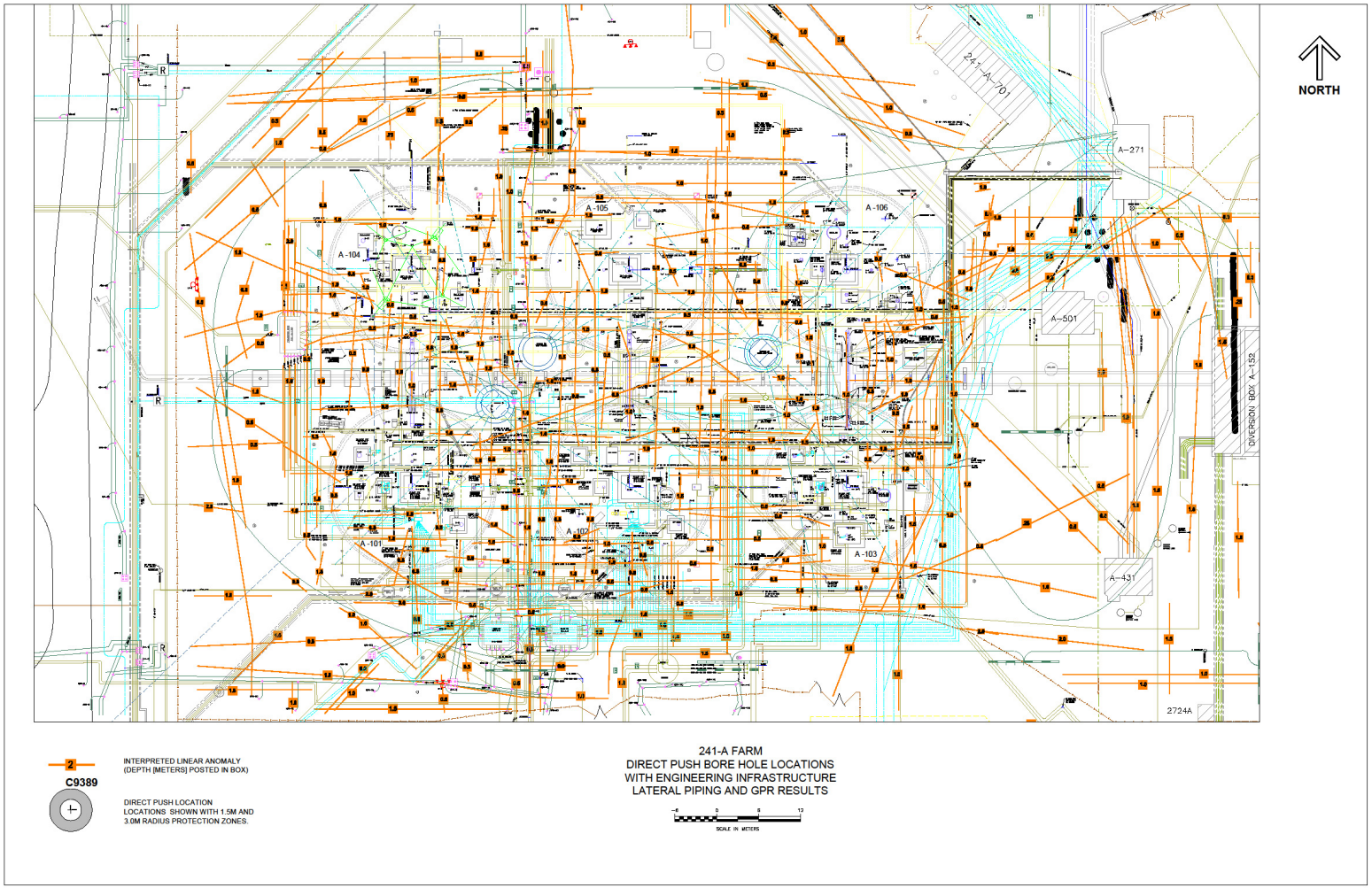


Figure C-11. Direct Push Locations for WMA A-AX Focus Area

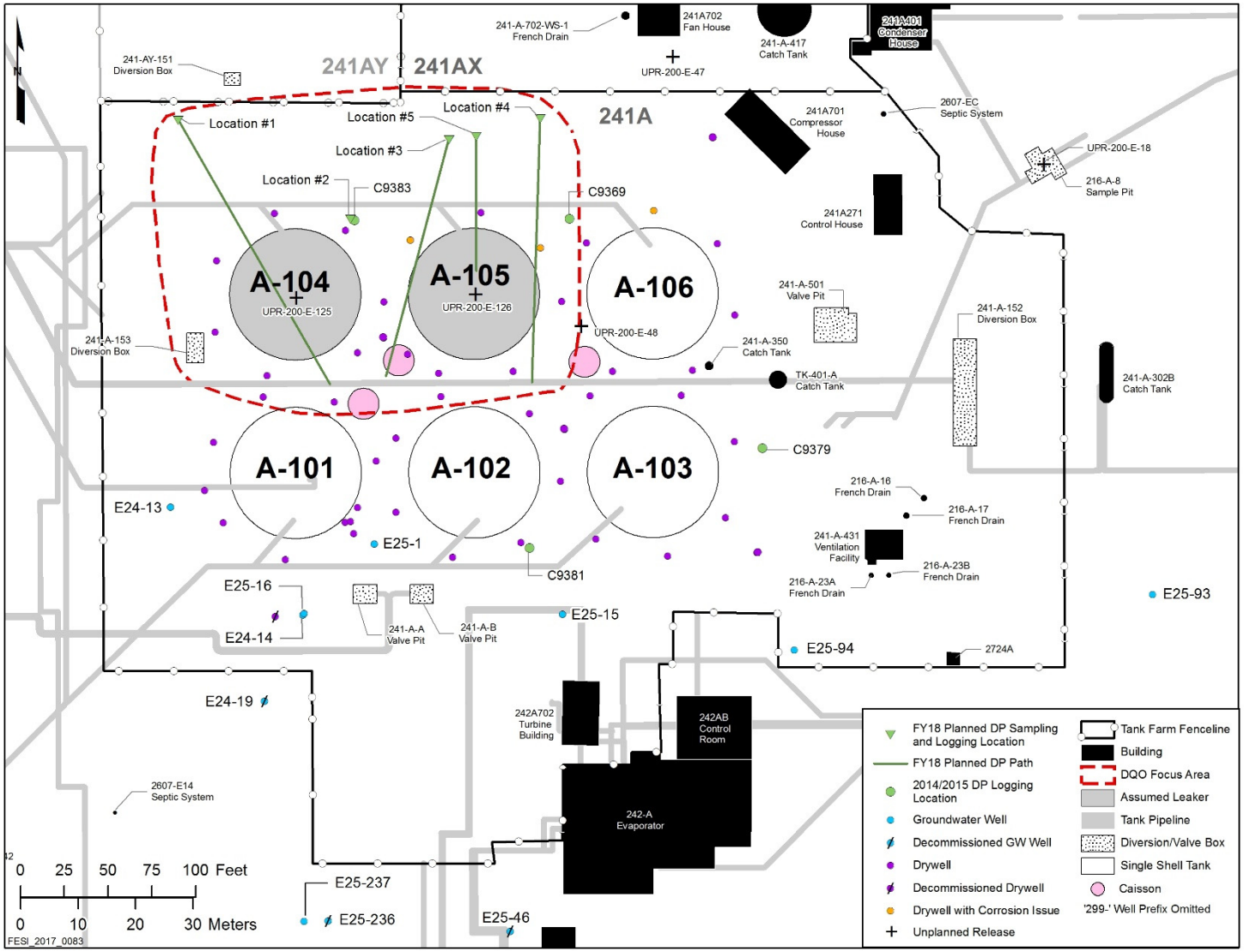


Figure C-12. Vertical Profile Depiction of Location #1

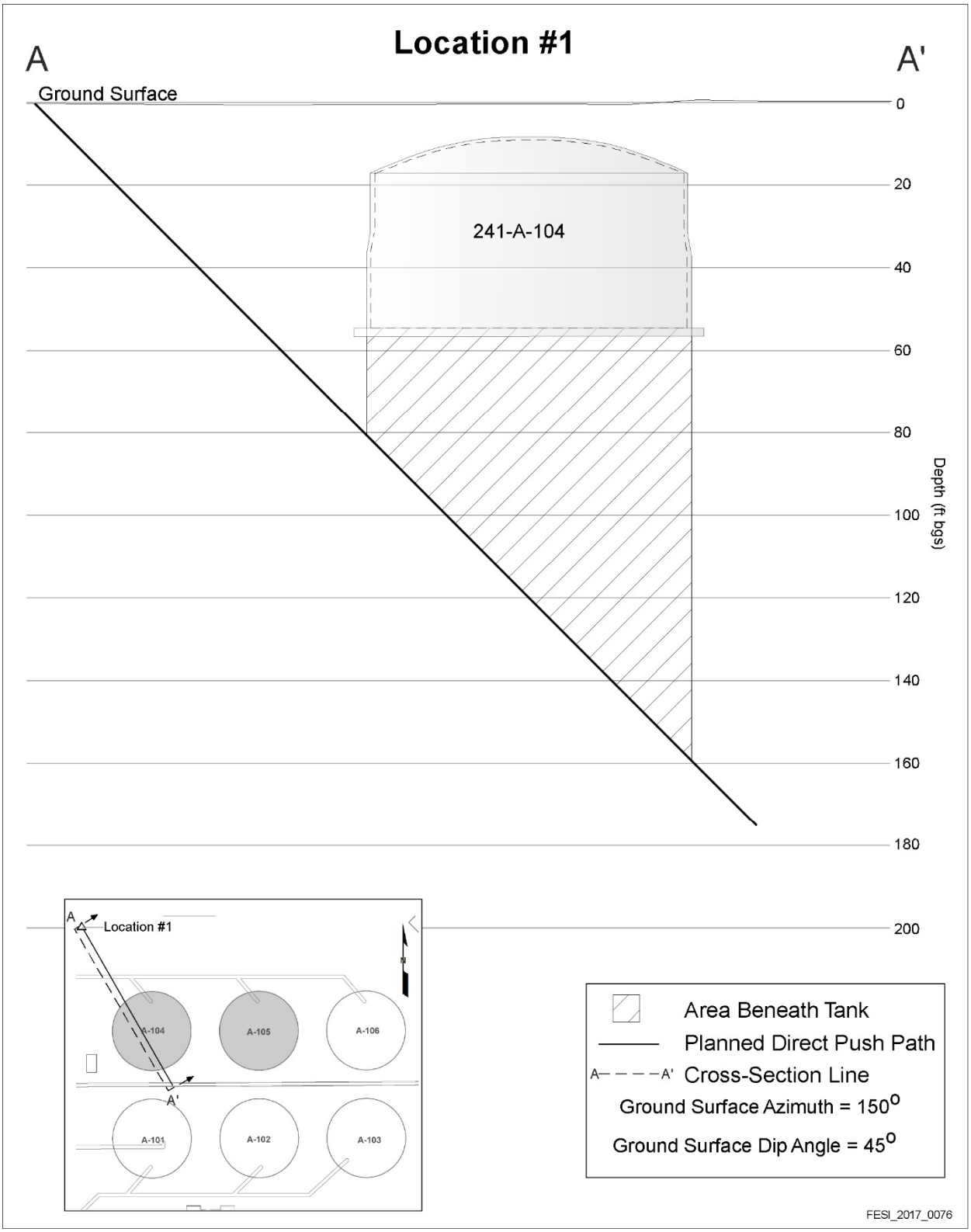
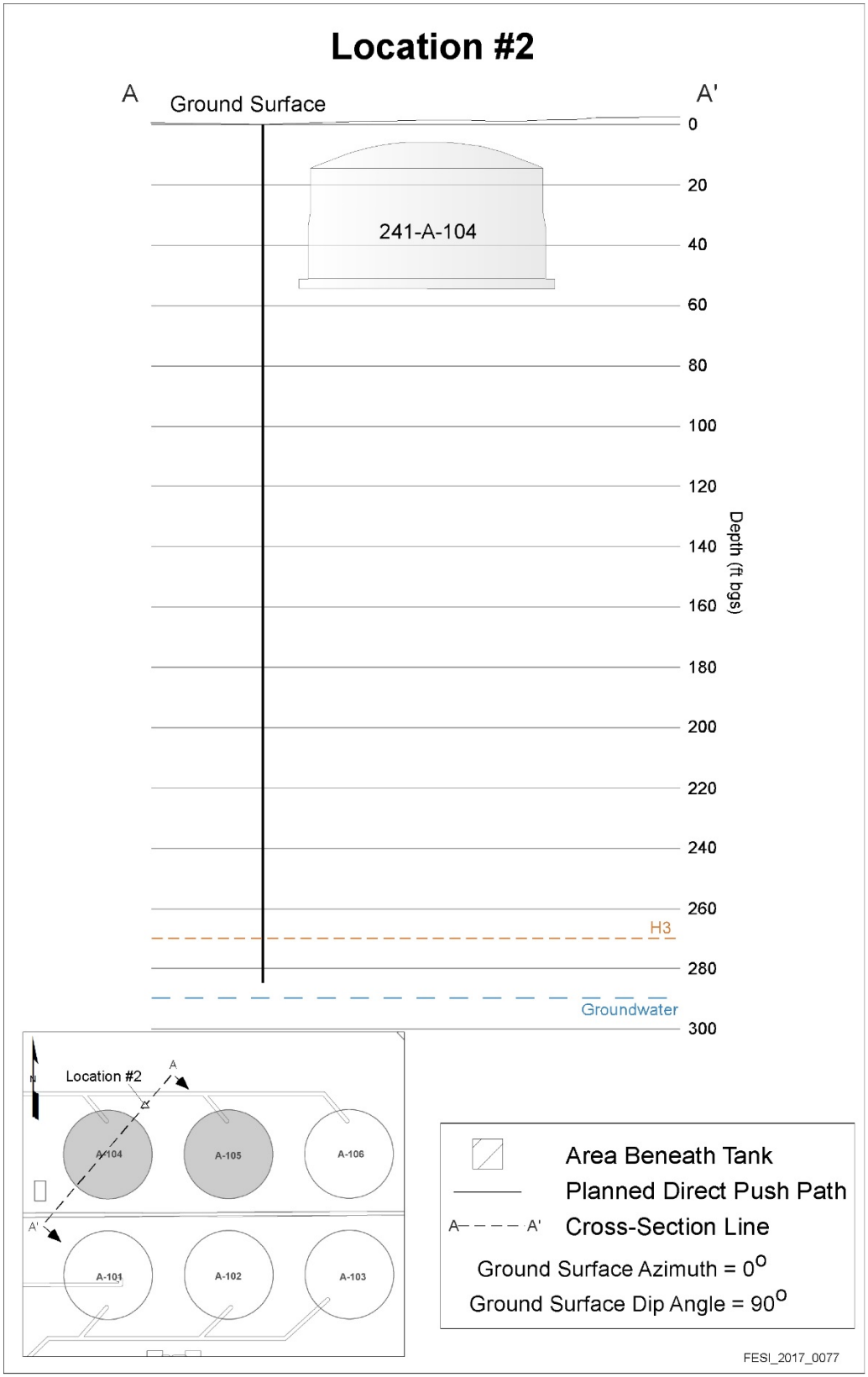


Figure C-13. Vertical Profile Depiction of Location #2



Note: This is a vertical push (90° dip angle from ground surface).

Figure C-14. Vertical Profile Depiction of Location #3

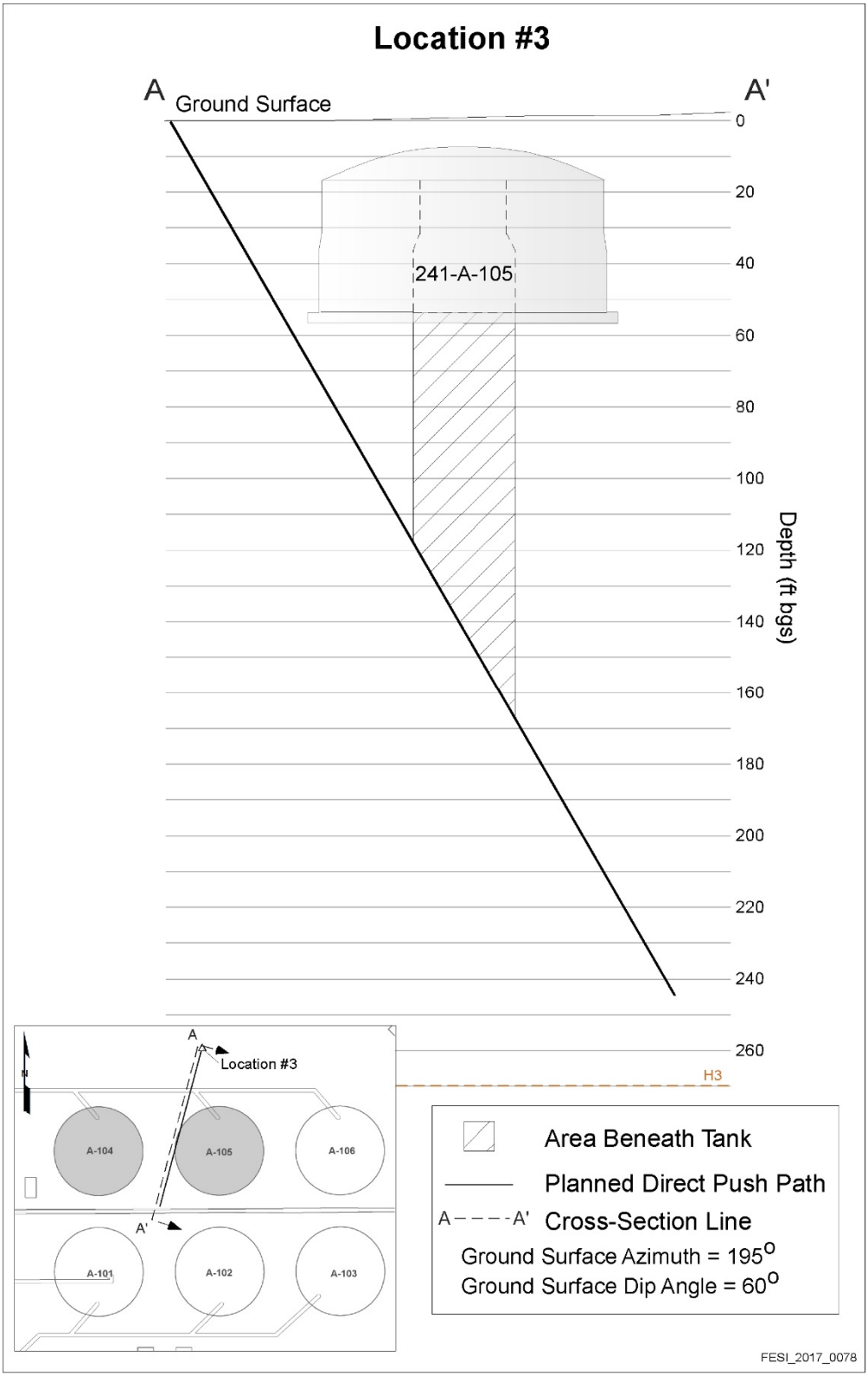


Figure C-15. Vertical Profile Depiction of Location #4

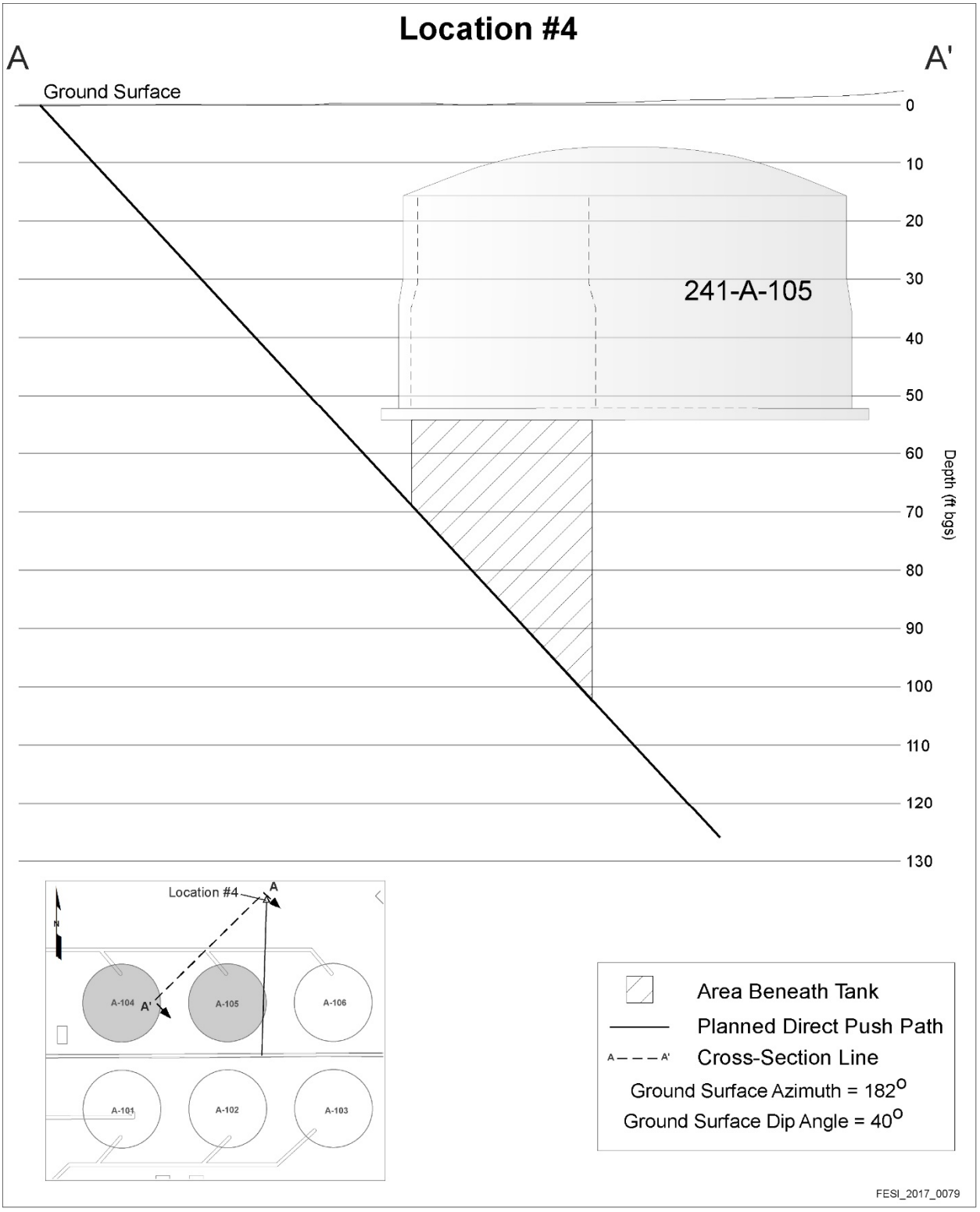


Figure C-16. Vertical Profile Depiction of Location #5

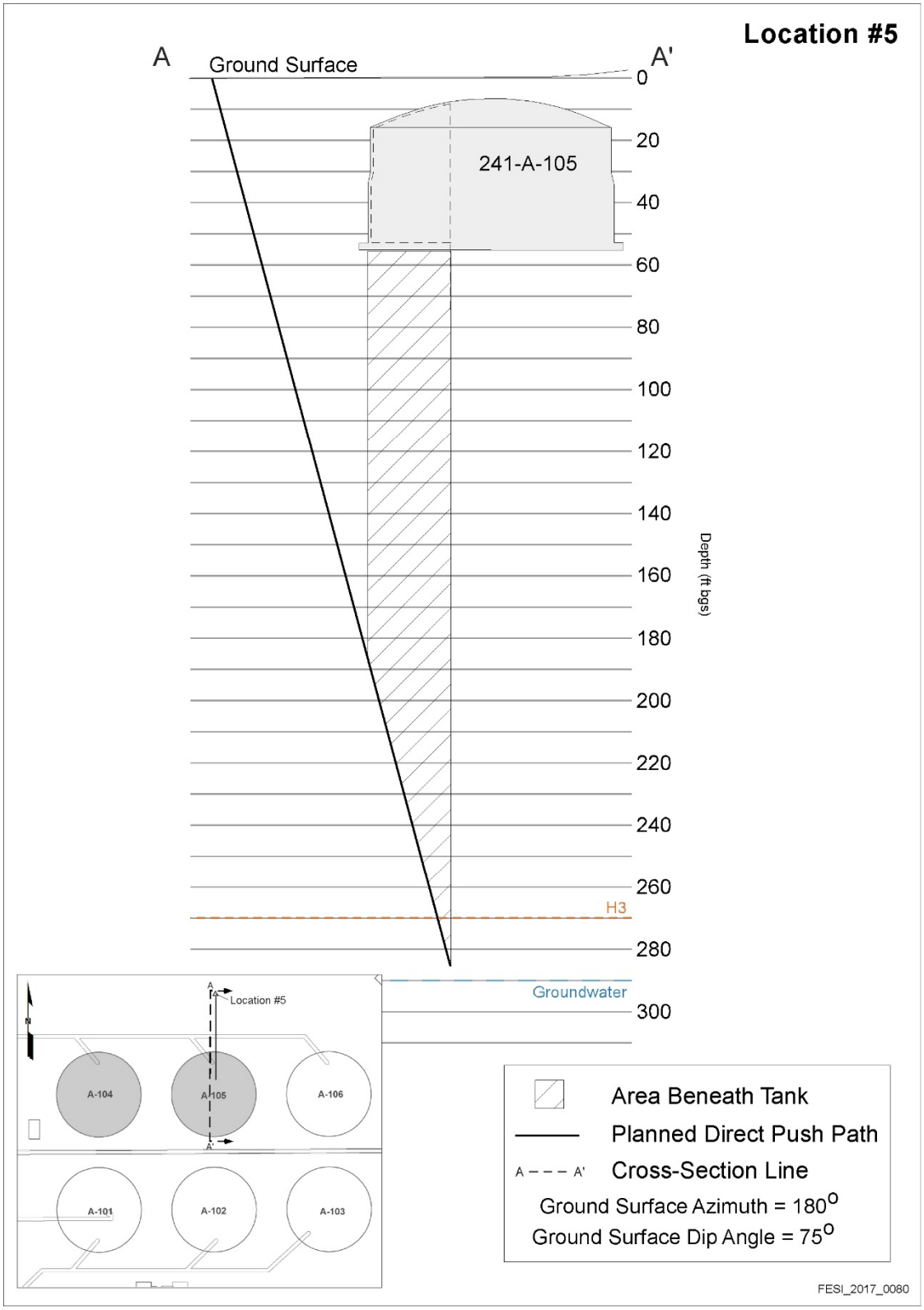


Table C-1. Direct Push Location Strategy for Tanks A-104 and A-105

Location #	**Approximate Location**	Input Factors Associated with Location **Reason for Sampling**	Target Depth (bgs) **Angle*** Pipe Run *Minimum distance from Tank*
1	Northwest of Tank A-104 (Angle push going southeast and directly under the tank)	• Tank A-104 designated as a leaker (~2,000 gallons) • Possible leak location area (Figure C-1) • Higher temperature and gross gamma readings in laterals (14-04-01 and 14-04-02, Figures C-3 and C-5) • Higher temperature and gross gamma readings in drywells (10-04-04 and 10-04-05) • Higher SGE conductivity area (Figure C-7) **Assess Tank A-104 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	174 ft **45** 246 ft *15.75 ft*
2	North and between Tanks A-104 and A-105 (Vertical push)	• Tanks A-104 and A-105 designated as a leaker (~2,000 gallons and ~2,000 to 40,000 gallons, respectively) • Direct push log at Location C9383, temperature of ~120 ºF, ~50 ft bgs • Possible location for deep push ~285 ft bgs **Assess Tanks A-104 and A-105 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	285 ft **None** 285 ft *54 ft*
3	North of Tank A-105 (Angle push towards southwest-side of tank)	• Tanks A-104 and A-105 designated as a leaker (~2,000 gallons and ~2,000 to 40,000 gallons, respectively) • Possible leak location area (Figure C-2) • Higher temperature and gross gamma readings in laterals (14-05-01,14-05-02, and 14-05-03, Figures C-4 and C-6) • Higher temperature readings in drywells (10-05-09, 10-04-04 and 10-04-05) • Drywell 10-05-10 indicated casing corrosion (~ 64 ft bgs) • Higher SGE conductivity area (Figure C-7) **Assess Tanks A-105 and A-104 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	241 ft **30** 279 ft *23 ft*

Table C-1. Direct Push Location Strategy for Tanks A-104 and A-105

Location #	**Approximate Location**	Input Factors Associated with Location **Reason for Sampling**	Target Depth (bgs) **Angle*** Pipe Run *Minimum distance from Tank*
4	Northeast of Tank A-105 (Angle push going south and under the east-side of tank)	• Tank A-105 designated as a leaker (~2,000 to 40,000 gallons) • Possible leak location area (Figure C-2) • Higher temperature and gross gamma readings in laterals (14-05-01,14-05-02, and 14-05-03, Figures C-4 and C-6) • Higher temperature readings in drywell (10-05-05) • Drywell 10-05-02 indicated casing corrosion (~ 64 ft bgs) **Assess Tank A-105 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	127 ft **50** 197 ft *7.5 ft*
5	North of Tank A-105 (Angle push going under the north side of tank)	• Tank A-105 designated as a leaker (~2,000 to 40,000 gallons) • Higher temperature and gross gamma readings in laterals (14-05-01,14-05-02, and 14-05-03, Figures C-4 and C-6) • Corrosion observed at drywells 10-05-02 and 10-05-10 **Assess Tank A-105 - magnitude and pathway of contamination for modeling, risk, and nature and extent.**	285 ft **15** 295 ft *29 ft*

*Angle is defined as degrees from vertical (i.e., 90 degrees minus dip).

The selection of all five direct push locations was based on information about known releases from Tanks A-104 and A-105, including their possible leak locations and other indicators described in Section C.1. From these five locations, it will be possible to obtain vadose zone soil samples from the ground surface, near the leak sources (the tanks), and through the vadose zone to the groundwater interface. Despite the existence of considerable physical interferences in the focus area, as shown in Figure C-10, the proposed push locations are appropriately located to yield valuable vadose zone soil characterization data on the impacts of releases from Tanks A-104 and A-105.

C4.2.3 Borehole Logging and Sample Depths

Two separate boreholes will be pushed at each of the five proposed direct push locations, one for geophysical logging, and another for soil sampling. At each of the five borehole locations, gross gamma, spectral gamma, neutron moisture, and temperature logging will be conducted, with the exception that at location #2 logging information from borehole C9383 will be utilized from the 2014/2015 campaign where available Geophysical logging data from the five new direct push borehole locations, boreholes pushed during the 2014/2015 investigation, and existing drywells

will be used to supplement soil sample analysis data to be obtained in the focus area. Gyroscope logging will also be used in the new boreholes for quality control. Information regarding logging technologies is provided in Section 4.1 and Section 4.3.2.

The geophysical logging tools will be specifically calibrated to the probe hole tubing conditions under which they will be deployed. At the Tanks A-104 and A-105 focus area, a combination gamma tool with dual detectors (lanthanum bromide and bismuth-germanium oxide) will be used for spectral gamma logging. As discussed in Section 4.3.2, use of this dual detector tool increases the efficiency for log data collection and improves data quality, resolution, and detection limits (cesium-137 detection of 1 to 1.5 piC/g and cobalt-60 detection of 0.5 to 1 piC/g).

Use of SGE at the focus area was evaluated at the 2017 DQO process meetings. In the past, SGE has been used to assist in identifying areas of unknown releases at Hanford Site tank farms. In turn, this information along with other available farm information has been used to help identify where sampling should be conducted. However, as described in Section 4.3.2 of this document, SGE results are impacted by interference from infrastructure such as pipelines, tanks, buildings, and other large features. At the focus area for Tanks A-104 and A-105, electrodes will be installed into direct push logging borings at the time of decommissioning to allow for their use in the future, if it is determined that there is value in obtaining SGE data (e.g., if there are improvements in data processing software, if infrastructure issues can be overcome).

Geophysical logging results, along with other available information (e.g., available analytical results, historical information) will be used to guide sample depth decisions at the proposed borehole locations. Sampling horizons in the sampling borehole at each of the five proposed locations will be selected in open meetings to which WRPS staff, DOE, Ecology, EPA, and other site contractors shall be invited.

C4.2.4 Number of Samples, Sample Size, and Analytes

Topics covered in detail at the calendar year 2017 WMA A-AX DQO process meetings included a review of sampling activities undertaken at WMA C so that lessons learned at that WMA could be applied to future efforts at WMA A-AX. Representatives of DOE, Ecology, and WRPS agreed that it would be beneficial to take additional samples at WMA A-AX. In summary, the meeting attendees agreed to the following: At each of the five proposed sampling boreholes, three samples will be taken at shallow depths (0 to 15 ft bgs), and at least seven samples will be taken at deep depths (>15 ft bgs to total borehole depth).

The following additional agreements were reached regarding the number of samples that will be taken, and the depths at which samples will be taken.

- Each sampling location consists of one surface sample, two additional shallow (≤ 15 ft bgs) samples, and at least seven deep (>15 ft bgs) samples.

- A duplicate sample will be collected at 25% (one in four) of the surface sample locations.

- Shallow samples taken from below the surface will be taken at ~7 to 9 ft bgs and ~12 to 14 ft bgs. The purpose of collecting samples in the first 15 ft is to provide data for the direct exposure pathway and to provide initial data for ecological risk.

- Deep samples will be taken down to a depth of ~240 to 285 ft bgs or refusal. The depths for sampling individual horizons will be selected by reviewing the gamma, temperature, and moisture logs of the first direct push and the following information: any leak loss inventory information pertinent to the site, geologic summary of the area, operational history, and historical characterization data at that site.

Physical and other constraints on borehole installation within WMA A-AX drove a decision to use a specialized small diameter hole direct push method for sampling more than 12 in. bgs. Due to the smaller diameter of the borehole, sample volumes will be smaller than if a larger diameter hole were pushed. It is estimated that at 100% recovery, each sample will yield approximately 594 grams of sampled material, based on the dual-string sampling system described in Section 4.3.

The available vadose zone soil sample material will be analyzed for the chemical, radiological and physical properties identified in Tables 6-1 through 6-2. These tables also provide analytical methods and associated detection limits for each constituent.

Both pesticides and PCBs were sampled in only the top 15 ft at WMA C; however, at WMA A-AX they will be sampled at all depths in the first focus area around Tanks A-104/A-105. Data from the first focus area will be reviewed to determine if samples should also be collected in subsequent focus areas at all depths or just within the top 15 ft.

It should be noted that Step 3 (Section 4.0) identified some constituents, VOCs, and several physical property tests, which will be evaluated for special studies (refer to Table 4-3). These constituents will not be analyzed in samples collected around the focus area of Tanks A-104 and A-105. The primary reasons for these special study constituents not being analyzed at this focus area are:

- There is not enough sample material collected via direct push to perform these analysis and those identified in Tables 6-1 and 6-2.

- There are no procedures in place for handling, packaging, and analyses/testing of soil.

- There needs to be further discussion and evaluation of existing data to determine where to best perform these analyses.

Specifically for VOCs, similar WMA C analyses were last conducted around 2010, and laboratory contract and personnel changes have resulted in a loss of expertise related to sample management and analysis. Procedures for handling and analyzing the samples will have to be recreated to meet the requirements of new laboratory contractors.

Additionally, analysis for dioxins and furans will not be performed at focus area around Tanks A-104/A-105. Dioxins and furans analyses have not been performed on vadose zone soil samples from the tank farm area and determinations will need to be made on such things as volumes needed to perform analysis, and if these volumes are achievable based on sampling methodology in the tank farms. Further discussions will continue on performing analysis of dioxins and furans in vadose zone soil samples.

C4.3 DRYWELL LOGGING

There are 18 drywells within the focus area around Tanks A-104 and A-105 (Table C-2) that will be logged for this characterization effort. Six of the 18 were logged using spectral gamma and temperature tools during the 2014/2015 characterization effort (Appendix B); these six will be relogged during the focus area investigation. Spectral gamma, neutron moisture, and temperature logging tools will be used to aid in locating areas of increased gamma radiation and to develop current temperature and moisture profiles in the vadose zone. As noted earlier in this section, the benefits and drawbacks of these tools are described in more detail in Section 4.3.2 of this document. Borehole cameras will be used to investigate the status of borehole casing.

As identified, corrosion has been observed in the past in drywells 10-05-10, 10-05-02, and 10-06-12. Two of these drywells are in the focus area: 10-05-10 and 10-05-02. The casing at 10-05-10 has been pulled and replaced. Documentation has been reviewed, and it is thought that these drywells can be logged; however, they will be evaluated during the field investigation to determine if they can be logged (e.g., via field and/or camera inspection).

Table C-2. Drywells Within the Focus Area for Tanks A-104 and A-105

Drywell Identification Number	Total Depth (ft bgs)	Year drywell was last logged
10-01-01	130	2015
10-01-11	130	1996
10-02-11	130	1996
10-04-01	75	1996
10-04-04	151	2015
10-04-05	75	2015
10-04-07	75	1996
10-04-08	130	1996
10-04-10	130	1996
10-04-12	75	1999
10-05-02	121	1996
10-05-05	75	2015
10-05-07	75	1996
10-05-08	56	2015

Table C-2. Drywells Within the Focus Area for Tanks A-104 and A-105

Drywell Identification Number	Total Depth (ft bgs)	Year drywell was last logged
10-05-09	75	2015
10-05-10	130	1996
10-05-12	75	1996
10-06-09	130	1996

C5.0 REFERENCES

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