DOCUMENT RELEASE AND CHANGE FORM

Prepared For the U.S. Department of Energy, Assistant Secretary for Environmental Management
By Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352
Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08RV14800

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DATE: Aug 13,2020

HANFORD RELEASE

1. **Doc No:** RPP-CALC-62319 **Rev.** 00

2. **Title:**
Residual Waste Source Inventory Term for the Waste Management Area A-AX Performance Assessment Inventory Case 1

3. **Project Number:** T2C25 ☐N/A

4. **Design Verification Required:** ☐Yes ☒No

5. **USQ Number:** ☒ N/A RPP-27195

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7. **Approvals**

Title	Name	Signature	Date
Clearance Review	Harrison, Sarah E	*Harrison, Sarah E*	08/13/2020
Checker	Watson, David (Dj) J	*Watson, David (Dj) J*	07/07/2020
Document Control Approval	Meinecke, Kathryn R	*Meinecke, Kathryn R*	08/13/2020
Originator	Lee, Kearn (Pat)	*Lee, Kearn (Pat)*	08/05/2020
Quality Assurance	Lungu, Cris C	*Lungu, Cris C*	06/08/2020
Responsible Engineer	Lee, Kearn (Pat)	*Lee, Kearn (Pat)*	08/05/2020
Responsible Manager	Rutland, Paul L	*Rutland, Paul L*	08/05/2020

8. **Description of Change and Justification**

Rev. 0 - Initial Issue

9. **TBDs or Holds** ☒N/A

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a. **Related Building/Facilities** ☒N/A	b. **Related Systems** ☒N/A	c. **Related Equipment ID Nos. (EIN)** ☒N/A

11. **Impacted Documents – Engineering** ☒N/A

Document Number	Rev.	Title

12. **Impacted Documents (Outside SPF):**

N/A

13. **Related Documents** ☐N/A

Document Number	Rev.	Title
RPP-CALC-62538	00	WMA A-AX Performance Assessment Groundwater Pathway Dose Calculation
RPP-CALC-62541	00	WMA A-AX Performance Assessment Uncertainty Calculation
RPP-CALC-63247	00	WMA A-AX Performance Assessment Sensitivity Analysis
RPP-ENV-61497	00	Preliminary Performance Assessment of Waste Management Area A-AX, Hanford Site, Washington
RPP-ENV-62206	00	Analysis of Post-Closure Groundwater Impacts from Hazardous Chemicals in Residual Wastes in Tanks and Ancillary Equipment at Waste Management Area A-AX at the Hanford Site, Southeast Washington
RPP-RPT-60885	00	Model Package Report System Model for the WMA A-AX Performance Assessment

14. **Distribution**

Name	Organization
Bergeron, Marcel P	CLOSURE & INTERIM MEASURES
Childress, Ryan D	CLOSURE & INTERIM MEASURES
Lee, Kearn (Pat)	CLOSURE & INTERIM MEASURES
Rutland, Paul L	CLOSURE & INTERIM MEASURES
Singleton, Kristin M	CLOSURE & INTERIM MEASURES
Watson, David (Dj) J	CLOSURE & INTERIM MEASURES

INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

Part I: Background Information

Title: Residual Waste Source Inventory Term for the Waste Management Area A-AX Performance Assessment Inventory Case 1

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- ☐ Abstract ☐ Journal Article ☐ Summary
- ☐ Internet ☐ Visual Aid ☐ Software
- ☐ Full Paper ☑ Report ☐ Other

Publish to OSTI? ☐ Yes ☑ No

Trademark/Copyright "Right to Use" Information or Permission Documentation	Yes	NA
	☐	☑

Document Number: RPP-CALC-62319 Revision 0 Date: July 2020

Author: Lee, Kearn (Pat)

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Description	*Yes*	*N/A*	*Print/Sign/Date*
Information Product meets requirements in TFC-BSM-AD-C-01?	☑	☐	Lee, Kearn (Pat) Approved via att. IDMS data file.
Document Release Criteria in TFC-ENG-DESIGN-C-25 completed? (Attach checklist)	☑	☐	Lee, Kearn (Pat) Approved via att. IDMS data file.
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Responsible Manager	WRPS		Rutland, Paul L Approved via att. IDMS data file.
Other:			

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Other: ORP SME & OCC	☑	☐	Approved via att. IDMS data file.
Other:	☐	☐	

Comments Required for WRPS-Indicate Purpose of Document:

This calculation report is being referenced by the preliminary Waste Management A-AX Performance Assessment (PA), which will be provided to Ecology later this year. In preparation for providing the preliminary PA to Ecology, the documents that support the PA are also be cleared for public release. The analysis was completed in September 2018, but finalization of the document was put on hold until DOE's Low-Level Waste Disposal Facility Federal Review Group (LFRG) reviewed the PA. That review completed in April so finalization of this report is now moving forward.

APPROVED
By Julia Raymer at 1:31 pm, Jul 30, 2020

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        Thank you, Julia Raymer, Information Clearance (509) 373-
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RPP-CALC-62319
Revision 0

Residual Waste Source Inventory Term for the Waste Management Area A-AX Performance Assessment Inventory Case 1

Prepared by:

Wei Zhou, INTERA, Inc. for
Washington River Protection Solutions, LLC

Date Published
October 2019

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

Contract No. DE-AC27-08RV14800

Approved for Public Release;
Further Dissemination Unlimited

EXECUTIVE SUMMARY

This environmental model calculation report documents the calculation steps and results of the inventory to be used in performance assessment of disposal of the tank residual waste in Waste Management Area A- and AX-farm (WMA A-AX). The calculated inventory includes the radioactive waste activities and chemical content masses remaining in the tanks and pipelines/ancillary equipment after the retrieval operations. Two different data sources were used in the calculation: Best-Basis Inventory (BBI) and Hanford Tank Waste Operations Simulator (HTWOS). The BBI data source was used for the residual waste inventory in the tanks. The HTWOS data source was used for the residual waste inventory in the pipeline and ancillary equipment of A/AX retrieval operations. Decay and ingrowth of radioactive contents were calculated from the reported activity dates to January 1st, 2050, the assumed WMA A/AX closure date that is also the beginning of performance assessment calculation. GoldSim and a qualified spreadsheet calculator were used to perform the calculation. The inventory results are tabulated in this report for each waste constituent in each tank or pipeline/ancillary equipment for each tank farm.

ENVIRONMENTAL MODEL CALCULATION COVER PAGE

SECTION 1: COMPLETED BY RESPONSIBLE MANAGER OR DESIGNEE

00
RELEASE/ISSUE

Project: WMA A-AX Performance Assessment

Date: 05/22/2018

Calculation Title and Description: Residual Waste Source Inventory Term for the Waste Management Area A-AX Performance Assessment Inventory Case 1

SECTION 2: COMPLETED BY PREPARER

Calculation No.: RPP-CALC-62319 Revision No.: 00

Revision History

Revision No.	Description	Date	ADD ROW Affected Pages
00	Initial draft for review		

D

SECTION 3: COMPLETED BY RESPONSIBLE MANAGER OR DESIGNEE

Document Control

1. Is document intended to be controlled within SmartPlant? ☒ Yes ☐ No
2. Does document contain scientific and technical information intended for public use? ☒ Yes ☐ No
3. Does document contain controlled-use information? ☐ Yes ☒ No

SECTION 4: TRAINING AND SOFTWARE INSTALLATION APPROVAL (COMPLETED PRIOR TO PERFORMING CALCULATION)

Modeler-Required Training Completed:

Training Coordinator:

Print First and Last Name	Position	Signature	Date
Ghada Saad	Training Coordinator	Ghada Saad	9-25-18

Software Installation and Checkout Certified:

Integration Lead:

Print First and Last Name	Position	Signature	Date
Will Nichols	Modeling Team Leader	[illegible]	24 SEP 2018

SECTION 5: DOCUMENT REVIEW AND APPROVAL

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Checker:

Print First and Last Name	Position	Signature	Date
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Senior Reviewer:

Print First and Last Name	Position	Signature	Date
Glenn Taylor	Senior Nuclear Engineer	[illegible]	9/27/18

Responsible Manager or Designee:

Print First and Last Name	Position	Signature	Date
Robert Hiergesell	Manager	Robert Hiergesell	9/24/18

Supporting Information for

Environmental Modeling Calculational File (RPP-CALC-62319)

1. Identification of Need for EMCF RPP-CALC-62319:

This EMCF is needed to document adjustments to the WMA A-AX tank residual inventories calculated in RPP-RPT-58293 Rev_01 *Hanford 241-A and 241-AX-Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates.* The tank residuals calculated in the EMCF are utilized as the anticipated residual source terms within simulations performed to evaluate long-term releases of these radionuclides to the subsurface. These analyses are being conducted as part of the preliminary WMA A-AX Performance Assessment. RPP-RPT-58293 Rev_01 is expected to be updated in FY2019 with the calculations described in this EMCF.

2. Identification of Originator, Checker, and Subject Matter Expert (SME)/Senior Reviewer (SR)

Originator:

Wei Zhou, Senior Nuclear Engineer, INTERA, Inc.
PhD, 1992, Nuclear Engineering, University of California at Berkeley
MS, 1986, Mechanical Engineering, San Jose State University
BS, 1982, Mechanical Engineering, Beijing University of Technology

Ms. Zhou has 32 years of experience in the areas of performance and safety assessment of near-surface and deep geological radioactive waste repositories; risk assessments for organic wastes including dense and light non-aqueous phase liquids and volatile organic compounds; and the geological sequestration of carbon dioxide (CO2). She has provided technical support in these areas to industrial, governmental, and international organizations such as the Electric Power Research Institute (EPRI), International Atomic Energy Agency (IAEA), Nuclear Energy Institute (NEI), Korean Hydro and Nuclear Power, Canadian Petroleum Technology Research Institute, U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), Swedish Nuclear Inspectorate (SSM), Japan Atomic Energy Agency (JAEA), Taiwan Institute of Nuclear Energy Research (INER), International Energy Agency (IEA), Nuclear Energy Agency (NEA), and the Commission for European Communities (CEC). She specializes in modeling and simulation of radionuclide transport, coupled heat and mass transfer in fractured media, as well as multiphase and multi-component transport systems using public or commercial codes including TOUGH2, TOUGHREACT, STOMP, ECLIPSE suite codes, MATLAB, and GoldSim. Her expertise also includes developing customized software using FORTRAN and C++. She has completed all reading assignments that are procedurally required to perform environmental fate and transport calculations.

Checker:

Arun K. Wahi, Senior Hydrogeologist, INTERA, Inc.
MS, 2005, Hydrology, University of Arizona
BS, 2003, Chemical Engineering, Carnegie Mellon University

Mr. Wahi has 14 years of consulting and research experience in the fields of hydrology, hydrogeology, and chemistry. He is a qualified user of GoldSim at the Hanford Site and has completed training in GoldSim and in WRPS quality assurance procedures, including all reading assignments that are procedurally required to perform environmental fate and transport calculations. He has led teams conducting modeling, hydrogeologic, geochemical, forensic, and remediation engineering analyses, as well as field investigations to perform soil and groundwater sampling and aquifer testing. His experience includes performing numerical modeling of contaminant fate and transport of radionuclides and organic and inorganic contaminants in the saturated and unsaturated zones in support of U.S. Department of Energy performance assessments. He led the pre-retrieval risk assessment of the Hanford Site AX Tank Farm. He was the lead modeler for vadose zone/saturated zone fate and transport for the 2017 Hanford Site Integrated Disposal Facility Performance Assessment.

Subject Matter Expert/Senior Reviewer:

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B Sci. University of Louisville, Engineering Physics
M. Sci. University of Texas-Austin, Nuclear Engineering.

Mr. Taylor has more than 35 years of engineering experience, the last 12 of which has been in DOE's Savannah River National Laboratory conducting various analyses for inclusion in DOE 435.1 Performance Assessments.

Responsible WRPS Manager:

Robert A. Hiergesell, Senior Scientist in the SST Closure & Interim Measures Department of Washington River Protection Solutions (WRPS) in Richland, WA.
M.Sci. in Hydrogeology from Univ. of Nebraska-Lincoln.
B.Sci in Geology at Virginia Polytechnic Institute.

Mr. Hiergesell is the Technical Lead, Waste Management Area A-AX Performance Assessment. His experience is in the areas of groundwater monitoring, subsurface flow and transport simulation, environmental remediation and performance assessment for low-level radioactive waste disposal. Prior to joining WRPS, He was employed for 28 years at the DOE Savannah River National Laboratory where he was the lead technical investigator for numerous environmental restoration and waste management projects.

Robert A. Hiergesell — 8/20/18
Robert A. Hiergesell — Date

CHECKER LOG FOR SYSTEM MODELS

Project and Environmental Model Calculation Specific Information:

Project: WMA A-AX Performance Assessment

Responsible Manager or Designee, and Position: Robert Hiergesell

Originating Group or Department: INTERA, Inc. | Date: 9/24/2018

Environmental Model Calculation File Report and Revision No.: RPP-CALC-62319 Rev. 0

Environmental Model Calculation File Title: Resid Wst Src Inv Term for WMA A-AX PA Inventory Case 1

Check: Environmental Model Calculation File Document Elements

	List where Information is Described *(EMCF Section Number)*	Is the Description Correct and Sufficient?			Checker Signature
		Yes	No	If No, describe deficiency:	
Purpose	Section 1	◉	○		Arun K. Wadi
Calculation Approach	Sections 3 and 6	◉	○		Arun K. Wadi
Assumptions	Section 4 (also 3 and 6)	◉	○		Arun K. Wadi
Inputs *(reference detailed checklist below as well)*	Section 4.2	◉	○		Arun K. Wadi
Equations used	Sections 3 and 6	◉	○		Arun K. Wadi
Conclusions	Section 7.2	◉	○		Arun K. Wadi
References	Section 8	◉	○		Arun K. Wadi

Check: Controlled Software Use

	List where Information is Described *(EMCF Section Number)*	Is the Criteria Met?			Checker Signature
		Yes	No	If No, describe deficiency:	
Software used in the calculation is appropriate for application	Sections 1 and 5	◉	○		Arun K. Wadi
Software use is approved and properly validated in accordance with approved software management plan	Sections 5.1, 5.1.3, 5.2, 5.2.3	◉	○		Arun K. Wadi
Software use is properly documented	Sections 1 and 5	◉	○		Arun K. Wadi
Verify data was input correctly to approved software or spreadsheets	Inputs are stated in Section 4 and verified during checks documented on this form.	◉	○		Arun K. Wadi
If a spreadsheet is used, verify inputs/outputs of calculation(s) to ensure accuracy	Inputs are stated in Section 4, outputs are stated in Section 7, and both are verified during checks documented on this form.	◉	○		Arun K. Wadi

CHECKER LOG FOR SYSTEM MODELS (Continued)

Check: Perform Calculation to Verify Free of Errors

	Describe how calculation was performed	List any discrepancies encountered *(If none, enter "None")*	Checker Signature
Perform the environmental model calculation as described to verify it is free of errors	Checks saved in RPP-CALC-62319_Checking.xlsx. For GoldSim Pro calculation steps, verified inputs and equations vs. EMCF, reran model, and verified outputs match Table 7-3 with maximum relative error of 0.45% (due to rounding in EMCF). For steps performed in spreadsheet, independently constructed calculation from inputs and equations given in EMCF and from copy of qualified decay spreadsheet application in EMMA, and verified outputs match Tables 7-1, 7-2, and 7-4 through 7-8 with maximum relative error of 0.49% (due to rounding in EMCF).	none	Ann R. Walsh

Check: Process Model Parameterization *(Specify Values and Units in Each Column)*

Model Parameter Type	(1) Input Documented in EMCF?	(2) Values checked against parameter source?	(3) Input in EMCF matches model input file(s)?
Simulation duration	Forward decays from 1/1/2008 and 7/1/2015 (Table 4-7) to 1/1/2050 (Section 4.1). Backward decay from 1/1/2062 to 1/1/2050 (Section 4.2).	yes (RPP-RPT-58293 Appendix A and RPP-RPT-60101 Appendix A)	yes
Simulation time step control	N/A (spreadsheet uses analytical solutions and GoldSim is used here only for decay, not transport)	N/A	N/A

CHECKER LOG FOR SYSTEM MODELS (Continued)

Model Parameter Type	(1) Input Documented in EMCF?	(2) Values checked against parameter source?	(3) Input in EMCF matches model input file(s)?
Simulated chemical list	Tables 4-1 and 4-2	yes (chemicals that both have data in RPP-RPT-58293 Appendix A.2 and appear in RPP-ENV-58782 Table 3-8, excluding oxalate since no toxicity value; total uranium to be calculated from isotopes)	yes
Simulated radionuclides list	Tables 4-3 and 4-4	yes (radionuclides that have data in RPP-RPT-58293 Appendix A.2 plus Pb-210, Rn-222, Th-230, and Am-242m)	yes
External model components identified and documented or referenced	N/A	N/A	N/A
External model linkages *(dynamic link libraries, etc.)* checked	N/A	N/A	N/A
If model is probabilistic, stochastic distributions are defined and consistent	N/A	N/A	N/A
Input units are declared and of correct dimensionality	yes (kg in Tables 4-1 and 4-2, Ci in Tables 4-3 and 4-4, kL in Tables 4-5 and 4-6)	yes (RPP-RPT-58293 Appendix A)	yes (primary inputs use same units and derived units use appropriate conversion factors in GoldSim and Excel files)
Equations used in the model file are presented in EMCF and consistent	yes (Sections 3 and 6)	yes (Bateman, 1910; Benedict et al, 1981; GoldSim Technology Group, 2017)	yes

Check: Further Checks *(Record additional checks performed and results)*

Model Parameter Type	(1) Input Documented in EMCF?	(2) Values checked against parameter source?	(3) Input in EMCF matches model input file(s)?
Inventory: Radiological Decay Correction. Does the inventory *(source term)* include radionuclides, and if so, is it decay-corrected to the appropriate date for inclusion as a source?	Yes and yes. See "Simulation duration" entries above.	Yes, see "Simulation duration" entries above.	Yes, see "Simulation duration" entries above.

CHECKER LOG FOR SYSTEM MODELS (Continued)

Model Parameter Type	(1) Input Documented in EMCF?	(2) Values checked against parameter source?	(3) Input in EMCF matches model input file(s)?
Inventory: Mass Balance. Is mass balance of inventory maintained in system model calculation(s)?	N/A -- not a transport calculation; inventories invoke retrieval assumptions that only estimate residual fractions; radioactive decay calculations only directly track long-lived nuclides related to BBI list	N/A	N/A

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TERMS

ALC	air lift circulator
BBI	best-basis inventory
CHPRC	CH2M HILL Plateau Remediation Company
CY	calendar year
DOE	U.S. Department of Energy
Ecology	State of Washington Department of Ecology
EMCF	environmental model calculation file
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HTWOS	Hanford Tank Waste Operations Simulator
PA	performance assessment
PUREX	plutonium uranium extraction
SST	single-shell tank
TWINS	Tank Waste Information Network System
WMA	waste management area
WMA A-AX	Waste Management Area A and AX
WRPS	Washington River Protection Solutions, LLC

1 PURPOSE

The purpose of this environmental model calculation file (EMCF) is to develop and document the residual inventory estimate of single-shell tanks (SSTs) and ancillary equipment at the assumed closure date of Waste Management Area A and AX (WMA A-AX) for conducting preliminary WMA A-AX performance assessment (PA). The closure date for the PA calculations is assumed to be January 1, 2050 (RPP-RPT-60101, "*Model Package Report: Flow and Contaminant Transport Numerical Model used in WMA A-AX Performance Assessment and RCRA Closure Analysis*") and as such the radionuclide inventory is decay corrected to this closure date for conducting fate and transport modeling. Besides that, a representative residual inventory estimate is developed from information presented in RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," based on discussions among the members of the PA team at the start of the PA effort. Given that there are a number of approaches for estimating residual inventory, this EMCF documents one such estimate for conducting the preliminary PA, which is referred to here as Case 1. Other inventory estimates will be developed and documented separately.

The primary purpose of the EMCF is to document the assumptions and methodology for developing the initial inventory estimates along with performing a decay correction. Since the inventory information is taken from RPP-RPT-58293, both forward and backward decay corrections are required to estimate the inventory at the assumed closure date of January 1, 2050. The forward-in-time decay calculations are performed using the GoldSim©[1] software while the backward-in-time decay calculations are performed using a previously-qualified "Decay Spreadsheet" (RPP-PLAN-61415, "*Software Management Plan for Grade D Utility Calculation Software GoldSIM Decay Spreadsheet*"). While the primary focus is on estimating radionuclide inventory at closure, for completeness, inventory of chemicals is also presented. The list of radionuclides and chemicals is chosen based on the previous WMA C PA (RPP-ENV-58782, "*Performance Assessment of Waste Management Area C, Hanford Site, Washington*"), without considering the supplemental analytes.

[1] GoldSim© simulation software is copyrighted by GoldSim Technology Group LLC of Issaquah, Washington. The GoldSim Decay Spreadsheet is designed to give equivalent results for radioactive decay equations implemented in GoldSim©, including the radionuclide-specific half-lives therein, in order to provide consistency with downstream calculations that may employ GoldSim©; the spreadsheet is neither affiliated with nor endorsed by GoldSim Technology Group LLC.

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2 BACKGROUND

Waste Management Area A-AX, part of the SST system, is located in the Central Plateau of the Hanford Site, near the eastern edge of the 200 East Area (Figure 2-1). WMA A-AX includes the 241-A Tank Farm (A Farm), the 241-AX Tank Farm (AX Farm), associated ancillary equipment, and adjacent areas of soil contamination from unplanned releases. A Farm was constructed between 1954 and 1955, and AX Farm was constructed between 1963 and 1964. Figure 2-2 is a map of WMA A-AX. The six underground SSTs in A Farm are numbered 241-A-101 (A-101) through 241-A-106 (A-106). The four underground SSTs in AX Farm include tanks 241-AX-101 (AX-101), 241-AX-102 (AX-102), 241-AX-103 (AX-103), and 241-AX-104 (AX-104). Ancillary equipment that supported the transfer and storage of waste within WMA A-AX SSTs includes pipelines (transfer lines), catch tanks, diversion boxes, vaults, valve pits, and other miscellaneous structures. Ancillary equipment is located (mostly buried) throughout WMA A-AX but concentrated around the SSTs. Design data and background information on the SSTs and ancillary equipment in WMA A-AX is provided in RPP-RPT-58693, "*Engineered System Data Package for Waste Management Area A-AX*."

Figure 2-1. Locations of Tank Farms on Hanford Site.

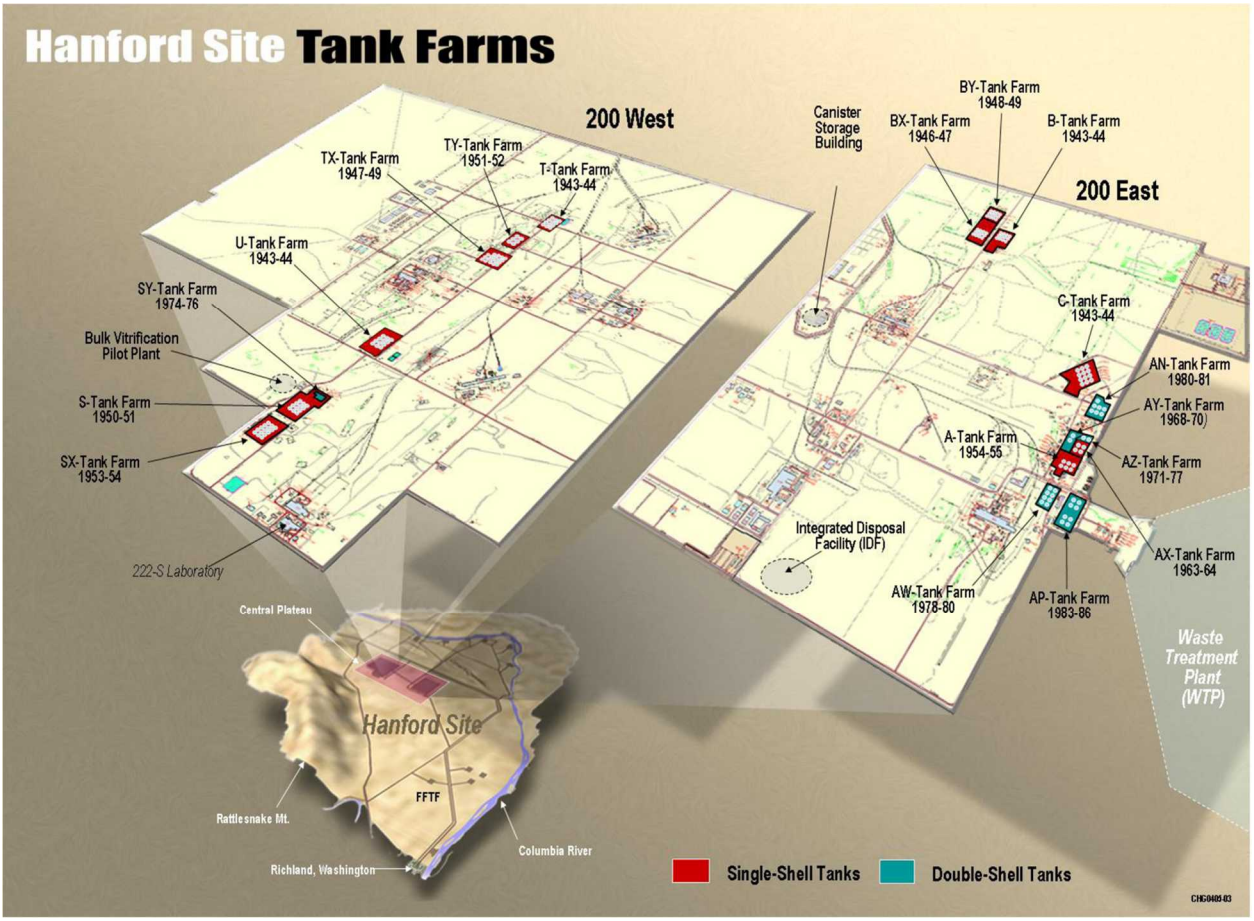
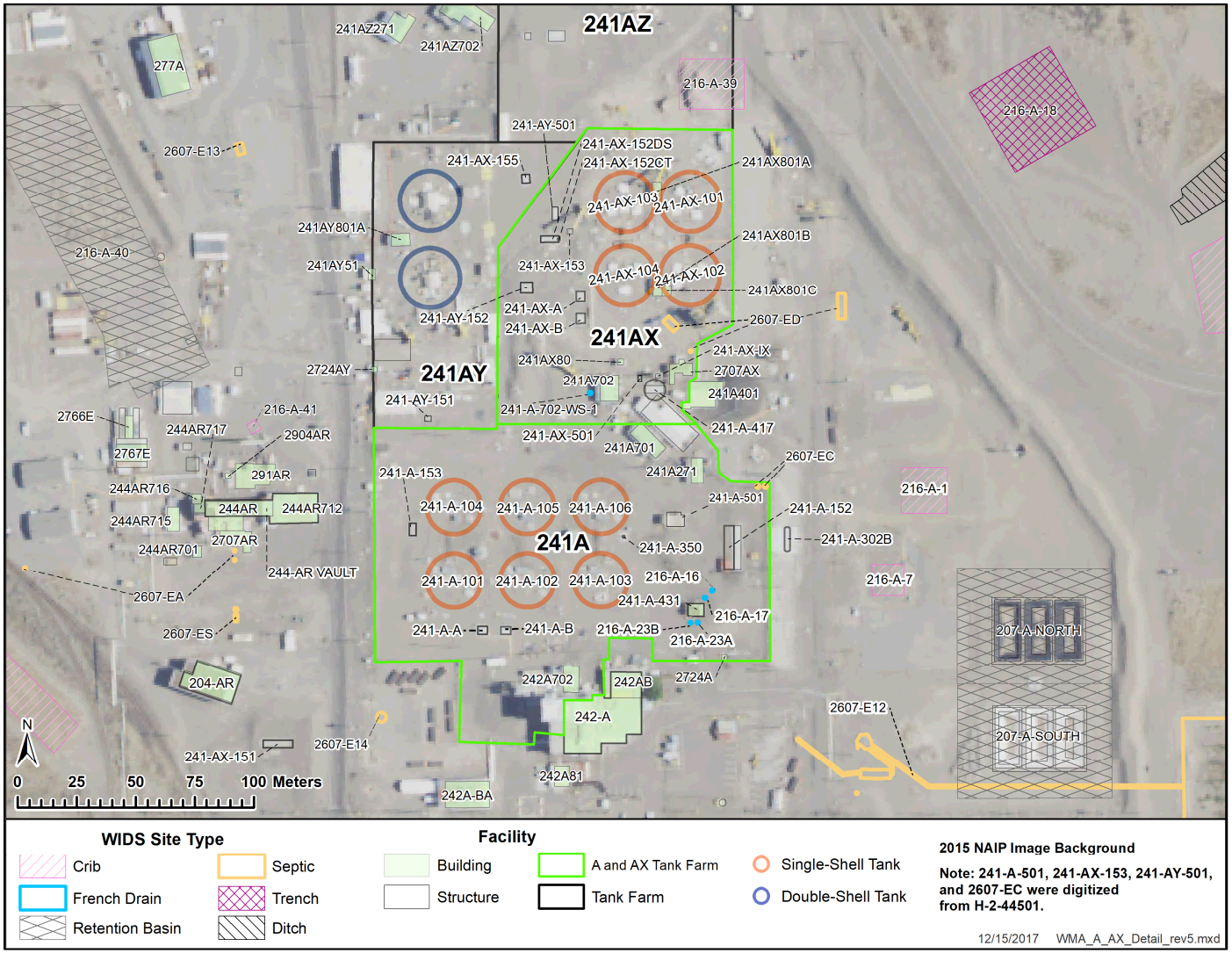


Figure 2-2. Detailed Layout of Waste Management Area A and AX.



NAIP = National Agriculture Imagery Program WIDS = Waste Information Data System

Reference: H-2-44501, "Area Map, 200 East, A Plant Facilities."

RPP-RPT-58293 provides historical background on waste stored at WMA A-AX, the best-basis inventory (BBI) in WMA A-AX tanks and ancillary equipment as of October 1, 2016, and bounding estimates of future inventory in waste residuals. Briefly, WMA A-AX was designed for the storage of boiling waste generated from irradiated fuel reprocessing at the 202-A Plutonium Uranium Extraction (PUREX) Plant and over time received other wastes such as saltcake from the 242-A Evaporator. The SSTs are interim stabilized; by the early 2000s, liquid waste was pumped out to the extent practicable, and the SSTs currently contain saltcake, sludge, supernate, interstitial liquid, and retained gas in proportions that vary from tank to tank. Most SSTs in WMA A-AX contain mostly saltcake solids and saltcake liquids, smaller fractions of sludge, and little or no supernate. Tanks 241-A-104 (A-104), 241-A-105 (A-105), and AX-104 contain only sludge. Tanks A-104 and A-105 have damage to their steel liners and have had confirmed past leaks (RPP-RPT-54912, "*Hanford Single-Shell Tank Leak Causes and Locations - 241-A Farm*"), and the liner damage has implications for retrieval that are still being evaluated. Inventories of the past release (RPP-RPT-58291, "*Hanford Waste Management Area A-AX Soil Contamination Inventory Estimates*") are not in the scope of this EMCF and are addressed in other inventory documents.

A PA is required by the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989) for assessment of the radiological impacts of waste residuals in a closed WMA A-AX under U.S. Department of Energy (DOE) Order 435.1, *Radioactive Waste Management* and evaluation of the hazardous chemical impacts for the same wastes under the *Resource Conservation and Recovery Act of 1976*. Under 78 FR 75913, "Record of Decision: Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington," waste currently stored in the SSTs at WMA A-AX will be retrieved to the maximum extent possible for treatment and disposal (e.g., RPP-RPT-58932, "*241-AX-101 Tank Waste Retrieval Work Plan*"; RPP-RPT-58933, "*241-AX-102 Tank Waste Retrieval Work Plan*"; RPP-RPT-58934, "*241-AX-103 Tank Waste Retrieval Work Plan*"; and RPP-RPT-58935, "*241-AX-104 Tank Waste Retrieval Work Plan*" for AX Farm), leaving only residual waste, and WMA A-AX will be closed by filling the SSTs with grout and installing a surficial infiltration barrier, among other measures. The overall objective of the modeling effort is to provide a basis for making informed closure decisions pertinent to WMA A-AX. An initial PA is being prepared before retrieval of the SSTs has begun, in part because documenting the current state of knowledge and developing the local-scale modeling tools for the PA are potentially useful for decision making once the retrieval process is underway. It is anticipated that as WMA A-AX proceeds toward closure, the PA will be updated to address pertinent new information including actual volumes and measured compositions of waste residuals.

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3 METHODOLOGY

The Case 1 inventory for WMA A-AX residual wastes is extracted from various inventory data that are available and documented. The steps depend on whether the inventory is for radionuclide or chemical as well as the waste affiliations (tanks or ancillary equipment). The assumptions and inputs adopted for Case 1 are further described in Section 4.

3.1 CONCEPTUAL MODEL

The conceptual model is a simple decay chain evaluation according to the fundamental laws of radioactive decay. For a parent radionuclide with no ingrowth from another source, the loss of activity because of radionuclide decay is an exponential decay consistent with the decay rate, which can be derived from the radionuclide half-life. For a daughter product, the change in activity over time is related to the production rate from the parent radionuclide and its own exponential decay. The production rate of daughter (*B*) from parent (*A*) is a function of the decay constant of the parent (λ_A). The decay rate of daughter (*B*) to daughter (*C*) is a function of the decay constant of daughter *B* (λ_B). The decay reaction is illustrated in Equation 3-1.

$$A \overset{\lambda_A}{\rightarrow} B \overset{\lambda_B}{\rightarrow} C \tag{3-1}$$

Additional terms can be added to Equation 3-1 to simulate longer decay chains.

3.2 MATHEMATICAL MODEL

The mathematical model for radionuclide decay of a radionuclide *A* is given in Equation 3-2.

$$A(t) = A^o e^{-\lambda t} \tag{3-2}$$

Where:

A = activity (Ci) of radionuclide *A* at time *t*
A^o = initial activity (Ci) of radionuclide *A* at time = 0 yr
λ = decay constant (yr^{-1}) of radionuclide *A* ($= \frac{\ln(2)}{t_{1/2}}$)
t = Time of evaluation (yr)
$t_{1/2}$ = Half-life (yr) of radionuclide *A*.

For a daughter product with a single parent radionuclide, the activity of the daughter at time *t* is given by Equation 3-3.

$$A_B(t) = \frac{\lambda_B}{\lambda_B - \lambda_A} A_A^o \left(e^{-\lambda_A t} - e^{-\lambda_B t}\right) + A_B^o e^{-\lambda_B t} \tag{3-3}$$

Where:

A_i = activity (Ci) of radionuclide *i* (= *A* or *B*) at time *t*
A_i^o = initial activity (Ci) of radionuclide *i* (= *A* or *B*) at time = 0 years
λ_i = decay constant (yr^{-1}) of radionuclide *i* (= *A* or *B*)
t = Time of evaluation (yr).

In general, the activity of the *i*th radionuclide in a decay chain is given by Bateman's equation (Equation 3-4) ("The solution of a system of differential equations occurring in the theory of radio-active transformations" [Bateman 1910]) rewritten in the following format in terms of activity (Nuclear Chemical Engineering [Benedict et al. 1981]):

$$N_i(t) = \sum_{l=1}^{i-1}\left[N_l^0\lambda_l\lambda_{l+1}\cdots\lambda_{i-1}\sum_{j=l}^{i}\frac{e^{-\lambda_j t}}{\prod_{\substack{k=l\\k\neq j}}^{i}(\lambda_k-\lambda_j)}\right]+N_i^0e^{-\lambda_i t} \tag{3-4}$$

where N_l^0 is the initial amount of the *l*th ($l < i$) radionuclide and N_i^0 is the initial amount of the *i*th radionuclide. The amount of radionuclides can be converted to activity unit (Ci) using radionuclide's decay constant and Ci/Bq conversion constant.

From the GoldSim Contaminant Transport Module User's Guide (GoldSim Technology Group 2017), pp. 279, GoldSim© was designed to simulate the solution to these first order decay reactions with the added complexity that a parent can branch to decay into different radionuclides with a specified stoichiometry (Equations 3-5 and 3-6).

$$\frac{dM_A}{dt} = -M_A\lambda_A \tag{3-5}$$

$$\frac{dM_B}{dt} = M_A\lambda_A R_{BA}\frac{W_B}{W_A} \tag{3-6}$$

Where:

M_i = mass (g) of radionuclide *i* (= *A* or *B*)
$\frac{dM_i}{dt}$ = The rate (g/yr) of change in mass of species *i* (= *A* or *B*)
λ_i = decay constant (yr^{-1}) of radionuclide *i* (= *A* or *B*)
t = time of evaluation (yr)
R_{BA} = stoichiometry (moles *B* produced per moles *A* decayed)
W_i = molecular (or atomic) weight of species *i* (= *A* or *B*).

In Decay Spreadsheet calculator, the decay product activity is calculated using Equation 3-3. In forward decay calculation, time in the equation $t > 0$. In backward decay calculation, $t < 0$.

3.3 CALCULATION PROCEDURES

3.3.1 Residual Inventories of Chemicals in Tanks

The inventory is derived for chemical based on BBI data that is provided in RPP-RPT-58293 in the spreadsheet format. The steps for deriving input inventory for the PA system model are:

a. The BBI inventories are divided by the tank volumes to obtain the BBI concentrations

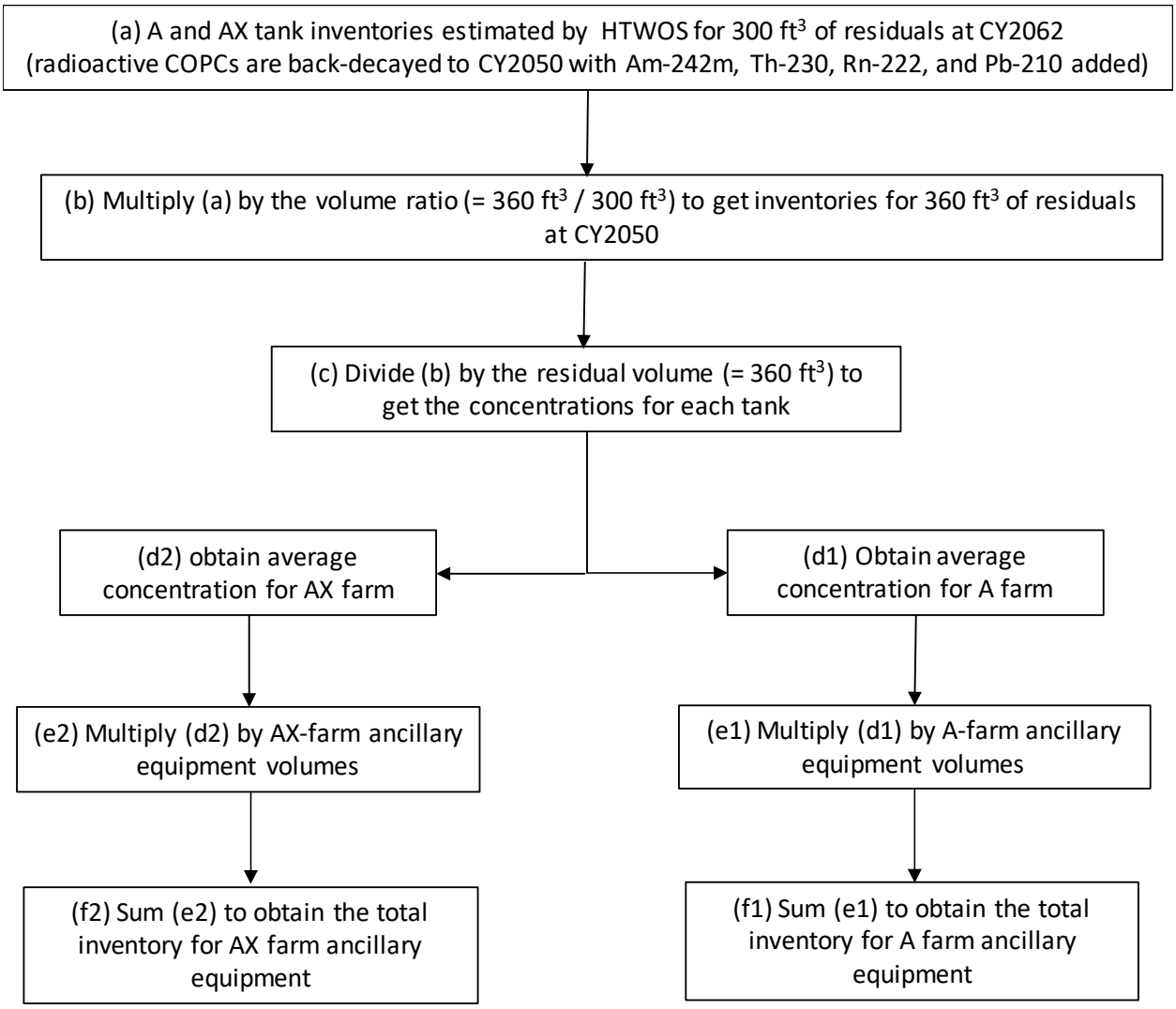
b. The BBI concentrations are multiplied by the residual volumes (see Section 4.2) to obtain the residual masses in the tanks.

3.3.2 Residual Inventories of Chemicals in Ancillary Equipment

The source data is downloaded from Hanford Tank Waste Operations Simulator (HTWOS) in spreadsheet format as documented in RPP-RPT-58293. The HTWOS download data are converted to the residual masses for WMA A-AX ancillary equipment according to steps c through f shown in Figure 3-1. In this figure, the volumes are based on Milestone M-045-00 in Appendix D of the HFFACO Action Plan:

> "Closure will follow retrieval of as much tank waste as technically possible, with tank waste residues not to exceed 360 cubic feet (cu. ft.) In each of the 100 series tanks, 30 cu. ft. In each of the 200 series tanks, or the limit of waste retrieval technology capability, whichever is less."

Figure 3-1. Steps of Calculating Waste Management Area A-AX Ancillary Equipment Residual Inventories.



COPC = constituent of potential concern CY = calendar year HTWOS = Hanford Tank Waste Operations Simulator

3.3.3 Residual Inventories of Radionuclides in Tanks

The data source for calculating inventories of radionuclides in WMA A-AX tank residuals at calendar year (CY) 2050, the assumed closure date, is from the BBI data provided in the RPP-RPT-58293 spreadsheet. The data was determined at different past times for the different tanks and needs to decay to CY 2050. The forward decay calculations are conducted using GoldSim©, as follows.

a. Missing radionuclides in the decay chain are added to the BBI inventory data provided by RPP-RPT-58293, which includes ^{230}Th, ^{210}Pb, ^{222}Rn, and ^{242m}Am. Because the BBI inventory for tanks A-101, AX-102, and AX-103 is provided at Year 2008 (January 1,

2008) while that for the remaining tanks (241-A-102 [A-102] through A-106, AX-101, and AX-104) is provided at Year 2015 (July 1, 2015), the missing radionuclide inventory is estimated in the following manner for these two starting times for the corresponding tanks to maintain consistency.

- Inventory for ^{230}Th is estimated from ^{234}U inventory. First, it is assumed that the ^{234}U inventory in a specific tank (for 2008 or 2015) would remain practically unchanged since end of operations at WMA A-AX due to the long half-life of ^{234}U. Next, by taking an arbitrary long-time period of 30 years, the ^{234}U inventory is decayed to in-grow ^{230}Th for estimating the tank-specific inventory at 2008 or 2015.

- Inventory for ^{242m}Am (for 2008 or 2015) is estimated using ^{242}Cm inventory assuming that ^{242}Cm is in secular equilibrium with ^{242m}Am.

- Inventory for ^{222}Rn (for 2008 or 2015) is estimated assuming that ^{222}Rn is in secular equilibrium with ^{226}Ra.

- Inventory for ^{210}Pb (for 2008 or 2015) is assumed to be 0 Ci.

b. Forward decay and ingrowth of the BBI inventories starting at January 1, 2008 and July 1, 2015, respectively, are simulated to January 1, 2050 using GoldSim©.

c. The BBI inventories at January 1, 2050 are then divided by the tank volumes to obtain the BBI concentrations at January 1, 2050.

d. The BBI concentrations at January 1, 2050 are then multiplied by the assumed residual volumes (at closure) to obtain the residual waste activities in the tanks at January 1, 2050.

3.3.4 Residual Inventories of Radionuclides in the Ancillary Equipment

The source data is obtained from the HTWOS run documented in RPP-RPT-58293 in spreadsheet format. The tank inventories are calculated for CY 2062 (assumed closure date for HTWOS) and hence must be decayed backward to CY 2050. This is done using a previously-qualified Decay Spreadsheet calculator. Missing radionuclides are added to the HTWOS download provided by RPP-RPT-58293, which includes ^{230}Th, ^{210}Pb, ^{222}Rn, and ^{242m}Am. The inventory at CY 2050 are converted to the residual activities for A Farm and AX Farm, respectively, according to steps shown in Figure 3-1.

Most calculations reported in this EMCF are performed in spreadsheet. The purpose is to keep the output in the same spreadsheet file as the input for traceability. The original data lists radionuclides according to their mass number sorted from 1 to 9, which is not consistent with GoldSim© species list format. The input for the calculation in Step 3.3.3 and output from Steps 3.3.1, 3.3.2, and 3.3.4 are converted to the GoldSim© format.

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4 ASSUMPTIONS AND INPUTS

4.1 KEY ASSUMPTIONS

RPP-RPT-58293 provides a comprehensive listing of radionuclide and dangerous chemical constituents. The basis for the inventory is the Hanford Site BBI estimate from as early as 2008. The BBI and HTWOS provided by RPP-RPT-58293 are the source for the inventory Case 1 developed in this EMCF. Additional inventory information provided in RPP-RPT-58293 can be used to develop upper and lower bound estimates.

It is assumed that the impact of short-lived radionuclides in decay chains can be addressed using an assumption of secular or transient equilibrium. Under this assumption, dose coefficients for short-lived species can include the short-lived daughters. For this reason, the inventory calculation in this EMCF includes both short-lived and longer-lived radionuclides to evaluate when the assumption of secular and transient equilibrium are and are not appropriate.

The decay chains and decay properties for the radionuclides that are included in the BBI are modeled using the built-in database of radionuclides in the RT Module of GoldSim©. The technical basis for the database records, such as half-lives and branch stoichiometry numbers, is "ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations" (ICRP 2008).

The calculation in this EMCF inherits all relevant assumptions made in RPP-RPT-58293. Additional assumptions needed for the calculation include:

1. The residual volume for all tanks, except A-104 and A-105, is assumed to be 360 ft^3 (HFFACO threshold retrieval volume). For tanks A-104 and 105, the current BBI volumes are used for inventory estimate. Since tanks A-104 and A-105 are categorized as "assumed leakers," it is conservatively assumed that no further retrieval may occur. The current BBI concentrations are assumed for tank inventory estimates due to lack of tank-specific retrieval information.

2. The HTWOS calculations (documented in RPP-RPT-58293) are used to develop residual inventory estimates for WMA A-AX ancillary equipment. This is because the ancillary equipment (pipelines, catch tanks, pits, and diversion boxes) that is assumed to have been flushed at the end of the operations would result in residual concentrations similar to those in the HTWOS estimates for the tanks following retrieval operations (based on wash and leach factors). Because little information is available for waste in ancillary equipment, it was assumed that the average HTWOS residual waste concentration is representative of waste in ancillary equipment.

3. The closure date of WMA A-AX is January 1, 2050 (RPP-RPT-60101 Appendix A).

In estimating ancillary equipment inventories, the ingrowth of radionuclides that are in decay chains are based on the second order decay of the immediate parent radionuclides.

4.2 INPUT

Inventory for estimated waste residuals to be evaluated in the initial WMA A-AX PA is provided in RPP-RPT-58293. Specifically, most information is obtained from a Microsoft Excel®[2] file "A and AX Resid Inv.xlsx" that is the same as Appendix A in RPP-RPT-58293 except for additional digits of precision. "A and AX Resid Inv.xlsx" is expanded to a new spreadsheet file specifically for this EMCF: "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx".

This file, instead of the original "A and AX Resid Inv.xlsx", will be cited in this EMCF whenever necessary. To avoid transcription errors, the modified spreadsheet mentioned above was used for arithmetic operations in Section 3.3.1 and 3.3.2 and to incorporate the backward decay calculations in Section 3.3.4. For the backward decay calculations in the spreadsheet, half-lives and stoichiometry numbers are from ICRP 2008.

The input data for calculating residual chemical inventories in WMA A-AX tanks and ancillary equipment are given in Table 4-1 and Table 4-2. The input data for calculating radionuclide residual inventories in WMA A-AX tanks and ancillary equipment are given in Table 4-3 and Table 4-4. These data are documented in RPP-RPT-58293. Note that the calculation retains full precision values from the spreadsheet data corresponding to the RPP-RPT-58293 appendices, whereas the printed document shows fewer digits. The chemical constituents listed in Table 4-1 and Table 4-2 are based on information presented in the WMA C PA (RPP-ENV-58782 Table 3-8) and the BBI (RPP-RPT-58293). Some chemicals, such as, boron (B), cyanide (CN), selenium (Se), tin (Sn), and Tri-butyl phosphate (TBP) are considered supplemental analytes and their inventory estimates will be discussed in the system model documents. Total uranium will be calculated as the sum of masses of all uranium isotopes considered in WMA A-AX PA. Oxalate is excluded because there is no toxicity value for this chemical. The radioactive constituents listed in Table 4-3 and Table 4-4 are those tracked in the BBI (RPP-RPT-58293), plus missing radionuclides in RPP-RPT-58293 are added to complete the decay chains as discussed in Sections 6.4 and 6.5.

Volumes of WMA A-AX tanks and residual wastes are provided in RPP-RPT-58293 and are shown in Table 4-5 and Table 4-6. For radionuclides in the tank residual wastes, the dates for calculating decay are given in Table 4-7. For radionuclides in the ancillary residual wastes, the date for calculating decay is January 1, 2062.

[2] Excel® is a registered trademark of Microsoft Corporation in the U.S. and other countries.

Table 4-1. Chemical Constituents from Best-Basis Inventory for Waste Management Area A-AX Tanks[a] (kg).

Chemicals[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Al	4.50E+04	7.73E+03	3.46E+04	7.08E+03	8.28E+03	1.02E+04	4.96E+04	2.37E+03	1.51E+04	1.71E+03
Cr	6.58E+03	1.63E+03	2.71E+03	1.58E+02	3.56E+02	1.93E+03	4.21E+03	1.02E+02	2.13E+03	1.87E+01
F	9.85E+02	5.36E+01	1.18E+03	1.92E+00	1.68E+01	1.04E+02	1.20E+03	5.92E+01	5.39E+02	3.27E+00
Fe	7.34E+02	4.65E+03	1.73E+03	2.59E+04	1.92E+04	1.83E+04	1.25E+03	6.40E+03	4.54E+03	8.77E+03
Hg	3.40E+00	9.92E-01	2.69E+00	3.20E+01	2.14E+01	1.80E+02	1.32E+01	7.59E+00	5.24E+00	5.32E+00
Mn	2.06E+02	9.12E+02	2.97E+02	3.63E+03	6.49E+02	8.85E+02	4.67E+01	5.22E+02	6.15E+02	1.52E+02
Ni	3.27E+02	1.36E+02	2.69E+02	1.68E+03	1.55E+03	7.03E+02	1.43E+02	1.49E+02	2.70E+02	4.72E+02
NO_2^-	1.33E+05	2.25E+04	1.63E+05	5.88E+03	3.73E+02	1.15E+04	1.64E+05	5.07E+03	5.39E+04	7.27E+01
NO_3^-	2.44E+05	2.49E+04	2.29E+05	3.02E+02	9.53E+03	3.10E+04	3.04E+05	2.58E+04	6.83E+04	1.48E+03
Pb	3.28E+02	3.20E+02	3.21E+02	5.65E+01	1.54E+03	8.50E+02	1.74E+02	4.43E+02	3.88E+02	3.00E+02
Sr	1.83E+01	1.34E+01	1.32E+01	4.21E+01	5.34E+01	8.07E+01	3.81E+00	1.16E+02	4.58E+01	3.09E+01

[a] From RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," Table A.2 (page A-3/A-4).

[b] This list of chemicals is based on RPP-ENV-58782, "*Performance Assessment of Waste Management Area C, Hanford Site, Washington*" and the Best-Basis Inventory data in RPP-RPT-58293. Total uranium mass will be calculated using the masses of all uranium isotopes.

Table 4-2. Chemical Constituents from Hanford Tank Waste Operations Simulator for Waste Management Area A-AX Tanks Residual Wastes[a] Scaled to 360 cubic feet (kg).

Chemicals[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Al	5.85E+03	3.46E+03	5.01E+03	1.71E+03	1.31E+03	2.36E+03	5.77E+03	9.19E+02	2.93E+03	1.40E+03
Cr	8.45E+02	7.51E+02	4.75E+02	3.45E+01	5.64E+01	4.83E+02	7.47E+02	4.42E+01	4.39E+02	8.56E+00
F	4.73E-04	1.17E-04	4.26E-04	8.98E-06	9.29E-06	6.73E-05	5.14E-04	7.25E-05	3.21E-04	1.28E-05
Fe	8.28E+01	1.70E+03	1.76E+02	6.25E+03	3.02E+03	2.73E+03	1.52E+02	2.88E+03	1.07E+03	7.17E+03
Hg	1.63E-06	4.23E-07	9.63E-07	1.55E-04	1.18E-05	3.03E-04	4.30E-06	9.30E-06	3.12E-06	2.08E-05
Mn	3.00E+01	2.94E+02	4.22E+01	8.76E+02	1.03E+02	1.46E+02	8.56E+00	2.35E+02	1.49E+02	1.24E+02
Ni	4.77E+01	3.66E+01	4.56E+01	4.07E+02	4.40E+02	6.47E+01	2.50E+01	6.69E+01	6.51E+01	3.86E+02
NO_2^-	6.42E-02	5.10E-02	5.90E-02	2.87E-02	1.20E-03	5.40E-02	5.26E-02	6.22E-03	3.22E-02	1.13E-03
NO_3^-	1.17E-01	5.53E-02	8.24E-02	1.16E-03	5.11E-03	5.85E-02	1.06E-01	3.16E-02	4.05E-02	5.72E-03
Pb	1.57E-04	5.77E-04	8.24E-05	2.44E-04	8.52E-04	7.88E-04	6.37E-05	5.43E-04	2.31E-04	1.17E-03
Sr	2.52E+00	2.49E+00	3.52E-01	8.53E+00	7.10E+00	4.86E+00	3.65E-01	2.58E+01	1.03E+01	1.81E+01

[a] From RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," Table A.3 (page A-25/A-26).

[b] This list of chemicals is based on RPP-ENV-58782, "*Performance Assessment of Waste Management Area C, Hanford Site, Washington*" and the Hanford Tank Waste Operations Simulator data in RPP-RPT-58293. Total uranium mass will be calculated using the masses of all uranium isotopes.

Table 4-3. Radioactive Constituents from Best-Basis Inventory for Waste Management Area A-AX Tanks[a] (Ci). (3 sheets)

Name[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Ac227	1.70E-02	4.20E-03	3.19E-02	1.56E-05	1.23E-05	2.04E-03	3.32E-02	1.27E-03	4.81E-03	3.06E-06
Am241	3.77E+02	3.58E+02	4.00E+02	7.09E+02	3.10E+03	1.35E+03	3.51E+02	2.14E+03	7.24E+02	6.03E+02
Am242m[c]	4.09E-01	3.53E-01	4.07E-01	5.38E-01	3.19E+00	4.90E+00	3.41E-01	3.83E+00	7.71E-01	6.19E-01
Am243	2.12E-01	2.00E-01	2.26E-01	3.58E-01	1.67E+00	3.09E+00	2.18E-01	1.96E+00	3.90E-01	3.24E-01
Ba137m	2.61E+05	3.07E+04	2.06E+05	3.94E+04	7.78E+04	5.90E+04	2.83E+05	2.11E+04	9.95E+04	2.31E+04
C14	6.57E+00	2.49E-01	4.61E+00	3.25E-01	2.76E-01	3.74E-01	6.80E+00	6.64E-02	1.73E+00	6.86E-02
Cd113m	6.31E+01	5.28E+00	3.98E+01	1.19E+00	1.70E+00	4.70E+00	4.58E+01	5.31E+00	1.73E+01	4.23E-01
Cm242	3.37E-01	2.91E-01	3.35E-01	4.43E-01	2.63E+00	4.03E+00	2.81E-01	3.15E+00	6.35E-01	5.10E-01
Cm243	1.57E-02	1.03E-02	1.26E-02	1.64E-02	1.20E-01	2.24E-01	1.49E-02	2.83E-01	3.29E-02	2.32E-02
Cm244	3.37E-01	2.01E-01	2.43E-01	3.15E-01	2.27E+00	4.39E+00	2.93E-01	6.25E+00	6.98E-01	4.41E-01
Co60	2.53E+01	5.27E+00	5.62E+00	2.57E+01	3.76E+01	1.76E+01	8.48E+00	5.98E+01	4.16E+01	2.10E+01
Cs134	4.56E-02	5.89E-04	3.72E-03	3.46E-03	3.30E-03	2.44E-03	3.75E-03	3.33E-03	1.99E-02	8.22E-04
Cs137	2.76E+05	3.25E+04	2.19E+05	4.17E+04	8.25E+04	6.25E+04	3.00E+05	2.24E+04	1.05E+05	2.45E+04
Eu152	6.48E+00	7.04E-01	3.38E+00	4.51E+00	3.88E+01	3.74E+01	2.99E+00	1.71E+01	1.33E+01	9.64E+00
Eu154	4.15E+02	3.64E+01	1.74E+02	4.49E+02	1.14E+03	1.90E+03	1.48E+02	5.61E+02	1.39E+03	2.23E+02
Eu155	1.39E+02	7.55E+00	3.53E+01	4.71E+01	9.07E+01	3.88E+02	2.75E+01	1.89E+02	3.00E+02	5.33E+01
H3	1.57E+01	1.14E+00	8.57E+00	7.86E-01	4.85E-01	1.61E+00	1.07E+01	1.48E+00	4.14E+00	1.21E-01
I129	2.33E-01	1.93E-02	4.83E-02	6.36E-03	9.47E-04	3.55E-02	2.52E-01	1.68E-02	6.77E-02	2.36E-04
Nb93m	3.46E+01	4.99E+00	3.73E+01	2.11E+00	2.67E+00	4.75E+00	3.88E+01	2.70E+00	1.03E+01	6.63E-01
Ni59	1.41E+01	1.76E+00	1.18E+01	8.62E+00	7.20E+00	6.96E+00	1.40E+01	1.71E+00	5.06E+00	1.79E+00
Ni63	1.28E+03	1.52E+02	1.02E+03	7.40E+02	6.26E+02	6.00E+02	1.21E+03	1.56E+02	4.61E+02	1.56E+02

Table 4-3. Radioactive Constituents from Best-Basis Inventory for Waste Management Area A-AX Tanks[a] (Ci). (3 sheets)

Name[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Np237	1.35E+00	1.48E-01	1.12E+00	5.04E-02	4.24E-02	1.49E-01	1.39E+00	2.71E-01	4.80E-02	1.06E-02
Pa231	8.26E-02	1.12E-02	8.53E-02	2.32E-05	1.57E-05	5.42E-03	8.89E-02	6.15E-03	2.34E-02	3.92E-06
Pb210[d]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu238	3.45E+00	1.22E+01	8.81E+00	1.81E+01	2.39E+01	5.41E+01	3.95E+00	1.37E+01	4.20E+00	7.43E+00
Pu239	7.99E+01	3.21E+02	2.28E+02	5.97E+02	5.56E+02	1.42E+03	1.05E+02	1.52E+02	9.26E+01	1.73E+02
Pu240	1.92E+01	7.46E+01	5.35E+01	1.31E+02	1.36E+02	3.31E+02	2.43E+01	4.87E+01	2.34E+01	4.24E+01
Pu241	1.22E+02	3.34E+02	2.39E+02	4.20E+02	6.05E+02	1.39E+03	1.04E+02	5.95E+02	1.44E+02	1.88E+02
Pu242	1.41E-03	5.57E-03	3.98E-03	6.54E-03	9.88E-03	2.28E-02	1.72E-03	7.45E-03	1.64E-03	3.08E-03
Ra226	7.28E-05	9.41E-06	7.10E-05	1.70E-06	2.21E-06	7.07E-06	7.72E-05	5.80E-06	2.05E-05	5.51E-07
Ra228	1.10E-04	1.49E-05	1.13E-04	1.63E-06	1.89E-11	7.76E-06	1.18E-04	1.19E-03	1.22E-04	4.71E-12
Rn222[e]	7.28E-05	9.41E-06	7.10E-05	1.70E-06	2.21E-06	7.07E-06	7.72E-05	5.80E-06	2.05E-05	5.51E-07
Ru106	1.62E-06	2.43E-09	8.28E-09	4.09E-09	2.84E-08	2.85E-07	2.57E-08	6.56E-05	1.92E-06	1.12E-08
Sb125	1.48E+00	7.98E-02	2.13E-01	1.93E+00	1.63E+00	3.06E+00	2.58E-01	1.37E+02	8.76E+00	8.53E-01
Se79	1.48E+00	1.96E-01	1.48E+00	8.89E-02	1.13E-01	1.82E-01	1.58E+00	3.55E-02	4.37E-01	2.82E-02
Sm151	1.84E+04	4.10E+03	1.46E+04	3.52E+04	7.30E+04	2.20E+05	2.50E+04	3.69E+04	2.06E+04	1.82E+04
Sn126	3.79E+00	6.40E-01	4.82E+00	1.79E-01	2.29E-01	4.01E-01	4.23E+00	1.08E+00	1.26E+00	5.69E-02
Sr90	1.10E+05	5.73E+04	1.05E+05	1.53E+06	2.19E+06	1.79E+06	1.49E+05	2.09E+05	4.04E+05	1.00E+06
Tc99	2.29E+02	3.62E+01	2.62E+02	1.24E+01	1.58E+01	8.76E+01	2.48E+02	6.30E+00	7.03E+01	1.32E+01
Th229	3.02E-05	4.10E-06	3.12E-05	6.40E-07	1.35E-08	2.22E-06	3.25E-05	2.25E-06	8.58E-06	3.35E-09
Th230[f]	1.31E-04	8.31E-04	3.22E-04	1.76E-04	3.02E-07	5.48E-05	1.67E-04	5.60E-05	2.87E-05	1.25E-05
Th232	1.10E-04	1.49E-05	1.13E-04	1.63E-06	1.89E-11	7.76E-06	1.18E-04	1.19E-03	1.22E-04	4.71E-12

Table 4-3. Radioactive Constituents from Best-Basis Inventory for Waste Management Area A-AX Tanks[a] (Ci). (3 sheets)

Name[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
U232	4.07E-02	1.98E-01	7.59E-02	2.74E-03	5.93E-08	3.29E-03	2.50E-02	1.66E-02	1.03E-02	2.45E-06
U233	2.63E+00	1.38E+01	5.27E+00	1.94E-01	1.24E-07	2.28E-01	1.73E+00	1.07E+00	9.15E-02	5.13E-06
U234	4.75E-01	2.41E+00	9.33E-01	5.10E-01	8.77E-04	1.59E-01	4.84E-01	2.03E-01	1.04E-01	3.63E-02
U235	1.93E-02	9.78E-02	3.78E-02	2.15E-02	3.67E-05	6.63E-03	1.99E-02	8.25E-03	2.75E-03	1.52E-03
U236	1.24E-02	6.33E-02	2.45E-02	1.22E-02	2.26E-05	4.11E-03	1.27E-02	5.67E-03	3.67E-03	9.34E-04
U238	4.27E-01	2.17E+00	8.39E-01	5.07E-01	8.57E-04	1.53E-01	4.48E-01	1.80E-01	6.45E-02	3.55E-02
Y90	1.10E+05	5.73E+04	1.05E+05	1.53E+06	2.19E+06	1.79E+06	1.49E+05	2.09E+05	4.04E+05	1.00E+06
Zr93	4.05E+01	5.57E+00	4.17E+01	2.35E+00	3.00E+00	5.33E+00	4.33E+01	3.16E+00	1.21E+01	7.46E-01

[a] From RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," Table A.2 (pages A-5/A-6). The starting decay date for each tank is given in Table 4-7.

[b] This list of radionuclides is based on RPP-ENV-58782, "*Performance Assessment of Waste Management Area C, Hanford Site, Washington*."

[c] Not present in RPP-RPT-58293 Table A.2 but added assuming secular equilibrium with Cm-242.

[d] Not present in RPP-RPT-58293 Table A.2 but added assuming 0 Ci.

[e] Not present in RPP-RPT-58293 Table A.2 but added assuming secular equilibrium with Ra-226.

[f] Not present in RPP-RPT-58293 Table A.2 but added assuming decayed from U-234 described in Section 6.4.

Table 4-4. Radionuclide Constituents from Hanford Tank Waste Operations Simulator Estimates for 300 cubic feet with Decay to 2062[a] (Ci). (3 sheets)

Name[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Ac227	7.732E-03	3.717E-03	1.032E-02	3.596E-06	2.856E-06	8.300E-04	8.533E-03	1.773E-03	3.624E-03	2.050E-06
Am241	4.226E+01	9.771E+01	2.619E+01	1.342E+02	6.788E+02	7.702E+01	3.865E+01	7.411E+02	1.343E+02	3.851E+02
Am242m[c]	1.254E-07	3.594E-07	5.555E-08	1.692E-06	1.172E-06	3.731E-07	7.990E-08	2.997E-06	2.932E-07	1.604E-06
Am243	2.552E-02	5.704E-02	1.569E-02	7.081E-02	3.936E-01	4.062E-02	2.554E-02	7.316E-01	7.815E-02	2.202E-01
Ba137m	3.004E-02	1.879E-02	2.116E-02	5.431E-02	6.852E-03	1.557E-02	2.666E-02	6.212E-03	1.421E-02	2.576E-02
C14	2.607E-06	4.700E-07	1.376E-06	1.302E-06	1.263E-07	5.029E-07	2.162E-06	6.737E-08	8.535E-07	2.221E-07
Cd113m	4.294E-01	1.029E-06	5.074E-01	4.854E-07	7.965E-08	9.127E-02	4.372E-01	3.817E-07	6.021E-07	2.917E-02
Cm242	1.033E-07	2.958E-07	4.573E-08	1.393E-06	9.645E-07	3.072E-07	6.578E-08	2.468E-06	2.414E-07	1.321E-06
Cm243	1.736E-09	3.722E-09	5.821E-10	2.124E-08	1.822E-08	5.403E-09	1.382E-09	7.986E-08	4.516E-09	2.495E-08
Cm244	1.701E-08	3.779E-08	5.895E-09	2.088E-07	1.765E-07	5.432E-08	1.392E-08	8.079E-07	4.378E-08	2.416E-07
Co60	2.541E-03	3.579E-03	1.173E-03	1.144E-02	1.959E-02	3.216E-03	2.309E-03	1.848E-02	6.901E-03	3.156E-02
Cs134	2.450E-16	1.539E-16	0.000E+00[g]	2.316E-15	2.529E-16	3.537E-16	1.933E-16	4.567E-17	1.323E-16	4.447E-16
Cs137	3.182E-02	1.990E-02	2.242E-02	5.754E-02	7.258E-03	1.649E-02	2.825E-02	6.581E-03	1.505E-02	2.728E-02
Eu152	4.974E-02	5.256E-03	1.714E-02	8.144E-02	8.462E-01	4.628E-01	3.190E-02	4.051E-01	1.685E-01	6.080E-01
Eu154	6.484E-01	6.650E-02	2.167E-01	2.122E+00	3.532E+00	5.882E+00	4.014E-01	2.699E+00	3.596E+00	3.568E+00
Eu155	6.401E-03	5.644E-04	1.872E-03	1.035E-02	1.351E-02	5.410E-02	3.575E-03	2.677E-02	2.287E-02	4.101E-02
H3	3.005E-07	1.559E-07	1.885E-07	2.321E-07	1.632E-08	1.806E-07	2.494E-07	7.241E-08	9.831E-08	2.870E-08
I129	9.313E-08	4.071E-08	6.327E-04	2.573E-08	4.359E-10	6.170E-08	7.806E-08	1.720E-08	3.358E-08	7.665E-10
Nb93m	4.857E+00	2.320E+00	6.454E+00	4.675E-01	6.973E-01	1.006E+00	5.334E+00	1.170E+00	2.396E+00	5.010E-01
Ni59	1.712E+00	6.129E-01	1.837E+00	1.737E+00	1.698E+00	1.507E+00	1.801E+00	6.409E-01	1.016E+00	1.220E+00

Table 4-4. Radionuclide Constituents from Hanford Tank Waste Operations Simulator Estimates for 300 cubic feet with Decay to 2062[a] (Ci). (3 sheets)

Name[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Ni63	1.071E+02	3.833E+01	1.149E+02	1.081E+02	1.070E+02	9.376E+01	1.126E+02	4.029E+01	6.371E+01	7.689E+01
Np237	1.631E-01	5.876E-02	1.717E-01	1.016E-02	1.001E-02	2.988E-02	1.783E-01	1.016E-01	8.909E-03	7.194E-03
Pa231	1.005E-02	4.833E-03	1.341E-02	4.675E-06	3.713E-06	1.079E-03	1.110E-02	2.306E-03	4.712E-03	2.666E-06
Pb210[d]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pu238	2.709E-01	3.270E+00	8.719E-01	2.519E+00	2.175E+00	3.410E+00	3.176E-01	3.346E+00	4.504E-01	3.506E+00
Pu239	9.599E+00	1.255E+02	3.466E+01	1.199E+02	7.308E+01	1.382E+02	1.213E+01	5.689E+01	1.521E+01	1.178E+02
Pu240	2.292E+00	2.899E+01	7.923E+00	2.610E+01	1.785E+01	3.138E+01	2.802E+00	1.816E+01	3.819E+00	2.878E+01
Pu241	1.094E+00	1.392E+01	3.628E+00	8.985E+00	8.492E+00	1.360E+01	1.288E+00	1.658E+01	1.764E+00	1.369E+01
Pu242	1.691E-04	2.181E-03	5.637E-04	1.311E-03	1.300E-03	2.092E-03	2.003E-04	2.792E-03	2.704E-04	2.096E-03
Ra226	2.842E-11	1.804E-11	2.093E-11	6.699E-12	9.996E-13	9.827E-12	2.371E-11	5.789E-12	9.925E-12	1.757E-12
Ra228	1.330E-05	6.401E-06	1.775E-05	3.290E-07	4.451E-12	1.654E-06	1.468E-05	4.453E-04	2.447E-05	3.200E-12
Rn222[e]	2.842E-11	1.804E-11	2.093E-11	6.699E-12	9.996E-13	9.827E-12	2.371E-11	5.789E-12	9.925E-12	1.757E-12
Ru106	7.467E-29	2.672E-29	3.230E-29	2.988E-28	1.374E-28	6.991E-27	1.346E-28	7.751E-27	1.099E-28	6.846E-28
Sb125	7.546E-13	3.694E-13	4.249E-13	6.543E-11	3.530E-12	1.378E-11	6.422E-13	1.786E-10	5.549E-12	2.332E-11
Se79	5.934E-07	3.856E-07	4.456E-07	3.582E-07	5.216E-08	2.802E-07	4.938E-07	3.622E-08	2.169E-07	9.172E-08
Sm151	1.480E+03	3.917E+02	1.268E+03	4.931E+03	1.204E+04	2.740E+04	2.035E+03	9.128E+03	2.736E+03	8.653E+03
Sn126	1.514E-06	1.311E-06	1.447E-06	7.194E-07	1.052E-07	5.668E-07	1.273E-06	1.099E-06	6.235E-07	1.851E-07
Sr90	3.591E+03	7.701E+03	4.482E+03	1.002E+05	9.376E+04	1.621E+04	5.380E+03	1.072E+04	2.213E+04	2.227E+05
Tc99	9.165E-05	6.893E-05	7.860E-05	4.985E-05	7.257E-06	1.448E-04	7.655E-05	6.440E-06	3.485E-05	4.306E-05
Th229	3.663E-06	1.759E-06	4.896E-06	1.290E-07	3.161E-09	4.823E-07	4.039E-06	8.399E-07	1.718E-06	2.276E-09

Table 4-4. Radionuclide Constituents from Hanford Tank Waste Operations Simulator Estimates for 300 cubic feet with Decay to 2062[a] (Ci). (3 sheets)

Name[b]	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Th230[f]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Th232	1.335E-05	6.427E-06	1.782E-05	3.303E-07	4.469E-12	1.661E-06	1.474E-05	4.470E-04	2.457E-05	3.212E-12
U232	2.902E-03	4.934E-02	7.536E-03	3.493E-04	4.927E-09	5.132E-04	2.315E-03	3.635E-03	1.208E-03	1.054E-06
U233	3.198E-01	5.438E+00	8.306E-01	3.915E-02	1.634E-08	5.655E-02	2.550E-01	4.005E-01	1.840E-02	3.492E-06
U234	5.780E-02	9.509E-01	1.482E-01	1.030E-01	1.156E-04	2.437E-02	6.381E-02	7.599E-02	2.098E-02	2.474E-02
U235	2.346E-03	3.855E-02	6.013E-03	4.334E-03	4.838E-06	1.012E-03	2.619E-03	3.096E-03	5.528E-04	1.034E-03
U236	1.514E-03	2.493E-02	3.879E-03	2.473E-03	2.979E-06	6.263E-04	1.675E-03	2.129E-03	7.388E-04	6.364E-04
U238	5.205E-02	8.538E-01	1.334E-01	1.025E-01	1.130E-04	2.313E-02	5.873E-02	6.736E-02	1.297E-02	2.418E-02
Y90	3.591E+03	7.701E+03	4.482E+03	1.002E+05	9.376E+04	1.621E+04	5.380E+03	1.072E+04	2.213E+04	2.227E+05
Zr93	4.927E+00	2.353E+00	6.546E+00	4.740E-01	7.079E-01	1.021E+00	5.411E+00	1.187E+00	2.431E+00	5.086E-01

[a] From RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," Table A.3 (pages A-21/A-22 and A-23/A-24).

[b] This list of radionuclides is based on RPP-ENV-58782, "*Performance Assessment of Waste Management Area C, Hanford Site, Washington*."

[c] Not present in RPP-RPT-58293 Table A.3 but added assuming secular equilibrium with Cm-242.

[d] Not present in RPP-RPT-58293 Table A.3 but added assuming 0 Ci in all tanks.

[e] Not present in RPP-RPT-58293 Table A.3 but added assuming secular equilibrium with Ra-226.

[f] Not present in RPP-RPT-58293 Table A.3 but added assuming 0 Ci.

[g] Cs-134 in tank 241-A-103 is not provided in RPP-RPT-58293 Table A.3 and is assumed to be 0 Ci.

Table 4-5. Waste Management Area A-AX Current and Residual Waste Volumes (kL).

Tanks	Current Waste Volume[a]	Residual Volume
241-A-101	1,037	10.19[b]
241-A-102	147	10.19[b]
241-A-103	1,471	10.19[b]
241-A-104	93	93[c]
241-A-105	139	139[c]
241-A-106	273	10.19[b]
241-AX-101	1,210	10.19[b]
241-AX-102	113	10.19[b]
241-AX-103	403	10.19[b]
241-AX-104	18	10.19[b]

[a] From RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," Table A.2 (page A-3/A-4).

[b] The assumed threshold for residual volume (360 ft^3 = 10.19 kL, the spreadsheet uses full precision 10.1941 kL) based on *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (RPP-RPT-58293 Section 3.1, Assumption c).

[c] Assumed to be same as the current waste volumes from RPP-RPT-58293 Table 4-4.

Table 4-6. Waste Management Area A-AX Ancillary Volumes (kL).

Ancillary Equipment	Volume	Ancillary Equipment	Volume
A-350 catch tank	4.16E-02	A Farm Div Box/Pits	3.90E-02
A-417 catch tank	4.16E-01	A Farm Pipelines	3.30E+00
A-302A catch tank	2.31E-01	AX-151 catch tank	1.06E+00
A-302B catch tank	2.31E+00	AX-152 catch tank	3.80E-02
204-AR catch tank	2.69E-01	AX-152/DS diversion box	7.57E-02
244-A catch tank	1.97E+00	AX Farm Div Box/Pits	2.90E-02
244-AR vault total	1.08E+00	AX Farm Pipelines	2.90E+00

Source: RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," Table A.4 (page A-37/A-38) for 241-A Tank Farm ancillary equipment and Table A.4 (page A-43) for 241-AX Tank Farm ancillary equipment.

Table 4-7. Starting Dates for Calculating Decay from Best Basis Inventory Tank Inventories (Table 4-3).

Tank	Date
241-A-101	January 1, 2008
241-A-102	July 1, 2015
241-A-103	July 1, 2015
241-A-104	July 1, 2015
241-A-105	July 1, 2015
241-A-106	July 1, 2015
241-AX-101	July 1, 2015
241-AX-102	January 1, 2008
241-AX-103	January 1, 2008
241-AX-104	July 1, 2015

Source: RPP-RPT-58293, "*Hanford 241-A and 241-AX Farm Tank and Ancillary Equipment Residual Waste Inventory Estimates*," page A-5/A-6 at the top of Table A.2.

5 SOFTWARE APPLICATIONS

Radionuclide decay calculations for this EMCF were performed using GoldSim© Pro Version 12.0. Simple arithmetic operations such as scaling current inventories to fractions assumed at the time of closure were performed in Microsoft Excel® for the residual inventories of chemicals and radionuclides of ancillary equipment.

The software used to perform this calculation are approved, managed, and used in compliance with the CH2M HILL Plateau Remediation Company (CHPRC) requirements of PRC-PRO-IRM-309, "Controlled Software Management." CHPRC's software requirements for the GoldSim© software also meet Washington River Protection Solutions, LLC's software requirements.

5.1 GOLDSIM© PRO

Calculations are performed using GoldSim© Pro simulator software, Version 12.0. GoldSim© Pro simulator is approved for use by CHPRC at the Hanford Site in accordance with the requirements of PRC-PRO-IRM-309. The installed GoldSim© Pro simulator software was tested in accordance with the procedure per CHPRC-00175, "*GoldSim Pro Software Management Plan*," Revision 3.

5.1.1 Description

Software is registered on the Hanford Information System Inventory and is identified as approved for use. The identification for the software package used in the calculation are as follows:

- GoldSim© Pro
- Version 12.0
- Hanford Information System Inventory Identification Number: 2461
- Workstation type and property number: Lenovo Yoga 900-131SK2 Signature Edition, SN PFOGS02H.

Software development of GoldSim© Pro meets AMSE NQA-1-2008, *Quality Assurance Requirements for Nuclear Facility Applications* with NQA-1a-2009 *Addenda to Quality Assurance Requirements for Nuclear Facility Applications* software requirements, as well as the requirements specified under DOE O 414.1D, *Quality Assurance* for Safety Software. The applicable software quality assurance documents are:

- CHPRC-00175, "*GoldSim Pro Software Management Plan*"
- CHPRC-00180, "*GoldSim Pro Functional Requirements Document*"
- CHPRC-00224, "*GoldSim Pro Software Test Plan*"

- CHPRC-00256, "*GoldSim Pro Requirements Traceability Matrix Version 12.0*"
- CHPRC-00262, "*GoldSim Pro Acceptance Test Report Version 12.0*."

5.1.2 Software Installation and Checkout

The software installation and checkout form for GoldSim© is provided in Appendix A to this EMCF.

5.1.3 Statement of Valid Software Application

GoldSim© Pro is a valid software application and was applied in this EMCF within its range of intended uses for which it was tested and approved. GoldSim© Pro was utilized for DOE for the Hanford Site to assist in performing simulation of radioactive mass conservation including decay and ingrowth.

In this EMCF, GoldSim© Pro is used to simulate decay and ingrowth of radionuclides from certain past dates to a common future date.

5.2 DECAY SPREADSHEET

Backward decay calculation in this EMCF is performed using Decay Spreadsheet. This is a tool to determine the initial state of decaying inventory by applying decay and regrow calculations in Excel®. The tool is approved for use by CHPRC at the Hanford Site in accordance with the requirements of RPP-PLAN-61415.

5.2.1 Descriptions

Decay Spreadsheet was created using Microsoft Excel® 2013 software and performs forward and backward radionuclide decay calculations for use in risk and performance assessment modeling. The spreadsheet consists of user input cells for start and end decay dates and initial activities for radionuclides included in RPP-19822, "*Hanford Defined Waste Model – Revision 5.0*." The spreadsheet uses standard half-lives from the GoldSim© library that are based on ICRP 2008 and includes calculation formulas to obtain the same radionuclide decay results as those obtained from GoldSim©.

5.2.2 Software Installation and Checkout

Decay Spreadsheet can be run on any platforms with Microsoft Excel® 2013 and later versions installed. No Software Installation and Checkout form is required.

5.2.3 Statement of Valid Software Application

Decay Spreadsheet is a valid software application and was applied in this EMCF within its range of intended uses for which it was tested and approved. In this EMCF, Decay Spreadsheet is used to simulate decay and ingrowth of radionuclides from a common future date (January 1, 2062) to the assumed closure date (January 1, 2050).

6 CALCULATION

6.1 DESCRIPTION OF OUTPUT

Output of this EMCF calculation is a series of data matrices. The row index of these matrices is contaminant names. The column index is tank or ancillary names.

6.2 CHEMICAL IN THE TANK RESIDUAL WASTES

Chemical inventories in WMA A-AX tank residual wastes are calculated in "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" worksheet "BBI Best_Est" using the steps provided in Section 3.3.1. These calculations are performed using the spreadsheet and kept in the same Excel® file as the original data for traceability.

6.3 CHEMICALS IN THE ANCILLARY EQUIPMENT RESIDUAL WASTES

The chemical inventories in WMA A-AX ancillary residual wastes are calculated in "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" worksheet "Anx Inventory_HTWOS" using the steps provided in Section 3.3.2. These calculations are performed using the spreadsheet and kept in the same spreadsheet file as the original data for traceability.

6.4 RADIONUCLIDES IN THE TANK RESIDUAL WASTES

Radionuclides contained in the WMA A-AX list in RPP-RPT-58293 include members of the decay chains shown in Figure 6-2. The following radionuclides are added to the list and their initial activities are estimated as follows, in which half-lives and stoichiometric numbers are based on ICRP 2008.

<u>Americium-242m</u>: RPP-RPT-58293 list contains ^{242}Cm that is a decay product of ^{242m}Am but has shorter half-life (163 days) than ^{242m}Am (141 years). For this reason, RPP-RPT-58293 assumes that ^{242}Cm has a half-life equal to ^{242m}Am's half-life. However, in the GoldSim© model, species half-lives cannot be modified if, like all other radionuclides, the default GoldSim© database is used. For this reason, ^{242m}Am is added. The initial activities of ^{242m}Am are calculated using ^{242}Cm's activities and stoichiometric number (0.82328 as shown in Figure 6-2) with the assumption of secular equilibrium:

$$A_{\mathrm{Am242m}} = A_{\mathrm{Cm242}}/0.82328 \tag{6-1}$$

where A is activity in Ci.

<u>Thorium-230</u>: This radionuclide is potentially important to ^{226}Ra and ^{222}Rn. To estimate ^{230}Th's initial activities, it is assumed that (a) its activities at 2008 or 2015 are determined by ^{234}U at

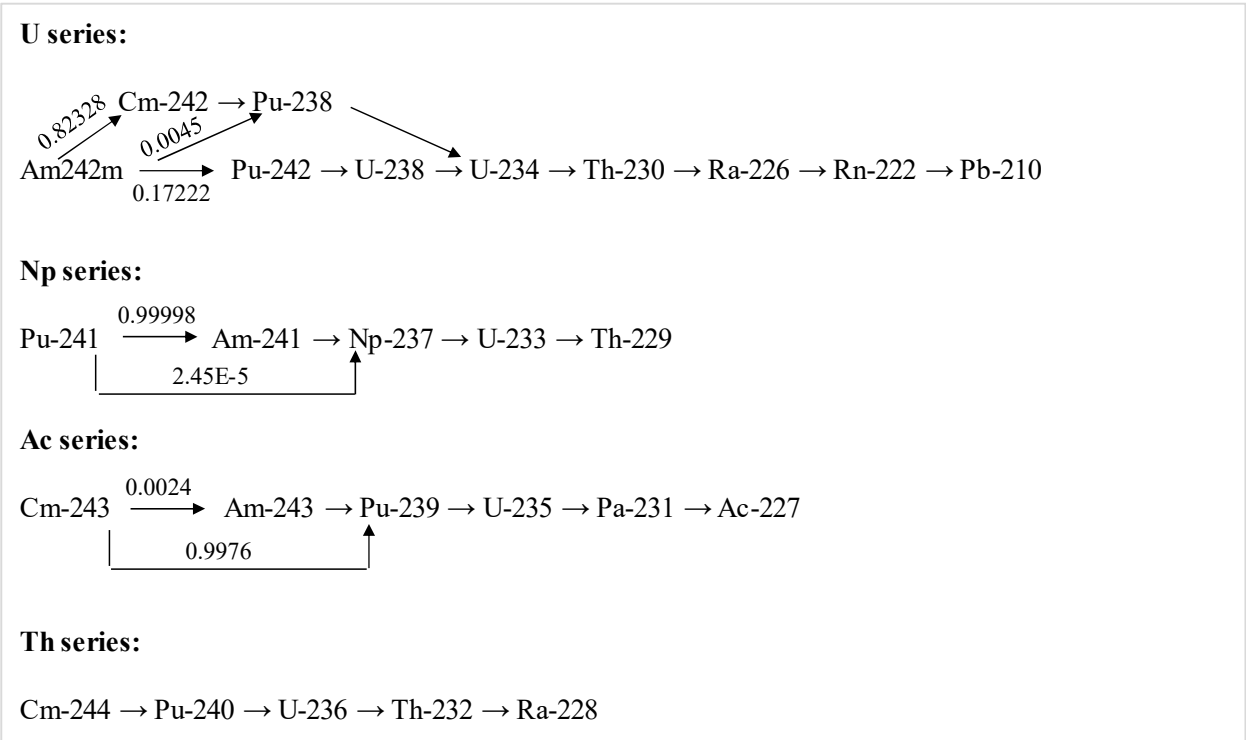
1978 and (b) ^{234}U's activities at 1978 are equal to those at 2008 or 2015 due to its long half-life. ^{230}Th's activity is calculated using Equation 3-4 and repeated below:

$$A_2 = \frac{\lambda_2 A_1^0}{\lambda_2 - \lambda_1}\left(e^{-\lambda_1 \Delta t} - e^{-\lambda_2 \Delta t}\right) + A_2^0 e^{-\lambda_2 \Delta t} \tag{6-2}$$

where the subscript "1" represents ^{234}U and "2" represents ^{230}Th, the superscript "0" represents activities at 1978, λ is decay constant (1/day), and Δt (days) is decay time from January 1, 1978 to January 1, 2008 or to July 1, 2015, respectively. ^{230}Th's activities at 1978 are assumed to be 0 Ci.

The assumption (a) above neglects buildup of ^{230}Th from ^{238}U and ^{238}Pu and other parent radionuclides. In this case, however, comparing with calculation using complete Bateman equations as shown in Equation 3-4, no significant differences were found and the assumption (a) is deemed reasonable.

Figure 6-1. Decay Chains with some Member Radionuclides in the Waste Management Area A-AX Residual waste Inventory List.



Note: Stoichiometric numbers for branches are based on "ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations" (ICRP 2008).

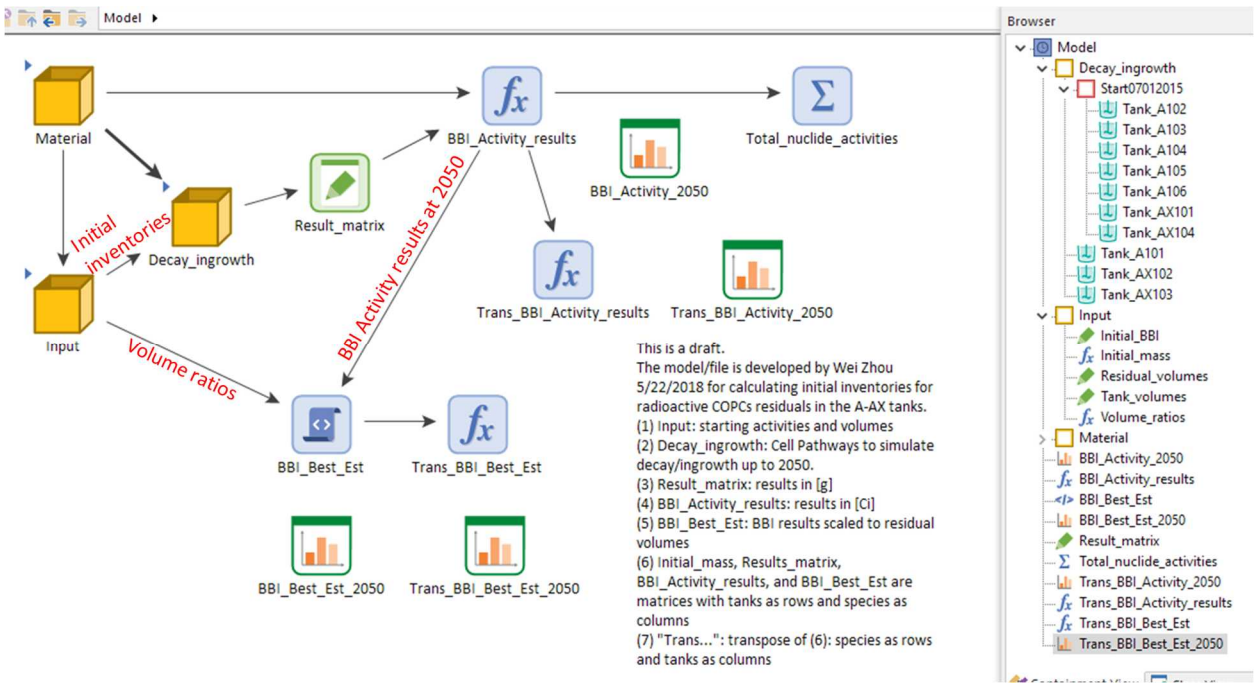
Radon-222: Initial activities of ^{222}Rn equal to ^{226}Ra's activities due to extremely short half-life of ^{222}Rn such that the two radionuclides are in secular equilibrium.

Lead-210: Initial activities are assumed to be 0 Ci in all tanks.

The calculated ^{242m}Am and ^{230}Th in each tank are shown in Table 4-3.

The radionuclide inventories in WMA A-AX tank residual wastes are calculated using the steps provided in Section 3.3.3 and implemented in GoldSim© model "AAX_initial_inventory.gsm". Figure 6-2 shows the model root directory of the model. The components are explained as follows.

Figure 6-2. Illustration of GoldSim© Model Components for Calculating Activities of Waste Management Area A-AX Tank Residuals at Closure (Calendar Year 2050).



a. Input container contains all user input needed in the calculation including initial (2008 and 2015, respectively) activities in the tanks ($A_{s,t}$ is a matrix [Ci] with species "*s*" as rows and tanks "*t*" as columns). The initial activity matrix is transposed (superscript "*T*" in the following equation) in order to convert activity to mass (g) because the specific activity γ_s (Ci/g) is a vector:

$$M_{t,s} = \frac{A_{s,t}^{T}}{\gamma_s} \tag{6-3}$$

where specific activity data are based on ICRP 2008 built in GoldSim©.

b. Users also need to input volumes of the tanks and residual wastes. The volume ratio vector is calculated using the tank and residual volume vectors:

$$r_t = \frac{RV_t}{TV_t} \tag{6-4}$$

where RV_t is the residual volume (kL) vector and TV_t (kL) is the tank volume vector. The numerical values are given in Table 4-5.

c. Decay_ingrowth container contains Cell Pathway elements for each tank. Initial activities in tanks A-102 through A-106, AX-101, and AX-104 are further conditionally contained in Start07012015 that is activated at July 1, 2015 or the elapsed simulation time of 2,738 days. The Result_matrix captures the masses for species (columns) in the tank (rows) cells that are then converted to activities written in BBI_Activity_results.

d. A simple script BBI_Best_Est converts BBI_Activity_results into activities in the residual wastes using the volume ratio vectors.

e. The BBI and the residual activities are transposed to matrices with species as rows and tanks as columns.

f. BBI_Activity_2050, Trans_BBI_Activity_2050, BBI_Best_Est_2050, and Trans_BBI_Best_Est_2050 are array result displays.

6.5 RADIONUCLIDES IN THE ANCILLARY EQUIPMENT

The data given for ancillary equipment residual inventory calculation comes from HTWOS (RPP-RPT-58293) calculation, where the inventories are reported at CY 2062. This requires backward decay calculation of CY 2062 inventories to the assumed closure date of CY 2050 for the PA. The HTWOS calculation adopted SVF-1259, Rev. 0, "EZDK_generic_FY 2007.xls" spreadsheet approach (RPP-17152, "*Hanford Tank Waste Operations Simulator (HTWOS) Version 8.1 Model Design Document*," Rev. 12) that is based on the following assumptions:

(a) All decay products are treated as second order decay; the approach does not track buildup of decay products from higher parent radionuclides.

(b) For actinide decay chains longer than three members as shown in Figure 6-2, only the following chain segment relevant to WMA A-AX is included:

Pu-241 → Am-241 → Np-237

(c) All radionuclides (except ^3H) have atomic masses equal to their mass numbers.

The assumption (a) may underestimate decay products by neglecting contributions from higher parent radionuclides. Taking an example of calculating moles of the third member in a decay chain, the Bateman equation for this member is:

$$N_3^e = \lambda_1\lambda_2 N_1^0 \left[\frac{e^{-\lambda_1 t_e}}{(\lambda_2-\lambda_1)(\lambda_3-\lambda_1)} + \frac{e^{-\lambda_2 t_e}}{(\lambda_1-\lambda_2)(\lambda_3-\lambda_2)} + \frac{e^{-\lambda_3 t_e}}{(\lambda_1-\lambda_3)(\lambda_2-\lambda_3)}\right] + \frac{\lambda_2 N_2^0}{\lambda_3-\lambda_2}\left(e^{-\lambda_2 t_e} - e^{-\lambda_3 t_e}\right) + N_3^0 e^{-\lambda_3 t_e} \quad (6\text{-}5)$$

where the subscript "*e*" represents "final" status and superscript "0" represents "initial" status and t_e is the decay time. In this equation, the second and the last terms are for the second order

decay. The first term is the contribution from the first member in the chain that was neglected by the EZDK approach in calculating HTWOS. This approximation may be problematic for certain radionuclides near the end of a decay chain, depending on the decay time, the radionuclide position (in this example, the position is 3) in the chain, half-lives and initial inventories of all radionuclides. If calculation is performed incrementally (i.e., many small time steps instead of the total decay time t_e), however, the second-order decay assumption will be more accurate.

Using HTWOS inventories at 2062, the ancillary residual inventories are calculated by decaying back to 2050. This is performed using the previously-qualified "Decay Spreadsheet." The calculation is performed in the spreadsheet "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" in the worksheet "HTWOS download." In this worksheet, A100:L146 is the 2062 HTWOS inventory that is the same as displayed in Table 4-4.

Before calculation of 2050 inventories, ^{242m}Am, ^{210}Pb, ^{222}Rn, and ^{230}Th are added. The ^{242m}Am activities at 2062 and 2050 are calculated in the same way as Equation 6-1. ^{222}Rn is assumed to be in secular equilibrium with ^{226}Ra at both 2062 and 2050. For all others, 0 Ci is assumed for their activities at 2062 and 2050. The added radionuclides and their activities are included in the output.

Calculations done using Decay Spreadsheet are expected to give results close to complete Bateman equation calculations for all radionuclides except for those radionuclides near the end of a chain such as ^{226}Ra. Some differences between the two methods are expected for these radionuclides because of second-order back-decay assumption adopted by Decay Spreadsheet. Nevertheless, the ^{226}Ra's activities variation with time throughout PA time frame and beyond are of the most concern. Further examining the impact of second-order back-decay on ^{226}Ra's forward decay indicates that the impact diminishes quickly as time increases, which means a negligible impact from second-order back-decay. In back-decay calculations, minor branches of decay chains shown in Figure 6-1 are neglected. If the back-decay activity results of a radionuclide are negative, 0 Ci are assumed for the radionuclide. All calculations reported in this section used radionuclide data (half-lives, stoichiometric numbers, atomic mass, etc.) based on ICRP 2008.

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7 RESULTS/CONCLUSIONS

7.1 RESULTS

The results are given in Table 7-1 through Table 7-4 for mass of chemicals in the residual wastes for tank (Table 7-1) and ancillary equipment (Table 7-2), as well as for radionuclide activities in the tank (Table 7-3) and ancillary equipment (Table 7-4). Note that the masses shown in Table 7-2 and the activities shown in Table 7-4 are for total ancillary equipment residual wastes in each tank farm. The residual waste inventories for individual ancillary equipment items are given in Table 7-5 through Table 7-8. The data source is also provided. Sources include Excel® filename, worksheet name, and data block defined by the beginning and ending cell numbers. Sources can also be GoldSim© model filename and output element name. The results are presented in this EMCF (Table 7-1 through Table 7-4) in 3 significant digits although both GoldSim© and the spreadsheet calculations retain full precision.

The spreadsheet format of the results is provided in
"A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" worksheet
"AAX_SystemModelInput".

The data can be imported or copied to the GoldSim© system model.

Table 7-1. Residual Inventory of Chemicals for Waste Management Area A-AX Tanks[a] (kg) at Closure[b] (Calendar Year 2050).

Chemicals	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Al	4.42E+02	5.36E+02	2.40E+02	7.08E+03	8.28E+03	3.81E+02	4.18E+02	2.14E+02	3.82E+02	9.68E+02
Cr	6.47E+01	1.13E+02	1.88E+01	1.58E+02	3.56E+02	7.21E+01	3.55E+01	9.20E+00	5.39E+01	1.06E+01
F	9.68E+00	3.72E+00	8.18E+00	1.92E+00	1.68E+01	3.88E+00	1.01E+01	5.34E+00	1.36E+01	1.85E+00
Fe	7.22E+00	3.22E+02	1.20E+01	2.59E+04	1.92E+04	6.83E+02	1.05E+01	5.77E+02	1.15E+02	4.97E+03
Hg	3.34E-02	6.88E-02	1.86E-02	3.20E+01	2.14E+01	6.72E+00	1.11E-01	6.85E-01	1.33E-01	3.01E+00
Mn	2.03E+00	6.32E+01	2.06E+00	3.63E+03	6.49E+02	3.30E+01	3.93E-01	4.71E+01	1.56E+01	8.61E+01
Ni	3.21E+00	9.43E+00	1.86E+00	1.68E+03	1.55E+03	2.63E+01	1.20E+00	1.34E+01	6.83E+00	2.67E+02
NO_2^-	1.31E+03	1.56E+03	1.13E+03	5.88E+03	3.73E+02	4.29E+02	1.38E+03	4.57E+02	1.36E+03	4.12E+01
NO_3^-	2.40E+03	1.73E+03	1.59E+03	3.02E+02	9.53E+03	1.16E+03	2.56E+03	2.33E+03	1.73E+03	8.38E+02
Pb	3.22E+00	2.22E+01	2.22E+00	5.65E+01	1.54E+03	3.17E+01	1.47E+00	4.00E+01	9.81E+00	1.70E+02
Sr	1.80E-01	9.29E-01	9.15E-02	4.21E+01	5.34E+01	3.01E+00	3.21E-02	1.05E+01	1.16E+00	1.75E+01

[a] From "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" worksheet "BBI Best_Est" Q6:Z16.

[b] Based on current/pre-retrieval Best-Basis Inventory concentrations.

Table 7-2. Residual Inventory of Chemicals for Waste Management Area A-AX Ancillary Equipment (kg) at Closure (Calendar Year 2050).

Chemicals	241-A Tank Farm Ancillary	241-AX Tank Farm Ancillary
Al	3.11E+03	1.11E+03
Cr	4.17E+02	1.25E+02
F	1.74E-04	9.26E-05
Fe	2.20E+03	1.13E+03
Hg	7.47E-05	3.77E-06
Mn	2.36E+02	5.20E+01
Ni	1.64E+02	5.47E+01
NO_2^-	4.08E-02	9.27E-03
NO_3^-	5.04E-02	1.85E-02
Pb	4.26E-04	2.02E-04
Sr	4.08E+00	5.50E+00

Source: From "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" worksheet "Anx Inventory_HTWOS" Z7:AA17.

Table 7-3. Residual Inventory of Radionuclides for Waste Management Area A-AX Tanks[a] (Ci) at Closure[b] (Calendar Year 2050). (3 sheets)

Name	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Ac227	6.42E-04	6.17E-04	4.68E-04	2.68E-05	1.46E-05	1.60E-04	5.92E-04	4.39E-04	4.68E-04	2.30E-06
Am241	3.50E+00	2.41E+01	2.67E+00	6.82E+02	2.95E+03	4.91E+01	2.82E+00	1.82E+02	1.72E+01	3.26E+02
Am242m	3.27E-03	2.07E-02	2.38E-03	4.54E-01	2.69E+00	1.54E-01	2.43E-03	2.81E-01	1.59E-02	2.96E-01
Am243	2.08E-03	1.38E-02	1.56E-03	3.57E-01	1.67E+00	1.15E-01	1.83E-03	1.76E-01	9.83E-03	1.83E-01
Ba137m	9.76E+02	9.63E+02	6.48E+02	1.78E+04	3.52E+04	9.97E+02	1.08E+03	7.27E+02	9.55E+02	5.93E+03
C14	6.43E-02	1.72E-02	3.18E-02	3.24E-01	2.75E-01	1.39E-02	5.71E-02	5.96E-03	4.35E-02	3.87E-02
Cd113m	7.87E-02	6.71E-02	5.06E-02	2.18E-01	3.12E-01	3.22E-02	7.08E-02	6.08E-02	5.55E-02	4.39E-02
Cm242	2.70E-03	1.71E-02	1.97E-03	3.75E-01	2.22E+00	1.28E-01	2.00E-03	2.32E-01	1.31E-02	2.44E-01
Cm243	5.68E-05	3.14E-04	3.84E-05	7.21E-03	5.28E-02	3.68E-03	5.52E-05	9.39E-03	3.06E-04	5.78E-03
Cm244	6.63E-04	3.72E-03	4.49E-04	8.40E-02	6.06E-01	4.37E-02	6.59E-04	1.13E-01	3.54E-03	6.66E-02
Co60	9.94E-04	3.91E-03	4.17E-04	2.75E-01	4.03E-01	7.04E-03	7.65E-04	2.16E-02	4.20E-03	1.27E-01
Cs134	3.38E-10	3.81E-10	2.41E-10	3.23E-08	3.08E-08	8.50E-10	2.95E-10	2.27E-10	3.80E-10	4.35E-09
Cs137	1.03E+03	1.02E+03	6.87E+02	1.89E+04	3.73E+04	1.06E+03	1.14E+03	7.70E+02	1.01E+03	6.28E+03
Eu152	7.42E-03	8.34E-03	4.00E-03	7.71E-01	6.63E+00	2.39E-01	4.31E-03	1.80E-01	3.92E-02	9.33E-01
Eu154	1.38E-01	1.56E-01	7.46E-02	2.78E+01	7.05E+01	4.39E+00	7.71E-02	1.71E+00	1.19E+00	7.81E+00
Eu155	3.02E-03	3.45E-03	1.61E-03	3.10E-01	5.97E-01	9.54E-02	1.53E-03	3.77E-02	1.68E-02	1.99E-01
H3	1.45E-02	1.14E-02	8.52E-03	1.13E-01	6.96E-02	8.63E-03	1.29E-02	1.26E-02	9.86E-03	9.84E-03
I129	2.29E-03	1.34E-03	3.35E-04	6.36E-03	9.47E-04	1.33E-03	2.12E-03	1.52E-03	1.71E-03	1.34E-04
Nb93m	3.80E-01	3.70E-01	2.77E-01	2.25E+00	2.87E+00	1.90E-01	3.49E-01	2.72E-01	2.92E-01	4.04E-01
Ni59	1.39E-01	1.22E-01	8.18E-02	8.62E+00	7.20E+00	2.60E-01	1.18E-01	1.54E-01	1.28E-01	1.01E+00
Ni63	9.41E+00	8.30E+00	5.57E+00	5.83E+02	4.93E+02	1.76E+01	8.03E+00	1.05E+01	8.72E+00	6.96E+01

Table 7-3. Residual Inventory of Radionuclides for Waste Management Area A-AX Tanks[a] (Ci) at Closure[b] (Calendar Year 2050). (3 sheets)

Name	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
Np237	1.33E-02	1.05E-02	7.79E-03	5.82E-02	7.62E-02	6.12E-03	1.17E-02	2.70E-02	1.46E-03	9.73E-03
Pa231	8.11E-04	7.81E-04	5.91E-04	3.89E-05	1.57E-05	2.02E-04	7.49E-04	5.55E-04	5.92E-04	2.85E-06
Pb210	5.33E-07	8.69E-07	3.39E-07	2.46E-06	1.45E-06	1.88E-07	4.36E-07	4.39E-07	3.83E-07	2.58E-07
Pu238	2.52E-02	6.49E-01	4.70E-02	1.39E+01	1.88E+01	1.57E+00	2.59E-02	9.60E-01	8.03E-02	3.27E+00
Pu239	7.85E-01	2.22E+01	1.58E+00	5.96E+02	5.56E+02	5.30E+01	8.84E-01	1.37E+01	2.34E+00	9.79E+01
Pu240	1.88E-01	5.16E+00	3.69E-01	1.31E+02	1.36E+02	1.23E+01	2.04E-01	4.38E+00	5.89E-01	2.39E+01
Pu241	1.58E-01	4.38E+00	3.13E-01	7.93E+01	1.14E+02	9.80E+00	1.66E-01	7.06E+00	4.79E-01	2.01E+01
Pu242	1.39E-05	3.87E-04	2.76E-05	6.55E-03	9.91E-03	8.53E-04	1.45E-05	6.76E-04	4.17E-05	1.75E-03
Ra226	7.42E-07	1.89E-06	5.33E-07	5.49E-06	2.19E-06	3.05E-07	6.71E-07	6.69E-07	5.32E-07	4.61E-07
Ra228	1.08E-06	1.03E-06	7.83E-07	1.63E-06	1.90E-11	2.90E-07	9.94E-07	1.07E-04	3.09E-06	3.37E-12
Rn222	7.42E-07	1.89E-06	5.33E-07	5.49E-06	2.19E-06	3.05E-07	6.71E-07	6.69E-07	5.32E-07	4.61E-07
Ru106	3.24E-18	2.29E-17	2.28E-18	3.30E-16	3.30E-16	1.23E-17	2.78E-18	2.98E-17	8.34E-18	1.87E-16
Sb125	3.80E-07	9.51E-07	2.54E-07	3.32E-04	2.80E-04	1.96E-05	3.73E-07	3.23E-04	5.79E-06	8.30E-05
Se79	1.46E-02	1.36E-02	1.03E-02	8.89E-02	1.13E-01	6.80E-03	1.33E-02	3.20E-03	1.11E-02	1.60E-02
Sm151	1.31E+02	2.18E+02	7.76E+01	2.70E+04	5.60E+04	6.30E+03	1.62E+02	2.41E+03	3.77E+02	7.90E+03
Sn126	3.73E-02	4.44E-02	3.34E-02	1.79E-01	2.29E-01	1.50E-02	3.56E-02	9.74E-02	3.19E-02	3.22E-02
Sr90	3.93E+02	1.73E+03	3.17E+02	6.67E+05	9.54E+05	2.91E+04	5.47E+02	6.86E+03	3.72E+03	2.47E+05
Tc99	2.25E+00	2.51E+00	1.82E+00	1.24E+01	1.58E+01	3.27E+00	2.09E+00	5.68E-01	1.78E+00	7.48E+00
Th229	1.03E-04	3.11E-03	1.19E-04	6.32E-04	2.70E-08	2.78E-05	4.77E-05	3.82E-04	9.38E-06	1.31E-08
Th230	3.09E-06	1.11E-04	4.28E-06	3.38E-04	9.21E-07	3.96E-06	2.70E-06	1.22E-05	1.74E-06	1.37E-05
Th232	1.08E-06	1.03E-06	7.83E-07	1.63E-06	1.91E-11	2.90E-07	9.94E-07	1.07E-04	3.09E-06	3.59E-12

Table 7-3. Residual Inventory of Radionuclides for Waste Management Area A-AX Tanks[a] (Ci) at Closure[b] (Calendar Year 2050). (3 sheets)

Name	241-A-101	241-A-102	241-A-103	241-A-104	241-A-105	241-A-106	241-AX-101	241-AX-102	241-AX-103	241-AX-104
U232	2.62E-04	9.70E-03	3.72E-04	1.94E-03	4.19E-08	8.68E-05	1.49E-04	9.82E-04	1.71E-04	9.81E-07
U233	2.59E-02	9.57E-01	3.65E-02	1.94E-01	9.05E-06	8.51E-03	1.46E-02	9.65E-02	2.31E-03	4.09E-06
U234	4.67E-03	1.67E-01	6.47E-03	5.12E-01	2.95E-03	6.11E-03	4.08E-03	1.84E-02	2.64E-03	2.09E-02
U235	1.90E-04	6.78E-03	2.62E-04	2.15E-02	5.56E-05	2.49E-04	1.68E-04	7.45E-04	6.97E-05	8.64E-04
U236	1.22E-04	4.40E-03	1.70E-04	1.23E-02	1.61E-04	1.66E-04	1.07E-04	5.17E-04	9.36E-05	5.53E-04
U238	4.20E-03	1.51E-01	5.81E-03	5.07E-01	8.57E-04	5.71E-03	3.77E-03	1.62E-02	1.63E-03	2.01E-02
Y90	3.94E+02	1.73E+03	3.17E+02	6.67E+05	9.54E+05	2.91E+04	5.47E+02	6.86E+03	3.72E+03	2.47E+05
Zr93	3.98E-01	3.86E-01	2.89E-01	2.35E+00	3.00E+00	1.99E-01	3.65E-01	2.85E-01	3.06E-01	4.23E-01

[a] From "AAX_initial_inventory.gsm" array output table "Trans_BBI_Best_Est_2050".
[b] Based on current/pre-retrieval Best-Basis Inventory concentrations.

Table 7-4. Residual Inventory of Radionuclides for Waste Management Area A-AX Ancillary Equipment* (Ci) at Closure. (2 sheets)

Name	241-A Tank Farm Ancillary Equipment	241-AX Tank Farm Ancillary Equipment
Ac227	3.68E-03	1.45E-03
Am241	2.04E+02	1.60E+02
Am242m	7.59E-07	6.37E-07
Am243	1.14E-01	1.28E-01
Ba137m	3.66E-02	1.16E-02
C14	1.21E-06	4.00E-07
Cd113m	3.51E-01	1.02E-01
Cm242	6.25E-07	5.25E-07
Cm243	1.28E-08	1.78E-08
Cm244	1.50E-07	2.12E-07
Co60	3.81E-02	3.47E-02
Cs134	3.53E-14	5.53E-15
Cs137	3.88E-02	1.23E-02
Eu152	5.12E-01	2.71E-01
Eu154	6.22E+00	3.26E+00
Eu155	9.44E-02	6.53E-02
H3	4.00E-07	1.06E-07
I129	1.20E-04	1.56E-08
Nb93m	3.02E+00	1.14E+00
Ni59	1.72E+00	5.65E-01
Ni63	1.17E+02	3.85E+01
Np237	8.32E-02	3.51E-02
Pa231	5.57E-03	2.19E-03
Pb210	0.00E+00	0.00E+00
Pu238	2.61E+00	1.01E+00
Pu239	9.49E+01	2.44E+01
Pu240	2.17E+01	6.48E+00
Pu241	1.68E+01	7.18E+00
Pu242	1.44E-03	6.47E-04
Ra226	1.62E-11	5.00E-12

Table 7-4. Residual Inventory of Radionuclides for Waste Management Area A-AX Ancillary Equipment* (Ci) at Closure. (2 sheets)

Name	241-A Tank Farm Ancillary Equipment	241-AX Tank Farm Ancillary Equipment
Ra228	7.37E-06	5.77E-05
Rn222	1.62E-11	5.00E-12
Ru106	4.87E-24	3.57E-24
Sb125	3.26E-10	5.12E-10
Se79	4.01E-07	1.01E-07
Sm151	9.87E+03	2.99E+03
Sn126	1.07E-06	3.84E-07
Sr90	5.72E+04	4.21E+04
Tc99	8.36E-05	1.94E-05
Th229	0.00E+00	0.00E+00
Th230	0.00E+00	0.00E+00
Th232	7.50E-06	5.87E-05
U232	1.30E-02	9.75E-04
U233	1.27E+00	8.14E-02
U234	2.43E-01	2.24E-02
U235	9.90E-03	8.81E-04
U236	6.33E-03	6.23E-04
U238	2.21E-01	1.97E-02
Y90	5.72E+04	4.21E+04
Zr93	3.04E+00	1.15E+00

*From “A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx” worksheet “Anx Inventory_HTWOS” AA35:AB84.

Table 7-5. Residual Inventory of Chemicals for 241-A Tank Farm Ancillary Equipment* (kg) at Closure (Calendar Year 2050).

Chemicals	241-A-350	241-A-417	241-A-302A	241-A-302B	204-AR	244-A	244-AR	Diversion Boxes/Pits	Pipelines	Total
Al	1.34E+01	1.34E+02	7.44E+01	7.44E+02	8.66E+01	6.34E+02	3.49E+02	1.26E+01	1.06E+03	3.11E+03
Cr	1.80E+00	1.80E+01	9.98E+00	9.98E+01	1.16E+01	8.51E+01	4.68E+01	1.69E+00	1.43E+02	4.17E+02
F	7.50E-07	7.50E-06	4.16E-06	4.16E-05	4.84E-06	3.54E-05	1.95E-05	7.02E-07	5.94E-05	1.74E-04
Fe	9.50E+00	9.50E+01	5.27E+01	5.27E+02	6.13E+01	4.49E+02	2.47E+02	8.90E+00	7.53E+02	2.20E+03
Hg	3.22E-07	3.22E-06	1.79E-06	1.79E-05	2.08E-06	1.52E-05	8.38E-06	3.02E-07	2.55E-05	7.47E-05
Mn	1.02E+00	1.02E+01	5.63E+00	5.63E+01	6.55E+00	4.80E+01	2.64E+01	9.51E-01	8.05E+01	2.36E+02
Ni	7.09E-01	7.09E+00	3.93E+00	3.93E+01	4.57E+00	3.35E+01	1.84E+01	6.64E-01	5.62E+01	1.64E+02
NO_2^-	1.76E-04	1.76E-03	9.74E-04	9.74E-03	1.13E-03	8.31E-03	4.57E-03	1.65E-04	1.39E-02	4.08E-02
NO_3^-	2.17E-04	2.17E-03	1.20E-03	1.20E-02	1.40E-03	1.03E-02	5.65E-03	2.03E-04	1.72E-02	5.04E-02
Pb	1.84E-06	1.84E-05	1.02E-05	1.02E-04	1.19E-05	8.69E-05	4.78E-05	1.72E-06	1.46E-04	4.26E-04
Sr	1.76E-02	1.76E-01	9.76E-02	9.76E-01	1.14E-01	8.32E-01	4.58E-01	1.65E-02	1.39E+00	4.08E+00

*From "A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx" worksheet "Anx Inventory_HTWOS" A7:N31.

Table 7-6. Residual Inventory of Chemicals for 241-AX Tank Farm Ancillary Equipment* (kg) at Closure (Calendar Year 2050).

Chemicals	241-AX-151	241-AX-152	241-AX-152/DS	Diversion Boxes/Pits	Pipelines	Total
Al	2.86E+02	1.03E+01	2.05E+01	7.84E+00	7.84E+02	1.11E+03
Cr	3.22E+01	1.15E+00	2.30E+00	8.81E-01	8.81E+01	1.25E+02
F	2.39E-05	8.58E-07	1.71E-06	6.55E-07	6.55E-05	9.26E-05
Fe	2.93E+02	1.05E+01	2.09E+01	8.02E+00	8.02E+02	1.13E+03
Hg	9.75E-07	3.49E-08	6.96E-08	2.67E-08	2.67E-06	3.77E-06
Mn	1.34E+01	4.81E-01	9.59E-01	3.67E-01	3.67E+01	5.20E+01
Ni	1.41E+01	5.06E-01	1.01E+00	3.86E-01	3.86E+01	5.47E+01
NO_2^-	2.40E-03	8.59E-05	1.71E-04	6.55E-05	6.55E-03	9.27E-03
NO_3^-	4.78E-03	1.71E-04	3.42E-04	1.31E-04	1.31E-02	1.85E-02
Pb	5.23E-05	1.87E-06	3.73E-06	1.43E-06	1.43E-04	2.02E-04
Sr	1.42E+00	5.09E-02	1.01E-01	3.89E-02	3.89E+00	5.50E+00

*From “A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx” worksheet “Anx Inventory_HTWOS” Q7:W31.

Table 7-7. Residual Inventory of Radionuclides for 241-A Tank Farm Ancillary Equipment* (Ci) at Closure (Calendar Year 2050). (3 sheets)

Name	241-A-350	241-A-417	241-A-302A	241-A-302B	204-AR	244-A	244-AR	Diversion Boxes/Pits	Pipelines	Total
Ac227	1.59E-05	1.59E-04	8.81E-05	8.81E-04	1.03E-04	7.51E-04	4.13E-04	1.49E-05	1.26E-03	3.68E-03
Am241	8.79E-01	8.79E+00	4.87E+00	4.87E+01	5.67E+00	4.15E+01	2.28E+01	8.23E-01	6.96E+01	2.04E+02
Am242m	3.27E-09	3.27E-08	1.81E-08	1.81E-07	2.11E-08	1.55E-07	8.51E-08	3.07E-09	2.59E-07	7.59E-07
Am243	4.93E-04	4.93E-03	2.74E-03	2.74E-02	3.18E-03	2.33E-02	1.28E-02	4.62E-04	3.91E-02	1.14E-01
Ba137m	1.58E-04	1.58E-03	8.76E-04	8.76E-03	1.02E-03	7.46E-03	4.11E-03	1.48E-04	1.25E-02	3.66E-02
C14	5.22E-09	5.22E-08	2.90E-08	2.90E-07	3.37E-08	2.47E-07	1.36E-07	4.89E-09	4.14E-07	1.21E-06
Cd113m	1.51E-03	1.51E-02	8.40E-03	8.40E-02	9.78E-03	7.16E-02	3.94E-02	1.42E-03	1.20E-01	3.51E-01
Cm242	2.69E-09	2.69E-08	1.49E-08	1.49E-07	1.74E-08	1.27E-07	7.01E-08	2.52E-09	2.14E-07	6.25E-07
Cm243	5.53E-11	5.53E-10	3.07E-10	3.07E-09	3.57E-10	2.62E-09	1.44E-09	5.18E-11	4.39E-09	1.28E-08
Cm244	6.47E-10	6.47E-09	3.59E-09	3.59E-08	4.18E-09	3.06E-08	1.68E-08	6.06E-10	5.13E-08	1.50E-07
Co60	1.64E-04	1.64E-03	9.12E-04	9.12E-03	1.06E-03	7.77E-03	4.27E-03	1.54E-04	1.30E-02	3.81E-02
Cs134	1.52E-16	1.52E-15	8.45E-16	8.45E-15	9.84E-16	7.20E-15	3.96E-15	1.43E-16	1.21E-14	3.53E-14
Cs137	1.67E-04	1.67E-03	9.28E-04	9.28E-03	1.08E-03	7.91E-03	4.35E-03	1.57E-04	1.33E-02	3.88E-02
Eu152	2.21E-03	2.21E-02	1.22E-02	1.22E-01	1.43E-02	1.04E-01	5.74E-02	2.07E-03	1.75E-01	5.12E-01
Eu154	2.68E-02	2.68E-01	1.49E-01	1.49E+00	1.73E-01	1.27E+00	6.97E-01	2.51E-02	2.13E+00	6.22E+00
Eu155	4.07E-04	4.07E-03	2.26E-03	2.26E-02	2.63E-03	1.92E-02	1.06E-02	3.81E-04	3.22E-02	9.44E-02
H3	1.72E-09	1.72E-08	9.56E-09	9.56E-08	1.11E-08	8.15E-08	4.48E-08	1.61E-09	1.37E-07	4.00E-07
I129	5.17E-07	5.17E-06	2.87E-06	2.87E-05	3.34E-06	2.44E-05	1.34E-05	4.84E-07	4.10E-05	1.20E-04
Nb93m	1.30E-02	1.30E-01	7.21E-02	7.21E-01	8.39E-02	6.15E-01	3.38E-01	1.22E-02	1.03E+00	3.02E+00
Ni59	7.44E-03	7.44E-02	4.12E-02	4.12E-01	4.80E-02	3.52E-01	1.93E-01	6.97E-03	5.89E-01	1.72E+00

Table 7-7. Residual Inventory of Radionuclides for 241-A Tank Farm Ancillary Equipment* (Ci) at Closure (Calendar Year 2050). (3 sheets)

Name	241-A-350	241-A-417	241-A-302A	241-A-302B	204-AR	244-A	244-AR	Diversion Boxes/Pits	Pipelines	Total
Ni63	5.05E-01	5.05E+00	2.80E+00	2.80E+01	3.26E+00	2.39E+01	1.31E+01	4.73E-01	4.00E+01	1.17E+02
Np237	3.59E-04	3.59E-03	1.99E-03	1.99E-02	2.32E-03	1.70E-02	9.33E-03	3.36E-04	2.84E-02	8.32E-02
Pa231	2.40E-05	2.40E-04	1.33E-04	1.33E-03	1.55E-04	1.13E-03	6.24E-04	2.25E-05	1.90E-03	5.57E-03
Pb210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu238	1.12E-02	1.12E-01	6.23E-02	6.23E-01	7.26E-02	5.31E-01	2.92E-01	1.05E-02	8.91E-01	2.61E+00
Pu239	4.09E-01	4.09E+00	2.27E+00	2.27E+01	2.64E+00	1.94E+01	1.06E+01	3.83E-01	3.24E+01	9.49E+01
Pu240	9.37E-02	9.37E-01	5.19E-01	5.19E+00	6.05E-01	4.43E+00	2.44E+00	8.78E-02	7.43E+00	2.17E+01
Pu241	7.25E-02	7.25E-01	4.02E-01	4.02E+00	4.68E-01	3.43E+00	1.89E+00	6.79E-02	5.75E+00	1.68E+01
Pu242	6.22E-06	6.22E-05	3.45E-05	3.45E-04	4.02E-05	2.94E-04	1.62E-04	5.83E-06	4.93E-04	1.44E-03
Ra226	6.97E-14	6.97E-13	3.87E-13	3.87E-12	4.50E-13	3.30E-12	1.81E-12	6.53E-14	5.53E-12	1.62E-11
Ra228	3.18E-08	3.18E-07	1.76E-07	1.76E-06	2.05E-07	1.50E-06	8.27E-07	2.98E-08	2.52E-06	7.37E-06
Rn222	6.97E-14	6.97E-13	3.87E-13	3.87E-12	4.50E-13	3.30E-12	1.81E-12	6.53E-14	5.53E-12	1.62E-11
Ru106	2.10E-26	2.10E-25	1.17E-25	1.17E-24	1.36E-25	9.93E-25	5.46E-25	1.97E-26	1.67E-24	4.87E-24
Sb125	1.40E-12	1.40E-11	7.79E-12	7.79E-11	9.06E-12	6.64E-11	3.65E-11	1.32E-12	1.11E-10	3.26E-10
Se79	1.73E-09	1.73E-08	9.58E-09	9.58E-08	1.12E-08	8.17E-08	4.49E-08	1.62E-09	1.37E-07	4.01E-07
Sm151	4.26E+01	4.26E+02	2.36E+02	2.36E+03	2.75E+02	2.01E+03	1.11E+03	3.99E+01	3.37E+03	9.87E+03
Sn126	4.63E-09	4.63E-08	2.57E-08	2.57E-07	2.99E-08	2.19E-07	1.20E-07	4.33E-09	3.67E-07	1.07E-06
Sr90	2.46E+02	2.46E+03	1.37E+03	1.37E+04	1.59E+03	1.16E+04	6.41E+03	2.31E+02	1.95E+04	5.72E+04
Tc99	3.60E-07	3.60E-06	2.00E-06	2.00E-05	2.33E-06	1.70E-05	9.37E-06	3.37E-07	2.86E-05	8.36E-05
Th229	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 7-7. Residual Inventory of Radionuclides for 241-A Tank Farm Ancillary Equipment* (Ci) at Closure (Calendar Year 2050). (3 sheets)

Name	241-A-350	241-A-417	241-A-302A	241-A-302B	204-AR	244-A	244-AR	Diversion Boxes/Pits	Pipelines	Total
Th230	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th232	3.23E-08	3.23E-07	1.79E-07	1.79E-06	2.09E-07	1.53E-06	8.41E-07	3.03E-08	2.56E-06	7.50E-06
U232	5.59E-05	5.59E-04	3.10E-04	3.10E-03	3.61E-04	2.64E-03	1.45E-03	5.24E-05	4.43E-03	1.30E-02
U233	5.46E-03	5.46E-02	3.03E-02	3.03E-01	3.52E-02	2.58E-01	1.42E-01	5.12E-03	4.33E-01	1.27E+00
U234	1.05E-03	1.05E-02	5.82E-03	5.82E-02	6.77E-03	4.96E-02	2.73E-02	9.82E-04	8.31E-02	2.43E-01
U235	4.27E-05	4.27E-04	2.37E-04	2.37E-03	2.76E-04	2.02E-03	1.11E-03	4.00E-05	3.38E-03	9.90E-03
U236	2.73E-05	2.73E-04	1.51E-04	1.51E-03	1.76E-04	1.29E-03	7.09E-04	2.55E-05	2.16E-03	6.33E-03
U238	9.52E-04	9.52E-03	5.28E-03	5.28E-02	6.14E-03	4.50E-02	2.47E-02	8.91E-04	7.54E-02	2.21E-01
Y90	2.46E+02	2.46E+03	1.37E+03	1.37E+04	1.59E+03	1.16E+04	6.41E+03	2.31E+02	1.95E+04	5.72E+04
Zr93	1.31E-02	1.31E-01	7.26E-02	7.26E-01	8.45E-02	6.19E-01	3.40E-01	1.23E-02	1.04E+00	3.04E+00

*From “A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx” worksheet “Anx Inventory_HTWOS” D35:N84.

Table 7-8. Residual Inventory of Radionuclides for 241-AX Tank Farm Ancillary Equipment* (Ci) at Closure (Calendar Year 2050). (2 sheets)

Name	241-AX-151	241-AX-152	241-AX-152/DS	Diversion Boxes/Pits	Pipelines	Total
Ac227	3.74E-04	1.34E-05	2.67E-05	1.02E-05	1.02E-03	1.45E-03
Am241	4.13E+01	1.48E+00	2.95E+00	1.13E+00	1.13E+02	1.60E+02
Am242m	1.65E-07	5.90E-09	1.18E-08	4.50E-09	4.50E-07	6.37E-07
Am243	3.30E-02	1.18E-03	2.35E-03	9.02E-04	9.02E-02	1.28E-01
Ba137m	2.99E-03	1.07E-04	2.14E-04	8.19E-05	8.19E-03	1.16E-02
C14	1.03E-07	3.70E-09	7.37E-09	2.82E-09	2.82E-07	4.00E-07
Cd113m	2.62E-02	9.41E-04	1.87E-03	7.18E-04	7.18E-02	1.02E-01
Cm242	1.36E-07	4.86E-09	9.68E-09	3.71E-09	3.71E-07	5.25E-07
Cm243	4.60E-09	1.65E-10	3.28E-10	1.26E-10	1.26E-08	1.78E-08
Cm244	5.47E-08	1.96E-09	3.91E-09	1.50E-09	1.50E-07	2.12E-07
Co60	8.96E-03	3.21E-04	6.40E-04	2.45E-04	2.45E-02	3.47E-02
Cs134	1.43E-15	5.13E-17	1.02E-16	3.91E-17	3.91E-15	5.53E-15
Cs137	3.17E-03	1.14E-04	2.26E-04	8.68E-05	8.68E-03	1.23E-02
Eu152	7.00E-02	2.51E-03	5.00E-03	1.91E-03	1.91E-01	2.71E-01
Eu154	8.43E-01	3.02E-02	6.02E-02	2.31E-02	2.31E+00	3.26E+00
Eu155	1.69E-02	6.05E-04	1.20E-03	4.61E-04	4.61E-02	6.53E-02
H3	2.75E-08	9.86E-10	1.96E-09	7.52E-10	7.52E-08	1.06E-07
I129	4.04E-09	1.45E-10	2.89E-10	1.11E-10	1.11E-08	1.56E-08
Nb93m	2.95E-01	1.06E-02	2.11E-02	8.08E-03	8.08E-01	1.14E+00
Ni59	1.46E-01	5.23E-03	1.04E-02	3.99E-03	3.99E-01	5.65E-01
Ni63	9.95E+00	3.57E-01	7.11E-01	2.72E-01	2.72E+01	3.85E+01
Np237	9.07E-03	3.25E-04	6.48E-04	2.48E-04	2.48E-02	3.51E-02
Pa231	5.65E-04	2.03E-05	4.04E-05	1.55E-05	1.55E-03	2.19E-03
Pb210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu238	2.61E-01	9.37E-03	1.87E-02	7.15E-03	7.15E-01	1.01E+00
Pu239	6.31E+00	2.26E-01	4.50E-01	1.72E-01	1.72E+01	2.44E+01
Pu240	1.67E+00	6.00E-02	1.19E-01	4.58E-02	4.58E+00	6.48E+00
Pu241	1.86E+00	6.65E-02	1.33E-01	5.08E-02	5.08E+00	7.18E+00
Pu242	1.67E-04	5.99E-06	1.19E-05	4.57E-06	4.57E-04	6.47E-04
Ra226	1.29E-12	4.63E-14	9.22E-14	3.53E-14	3.53E-12	5.00E-12

Table 7-8. Residual Inventory of Radionuclides for 241-AX Tank Farm Ancillary Equipment* (Ci) at Closure (Calendar Year 2050). (2 sheets)

Name	241-AX-151	241-AX-152	241-AX-152/DS	Diversion Boxes/Pits	Pipelines	Total
Ra228	1.49E-05	5.35E-07	1.07E-06	4.08E-07	4.08E-05	5.77E-05
Rn222	1.29E-12	4.63E-14	9.22E-14	3.53E-14	3.53E-12	5.00E-12
Ru106	9.21E-25	3.30E-26	6.58E-26	2.52E-26	2.52E-24	3.57E-24
Sb125	1.32E-10	4.75E-12	9.46E-12	3.62E-12	3.62E-10	5.12E-10
Se79	2.62E-08	9.38E-10	1.87E-09	7.16E-10	7.16E-08	1.01E-07
Sm151	7.72E+02	2.77E+01	5.51E+01	2.11E+01	2.11E+03	2.99E+03
Sn126	9.92E-08	3.56E-09	7.09E-09	2.71E-09	2.71E-07	3.84E-07
Sr90	1.09E+04	3.90E+02	7.76E+02	2.97E+02	2.97E+04	4.21E+04
Tc99	5.02E-06	1.80E-07	3.58E-07	1.37E-07	1.37E-05	1.94E-05
Th229	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th230	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th232	1.52E-05	5.44E-07	1.08E-06	4.15E-07	4.15E-05	5.87E-05
U232	2.52E-04	9.03E-06	1.80E-05	6.89E-06	6.89E-04	9.75E-04
U233	2.10E-02	7.54E-04	1.50E-03	5.75E-04	5.75E-02	8.14E-02
U234	5.78E-03	2.07E-04	4.13E-04	1.58E-04	1.58E-02	2.24E-02
U235	2.28E-04	8.16E-06	1.63E-05	6.23E-06	6.23E-04	8.81E-04
U236	1.61E-04	5.77E-06	1.15E-05	4.40E-06	4.40E-04	6.23E-04
U238	5.09E-03	1.83E-04	3.64E-04	1.39E-04	1.39E-02	1.97E-02
Y90	1.09E+04	3.90E+02	7.76E+02	2.97E+02	2.97E+04	4.21E+04
Zr93	2.98E-01	1.07E-02	2.12E-02	8.14E-03	8.14E-01	1.15E+00

*From “A and AX Resid Inv_SM_04-24-2018_WZ_06-15-2018.xlsx” worksheet “Anx Inventory_HTWOS” Q35:W84.

7.2 CONCLUSIONS

An estimate of residual inventory, designated as Case 1, needed for preliminary WMA A-AX PA calculations is presented in this EMCF. The source of data along with assumptions, calculation procedures, and results are described. The forward decay of radioactive inventory for the tanks from the available BBI inventory dates to the closure date is performed using GoldSim©. The backward decay of radioactive inventory based on the HTWOS calculation to the closure date is performed using a spreadsheet approach for the ancillary equipment.

It is recognized that alternative data sources and approaches (e.g., RPP-CALC-57152, "*Analysis of Potential Waste in Airlift Circulators and Steam Coils in AX Tanks Post Retrieval*" and RPP-PLAN-47559, "*Single-Shell Tank Waste Management Area C Pipeline Feasibility Evaluation*," or BBI of RPP-RPT-58293 for estimating ancillary equipment residual wastes) could be used for deriving additional inventory cases to evaluate the uncertainty and sensitivity within the PA.

The conclusions presented here only apply to WMA A-AX inventory data sets.

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APPENDIX A

SOFTWARE INSTALLATION AND CHECKOUT FORM

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:
Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:
Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: GoldSim Pro Software Version No.: 12.0

EXECUTABLE INFORMATION:

2. Executable Name [redacted] GoldSim.exe
3. Executable Size (bytes): 2,836 kB

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):
   Compiled by vendor
5. Operating System (include version number):
   Windows 10

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):
   Lenovo YOGA 900-131SK2 Signature Edition SN: PFOGS02H
7. Operating System (include version number):
   Window 10
8. Open Problem Report? (●) No ( ) Yes PR/CR No.

TEST CASE INFORMATION:

[redacted]

10. Procedure(s):
    per CHPRC-00224 Rev 1, GoldSim Pro Software Test Plan
11. Libraries:
    N/A
12. Input Files:
    FirstModel.gsm
13. Output Files:
    FirstModel.gsm
14. Test Cases:
    GS-ITC-1
15. Test Case Results:
    Match expected results as presented in CHPRC-00224, GoldSim Pro Software Test Plan
16. Test Performed By: Wei Zhou
17. Test Results: (●) Satisfactory, Accepted for Use ( ) Unsatisfactory
18. Disposition (include HISI update): ADDED TO HISI ENTRY [signature]

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: GoldSim Pro Software Version No.: 12.0

Prepared By:

19. _____ Software Owner (Signature) | WE Nichols Print | 12 APR 2018 Date

20. Test Personnel:

_____ Sign | Wei Zhou Print | 4/12/2018 Date

_____ Sign | _____ Print | _____ Date

_____ Sign | _____ Print | _____ Date

Approved By:

21. _____ Software SME (Signature) | N/R per SMP Print | _____ Date

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