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H-Area Tank Farm Closure Inventory for use in Performance Assessment Modeling

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ACRONYMS/ABBREVIATIONS

C&WDA	Closure and Waste Disposal Authority
DOE	U.S. Department of Energy
CTS	Concentrate Transfer System
DB	Diversion Box
EPA	United States Environmental Protection Agency
ETP	Effluent Treatment Project
GDL	Gravity Drain Line
FTF	F-Area Tank Farm
HTF	H-Area Tank Farm
HRR	Highly Radioactive Radionuclide
MOP	Member of the Public
OA	Oxalic Acid
NE	Not Estimated
PA	Performance Assessment
PP	Pump Pit
PUREX	Plutonium Recovery and Extraction
QA	Quality Assurance
SDF	Saltstone Disposal Facility
SRS	Savannah River Site
TSR	Technical Safety Requirements
WCS	Waste Characterization System

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to provide inventories of radiological and non-radiological constituents in the residual material in the H-Area Tank Farm (HTF) waste tanks and ancillary equipment at the time of closure to support Performance Assessment (PA) modeling.

1.2 Scope

The inventories provided apply to the 29 underground waste tanks and specified ancillary equipment in HTF and include radiological and non-radiological waste constituents based on projections of HTF tank residual material at closure.

1.3 Waste Tank Closure Inventory Approach

The Savannah River Site (SRS) used the following general approach for estimating radiological and non-radiological inventories for use in the HTF PA:

- The contaminant screening process consisted of several steps to arrive at an appropriate list of isotopes to be included in the HTF waste tank closure inventory estimates to be used in the HTF PA modeling. An initial radionuclide screening process was developed and performed to evaluate 849 isotopes. [CBU-PIT-2005-00228]
- Both residual material concentrations and volumes were estimated to develop initial inventory estimates.
- Adjustments were made to the initial inventory estimates to develop the final inventory estimates
- The Type II tank annuli (Tanks 13 through 16) were assumed to contain residual material, including the sand bed beneath the primary liner.
- The sand bed beneath the Tank 16 secondary liner was assumed to contain residual material.
- The HTF non-radiological (chemical) inventory was estimated using the same methodology.
- After a waste tank is cleaned, the estimated inventory used in the HTF PA for that tank will be replaced with the actual inventory for that tank, which will be developed from an estimate of the residual material volume combined with analytical data from a statistically based sampling program of the residual material after cleaning the tank.
- During the closure process for each waste tank, the actual tank inventory will be used to determine projected dose and risk impacts for that tank.

Key elements of this process are discussed as follows, beginning with the residual solids initial inventory. Tables showing the estimated radiological and non-radiological inventories in each HTF waste tank developed using this process appear in Tables 3.1-2 and 3.1-3, respectively.

2.0 INITIAL RESIDUAL INVENTORY ESTIMATES

This section begins with a brief summary of how the tank waste initial inventory estimates have been made, identifying the residual volume and concentration estimates to be used to support the development of the inventory estimates used in the HTF PA. This section concludes with a discussion of residual material in areas other than the tank floor.

An initial radionuclide screening process was developed and performed to evaluate 849 isotopes. [CBU-PIT-2005-00228] Following the steps described in detail in Appendix A, the list of isotopes to be evaluated was reduced to 159 isotopes of concern for the HTF PA modeling. The 159 isotopes are presented in the Table A.0-1.

The 159 isotopes resulting from the initial screening were further evaluated to determine which isotopes could be eliminated from the initial inventory. This process eliminated 95 additional isotopes based on short half-life, the presence or absence of parent radionuclides, and the expectation in the waste inventory. The elimination process is described in Appendix B and presented in Table B.0-1.

In addition to the isotopes eliminated in Table B.0-1, the following daughters were also eliminated: Nb-93m, Sb-126, and Sb-126m. At the conclusion of the elimination process, only the radionuclides that required further evaluation remained for inclusion in the HTF PA and are shown in Table 2.0-1.

Table 2.0-1: Radionuclides of Concern for the HTF PA

Ac-227	Cl-36	Eu-152	Pa-231	Ra-226	Th-232
Al-26	Cm-243	Eu-154	Pd-107	Ra-228	U-232
Am-241	Cm-244	H-3	Pt-193	Se-79	U-233
Am-242m	Cm-245	I-129	Pu-238	Sm-151	U-234
Am-243	Cm-247	K-40	Pu-239	Sn-126	U-235
Ba-137m	Cm-248	Nb-94	Pu-240	Sr-90	U-236
C-14	Co-60	Ni-59	Pu-241	Tc-99	U-238
Cf-249	Cs-135	Ni-63	Pu-242	Th-229	Y-90
Cf-251	Cs-137	Np-237	Pu-244	Th-230	Zr-93

The list of non-radiological constituents that were included in the PA modeling was derived from the State Primary Drinking Water Regulations for inorganic contaminants specified in SCDHEC R.61-58. Asbestos, beryllium, cyanide, and thallium were removed from the list because of lack of inventory in the waste tanks. This list was compared to the list of inorganic characteristic hazards specified in 40 CFR 261 and silver and lead were added to the list. Secondary contaminants copper, manganese, iron, and zinc were also included due to the process knowledge that they were potentially present in the waste. Specific controls exist that preclude the introduction of organic constituents to the waste tank systems and were therefore not considered for establishing inventory or for PA modeling. The non-radiological (chemical) inventory of concern is listed in Table 2.0-2.

Table 2.0-2: Non-Radiological Inventory of Concern for the HTF PA

Ag	F	NO_3
As	Fe	Pb
Ba	Hg	Sb
Cd	Mn	Se
Cr	Ni	U
Cu	NO_2	Zn

At the time of tank closure, sampling and analysis will be performed. During residual characterization for closure, radionuclides listed in Table 2.0-1 will be analyzed, although only highly radioactive radionuclides (HRRs) will be quanitifed. Those that are not detectable or below detection limits will be determined via special analysis (e.g., ratios to other radionuclides or fission yields) in order to conduct an appropriate comparison to the PA estimated residual inventory.

2.1 The Waste Characterization System

The WCS is an electronic information system that tracks waste tank data, including projected radiological and non-radiological inventories, based on sample analyses, process histories, composition studies, and theoretical relationships. The system (initially developed in 1995) tracks the dry sludge concentrations of 40 radionuclides and of 37 non-radiological waste compounds in each of the SRS waste tanks. The 40 radionuclides tracked in the WCS were selected primarily based on their impact on tank safety basis source term, inhalation dose potential, or on the E-Area Vault Waste Acceptance Criteria.

2.1.1 Use of the Waste Characterization System

The WCS consists of two functional areas: (1) a sample data repository and (2) waste characterization. The waste characterization area contains inputs and calculations used to represent real-time conditions in the waste tanks. These real-time conditions are used to determine compliance (as input to safety basis calculations) with several nuclear safety administrative control programs such as tank flammability control and a waste tank corrosion control. Tracked dry sludge activity inventories for each tank and volume of settled sludge for each tank are extracted directly from WCS.

2.1.2 Updating the System

The WCS is routinely updated to reflect changes in waste inventory resulting from the receipt of new waste from the SRS canyon facilities, the Effluent Treatment Project (ETP), or recycle waste from the Defense Waste Processing Facility (DWPF). Additionally, WCS is updated to reflect changes due to the transfer of waste for processing at the DWPF or Saltstone Disposal Facility (SDF), and new characterization information in the form of sample analysis results, field measurements, waste tank video inspections, or technical reports. The tank contents in WCS are also adjusted to reflect the impacts of evaporator operation and to account for tank to tank transfers. [WSRC-TR-2003-00048]

2.1.3 Quality Assurance

The WCS is a controlled database that complies with strict Quality Assurance (QA) requirements. The QA requirements apply to not only data entry but also configuration control of the database software itself. All data entries into WCS must be independently verified. A Software Quality Assurance Plan governs the methods that must be utilized to maintain the database baseline configuration and to ensure the proper handling of the database. [B-SQP-H-00041]

2.1.4 Conservatism

The WCS generated values are generally conservative because each reactor spent fuel assembly that was reprocessed is assumed to have received the maximum burn-up possible, and therefore the amounts of actual fission products contained in an assembly were actually less than those entered into WCS. [LWO-PIT-2007-00025] Another factor expected to provide additional conservatism is the likelihood that actual concentrations for some constituents in the residual sludge on the waste tank bottoms after tank cleaning will be significantly less than the concentrations for dried sludge currently given in the WCS. This condition is expected to result from the use of OA to clean the tanks, with the exception of Tank 24.

2.2 Other Constituents Not Addressed in the WCS

2.2.1 Radionuclides and Chemicals

In addition to the nuclides tracked in WCS, updated special analysis methods provided estimates for additional isotopes. Methods used to estimate the inventories of the additional 30 isotopes, as described in the report for the updated HTF inventory projections, are shown in Table 2.2.1. [SRR-LWE-2009-00014] These inventories were based on the tank entrained sludge radiological contents, radiological alpha constant and surrogate tank designations. The surrogate designations are justified based on documented transfer history and the availability of comprehensive data on the surrogate tank's liquid actinide concentrations. For HTF, the designated surrogates are Tank 13 for Tanks 9, 10, 29, 31, and 36, Tank 32 for Tanks 30 and 37, and Tank 43 for Tanks 24, 38, 41, and 49. [SRR-LWE-2009-00014]

For a number of radionuclide concentrations (i.e., Cl-36, K-40, Pd-107, Pt-193, and Zr-93) not estimated in the report for the updated HTF inventory projections, an estimate was developed as described in Table 2.2-1. Also, there were other constituents for which WCS did not estimate an inventory for all HTF tanks. Therefore, these radionuclide concentrations were estimated only for waste tanks where no estimate was present and no surrogate tank was designated. The isotopes requiring additional estimates were Ba-137m, Cl-36, H-3, K-40, Pd-107, Pt-193, Ra-226, Ra-228, Th-229, Th-230, Th-232, U-232, U-234, U-236, Y-90, and Zr-93. Also, additional estimates were required for the silver, arsenic, barium, cadmium, fluorine, nickel, nitrate, nitrite, manganese, antimony, selenium, and zinc non-radiological (chemical) inventories. The additional estimates are described in Table 2.2-1.

Table 2.2-1: Initial Concentration Estimate Method

Constituent	Estimate Method
Radionuclides	
Ba-137m	Secular equilibrium with Cs-137 based on its decay chain.
C-14	An average C-14 HTF concentration. [SRR-LWE-2009-00014]
Cl-36	Activations of Cl-35 and K-39 in the reactors and waste tanks. Since these inventories are expected to be minimal, detection limits were used as the basis for the concentration estimate. [LWO-PIT-2006-00039]
H-3	Interstitial liquid concentration. [X-ESR-G-00004]
K-40	Activation of K-39 in the reactors and waste tanks. Since these inventories are expected to be minimal, detection limits were used as the basis for the concentration estimate. [LWO-PIT-2006-00039]
Pd-107	Irradiated reactor assemblies. Since these inventories are expected to be minimal, detection limits were used as the basis for the concentration estimate. [CBU-PIT-2005-00178]
Pt-193	Activation of Pt-192. Since these inventories are expected to be minimal, detection limits were used as the basis for the concentration estimate. [LWO-PIT-2006-00039]
Ra-226	For waste tanks that require an estimate of Ra-226 concentration, a minimal concentration would be expected; therefore the minimum HTF tank concentration was used.
Ra-228	For waste tanks that require an estimate of Ra-228 concentration, a minimal concentration would be expected; therefore the minimum HTF tank concentration was used.
Th-229	For waste tanks that require an estimate of Th-229 concentration, a minimal concentration would be expected; therefore the minimum HTF tank concentration was used.
Th-230	For waste tanks that require an estimate of Th-230 concentration, a minimal concentration would be expected; therefore the minimum HTF tank concentration was used.
Th-232	For waste tanks that require an estimate of Th-232 concentration, a minimal concentration would be expected; therefore the minimum HTF tank concentration was used.
U-232	For waste tanks that require an estimate of U-232 concentration, a minimal concentration would be expected; therefore the minimum HTF tank concentration was used.
U-234	The activity of U-234 in natural uranium is approximately equal to that of U-238. Uranium, in a fission reaction burns U-234 as well as U-235. So, it is assumed if U-235 is depleted, U-234 is also depleted. Reviewing the ratio of U-235 to U-238 in HTF waste indicates uranium content ranging from slightly, to highly depleted. Therefore it is reasonable to assume the U-234 activity is equal to that of U-238.

Table 2.2-1: Initial Concentration Estimate Method (Continued)

Constituent	Estimate Method
Radionuclides	
U-236	Reviewing highly depleted to highly enriched uranium indicates U-236 activity ranging from 0 - 1% of the total activity of U-234, U-235, and U-238. So, the U-236 concentration was set at 1% of the total concentration of U-234, U-235, and U-238.
Y-90	Secular equilibrium with Sr-90.
Zr-93	Irradiated reactor assemblies. Since these inventories are expected to be minimal, detection limits were used as the basis for the concentration estimate. [CBU-PIT-2005-00178]
Chemicals	
Ag	Average silver concentration in HTF. [SRR-LWE-2009-00014]
As	Representative concentrations of the elements have been established and used to estimate the residual inventory. [CBU-PIT-2005-00182]
Ba	Average barium concentration in HTF. [SRR-LWE-2009-00014]
Cd	Representative concentrations of the elements have been established and used to estimate the residual inventory. [CBU-PIT-2005-00182]
F	Average iron concentration in HTF. [SRR-LWE-2009-00014]
Ni	Average nickel concentration in HTF. [SRR-LWE-2009-00014]
NO_2	Average nitrite concentration in HTF. [SRR-LWE-2009-00014]
NO_3	Average nitrate concentration in HTF. [SRR-LWE-2009-00014]
Mn	Average manganese concentration in HTF. [SRR-LWE-2009-00014]
Sb	Representative concentrations of the elements have been established and used to estimate the residual inventory. [CBU-PIT-2005-00182]
Se	Representative concentrations of the elements have been established and used to estimate the residual inventory. [CBU-PIT-2005-00182]
Zn	Average zinc concentration in HTF. [SRR-LWE-2009-00014]

Note: The concentration (in Ci/gal) is calculated by dividing the dry sludge activity (curie) by the corresponding settled sludge volume (gallon) extracted from WCS. Where appropriate, zeolite volume is taken into account.

In the report for HTF estimate projections, Tanks 22 and 23 had several radionuclide concentrations that were not estimated. [SRR-LWE-2009-00014] Therefore, a surrogate tank was chosen to provide concentrations for these radionuclides. Tank 21 was chosen for Tank 22 because the Type IV tank make-up for estimated radionuclides was similar. However, Tank 24, the most conservative of the Type IV tanks, was chosen as a surrogate for Tank 23, which had no estimate for the majority of its radiological concentrations.

Tank 16 underwent sludge removal and cleaning which was completed in 1980. After the final acid wash in 1980 and prior to the final water rinse, a 3 inch diameter sample pan was installed on the bottom of Tank 16 and remained there until the waste tank bottom had dried. Analysis of the material was performed and an estimated inventory was generated. The analysis was performed on a limited number of radionuclides. [DPST-81-441] Due to the number of constituents needed to be estimated and lack of actual sample analysis, Tank 15

was designated as a surrogate for Tank 16. Tank 15 was chosen because during sludge removal from Tank 16, material was transferred to Tank 15.

2.2.2 Accounting for Zeolite

Certain waste tanks contain zeolite in addition to the sludge material. Liquid overheads from the evaporator systems were treated in cesium removal columns containing zeolite, which functions as a molecular sieve. In HTF, these columns were located on Tanks 24, 32, and 42.

When the zeolite became loaded, the spent zeolite resins and captured cesium were discarded into the waste tanks. Spent zeolite was transferred into Tanks 38, 40, and 51. [CBU-PIT-2005-00099]

The estimated radiological and non-radiological concentrations for Tanks 24, 32, 38, 40, 42, and 51 have been adjusted to account for the zeolite and corresponding captured cesium.

The solids (sludge and zeolite) concentrations assume that zeolite will remain unchanged during the waste removal processes. Experience with Tanks 18 and 19 has shown that the only element that accumulated on zeolite under actual in-tank conditions was cesium. The zeolite volume percents were calculated with the assumption that zeolite weight and volume percents are the same in residual material.

2.3 Estimated Residual Volumes

The initial inventory estimates were based on residual solids volume using an average height of 0.0625 inch on the waste tank floor. This height was based on plans to use Oxalic Acid (OA) for waste tank cleaning because of prior experience with OA cleaning of Tank 16. This assumption was necessary to develop an estimated residual solids volume, which was used to calculate an initial value for the residual radiological and non-radiological inventories. This initial value was then adjusted as discussed Section 3.0. However, it is important to note that it is the radiological inventories (curies) and non-radiological inventories (kilograms) that are important to the PA analysis, and not the specific estimated height of the residual solids.

2.3.1 Waste in Liquid and on Other Surfaces

The inventories of radiological and non-radiological constituents in residual liquid were assumed to be included in the final closure solids inventory as the residual liquid has typically evaporated by the time samples are taken from the tank.

Inventories inside failed cooling coils, and on the surface of the waste tank walls, cooling coils, and columns were assumed to be encompassed by the estimated total tank inventories shown in Tables 3.1-2 and 3.1-3 for the following reasons: (1) cooling coils with the potential for waste holdup will be internally inspected and/or flushed and (2) flushing is expected to remove essentially all waste that may have entered damaged coils. Flushing of damaged coils will include both inlets and outlets to ensure both sides of damaged coils are flushed.

The surfaces of waste tank internal walls, cooling coils, and support columns are not expected to contain significant deposits based on sludge mapping inspections of Tanks 5 and 6 performed to date. Waste tank internal walls, cooling coils, and support columns will be rinsed with OA and this process is expected to effectively clean these surfaces. This assumed

effectiveness of OA rinsing will be verified by laboratory testing. Samples of a representative internal tank component will be obtained and analyzed to provide data to develop the contaminant inventory estimate associated with internal tank components at tank closure, when other tank work affords the opportunity.

2.3.2 Initial Tank Inventory

The estimated volume of residual solids was multiplied by the concentrations established, as discussed in the previous section, to estimate the inventory of radiological and non-radiological constituents remaining in the tanks.

2.3.3 Waste in Type II Sand Layers and Annulus

All Type II tanks have both a primary and secondary sand layer. The 1 inch thick primary sand layer is between the primary and secondary liners and the 1 inch thick secondary sand layer is between the secondary liner and the basemat. All the Type II tank primary liners have formed leak sites during their operational history. This has resulted in material accumulating on the annulus floor for each of these waste tanks. [LWO-CES-2009-00001] Therefore, it is assumed for this inventory estimate that this layer was saturated with supernate material for all Type II tanks.

Tank 16 experienced the largest quantity of material leaving the tank and gathering in the annulus. In 1960, enough material filled the annulus that tens of gallons overflowed the annulus pan. [DPSPU-77-11-17_OUO] For the purpose of this inventory evaluation, it is conservatively assumed that all of the material that overflowed the annulus pan entered the secondary sand layer below Tank 16. Based on sand layer porosity, this amount of overflow represents approximately 2% of the total potential available volume for the secondary sand layer. Therefore, the assumption is made that the secondary sand layer for Tank 16 contains approximately 2% of the inventory of the Tank 16 primary sand layer. For Tanks 13 through 15, no material has leaked beyond the secondary containment; therefore, it is assumed that the secondary sand layers below these tanks contain no inventory.

Closure planning includes removing material from the tank annulus, when possible. To be consistent with the tank cleaning estimate, 0.0625 inch is estimated to remain on the annulus floor beyond the material in the sand beds.

As discussed previously, the material inventories estimated in the Type II tank sand layers and annulus were based on constituent data available in the WCS for Tank 16. In addition, three samples of material in the Tank 16 annulus were collected and analyzed. [WSRC-STI-2008-00203] Since the sample analysis only included a limited number of analytes, the remaining constituents were estimated. The radionuclide constituent estimates were based on a ratio of a chemically similar element, within the analysis, and the Tank 16 residual estimate. A ratio to measure for the Pu-238 analysis was used for the radionuclides that would tend to be insoluble, while a ratio for the Tc-99 analysis was used for the soluble components. A ratio to the iron measurement was used for the non-radiological constituents not analyzed. The maximum concentrations for each of these constituents were used in the inventory for conservatism.

Limited analytical data was also available based on previous Tanks 15 and 16 annulus sampling (Cs-137 and Sr-90) and were included to calculate inventories. [WSRC-RP-99-00124, DPST-82-788] Values from these earlier sampling events were initially decayed to bring them to 2010 levels. The primary sand layer and annulus inventories presented in Tables 2.3-1 and 2.3-2 apply to all Type II tanks; however, the for the secondary sand layer inventories only apply to Tank 16. The decay date for these inventories is 2032.

Table 2.3-1: Type II Tank Sand Layer and Annulus Estimated Radiological Inventory

Radionuclide	Primary Sand Layer (Ci)	Annulus Floor (Ci)	Secondary Sand Layer (Ci)
Ac-227	6.1E-04	1.3E-05	1.2E-05
Al-26	1.0E+00	1.0E+00	1.0E+00
Am-241	8.3E+00	1.8E-01	1.7E-01
Am-242m	1.0E+00	1.0E+00	1.0E+00
Am-243	1.0E+00	1.0E+00	1.0E+00
Ba-137m	4.4E+02	9.5E+00	8.9E+00
C-14	1.0E+00	1.0E+00	1.0E+00
Cf-249	6.1E-04	1.3E-05	1.2E-05
Cf-251	6.1E-04	1.3E-05	1.2E-05
Cl-36	6.1E-04	1.3E-05	1.2E-05
Cm-243	1.0E+00	1.0E+00	1.0E+00
Cm-244	5.2E-02	1.1E-03	1.0E-03
Cm-245	6.1E-04	1.3E-05	1.2E-05
Cm-247	6.1E-04	1.3E-05	1.2E-05
Cm-248	6.1E-04	1.3E-05	1.2E-05
Co-60	6.1E-04	1.3E-05	1.2E-05
Cs-135	3.7E-03	7.9E-05	7.4E-05
Cs-137	4.7E+02	1.0E+01	9.4E+00
Eu-152	1.0E+00	1.0E+00	1.0E+00
Eu-154	3.4E+00	7.2E-02	6.8E-02
H-3	1.0E+00	1.0E+00	1.0E+00
I-129	6.1E-04	1.3E-05	1.2E-05
K-40	6.1E-04	1.3E-05	1.2E-05
Nb-94	6.1E-04	1.3E-05	1.2E-05
Ni-59	1.0E+00	1.0E+00	1.0E+00
Ni-63	1.1E+01	2.4E-01	2.3E-01
Np-237	3.1E-02	6.5E-04	6.2E-04

Table 2.3-1: Type II Tank Sand Layer and Annulus Estimated Radiological Inventory (Continued)

Radionuclide	Primary Sand Layer (Ci)	Annulus Floor (Ci)	Secondary Sand Layer (Ci)
Pa-231	6.1E-04	1.3E-05	1.2E-05
Pd-107	6.1E-04	1.3E-05	1.2E-05
Pt-193	6.1E-04	1.3E-05	1.2E-05
Pu-238	2.9E+01	6.2E-01	5.8E-01
Pu-239	5.1E+00	1.1E-01	1.0E-01
Pu-240	4.5E+00	9.7E-02	9.1E-02
Pu-241	5.2E+00	1.1E-01	1.0E-01
Pu-242	1.0E+00	1.0E+00	1.0E+00
Pu-244	6.1E-04	1.3E-05	1.2E-05
Ra-226	6.1E-04	1.3E-05	1.2E-05
Ra-228	6.1E-04	1.3E-05	1.2E-05
Se-79	1.0E+00	1.0E+00	1.0E+00
Sm-151	1.5E+02	3.2E+00	3.1E+00
Sn-126	1.0E+00	1.0E+00	1.0E+00
Sr-90	3.6E+03	7.6E+01	7.2E+01
Tc-99	3.6E+00	7.6E-02	7.1E-02
Th-229	6.1E-04	1.3E-05	1.2E-05
Th-230	6.1E-04	1.3E-05	1.2E-05
Th-232	7.4E-04	1.6E-05	1.5E-05
U-232	6.1E-04	1.3E-05	1.2E-05
U-233	4.1E-02	8.8E-04	8.2E-04
U-234	2.1E-02	4.6E-04	4.3E-04
U-235	2.4E-04	5.2E-06	4.9E-06
U-236	8.3E-04	1.8E-05	1.7E-05
U-238	1.1E-03	2.2E-05	2.1E-05
Y-90	3.6E+03	7.6E+01	7.2E+01
Zr-93	7.0E-03	1.5E-04	1.4E-04

Table 2.3-2: Type II Tank Sand Layer and Annulus Estimated Non-Radiological Inventory

Chemical	Primary Sand Bed (kg)	Annulus Floor (kg)	Secondary Sand Bed (kg)
Ag	6.1E+00	1.3E-01	9.2E-02
As	1.7E-02	3.7E-04	2.6E-04
Ba	2.8E+00	6.0E-02	4.2E-02
Cd	5.3E-01	1.1E-02	7.9E-03
Cr	2.7E+00	5.7E-02	4.0E-02
Cu	1.5E+00	3.1E-02	2.2E-02
F	1.3E+00	2.8E-02	2.0E-02
Fe	1.2E+02	2.5E+00	1.8E+00
Hg	4.0E+01	8.4E-01	6.0E-01
Mn	1.9E+00	4.0E-02	2.9E-02
Ni	3.9E+00	8.3E-02	5.8E-02
NO_2	5.1E+02	1.1E+01	7.6E+00
NO_3	9.9E+02	2.1E+01	1.5E+01
Pb	3.4E+01	7.1E-01	5.0E-01
Sb	1.2E+01	2.5E-01	1.8E-01
Se	1.4E-02	3.0E-04	2.1E-04
U	1.9E-02	4.1E-04	2.9E-04
Zn	4.7E+00	9.9E-02	7.0E-02

3.0 INVENTORY ADJUSTMENTS

Following the development of the initial inventory estimates, adjustments were made. Below is a summary of the adjustments with more detailed explanations following.

A methodical approach was used to construct estimates of HTF waste tank closure inventories to be used in PA modeling. Independent steps were developed to systematically construct the HTF tank inventories, with each step adjusting inventory either by tank or by radionuclide. The steps used in inventory development were as follows:

1. The inventory adjustment used the initial inventory estimates as the starting point (Section 2.0).
2. The waste tanks were grouped according to waste tank use and design (Section 3.1).
3. Within each tank grouping, the inventories were adjusted as applicable within that group (Sections 3.1.1-3.1.4).
4. Due to future waste removal uncertainties (e.g., unknowns regarding the effectiveness of tank cleaning technologies), the initial individual tank inventories were increased one order of magnitude for the Type I, Type II , and Type IV waste tanks.
5. Within the Type IV Tank grouping, the Tank 24 inventories were revised to account for an increased level of uncertainty surrounding the residual inventories remaining after waste removal impacted by the presence of zeolite. (Section 3.1.3.3)
6. To account for uncertainty surrounding future operations and movement of material within the HTF, the maximum concentration of each radionuclide or non-radionuclide from any tank within a group was applied to the other tanks within the tank grouping.

3.1 Tank Groupings

The tank type generally had an effect on the type of waste received and therefore guided the group selection. In general, each waste tank was built at approximately the same time as others of the same type. In addition, the tanks generally contain one of two waste types, metal hydroxides (commonly referred to as sludge) and sodium nitrate/nitrite salt (commonly referred to as salt). For the tanks categorized as either salt or sludge, the predominant use was considered. This was established as the use (past and future) for the majority of the tank's life.

The waste tanks were grouped based on use and design as presented in Table 3.1-1.

Table 3.1-1: Waste Tank Groupings

Types I and II		Type III/IIIA				Type IV
Salt	Sludge	Salt (West)	Salt (East)	Sludge (West)	Sludge (East)	N/A*
Tanks 9 and 10	Tanks 11, 12, 13, 14, and 15	Tanks 29, 30, 31, 35, 36, and 37	Tanks 38, 41, 48, 49, and 50	Tank 32	Tanks 39, 40, 42, 43, and 51	Tanks 21, 22, 23, and 24

Note: Tank 16 is a special case with its own grouping
*No additional criteria can be attributed to this tank type group

The Type I and II tanks were grouped together. Within this grouping, the tanks were split into two smaller groups based on the waste makeup. For the Type IV, the waste type is similar for all the tanks, so this formed another grouping. The last grouping was for the Type III and IIIA tanks. This group was also divided further based on the two different waste types. This group was again divided based on tank location within HTF (East and West Hills). So, for the Type III and IIIA tanks, groups were based on both their location and waste type.

3.1.1 Types I & II Tanks

The Type I & II tank groupings consists of Tanks 9 through 15. These tanks were split between two groups based on the predominate type of material, salt and sludge, contained within each tank. These tanks are the oldest tanks within the HTF and provided the initial storage for SRS following the startup of H-Canyon.

3.1.1.1 Nominal Activities for Radionuclides

Allowing for more efficient and cost effective means of confirming radionuclide concentrations with a limited potential impact to dose, the inventories for a group of radionuclides were adjusted to either 1 curie, or used an analytical detection limit that resulted in an inventory of 1.0E-04 curie. If the radionuclide inventory estimated was less than 1.0E-04 curie, then it was adjusted up to 1.0E-04 curie. However, if the radionuclide inventory estimated was at least 1.0E-04 curie, then it was adjusted up to 1 curie. For I-129, the detection limit used resulted in an inventory estimate of 1.0E-05 curie because the analytical laboratory was able to achieve lower analytical detection limits during analysis of Tanks 18 and 19 samples. [SRNL-STI-2010-00386, SRNL-STI-2010-00439] The

adjustments to either 1.0E-04 curie or to 1 curie exclusively increased residual inventories estimates. Inventory estimates were not adjusted lower, only higher.

For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit.

Note that those radionuclides with estimated inventories greater than 1 curie were not adjusted in this step. In addition, this adjustment only applied to the radiological inventories and not to the non-radiological inventories.

3.1.1.2 Future Operations

Within each of the two Types I and II tank groups, the maximum tank inventory for any one tank was used to estimate inventory for the other tanks within the grouping due to the uncertain order of waste removal and closure activities. While a waste tank is in the closure process, material will be removed and transferred to another waste tank. This will cause the concentrations of the two waste tanks to become more similar. Since the order of waste tank closure and the transfer sequences are uncertain, all the radiological and non-radiological waste tank inventory within each group were adjusted to match the maximum waste tank inventory within Type I and Type II tank groups.

3.1.1.3 Chemical Cleaning

Based on the differences in concentrations observed during the chemical cleaning of Tank 5, decreases in concentrations are anticipated for cesium, strontium, technetium, and uranium. [WSRC-STI-2007-00192, SRNL-STI-2009-00492] Based on this observation, all the tank inventories of these elements were adjusted one order of magnitude lower to reflect the cleaning efficiency expected by chemical cleaning these tanks.

3.1.2 Tank 16

Tank 16 has been cleaned with OA and samples of the residual material have been analyzed and formed the basis for a portion of its inventory. Using Tank 15 as a surrogate provided the remaining inventory estimates. No further adjustments were made the inventory estimates of Tank 16.

3.1.3 Type IV Tanks

The Type IV tank grouping consists of Tanks 21 through 24.

3.1.3.1 Nominal Activities for Radionuclides

Allowing for more efficient and cost effective means of confirming radionuclide concentrations with a limited potential impact to dose, the inventories for a group of radionuclides were adjusted to either 1 curie, or used an analytical detection limit that resulted in an inventory of 1.0E-04 curie. If the radionuclide inventory estimated was less than 1.0E-04 curie, then it was adjusted up to 1.0E-04 curie. However, if the radionuclide inventory estimated was at least 1.0E-04 curie, then it was adjusted up to 1 curie. For I-129, the detection limit used resulted in an inventory estimate of 1.0E-05 curie because the analytical laboratory was able to achieve lower analytical detection limits during analysis of Tanks 18 and 19 samples. [SRNL-STI-2010-00386, SRNL-STI-2010-00439] The

adjustments to either 1.0E-04 curie or to 1 curie exclusively increased residual inventories estimates. Inventory estimates were not adjusted lower, only higher.

For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit.

Note that those radionuclides with estimated inventories greater than 1 curie were not adjusted in this step. In addition, this adjustment only applied to the radiological inventories and not to the non-radiological inventories.

3.1.3.2 Future Operations

Within the Types IV tank group, the maximum tank inventory for any one tank was used to estimate inventory for the other tanks within the grouping due to the uncertain order of waste removal and closure activities. While a waste tank is in the closure process, material will be removed and transferred to another waste tank. This will cause the concentrations of the two waste tanks to become more similar. Since the order of waste tank closure and the transfer sequences are uncertain, all the radiological and non-radiological waste tank inventory within each group were adjusted to match the maximum waste tank inventory within Type IV tank group.

3.1.3.3 Chemical Cleaning

Based on the differences in concentrations observed during the chemical cleaning of Tank 5, decreases in concentrations are anticipated for cesium, strontium, technetium, and uranium. [WSRC-STI-2007-00192, SRNL-STI-2009-00492] Based on this observation, all the tank inventories of these elements were adjusted one order of magnitude lower to reflect the cleaning efficiency expected by chemical cleaning these tanks. However, the chemical cleaning process is not planned for Tank 24 because the acid effect on zeolite hampers future waste removal efforts. Therefore, this adjustment was not applied to Tank 24.

3.1.4 Types III & IIIA Tanks

The Type III and IIIA tank grouping consists of Tanks 29 through 32, 35 through 43, and 48 through 51. This grouping was divided further based on tank location and contents.

3.1.4.1 Nominal Activities for Radionuclides

Allowing for more efficient and cost effective means of confirming radionuclide concentrations with a limited potential impact to dose, the inventories for a group of radionuclides were adjusted to either 1 curie, or used an analytical detection limit that resulted in an inventory of 1.0E-04 curie. If the radionuclide inventory estimated was less than 1.0E-04 curie, then it was adjusted up to 1.0E-04 curie. However, if the radionuclide inventory estimated was at least 1.0E-04 curie, then it was adjusted up to 1 curie. For I-129, the detection limit used resulted in an inventory estimate of 1.0E-05 curie because the analytical laboratory was able to achieve lower analytical detection limits during analysis of Tanks 18 and 19 samples. [SRNL-STI-2010-00386, SRNL-STI-2010-00439] The adjustments to either 1.0E-04 curie or to 1 curie exclusively increased residual inventories estimates. Inventory estimates were not adjusted lower, only higher.

For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit.

Note that those radionuclides with estimated inventories greater than 1 curie were not adjusted in this step. In addition, this adjustment only applied to the radiological inventories and not to the non-radiological inventories.

3.1.4.2 Future Operations

Within the Type III and IIIA tank group, the maximum tank inventory for any one tank was used to estimate inventory for the other tanks within the grouping due to the uncertain order of waste removal and closure activities. These tanks were split between two groups based on the predominate type of material, salt and sludge, contained within each tank at the time of closure. In addition, the tanks were also further subdivided based on their location on the east or west hill of the HTF, with the expectation that the east hill tanks would be closed last. [SRR-LWP-2009-00001] While a waste tank is in the closure process, material will be removed and transferred to another waste tank. This will cause the concentrations of the two waste tanks to become more similar. Since the order of waste tank closure and the transfer sequences are uncertain, all the radiological and non-radiological waste tank inventory within

3.1.4.3 Chemical Cleaning

Based on the differences in concentrations observed during the chemical cleaning of Tank 5, decreases in concentrations are anticipated for cesium, strontium, technetium, and uranium. [WSRC-STI-2007-00192, SRNL-STI-2009-00492] Based on this observation, all the tank inventories of these elements were adjusted one order of magnitude lower to reflect the cleaning efficiency expected by chemical cleaning these tanks.

3.1.5 Final Tank Inventory Estimates

The system plan calls for the last waste tank to be grouted at the end of fiscal year 2032. Therefore, all the radiological inventories have been decay corrected to 2032. After all waste inventory adjustments, the final radionuclide estimates are provided in Table 3.1-2. The estimated non-radiological constituent inventories are provided in Table 3.1-3.

It should be kept in mind that the curies of residual radiological and the mass of residual non-radiological waste constituents are important to the analyses, not the estimated residual waste volume. While the estimated solids volume was used to calculate the residual radiological and non-radiological waste constituent inventories, the volume estimate was not significant in its own right.

Table 3.1-2: HTF Estimated Radiological Inventory (Ci) at Closure (2032)

Tank	Ac-227	Al-26	Am-241	Am-242m	Am-243	Ba-137m	C-14	Cf-249	Cf-251	Cl-36	Cm-243	Cm-244	Cm-245
9	1.0E-03	1.0E+00	1.9E+02	1.0E+00	1.0E+00	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	1.1E-02	1.0E-03
10	1.0E-03	1.0E+00	1.9E+02	1.0E+00	1.0E+00	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	1.1E-02	1.0E-03
11	1.0E-03	1.0E+00	2.1E+02	1.0E+00	1.0E+00	2.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	2.3E+00	1.0E-03
12	1.0E-03	1.0E+00	2.1E+02	1.0E+00	1.0E+00	2.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	2.3E+00	1.0E-03
13	1.0E-03	1.0E+00	2.1E+02	1.0E+00	1.0E+00	2.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	2.3E+00	1.0E-03
14	1.0E-03	1.0E+00	2.1E+02	1.0E+00	1.0E+00	2.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	2.3E+00	1.0E-03
15	1.0E-03	1.0E+00	2.1E+02	1.0E+00	1.0E+00	2.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	2.3E+00	1.0E-03
16	1.0E-04	1.0E+00	1.9E+01	1.0E+00	1.0E+00	2.8E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.2E-01	1.0E-04
21	1.0E-03	1.0E+00	2.7E+01	1.0E+00	1.0E+00	1.3E+03	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	3.5E+00	1.0E+00
22	1.0E-03	1.0E+00	2.7E+01	1.0E+00	1.0E+00	1.3E+03	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	3.5E+00	1.0E+00
23	1.0E-03	1.0E+00	2.7E+01	1.0E+00	1.0E+00	1.3E+03	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	3.5E+00	1.0E+00
24	1.0E-03	1.0E+00	2.7E+01	1.0E+00	1.0E+00	1.3E+04	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	3.5E+00	1.0E+00
29	1.0E-04	1.0E+00	5.7E+01	1.0E+00	1.0E+00	5.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.9E-01	1.0E-04
30	1.0E-04	1.0E+00	5.7E+01	1.0E+00	1.0E+00	5.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.9E-01	1.0E-04
31	1.0E-04	1.0E+00	5.7E+01	1.0E+00	1.0E+00	5.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.9E-01	1.0E-04
32	1.0E-04	1.0E+00	8.6E+01	1.0E+00	1.0E+00	8.1E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.0E-01	1.0E-04
35	1.0E-04	1.0E+00	5.7E+01	1.0E+00	1.0E+00	5.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.9E-01	1.0E-04
36	1.0E-04	1.0E+00	5.7E+01	1.0E+00	1.0E+00	5.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.9E-01	1.0E-04
37	1.0E-04	1.0E+00	5.7E+01	1.0E+00	1.0E+00	5.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.9E-01	1.0E-04
38	1.0E-04	1.0E+00	1.8E+01	1.0E+00	1.0E+00	2.2E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	8.5E+00	1.0E+00
39	1.0E-04	1.0E+00	4.2E+01	1.0E+00	1.0E+00	3.9E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.8E+01	1.0E+00
40	1.0E-04	1.0E+00	4.2E+01	1.0E+00	1.0E+00	3.9E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.8E+01	1.0E+00
41	1.0E-04	1.0E+00	1.8E+01	1.0E+00	1.0E+00	2.2E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	8.5E+00	1.0E+00
42	1.0E-04	1.0E+00	4.2E+01	1.0E+00	1.0E+00	3.9E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.8E+01	1.0E+00
43	1.0E-04	1.0E+00	4.2E+01	1.0E+00	1.0E+00	3.9E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.8E+01	1.0E+00
48	1.0E-04	1.0E+00	1.8E+01	1.0E+00	1.0E+00	2.2E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	8.5E+00	1.0E+00
49	1.0E-04	1.0E+00	1.8E+01	1.0E+00	1.0E+00	2.2E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	8.5E+00	1.0E+00
50	1.0E-04	1.0E+00	1.8E+01	1.0E+00	1.0E+00	2.2E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	8.5E+00	1.0E+00
51	1.0E-04	1.0E+00	4.2E+01	1.0E+00	1.0E+00	3.9E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.8E+01	1.0E+00

Table 3.1-2: HTF Estimated Radiological Inventory (Ci) at Closure (2032) (Continued)

Tank	Cm-247	Cm-248	Co-60	Cs-135	Cs-137	Eu-152	Eu-154	H-3	I-129	K-40	Nb-94	Ni-59	Ni-63	Np-237
9	1.0E-03	1.0E-03	1.0E-03	1.8E-03	1.8E+02	3.8E+00	6.6E+00	1.0E+00	1.0E-04	1.0E-03	1.2E-03	2.3E+00	1.5E+02	1.3E-01
10	1.0E-03	1.0E-03	1.0E-03	1.8E-03	1.8E+02	3.8E+00	6.6E+00	1.0E+00	1.0E-04	1.0E-03	1.2E-03	2.3E+00	1.5E+02	1.3E-01
11	1.0E-03	1.0E-03	1.0E-03	2.3E-03	2.9E+02	6.2E+00	7.8E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	3.7E+00	2.6E+02	1.3E-01
12	1.0E-03	1.0E-03	1.0E-03	2.3E-03	2.9E+02	6.2E+00	7.8E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	3.7E+00	2.6E+02	1.3E-01
13	1.0E-03	1.0E-03	1.0E-03	2.3E-03	2.9E+02	6.2E+00	7.8E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	3.7E+00	2.6E+02	1.3E-01
14	1.0E-03	1.0E-03	1.0E-03	2.3E-03	2.9E+02	6.2E+00	7.8E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	3.7E+00	2.6E+02	1.3E-01
15	1.0E-03	1.0E-03	1.0E-03	2.3E-03	2.9E+02	6.2E+00	7.8E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	3.7E+00	2.6E+02	1.3E-01
16	1.0E-04	1.0E-04	1.0E-04	2.3E-04	2.9E+01	1.0E+00	7.8E+00	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	2.6E+01	5.2E-03
21	1.0E-03	1.0E-03	1.0E-03	7.0E-03	1.4E+03	1.0E+00	4.5E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	1.0E+00	2.6E+01	3.4E-02
22	1.0E-03	1.0E-03	1.0E-03	7.0E-03	1.4E+03	1.0E+00	4.5E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	1.0E+00	2.6E+01	3.4E-02
23	1.0E-03	1.0E-03	1.0E-03	7.0E-03	1.4E+03	1.0E+00	4.5E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	1.0E+00	2.6E+01	3.4E-02
24	1.0E-03	1.0E-03	1.0E-03	7.0E-02	1.4E+04	1.0E+00	4.5E+01	1.0E+00	1.0E-04	1.0E-03	1.0E-03	1.0E+00	2.6E+01	3.4E-02
29	1.0E-04	1.0E-04	1.0E-04	3.6E-04	5.9E+01	1.2E+00	2.9E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	4.4E+01	1.3E-02
30	1.0E-04	1.0E-04	1.0E-04	3.6E-04	5.9E+01	1.2E+00	2.9E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	4.4E+01	1.3E-02
31	1.0E-04	1.0E-04	1.0E-04	3.6E-04	5.9E+01	1.2E+00	2.9E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	4.4E+01	1.3E-02
32	1.0E-04	1.0E-04	1.0E-04	4.8E-04	8.6E+01	1.8E+00	5.0E+01	1.0E+00	1.0E-05	1.0E-04	1.1E-04	1.0E+00	6.0E+01	3.4E-03
35	1.0E-04	1.0E-04	1.0E-04	3.6E-04	5.9E+01	1.2E+00	2.9E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	4.4E+01	1.3E-02
36	1.0E-04	1.0E-04	1.0E-04	3.6E-04	5.9E+01	1.2E+00	2.9E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	4.4E+01	1.3E-02
37	1.0E-04	1.0E-04	1.0E-04	3.6E-04	5.9E+01	1.2E+00	2.9E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	4.4E+01	1.3E-02
38	1.0E-04	1.0E-04	1.0E-04	1.3E-04	2.3E+01	1.0E+00	9.8E+00	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	1.5E+01	6.5E-03
39	1.0E-04	1.0E-04	1.0E-04	2.0E-04	4.1E+01	1.0E+00	3.6E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	2.6E+01	1.6E-02
40	1.0E-04	1.0E-04	1.0E-04	2.0E-04	4.1E+01	1.0E+00	3.6E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	2.6E+01	1.6E-02
41	1.0E-04	1.0E-04	1.0E-04	1.3E-04	2.3E+01	1.0E+00	9.8E+00	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	1.5E+01	6.5E-03
42	1.0E-04	1.0E-04	1.0E-04	2.0E-04	4.1E+01	1.0E+00	3.6E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	2.6E+01	1.6E-02
43	1.0E-04	1.0E-04	1.0E-04	2.0E-04	4.1E+01	1.0E+00	3.6E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	2.6E+01	1.6E-02
48	1.0E-04	1.0E-04	1.0E-04	1.3E-04	2.3E+01	1.0E+00	9.8E+00	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	1.5E+01	6.5E-03
49	1.0E-04	1.0E-04	1.0E-04	1.3E-04	2.3E+01	1.0E+00	9.8E+00	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	1.5E+01	6.5E-03
50	1.0E-04	1.0E-04	1.0E-04	1.3E-04	2.3E+01	1.0E+00	9.8E+00	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	1.5E+01	6.5E-03
51	1.0E-04	1.0E-04	1.0E-04	2.0E-04	4.1E+01	1.0E+00	3.6E+01	1.0E+00	1.0E-05	1.0E-04	1.0E-04	1.0E+00	2.6E+01	1.6E-02

Table 3.1-2: HTF Estimated Radiological Inventory (Ci) at Closure (2032) (Continued)

Tank	Pa-231	Pd-107	Pt-193	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Pu-244	Ra-226	Ra-228	Se-79	Sm-151	Sn-126
9	1.0E-03	1.0E-03	1.0E-03	2.3E+01	3.9E+00	8.7E-01	1.0E+00	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.6E+00	2.2E+03	2.9E+00
10	1.0E-03	1.0E-03	1.0E-03	2.3E+01	3.9E+00	8.7E-01	1.0E+00	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.6E+00	2.2E+03	2.9E+00
11	1.0E-03	1.0E-03	1.0E-03	1.4E+03	2.8E+01	1.5E+01	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	2.0E+00	3.5E+03	1.9E+00
12	1.0E-03	1.0E-03	1.0E-03	1.4E+03	2.8E+01	1.5E+01	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	2.0E+00	3.5E+03	1.9E+00
13	1.0E-03	1.0E-03	1.0E-03	1.4E+03	2.8E+01	1.5E+01	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	2.0E+00	3.5E+03	1.9E+00
14	1.0E-03	1.0E-03	1.0E-03	1.4E+03	2.8E+01	1.5E+01	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	2.0E+00	3.5E+03	1.9E+00
15	1.0E-03	1.0E-03	1.0E-03	1.4E+03	2.8E+01	1.5E+01	1.7E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	2.0E+00	3.5E+03	1.9E+00
16	1.0E-04	1.0E-04	1.0E-04	6.7E+01	1.8E+00	8.6E-01	4.8E+00	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	3.5E+02	1.0E+00
21	1.0E-03	1.0E-03	1.0E-03	6.2E+02	3.1E+00	2.6E+00	1.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	5.9E+02	1.0E+00
22	1.0E-03	1.0E-03	1.0E-03	6.2E+02	3.1E+00	2.6E+00	1.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	5.9E+02	1.0E+00
23	1.0E-03	1.0E-03	1.0E-03	6.2E+02	3.1E+00	2.6E+00	1.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	5.9E+02	1.0E+00
24	1.0E-03	1.0E-03	1.0E-03	6.2E+02	3.1E+00	2.6E+00	1.8E+02	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	5.9E+02	1.0E+00
29	1.0E-04	1.0E-04	1.0E-04	3.7E+01	7.5E+00	5.5E+00	1.0E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.0E+02	1.0E+00
30	1.0E-04	1.0E-04	1.0E-04	6.9E+02	7.5E+00	5.5E+00	1.0E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.0E+02	1.0E+00
31	1.0E-04	1.0E-04	1.0E-04	3.7E+01	7.5E+00	5.5E+00	1.0E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.0E+02	1.0E+00
32	1.0E-04	1.0E-04	1.0E-04	1.1E+03	1.1E+01	8.7E+00	1.8E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	1.0E+03	1.0E+00
35	1.0E-04	1.0E-04	1.0E-04	6.9E+02	7.5E+00	5.5E+00	1.0E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.0E+02	1.0E+00
36	1.0E-04	1.0E-04	1.0E-04	3.7E+01	7.5E+00	5.5E+00	1.0E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.0E+02	1.0E+00
37	1.0E-04	1.0E-04	1.0E-04	6.9E+02	7.5E+00	5.5E+00	1.0E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	7.0E+02	1.0E+00
38	1.0E-04	1.0E-04	1.0E-04	1.8E+02	3.3E+00	1.8E+00	3.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	2.8E+02	1.0E+00
39	1.0E-04	1.0E-04	1.0E-04	6.1E+02	9.4E+00	5.8E+00	1.8E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	4.9E+02	1.0E+00
40	1.0E-04	1.0E-04	1.0E-04	6.1E+02	9.4E+00	5.8E+00	1.8E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	4.9E+02	1.0E+00
41	1.0E-04	1.0E-04	1.0E-04	1.8E+02	3.3E+00	1.8E+00	3.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	2.8E+02	1.0E+00
42	1.0E-04	1.0E-04	1.0E-04	6.1E+02	9.4E+00	5.8E+00	1.8E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	4.9E+02	1.0E+00
43	1.0E-04	1.0E-04	1.0E-04	6.1E+02	9.4E+00	5.8E+00	1.8E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	4.9E+02	1.0E+00
48	1.0E-04	1.0E-04	1.0E-04	1.8E+02	3.3E+00	1.8E+00	3.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	2.8E+02	1.0E+00
49	1.0E-04	1.0E-04	1.0E-04	1.8E+02	3.3E+00	1.8E+00	3.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	2.8E+02	1.0E+00
50	1.0E-04	1.0E-04	1.0E-04	1.8E+02	3.3E+00	1.8E+00	3.6E+01	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	2.8E+02	1.0E+00
51	1.0E-04	1.0E-04	1.0E-04	6.1E+02	9.4E+00	5.8E+00	1.8E+02	1.0E+00	1.0E-04	1.0E-04	1.0E-04	1.0E+00	4.9E+02	1.0E+00

Table 3.1-2: HTF Estimated Radiological Inventory (Ci) at Closure (2032) (Continued)

Tank	Sr-90	Tc-99	Th-229	Th-230	Th-232	U-232	U-233	U-234	U-235	U-236	U-238	Y-90	Zr-93
9	2.5E+03	2.7E+00	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.3E-02	1.8E-03	1.0E-03	1.0E+00	1.8E-03	2.5E+03	7.5E-02
10	2.5E+03	2.7E+00	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.3E-02	1.8E-03	1.0E-03	1.0E+00	1.8E-03	2.5E+03	7.5E-02
11	5.2E+03	3.4E+00	1.3E-03	1.0E-03	1.7E-02	1.0E-03	4.5E-02	5.6E-03	1.3E-03	1.0E+00	1.6E-03	5.2E+03	1.6E-01
12	5.2E+03	3.4E+00	1.3E-03	1.0E-03	1.7E-02	1.0E-03	4.5E-02	5.6E-03	1.3E-03	1.0E+00	1.6E-03	5.2E+03	1.6E-01
13	5.2E+03	3.4E+00	1.3E-03	1.0E-03	1.7E-02	1.0E-03	4.5E-02	5.6E-03	1.3E-03	1.0E+00	1.6E-03	5.2E+03	1.6E-01
14	5.2E+03	3.4E+00	1.3E-03	1.0E-03	1.7E-02	1.0E-03	4.5E-02	5.6E-03	1.3E-03	1.0E+00	1.6E-03	5.2E+03	1.6E-01
15	5.2E+03	3.4E+00	1.3E-03	1.0E-03	1.7E-02	1.0E-03	4.5E-02	5.6E-03	1.3E-03	1.0E+00	1.6E-03	5.2E+03	1.6E-01
16	5.2E+02	3.4E-01	1.0E-04	1.0E-04	1.7E-03	1.0E-04	2.0E-03	5.6E-04	1.0E-04	1.0E+00	1.0E-04	5.2E+02	1.6E-02
21	8.9E+02	3.5E-01	1.0E-03	1.0E-03	1.0E-03	1.0E-03	4.1E-03	3.2E-03	1.0E-03	1.0E+00	1.0E-03	8.9E+02	2.7E-02
22	8.9E+02	3.5E-01	1.0E-03	1.0E-03	1.0E-03	1.0E-03	4.1E-03	3.2E-03	1.0E-03	1.0E+00	1.0E-03	8.9E+02	2.7E-02
23	8.9E+02	3.5E-01	1.0E-03	1.0E-03	1.0E-03	1.0E-03	4.1E-03	3.2E-03	1.0E-03	1.0E+00	1.0E-03	8.9E+02	2.7E-02
24	8.9E+03	3.5E+00	1.0E-03	1.0E-03	1.0E-03	1.0E-03	4.1E-02	3.2E-02	1.0E-03	1.0E+00	5.0E-03	8.9E+03	2.7E-02
29	1.0E+03	5.4E-01	1.0E-04	1.0E-04	1.7E-04	1.0E-04	3.5E-03	5.9E-04	1.3E-04	1.0E+00	1.6E-04	1.0E+03	3.2E-02
30	1.0E+03	5.4E-01	1.0E-04	1.0E-04	1.7E-04	1.0E-04	3.5E-03	5.9E-04	1.3E-04	1.0E+00	1.6E-04	1.0E+03	3.2E-02
31	1.0E+03	5.4E-01	1.0E-04	1.0E-04	1.7E-04	1.0E-04	3.5E-03	5.9E-04	1.3E-04	1.0E+00	1.6E-04	1.0E+03	3.2E-02
32	1.5E+03	7.2E-01	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-03	9.5E-04	1.6E-04	1.0E+00	1.0E-04	1.5E+03	4.6E-02
35	1.0E+03	5.4E-01	1.0E-04	1.0E-04	1.7E-04	1.0E-04	3.5E-03	5.9E-04	1.3E-04	1.0E+00	1.6E-04	1.0E+03	3.2E-02
36	1.0E+03	5.4E-01	1.0E-04	1.0E-04	1.7E-04	1.0E-04	3.5E-03	5.9E-04	1.3E-04	1.0E+00	1.6E-04	1.0E+03	3.2E-02
37	1.0E+03	5.4E-01	1.0E-04	1.0E-04	1.7E-04	1.0E-04	3.5E-03	5.9E-04	1.3E-04	1.0E+00	1.6E-04	1.0E+03	3.2E-02
38	3.8E+02	2.0E-01	1.0E-04	1.0E-04	3.6E-04	1.0E-04	1.5E-03	7.8E-04	1.2E-04	1.0E+00	1.1E-04	3.8E+02	1.2E-02
39	7.5E+02	3.0E-01	1.0E-04	1.0E-04	5.5E-04	1.0E-04	1.6E-03	2.6E-03	4.1E-04	1.0E+00	1.2E-04	7.5E+02	2.3E-02
40	7.5E+02	3.0E-01	1.0E-04	1.0E-04	5.5E-04	1.0E-04	1.6E-03	2.6E-03	4.1E-04	1.0E+00	1.2E-04	7.5E+02	2.3E-02
41	3.8E+02	2.0E-01	1.0E-04	1.0E-04	3.6E-04	1.0E-04	1.5E-03	7.8E-04	1.2E-04	1.0E+00	1.1E-04	3.8E+02	1.2E-02
42	7.5E+02	3.0E-01	1.0E-04	1.0E-04	5.5E-04	1.0E-04	1.6E-03	2.6E-03	4.1E-04	1.0E+00	1.2E-04	7.5E+02	2.3E-02
43	7.5E+02	3.0E-01	1.0E-04	1.0E-04	5.5E-04	1.0E-04	1.6E-03	2.6E-03	4.1E-04	1.0E+00	1.2E-04	7.5E+02	2.3E-02
48	3.8E+02	2.0E-01	1.0E-04	1.0E-04	3.6E-04	1.0E-04	1.5E-03	7.8E-04	1.2E-04	1.0E+00	1.1E-04	3.8E+02	1.2E-02
49	3.8E+02	2.0E-01	1.0E-04	1.0E-04	3.6E-04	1.0E-04	1.5E-03	7.8E-04	1.2E-04	1.0E+00	1.1E-04	3.8E+02	1.2E-02
50	3.8E+02	2.0E-01	1.0E-04	1.0E-04	3.6E-04	1.0E-04	1.5E-03	7.8E-04	1.2E-04	1.0E+00	1.1E-04	3.8E+02	1.2E-02
51	7.5E+02	3.0E-01	1.0E-04	1.0E-04	5.5E-04	1.0E-04	1.6E-03	2.6E-03	4.1E-04	1.0E+00	1.2E-04	7.5E+02	2.3E-02

Table 3.1-3: HTF Estimated Non-Radiological Inventory (kg) at Closure (2032)

Tank	Ag	As	Ba	Cd	Cr	Cu	F	Fe	Hg
9	3.3E+00	2.0E-02	4.1E+00	2.1E+00	3.9E+00	2.0E+00	4.6E+00	3.7E+02	1.7E+00
10	3.3E+00	2.0E-02	4.1E+00	2.1E+00	3.9E+00	2.0E+00	4.6E+00	3.7E+02	1.7E+00
11	1.3E+00	7.2E-02	1.2E+01	7.6E+00	8.7E+00	3.0E+00	4.5E+00	1.8E+03	1.7E+02
12	1.3E+00	7.2E-02	1.2E+01	7.6E+00	8.7E+00	3.0E+00	4.5E+00	1.8E+03	1.7E+02
13	1.3E+00	7.2E-02	1.2E+01	7.6E+00	8.7E+00	3.0E+00	4.5E+00	1.8E+03	1.7E+02
14	1.3E+00	7.2E-02	1.2E+01	7.6E+00	8.7E+00	3.0E+00	4.5E+00	1.8E+03	1.7E+02
15	1.3E+00	7.2E-02	1.2E+01	7.6E+00	8.7E+00	3.0E+00	4.5E+00	1.8E+03	1.7E+02
16	1.3E-01	5.2E-03	3.9E-01	5.5E-01	4.8E-01	1.4E-01	4.0E-01	3.6E+01	1.2E+01
21	1.3E+00	1.4E-02	2.1E+00	1.5E+00	3.5E+00	4.1E-01	4.4E+00	4.2E+02	3.1E+01
22	1.3E+00	1.4E-02	2.1E+00	1.5E+00	3.5E+00	4.1E-01	4.4E+00	4.2E+02	3.1E+01
23	1.3E+00	1.4E-02	2.1E+00	1.5E+00	3.5E+00	4.1E-01	4.4E+00	4.2E+02	3.1E+01
24	1.3E+00	1.4E-02	1.8E-03	1.5E+00	3.5E+00	4.1E-01	4.4E+00	4.2E+02	3.1E+01
29	1.3E-01	8.3E-03	1.2E+00	8.8E-01	1.6E+00	4.4E-01	1.4E+00	1.8E+02	3.8E+01
30	1.3E-01	8.3E-03	1.2E+00	8.8E-01	1.6E+00	4.4E-01	1.4E+00	1.8E+02	3.8E+01
31	1.3E-01	8.3E-03	1.2E+00	8.8E-01	1.6E+00	4.4E-01	1.4E+00	1.8E+02	3.8E+01
32	1.3E-01	9.4E-03	1.1E+00	9.9E-01	1.6E+00	4.4E-01	1.4E+00	8.3E+01	3.8E+01
35	1.3E-01	8.3E-03	1.2E+00	8.8E-01	1.6E+00	4.4E-01	1.4E+00	1.8E+02	3.8E+01
36	1.3E-01	8.3E-03	1.2E+00	8.8E-01	1.6E+00	4.4E-01	1.4E+00	1.8E+02	3.8E+01
37	1.3E-01	8.3E-03	1.2E+00	8.8E-01	1.6E+00	4.4E-01	1.4E+00	1.8E+02	3.8E+01
38	1.3E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	1.8E-01	3.5E-01	6.2E+01	1.1E+01
39	3.6E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	2.5E-01	3.7E-01	6.8E+01	1.2E+01
40	3.6E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	2.5E-01	3.7E-01	6.8E+01	1.2E+01
41	1.3E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	1.8E-01	3.5E-01	6.2E+01	1.1E+01
42	3.6E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	2.5E-01	3.7E-01	6.8E+01	1.2E+01
43	3.6E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	2.5E-01	3.7E-01	6.8E+01	1.2E+01
48	1.3E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	1.8E-01	3.5E-01	6.2E+01	1.1E+01
49	1.3E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	1.8E-01	3.5E-01	6.2E+01	1.1E+01
50	1.3E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	1.8E-01	3.5E-01	6.2E+01	1.1E+01
51	3.6E-01	9.4E-03	5.3E-01	9.9E-01	5.6E-01	2.5E-01	3.7E-01	6.8E+01	1.2E+01

Table 3.1-3: HTF Estimated Non-Radiological Inventory (kg) at Closure (2032) (Continued)

Tank	Mn	Ni	NO_2	NO_3	Pb	Sb	Se	U	Zn
9	3.6E+02	4.0E+01	6.6E+02	2.2E+01	4.8E+00	8.4E-01	1.6E-02	5.5E+00	3.8E+00
10	3.6E+02	4.0E+01	6.6E+02	2.2E+01	4.8E+00	8.4E-01	1.6E-02	5.5E+00	3.8E+00
11	3.0E+02	3.1E+01	1.5E+03	9.8E+01	3.0E+01	3.1E+00	5.8E-02	4.7E+00	2.5E+00
12	3.0E+02	3.1E+01	1.5E+03	9.8E+01	3.0E+01	3.1E+00	5.8E-02	4.7E+00	2.5E+00
13	3.0E+02	3.1E+01	1.5E+03	9.8E+01	3.0E+01	3.1E+00	5.8E-02	4.7E+00	2.5E+00
14	3.0E+02	3.1E+01	1.5E+03	9.8E+01	3.0E+01	3.1E+00	5.8E-02	4.7E+00	2.5E+00
15	3.0E+02	3.1E+01	1.5E+03	9.8E+01	3.0E+01	3.1E+00	5.8E-02	4.7E+00	2.5E+00
16	6.2E+00	2.5E-02	2.6E+00	9.5E+00	3.3E-01	2.2E-01	4.2E-03	5.9E-03	1.2E-01
21	1.4E+02	1.8E+01	3.0E+02	1.9E+01	6.9E+00	6.1E-01	1.2E-02	1.5E+00	1.2E+01
22	1.4E+02	1.8E+01	3.0E+02	1.9E+01	6.9E+00	6.1E-01	1.2E-02	1.5E+00	1.2E+01
23	1.4E+02	1.8E+01	3.0E+02	1.9E+01	6.9E+00	6.1E-01	1.2E-02	1.5E+00	1.2E+01
24	1.4E+02	1.8E+01	3.0E+02	1.9E+01	6.9E+00	6.1E-01	1.2E-02	1.5E+00	1.2E+01
29	2.6E+01	2.5E+00	6.7E+01	3.3E+01	3.0E+00	1.4E+00	2.7E+00	4.7E-01	4.2E-01
30	2.6E+01	2.5E+00	6.7E+01	3.3E+01	3.0E+00	1.4E+00	2.7E+00	4.7E-01	4.2E-01
31	2.6E+01	2.5E+00	6.7E+01	3.3E+01	3.0E+00	1.4E+00	2.7E+00	4.7E-01	4.2E-01
32	1.2E+01	1.9E+00	4.1E+01	3.3E+01	7.7E-01	4.0E-01	7.5E-03	2.9E-01	4.2E-01
35	2.6E+01	2.5E+00	6.7E+01	3.3E+01	3.0E+00	1.4E+00	2.7E+00	4.7E-01	4.2E-01
36	2.6E+01	2.5E+00	6.7E+01	3.3E+01	3.0E+00	1.4E+00	2.7E+00	4.7E-01	4.2E-01
37	2.6E+01	2.5E+00	6.7E+01	3.3E+01	3.0E+00	1.4E+00	2.7E+00	4.7E-01	4.2E-01
38	1.4E+01	1.8E+00	3.7E+01	8.3E+00	7.7E-01	4.0E-01	7.5E-03	2.9E-01	2.5E-01
39	1.4E+01	1.8E+00	5.5E+01	9.2E+00	9.1E-01	4.0E-01	7.5E-03	3.5E-01	3.9E-01
40	1.4E+01	1.8E+00	5.5E+01	9.2E+00	9.1E-01	4.0E-01	7.5E-03	3.5E-01	3.9E-01
41	1.4E+01	1.8E+00	3.7E+01	8.3E+00	7.7E-01	4.0E-01	7.5E-03	2.9E-01	2.5E-01
42	1.4E+01	1.8E+00	5.5E+01	9.2E+00	9.1E-01	4.0E-01	7.5E-03	3.5E-01	3.9E-01
43	1.4E+01	1.8E+00	5.5E+01	9.2E+00	9.1E-01	4.0E-01	7.5E-03	3.5E-01	3.9E-01
48	1.4E+01	1.8E+00	3.7E+01	8.3E+00	7.7E-01	4.0E-01	7.5E-03	2.9E-01	2.5E-01
49	1.4E+01	1.8E+00	3.7E+01	8.3E+00	7.7E-01	4.0E-01	7.5E-03	2.9E-01	2.5E-01
50	1.4E+01	1.8E+00	3.7E+01	8.3E+00	7.7E-01	4.0E-01	7.5E-03	2.9E-01	2.5E-01
51	1.4E+01	1.8E+00	5.5E+01	9.2E+00	9.1E-01	4.0E-01	7.5E-03	3.5E-01	3.9E-01

4.0 ANCILLARY EQUIPMENT

Ancillary equipment includes transfer lines, transfer line secondary containment, pump Ancillary equipment includes transfer lines, transfer line secondary containment, pump tanks, PPs, a catch tank, DBs, valve boxes, and the evaporator systems. Over the operating life of the facility, radioactive waste comes in physical contact with some of these components, leaving behind varying degrees of contamination depending on the service life of the component, the material of construction, and the type of waste in contact with the component. Components that directly contacted waste material have an estimated modeling inventory and are as follows:

1. Transfer lines
2. Pump tanks
3. CTS tanks
4. Evaporator vessels

Other ancillary equipment, such as transfer line secondary containment, PPs, HTF catch tank, DBs, and valve boxes were not considered as part of the source term for the PA modeling.

The initial estimates of each tank are used to establish the characterization of the residual material in the ancillary equipment. [SRR-LWE-2009-00014] The results of a review of waste transfers within HTF and between F-Tank Farm (FTF) and HTF were sorted to determine the percent of the volume of all waste transfers that can be attributed to each HTF waste tank. The representative concentration was then determined by applying a weighted average to each radiological distribution in the HTF tanks. Because the characterization of dry sludge was used for each tank for conservatism, it was assumed that the sludge would have to be slurried in order to remove it from the tanks through the ancillary equipment. It is important to note that, while the sludge concentrations were used, dry sludge is only a small portion of the total waste that passes through the transfer lines that are routinely flushed with a high volume of supernate. Using the dry sludge concentrations provided a conservative representation of the actinides and long-lived isotopes. The short-lived radionuclides, which are more concentrated in the supernate than the sludge, will have decayed significantly during the 100 year active institutional control period.

The Technical Safety Requirements (TSR) limit waste transfers to less than or equal to 16.7 wt% solids and operational conditions are typically well below TSR limits. [S-TSR-G-00001] Conservatively, the slurry concentration was reduced to 20% of the dry sludge concentration. As part of this document, the weighted concentrations of radiological and non-radiological constituents in the slurried sludge were developed and are presented in Tables 4.0-1 and 4.0-2, respectively.

Table 4.0-1: Representative Radiological Concentrations of Sludge Slurry

Radionuclide	Concentration (Ci/gal)	Radionuclide	Concentration (Ci/gal)	Radionuclide	Concentration (Ci/gal)
Ac-227	8.0E-12	**Eu-152**	2.8E-04	**Ra-226**	7.9E-12
Al-26	2.7E-07	**Eu-154**	5.0E-03	**Ra-228**	6.1E-09
Am-241	1.1E-02	**H-3**	1.2E-05	**Se-79**	8.6E-05
Am-242m	9.2E-06	**I-129**	7.2E-09	**Sm-151**	1.6E-01
Am-243	4.4E-05	**K-40**	9.3E-08	**Sn-126**	1.0E-04
Ba-137m	1.5E-01	**Nb-94**	3.2E-08	**Sr-90**	2.3E+00
C-14	1.2E-07	**Ni-59**	1.4E-04	**Tc-99**	1.5E-03
Cf-249	1.9E-15	**Ni-63**	1.0E-02	**Th-229**	3.2E-08
Cf-251	6.8E-17	**Np-237**	6.0E-06	**Th-230**	9.7E-10
Cl-36	9.3E-08	**Pa-231**	4.7E-11	**Th-232**	1.0E-07
Cm-243	1.0E-06	**Pd-107**	9.3E-08	**U-232**	1.2E-08
Cm-244	9.2E-04	**Pt-193**	9.3E-08	**U-233**	1.3E-05
Cm-245	3.7E-07	**Pu-238**	8.5E-02	**U-234**	3.6E-06
Cm-247	3.5E-16	**Pu-239**	1.3E-03	**U-235**	7.4E-08
Cm-248	3.6E-16	**Pu-240**	7.4E-04	**U-236**	5.0E-07
Co-60	3.7E-08	**Pu-241**	1.4E-02	**U-238**	6.4E-07
Cs-135	1.5E-06	**Pu-242**	2.0E-06	**Y-90**	2.3E+00
Cs-137	1.6E-01	**Pu-244**	9.0E-09	**Zr-93**	6.9E-05

Table 4.0-2: Representative Non-Radiological Concentrations of Sludge Slurry

Chemical	Concentration (kg/gal)
Ag	1.2E-04
As	3.6E-06
Ba	5.5E-04
Cd	3.6E-04
Cr	4.7E-04
Cu	1.5E-04
F	2.4E-04
Fe	7.9E-02
Hg	9.5E-03
Mn	1.4E-02
Ni	1.7E-03
NO2	3.4E-02
NO3	5.3E-03
Pb	1.3E-03
Sb	2.0E-04
Se	1.1E-04
U	1.9E-03
Zn	1.9E-04

4.1 Transfer Line Inventory

The amount of residual material in the piping systems was determined analytically. [CBU-PIT-2005-00120] The methodology in the referenced document was used for transfer lines. These conditions provide conservatism to these estimates. Diffusion calculations assume a 100 year contact time and a 100°C exposure temperature. Appendix B of CBU-PIT-2005-00120 describes the methodology in which diffusion estimates are made.

4.1.1 Estimation of Residue in Transfer Line Systems

A list of transfer lines in the tank farm are identified in the HTF ancillary equipment input package. The list documents the pipe diameter, material of construction, and the core pipe dimensions. The inventory of residue in the transfer lines is the sum of:

1. Residue by diffusion into metal
2. Residue in the oxide film formed on the carbon steel and the stainless steel
3. Residue of particles remaining after the transfer lines are flushed

4.1.1.1 Residue Diffusion into Metal

Diffusion is the technique for carburizing and nitriding of metals; and therefore is a known industrial transport phenomenon. CBU-PIT-2005-00120 describes the derivation of the diffusion correlations.

4.1.1.2 Estimation of Diffusion of Isotopes into Carbon and Stainless Steels

A standard methodology for estimating the migration of radionuclides into carbon and stainless steel, CBU-PIT-2005-00120 demonstrates that Fick's Second Law of Diffusion can be used to calculate diffusion in metal. The results of the diffusion calculation are shown in Tables 4.1-1 and 4.1-2.

Table 4.1-1: Radiological Surface Concentration by Diffusion into Metal

Radionuclide	Diffusion Coefficient (cm^2/sec)		Surface Concentration (Ci/ft^2)	
	Carbon Steel	Stainless	Carbon Steel	Stainless
Ac-227	5.3E-43	1.9E-49	9.5E-30	5.6E-33
Al-26	5.5E-23	7.1E-35	3.3E-15	3.7E-21
Am-241	3.3E-44	1.0E-49	3.3E-21	5.7E-24
Am-242m	3.3E-44	1.0E-49	2.7E-24	4.7E-27
Am-243	3.3E-44	1.0E-49	1.3E-23	2.3E-26
Ba-137m	2.5E-35	6.5E-47	1.2E-15	1.9E-21
C-14	1.5E-17	1.8E-21	7.2E-13	7.9E-15
Cf-249	8.6E-45	7.6E-50	2.9E-34	8.6E-37
Cf-251	8.6E-45	7.6E-50	1.0E-35	3.0E-38
Cl-36	1.2E-25	2.4E-37	5.3E-17	7.4E-23
Cm-243	2.1E-44	9.1E-50	2.4E-25	5.1E-28
Cm-244	2.1E-44	9.1E-50	2.2E-22	4.5E-25
Cm-245	2.1E-44	9.1E-50	8.6E-26	1.8E-28
Cm-247	2.1E-44	9.1E-50	8.2E-35	1.7E-37
Cm-248	2.1E-44	9.1E-50	8.6E-35	1.8E-37
Co-60	2.6E-36	2.4E-43	9.5E-23	2.9E-26
Cs-135	4.7E-35	8.5E-47	1.6E-20	2.2E-26
Cs-137	4.7E-35	8.5E-47	1.7E-15	2.3E-21
Eu-152	3.8E-37	1.2E-47	2.8E-19	1.6E-24
Eu-154	3.8E-37	1.2E-47	4.9E-18	2.8E-23
H-3	9.7E-08	1.5E-09	5.8E-06	7.2E-07
I-129	1.7E-34	1.5E-46	1.5E-22	1.4E-28
K-40	1.0E-26	2.4E-38	1.5E-17	2.3E-23
Nb-94	3.0E-34	1.0E-44	9.1E-22	5.3E-27
Ni-59	2.0E-33	4.3E-40	1.0E-17	4.8E-21
Ni-63	2.0E-33	4.3E-40	7.4E-16	3.4E-19
Np-237	8.3E-44	1.2E-49	2.8E-24	3.4E-27
Pa-231	2.1E-43	1.5E-49	3.5E-29	2.9E-32

Table 4.1-1: Radiological Surface Concentration by Diffusion into Metal (Continued)

Radionuclide	Diffusion Coefficient (cm^2/sec)		Surface Concentration (Ci/ft^2)	
	Carbon Steel	Stainless	Carbon Steel	Stainless
Pd-107	1.9E-32	1.4E-45	2.1E-20	5.7E-27
Pt-193	1.1E-40	7.7E-49	1.6E-24	1.3E-28
Pu-238	5.2E-44	1.1E-49	3.2E-20	4.6E-23
Pu-239	5.2E-44	1.1E-49	4.7E-22	6.8E-25
Pu-240	5.2E-44	1.1E-49	2.7E-22	4.0E-25
Pu-241	5.2E-44	1.1E-49	5.2E-21	7.6E-24
Pu-242	5.2E-44	1.1E-49	7.3E-25	1.1E-27
Pu-244	5.2E-44	1.1E-49	3.4E-27	4.9E-30
Ra-226	8.6E-43	2.1E-49	1.2E-29	5.8E-33
Ra-228	8.6E-43	2.1E-49	9.1E-27	4.5E-30
Se-79	2.0E-32	2.8E-43	2.0E-17	7.3E-23
Sm-151	6.7E-37	1.5E-47	2.1E-16	1.0E-21
Sn-126	1.2E-33	3.7E-46	5.6E-18	3.1E-24
Sr-90	1.6E-33	3.8E-44	1.5E-13	7.2E-19
Tc-99	1.7E-31	4.4E-45	9.7E-16	1.6E-22
Th-229	3.3E-43	1.7E-49	3.0E-26	2.1E-29
Th-230	3.3E-43	1.7E-49	9.1E-28	6.4E-31
Th-232	3.3E-43	1.7E-49	9.4E-26	6.6E-29
U-232	1.3E-43	1.3E-49	7.1E-27	7.2E-30
U-233	1.3E-43	1.3E-49	7.5E-24	7.5E-27
U-234	1.3E-43	1.3E-49	2.1E-24	2.1E-27
U-235	1.3E-43	1.3E-49	4.3E-26	4.4E-29
U-236	1.3E-43	1.3E-49	2.9E-25	3.0E-28
U-238	1.3E-43	1.3E-49	3.8E-25	3.8E-28
Y-90	9.1E-34	2.4E-44	1.1E-13	5.7E-19
Zr-93	5.2E-34	1.5E-44	2.5E-18	1.4E-23

Table 4.1-2: Non-Radiological Surface Concentration by Diffusion into Metal

Chemical	Diffusion Coefficient (cm^2/sec)		Surface Concentration (kg/ft^2)	
	Carbon Steel	Stainless	Carbon Steel	Stainless
Ag	9.4E-33	1.0E-45	1.9E-17	6.1E-24
As	3.9E-32	4.8E-43	1.2E-18	4.0E-24
Ba	2.5E-35	6.5E-47	4.5E-18	7.2E-24
Cd	4.7E-33	7.2E-46	4.0E-17	1.6E-23
Cr	5.1E-29	2.2E-40	5.5E-15	1.1E-20
Cu	7.2E-31	5.4E-42	2.1E-16	5.8E-22
F	2.3E-19	2.1E-31	1.9E-10	1.8E-16
Fe	8.4E-30	4.5E-41	3.7E-13	8.6E-19
Hg	4.2E-41	5.8E-49	9.9E-20	1.2E-23
Mn	2.0E-29	9.6E-41	1.0E-13	2.2E-19
Ni	1.6E-30	1.1E-41	3.5E-15	9.1E-21
NO_2	7.2E-17	5.7E-29	4.7E-07	4.2E-13
NO_3	7.2E-17	5.7E-29	7.2E-08	6.4E-14
Pb	1.6E-41	4.4E-49	8.0E-21	1.3E-24
Sb	6.2E-34	2.7E-46	7.9E-18	5.3E-24
Se	2.0E-32	2.8E-43	2.5E-17	9.3E-23
U	1.3E-43	1.3E-49	1.1E-21	1.1E-24
Zn	3.3E-31	2.9E-42	1.8E-16	5.3E-22

4.1.1.3 Residue in the Oxide Film

Stainless and carbon steels form an oxide film, which provides corrosion protection. Diffusion data of the isotopes into the films is sparse; therefore, a conservative assumption was used to equate the isotopic and chemical concentration of the layer equivalent to that of slurry with 20 wt% solids. The oxide film thicknesses for the two metals are:

Stainless Steel: 10 μm (thickness is used for a conservative estimate). [CBU-PIT-2005-00120]

Carbon Steel: 0.018 inches (the thickness of rust from 100 years of accumulation on the pipe walls at a rate of approximately 0.9 mil/5 yrs). [SRT-MTS-2002-20004]

Therefore, the specific volume of oxide for 304L stainless steel was found to be approximately 2.5E-04 gal/ft^2; the specific volume for carbon steel was found to be approximately 1.1E-02 gal/ft^2. Tables 4.1-3 and 4.1-4 present the results of multiplying by these volumetric terms and the slurry concentrations in Tables 4.0-1 and 4.0-2.

Table 4.1-3: Radiological Surface Concentration in the Oxide Layer

Radionuclide	Carbon Steel (Ci/ ft^2)	Stainless Steel (Ci/ ft^2)	Radionuclide	Carbon Steel (Ci/ ft^2)	Stainless Steel (Ci/ ft^2)
Ac-227	9.0E-14	2.0E-15	**Pa-231**	5.2E-13	1.1E-14
Al-26	3.1E-09	6.7E-11	**Pd-107**	1.0E-09	2.3E-11
Am-241	1.2E-04	2.7E-06	**Pt-193**	1.0E-09	2.3E-11
Am-242m	1.0E-07	2.3E-09	**Pu-238**	9.6E-04	2.1E-05
Am-243	5.0E-07	1.1E-08	**Pu-239**	1.4E-05	3.1E-07
Ba-137m	1.6E-03	3.6E-05	**Pu-240**	8.3E-06	1.8E-07
C-14	1.3E-09	2.8E-11	**Pu-241**	1.6E-04	3.4E-06
Cf-249	2.2E-17	4.7E-19	**Pu-242**	2.2E-08	4.9E-10
Cf-251	7.6E-19	1.7E-20	**Pu-244**	1.0E-10	2.2E-12
Cl-36	1.0E-09	2.3E-11	**Ra-226**	8.8E-14	1.9E-15
Cm-243	1.2E-08	2.6E-10	**Ra-228**	6.8E-11	1.5E-12
Cm-244	1.0E-05	2.3E-07	**Se-79**	9.6E-07	2.1E-08
Cm-245	4.1E-09	9.0E-11	**Sm-151**	1.8E-03	3.9E-05
Cm-247	3.9E-18	8.6E-20	**Sn-126**	1.1E-06	2.5E-08
Cm-248	4.1E-18	8.9E-20	**Sr-90**	2.6E-02	5.6E-04
Co-60	4.1E-10	9.0E-12	**Tc-99**	1.6E-05	3.6E-07
Cs-135	1.6E-08	3.6E-10	**Th-229**	3.5E-10	7.7E-12
Cs-137	1.7E-03	3.8E-05	**Th-230**	1.1E-11	2.4E-13
Eu-152	3.1E-06	6.9E-08	**Th-232**	1.1E-09	2.5E-11
Eu-154	5.6E-05	1.2E-06	**U-232**	1.4E-10	3.0E-12
H-3	1.3E-07	2.8E-09	**U-233**	1.4E-07	3.1E-09
I-129	8.1E-11	1.8E-12	**U-234**	4.0E-08	8.7E-10
K-40	1.0E-09	2.3E-11	**U-235**	8.3E-10	1.8E-11
Nb-94	3.6E-10	8.0E-12	**U-236**	5.6E-09	1.2E-10
Ni-59	1.6E-06	3.5E-08	**U-238**	7.2E-09	1.6E-10
Ni-63	1.1E-04	2.5E-06	**Y-90**	2.6E-02	5.6E-04
Np-237	6.7E-08	1.5E-09	**Zr-93**	7.8E-07	1.7E-08

Table 4.1-4: Non-Radiological Surface Concentration in the Oxide Layer

Chemical	Carbon Steel (kg/ft^2)	Stainless Steel (kg/ft^2)
Ag	1.3E-06	2.9E-08
As	4.0E-08	8.8E-10
Ba	6.2E-06	1.4E-07
Cd	4.0E-06	8.8E-08
Cr	5.3E-06	1.2E-07
Cu	1.7E-06	3.8E-08
F	2.7E-06	5.9E-08
Fe	8.9E-04	1.9E-05
Hg	1.1E-04	2.3E-06
Mn	1.6E-04	3.4E-06
Ni	1.9E-05	4.2E-07
NO2	3.8E-04	8.4E-06
NO3	5.9E-05	1.3E-06
Pb	1.4E-05	3.1E-07
Sb	2.2E-06	4.8E-08
Se	1.2E-06	2.7E-08
U	2.2E-05	4.7E-07
Zn	2.2E-06	4.7E-08

4.1.1.4 Residue of Particles After Flushing

The transfer line core piping is flushed three times the line volume following transfers as normal operating procedure. By performance of a mass balance, the waste concentrations follow an exponential decay curve with respect to time. [HLW-STE-99-0023]

$$C(t) = C_o e^{-Qt/V} \quad (1)$$

Where:

Q = *Volumetric flow rate*
V = *Volume of liquid*
t = *time*

Let F equal the number of flush volumes (3), and since $Q = V/t$, the previous equation becomes,

$$C = C_o e^{-F} \quad (2)$$

Where C_O is the initial concentration and F is the number of flush volumes. In this case, $F = 3$ for the number of volumes.

On a per area basis, the following equation applies:

Unit Volume/Unit Area = $\pi (d/2)^2 / \pi d = d/4$

*Surface Area Concentration (*Ci/ft^2 *or* kg/ft^2) =

C (Ci/gal or kg/gal) x (7.48 gallons/ft^3) x d/4 x (1 ft/12 in)

Or

$$C_{per\ unit\ area} = 0.156\ C\ d \qquad (3)$$

Where C is concentration in Ci/gal or kg/gal and d is pipe diameter in inches.

Tables 4.1-5 and 4.1-6 present the remaining surface concentration following three flush volumes.

The gravity drain lines (GDLs) leading from the evaporators to the waste tanks have been plugged with salt waste in the past. However, they have been easily cleaned and are expected to be at least as clean as the bulk waste transfer lines after three volume flushes. For the purpose of this calculation of transfer line inventory, the GDLs are assumed to be the same as the bulk waste transfer lines.

Table 4.1-5: Radiological Surface Concentration by Residue After Three Volume Flush

Radionuclide	Core Pipe Size			Radionuclide	Core Pipe Size		
	2-inch (Ci/ ft^2)	3-inch (Ci/ ft^2)	4-inch (Ci/ ft^2)		2-inch (Ci/ ft^2)	3-inch (Ci/ ft^2)	4-inch (Ci/ ft^2)
Ac-227	1.3E-13	1.9E-13	2.5E-13	Pa-231	7.5E-13	1.1E-12	1.5E-12
Al-26	4.4E-09	6.5E-09	8.6E-09	Pd-107	1.5E-09	2.2E-09	2.9E-09
Am-241	1.8E-04	2.7E-04	3.5E-04	Pt-193	1.5E-09	2.2E-09	2.9E-09
Am-242m	1.5E-07	2.2E-07	2.9E-07	Pu-238	1.4E-03	2.0E-03	2.7E-03
Am-243	7.1E-07	1.1E-06	1.4E-06	Pu-239	2.0E-05	3.0E-05	3.9E-05
Ba-137m	2.4E-03	3.5E-03	4.6E-03	Pu-240	1.2E-05	1.8E-05	2.3E-05
C-14	1.8E-09	2.7E-09	3.6E-09	Pu-241	2.3E-04	3.3E-04	4.4E-04
Cf-249	3.1E-17	4.6E-17	6.0E-17	Pu-242	3.2E-08	4.7E-08	6.2E-08
Cf-251	1.1E-18	1.6E-18	2.1E-18	Pu-244	1.5E-10	2.2E-10	2.8E-10
Cl-36	1.5E-09	2.2E-09	2.9E-09	Ra-226	1.3E-13	1.9E-13	2.5E-13
Cm-243	1.7E-08	2.5E-08	3.3E-08	Ra-228	9.7E-11	1.4E-10	1.9E-10
Cm-244	1.5E-05	2.2E-05	2.9E-05	Se-79	1.4E-06	2.0E-06	2.7E-06
Cm-245	5.9E-09	8.7E-09	1.1E-08	Sm-151	2.6E-03	3.8E-03	5.0E-03
Cm-247	5.6E-18	8.3E-18	1.1E-17	Sn-126	1.6E-06	2.4E-06	3.1E-06
Cm-248	5.8E-18	8.7E-18	1.1E-17	Sr-90	3.7E-02	5.5E-02	7.2E-02
Co-60	5.9E-10	8.7E-10	1.1E-09	Tc-99	2.3E-05	3.5E-05	4.6E-05
Cs-135	2.3E-08	3.5E-08	4.6E-08	Th-229	5.1E-10	7.5E-10	9.9E-10
Cs-137	2.5E-03	3.7E-03	4.8E-03	Th-230	1.6E-11	2.3E-11	3.0E-11
Eu-152	4.5E-06	6.7E-06	8.8E-06	Th-232	1.6E-09	2.4E-09	3.1E-09
Eu-154	8.0E-05	1.2E-04	1.6E-04	U-232	1.9E-10	2.9E-10	3.8E-10
H-3	1.9E-07	2.8E-07	3.6E-07	U-233	2.0E-07	3.0E-07	4.0E-07
I-129	1.2E-10	1.7E-10	2.2E-10	U-234	5.7E-08	8.5E-08	1.1E-07
K-40	1.5E-09	2.2E-09	2.9E-09	U-235	1.2E-09	1.8E-09	2.3E-09
Nb-94	5.2E-10	7.7E-10	1.0E-09	U-236	8.0E-09	1.2E-08	1.6E-08
Ni-59	2.3E-06	3.4E-06	4.4E-06	U-238	1.0E-08	1.5E-08	2.0E-08
Ni-63	1.6E-04	2.4E-04	3.2E-04	Y-90	3.7E-02	5.5E-02	7.2E-02
Np-237	9.5E-08	1.4E-07	1.9E-07	Zr-93	1.1E-06	1.6E-06	2.2E-06

Table 4.1-6: Non-Radiological Surface Concentration by Residue After Three Volume Flush

Chemical	Core Pipe Size		
	2 inch (kg/ft^2)	3 inch (kg/ft^2)	4 inch (kg/ft^2)
Ag	1.9E-06	2.8E-06	3.7E-06
As	5.8E-08	8.6E-08	1.1E-07
Ba	8.9E-06	1.3E-05	1.7E-05
Cd	5.7E-06	8.5E-06	1.1E-05
Cr	7.6E-06	1.1E-05	1.5E-05
Cu	2.5E-06	3.7E-06	4.8E-06
F	3.9E-06	5.7E-06	7.5E-06
Fe	1.3E-03	1.9E-03	2.5E-03
Hg	1.5E-04	2.3E-04	3.0E-04
Mn	2.2E-04	3.3E-04	4.3E-04
Ni	2.8E-05	4.1E-05	5.4E-05
NO_2	5.5E-04	8.1E-04	1.1E-03
NO_3	8.4E-05	1.3E-04	1.6E-04
Pb	2.0E-05	3.0E-05	3.9E-05
Sb	3.2E-06	4.7E-06	6.2E-06
Se	1.7E-06	2.6E-06	3.4E-06
U	3.1E-05	4.6E-05	6.0E-05
Zn	3.1E-06	4.6E-06	6.0E-06

The total affected surface area of the transfer lines is approximately 74,100 square feet. The HTF transfer line data was obtained from the Structural Integrity Database (M-ML-G-0005), an engineering database developed to help control and maintain the technical baseline of the Savannah River Site (SRS) facilities including HTF.

The total radiological (decayed to 2032) and non-radiological (chemical) inventories in the transfer lines using analytical methods are presented in Tables 4.1-7 and 4.1-8.

Table 4.1-7: Estimate of Residual Radioactivity in HTF Transfer Lines

Radionuclide	Remaining Curies	Radionuclide	Remaining Curies	Radionuclide	Remaining Curies
Ac-227	7.2E-09	Eu-152	1.6E-01	Ra-226	1.5E-08
Al-26	5.1E-04	Eu-154	1.4E+00	Ra-228	6.9E-07
Am-241	2.0E+01	H-3	2.7E-02	Se-79	1.6E-01
Am-242m	1.5E-02	I-129	1.3E-05	Sm-151	2.5E+02
Am-243	8.3E-02	K-40	1.7E-04	Sn-126	1.9E-01
Ba-137m	1.6E+02	Nb-94	6.1E-05	Sr-90	2.5E+03
C-14	2.2E-04	Ni-59	2.7E-01	Tc-99	2.5E+00
Cf-249	3.4E-12	Ni-63	1.6E+01	Th-229	5.9E-05
Cf-251	1.2E-13	Np-237	1.1E-02	Th-230	1.8E-06
Cl-36	1.7E-04	Pa-231	8.8E-08	Th-232	1.9E-04
Cm-243	1.1E-03	Pd-107	1.7E-04	U-232	1.8E-05
Cm-244	7.1E-01	Pt-193	1.3E-04	U-233	2.4E-02
Cm-245	6.8E-04	Pu-238	1.3E+02	U-234	6.7E-03
Cm-247	6.5E-13	Pu-239	2.4E+00	U-235	1.4E-04
Cm-248	6.8E-13	Pu-240	1.4E+00	U-236	9.3E-04
Co-60	3.2E-06	Pu-241	8.5E+00	U-238	1.2E-03
Cs-135	2.7E-03	Pu-242	3.7E-03	Y-90	2.5E+03
Cs-137	1.7E+02	Pu-244	1.7E-05	Zr-93	1.3E-01

Table 4.1-8: Estimate of Residual Chemicals in HTF Transfer Lines

Chemical	Remaining Kilograms	Chemical	Remaining Kilograms
Ag	2.2E-01	Mn	2.6E+01
As	6.8E-03	Ni	3.2E+00
Ba	1.0E+00	NO_2	6.4E+01
Cd	6.7E-01	NO_3	9.9E+00
Cr	8.9E-01	Pb	2.3E+00
Cu	2.9E-01	Sb	3.7E-01
F	4.5E-01	Se	2.0E-01
Fe	1.5E+02	U	3.6E+00
Hg	1.8E+01	Zn	3.6E-01

The majority of the contribution for the transfer line inventory is from the residue after flushing. To illustrate, Table 4.1-9 presents examples of the contribution from each transfer line inventory contributor.

Table 4.1-9: Distribution of Estimate Contributions

	Diffusion into Metal (Ci/ft^2)	% of Total	Residue in Oxide (Ci/ft^2)	% of Total	Particle Residues (Ci/ft^2)	% of Total
Cs-137	2.3E-21	4.7E-17	3.8E-05	0.77	4.9E-03	99
Np-237	3.4E-27	1.8E-18	1.5E-09	0.77	1.9E-07	99
Pu-238	4.6E-23	1.7E-18	2.1E-05	0.77	2.7E-03	99
Ra-226	5.8E-33	2.3E-18	1.9E-15	0.77	2.5E-13	99
Tc-99	1.6E-22	3.4E-16	3.6E-07	0.77	4.6E-05	99
U-234	2.1E-27	1.9E-18	8.7E-10	0.77	1.1E-07	99
U-238	3.8E-28	1.9E-18	1.6E-10	0.77	2.0E-08	99

4.2 Pump Tank and CTS Tank Inventory

Pump tanks differ from piping systems with respect to such features as geometry and usage. Only residue left behind after rinsing and flushing was considered for these components. After tanks are cleaned and inspected, it is expected that residual inventory will be very low. It is assumed that 0.0625 inch of residual material will remain in these vessels, consistent with the waste tank residual depth.

The material concentrations presented in Tables 4.0-1 and 4.0-2 were used to determine the residual inventory in pump tanks HPT-2 through HPT-10 (HTP-1 has been removed from HTF). All of these tanks are accessible for waste removal and cleaning. As described for the waste tanks, the residual for the nine pump tanks was estimated as 0.0625 inch of residue remaining on the floor of the tank. The diameter of the base of the pump tanks is 12 feet. The residue for each pump tank was therefore estimated at approximately 4.4 gallons each.

The HTF has two CTS tanks. The CTS tanks are comparable in capacity to the pump tanks, thus a similar residual inventory is expected. Therefore, the estimated inventory, decayed to 2032, was the same for each pump tank and each CTS tank as presented in Tables 4.2-1 and 4.2-2.

Table 4.2-1: Estimate of Residual Radioactivity in Each Pump Tank and CTS Tank

Radionuclide	HPT and CTS Residual (Ci)	Radionuclide	HPT and CTS Residual (Ci)
Ac-227	1.7E-11	Pa-231	2.1E-10
Al-26	1.2E-06	Pd-107	9.8E-05
Am-241	4.7E-02	Pt-193	1.4E-02
Am-242m	3.6E-05	Pu-238	3.1E-01
Am-243	2.0E-04	Pu-239	5.5E-03
Ba-137m	3.8E-01	Pu-240	3.2E-03
C-14	5.1E-07	Pu-241	2.0E-02
Cf-249	8.1E-15	Pu-242	8.7E-06
Cf-251	2.9E-16	Pu-244	4.0E-08
Cl-36	2.0E-04	Ra-226	3.4E-11
Cm-243	2.6E-06	Ra-228	1.6E-09
Cm-244	1.7E-03	Se-79	3.8E-04
Cm-245	1.6E-06	Sm-151	5.9E-01
Cm-247	1.5E-15	Sn-126	4.4E-04
Cm-248	1.6E-15	Sr-90	5.8E+00
Co-60	7.6E-09	Tc-99	6.4E-03
Cs-135	6.4E-06	Th-229	1.4E-07
Cs-137	4.0E-01	Th-230	4.3E-09
Eu-152	3.7E-04	Th-232	4.4E-07
Eu-154	3.4E-03	U-232	4.2E-08
H-3	1.4E-05	U-233	5.6E-05
I-129	3.2E-08	U-234	1.6E-05
K-40	1.8E-05	U-235	3.3E-07
Nb-94	1.4E-07	U-236	2.2E-06
Ni-59	6.3E-04	U-238	2.8E-06
Ni-63	3.8E-02	Y-90	5.8E+00
Np-237	2.6E-05	Zr-93	3.0E-04

Table 4.2-2: Estimate of Residual Chemicals in Each Pump Tank and CTS Tank

Chemical	HPT and CTS (kg)
Ag	5.2E-04
As	1.6E-05
Ba	2.4E-03
Cd	1.6E-03
Cr	2.1E-03
Cu	6.8E-04
F	1.1E-03
Fe	3.5E-01
Hg	4.2E-02
Mn	6.1E-02
Ni	7.6E-03
NO_2	1.5E-01
NO_3	2.3E-02
Pb	5.5E-03
Sb	8.7E-04
Se	4.8E-04
U	8.4E-03
Zn	8.5E-04

4.3 Evaporators

4.3.1 Evaporator System Inventory

Field characterization data for the FTF 242-F evaporator was used to estimate the residual material in each of the three evaporators in HTF. Samples were taken to estimate the characterization of residual solids for 242-F. Figure 4.3-1 indicates the location of the samples. Analytical results for the 242-F evaporator are shown in Tables 4.3-1 and 4.3-2. The HTF evaporators were assigned the same values as the 242-F evaporator.

A sample of the overheads was also taken during the heel removal campaign. Due to the low activity and low volume in the overheads and CTS tanks, compared to

evaporators, the inventory of the overheads was not included in the inventory. Residual liquids will be removed prior to closure.

Figure 4.3-1: 242-F Evaporator System Sample Locations

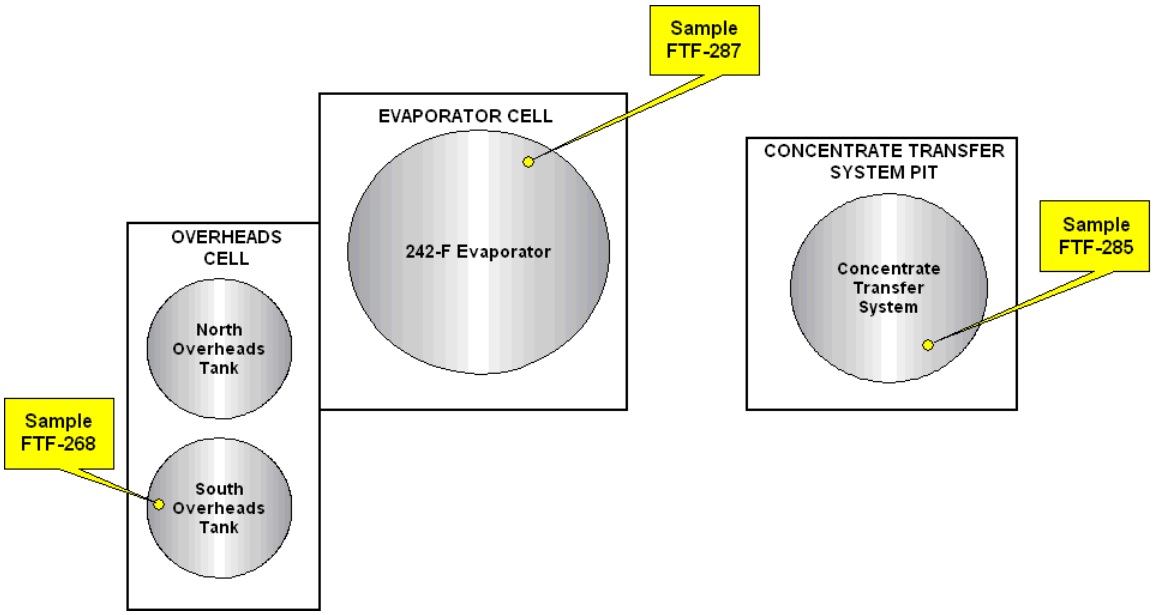


Table 4.3-1: Measured Radionuclide Concentrations in Samples

Radionuclide	Evaporator Sample FTF 287 ($\mu Ci/g$)
Am-241	4.41E+00
Co-60	1.33E+00
Cs-137	1.02E+03
H-3	<1.62E-02
Np-237	3.89E-03
Pu-238	5.74E+00
Pu-239	1.50E+01
Pu-240	3.32E+00
Pu-241	4.73E+01
Pu-242	<4.80E-03
Se-79	8.27E-06
Sr-90	5.95E+01
Tc-99	1.37E+00
U-233	<1.20E-02
U-234	<7.60E-03
U-235	8.72E-05
U-236	1.47E-04
U-238	8.05E-03

[CBU-LTS-2004-00078, Table 5-5]

Table 4.3-2: Measured Chemical Concentrations in Samples

Chemical	Evaporator Sample FTF 287 Wt%
Ag	2.33E-02
Ba	7.95E-02
Cd	3.19E-02
Cr	2.72E-01
Cu	8.96E-02
Fe	2.32E+01
Mn	9.31E-01
Ni	3.23E-01
Pb	1.74E-01
Sb	8.85E-02
U	2.40E+00
V	5.32E-03
Zn	2.98E-01
Hg	1.08E-01
As	<2.20E-03
Se	2.20E-03

[CBU-LTS-2004-00078, Table 5-13]

4.3.2 242-16H and 242-25H Evaporator & Vessel

The 242-16H and 242-25H evaporator cells and vessels remain operational. It is expected that the 242-16H and 242-25H evaporator systems will meet or exceed the decontamination levels achieved in the 242-F evaporator system. To support the PA modeling, the estimate of residues remaining in 242-F were used to estimate the residues that will remain in 242-16H and 242-25H at the time of closure.

The total remaining inventory for each evaporator vessel was estimated based on 0.3 gallons of sludge and a dry sludge density of 6.83 lb/gal. [CBU-LTS-2004-00078] The radiological (decayed to 2032) and non-radiological inventories are presented in Tables 4.3-3 and 4.3-4.

Table 4.3-3: Residual Radionuclide Inventory in Each Evaporator System

Radionuclide	Inventory in Evaporator Vessel (Ci)
Am-241	3.9E-03
Ba-137m	4.7E-01
Co-60	3.0E-05
Cs-137	5.0E-01
H-3	3.0E-06
Np-237	3.6E-06
Pu-238	4.3E-03
Pu-239	1.4E-02
Pu-240	3.1E-03
Pu-241	1.1E-02
Pu-242	4.5E-06
Se-79	7.7E-09
Sr-90	2.8E-02
Tc-99	1.3E-03
U-233	1.1E-05
U-234	7.1E-06
U-235	8.1E-08
U-236	1.4E-07
U-238	7.5E-06
Y-90	2.8E-02

Table 4.3-4: Residual Chemical Inventory in Each Evaporator System

Chemical	Inventory in Evaporator Vessel (kg)
Ag	2.2E-04
As	2.1E-05
Ba	7.4E-04
Cd	3.0E-04
Cr	2.5E-03
Cu	8.3E-04
Fe	2.2E-01
Hg	1.0E-03
Mn	8.7E-03
Ni	3.0E-03
Pb	1.6E-03
Sb	8.2E-04
Se	2.1E-05
U	2.2E-02
Zn	2.8E-03

4.3.3 242-H Evaporator and Vessel

The 242-H evaporator cell and vessel is non-operational. It is expected that the 242-H evaporator system will meet or exceed the decontamination levels achieved in the 242-F evaporator system. To support the PA modeling, the estimate of residues remaining in 242-F were used to estimate the residues that will remain in 242-H evaporator at the time of closure.

The total remaining inventory for the 242-H evaporator vessel is estimated based on 0.3 gallons of sludge and a dry sludge density of 6.83 lb/gal. [CBU-LTS-2004-00078] The inventory has been decayed to the expected year of closure, 2032, and is previously presented in Tables 4.3-3 and 4.3-4.

4.4 Other Ancillary Equipment

4.4.1 Pump Pits

The PPs are shielded reinforced concrete structures located below grade at the low points of transfer lines and are lined with stainless steel. These structures are secondary containments that house the pump tanks, and are accessible for cleaning at the time of closure. No inventory was assigned to these structures.

4.4.2 Catch Tank

There is a single catch tank in HTF designed to collect drainage from HDB-1 and the Type I tank transfer line encasements. These transfer lines run primarily from Tanks 9 through 16 to HDB-1 and HDB-2. The transfer line encasement slopes towards the catch tank to collect leakage from the transfer line core pipe and in-leakage from ground water. The catch tank is located west of HDB-1. No significant contamination has been collected in this waste tank and it was not modeled as a source for contamination in the HTF PA.

4.4.3 Diversion Boxes

The DBs are shielded reinforced concrete structures containing transfer line nozzles to which jumpers are connected in order to direct waste transfers to the desired location. The majority of DBs are located below ground and are either stainless steel lined or sealed with water proofing compounds to prevent ground contamination. These structures are accessible for cleaning at the time of closure. No inventory was assigned to these structures.

4.4.4 Valve Boxes

Transfer valve boxes facilitate specific waste transfers that are conducted frequently. The valves are generally manual ball valves in removable jumpers with flush water connections on the transfer lines. The valve boxes provide secondary containment. These structures are accessible for cleaning at the time of closure. No inventory was assigned to these structures.

5.0 DECAY DATE

The system plan calls for the last waste tank to be grouted at the end of fiscal year 2032. Therefore, all the radiological inventories have been decayed to 2032.

6.0 RESULTING ESTIMATES

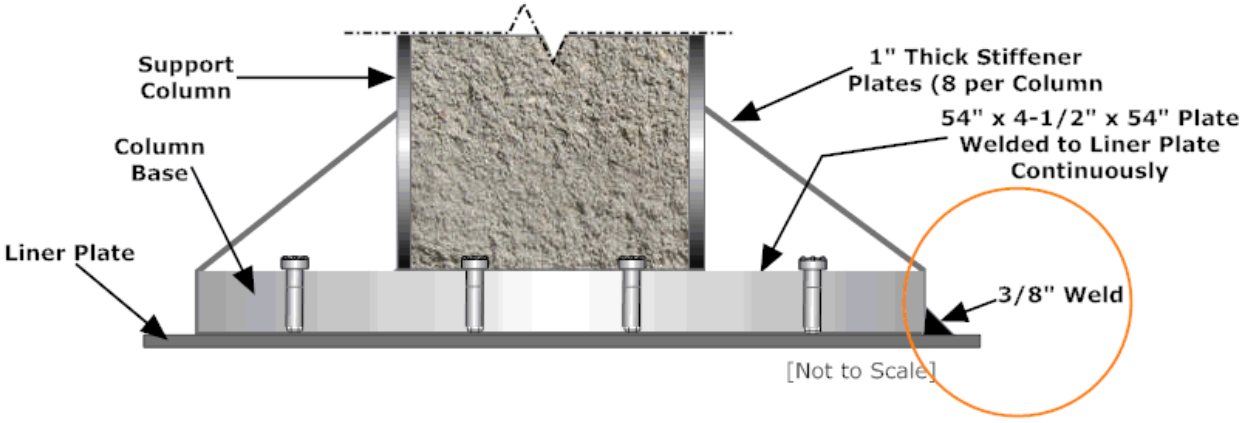
As noted previously, Table 3.1-2 provides the estimated radionuclide inventories for HTF developed using the processes described above. Table 3.1-3 provides the estimated non-radiological constituent inventory in the residual waste.

Table 2.3-1 provides the estimated radionuclide inventories within the Type II sand layers and annulus. Table 2.3-2 provides the estimate non-radiological inventories within Type II sand layers and annulus.

7.0 ESTIMATING RESIDUAL VOLUMES FOLLOWING CLEANING

After each waste tank is cleaned, the amount of residual material remaining is determined as follows. The current visual inspection (via remote video camera) technique using landmarks is assumed to be the method for determining the volume of residual material inside cleaned tanks in the future. The 0.375 inch weld at the base of the support columns in Type I tanks is an example of a landmark that may be used as a visual reference point to estimate the height of residual material (Figure 7.0-1).

Figure 7.0-1: Landmark for Visual Inspection - Type I Tank Support Column Base



[W145379]

Based on experience gained from visually inspecting the inside of waste tanks via remote video camera at SRS, it is estimated that the height of residual material on the bottom of a tank can be accurately measured to 0.0625 of an inch. If needed, additional landmark objects with known dimensions/markings may be placed in the tank to support accurate material height measurement by visual inspection techniques.

For the Type III and IIIA tanks, the amount of residual material was estimated at a height of 0.0625 inch.

For the Type I, II, and IV tanks, based on recent waste removal activities in Tanks 5 and 6, there is uncertainty around the projected inventories for the waste tanks remaining to

be cleaned. To account for this uncertainty and ensure that the PA would provide a reasonable conservative inventory projection, the 0.0625 inch level was adjusted by multiplying by a factor of 10.

The estimate of residual inventory was determined by applying a radiological or non-radiological (chemical) concentration to the assumed residual volume per tank. Following that determination, adjustments were made and are explained below.

8.0 INVENTORY ESTIMATE USE

The inventory estimates in Tables 3.1-2 and 3.1-3 are proposed for use in the current HTF PA modeling. In using these in the PA, it should be kept in mind that the curies of residual radionuclides and the kilograms of residual non-radiological waste constituents are important to the analyses, not the estimated residual waste volume. While the estimated solids volume is used to calculate the residual radiological and non-radiological waste constituent inventories, the volume estimate is not significant in its own right.

9.0 INTRUDER INVENTORY

For the intruder scenarios, an inventory was estimated using a tank from the Type I/II tank grouping represented by Tank 13, a Type IV tank represented by Tank 24, a 3-inch pipe, and a 4-inch pipe. The residual material was assumed to be uniformly distributed across the tank floor. The well diameter was assumed to be 8 inches. The inventories used for the well drilling scenarios are provided in Tables 9.0-1 and 9.0-2.

Table 9.0-1: HTF Intruder Radionuclide Inventories

Radionuclide	Tk 13 (Ci)	Tk 24 (Ci)	3 in. pipe (Ci)	4 in. pipe (Ci)	Radionuclide	Tk 13 (Ci)	Tk 24 (Ci)	3 in. pipe (Ci)	4 in. pipe (Ci)
Ac-227	6.2E-08	6.2E-08	5.9E-14	7.6E-14	**Pa-231**	6.2E-08	6.2E-08	7.2E-13	9.3E-13
Al-26	6.2E-05	6.2E-05	4.2E-09	5.5E-09	**Pd-107**	6.2E-08	6.2E-08	1.4E-09	1.8E-09
Am-241	1.3E-02	1.7E-03	1.7E-04	2.1E-04	**Pt-193**	6.2E-08	6.2E-08	1.0E-09	1.3E-09
Am-242m	6.2E-05	6.2E-05	1.3E-07	1.6E-07	**Pu-238**	8.9E-02	3.8E-02	1.1E-03	1.4E-03
Am-243	6.2E-05	6.2E-05	6.9E-07	8.8E-07	**Pu-239**	1.7E-03	1.9E-04	1.9E-05	2.5E-05
Ba-137m	1.7E-02	7.9E-01	1.3E-03	1.7E-03	**Pu-240**	9.4E-04	1.6E-04	1.1E-05	1.5E-05
C-14	6.2E-05	6.2E-05	1.8E-09	2.3E-09	**Pu-241**	1.0E-02	1.1E-02	7.0E-05	9.0E-05
Cf-249	6.2E-08	6.2E-08	2.8E-17	3.7E-17	**Pu-242**	6.2E-05	6.2E-05	3.1E-08	3.9E-08
Cf-251	6.2E-08	6.2E-08	1.0E-18	1.3E-18	**Pu-244**	6.2E-08	6.2E-08	1.4E-10	1.8E-10
Cl-36	6.2E-08	6.2E-08	1.4E-09	1.8E-09	**Ra-226**	6.2E-08	6.2E-08	1.2E-13	1.5E-13
Cm-243	6.2E-05	6.2E-05	9.2E-09	1.2E-08	**Ra-228**	6.2E-08	6.2E-08	5.7E-12	7.3E-12
Cm-244	1.4E-04	2.1E-04	5.8E-06	7.5E-06	**Se-79**	1.3E-04	6.2E-05	1.3E-06	1.7E-06
Cm-245	6.2E-08	6.2E-05	5.6E-09	7.3E-09	**Sm-151**	2.2E-01	3.6E-02	2.1E-03	2.7E-03
Cm-247	6.2E-08	6.2E-08	5.4E-18	6.9E-18	**Sn-126**	1.2E-04	6.2E-05	1.5E-06	2.0E-06
Cm-248	6.2E-08	6.2E-08	5.6E-18	7.2E-18	**Sr-90**	3.2E-01	5.5E-01	2.0E-02	2.6E-02
Co-60	6.2E-08	6.2E-08	2.7E-11	3.4E-11	**Tc-99**	2.1E-04	2.1E-04	2.0E-05	2.6E-05
Cs-135	1.4E-07	4.3E-06	2.3E-08	2.9E-08	**Th-229**	7.8E-08	6.2E-08	4.9E-10	6.3E-10
Cs-137	1.8E-02	8.4E-01	1.4E-03	1.8E-03	**Th-230**	6.2E-08	6.2E-08	1.5E-11	1.9E-11
Eu-152	3.8E-04	6.4E-05	1.3E-06	1.7E-06	**Th-232**	1.0E-06	6.2E-08	1.5E-09	2.0E-09
Eu-154	4.8E-03	2.8E-03	1.2E-05	1.5E-05	**U-232**	6.2E-08	6.2E-08	1.5E-10	1.9E-10
H-3	6.2E-05	6.2E-05	2.2E-07	2.8E-07	**U-233**	2.8E-06	2.5E-06	2.0E-07	2.5E-07
I-129	6.2E-09	6.2E-09	1.1E-10	1.4E-10	**U-234**	3.4E-07	2.0E-06	5.5E-08	7.1E-08
K-40	6.2E-08	6.2E-08	1.4E-09	1.8E-09	**U-235**	8.2E-08	6.2E-08	1.1E-09	1.5E-09
Nb-94	6.2E-08	6.2E-08	5.0E-10	6.4E-10	**U-236**	6.2E-05	6.2E-05	7.7E-09	9.9E-09
Ni-59	2.3E-04	6.2E-05	2.2E-06	2.8E-06	**U-238**	9.6E-08	3.1E-07	1.0E-08	1.3E-08
Ni-63	1.6E-02	1.6E-03	1.3E-04	1.7E-04	**Y-90**	3.2E-01	5.5E-01	2.0E-02	2.6E-02
Np-237	7.7E-06	2.1E-06	9.2E-08	1.2E-07	**Zr-93**	9.6E-06	1.7E-06	1.1E-06	1.4E-06

Table 9.0-2: HTF Intruder Chemical Inventories

Chemical	Tk 13 (Kg)	Tk 24 (Kg)	3 in. pipe (Kg)	4 in. pipe (Kg)	Chemical	Tk 13 (Kg)	Tk 24 (Kg)	3 in. pipe (Kg)	4 in. pipe (Kg)
Ag	8.3E-05	8.3E-05	1.8E-06	2.3E-06	**Mn**	1.8E-02	8.7E-03	2.1E-04	2.7E-04
As	4.5E-06	8.8E-07	5.6E-08	7.2E-08	**Ni**	1.9E-03	1.1E-03	2.7E-05	3.4E-05
Ba	7.2E-04	1.1E-07	8.6E-06	1.1E-05	**NO_2**	9.1E-02	1.8E-02	5.3E-04	6.8E-04
Cd	4.7E-04	9.3E-05	5.5E-06	7.1E-06	**NO_3**	6.0E-03	1.2E-03	8.1E-05	1.0E-04
Cr	5.4E-04	2.1E-04	7.3E-06	9.4E-06	**Pb**	1.8E-03	4.2E-04	1.9E-05	2.5E-05
Cu	1.9E-04	2.5E-05	2.4E-06	3.1E-06	**Sb**	1.9E-04	3.8E-05	3.0E-06	3.9E-06
F	2.7E-04	2.7E-04	3.7E-06	4.8E-06	**Se**	3.6E-06	7.1E-07	1.7E-06	2.2E-06
Fe	1.1E-01	2.6E-02	1.2E-03	1.6E-03	**U**	2.9E-04	9.3E-05	3.0E-05	3.8E-05
Hg	1.1E-02	1.9E-03	1.5E-04	1.9E-04	**Zn**	1.6E-04	7.5E-04	3.0E-06	3.8E-06

10.0 INVENTORY STOCHASTICS

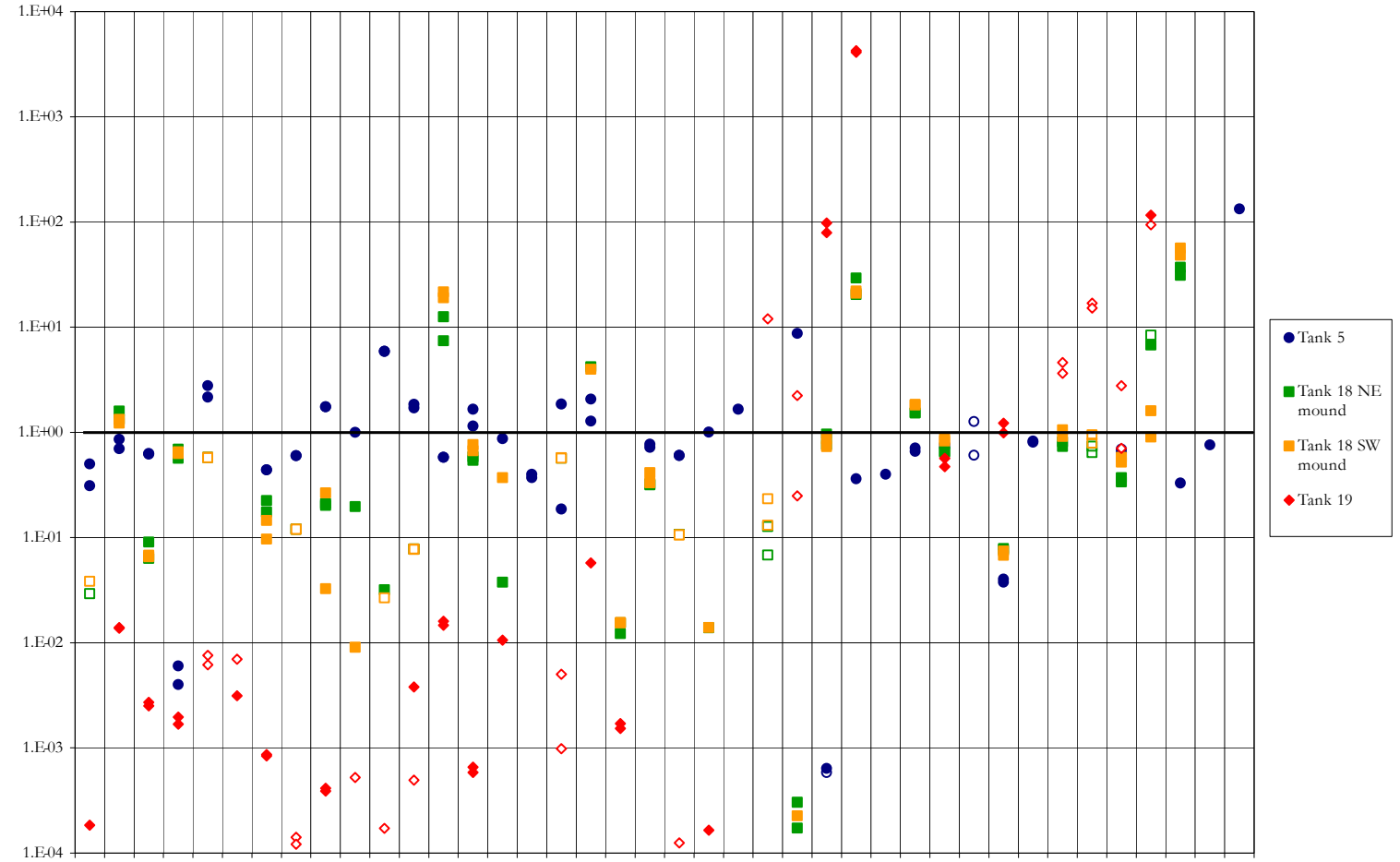
The waste tank and ancillary equipment inventories in the GoldSim HTF transport model control the total amount of contaminants available for release. Sections 3.0 and 4.0 describe the basis for estimates of residual radiological inventory in the HTF waste tanks and ancillary equipment.

The process used to estimate the waste tanks' residual material at operational closure created estimates that were both bounding and reasonable. Estimates were developed for all radionuclides and chemicals expected to occur in the HTF, but those components expected to affect dose are closely scrutinized, and the values selected are intended to provide conservatism over what is expected to remain at operational closure.

The initial inventories are considered conservative estimates. For instance, in estimating residuals from reprocessed reactor spent fuel, maximum burn-up is assumed, consequently certain radionuclide byproducts are also maximized. An unknown amount of residual material characterized as fission products bearing PUREX Low Heat Waste actually originated as cladding waste or other low radionuclide bearing wastes that contain relatively small amounts of fission products. [LWO-PIT-2007-00025] Additional conservatism is added to the estimate of residuals assumed to remain in the waste tanks after cleaning. It is probable that less residuals, and thus a lower inventory of contaminants, will actually remain. These process-related uncertainties have not been quantified; instead, this uncertainty is accounted for by applying a lower and upper bound to the initial inventory estimates, using a log uniform distribution.

A comparison between actual waste tank samples and WCS estimated values was completed. Tanks 5, 18 and 19 contents have been sampled and tested to allow for a comparison. Figure 10.0-1 shows a ratio of the actual sample measure values over the predicted WCS values for each constituent (i.e., values less than 1.0 are overestimated by WCS). The comparison of data shows that 75% of the approximately 215 sample results indicate WCS conservatively overestimated or closely matched the sample measure values. Excluding less than detection limit values, less than 25% of the sample results indicate that WCS underestimated the sample measure values. [SRS-REG-2007-00008]

Figure 10.0-1: Sample to Prediction Ratio



Note: 1 = non-conservative
A symbol's empty center indicates the value determined using detection limit values
WCS does not provide estimates for As, Cd, Sb, Se, U-233, U-234, U-236, Am-243, and Cm-242 for Tanks 5, 18 and 19

Discrete multipliers are applied (between 0.01 and 10 are applied to both radionuclide and non-radiological chemical elements) to the initial inventory for each radionuclide and chemical constituent. The multipliers are presented in Tables 10.0-1 and 10.0-2 and are based on the confidence in the initial estimate.

Table 10.0-1: HTF Radionuclide Inventory Multipliers

Distribution	Type I/II (Salt)		Type I/II (Sludge)		Tank 16		Type IV		Type III/IIIA	
	Log Uniform		Log Uniform		Log Uniform		Log Uniform		Log Uniform	
Radionuclide	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Ac-227	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ag-108m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Al-26	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Am-241	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Am-242m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Am-243	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Bi-210m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
C-14	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ca-41	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cf-249	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cf-251	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cl-36	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-243	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-244	0.01	10	0.01	10	0.01	10	0.01	10	0.1**	10**
Cm-245	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-246	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-247	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-248	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Co-60	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cs-135	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Cs-137	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Eu-152	0.01	10	0.01	10	0.01	1	0.01	1	0.1***	10***
Eu-154	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Eu-155	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Gd-152	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
H-3	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
I-129	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
K-40	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Lu-174	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Mo-93	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1

Table 10.0-1: HTF Radionuclide Inventory Multipliers (Continued)

Distribution	Type I/II (Salt)		Type I/II (Sludge)		Tank 16		Type IV		Type III/IIIA	
	Log Uniform		Log Uniform		Log Uniform		Log Uniform		Log Uniform	
Radionuclide	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Nb-93m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Nb-94	0.01	10	0.01	1	0.01	1	0.01	1	0.01	1
Ni-59	0.01	10	0.01	10	0.01	1	0.01	1	0.01	1
Ni-63	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Np-237	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Pa-231	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pb-210	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pd-107	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pt-193	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pu-238	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Pu-239	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Pu-240	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Pu-241	0.01	1	0.01	10	0.01	10	0.01	10	0.1	10
Pu-242	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pu-244	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ra-226	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ra-228	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Se-79	0.01	10	0.01	10	0.01	1	0.01	1	0.01	1
Sm-147	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Sm-151	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Sn-126	0.01	10	0.01	10	0.01	1	0.01	1	0.01	1
Sr-90	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Tc-99	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
Th-229	0.01	1	0.01	10	0.01	1	0.01	1	0.01	1
Th-230	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Th-232	0.01	1	0.01	10	0.01	10	0.01	1	0.1**	10**
U-232	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-233	0.01	10	0.01	10	0.01	10	0.01	10	0.1**	10**
U-234	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10
U-235	0.01	1	0.01	10	0.01	1	0.01	1	0.1	10
U-236	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-238	0.01	10	0.01	10	0.01	1	0.01	1*	0.1**	10**
Zr-93	0.01	10	0.01	10	0.01	10	0.01	10	0.1	10

* For Tank 24, the maximum multiplier is 10
** For Tank 32, the multipliers are 0.01 (minimum) and 1 (maximum)
*** For Tanks 38-51, the multipliers are 0.01 (minimum) and 1 (maximum)

Table 10.0-2: HTF Chemical Inventory Multipliers

	Probability	Multiplier
All Chemicals	0.25	0.01
	0.25	0.1
	0.25	1
	0.25	10

An initial inventory is modeled to exist in the sand pads, and in the ancillary equipment including the transfer lines. Because peak dose is driven by the initial inventory in the tanks, and because of lack of sample data to better define the uncertainty of these components, it was determined that applying uncertainty to the ancillary equipment and sand pad initial inventory was unjustified.

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APPENDIX A: SOURCE TERM SCREENING

An initial radionuclide screening process was developed and performed to support characterization efforts and was applicable for HTF PA modeling. CBU-PIT-2005-00228 identifies how SRS performed a screening of radionuclides by initially evaluating 849 isotopes. Of the original 849 isotopes, 159 remained on the list and 690 were excluded from further consideration.

This screening process used the following information:

- physical properties of each radioisotope such as half-life and decay mechanism,
- source and handling of the waste was used in the decisions based on isotope production mechanisms and time since the isotope was produced, and
- screening factors for ground disposal of radionuclides developed in NCRP-123 which convert a quantity of each radionuclide to a dose.

The screening process performed in the initial screening was presented in CBU-PIT-2005-00228 was as follows:

Step 1. Identify isotopes that were part of any of the four decay series (Actinium, Neptunium, Thorium, or Uranium) and retained for further analysis because the HTF waste was known to contain the first member of each of the series.

Step 2. Identify isotopes for which there was high-level waste sludge characterization information and retained for further analysis since these have been determined to be likely to be present in the waste and of importance to some aspect of the program. Note that this step may identify isotopes for inclusion that could have been screened out at some later step if they had not been so designated.

Next, the remaining list of radionuclides was examined to eliminate those isotopes which can be excluded based on the criteria presented for each evaluation step. In the following steps, those that have very long half-lives (and correspondingly low specific activity) and those that have been screened out using the most up-to-date method presented in NCRP-123 were identified for exclusion.

Step 3. Identify isotopes for which there is no dose conversion information (typically very long lived and essentially stable isotopes). The two most comprehensive sources of information are the NCRP-123 and United States Environmental Protection Agency (EPA) Risk Assessment Web Site (www.epa.gov/radiation/heast), and both of these sources were consulted. Dose Conversion Factors do not exist for these isotopes because they were not considered to merit the development of factors.

Step 4. Identify isotopes that have been screened out in NCRP-123 using the screening methodology for ground disposal.

The next part of the screening process employs some general information about an assumed residual inventory of radionuclides in high-level waste sludge that is an order of magnitude or more than expected at closure.

Step 5. Assuming a large activity level (one million curies) of any isotope remaining in the residual material, and using the screening factors from NCRP-123, identify those that would result in a hypothetical exposure to a MOP of 1 mrem/yr or less and eliminate them from the list. Note that this analysis includes the exposure due to all daughter radionuclides.

Step 6. Assuming a large mass (1,000 lbs) of any isotope remaining in the residual material, and using the screening factors from NCRP-123, identify those that would result in a hypothetical exposure to a MOP of 1 mrem/yr or less and eliminate them from the list. Note that this analysis includes the exposure due to all daughter radionuclides.

Step 7. Identify isotopes that would not be in the waste due to their physical properties (e.g., present as a gas and released in the reactor or during fuel processing).

More specific information about the waste at the SRS is used to identify those radionuclides which can be excluded based on history of the site waste.

Step 8. Employ information about the age of the HTF waste (minimum of 15 years) to identify those radionuclides that would not be expected to be in the waste at the time of closure due to their short half-lives. Restrict this analysis to those isotopes that have no on-going source and decay directly to stable products so that no isotopes with significant daughters are prematurely eliminated.

Step 9. Employ information about the age of the HTF waste (minimum of 15 years) to identify those radionuclides that would not be expected to be in the waste at the time of closure due to their short half-lives. Apply this analysis to those isotopes that have no on-going source and decay to short-lived daughters (less than 1 year) and then to stable products so that no isotopes with significant daughters are prematurely eliminated.

Next, some basic information about the duration of institutional control combined with specific isotope characteristics can be used to eliminate radionuclides that are not going to be of future concern to MOP or worker exposure.

Step 10. Employ detailed decay scheme information to identify short-lived isotopes with no ongoing sources that will decay to stable isotopes in multiple short steps. This step requires the careful review of each decay scheme individually. Although there is not a general rule of thumb, it is obvious from inspection of the decay chain that both the parent and the daughters are effectively extinct.

Step 11. Employ detailed decay scheme information to identify those short-lived isotopes with no ongoing sources that will decay to a longer lived isotope that is separately tracked. Once this decay has happened, the short-lived parent isotope is no longer of interest.

Step 12. Employ detailed decay scheme information and an assumed period of institutional control (100 years) to identify those isotopes with no ongoing sources that will decay to a stable isotope during the period of institutional control.

Step 13. Employ detailed decay scheme information and an assumed period of institutional control (100 years) to identify those isotopes with no ongoing sources that will decay to a longer lived isotope that is separately tracked during the period of institutional control. Once this decay has happened, the parent isotope is no longer of interest.

The isotopes remaining on the list which have not been identified for either inclusion or exclusion can now be examined. Many of the isotopes on the list were not created in the SRS reactors. This is because the initial list of isotopes for evaluation was pulled from a variety of sources and includes isotopes of interest for many different reasons due to other SRS activities other than just reactor operations.

Step 14. The remaining isotopes are now identified as those isotopes which require further analysis (i.e., pathway and/or inventory specific screening).

The results of the screening process yielded 159 remaining radionuclides for evaluation presented in Table A.0-1

Table A.0-1: Radionuclides Requiring Further Evaluation

Ac-225	Bk-250	Eu-152	Nb-94	Po-213	Rh-106	Th-227
Ac-227	C-14	Eu-154	Ni-59	Po-214	Rn-219	Th-228
Ac-228	Ca-41	Eu-155	Ni-63	Po-215	Rn-220	Th-229
Ag-108m	Ce-144	Fe-60	Np-236	Po-216	Rn-222	Th-230
Al-26	Cf-249	Fr-221	Np-237	Po-218	Ru-106	Th-231
Am-241	Cf-250	Fr-223	Np-239	Pr-144	Sb-125	Th-232
Am-242	Cf-251	Gd-148	Np-240	Pt-193	Sb-126	Th-234
Am-242m	Cf-252	H-3	Pa-231	Pu-236	Sb-126m	Ti-44
Am-243	Cl-36	Hf-178m	Pa-233	Pu-238	Se-79	Tl-207
Am-246	Cm-242	Hf-182	Pa-234	Pu-239	Si-32	Tl-208
At-217	Cm-243	Hg-194	Pb-202	Pu-240	Sm-146	Tl-209
At-218	Cm-244	Ho-166m	Pb-205	Pu-241	Sm-147	Tl-210
Ba-137m	Cm-245	I-129	Pb-209	Pu-242	Sm-151	U-232
Be-10	Cm-246	Ir-192	Pb-210	Pu-243	Sn-121m	U-233
Bi-207	Cm-247	Ir-192m	Pb-211	Pu-244	Sn-126	U-234
Bi-210	Cm-248	K-40	Pb-212	Pu-246	Sr-90	U-235
Bi-210m	Cm-250	La-137	Pb-214	Ra-223	Ta-182	U-236
Bi-211	Co-60	La-138	Pd-107	Ra-224	Tb-157	U-238
Bi-212	Co-60m	Lu-176	Pm-145	Ra-225	Tb-158	U-240
Bi-213	Cs-134	Mn-53	Pm-147	Ra-226	Tc-97	Y-90
Bi-214	Cs-135	Mo-93	Po-210	Ra-228	Tc-98	Zr-93
Bk-247	Cs-137	Na-22	Po-211	Rb-87	Tc-99	
Bk-249	Eu-150	Nb-93m	Po-212	Re-186m	Te-125m	

APPENDIX B: EVALUATION OF REMAINING RADIONUCLIDES

From Table A.0-1, 95 isotopes are screened out for the initial inventory for the reasons described in Table B.0-1. There are radionuclides that are removed from the initial inventory although they are known to exist due to decay behavior. Justification for removing the in-growth from the initial inventories is discussed below.

The in-growth of radionuclides within a decay series is insignificant. For the short lived isotopes, the in-growth occurs quickly such that they are at equilibrium within the institutional control period (100 years). For the longer lived isotopes, the in-growth would be insignificant due to the length of the evaluation period (10,000 years). For example, assuming no in-growth within the initial inventory, the Th-299 in-growth from U-233 decay would be 62.2% of the initial U-233 inventory at 10,000 years. If in-growth is included, the Th-229 in-growth would be 62.5% of the U-233 initial inventory.

Although these radionuclides are not included in the initial inventories, they are included in the modeling software and are grown in as a function of their parent's inventory and time.

Table B.0-1: Continued Evaluation of Radionuclides

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Ac-225	10 days	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Ac-228	6.15 hours	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Ag-108m	438 years	No decay source	Ag-108m → Ag-108 → Cd-108 (stable) and Pd-108 (stable)
Am-242	16 hours	Decay from Am-242m in modeling	Am-242m → Am-242 → Cm-242 → Pu-238 → U-234 (in Uranium Series)
Am-246	39 minutes	Ancestors not present, decays to U-238 series	Cm-250 → Pu-246 → Am-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
At-217	<1 second	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
At-218	1.5 seconds	Generated by U-238 decay in modeling; short half-life	Decay mode less than 1% of Po-218 decay.
Be-10	1,510,000 years	No decay source	Be-10 → Ba-10 (stable) Long-lived naturally occurring isotope
Bi-207	32.9 years	Ancestors not present	At-207 → Po-207 → Bi-207 → Pb-207 (stable)
Bi-210	5 days	Generated by U-238 decay in modeling; short half-life	Uranium Series
Bi-210m	3,040,000 years	No decay source	Bi-210m →Tl-206 → Pb-206 (stable)
Bi-211	2.14 seconds	Generated by U-235 decay in modeling; short half-life	Actinium Series
Bi-212	60.55 minutes	Generated by Th-232 decay in modeling; short half-life	Thorium Series

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Bi-213	45.6 minutes	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Bi-214	20 minutes	Generated by U-238 decay in modeling; short half-life	Uranium Series
Bk-247	1,380 years	Ancestors not present, decays to U-235 series	Cf-247 → Bk-247 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series)
Bk-250	3.2 hours	Ancestors not present, decays to U-238 series	Md-258 → Es-254 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series); Cm-250 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
Ca-41	102,000 years	No decay source	Ca-41 → K-41 (stable)
Cf-250	13.1 years	Ancestors not present, decays to U-238 series	Md-258 → Es-254 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series) Cm-250 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238
Cm-246	4760 years	Ancestors not present, decays to U-238 series	Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series); Es-250m → Cf-250 and Bk-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series) Cm-250 → Pu-246 → Am-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
Cm-250	8,300 years	No decay source	Cm-250 → Pu-246 → Am-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
Co-60m	10.5 seconds	Ancestors not present	Fe-60 → Co-60m → Co-60 → Ni-60 (stable)
Eu-150	36.9 years	No decay source	Eu-150 → Sm-150 (stable)

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Fe-60	1,500,000 years	No decay source	Fe-60 → Co-60m → Co-60 → Ni-60 (stable)
Fr-221	5 minutes	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Fr-223	22 minutes	Generated by U-235 decay in modeling; short half-life	Actinium Series
Gd-148	70.9 years	No decay source	Gd-148→ Sm-144 (stable)
Hf-178m	31 years	No decay source	Hf-178m → Hf-178 (stable)
Hf-182	8,900,000 years	Ancestors not present	Hf-182m → Hf-182 → Ta-182 → W-182 (stable)
Hg-194	444 years	Ancestors not present	[Ti-194 and Ti-194m] → Hg-194 → Au-194 → Pt-194 (stable)
Ho-166m	1200 years	No decay source	Ho-166m → Er-166 (stable)
Ir-192	74 days	Ancestors not present	Ir-192m → Ir-192 → Pt-192 (stable) or Os-192 (stable)
Ir-192m	241 years	No decay source	Ir-192m → Ir-192 → Pt-192 (stable) or Os-192 (stable)
La-137	60,000 years	Ancestors not present	Ce-137m → Ce-137 → La-137 → Ba-137 (stable); Pr-137 → Ce-137 → La-137 → Ba-137 (stable)
La-138	1.02E+11 years	No decay source	La-138→ Ce-138 (stable) Long-lived naturally occurring isotope
Lu-176	3.76E+10 years	No decay source	Lu-176 → Hf-176 (stable) Long-lived naturally occurring isotope
Mn-53	374,000 years	No decay source	Mn-53 → Cr-53 (stable)
Mo-93	4,000 years	Ancestors not present	[Mo-93m and Tc-93 and Tc-93m] → Mo-93 → Nb-93m → Nb-93 (stable)

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Np-236	1,540 years	No decay source	Np-236 → U-236 → Th-232 (in Thorium Series); Np-236 → Pu-236 Np-236a → U-232 to Th-228 (in Thorium Series)
Np-239	2.4 days	Decay from Am-243 in modeling; short half-life	Cf-247 → Bk-247 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series); Es-255 → Bk-251 or Fm-255 → Cf-251→ Cm-247→ Pu-243 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series)
Np-240	62 minutes	Decay from Pu-244 in modeling; short half-life	Cf-252 → Cm-248 → Pu-244 → U-240 → Np-240 → Pu-240 → U-236 → Th-232 in Thorium Series
Pa-233	27 days	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Pa-234	6.7 hours	Generated by U-238 decay in modeling; short half-life	Uranium Series
Pb-202	52,500 years	Ancestors not present	Po-202 → Bi-202 → Pb-202 → [Tl-202 and Hg-198 (stable)]; Tl-202 → Hg-202 (stable)
Pb-205	1.73E+07 years	Ancestors not present	Po-205 → Bi-205 → Pb-205 → Tl-205 (stable)
Pb-209	3.3 hours	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Pb-210	22 years	Generated by U-238 decay in modeling	Uranium Series
Pb-211	36 minutes	Generated by U-235 decay in modeling; short half-life	Actinium Series
Pb-212	10.6 hours	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Pb-214	27 minutes	Generated by U-238 decay in modeling; short half-life	Uranium Series

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Pm-145	18 years	Ancestors not present	Gd-145 → Eu-145 → Sm-145 → Pm-145 → Nd-145 (stable)
Po-210	138 days	Generated by U-238 decay in modeling	Uranium Series
Po-211	<1 second	Generated by U-235 decay in modeling; short half-life	Decay mode less than 1% of Bi-211 decay.
Po-212	<1 second	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Po-213	<1 second	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Po-214	<1 second	Generated by U-238 decay in modeling; short half-life	Uranium Series
Po-215	<1 second	Generated by U-235 decay in modeling; short half-life	Actinium Series
Po-216	<1 second	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Po-218	3 minutes	Generated by U-238 decay in modeling; short half-life	Uranium Series
Pu-236	3 years	Ancestors not present, decays to Th-228 series	Cf-244 → Cm-240 → Pu-236 → U-232 → Th-228 (in Thorium Series)
Pu-243	5 hours	Decay from Cf-251 in modeling	Cf-251 → Cm-247→ Pu-243 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series)
Pu-246	11 days	Ancestors not present	Cm-250 → Pu-246 →Am-246 → Cm-245 Pu-241 (in Neptunium Series);

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Ra-223	11 days	Generated by U-235 decay in modeling; short half-life	Actinium Series
Ra-224	3.6 days	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Ra-225	15 days	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Rb-87	4.97E+10 years	Ancestors not present	[Kr-87 and Sr-87m] → Rb-87 → Sr-87 (stable)
Re-186m	200,000 years	No decay source	Re-186m → Re-186 → Os-186 → W-182 (stable)
Rn-219	4 seconds	Generated by U-235 decay in modeling; short half-life	Actinium Series
Rn-220	56 seconds	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Rn-222	4 days	Generated by U-238 decay in modeling; short half-life	Uranium Series
Si-32	132 years	No decay source	Si-32 → P-32 → S-32 (stable)
Sm-146	1.03E+08 years	Ancestors not present	[Gd-146 and Tb-150] → Eu-146 → Sm-146 → Nd-142 (stable); Eu-150m → Gd-150 → Sm-146 → Nd-142 (stable)
Sm-147	1.06E+11 years	Decay from Pm-147 in modeling	Pr-147 → Nd-147 → Pm-147 → Sm-147 → Nd-143 (stable); Tb-147 → Gd-147 → Eu-147 → Sm-147 → Nd-143 (stable)
Sn-121m	44 years	No decay source	Sn-121m → Sn-121 → Sb-121 (stable)
Ta-182	114 days	Ancestors not present	Hf-182m → Hf-182 → Ta-182 → W-182 (stable)
Tb-157	71 years	Ancestors not present	Ho-157 → Dy-157 → Tb-157 → Gd-157 (stable)
Tb-158	180 years	No decay source	Tb-158 → Gd-158 (stable)

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Radionuclide	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Tc-97	4,210,000 years	Ancestors not present	[Ru-97 and Tc-97m] → Tc-97→ Mo-97 (stable)
Tc-98	4,200,000 years	No decay source	Tc-98 → Ru-98 (stable)
Th-227	19 days	Generated by U-235 decay in modeling; short half-life	Actinium Series
Th-228	1.9 years	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Th-231	25.5 hours	Generated by U-235 decay in modeling; short half-life	Actinium Series
Th-234	24 days	Generated by U-238 decay in modeling; short half-life	Uranium Series
Ti-44	60 years	No decay source	Ti-44 → Sc-44 → Ca-44 (stable)
Tl-207	5 minutes	Generated by U-235 decay in modeling; short half-life	Actinium Series
Tl-208	3 minutes	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Tl-209	2.2 minutes	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Tl-210	1.3 minutes	Generated by U-238 decay in modeling; short half-life	Decay mode less than 1% of Bi-214 decay.
U-240	14 hours	Decay from Cf-252 in modeling; short half-life	Cf-252 → Cm-248 → Pu-244 → U-240 → Np-240 → Pu-240 → U-236 → Th-232 (in Thorium Series)

*Half-life years obtained from the April 2005 Nuclear Wallet Cards. [PIT-MISC-0072]