SRR-CWDA-2010-00124
Revision 0

Tank 18/Tank 19 Special Analysis for the Performance Assessment for the F-Tank Farm at the Savannah River Site

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ACRONYMS/ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMCOC	Contaminant Migration Constituents of Concern
CTS	Concentrate Transfer System
CZ	Contamination Zone
DB	Diversion Box
DCF	Dose Conversion Factor
DOE	United States Department of Energy
DOE-EM	DOE-Environmental Management
DOE-SR	DOE-Savannah River
DRF	Dose Release Factors
FFA	Federal Facility Agreement
FTF	F-Tank Farm
GSA	General Separations Area
HTF	H-Tank Farm
ICM	Integrated Conceptual Model
LANL	Los Alamos National Laboratory
MCL	Maximum Contaminant Level
MEI	Maximally Exposed Individual
MOP	Member of the Public
N/A	Not Applicable/Not Available
NC	Not Calculated
NDAA	Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005
NEA-TDB	Nuclear Energy Agency – Thermochemical Database
NRC	United States Nuclear Regulatory Commission
PA	Performance Assessment
PCA	Pollution Control Act
PNNL	Pacific Northwest National Laboratory
PP	Pump Pit
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RSL	Regional Screening Level
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site
TER	Technical Evaluation Report
UTR	Upper Three Runs
UTR-LZ	Upper Three Runs – Lower Zone
UTR-UZ	Upper Three Runs – Upper Zone

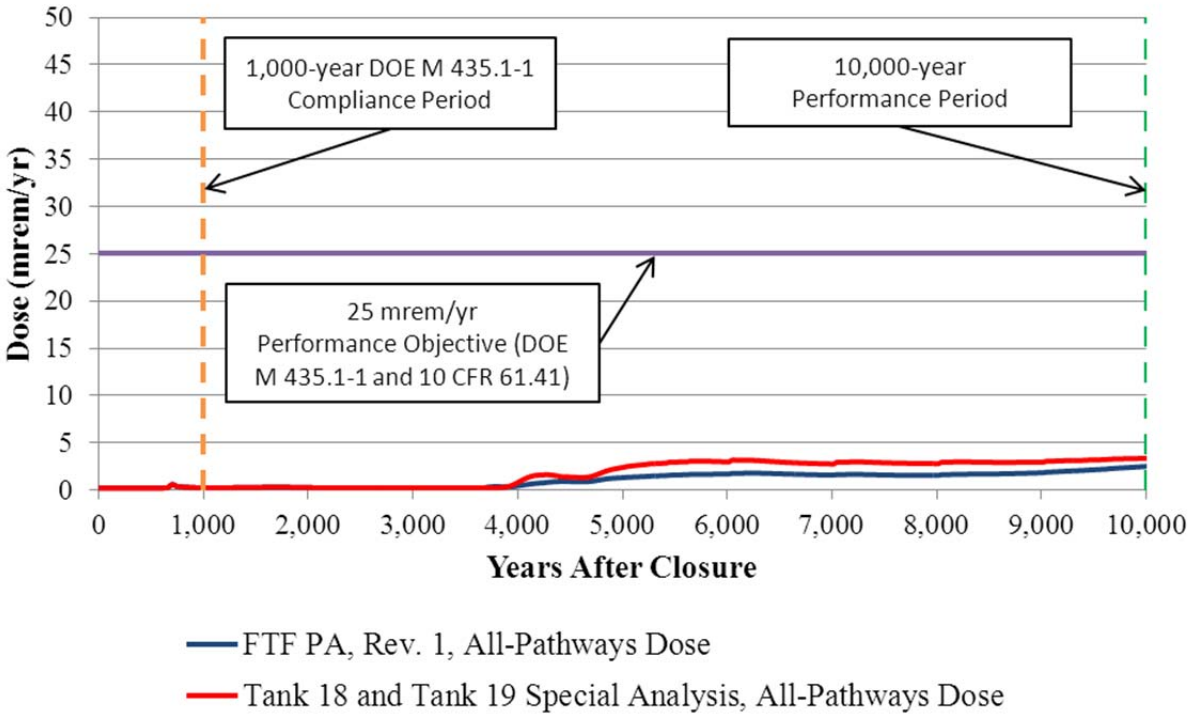
EXECUTIVE SUMMARY

Special Analyses are performed to evaluate the significance of new information or new analytical methods to the results and associated conclusions of a performance assessment (PA). As waste tanks and ancillary equipment are cleaned at the F-Tank Farm (FTF) at the Savannah River Site (SRS), final residual inventories will be used to update the FTF fate and transport modeling performed as part of SRS-REG-2007-00002, Revision 1 (hereinafter referred to as FTF PA). This allows for evaluation of the difference between the projected and final waste tank inventories to determine if the results and conclusions of the FTF PA remain valid. This Special Analysis uses the FTF PA Base Case model to evaluate the final residuals that are planned to be grouted in-place in Tanks 18 and 19 (utilizing final residual characterization data). This Special Analysis also takes advantage of new information gathered/generated since FTF PA was developed, including information used to address Tank 18 observations and recommendations found in the United States Nuclear Regulatory Commission (NRC) *Technical Evaluation Report for F-Area Tank Farm Facility* (ML112371715). The issuance of the technical evaluation report (TER) culminated a multi-year consultation with NRC under the *Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005* Section 3116.

The results of this Special Analysis demonstrate that the conclusions of the FTF PA are reasonably bounding, and the sensitivity analysis (using Nuclear Energy Agency – Thermochemical Database (NEA-TDB) information, "realistic" E_h values, and more realistic plutonium soil K_ds) show that peak dose, beyond 10,000 years after FTF facility closure, is more attenuated and later in time than projected in the FTF PA Base Case. In addition, the Special Analysis process has confirmed that there continues to be reasonable assurance that the Title 10 Code of Federal Regulations (CFR) Part 61 Subpart C performance objectives will be met for FTF during the 10,000-year performance period.[1] A comparison of the peak all-pathways dose within 10,000 years, calculated using projected FTF waste tank inventories (i.e., FTF PA inventories) and using the updated actual waste tank inventories (i.e., Tanks 18 and 19 Special Analysis inventories) that are shown in Figure ES-1. As shown in Figure ES-1, the maximum peak annual all-pathways dose to a member of the public (MOP) during the 10,000-year performance period using the Tanks 18 and 19 actual inventories remains less than 5 millirem and occurs at year 10,000. This maximum peak all-pathways dose during the 10,000-year performance period remains essentially unchanged from the peak dose calculated in the FTF PA. The maximum peak annual dose to a FTF intruder is 73 millirem at year 101 from a chronic scenario, drilling through a transfer line and using groundwater maximum concentrations at 1 meter from the FTF. The 73 millirem, peak intruder annual dose value is unchanged from the FTF PA.

[1] In accordance with DOE Manual 435.1-1, Chapter 4, the performance assessment considers a period of 1,000 years after the disposal facility has been closed, to assess compliance with the performance objectives. The Manual concludes that longer times of assessment are not used to assess compliance because of the inherently large uncertainties in extrapolating such calculations over long periods of time. Nevertheless, DOE considers a performance period 10 times that normal analytical period, consistent with NRC practice (NUREG-1854 Section 4.1).

Figure ES-1: Base Case Results – Comparison of the 100-Meter MOP Peak All-Pathways Dose within 10,000 Years for FTF PA and the Tanks 18 and 19 Special Analysis



Peak groundwater-radionuclide concentrations were also calculated utilizing the Tanks 18 and 19 inventories at closure and no maximum contaminant levels (MCLs) were exceeded at 100 meters from the FTF boundary; only K-40, Np-237, Pa-231, and U-234 were above the preliminary remediation goal (PRG) at 100 meters. All radionuclides were well below the MCL or PRG at the seepline. These peak groundwater-radionuclide concentrations are slightly different from FTF PA with K-40 and Pa-231 now exceeding the PRG at 100 meters and U-233 no longer exceeding the PRG at 100 meters. The peak concentrations for the chemicals of concern were also calculated, and all were less than the MCL or regional screening level (RSL) at a distance of 100 meters from the FTF boundary. These peak chemical concentration results are unchanged from the FTF PA.

In the technical evaluation report (TER) for the FTF facility, ML11237175, the NRC stated:

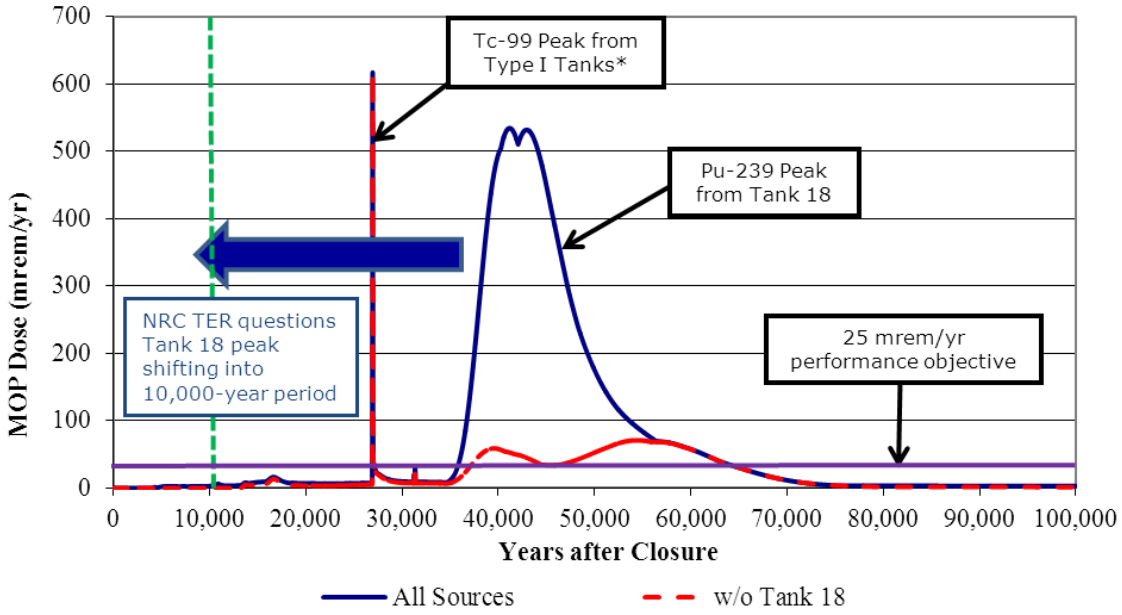
> *"However, considering the fact that unacceptably high peak doses could occur within the 10,000 year period of compliance with only a factor of 3 or 4 faster time to collective failure of a combination of barriers for Tc or Pu, respectively, and considering the large uncertainty associated with predictions of long-term performance of engineered barriers, NRC staff are not convinced that the high peak doses currently presented in DOE's PA (or lower peak doses of unknown magnitude that might be associated with a more realistic model) could not be realized within a 10,000 year compliance period."*

The peak dose of NRC concern relating to Tanks 18 and 19 was an approximately 500 millirem annual dose occurring approximately 40,000 years following the FTF closure (i.e., 30,000 years beyond the 10,000-year performance period). This concern is illustrated in Figure ES-2. This

peak dose is associated with the residual Pu-239 inventory in Tank 18. The NRC's TER recommends that the United States Department of Energy (DOE) provide additional model support to further reduce the uncertainty surrounding the FTF PA, Rev.1 assumptions that, if found to be significantly non-conservative, could result in this peak dose shifting into the 10,000-year performance period. Specifically, in the concluding paragraph of the TER, NRC states the following:

> *"NRC staff has provided a number of recommendations, the implementation of which will strengthen DOE's basis for concluding stabilized waste in FTF tank and associated ancillary structures and equipment can meet NDAA criteria at the time of closure. Additionally, NRC staff suggests that at a minimum, implementation of a subset of its recommendations (e.g., high risk, short term recommendations) is needed for NRC staff to have reasonable assurance that performance objectives in 10 CFR Part 61, Subpart C can be met."*

Figure ES-2: Illustration of NRC Concern Regarding 40,000-year Peak Dose



Note: NRC acknowledged that the Tc-99 peak is likely overestimated by one to two orders of magnitude.

As a first step in addressing the NRC "high risk, short term" recommendations, DOE-Savannah River (DOE-SR) sought to determine if additional model support (focusing on plutonium solubility) existed outside of the DOE-Environmental Management (DOE-EM) community, specifically within the DOE weapons laboratories. An expert panel was convened to provide technical advice relating to further documenting plutonium waste release and transport. The expert panel issued a *Plutonium Solubility Peer Review Report* (LA-UR-12-00079), containing several suggestions and opportunities for improvement regarding the plutonium modeling assumptions and Tank 18 residual waste experiments that would further strengthen the technical arguments. To implement the suggestions provided in the peer review report and address the NRC "high risk, short term" recommendations, a series of new activities were completed that provides enhanced model support. These activities included:

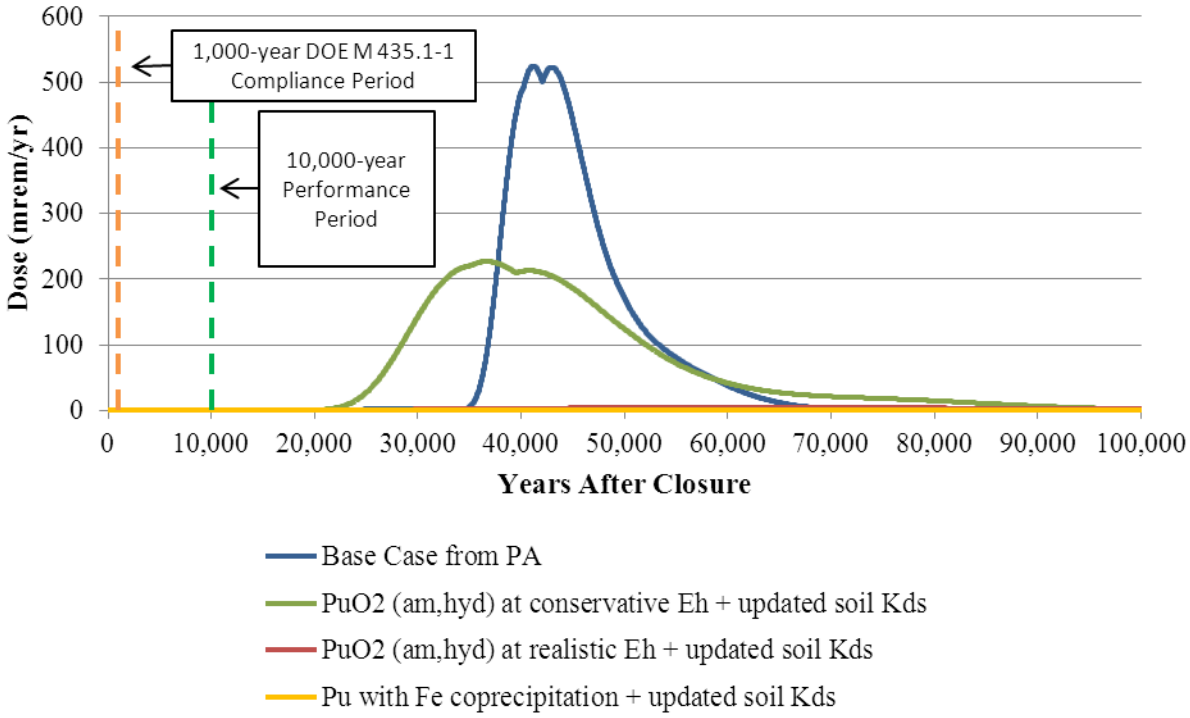
1) Analyzing additional potential plutonium waste forms, including calculation of new plutonium solubility values utilizing the NEA-TDB for use in the waste release model
2) Issuing studies regarding potential areas of significant conservatism within the FTF PA conceptual model noted by the expert panel
3) Performing a series of new parametric barrier analyses for plutonium waste release (i.e., variability around plutonium solubility values) and plutonium transport (i.e., variability around plutonium sandy soil K_d values)
4) Utilizing updated plutonium K_d values that better reflect expected FTF soil conditions;
5) Performing deterministic Base Case sensitivity runs showing the dose impact of uncertainty regarding both plutonium solubility and transport;
6) Performing new probabilistic analysis incorporating the revised plutonium solubility values and updated plutonium K_d values
7) Testing of a Tank 18 waste sample using X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) techniques

In addition to evaluating the impact of the final Tanks 18 and 19 inventories on peak doses within the 10,000-year performance period, additional sensitivity analyses were performed as listed above. The results of these sensitivity analyses are used to assess the potential dose impacts of the final inventory, including evaluating an additional 90,000 years beyond the performance period for the purposes of "chasing the peaks" to further understand system performance and inform the closure decision process. These additional sensitivity analyses placed emphasis on understanding releases associated with the Pu-239 residual inventory remaining in Tank 18 at closure and on the barriers to Pu-239 release. There are multiple barriers to Pu-239 release and transport that prevent the Pu-239-related peak near year 40,000 from occurring significantly earlier (i.e., within or close to year 10,000, the outer bound of the performance period). These barriers are discussed in Section 6.3.5.3. Given the multiple barriers to early release and transport of Pu-239, it is reasonable to conclude that the uncertainty surrounding the factors driving the Pu-239 peak dose is not sufficient to impact demonstration of meeting performance objective within the 10,000-year performance period.

The additional sensitivity analyses regarding Pu-239 that were performed show that, for several of the barriers to Pu-239 release and transport, the FTF PA Base Case incorporates conservative approaches/inputs and the peak doses associated with Pu-239 would likely occur even farther beyond the 10,000-year performance period if these conservative approaches/inputs are eliminated. The sensitivity analyses documented in Section 6.3.6 highlight the fact that doses associated with Pu-239 can be expected to occur later than currently reflected in the FTF PA Base Case deterministic as additional conservatisms are removed. Figures ES-3 and ES-4 show that the peak dose associated with Pu-239 occurs well beyond the 10,000-year performance period for all of the FTF PA Base Case sensitivity studies performed, and in most cases, the peak dose occurred much later, and is significantly attenuated when compared to FTF PA Base Case results. These sensitivity analyses confirm the uncertainty surrounding whether the doses associated with Tank 18 Pu-239 can be bounded and that waste release experiments to increase support for key modeling assumptions related to Pu-239 waste release are not necessary to provide reasonable assurance that the peak doses associated with Tank 18 Pu-239 will not move forward in time into the 10,000-year performance period. While there is uncertainty around the peak dose associated with the residual Pu-239 in Tank 18, the timing associated with the Pu-239

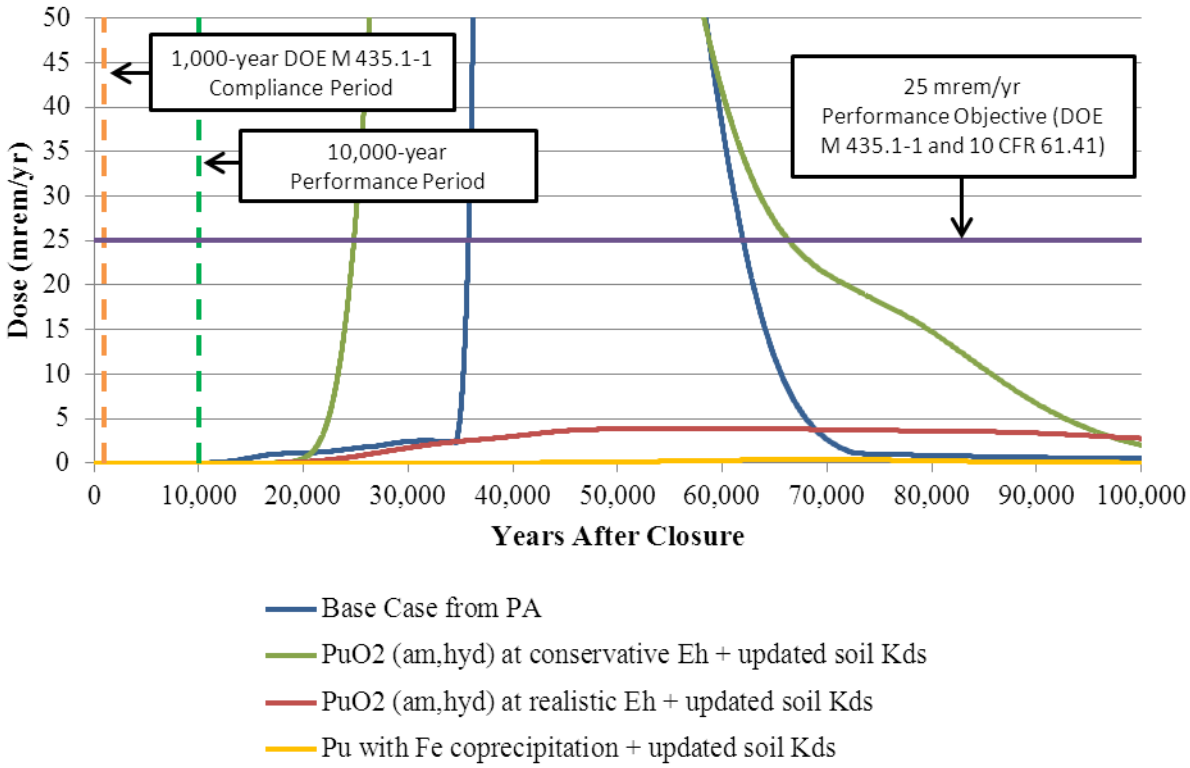
peak dose is understood and under both expected and reasonably bounding conditions there is reasonable assurance that the Pu-239 peak dose will not move forward into the 10,000-year performance period. While the testing in this area might be useful in better defining the precise timing of the peak doses associated with Tank 18 Pu-239, these tests are not necessary to provide reasonable assurance that the peak dose associated with Pu-239 will not occur within the 10,000-year performance period.

Figure ES-3: Pu-239 Sensitivity Studies - Peak All Pathways Pu-239 Dose within 100,000 Years



Note: Modeling cases defined in Section 6.3.6.3

Figure ES-4: Pu-239 Sensitivity Studies - Peak All Pathways Pu-239 Dose within 100,000 Years (Expanded View)



Based on the above discussion and Figures ES-3 and ES-4, the Special Analysis results continue to provide reasonable assurance that compliance is maintained with the specific requirements of NDAA Section 3116, DOE M 435.1-1, and the MCLs. The conclusions that were made based on the FTF PA regarding the final closure of Tanks 18 and 19 are not significantly impacted by new information regarding the final residual inventories that are planned to be grouted in-place in Tanks 18 and 19.

1.0 SPECIAL ANALYSIS PURPOSE

The purpose of this Special Analysis is to evaluate the information regarding the final residual inventories that are planned to be grouted in-place in Tanks 18 and 19. This new inventory information was used to update the FTF fate and transport modeling performed as part of the FTF PA. The potential impact of the new inventory information on FTF PA assumptions was also considered. Because the FTF PA analyzed projected inventories for Tanks 18 and 19, this report focuses on the impact of the final residual waste data on the information presented in the FTF PA. Because there is a significant dose associated with Pu-239 from Tank 18 occurring beyond the performance period (approximately 500 mrem/yr occurring approximately 40,000 years following FTF closure), additional sensitivity analyses regarding plutonium were also performed as part of this Special Analysis. These additional sensitivity analyses demonstrate that the FTF Base Case model incorporates conservative approaches/inputs and the peak doses associated with Pu-239 would likely occur even farther beyond the 10,000-year performance period if these conservative approaches/inputs were eliminated. It is not intended that information previously provided in the FTF PA that is unaffected by the new residual waste data be duplicated in this report. The Special Analysis results may be used to inform decisions regarding Tanks 18 and 19 closure documents.

2.0 BASIS

The *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses* (DOE_11-10-1999) recognizes that conduct of a PA is not a static process, and states that, "*Special analyses are expected to be needed as part of the routine maintenance of the performance assessment.*" As described in the maintenance guide, "*special analyses are analyses performed to evaluate the significance of new information or new analytical methods to the results of the performance assessment, or to supplement or amend the analyses performed in the original performance assessment. A special analysis is not the same as a revision to the performance assessment, but the results of the special analysis may be used to determine whether a performance assessment revision is needed.*" As stated in the maintenance guide, a number of different factors may prompt a special analysis, including "*wastes that exceed the concentrations analyzed for performance assessment-significant radionuclides.*"

The guide also states, "*the purpose of conducting special analyses can be thought of as similar to the process for resolving unreviewed safety questions described in the DOE Order 5480.21, Unreviewed Safety Questions. The intent of the process is to provide flexibility in day-to-day operations and to require those issues with a significant impact on the performance assessment's conclusions, and therefore the projected compliance with performance objectives, to be brought to the proper level for attention.*" [DOE_11-10-1999]

3.0 TANKS 18 AND 19 BACKGROUND INFORMATION

3.1 Savannah River Site Characteristics

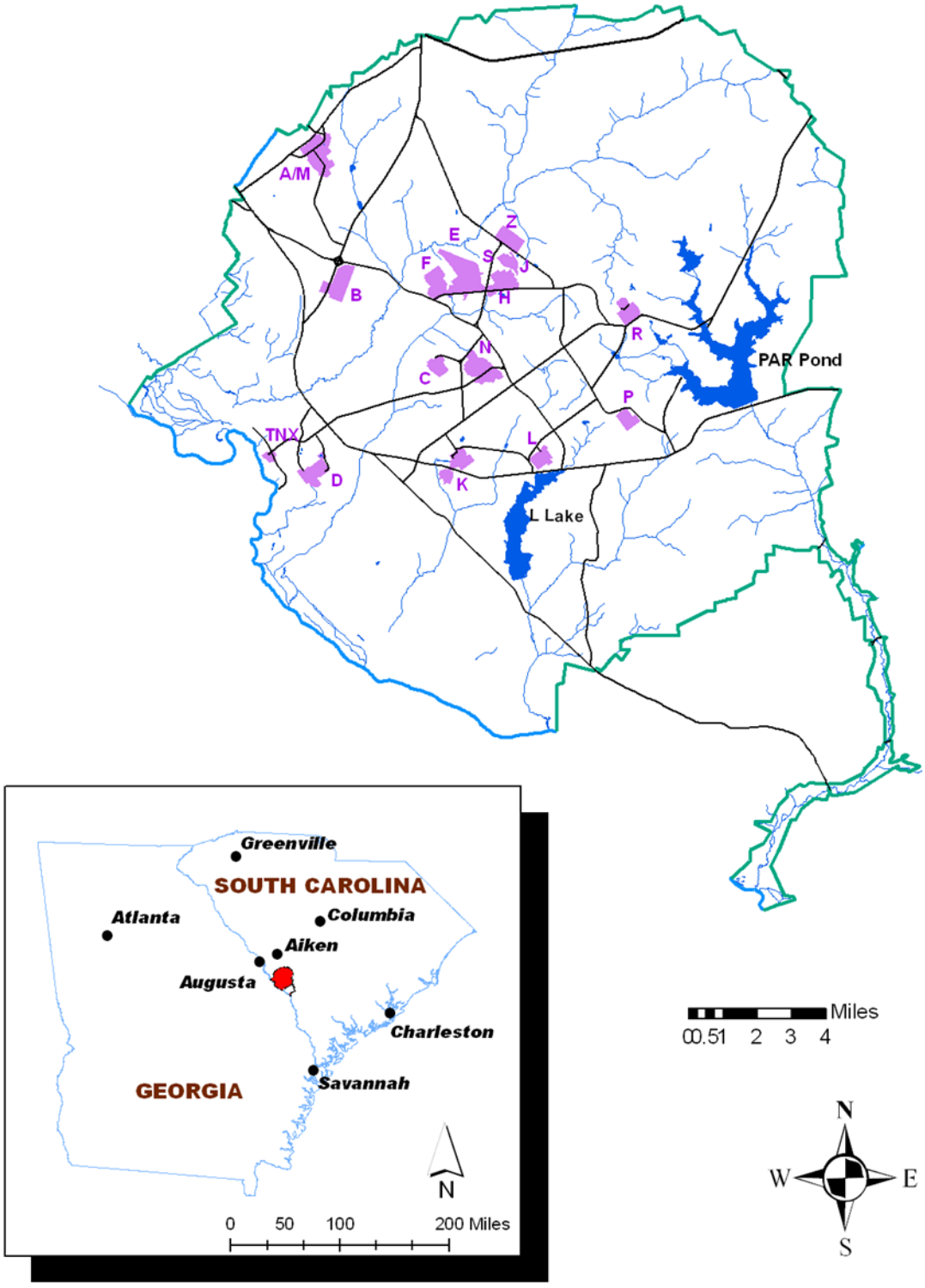
The SRS is located in south-central South Carolina, approximately 100 miles from the Atlantic Coast. The major physical feature at SRS is the Savannah River, approximately 20 miles of which serves as the southwestern boundary of the site and the South Carolina-Georgia border. The SRS encompasses portions of Aiken, Barnwell, and Allendale counties in South Carolina. The SRS occupies approximately 310 square miles, or more than 198,000 acres, and contains operations, service, and research and development areas. The developed areas occupy less than 10 % of the SRS footprint while the remainder of the site is undeveloped forest or wetlands. [SRS-REG-2007-00002]

Additional site characteristics are addressed in Section 3.1 of FTF PA. Topics addressed in Section 3.1 of FTF PA include Geography, Demography, Meteorology, Climatology, Ecology, Geology, Seismology, Hydrogeology, Geochemistry, and Natural Resources.

3.2 F-Tank Farm Facility Description

A legacy of the SRS mission was the generation of liquid waste from chemical separations processes in both F and H Areas. Since the beginning of SRS operations, an integrated waste management system has evolved, which consists of several facilities designed for the overall processing of liquid waste. Two of the major components of this system are the FTF and H-Tank Farm (HTF) (located in F Area and H Area, respectively), near the center of the site (Figure 3.2-1). In F Area, plutonium, uranium, and other radionuclides were separated from target assemblies using chemical separations processes. The tank farms, which store and process waste from the chemical separations process, include waste tanks, evaporators, transfer line systems, and other ancillary structures.

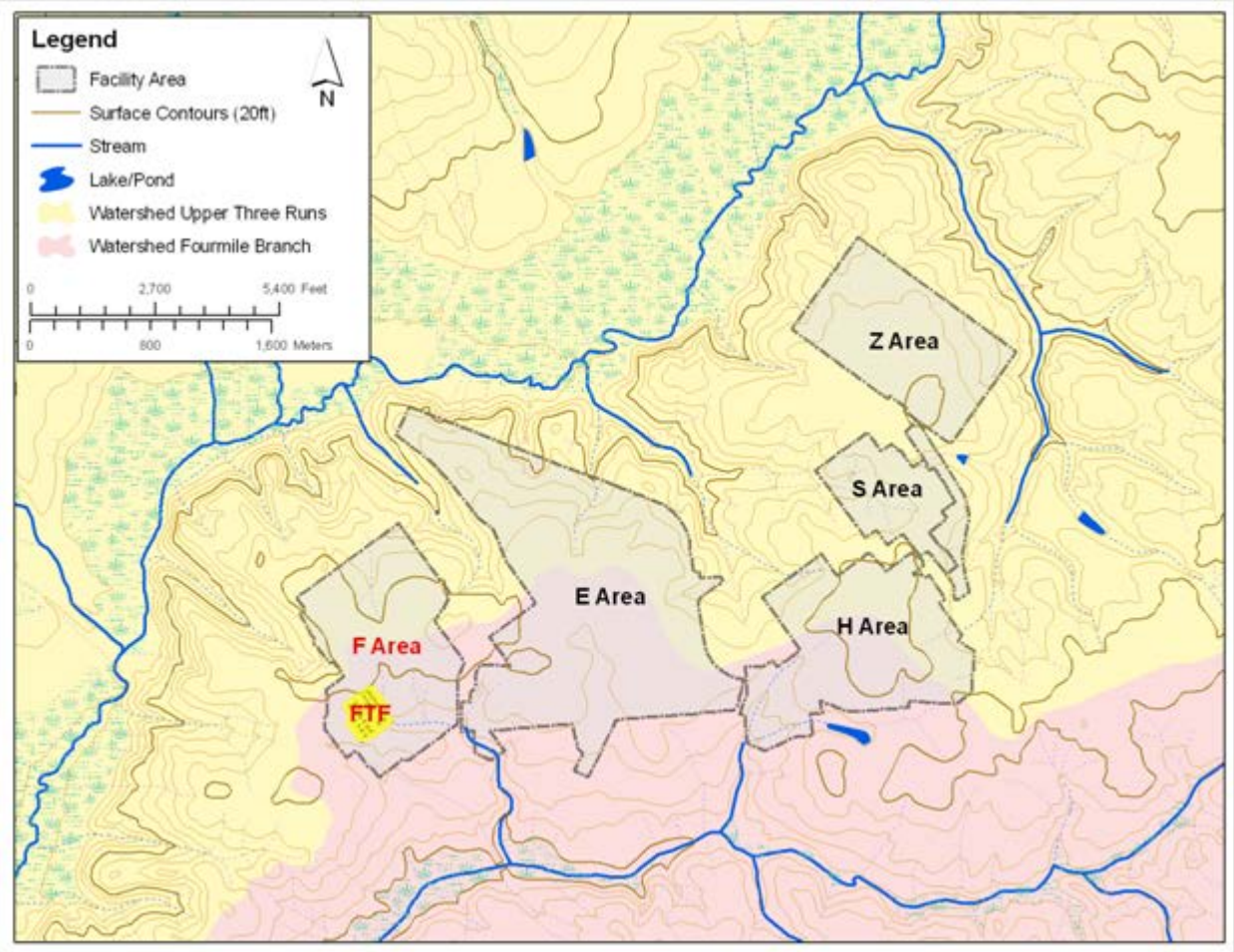
Figure 3.2-1: SRS Operational Area Location Map



Additional FTF facility characteristics are addressed in Section 3.2 of FTF PA.

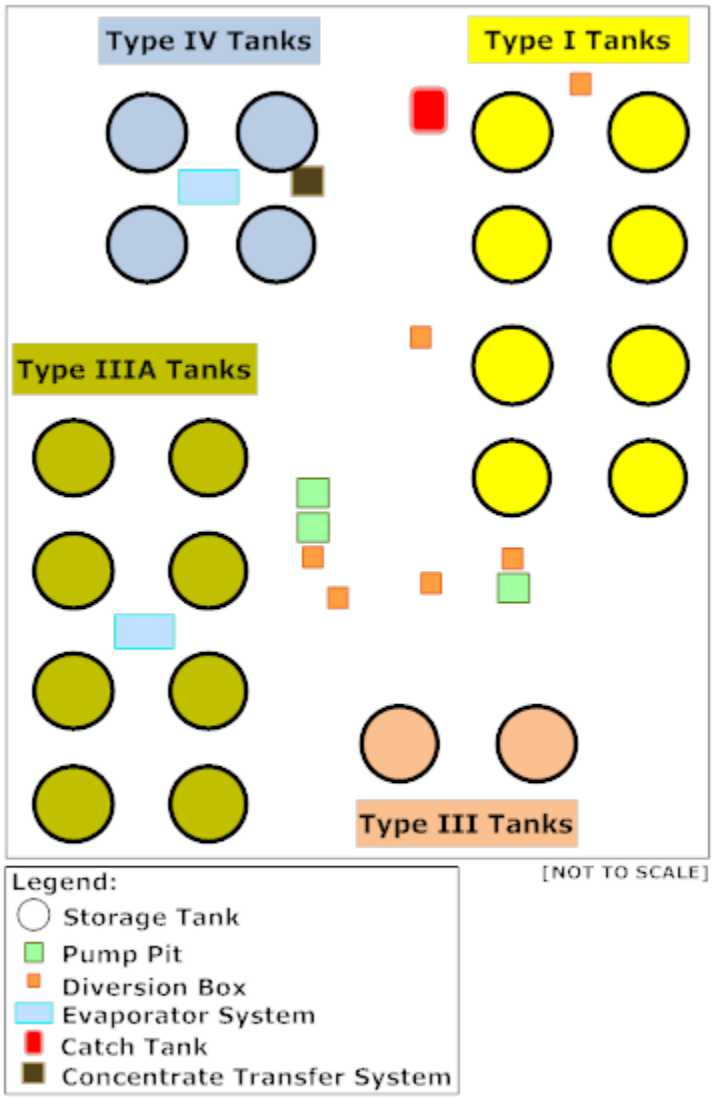
The FTF site was chosen because of its favorable terrain, proximity to the F-Canyon Separations Facility (the major waste generation source), and isolation distance from the SRS boundaries. Figure 3.2-2 shows the setting of F Area and FTF within the General Separations Area (GSA).

Figure 3.2-2: Layout of the General Separations Area



The FTF is a 22-acre site, which consists of 22 waste tanks and supporting ancillary structures. The major FTF ancillary structures are two evaporator systems, transfer lines, six diversion boxes (DBs), one catch tank, a concentrate transfer system (CTS) tank and three pump pits (PPs). There are three major waste tank types in FTF with nominal operating capacities ranging from 750,000 gallons (Type I tanks) to 1.3 million gallons (Type III, IIIA, and Type IV tanks). Figure 3.2-3 shows the general layout of FTF. The waste tanks have varying degrees of secondary containment (liner) and in-tank structural features such as cooling coils and columns. All FTF waste tank types have primary liners constructed of carbon steel. The FTF was constructed to receive waste generated by various SRS production, processing, and laboratory facilities. The use of FTF isolated these wastes from the environment, SRS workers, and the public. The FTF PA provides extensive descriptions of the FTF and waste processing facilities. [SRS-REG-2007-00002]

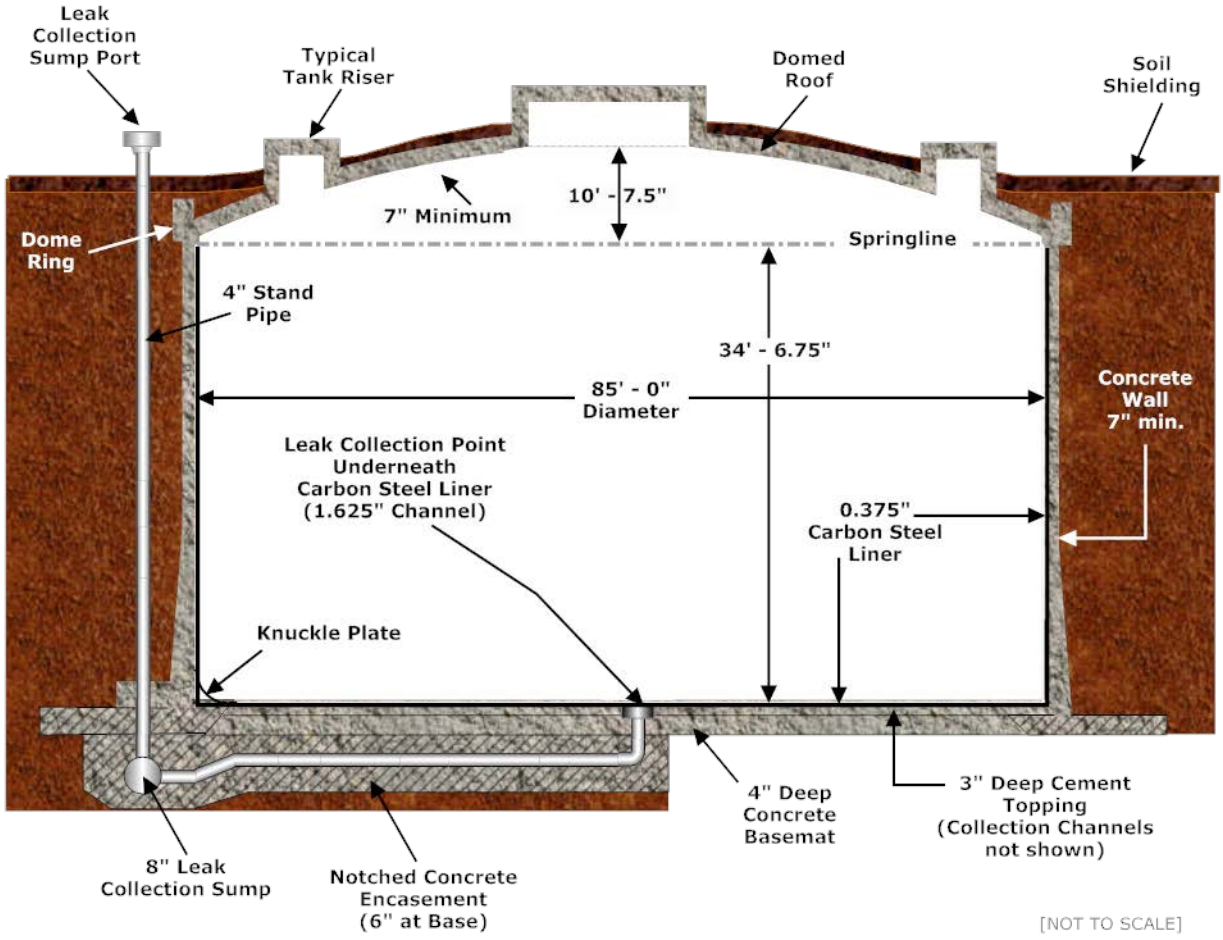
Figure 3.2-3: General Layout of F-Tank Farm



3.3 Waste Tanks 18 and 19

Tanks 18 and 19 are Type IV tanks. There are four Type IV tanks in FTF (Tanks 17 through 20). The FTF Type IV tanks were constructed in the late 1950s. Figure 3.3-1 shows a typical Type IV tank. These waste tanks have a single carbon-steel liner with a reinforced concrete domed roof that is self-supporting. Type IV tanks are 85 feet in diameter and approximately 34 feet in height at the side wall with a nominal operating capacity of 1,300,000 gallons. Type IV tanks do not have secondary containment and do not have cooling coils. Tanks 17 and 20 were removed from service and filled with grout in 1997 under the South Carolina Department of Health and Environmental Control (SCDHEC) approved closure modules. [PIT-MISC-0002, PIT-MISC-0004] Section 3.2.1.3 of the FTF PA provides additional details of the Type IV tanks. [SRS-REG-2007-00002]

Figure 3.3-1: Sketch of Typical Type IV Tank (Cross-sectional View)



4.0 F-TANK FARM PERFORMANCE ASSESSMENT BACKGROUND INFORMATION

This Special Analysis is being prepared based on the information presented in the FTF PA. The FTF PA was prepared to support the eventual operational closure of the FTF underground waste tanks and ancillary equipment. The FTF PA provides the technical basis and results to be used in subsequent documents to demonstrate compliance with the pertinent requirements from the documents identified below for final closure of FTF as indicated in Table 4.0-1:

- DOE Manual 435.1-1
- *Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005* Section 3116
- *Bureau of Water Pollution Control Permit to Construct, F and H-Area High-Level Radioactive Waste Tank Farms, Construction Permit #17,424-IW*
- *Federal Facility Agreement* (FFA) *for the Savannah River Site*

The key requirements from the preceding documents necessitate development and calculation of the following for the FTF: potential radiological doses to a hypothetical MOP; potential radiological doses to a hypothetical inadvertent intruder; radiological dose to a human receptor via the air pathway, radon flux and water concentrations. All of these calculations were performed to provide results over a minimum of 10,000 years. The water concentrations were calculated for both radioactive and non-radioactive contaminants at multiple locations outside FTF.

Table 4.0-1: Key Performance Objectives

Requirement	All-Pathways Dose	Intruder Dose	Air Pathway Dose	Radon Flux	Groundwater Protection
NDAA Section 3116: 10 CFR 61.41 and 61.42	25 mrem/yr	500 mrem/yr	N/A	N/A	N/A
DOE M 435.1-1	25 mrem/yr	500 mrem – acute 100 mrem/yr – chronic	10 mrem/yr	20 $pCi/m^2/s$ at ground surface	< MCL
SCDHEC Primary Drinking Water Regulations	N/A	N/A	N/A	N/A	< MCL

N/A = Not applicable
MCL = Maximum Contaminant Level

In accordance with the FFA requirements for high-level radioactive waste tank system(s), a construction and operating permit was obtained from the SCDHEC for the SRS tank farm waste tank systems; the *Bureau of Water Pollution Control Permit to Construct, F and H-Area High-Level Radioactive Waste Tank Farms, Construction Permit #17,424-IW* (hereinafter referred to as Permit #17,424-IW). [DHEC_01-25-1993] The FFA requires that waste tank system(s) that have been issued an industrial wastewater (IWW) operating permit under the Pollution Control Act (PCA), shall be removed from service in accordance with S.C. Code Ann., Section 48-1-10,

et seq. (1985) and all applicable regulations promulgated pursuant to the PCA. [Title 48_Chapter 1_SC Laws] Applicable regulations include SCDHEC Regulation 61-67, *Standards for Wastewater Facility Construction* and SCDHEC Regulation 61-82, *Proper Closeout of Wastewater Treatment Facilities*. [WSRC-OS-94-42 Section IX.E (4)] The SCDHEC has advised that this process will involve two bureaus (Bureau of Water and Bureau of Land and Waste Management).

The regulatory process to complete closure of the FTF requires the development of multiple detailed technical documents with reviews and approvals by state and federal agencies. The documents involved include DOE's final revision of the FTF basis for Section 3116 determination for facility closure, which will be used to demonstrate that the criteria in *Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005* Section 3116 (hereinafter referred to as NDAA Section 3116) are met. [NDAA_3116] DOE's final revision of the FTF basis for Section 3116 determination for facility closure document will provide a basis upon which the Secretary of Energy, in consultation with the NRC, may determine that the criteria in NDAA Section 3116 are met and that the stabilized residual waste at closure is not high-level waste. The criteria in NDAA Section 3116 provide that the waste will be disposed of in compliance with the performance objectives in the NRC regulations at 10 CFR Part 61, Subpart C. The current revision of the FTF PA (SRS-REG-2007-00002) provides the technical basis that will be used to demonstrate compliance with 10 CFR 61.41 (*Protection of the General Population from Releases of Radioactivity*) and 61.42 (*Protection of Individuals from Inadvertent Intrusion*) performance objectives, which will be presented in the final FTF basis for Section 3116 determination for facility closure document. [10 CFR 61] These performance objectives are used in lieu of the comparable performance objectives from DOE M 435.1-1. Compliance with the SCDHEC requirements will be demonstrated using two primary documents that are supported by FTF PA. The first is the I*ndustrial Wastewater General Closure Plan for F-Area Waste Tank Systems, Industrial Wastewater Construction Permit #17,424-IW* (LWO-RIP-2009-00009), which establishes the general protocols, requirements, and processes for operational closure of FTF. The second document(s) are waste tank-specific closure modules that authorize the operational closure and grouting of a specific waste tank, group of waste tanks, or ancillary equipment.

The FTF PA provides the technical information at different points of assessment that can be utilized in subsequent decision documents (e.g., waste tank-specific closure modules). The FTF PA provides groundwater radionuclide concentrations at 1 meter, 100 meters, and exposure points at the two seeplines approximately 1,600 meters from FTF. The groundwater concentrations are provided for each of the three aquifers as applicable as a part of the FTF groundwater modeling. FTF PA also provides groundwater concentrations for chemical contaminants at 1 meter and 100 meters. In addition to intruder doses consistent with the requirements for 10 CFR 61.42, as well as analyses for the air pathways and radon ground-surface flux.

5.0 TANKS 18 AND 19 RESIDUAL WASTE INFORMATION

As part of the Tanks 18 and 19 operational closure process, actual residual inventories at operational closure have been determined for Tanks 18 and 19 utilizing samples from the tanks after waste removal activities were completed. The waste characterization methodology used to develop the Tanks 18 and 19 characterizations summed the inventory from discrete areas of each waste tank. Each area's residual inventory was determined by taking its material concentration and multiplying it by the corresponding residual volume (or surface area). The calculation was repeated for each constituent (radionuclides and chemicals). Tables 5.0-1 and 5.0-2 list Tanks 18 and 19 residual inventories at final facility closure for the FTF radionuclides and chemicals. [SRR-CWDA-2010-00117, SRR-CWDA-2010-00118]

Table 5.0-1: Tanks 18 and 19 Radionuclide Inventories (Ci)

Radionuclide	Tank 18 Actual	Tank 19 Actual	Radionuclide	Tank 18 Actual	Tank 19 Actual
Ac-227	1.5E-04	9.6E-06	Pa-231	4.6E-02	6.9E-05
Al-26	1.9E-04	3.8E-05	Pd-107	1.2E-01	2.0E-01
Am-241	1.6E+02	2.6E+00	Pt-193	3.6E-03	1.5E-03
Am-242m	3.8E-02	2.5E-04	Pu-238	1.3E+03	3.4E+00
Am-243	2.3E+00	6.8E-03	Pu-239	2.8E+02	4.0E+00
Ba-137m	8.7E+03	4.0E+03	Pu-240	6.5E+01	9.8E-01
C-14	9.0E-01	4.1E+00	Pu-241	2.7E+02	3.9E+00
Cf-249	2.3E-03	5.2E-04	Pu-242	2.7E-02	1.7E-03
Cl-36	2.8E-04	9.1E-05	Pu-244	6.2E-06	5.3E-06
Cm-243	1.8E-02	1.7E-03	Ra-226	3.4E-03	4.1E-03
Cm-244	9.8E+01	2.7E-01	Sb-126	1.8E-03	4.7E-04
Cm-245	1.2E-02	1.6E-03	Sb-126m	1.3E-02	3.3E-03
Cm-247	2.1E-06	1.3E-06	Se-79	4.8E-04	4.6E-04
Cm-248	9.5E-05	5.8E-05	Sm-151	3.7E+01	1.5E-01
Co-60	3.2E-01	1.2E-02	Sn-126	1.3E-02	3.3E-03
Cs-135	3.0E-02	5.4E-02	Sr-90	2.5E+03	6.9E+00
Cs-137	9.2E+03	4.2E+03	Tc-99	9.0E-01	3.8E-01
Eu-152	4.7E-03	1.7E-04	Th-229	8.9E-04	2.0E-04
Eu-154	2.1E-01	3.8E-03	Th-230	2.1E-03	1.1E-04
H-3	8.0E-03	2.5E-03	U-232	6.9E-04	9.5E-05
I-129	2.7E-04	2.2E-04	U-233	4.0E-02	4.3E-03
K-40	1.6E-02	1.0E-03	U-234	3.1E-01	4.8E-03
Nb-93m	8.6E-02	1.8E-02	U-235	1.1E-02	1.7E-04
Nb-94	5.5E-04	1.0E-04	U-236	1.2E-02	2.5E-04
Ni-59	3.3E-01	3.5E-04	U-238	2.8E-01	5.4E-03
Ni-63	1.6E+01	1.3E-02	Y-90	2.5E+03	6.9E+00
Np-237	1.9E-01	1.5E-03	Zr-93	8.6E-02	1.8E-02

[SRR-CWDA-2010-00117, SRR-CWDA-2010-00118]

Table 5.0-2: Tanks 18 and 19 Chemical Inventories (kg)

Chemical	Tank 18 Actual	Tank 19 Actual
Ag	4.5E+00	7.1E-01
As	8.5E-02	2.9E-02
Ba	5.4E+00	8.0E+00
Cd	1.6E+02	1.2E+00
Cr	1.2E+01	3.0E+00
Cu	1.8E+00	5.0E-01
F	8.3E+00	1.5E+01
Fe	1.9E+03	4.0E+02
Hg	1.7E+01	3.8E+00
Mn	2.4E+02	1.6E+01
Ni	2.4E+01	2.3E+00
NO_2	9.6E+00	8.8E+01
NO_3	8.2E+00	1.7E+02
Pb	1.2E+01	3.5E+00
Sb	8.8E+00	3.5E+00
Se	1.7E-01	8.8E-03
U	9.0E+02	1.6E+01
Zn	3.9E+00	6.9E-01

[SRR-CWDA-2010-00117, SRR-CWDA-2010-00118]

6.0 F-TANK FARM PERFORMANCE ASSESSMENT EVALUATION

This section will evaluate the new information (i.e., final characterization) on Tanks 18 and 19 residual waste at operational closure presented in Section 5.0. This new inventory information is used to update the FTF fate and transport modeling performed as part of FTF PA. The potential impact of the new inventory information on FTF PA assumptions is also considered. Because there is a significant dose associated with Pu-239 from Tank 18 occurring beyond the performance period (approximately 500 mrem/yr occurring approximately 40,000 years following FTF final facility closure), additional sensitivity analyses regarding plutonium were also performed as part of this Special Analysis. These additional sensitivity analyses demonstrate that the FTF PA Base Case incorporates conservative approaches/inputs and the peak doses associated with Pu-239 would likely occur even farther beyond the 10,000-year performance period if these conservative approaches/inputs are eliminated. Since this evaluation is applicable only to FTF PA, Rev.1, documents prepared subsequent to FTF PA, Rev.1 are outside the scope of this Special Analysis.

6.1 F-Tank Farm Facility Characteristics

This section will discuss the impact of the new residual waste information on the FTF facility characteristics information presented in Section 3.0 of the FTF PA.

6.1.1 Site Characteristics

Section 3.1 of FTF PA contains a description of SRS site characteristics. The site characteristics information presented in the FTF PA is not affected by the new residual waste information.

6.1.2 Principal Facility Design Features

Section 3.2 of FTF PA contains a description of the FTF facility design features. The FTF facility design features information presented in the FTF PA is not affected by the new residual waste information.

6.1.3 Stabilized Contaminant Characteristics

Section 3.3 of FTF PA contains a description of the FTF stabilized contaminant characteristics, which is affected by the new residual waste information as detailed below.

Section 3.3.1 of FTF PA describes the stabilized contaminant characterization screening process. The screening process utilized is not affected by the new residual waste information.

Section 3.3.2 of FTF PA includes the individual waste tank inventories, which are an integral part of the modeling process. The projected Tanks 18 and 19 waste tank radionuclide and chemical inventories utilized in FTF PA are presented in Tables 6.1-1 and 6.1-2. The revised (i.e., final) Tanks 18 and 19 waste tank inventories, based on the new residual waste information presented in Section 5.0 of this Special Analysis, are also included in Tables 6.1-1 and 6.1-2. Additional details regarding determination of the Tanks 18 and 19 inventories at operational closure can be found in the Tanks 18 and 19 waste characterization reports (SRR-CWDA-2010-00117 and SRR-CWDA-2010-00118).

Table 6.1-1: Tanks 18 and 19 Radionuclide Inventories (Ci)

Radionuclide	Tank 18 PA Rev1	Tank 18 Actual	Tank 18 Delta	Tank 19 PA Rev1	Tank 19 Actual	Tank 19 Delta
Ac-227	1.0E-03	1.5E-04	(0.00)	1.0E-03	9.6E-06	(0.00)
Al-26	1.0E+00	1.9E-04	(1.00)	1.0E+00	3.8E-05	(1.00)
Am-241	8.2E+01	1.6E+02	78.00	2.3E+00	2.6E+00	0.30
Am-242m	1.0E+00	3.8E-02	(0.96)	1.0E+00	2.5E-04	(1.00)
Am-243	1.0E-01	2.3E+00	2.20	1.0E-01	6.8E-03	(0.09)
Ba-137m	9.1E+03	8.7E+03	(400.00)	6.2E+03	4.0E+03	(2200.00)
C-14	1.0E+00	9.0E-01	(0.10)	1.0E+00	4.1E+00	3.10
Cf-249	1.0E+00	2.3E-03	(1.00)	1.0E+00	5.2E-04	(1.00)
Cl-36	1.0E-03	2.8E-04	(0.00)	1.0E-03	9.1E-05	(0.00)
Cm-243	1.0E+00	1.8E-02	(0.98)	1.0E+00	1.7E-03	(1.00)
Cm-244	1.0E+02	9.8E+01	(2.00)	1.0E+00	2.7E-01	(0.73)
Cm-245	1.0E+00	1.2E-02	(0.99)	1.0E+00	1.6E-03	(1.00)
Cm-247	1.0E-03	2.1E-06	(0.00)	1.0E-03	1.3E-06	(0.00)
Cm-248	1.0E-03	9.5E-05	(0.00)	1.0E-03	5.8E-05	(0.00)
Co-60	1.0E+00	3.2E-01	(0.68)	1.0E+00	1.2E-02	(0.99)
Cs-135	1.0E+00	3.0E-02	(0.97)	1.0E+00	5.4E-02	(0.95)
Cs-137	9.7E+03	9.2E+03	(500.00)	6.5E+03	4.2E+03	(2300.00)
Eu-152	1.0E+00	4.7E-03	(1.00)	1.0E+00	1.7E-04	(1.00)
Eu-154	3.2E+00	2.1E-01	(2.99)	1.0E+00	3.8E-03	(1.00)
H-3	1.0E+00	8.0E-03	(0.99)	1.0E+00	2.5E-03	(1.00)
I-129	1.0E-03	2.7E-04	(0.00)	1.0E-03	2.2E-04	(0.00)
K-40	1.0E-03	1.6E-02	0.02	1.0E-03	1.0E-03	0.00
Nb-93m	1.0E-03	8.6E-02	0.09	1.0E-03	1.8E-02	0.02
Nb-94	1.0E-03	5.5E-04	(0.00)	1.0E-03	1.0E-04	(0.00)
Ni-59	1.0E+00	3.3E-01	(0.67)	1.0E+00	3.5E-04	(1.00)
Ni-63	8.2E+01	1.6E+01	(66.00)	1.4E+01	1.3E-02	(13.99)
Np-237	2.4E-01	1.9E-01	(0.05)	2.2E-03	1.5E-03	(0.00)
Pa-231	1.0E-03	4.6E-02	0.05	1.0E-03	6.9E-05	(0.00)
Pd-107	1.0E-03	1.2E-01	0.12	1.0E-03	2.0E-01	0.20
Pt-193	1.0E-03	3.6E-03	0.00	1.0E+00	1.5E-03	(1.00)
Pu-238	7.0E+01	1.3E+03	1230.00	4.4E+00	3.4E+00	(1.00)
Pu-239	1.6E+02	2.8E+02	120.00	6.4E+00	4.0E+00	(2.40)
Pu-240	4.9E+01	6.5E+01	16.00	2.3E+00	9.8E-01	(1.32)
Pu-241	1.3E+02	2.7E+02	140.00	4.6E+00	3.9E+00	(0.70)
Pu-242	1.0E+00	2.7E-02	(0.97)	1.0E+00	1.7E-03	(1.00)
Pu-244	1.0E-03	6.2E-06	(0.00)	1.0E-03	5.3E-06	(0.00)
Ra-226	1.9E-03	3.4E-03	0.00	1.1E-03	4.1E-03	0.00
Sb-126	2.3E-02	1.8E-03	(0.02)	3.6E-03	4.7E-04	(0.00)
Sb-126m	1.6E-01	1.3E-02	(0.15)	2.6E-02	3.3E-03	(0.02)
Se-79	1.0E+00	4.8E-04	(1.00)	1.0E+00	4.6E-04	(1.00)
Sm-151	4.6E+01	3.7E+01	(9.00)	1.0E+00	1.5E-01	(0.85)
Sn-126	1.6E-01	1.3E-02	(0.15)	2.6E-02	3.3E-03	(0.02)
Sr-90	1.1E+03	2.5E+03	1400.00	5.2E+00	6.9E+00	1.70
Tc-99	1.0E+00	9.0E-01	(0.10)	1.4E+00	3.8E-01	(1.02)
Th-229	2.6E-03	8.9E-04	(0.00)	1.0E-03	2.0E-04	(0.00)
Th-230	1.9E-03	2.1E-03	0.00	1.1E-03	1.1E-04	(0.00)
U-232	1.0E+00	6.9E-04	(1.00)	1.0E+00	9.5E-05	(1.00)
U-233	1.1E+00	4.0E-02	(1.06)	1.9E-01	4.3E-03	(0.19)
U-234	3.8E-01	3.1E-01	(0.07)	1.1E-02	4.8E-03	(0.01)
U-235	8.4E-03	1.1E-02	0.00	2.6E-04	1.7E-04	(0.00)
U-236	1.0E+00	1.2E-02	(0.99)	1.0E+00	2.5E-04	(1.00)
U-238	2.2E-01	2.8E-01	0.06	8.7E-03	5.4E-03	(0.00)
Y-90	1.1E+03	2.5E+03	1400.00	5.2E+00	6.9E+00	1.70
Zr-93	1.0E-03	8.6E-02	0.09	1.0E-03	1.8E-02	0.02

Note: Red numerals denote an inventory decrease.
[SRS-REG-2007-00002, SRR-CWDA-2010-00117, SRR-CWDA-2010-00118]

Table 6.1-2: Tanks 18 and 19 Chemical Inventories (kg)

Chemical	Tank 18 PA R1	Tank 18 Actual	Tank 18 Delta	Tank 19 PA R1	Tank 19 Actual	Tank 19 Delta
Ag	3.2E+00	4.50E+00	1.30	1.2E+00	7.10E-01	(0.49)
As	8.2E-01	8.50E-02	(0.74)	9.7E-01	2.90E-02	(0.94)
Ba	3.8E+00	5.40E+00	1.60	9.9E+00	8.00E+00	(1.90)
Cd	1.2E+02	1.60E+02	40.00	1.1E+00	1.20E+00	0.10
Cr	1.1E+01	1.20E+01	1.00	4.2E+00	3.00E+00	(1.20)
Cu	5.1E+00	1.80E+00	(3.30)	5.1E-01	5.00E-01	(0.01)
F	7.2E-01	8.30E+00	7.58	1.8E+01	1.50E+01	(3.00)
Fe	1.7E+03	1.90E+03	200.00	2.1E+02	4.00E+02	190.00
Hg	2.0E+01	1.70E+01	(3.00)	2.0E+00	3.80E+00	1.80
Mn	2.1E+02	2.40E+02	30.00	1.5E+01	1.60E+01	1.00
Ni	1.9E+01	2.40E+01	5.00	1.6E+00	2.30E+00	0.70
NO_2	7.8E+00	9.60E+00	1.80	5.5E+02	8.80E+01	(462.00)
NO_3	4.6E+00	8.20E+00	3.60	3.8E+02	1.70E+02	(210.00)
Pb	4.0E+01	1.20E+01	(28.00)	5.3E+00	3.50E+00	(1.80)
Sb	2.5E+01	8.80E+00	(16.20)	2.2E+01	3.50E+00	(18.50)
Se	8.2E-01	1.70E-01	(0.65)	8.8E+00	8.80E-03	(8.79)
U	5.4E+02	9.00E+02	360.00	1.9E+01	1.60E+01	(3.00)
Zn	9.0E+00	3.90E+00	(5.10)	7.1E-01	6.90E-01	(0.02)

Note: Red numerals denote an inventory decrease.
[SRS-REG-2007-00002, SRR-CWDA-2010-00117, SRR-CWDA-2010-00118]

The impacts of these new FTF inventories on various PA analyses (e.g., public dose analyses) are presented later in Section 6.3 of this Special Analysis.

Section 3.3.3 of FTF PA describes the FTF ancillary equipment inventory. The ancillary equipment inventory is based on the residual inventories at those specific locations (e.g., evaporator vessels, pump tanks) and is not affected by the new residual waste information.

6.2 The F-Tank Farm Analysis of Performance

This section will discuss the impact of the new residual waste information on the FTF analysis of performance information presented in Section 4.0 of the FTF PA.

6.2.1 Overview of Analysis

Section 4.1 of FTF PA contains an overview of analysis. The overview of analysis information presented in the FTF PA is not affected by the new residual waste information.

6.2.2 Integrated Site Conceptual Model of Facility Performance

Section 4.2 of FTF PA describes the Integrated Conceptual Model (ICM), which is used to simulate the release of radiological and chemical contaminants from the 22 underground waste tanks and associated ancillary equipment in FTF. The Section 4.2 ICM information presented in the FTF PA is not affected by the new residual waste information.

Section 4.2.2 (Source Term Release) of FTF PA includes a discussion of the waste release model, which is an integral part of the modeling process. The information regarding the residual waste characteristics presented in the Tanks 18 and 19 waste characterization reports (SRR-CWDA-2010-00117 and SRR-CWDA-2010-00118) are summarized in Section 5.0 of this Special Analysis, is consistent with the source term release assumptions, and does not impact the waste release model.

6.2.3 Modeling Codes

Section 4.3 of FTF PA contains a discussion of the modeling codes. The FTF PA Base Case (i.e., deterministic) modeling was performed using the PORFLOW model as was done in FTF PA. The FTF PORFLOW model itself was not changed for the PORFLOW modeling runs performed for this Special Analysis but the model was rerun with some modeling inputs revised. For the FTF Base Case PORFLOW modeling runs, the Tanks 18 and 19 actual residual inventories at operational closure were updated. For the PORFLOW deterministic sensitivity runs, some select plutonium solubility and retardation inputs were updated. FTF probabilistic modeling for the Special Analysis was performed using the GoldSim FTF model version "SRS FTF v2.5." GoldSim FTF model version "SRS FTF v2.5" is the same as the model used for FTF PA except that the Tanks 18 and 19 inventories and inventory distributions were revised to reflect the actual residual inventories at operational closure. Quality assurance (e.g., verification of modeling inputs used) for these modeling input revisions is documented in the *Tank 18/Tank 19 Special Analysis for the Performance Assessment for the F-Area Tank Farm at the Savannah River Site Quality Assurance Report* (SRR-CWDA-2010-00131). The modeling codes information presented in FTF PA is not affected by the new residual waste information.

6.2.4 Closure System Modeling

Section 4.4 of FTF PA describes how the FTF design elements and their associated properties were represented in the computer modeling codes. The closure system modeling information presented in the FTF PA is not affected by the new residual waste information.

6.2.5 Airborne and Radon Analysis

Section 4.5 of FTF PA contains a discussion of the airborne and radon analysis methodology. The air and radon pathway conceptual model and analysis approach presented in the FTF PA is not affected by the new residual waste information.

6.2.6 Biotic Pathways

Section 4.6 of FTF PA documents the bioaccumulation factors and human health exposure parameters used in the FTF PA modeling effort. The bioaccumulation factors and human health exposure parameters presented in the FTF PA are not affected by the new residual waste information.

6.2.7 Dose Analysis

Section 4.7 of FTF PA contains a discussion of the dose analysis approach used and presents the set of dose conversion factors (DCFs) used in the dose calculations modeling effort methodology. The dose analysis information presented in FTF PA is not affected by the new residual waste information.

6.2.8 RCRA/CERCLA Risk Evaluation

Section 4.8 of FTF PA contains a discussion of the Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (RCRA/CERCLA) risk evaluation methodology. The RCRA/CERCLA risk evaluation approach presented in the FTF PA is not affected by the new residual waste information.

6.3 FTF Results of Analysis

This section will discuss the impact of the new residual waste information on the FTF results presented in Section 5.0 of FTF PA.

6.3.1 Source Term (Analyses Results)

Section 5.1 of FTF PA presents the peak stabilized contaminant release rates from the FTF waste tanks and ancillary equipment. The release rates (fluxes) were calculated using the PORFLOW FTF baseline model, with the flux from the FTF waste tanks and ancillary equipment calculated at two locations: 1) exiting the inventory source containment and 2) entering the upper aquifer below the associated inventory source. The peak fluxes presented in Section 5.1 of the FTF PA were reassessed using the new residual waste information and are not significantly different from those presented in the FTF PA. Those radionuclides with flux differences (e.g., Pa-231) are discernible in the groundwater concentrations at 100 meters from the FTF boundary (Section 6.3.2.1).

6.3.2 Environmental Transport of Radionuclides

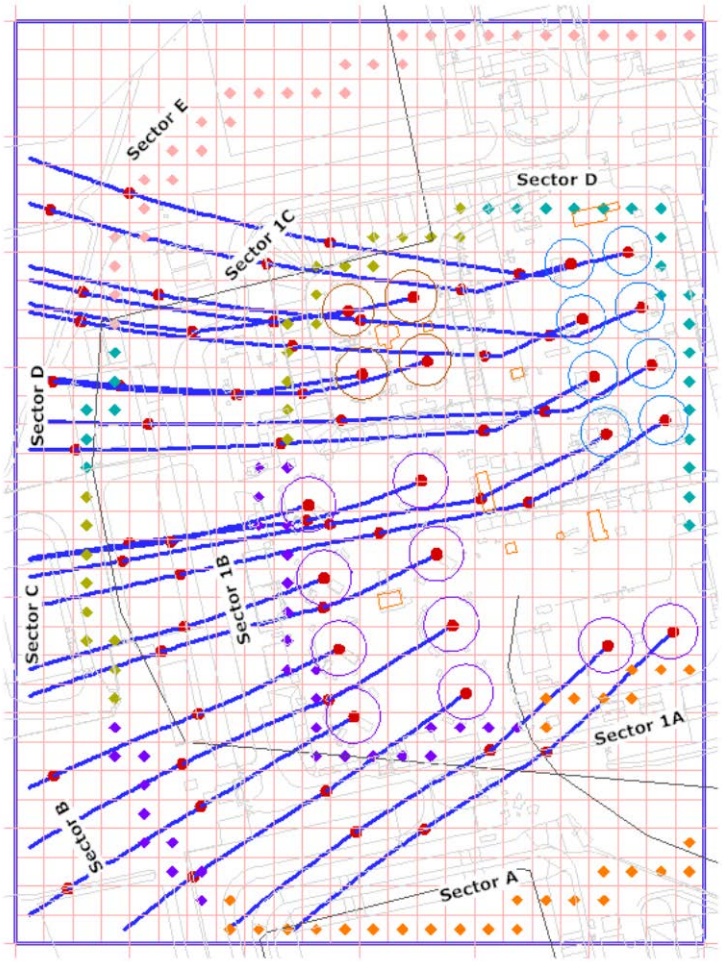
Section 5.2 (Environmental Transport of Radionuclides) of FTF PA presents the groundwater concentrations for the FTF radionuclides and chemicals. Maximum groundwater concentrations are presented for two exposure points: 1) 100 meters from the FTF and 2) at the seeplines for Upper Three Runs (UTR) and Fourmile Branch. Results are presented in FTF PA for the three distinct aquifers modeled, UTR-Upper Zone (UTR-UZ), UTR-Lower Zone (UTR-LZ), and Gordon Aquifer. The groundwater concentrations at 100 meters and at the seepline were recalculated using the PORFLOW FTF model for the FTF PA Base Case using the Tanks 18 and 19 residual inventories at operational closure presented in Section 6.1.3 of this Special Analysis.

6.3.2.1 Groundwater Concentrations at 100 Meters

Groundwater concentrations at 100 meters are calculated in FTF PA using the PORFLOW FTF model, which divides the area around FTF into computational cells. Calculation of the 100-meter groundwater concentrations using the PORFLOW FTF model is discussed in more detail in Section 5.2.2 of the FTF PA. The PORFLOW 100-meter concentrations are calculated for five sectors (Sectors A through E) as shown on Figure 6.3-1. The peak concentration values for the 100-meter results are recorded for the three aquifers of concern

(i.e., UTR-UZ, UTR-LZ, and Gordon Aquifer). The five sectors are analyzed for each radionuclide and chemical to find the maximum groundwater concentrations at 100 meters from the FTF. The PORFLOW 1-meter concentrations are calculated for four sectors (Sector 1A through 1D), as shown in Figure 6.3-1. Using the sectors to determine the highest groundwater concentrations causes the calculated peak doses to be higher than they actually are, since the peak concentrations are determined for each radionuclide independent of the location (i.e., horizontal mesh and aquifer) within the sector.

Figure 6.3-1: PORFLOW FTF 1-Meter and 100-Meter Model Evaluation Sectors



Note: The individual sectors are indicated by unique diamond colors.

Tables A-1 through A-3 (Appendix A) present the updated peak 100-meter radionuclide concentrations within the 10,000-year performance period in each sector for the three aquifers. These radionuclide concentrations reflect the peak concentrations for each radionuclide in the sector. These values are conservatively high for the radionuclides present in multiple decay chains because the totals are simply the sum of the individual peaks within that sector for a given radionuclide, without regard to time or location. For example, if Pb-210 were present as a daughter product in six decay chains, those six concentrations would all be added (along with the initial Pb-210 concentration) together to arrive at a single

Pb-210 concentration for that sector, even though the peaks for six daughters might have occurred at different times and at different locations within the sector.

Tables A-1 through A-3 (Appendix A) also list the MCL for each constituent with the derived values for beta and photo emitters from Table II-3 of FR-00-9654. The MCLs provided in the reference are derived for a beta-gamma dose of 4 mrem/yr. The peak concentration of each beta-gamma emitter is compared to a specific MCL to determine their fraction. To determine if the 4 mrem/yr beta-gamma limit is met, the sum of the fractions must be less than 1.0. The total alpha MCL includes Ra-226, but does not include radon or uranium. The radium MCL includes both Ra-226 and Ra-228. [SCDHEC R.61-58]

Tables A-4 through A-6 (Appendix A) show the peak updated 100-meter chemical concentrations within the 10,000-year performance period in each sector for the three aquifers.

6.3.2.2 Sensitivity Run Radionuclide Determination

Section 5.2.2 of FTF PA presents the methodology used to determine which radionuclides were most significant and to document which radionuclides would be considered a "sensitivity run radionuclide." While all radionuclides identified in the FTF waste tank inventory were included in 100-meter groundwater modeling efforts, narrowing the catalog of radionuclides down to a sensitivity run radionuclide list allowed the analysis to concentrate on the few radionuclides which posed more risk and concentrated modeling efforts on the areas of greatest concern. Only the sensitivity run radionuclides were included in the PORFLOW seepline modeling runs, with doses associated with seepline concentrations for the other radionuclides calculated by using 20 % of the applicable 100-meter concentrations. The 20 % factor is based on the ratio seen between the bounding concentrations for the sensitivity run radionuclides at 100 meters and the seepline.

The sensitivity run radionuclides were recalculated based on the peak 100-meter groundwater concentrations determined using the Tanks 18 and 19 residual inventories at operational closure. Any radionuclide with a dose (assuming FTF PA Base Case pathways and assumptions) greater than 0.1 mrem/yr was considered a sensitivity run radionuclide. The sensitivity run, radionuclide determination was conducted based on the peak 100-meter groundwater dose within 20,000 years. The new screening conclusions are provided in Table 6.3-1. The resulting list of sensitivity run radionuclides (Am-241, Am-243, C-14, Cm-244, Cs-135, I-129, Np-237, Pa-231, Pu-238, Pu-239, Pu-240, Ra-226, Tc-99, Th-230, U-234, and U-235) is slightly reduced from the FTF PA, with Th-229 and U-233 being deleted.

Table 6.3-1: Determination of Sensitivity Run Radionuclides

Radionuclide	Sector A 20k Peak dose (mem/yr)	Sector B 20k Peak dose (mem/yr)	Sector C 20k Peak dose (mem/yr)	Sector D 20k Peak dose (mem/yr)	Sector E 20k Peak dose (mem/yr)	Key Cause
Ac-227	0.00	0.00	0.00	0.00	0.00	N/A
Al-26	0.00	0.00	0.00	0.00	0.00	N/A
Am-241	0.01	0.01	0.01	0.01	0.01	Np-237 parent
Am-242m	0.00	0.00	0.00	0.00	0.00	N/A
Am-243	0.00	0.00	0.00	0.00	0.00	Pu-239 parent
C-14	0.09	0.18	0.18	1.04	0.35	Dose > 0.1
Cf-249	0.00	0.00	0.00	0.00	0.00	N/A
Cl-36	0.01	0.02	0.02	0.01	0.01	N/A
Cm-243	0.00	0.00	0.00	0.00	0.00	N/A
Cm-244	0.00	0.00	0.00	0.00	0.00	Pu-240 parent
Cm-245	0.00	0.00	0.00	0.00	0.00	N/A
Cm-247	0.00	0.00	0.00	0.00	0.00	N/A
Cm-248	0.00	0.00	0.00	0.00	0.00	N/A
Co-60	0.00	0.00	0.00	0.00	0.00	N/A
Cs-135	0.68	0.69	0.72	0.71	0.63	Dose > 0.1
Cs-137	0.00	0.00	0.00	0.00	0.00	N/A
Eu-152	0.00	0.00	0.00	0.00	0.00	N/A
Eu-154	0.00	0.00	0.00	0.00	0.00	N/A
H-3	0.00	0.00	0.00	0.00	0.00	N/A
I-129	0.24	0.44	0.43	0.46	0.44	Dose > 0.1
K-40	0.01	0.01	0.01	0.04	0.06	N/A
Mo-93m	0.00	0.00	0.00	0.00	0.00	N/A
Nb-93m	0.00	0.00	0.00	0.04	0.07	N/A
Nb-94	0.03	0.03	0.05	0.08	0.06	N/A
Ni-59	0.01	0.01	0.02	0.02	0.02	N/A
Ni-63	0.00	0.00	0.00	0.00	0.00	N/A
Np-237	1.26	2.40	9.17	10.54	10.00	Dose > 0.1
Pa-231	0.08	0.17	0.25	0.68	1.24	Dose > 0.1
Pb-210	0.01	0.01	0.03	0.03	0.04	N/A
Pd-107	0.00	0.00	0.00	0.00	0.00	N/A
Pu-238	0.00	0.00	0.00	0.00	0.00	Ra-226 parent
Pu-239	0.00	0.01	0.05	0.81	1.11	Dose > 0.1
Pu-240	0.00	0.00	0.04	0.59	0.63	Dose > 0.1
Pu-241	0.00	0.00	0.00	0.00	0.00	N/A
Pu-242	0.00	0.00	0.00	0.02	0.02	N/A
Pu-244	0.00	0.00	0.00	0.00	0.00	N/A
Ra-226	0.74	1.57	3.98	4.83	5.84	Dose > 0.1
Ra-228	0.00	0.00	0.00	0.00	0.00	N/A
Rn-222	0.00	0.00	0.00	0.01	0.01	N/A

N/A = Not Applicable

Table 6.3-1: Determination of Sensitivity Run Radionuclides (Continued)

Radionuclide	Sector A 20k Peak dose (mem/yr)	Sector B 20k Peak dose (mem/yr)	Sector C 20k Peak dose (mem/yr)	Sector D 20k Peak dose (mem/yr)	Sector E 20k Peak dose (mem/yr)	Key Cause
Se-79	0.00	0.00	0.00	0.00	0.00	N/A
Sm-151	0.00	0.00	0.00	0.00	0.00	N/A
Sn-126	0.00	0.00	0.00	0.00	0.00	N/A
Sr-90	0.00	0.00	0.00	0.00	0.00	N/A
Tc-99	0.05	0.09	0.09	0.27	0.33	Dose > 0.1
Th-228	0.00	0.00	0.00	0.00	0.00	N/A
Th-229	0.00	0.00	0.00	0.05	0.08	N/A
Th-230	0.00	0.00	0.00	0.04	0.07	Ra-226 parent
Th-232	0.00	0.00	0.00	0.00	0.00	N/A
U-232	0.00	0.00	0.00	0.00	0.00	N/A
U-233	0.00	0.00	0.00	0.04	0.06	N/A
U-234	0.00	0.00	0.01	0.69	1.13	Dose > 0.1
U-235	0.00	0.00	0.00	0.00	0.00	Pa-231 parent
U-236	0.00	0.00	0.00	0.02	0.03	N/A
U-238	0.00	0.00	0.00	0.00	0.00	N/A
Zr-93	0.00	0.00	0.00	0.00	0.00	N/A

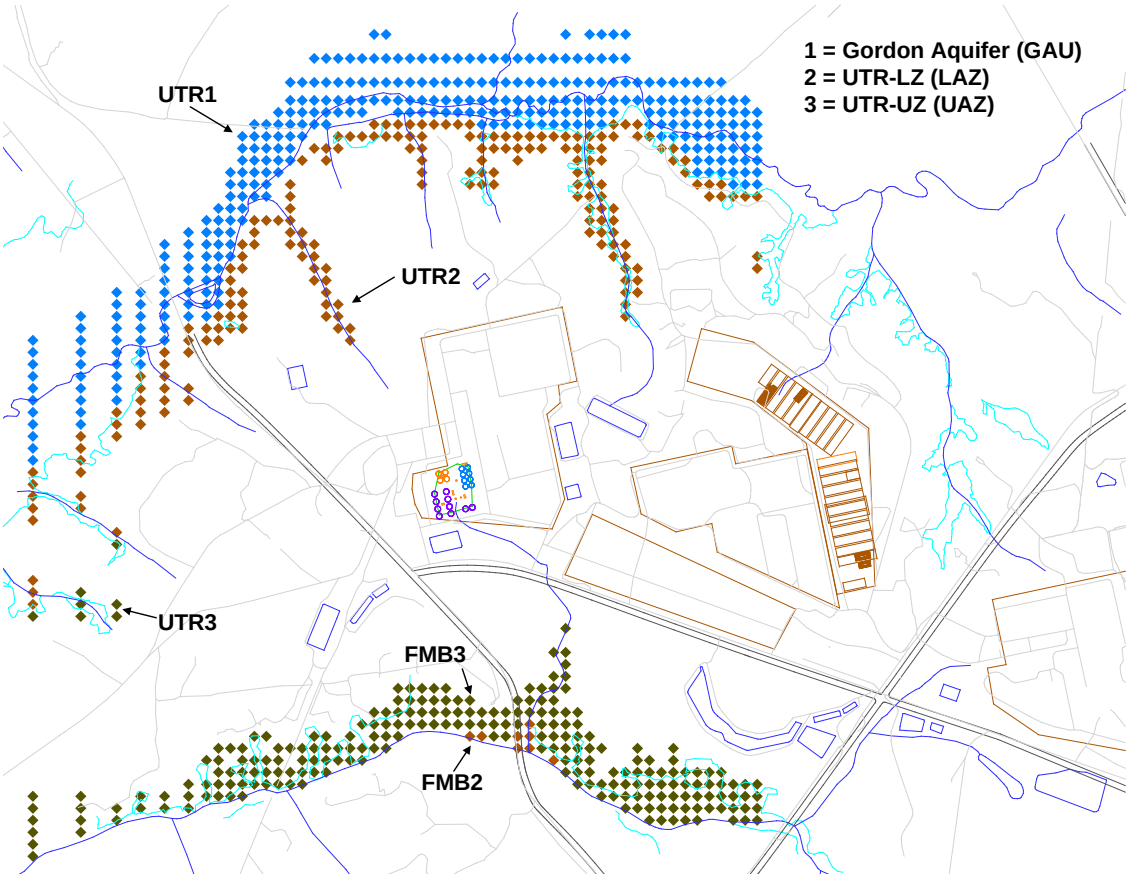
N/A = Not Applicable

6.3.2.3 Groundwater Concentrations at the Seeplines

The seepline groundwater concentrations were recalculated using the PORFLOW FTF model, which grids the GSA surrounding FTF. Figure 6.3-2 shows the FTF seeplines by aquifer (UTR-UZ, UTR-LZ, and Gordon Aquifer) in relation to the sectors (streams). The PORFLOW seepline concentrations are provided for two sectors (UTR and Fourmile Branch) and five aquifers (three for UTR and two for Fourmile Branch) as shown on Figure 6.3-2. The peak concentration values for the seepline results were recorded for the three aquifers of concern (i.e., UTR-UZ, UTR-LZ, and Gordon Aquifer).

Tables A-7 (UTR) and A-8 (Fourmile Branch) in Appendix A present the updated peak seepline, radionuclide concentrations in the 10,000-year performance period and out to 20,000 years. These radionuclide concentrations reflect the peak concentrations for each radionuclide in the highest sector. These values are conservatively high for the radionuclides present in multiple decay chains because the totals are simply the sum of the individual peaks within that sector for a given radionuclide, without regard to time or location.

Figure 6.3-2: PORFLOW FTF Seepline Evaluation Sectors



6.3.3 Air Pathway and Radon Analysis

Section 5.3 of FTF PA presents the air pathway and radon analysis results. Section 4.5 of FTF PA describes the method used to conservatively bound the dose from airborne radionuclides and the results in that section provides a dose to maximally exposed individual (MEI) per curie of inventory.

Table 6.3-2 summarizes the total waste tank and ancillary equipment inventory of selected potentially airborne (i.e., gaseous) isotopes, including the Tanks 18 and 19 actual residual inventories at operational closure presented in Section 6.1.3. Table 6.3-3 presents FTF inventories, specific SRS 100-meter dose release factors (DRFs) and the calculated exposure levels for the 100-year to 10,000-year MEI at 100 meters. Table 6.3-4 presents specific SRS 1,600 meter (seepline) DRFs and the calculated exposure levels for the 10,000-year MEI at 1,600 meters. The contribution of Sb-125 to the air pathways dose is insignificant based on the revised waste tank inventory and the short half-life of Sb-125, and is not included in Tables 6.3-3 and 6.3-4. Because the DRFs for 100 meters are calculated from an assumed area source, while the 1,600-meter DRFs are calculated from an assumed point source, the results reflect a conservative estimate at 1,600 meters, which results in a higher estimated dose at 1,600 meters than at 100 meters for C-14.

Table 6.3-2: Summary of Projected Total FTF Inventory of Gaseous Radionuclides

Inventory Location	C-14 (Ci)	Cl-36 (Ci)	H-3 (Ci)	I-129 (Ci)	Se-79 (Ci)	Sn-126 (Ci)	Tc-99 (Ci)
All Waste Tanks	2.30E+01	1.84E-02	2.40E+01	1.84E-02	4.60E+01	5.83E+00	6.69E+02
Transfer Lines	1.5E-03	NE	1.1E-01	2.5E-06	3.0E-02	5.6E-02	5.3E-01
FPT-1	8.0E-06	NE	1.5E-04	1.3E-08	1.6E-04	3.0E-04	2.8E-03
FPT-2	8.0E-06	NE	1.5E-04	1.3E-08	1.6E-04	3.0E-04	2.8E-03
FPT-3	8.0E-06	NE	1.5E-04	1.3E-08	1.6E-04	3.0E-04	2.8E-03
FTF Catch Tank	3.8E-05	NE	8.6E-04	7.2E-08	8.7E-04	1.6E-03	1.5E-02
242-3F CTS	NE	NE	6.7E-02	NE	1.8E-06	NE	1.1E-01
Evaporator Vessel - 242-F	NE	NE	NE	NE	7.7E-09	NE	1.3E-03
Evaporator Vessel - 242-16F	NE	NE	NE	NE	7.7E-09	NE	1.3E-03
Total FTF Inventory	**2.30E+01**	**1.84E-02**	**2.42E+01**	**1.84E-02**	**4.60E+01**	**5.89E+00**	**6.70E+02**

Table 6.3-3: 100-Meter DRFs and 10,000-Year FTF Dose

Radionuclide	Peak Flux (Ci/yr/Ci)	SRS 100-meter DRF[1] (mrem/Ci)	Dose to MEI at 100-meter Boundary[2] (mrem/yr/Ci)	FTF Inventory (Ci)	Dose to MEI at 100-meter Boundary (mrem/yr)
C-14	2.6E-04	2.8E-04	7.2E-08	2.3E+01	1.7E-06
Cl-36	6.1E-04	2.9E-02	1.7E-05	1.8E-02	3.1E-07
H-3	3.1E-10	1.3E-02	4.2E-12	2.4E+01	1.0E-10
I-129	2.4E-03	2.0E+01	4.8E-02	1.8E-02	8.9E-04
Se-79	7.0E-04	3.8E-02	2.7E-05	4.6E+01	1.2E-03
Sn-126	1.3E-03	1.8E+01	2.3E-02	5.9E+00	1.4E-01
Tc-99	9.7E-04	1.1E-01	1.0E-04	6.7E+02	6.7E-02
				Total Dose	**2.0E-01**

[1] From WSRC-STI-2007-00343
[2] Dose to MEI = Peak Flux × DRF

Table 6.3-4: 1,600-Meter DRFs and 10,000-Year FTF Dose

Radionuclide	Peak Flux (Ci/yr/Ci)	SRS 1,600-meter DRF[1] (mrem/Ci)	Dose to MEI at 1,600-meter Boundary[2] (mrem/yr/Ci)	FTF Inventory (Ci)	Dose to MEI at 1,600-meter Boundary (mrem/yr)
C-14	2.6E-04	2.4E-03	6.2E-07	2.3E+01	1.4E-05
Cl-36	6.1E-04	6.2E-03	3.7E-06	1.8E-02	6.8E-08
H-3	3.1E-10	4.9E-05	1.5E-14	2.4E+01	3.6E-13
I-129	2.4E-03	2.3E+00	5.5E-03	1.8E-02	1.0E-04
Se-79	7.0E-04	9.1E-03	6.4E-06	4.6E+01	2.9E-04
Sn-126	1.3E-03	4.4E+00	5.7E-03	5.9E+00	3.4E-02
Tc-99	9.7E-04	2.6E-02	2.6E-05	6.7E+02	1.7E-02
				Total Dose	**5.1E-02**

[1] From WSRC-STI-2007-00343
[2] Dose to MEI = Peak Flux × DRF

The instantaneous radon flux is determined by multiplying the peak flux by the total inventory divided by the total area in the FTF. Table 6.3-5 summarizes the total inventory of isotopes contributing to the radon flux. The peak dose of radon for the performance period is assumed to be at 10,000 years. These results are highly conservative because the entire inventory is assumed concentrated in a 1-foot layer in a Type I tank. As shown in Table 6.3-6, the peak instantaneous radon flux using the entire FTF inventory (including the Tanks 18 and 19 residual inventories at operational closure presented in Section 6.1.3) is 3.8E-08 $pCi/m^2/s$.

Table 6.3-5: Summary of Total Projected FTF Inventory of Isotopes Producing Rn-222

Inventory Location	Pu-238 (Ci)	U-238 (Ci)	U-234 (Ci)	Th-230 (Ci)	Ra-226 (Ci)
Total Waste Tank	3.5E+03	2.1E+00	2.0E+00	2.0E-02	2.6E-02
Transfer Lines	6.5E+00	5.0E-03	8.5E-03	5.1E-03	5.1E-03
FPT-1	3.4E-02	2.6E-05	4.5E-05	2.7E-05	2.7E-05
FPT-2	3.4E-02	2.6E-05	4.5E-05	2.7E-05	2.7E-05
FPT-3	3.4E-02	2.6E-05	4.5E-05	2.7E-05	2.7E-05
FTF Catch Tank	1.0E-01	9.0E-05	9.0E-05	1.3E-04	1.3E-04
242-3F CTS	9.2E-01	3.9E-04	2.1E-03	N/A	N/A
242-F Evaporator	4.7E-03	7.5E-06	7.1E-06	N/A	N/A
242-16F Evaporator	4.7E-03	7.5E-06	7.1E-06	N/A	N/A
Total FTF Inventory	**3.5E+03**	**2.1E+00**	**2.0E+00**	**2.6E-02**	**3.1E-02**

Table 6.3-6: Peak Instantaneous Rn-222 Flux at Land Surface

Parent Source	FTF Inventory (Ci)	FTF Inventory (Ci/m^2) [1]	Peak Instantaneous Rn-222 flux at Land Surface	
			($pCi/m^2/sec$) / (Ci/m^2)	($pCi/m^2/sec$)
Pu-238	3.5E+03	4.3E-02	2.7E-07	1.2E-08
U-238	2.1E+00	2.5E-05	9.3E-06	2.3E-10
U-234	2.0E+00	2.5E-05	7.7E-04	1.9E-08
Th-230	2.6E-02	3.1E-07	1.0E-02	3.1E-09
Ra-226	3.1E-02	3.7E-07	1.1E-02	4.1E-09
			Total	**3.8E-08**

[1] Total area of FTF is 82,910 m^2

6.3.4 Biotic Pathways

Section 5.4 of FTF PA describes how the biotic pathways doses to the MOP are calculated for the receptor with 100-meter well water as a primary water source and for the receptor with groundwater from a stream as a primary water source. The information regarding biotic pathways calculations presented in the FTF PA is not affected by the new residual waste information.

6.3.5 Dose Analysis

Section 5.5 (Dose Analysis) of FTF PA contains calculations of the peak total doses for a) the MOP at the 100-meter well and b) the MOP at applicable streams (either UTR or Fourmile Branch). The peak doses have been recalculated using the peak groundwater concentrations identified in Section 6.3.2 of this Special Analysis (i.e., the groundwater concentrations at 100 meters and at the seepline recalculated using the PORFLOW FTF model for the FTF PA Base Case using the Tanks 18 and 19 residual inventories at operational closure). A peak dose is identified both for the 10,000-year performance period and after the performance period. The data outside the performance period is included to improve understanding of the overall FTF PA model and not for comparison to performance objectives (consistent with guidance in DOE Guide 435.1-1 Section IV.P.(2) and NUREG-1854 Section 4.1.1.1).

6.3.5.1 Member of the Public at 100-Meter Groundwater Pathway Dose Results

Table 6.3-7 shows a comparison of the 100-meter peak groundwater pathway doses (recalculated using the concentration associated with the Tanks 18 and 19 residual inventories at operational closure) for the different 100-meter sectors within both 10,000 and 20,000 years. In calculating the peak groundwater pathway dose, the highest radionuclide concentration within the vertical computational meshes is used from each of the three distinct aquifers modeled (UTR-UZ, UTR-LZ, and the Gordon Aquifer).

Table 6.3-7: 100-Meter MOP Peak Groundwater Pathways Dose by Sector

Sector	Highest Peak Dose in 10,000 Years	Highest Peak Dose in 20,000 Years
A	**0.1 mrem/yr (year 752)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclide: Tc-99	**2.1 mrem/yr (year 17,950)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Ra-226
B	**0.1 mrem/yr (year 754)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclide: Tc-99	**3.6 mrem/yr (year 16,664)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Ra-226
C	**0.2 mrem/yr (year 4,308)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Ra-226, C-14	**12 mrem/yr (year 16,656)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Ra-226
D	**1.7 mrem/yr (year 6,058)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Pa-231, Np-237, Ra-226	**16 mrem/yr (year 16,652)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Ra-226
E	**3.2 mrem/yr (year 10,000)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Ra-226, Pa-231, U-234	**17 mrem/yr (year 16,648)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Ra-226

The highest peak-groundwater pathway dose in the 10,000-year performance period remains associated with Sector E. Sector E is the sector associated most closely with the Type IV tanks, which are the waste tanks whose liners are modeled as failing earlier than any other waste tank type (and within the 10,000-year performance period).

Figure 6.3-3 shows the peak doses to the 100-meter MOP receptor over time during the performance period (10,000 years) for the five 100-meter sectors. The highest 100-meter MOP-groundwater pathway peak dose in the 10,000-year performance period is a 3.2 mrem/yr dose at year 10,000. The peak dose in 10,000 years increased (from the FTF PA results) by approximately 0.9 mrem/yr primarily due to increased contributions from Pa-231 and Ra-226, as explained further in Section 6.3.5.2.

Figure 6.3-4 shows the 100-meter MOP receptor doses within 20,000 years for the five-100-meter sectors. The 100-meter MOP peak groundwater pathway peak dose within 100,000 years for the peak sector (Sector E) is shown in Figure 6.3-5 (linear y-axis scale) and Figure 6.3-6 (logarithmic y-axis scale).

Figure 6.3-3: 100-Meter MOP Peak Groundwater Pathway Dose within 10,000 Years for the Five 100-Meter Sectors

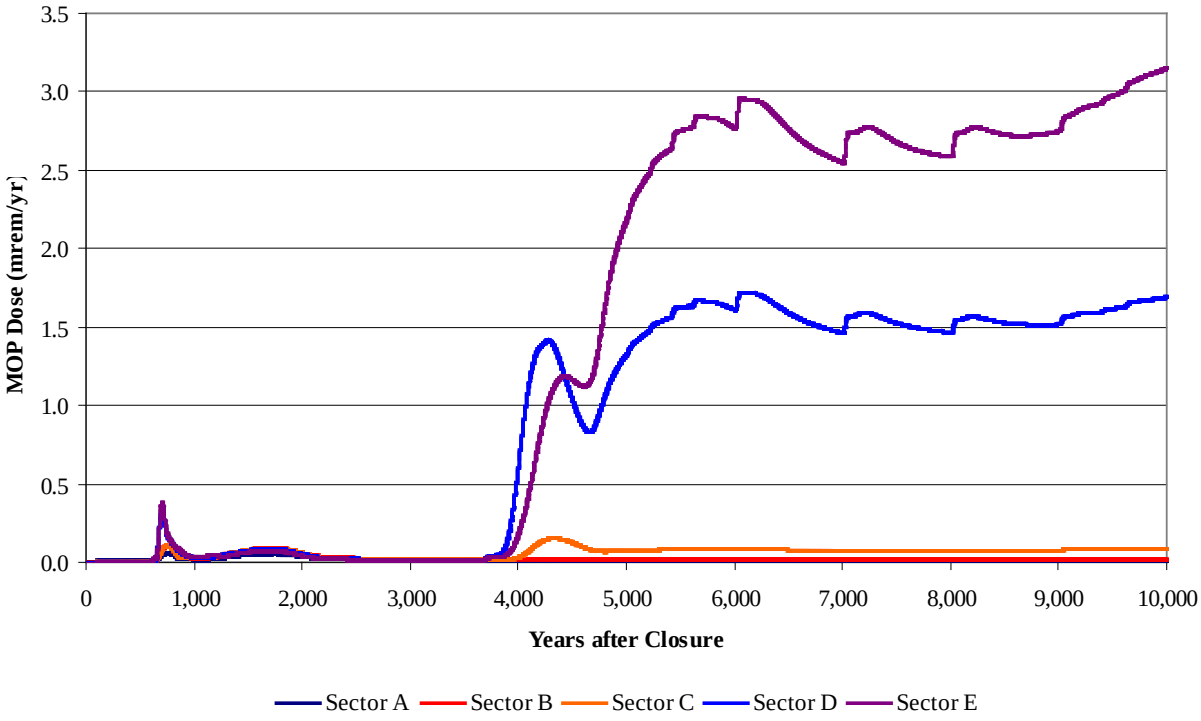


Figure 6.3-4: 100-Meter MOP Peak Groundwater Pathway Dose within 20,000 Years for the Five 100-Meter Sectors

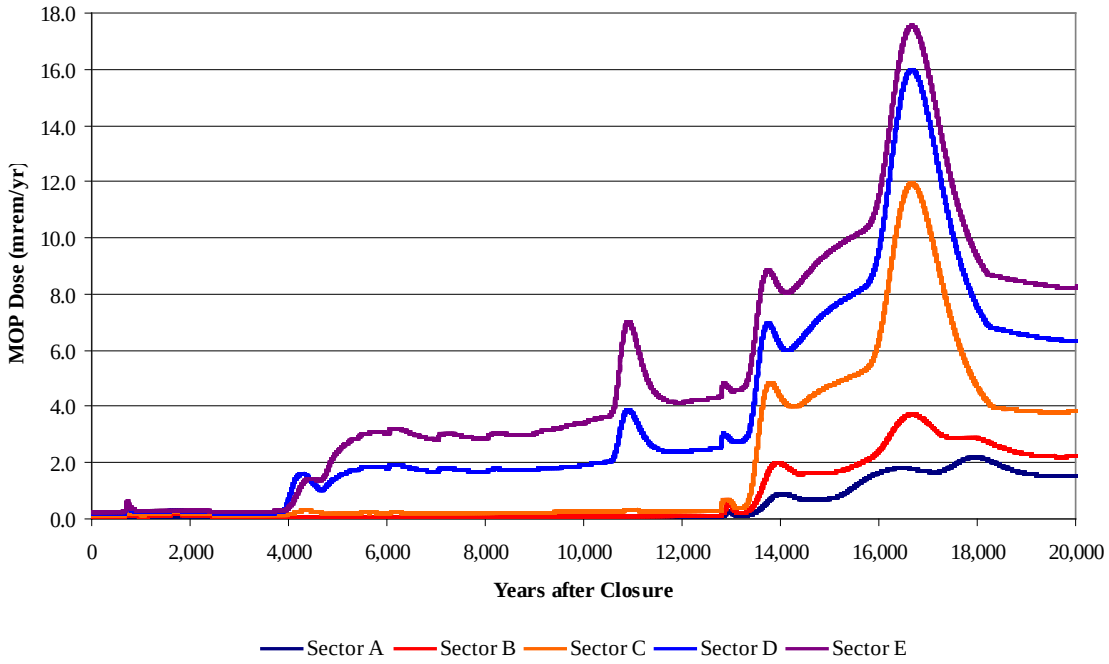


Figure 6.3-5: 100-Meter MOP Peak Groundwater Pathway Dose within 100,000 Years for Sector E (Linear Y-Axis Scale)

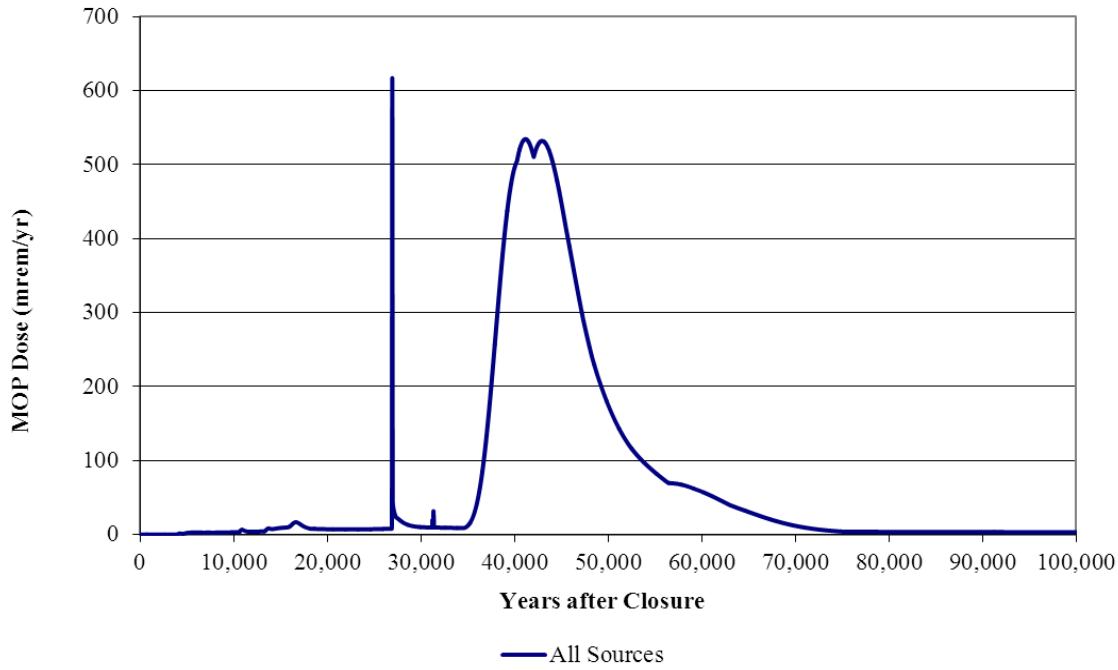
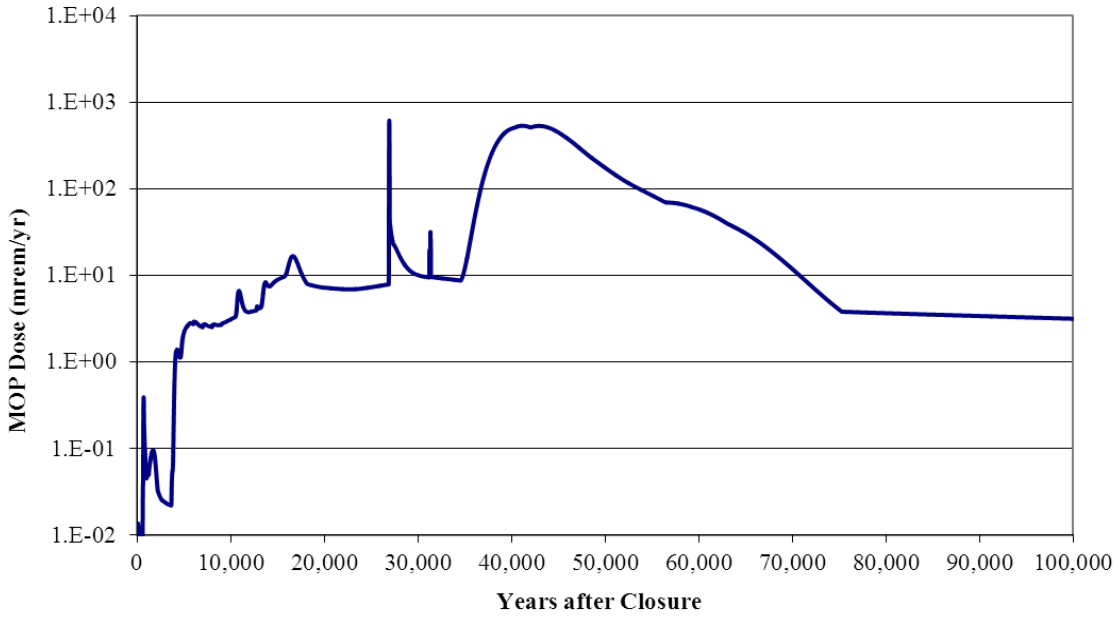


Figure 6.3-6: 100-Meter MOP Peak Groundwater Pathway Dose within 100,000 Years for Sector E (Logarithmic Y-Axis Scale)



Utilizing the actual residual inventories at operational closure for Tanks 18 and 19 does not significantly impact the peak groundwater pathway doses during the 10,000-year performance period. The peak, groundwater pathway dose in 20,000 years decreased slightly from 18 to 17 mrem/yr, while the peak groundwater pathway dose in 10,000 years increased from 2.3 to 3.2 mrem/yr.

6.3.5.2 Individual Radionuclide Contributions to the MOP 100-Meter Peak Annual Groundwater Pathway Dose

Figures 6.3-7 through 6.3-10 show the relative contribution from the sensitivity run radionuclides to the recalculated Sector E 100-meter groundwater pathway dose over time. Table 6.3-8 presents the relative contribution from the sensitivity run radionuclides to the 3.2 mrem/yr peak groundwater pathway dose. The peak, groundwater pathway dose to the MOP at 100-meters during the 10,000-year performance period is primarily associated with Ra-226 (52 %) and Np-237 (17 %). The top contributors (> 5 % contribution) to the MOP at 100-meter peak groundwater pathway dose are Ra-226, Np-237, Pa-231, and U-234. The individual contributions to the peak, groundwater pathway dose in 10,000 years increased (relative to FTF PA) for some radionuclides when the actual residual inventories at operational closure are utilized for Tanks 18 and 19. The increase in peak dose in 10,000 years associated with Ra-226 is due to the Pu-238 inventory at operational closure in Tank 18 (Pu-238 is a Ra-226 parent) being higher than the projected inventory used in the FTF PA. The peak dose in 10,000 years associated with Pa-231 increased solely due to the Pa-231 inventory at operational closure in Tank 18 differing from the projected inventory.

Figure 6.3-7: Individual Radionuclide Contributors to the Sector E 100-Meter Peak Groundwater Pathway Dose, 10,000 years

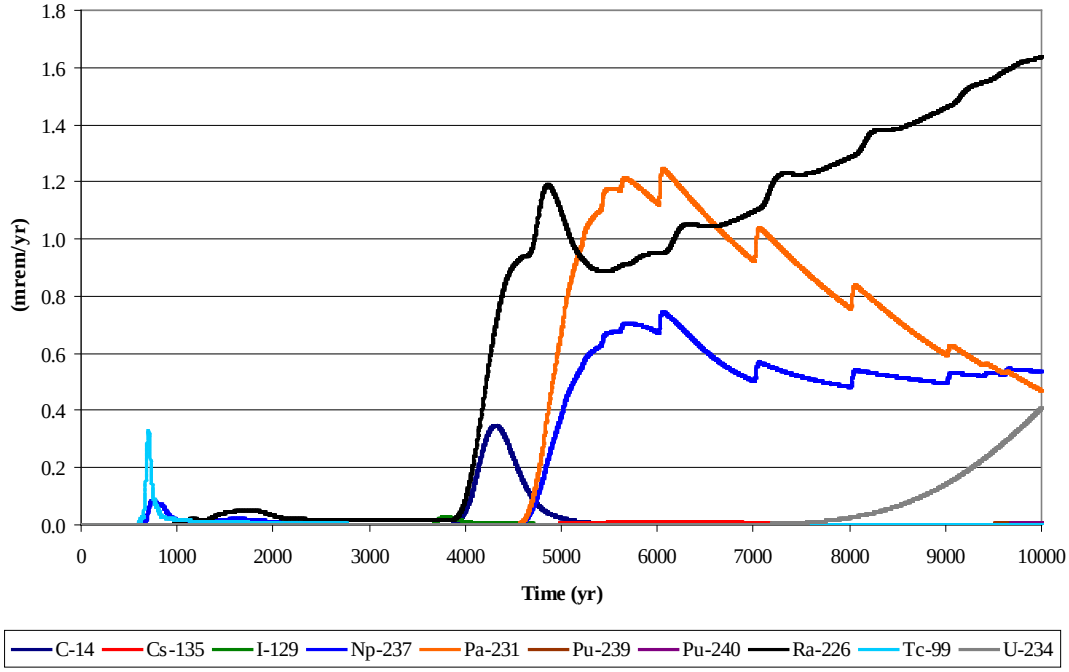


Figure 6.3-8: Individual Radionuclide Contributors to the Sector E 100-Meter Peak Groundwater Pathway Dose, 20,000 Years

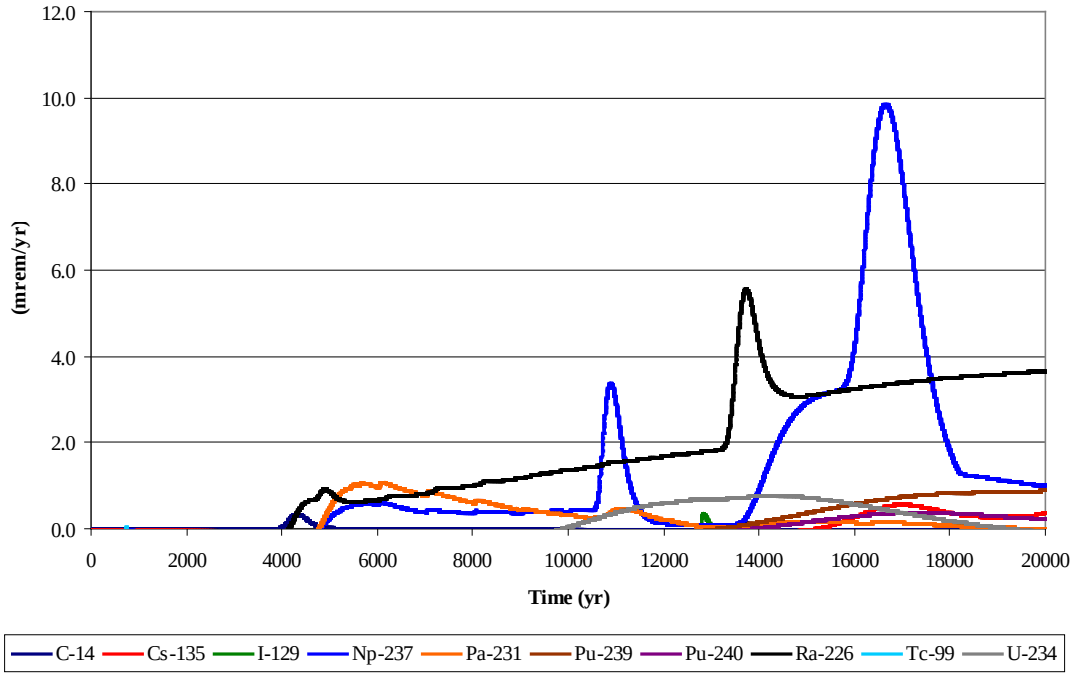


Figure 6.3-9: Individual Radionuclide Contributors to the Sector E 100-Meter Peak Groundwater Pathway Dose, 100,000 Years (linear scale)

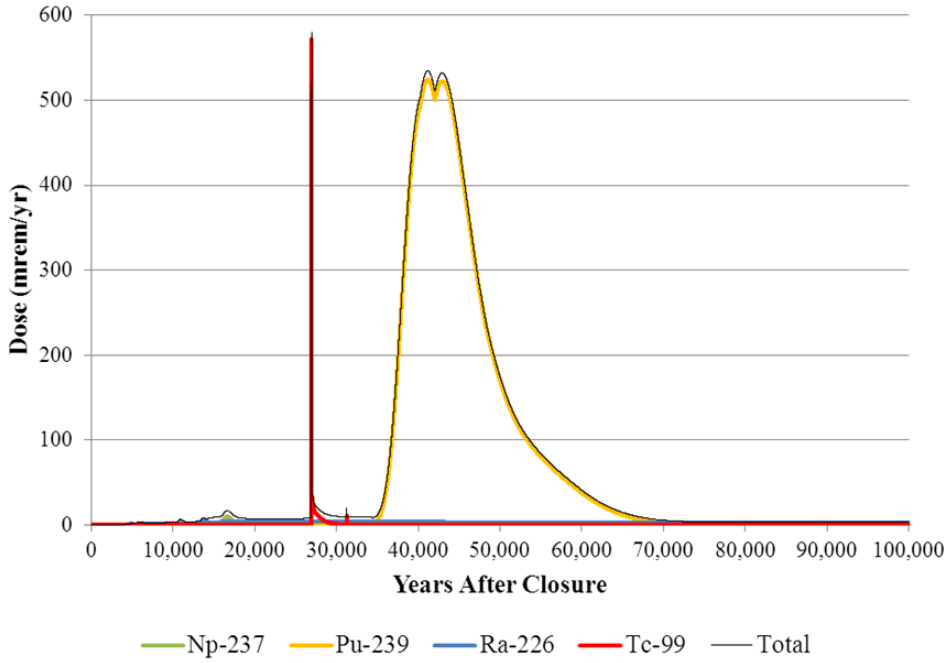


Figure 6.3-10: Individual Radionuclide Contributors to the Sector E 100-Meter Peak Groundwater Pathway Dose, 100,000 Years (log scale)

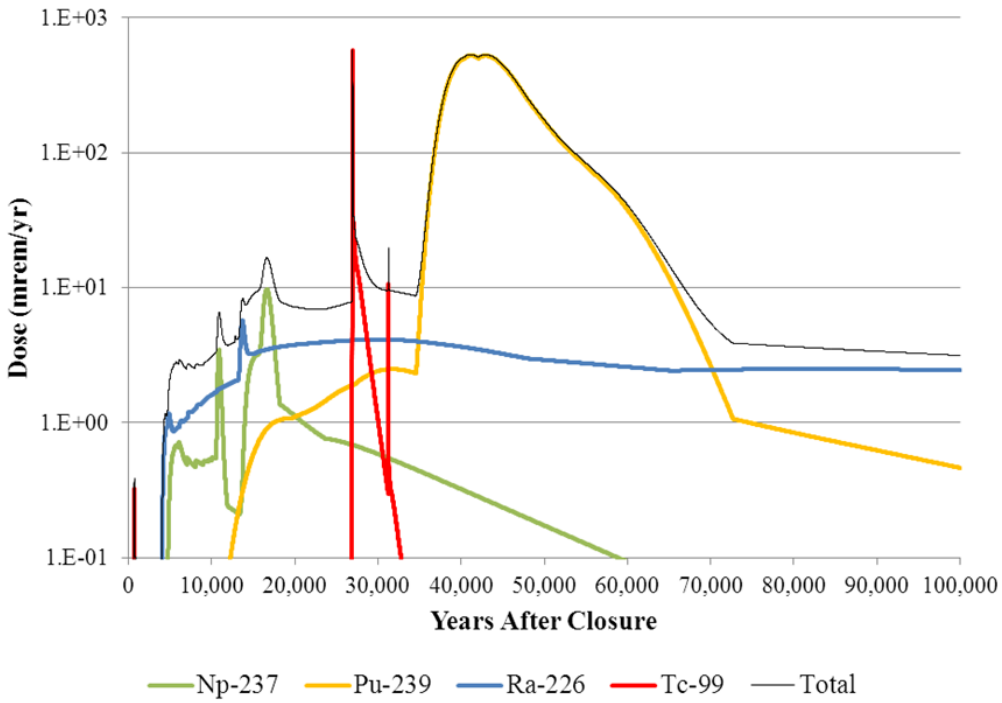


Table 6.3-8: 100-Meter MOP Peak Groundwater Pathway Dose Individual Radionuclide Contributions at Year 10,000 (Peak Year)

Radionuclide	Contribution to Sector E Peak dose at year 10,000 (mrem/yr)	Percentage of Total Peak Dose
Am-241	<0.1	<1%
Am-243	<0.1	<1%
C-14	<0.1	<1%
Cm-244	<0.1	<1%
Cs-135	<0.1	<1%
I-129	<0.1	<1%
Np-237	0.54	17%
Pa-231	0.47	15%
Pu-238	<0.1	<1%
Pu-239	<0.1	<1%
Pu-240	<0.1	<1%
Ra-226	1.64	52%
Tc-99	<0.1	<1%
Th-229	<0.1	<1%
Th-230	<0.1	<1%
U-233	<0.1	<1%
U-234	0.41	13%
U-236	<0.1	<1%
Total	**3.2**	**100%**

6.3.5.3 Individual Tank Contributions to MOP 100-Meter Peak Annual Groundwater Pathway Dose

Table 6.3-9 presents the relative contributions from those residual inventories (Tanks 17 through 20 and the transfer lines) which will contribute to the Sector E 100-meter MOP groundwater pathway dose at 10,000 years (the year of the peak dose). Tanks 1 through 8 and Tanks 33 and 34 were excluded because the liners for these waste tanks are not expected to fail within 10,000 years. Tanks 25 through 28 and 44 through 47, and the other ancillary equipment were excluded from individual analysis because they have a relatively insignificant projected residual inventory for the sensitivity run radionuclides. Tank 18 remains the primary contributor (approximately 91 %) to the 100-meter peak groundwater-pathway dose in Sector E at year 10,000. The Sector E 100-meter MOP peak groundwater-pathway dose associated with the Tank 18 residual inventory only is shown in Figure 6.3-11 for 20,000 years and in Figure 6.3-12 for 60,000 years. Comparison of the Sector E 100-meter MOP peak groundwater pathway dose for all sources and for all sources except Tank 18 is shown in Figure 6.3-13 (20,000 years), Figure 6.3-14 (100,000 years, linear y-axis scale) and Figure 6.3-15 (100,000 years, logarithmic y-axis scale).

Table 6.3-9: 100-Meter MOP Peak Groundwater Pathway Dose Individual Source Contributions at Year 10,000 (Peak Year) for Sector E

Waste Source	Contribution to Sector E Peak Dose at year 10,000 (mrem/yr)	Percentage of Total Peak Dose
Tank 17	0.1	4%
Tank 18	3.0	91%
Tank 19	<0.05	1%
Tank 20	<0.05	0%
Transfer Lines	<0.05	1%
Other Sources	0.1	3%
Total	**3.2**	**100%**

Figure 6.3-11: 100-Meter MOP Peak Groundwater Pathway Dose within 20,000 Years for Sector E - Tank 18 Only Contribution

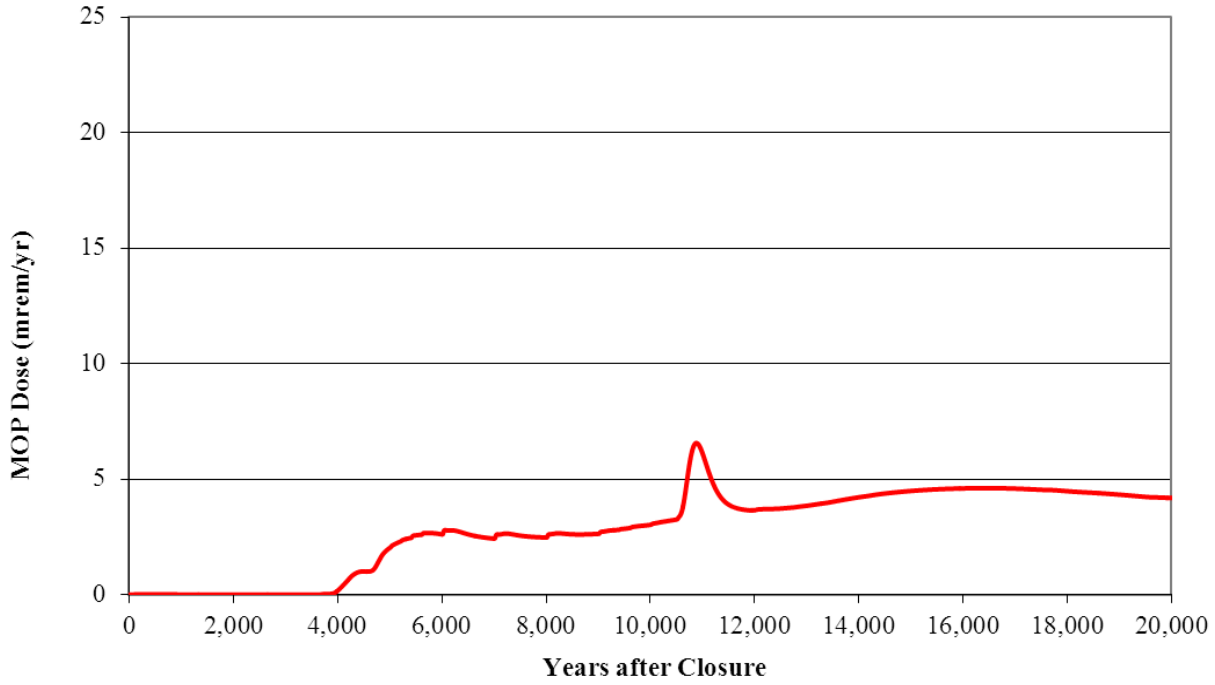


Figure 6.3-12: 100-Meter MOP Peak Groundwater Pathway Dose within 60,000 Years for Sector E - Tank 18 Only Contribution

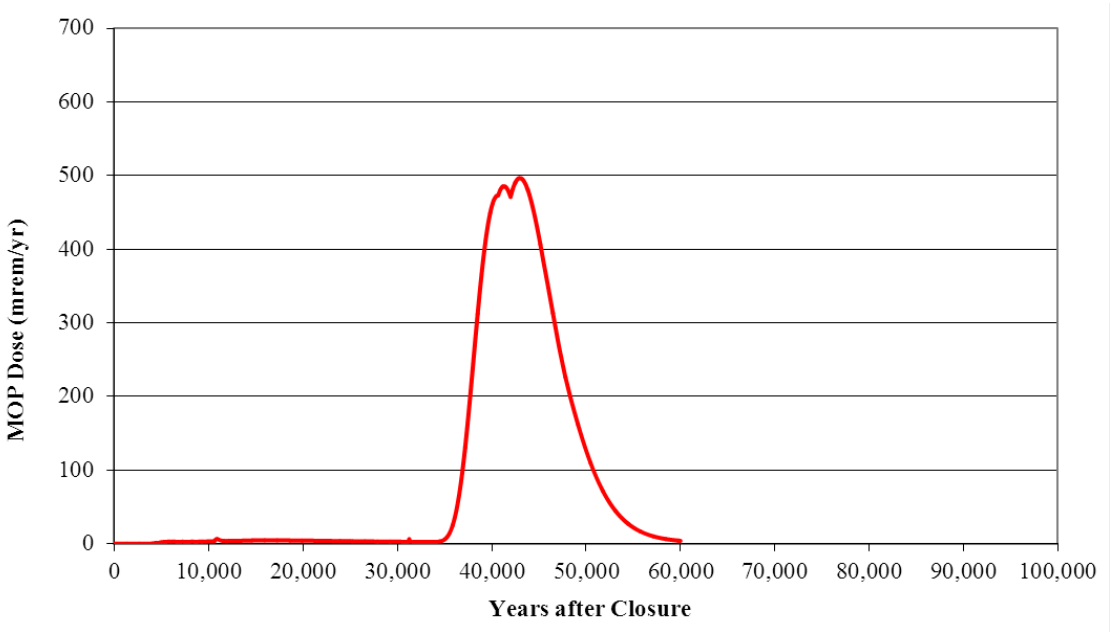


Figure 6.3-13: Sector E 100-Meter MOP Peak Groundwater Pathway Dose within 20,000 Years for All Sources and for All Sources except Tank 18

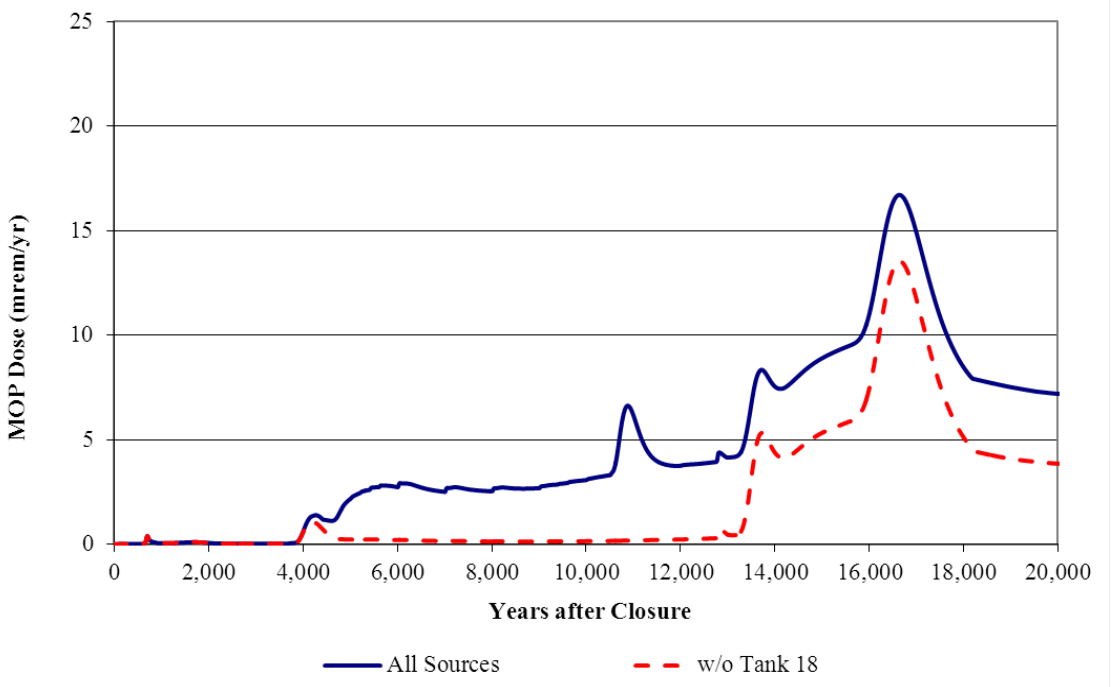


Figure 6.3-14: Sector E 100-Meter MOP Peak Groundwater Pathway Dose within 100,000 Years for All Sources and for All Sources except Tank 18 (Linear Y-Axis Scale)

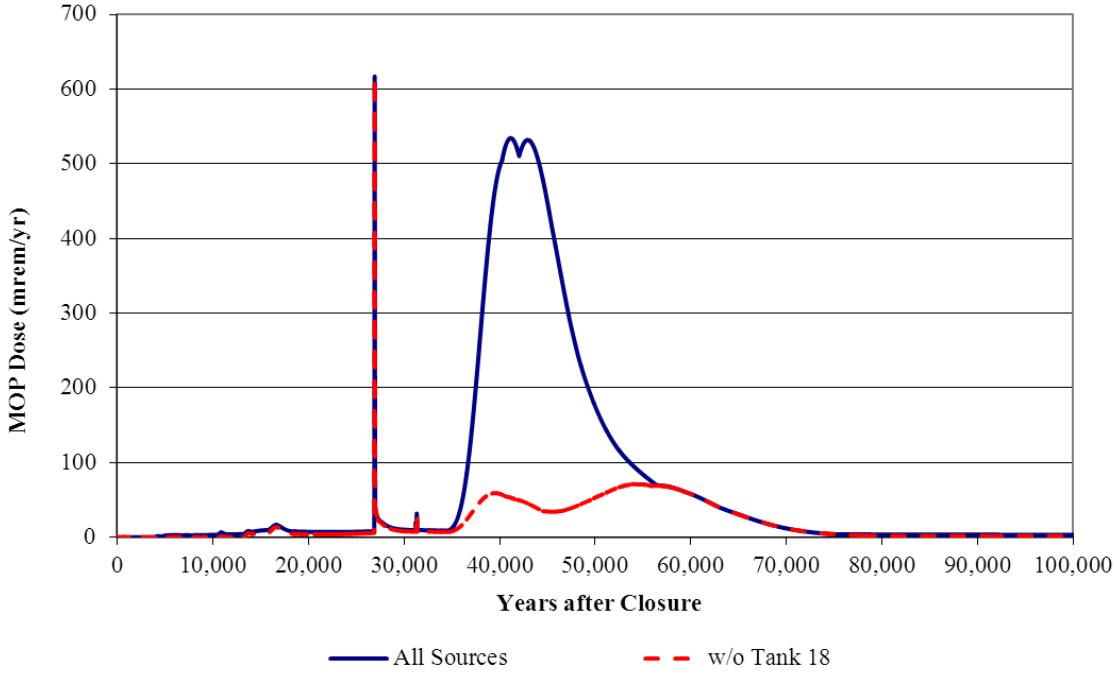
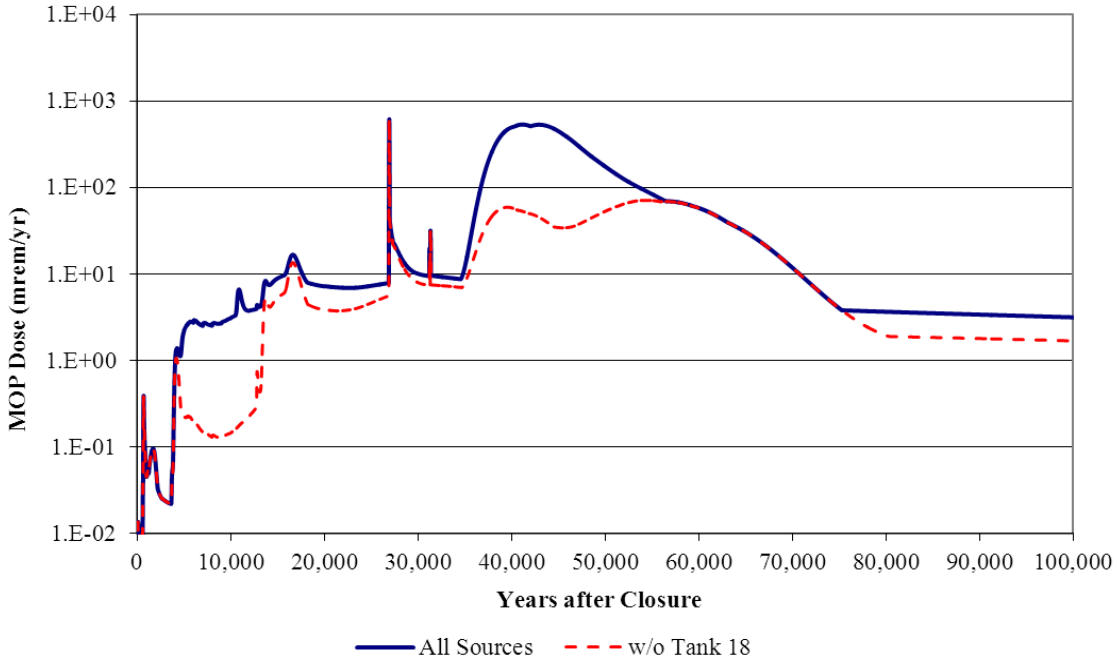


Figure 6.3-15: Sector E 100-Meter MOP Peak Groundwater Pathway Dose within 100,000 Years for All Sources and for All Sources except Tank 18 (Logarithmic Y-Axis Scale)



With respect to Tanks 18 and 19, the most significant peak dose within 100,000 years is associated with Pu-239 from Tank 18. This later peak is approximately 500 mrem/yr and occurs at approximately year 40,000. To better assess the uncertainty associated with the dose peaks associated with Pu-239, DOE-SR sought to determine if additional model support (primarily focusing on plutonium solubility) existed outside of the DOE-EM community, specifically within the DOE weapons laboratories. An expert panel convened to provide technical advice relating to better understanding of plutonium waste release and transport. The external independent reviewers included four scientists from Los Alamos National Laboratory (LANL) and one from the Pacific Northwest National Laboratory (PNNL). From LANL, David Clark, David Janecky, Wolfgang Runde, and John Psaras participated. The participant from PNNL was Kirk Cantrell. Several of the LANL experts had significant involvement in development and public engagement of the Rocky Flats site final facility closure.

The expert panel issued a *Plutonium Solubility Peer Review Report,* LA-UR-12-00079, containing several suggestions and opportunities for improvement regarding the plutonium modeling assumptions and Tank 18 residual waste experiments.

> *"It is recommended that a properly vetted, internationally-accepted thermodynamic database (such as the NEA- TDB) be used to calculate plutonium solubility. …using amorphous $PuO_2 \cdot xH_2O_{(am)}$ as the solubility controlling phase. …that plutonium adsorption on decomposing grout material and sediments in the vadose zone are calculated using readily available literature data (K_d values) that are applicable to the relevant conditions.*
>
> *Important geochemical parameters need to be properly evaluated and considered, in specific the oxygen levels in infiltration water contacting the waste can be expected to be much lower while carbon dioxide partial pressures may be much higher."*

Concerning experimental verification, the report states that:

> *"Samples of residual tank waste solids can be obtained for leaching and spectroscopic study and archived prior to commencing with tank grouting activities, such that the experimental verification of the modeling can take place while grouting activities are underway. This offers a reasonable path forward to a scientifically defensible closure model while allowing tank closure activities to continue in parallel."*

To implement the suggestions provided in LA-UR-12-00079 and address the questions related to doses associated with Tank 18, several tasks were undertaken to provide enhanced model support. As suggested by the expert panel, the NEA-TDB was used to develop alternative plutonium solubility values to support sensitivity studies associated with the Base Case waste release model. [SRNL-STI-2012-00087] The NEA-TDB has been used during solubility model development at the Yucca Mountain Project as discussed in *Dissolved Concentration Limits of Elements with Radioactive Isotopes,* ANL-WIS-MD-000010. As stated in the document, the NEA-TDB is widely used and well accepted by the nuclear waste management community. The NEA-TDB is a comprehensive, internally consistent,

internationally recognized, and quality-assured chemical thermodynamic database of selected chemical elements. This database was intended to meet the specialized modeling requirements for PAs of radioactive waste disposal systems, making it appropriate for use in the FTF PA waste release modeling. The database presents information regarding basic properties of various elements of interest (e.g., plutonium) under diverse conditions, which can be related to specific FTF conditions, as applicable. The unique feature of the NEA-TDB database is that it contains extensive data, which has been developed and evaluated directly from original experimental data. The NEA-TDB reviews were prepared by teams of leading experts drawn from universities and research institutes around the world. Data from other compilations and estimates were in principle not considered, other than where they contain useful references to original data source.

To help further inform about the uncertainty surrounding plutonium solubility and provide enhanced model support, studies were prepared and documented to investigate three areas that the expert panel noted as potential areas of conservatism within the FTF PA conceptual model.

1) The impact of dissolved oxygen on the waste release model (SRNL-L3200-2011-00011)
2) The impact of degraded liner corrosion products on plutonium sorption (SRNL-STI-2012-00040)
3) The impact of aging on plutonium speciation (SRNL-STI-2012-00106)

The results of these studies provide more background for the FTF waste release model to go along with new data on plutonium solubility resulting from the NEA-TDB related activities. These activities provide better understanding of the uncertainty surrounding peak doses associated with Pu-239 under varying conditions.

As discussed by the expert panel, there are multiple barriers to Pu-239 release and transport that prevent this peak near year 40,000 from occurring much earlier (i.e., within or close to the performance period). These barriers are discussed in FTF PA Section 7.1, with the barriers most impacting Pu-239 doses being the CZ chemistry, the waste tank liner, the concrete basemat, and the vadose zone beneath the waste tank (as discussed below). Given the multiple barriers to early release of Pu-239, it is reasonable to conclude that the uncertainty surrounding the factors driving the Pu-239 peak dose past year 10,000 is not sufficient enough to impact the performance objectives within the 10,000-year performance period. Additional sensitivity analyses regarding Pu-239 release were performed and documented in Section 6.3.6.

6.3.5.3.1 Waste Release Barrier

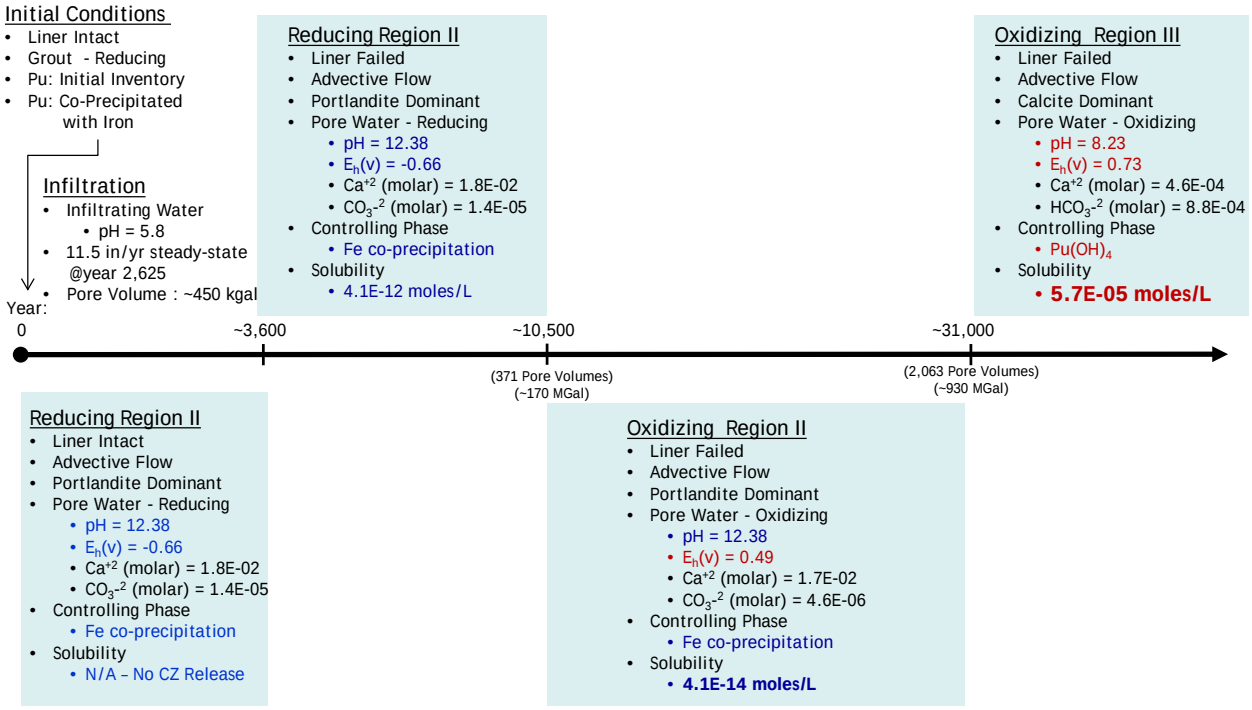
In the FTF PA Base Case, the release rate of contaminants from the CZ is solubility controlled and coupled to the chemical properties (e.g., E_h, pH) of the waste-tank pore water. The release rate from the CZ is independent of the grout or CZ K_d values. The assumed solubility limit varies depending on waste tank pore water chemistry and the controlling phase of the element being released. Different solubility limits for different waste tank chemistries were derived for the radionuclides in the CZ (as discussed in Section 4.2.2 of the FTF PA). Additional emphasis and analysis was placed on those elements shown during

initial modeling to have the most impact on peak dose (e.g., plutonium, neptunium, uranium, technetium), including an uncertainty study and development of stochastic distributions for alternative controlling phases (Section 4.2.2.3 of the FTF PA). Plutonium release modeling is based on a site-specific sub-model, which has iron co-precipitation controlling plutonium release in Region II. The Type IV tank plutonium-solubility modeling parameters, utilized in the FTF PA Base Case, are summarized in Figure 6.3-16.

The magnitude of the Tank 18 Pu-239 dose peak is artificially amplified by the deterministic modeling approach and the effects of the solubility controls in the CZ. The Pu-239 solubility limit in Reduced Region II is 4.1E-12 mol/L, then in Oxidized Region II the solubility limit is 4.0E-14 mol/L (FTF PA Table 4.2-10). Therefore, when CZ grout transitions between Reduced Region II and Oxidized Region II, the release rate of Pu-239 generally reduces, however the magnitude of this reduction is typically overwhelmed by the effects of other barriers. When the CZ transitions to Oxidized Region III, it is assumed that the Pu-239 solubility limit transitions to 5.7E-05 mol/L, allowing the flux to increase by many orders of magnitude. When this final CZ transition occurs, more Pu-239 mass becomes available for release, assuming that the waste tank liner had already failed. The difference between the solubility controls for Pu-239 under Oxidizing Region II versus Oxidizing Region III conditions is roughly nine orders of magnitude. This can have a pronounced impact, especially if the assumption is that other barriers did not perform as expected.

As pore volumes pass through the waste tank, the pH and reducing capability of the grout is affected. The number of pore water volumes passing through the waste tank and the corresponding transitions to different waste tank chemistry conditions is included in the FTF modeling. As part of the waste release modeling (discussed in detail in Section 4.2.2 of FTF PA), the estimated transition times between various chemical phases was calculated for the waste tank pore water. The waste-tank pore water chemistry was calculated to change from Reducing Region II conditions (middle age reducing) to Oxidizing Region II conditions (middle age oxidizing) after 371 pore-volumes have passed through the reducing grout. The change from Region II conditions (middle age) to Region III conditions (old age) was calculated to occur after 2,063 pore volumes (a summary of the chemical phases can be found in FTF PA Table 4.2-1).

Figure 6.3-16: Type IV Tank Plutonium Solubility Modeling Parameters in the FTF PA



In the case of the CZ, the pore water chemistry of the overlying waste tank grout is assumed imparted on the very thin CZ in intimate contact with grout, and the chemical transition times are identical for the two materials. This assumption holds for all configurations, including the fast-flow configurations (e.g., Configuration D). Based on the flow field data observed for all configurations, the infiltrate reaching the CZ does not bypass the waste tank grout (via the fast flow path) after cementitious materials have degraded. Instead, downward flow through the grout and basemat remains relatively uniform and significant across the plane of the CZ surface; such that pore water chemistry and transition times remain linked. Chemical degradation is indirectly coupled to hydraulic degradation through infiltrate pore volumes. Hydraulic degradation does not affect chemical transitions as a function of infiltrate pore volumes. However, hydraulic degradation that alters the flow field may affect the infiltrate pore-volume count, and thus the timing of E_h and pH transitions.

Given that the Pu-239 in the CZ is assumed to be very soluble after transition to the Oxidized Region III state, faster transitions can result in the CZ material being released much more rapidly (i.e., the solubility limits associated with Pu-239 under Oxidized Region III conditions are much higher than under Oxidized Region II conditions). Faster transition can be due to the grout being depleted of reducing capacity quicker (e.g., due to faster flow) or due to the grout not imparting its reducing capacity onto the CZ. In the FTF PA Base Case, the CZ transitions from Reduced Region II to Oxidized Region II at year 15,286 for Type I tanks and year 10,456 for Type IV tanks. In the FTF PA Base Case, the CZ transitions from Oxidized Region II to Oxidized Region III at the years 26,868 and 31,222, respectively for Type I and Type IV tanks. In Configuration D, the CZ transitions from Reduced Region II to

Oxidized Region II at year 4,022 for Type I tanks and at year 5,957 for Type IV tanks. In Configuration D, the CZ transitions from Oxidized Region II to Oxidized Region III at year 16,180 for Type I tanks and at year 28,218 for Type IV tanks.

Since the waste release model (WSRC-STI-2007-00544) assumed that water infiltrating the waste tanks is in equilibrium with atmospheric oxygen, a review of available groundwater data was performed to see if this assumption was reasonable. This review showed that the modeling assumption of water being in equilibrium with the atmosphere is reasonable, and in fact might be slightly conservative. The dissolved oxygen levels observed through the various available groundwater data sources were slightly below the dissolved oxygen value of 8.0 mg/L used in the FTF waste release model. [SRNL-L3200-2011-00011]

There are additional potential modeling conservatisms that were not included in the waste release model. For example, the waste release model assumes that there is no mixing of the radionuclides in the CZ with the reducing grout in the waste tank, since the CZ is modeled as a uniform layer at the bottom of the waste tank directly above the waste tank liner. In actuality, it is probable that some of the radionuclides within the CZ would mix with the grout. Any radionuclides mixed with the grout would be generally less mobile, with the degree of restriction affected by the nature of the mixing. In addition, the waste release model does not simulate a mechanism for radionuclides to be made less mobile (i.e., recaptured into the CZ) once that radionuclide is made mobile and is released into the waste tank pore water. In actuality, it is possible that some of the radionuclides released in the pore water will change to a less soluble form during transport from the CZ.

Because the waste release barrier is significant with respect to plutonium and since Pu-239 solubility can have a pronounced impact, if other barriers are assumed as not to perform as expected, additional studies were carried out to investigate the uncertainty regarding plutonium solubility within the FTF PA Base Case modeling. Based on the previously discussed *Plutonium Solubility Peer Review Report*, LA-UR-12-00079, new data from the NEA-TBD was used to recalculate the FTF PA Base Case plutonium solubility limits under various conditions. [SRNL-STI-2012-00087] These new solubility limits were used to perform additional new sensitivity analyses, substituting these values into the FTF PA Base Case, as shown in Section 6.3.6 of this Special Analysis.

6.3.5.3.2 Liner Barrier

After leaving the CZ and entering the waste-tank pore water, most of the waste-tank radionuclide inventory does not leave the waste tank until the waste tank liner fails. In addition, in the Type IV tanks, because there is no liner on top, a convection cell forms in the waste tank grout and mass can migrate around the liner at the top of the waste tank and escape outward through the waste-tank top and the wall. The liner failure time was determined by analysis for each waste tank type. While it utilizes many of the same assumptions, the waste-tank liner analyses calculate failure times independent of the flow and transport model. As discussed in Section 4.4.3.3 of the FTF PA, when the liner fails, it is assumed to fail completely, and have no further impact in the model.

As documented in the FTF PA, predictions for failure of the carbon-steel waste tank liners are based on the results of a liner degradation study. The time of liner failure is calculated based on steel corrosion rates under different conditions (e.g., differing diffusion coefficients). These failure times vary with waste tank design, owing to differences in construction. The failure analysis considers general and localized corrosion mechanisms of the waste tank steel. Consumption of the waste tank steel encased in grouted conditions is anticipated to occur due to carbonation of the concrete leading to low pH conditions, and the chloride-induced de-passivation of the steel leading to accelerated corrosion. Liner failure is modeled to occur at year 3,638 for Type IV tanks in the FTF PA Base Case. Liner failure has a direct impact on the timing of the release, but a less appreciable impact on the magnitude. The waste tank inventories for a particular tank type all being released at the same time can magnify the impact of the Pu-239 release. Alternate waste tank configurations (e.g., Configurations C though E) addressed early liner failure (year 75 for Type IV tanks) in the FTF PA.

There are potential modeling conservatisms related to the waste tank liner that were not included in FTF PA Base Case conceptual model. For example, the entire liner was modeled as failing instantaneously, which resulted in a build-up of inventory, which released as a single "pulse" that maximized the effect on dose. Additionally, although the timing of liner failures for each waste tank type differs based on the waste tank construction all waste tanks of the same type are considered to fail in the same year. In assuming that a "failed" liner would be completely permeable with no impact on flow or retardation, the conceptual model also ignores the fact that the degraded liner would most likely serve to retard plutonium transport significantly. [SRNL-STI-2012-00040]

6.3.5.3.3 Basemat Concrete Barrier

The basemat concrete retards contaminant transport, with some radionuclides being slowed greatly depending on their K_d values for concrete. FTF PA Table 4.2-33 provides K_d values for cementitious materials as a function of aging, with the cementitious material's "age" dependent on the pH of the pore water, which in turn is dependent upon the amount of water (number of pore water volumes) that has passed through the cementitious material over time. A description of pore-water chemistry modeling is provided in Section 4.4.3.5 of FTF PA. As the waste tank chemistry changes, the cementitious material transitions from middle age (Region II) to old age (Region III), and the associated material properties are modeled as changing with this transition (note that the basemat K_d values start with the Oxidized Region

II values). The plutonium basemat K_d values used for the FTF PA modeling (FTF PA Table 4.2-33) are 10,000 mL/g (Oxidizing Region II) and 1,000 mL/g (Oxidizing Region III). The plutonium basemat K_d values are based on site-specific test results. [WSRC-TR-2006-00004, WSRC-RP-2007-01122]

The difference in the plutonium K_d values, when the basemat transitions from Oxidized Region II to Oxidized Region III cements, can have a significant impact on flux and dose results for Pu-239. However, in the FTF PA Base Case, this transition occurs less than 1,000 years after liner failure (for Type IV tanks) so the impact is muted by the impact of the liner failure. Because plutonium is strongly sorbed in the basemat, and the FTF PA Base Case Oxidizing Region II K_d value is 10,000 mL/g and the Oxidizing Region III K_d value is 1,000 mL/g, the basemat can significantly delay the Pu-239 release if not bypassed. The impact on Type IV tanks is lessened by the fact that the basemat is relatively thin (approximately 7 inches thick). The FTF PA barrier analysis results (Section 5.6.7.2 of FTF PA) show that the Pu-239 flux is significantly impacted by K_d changes, although this is less pronounced in Tank 18, relative to the other waste tanks.

6.3.5.3.4 Natural Soil Barrier

After contaminants exit the basemat, they enter the vadose zone (i.e., soil) beneath the waste tank, which serves as a natural barrier, as discussed in detail in Section 4.2.3.2.2 of FTF PA. The plutonium soil K_d values (FTF PA Table 4.2-29) are relatively high compared to the soil K_d values for other elements (K_d in sandy soil 270 mL/g, K_d in clayey soil 5,900 mL/g). The vadose zone material properties impact both the flow rate through the soil and the associated K_d values, with both being important to the model. The vadose zone depth below each waste tank can vary depending on the waste tank involved, as shown in FTF PA Table 4.2-23. The vadose zone material properties are not modeled as changing over time. In the probabilistic model however, the vadose zone thickness was allowed to vary, which did impact transport time through the soil. The working slabs under waste tank basemats were not explicitly modeled and instead were simply assumed as soil. Given the small thickness of the working slabs relative to the waste tank basemats, as well as the possibility of cracks in the working slabs, it is reasonable to disregard the working slabs in modeling contaminant transport through the waste tank bottom and basemat into the vadose zone.

The plutonium K_d in sandy soil is high enough (270 mL/g) to provide an impact on the magnitude of the dose results. For the Type IV tanks the impact is mitigated by the relatively short distance (approximately 2 feet) from the bottom of the waste tank basemat to the water table, as opposed to between 9 and 13.5 feet for Type I tanks. The plutonium soil K_d values are based on site-specific test results under conservative conditions. [WSRC-TR-2006-00004] Because the plutonium K_d in sandy soil can have a pronounced impact if other barriers are assumed to not perform as expected, additional studies have been performed (e.g., SRNL-STI-2011-00672) to investigate likely conservatisms imbedded in the FTF PA Base Case regarding the plutonium K_d values used for sandy soil. These additional studies showed that plutonium is expected to be less mobile in sandy soil (i.e., K_d = 650 mL/g, than what is assumed in the FTF PA, modeling Base Case), with the new value better representing the soil conditions expected in the FTF. The revised value is based on a literature review of

K_d values for soil conditions representative of SRS soils. The impact of the revised K_d values is evaluated in Section 6.3.6.1 of this Special Analysis.

There are additional potential modeling conservatisms that were not included in the FTF PA conceptual model for soil. For example, the model did not account for the fact that the high pH leachate exiting the waste tank can cause increased adsorption (i.e., the K_d values increase) for some radionuclides, including plutonium. The *Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site* provides information for soil-distribution coefficient values when influenced by the high pH of cementitious material leachate. [SRNL-STI-2009-00473] The values are applicable to vadose (unsaturated) zone soils under the waste tank, with the K_d values for plutonium in vadose soil doubling due to the impact of the cement leachate (e.g., K_d = 1,300 mL/g vs. 650 mL/g).

6.3.5.3.5 Plutonium Waste Release Modeling Support

The purpose of this section of this Special Analysis is to provide additional information regarding plutonium speciation and solubility. Three reports have been prepared in support of this purpose: *Form and Aging of Plutonium in Savannah River Site Waste Tank 18* (SRNL-STI-2012-00106), *Summary of XRD and SEM Analysis of Tank 18 Samples* (SRNL-L3100-2012-00017), and *Evolution of Chemical Conditions and Estimated Plutonium Solubility in the Residual Waste Layer During Post-Closure Aging of Tank 18* (SRNL-STI-2012-00087).

6.3.5.3.5.1 Form and Aging of Plutonium in Tank 18

The analysis of form and aging of plutonium in Tank 18 (SRNL-STI-2012-00106) included a review of the Tank 18 operational history and a literature review on alkaline plutonium chemistry. This evaluation reviewed the different forms of plutonium that might be present after waste tank operational closure. The report concludes:

> *"During the operational history, most of the Pu(IV) was present as amorphous plutonium hydroxide, $Pu(OH)_{4(am)}$. The $Pu(OH)_{4(am)}$ is likely present within a mixture of hydrous metal oxide phases containing metals such as iron, uranium and aluminum. …Over the operational period and after closure of Tank 18, Ostwald ripening has and will continue to transform $Pu(OH)_{4(am)}$ to a more crystalline form of plutonium dioxide, $PuO_{2(c)}$. …Due to the high alkalinity and low carbonate concentration in the grout formulation, it is expected that upon interaction with the grout, the plutonium carbonate complexes will transform back into plutonium hydroxide."*

The conclusions of the form and aging of plutonium report were utilized within the plutonium solubility analysis (SRNL-STI-2012-00087), with the analyses concentrating on plutonium co-precipitated with iron and amorphous plutonium hydroxide, since these are the plutonium forms anticipated to be dominating plutonium waste release.

6.3.5.3.5.2 Summary of XRD and SEM Analyses of Tank 18 Samples

The objective of SRNL-L3100-2012-00017 is to document the XRD and SEM analyses that were performed on Tank 18 samples in early 2012. The XRD of a Tank 18 wall sample found similar mineral phases as the major components of the waste, although some of the minor phases were different between the samples. No plutonium containing crystalline phases were detected in the XRD of the residual samples from Tank 18. The SEM of the Tank 18 residual samples found particles with compositions consistent with the mineral phases identified in the XRD. The major elements identified are consistent with the elemental composition determined in the chemical characterization of the Tank 18 floor samples. The majority of the individual particles scanned on each sample consisted of some form of aluminum oxide with silicon and sometimes-other metals present. Most of the individual particles seem to be composed of a single discrete mineral phase as opposed to mixtures of more than one phase.

Two distinct iron oxide matrices were observed in the SEM with one matrix being more dense than the other is. The less dense (more porous) iron oxide phase generally contained aluminum, magnesium, manganese, and uranium. The denser iron oxide matrix (brighter particles in the photos) contained less of these other metals. All of the plutonium located during the SEM analysis of the Tank 18 floor samples was associated with the less dense (more porous) iron oxide phase. The plutonium identified in the samples was in the form of discrete particles usually < 1 micrometer in size distributed unevenly within the less dense (more porous) iron oxide phase. The spectrum of the plutonium spots matrix indicates the plutonium is probably not co-precipitated into an iron oxide matrix but instead a particle of a discrete plutonium phase contained in an iron oxide particle. Due to the small size and low concentration of the plutonium particles, the chemical form of the plutonium remains uncertain.

6.3.5.3.5.3 Evolution of Chemical Conditions and Estimated Plutonium Solubility in the Residual Waste during Post-Closure Aging of Tank 18

The objective of SRNL-STI-2012-00087 is to provide additional waste-release model support concerning solubility controls on release of plutonium from residual waste in the FTF waste tanks. The update to the waste release model is based on new information including a chemical analysis of Tank 18 samples, more current thermodynamic data for plutonium and grout minerals, and a revised grout formulation. In addition, minor updates were made to the modeling of the grout chemical evolution. The intent of this update to the waste release model is to provide reasonably bounding solubilities for plutonium to be used in FTF PA modeling rather than accurately predict the concentration of plutonium in pore fluids released from a waste tank at any given time. SRNL-STI-2012-00087 also considers suggestions and opportunities for improvement regarding the plutonium modeling assumptions from the LA-UR-12-00079.

In SRNL-STI-2012-00087, amorphous plutonium hydrous oxide (hereinafter referred to as $PuO_{2(am,hyd)}$)) is assumed to be the form plutonium will take if it is in discrete particles. It is the most soluble of the reasonable forms for the relevant conditions. $PuO_{2(am,hyd)}$) is known to dehydrate and become less soluble as it ages. The final product of the aging is crystalline

PuO_2 that is two or more orders of magnitude less soluble than $PuO_{2(am,hyd)}$. However, in a wet environment the crystalline form will never be reached. Nonetheless, it is unknown whether some dehydration may occur shortly after grout is poured due to elevated temperatures and pressures or whether partial crystallization would occur with waste tank aging. [SRNL-STI-2012-00106] If these processes occur, they would tend to lower the solubility of plutonium.

Plutonium co-precipitated in iron minerals is the other form considered in SRNL-STI-2012-00087. By the definition used in SRNL-STI-2012-00087, co-precipitation means plutonium bound in an iron phase that is occluded from reacting with pore fluids. The plutonium only reacts as the iron host phase is dissolved, with the mechanism not specified. Plutonium could be bound in the crystal lattice of the iron phase, it could be adsorbed to iron phase particles that are agglomerated together to form the residual waste layer, or it could occur as small discrete plutonium particles surrounded by the host iron phase. As discussed previously, recent characterization of Tank 18 residual waste samples (SRNL-L3100-2012-00017) show plutonium in discrete particles embedded in much large particles dominated by iron. This was the only plutonium observed in SEM analysis with elemental analysis capability. It is unclear whether dissolution of these particles would depend on dissolution of the host or whether they would behave as discrete particles. It also does not preclude the occurrence of plutonium in the other forms considered here as co-precipitated.

The assumption used within SRNL-STI-2012-00087 to estimate an apparent solubility of co-precipitated plutonium is that plutonium is released into the pore fluid, as the iron phase dissolves, in the same plutonium to iron molar ratio as exists in the host solid. This assumption is the most valid for plutonium bound in the crystal lattice of the iron phase with a distribution coefficient of one. Depending on plutonium concentration, distribution, and fluid flow through the residual layer, it could approximate the apparent solubility for other mechanisms as well. This said the estimate of apparent solubility presented within SRNL-STI-2012-00087 probably represents the lower bounding value for apparent solubility of co-precipitated plutonium. The upper bounding value is the solubility of $PuO_{2(am,hyd)}$. No adsorption of plutonium onto the residual waste layer is considered. In this waste release model when plutonium is dissolved from the host phase, it is released from the tank unimpeded. In reality, it would be subject to retardation caused by adsorption to the minerals of the residual waste layer.

Characterization data of Tank 18 residual waste samples suggests that another form of plutonium may occur in the tanks prior to grouting (SRNL-STI-2012-00106). This report hypothesizes that any discrete particles of plutonium in the waste tank today may be the hydroxy carbonate, $Pu(OH)_2CO_3$. This is based on the carbonate concentration in water separated from Tank 18 residual waste samples and is consistent with behavior predicted by plutonium thermodynamics. However, two factors suggest that $PuO_{2(am,hyd)}$ will be the stable phase at conditions in the waste tank after removal from service. The dissolved carbonate concentration in the residual waste layer will decrease because any dissolved or soluble carbonate will react with grout influenced pore fluids or with the grout itself to form calcium carbonate. Carbonate concentrations in equilibrium with calcium carbonate in the pH range of 10 to 11 are < 1.0E-03 mol/L and below this concentration, $PuO_{2(am,hyd)}$ will be the stable phase. Likewise, pH will increase to 11.1 because of the influence of the grout. Even at

relatively high dissolved carbonate concentrations the stable phase will be $PuO_{2(am,hyd)}$ after waste tank operational closure.

Even assuming $PuO_{2(am,hyd)}$ as the plutonium form present in the residual waste, the plutonium solubility is very sensitive to E_h at highly oxidizing conditions. Slight changes in E_h above a value of 0.45 volts results in large changes in $PuO_{2(am,hyd)}$ solubility. The E_h that results from the grout simulations is in equilibrium with dissolved oxygen, and hence the maximum E_h possible in an aqueous system. This results in solubilities in the oxidized regions that are maximums. The E_h values of natural waters are rarely in equilibrium with dissolved oxygen, predominantly because of slow reaction kinetics for oxidation by dissolved oxygen. As discussed in SRNL-STI-2012-00087, a range of E_h values below the "conservative E_h" (i.e., the maximum E_h possible in an aqueous system) would be "realistic" for calculating solubilities at these pH values. It is reasonable to assume that E_h values controlling solubility in the oxidized regions would be lower than those resulting from the grout simulations would (i.e., lower than equilibrium with the dissolved oxygen).

Based on the preceding, revised waste release model transition times and variable solubility limits were calculated in SRNL-STI-2012-00087 are shown in Tables 6.3-10 and 6.3-11. The revised transition times were recalculated based on a revised final reducing grout formulation.

Table 6.3-10: Revised E_h/pH Transition Times

Material	Eh/pH Transition	Value (pore volumes)	Base Case (pore volumes)
Cementitious	Reducing → Oxidizing	523	371
Cementitious	II → III	2,119	2,063

[SRNL-STI-2012-00087]

Table 6.3-11: Revised Plutonium Solubilities

E_h/pH Regime	Base Case (mol/L)	Fe co-precipitation (mol/L)	$PuO_{2(am,hyd)}$ (conservative E_h) (mol/L)	$PuO_{2(am,hyd)}$ (realistic E_h) (mol/L)
Reducing II	4.1E-12	3.0E-14	3.2E-11	3.2E-11
Oxidizing II	4.0E-14	2.5E-13	5.2E-8	3.2E-11
Oxidizing III	5.7E-5	5.0E-15	7.8E-8	3.2E-11

[SRNL-STI-2012-00087]

6.3.5.4 Individual Pathway Contributions to MOP 100-Meter Peak Annual Groundwater Pathway Dose

As stated previously, the total peak groundwater pathway dose results are the summation of the doses associated with all the individual 100-meter well pathways. Table 6.3-12 shows the relative contributions from the individual groundwater pathways to the recalculated (i.e., final Tanks 18 and 19 inventory) Sector E 100-meter MOP receptor dose at 10,000 years (the year of the peak dose). The primary contributors are water ingestion (67 % of peak dose) and vegetable ingestion (30 % of peak dose), with Ra-226 being the principal radionuclide contributor for all of the individual groundwater pathways. The individual pathway contributions are not significantly impacted by utilizing the actual residual inventories at operational closure for Tanks 18 and 19.

Table 6.3-12: 100-Meter MOP Peak Dose Individual Groundwater Pathway Contributions for Sector E

Pathway	Associated Contribution at year 10,000 (mrem/yr)	Percentage of Total Peak Dose
Water Ingestion	2.1	67%
Vegetable Ingestion	1.0	30%
Finfish Ingestion	<0.05	1%
Milk Ingestion	<0.05	1%
Beef Ingestion	<0.05	1%
Total	**3.2**	**100%**

Table 6.3-13 shows a comparison of the 100-meter peak, water ingestion doses for the different 100-meter sectors within both 10,000 and 20,000 years. Figure 6.3-17 shows the water ingestion doses to the 100-meter MOP receptor over time during the 10,000-year period for the five 100-meter sectors. The highest 100-meter MOP water ingestion dose in the 10,000-year performance period for Sector E is 2.1 mrem/yr, at year 10,000. Figure 6.3-18 shows the 100-meter MOP receptor, water ingestion doses within 20,000 years for the five 100-meter sectors. Figures 6.3-19 and 6.3-20 show the vegetable ingestion doses to the 100-meter MOP receptor for the five 100-meter sectors within 10,000 and 20,000 years respectively.

Table 6.3-13: 100-Meter MOP Peak Water Ingestion Doses by Sector

Sector	Peak Water Ingestion Dose in 10,000 years (mrem/yr)	Principal Radionuclide	Peak Water Ingestion Dose in 20,000 Years (mrem/yr)	Principal Radionuclide
A	0.03 (year 750)	Tc-99	1.3 (year 17,906)	Np-237
B	0.06 (year 752)	Tc-99	2.3 (year 16,654)	Np-237
C	0.09 (year 4,310)	C-14	7.8 (year 16,652)	Np-237
D	1.2 (year 6,056)	Ra-226	10.5 (year 16,640)	Np-237
E	2.1 (year 10,000)	Ra-226	11.5 (year 16,638)	Np-237

Figure 6.3-17: 100-Meter MOP Peak Water Ingestion Dose Results within 10,000 Years for the Five 100-Meter Sectors

Figure 6.3-18: 100-Meter Peak MOP Water Ingestion Dose Results within 20,000 Years for the Five 100-Meter Sectors

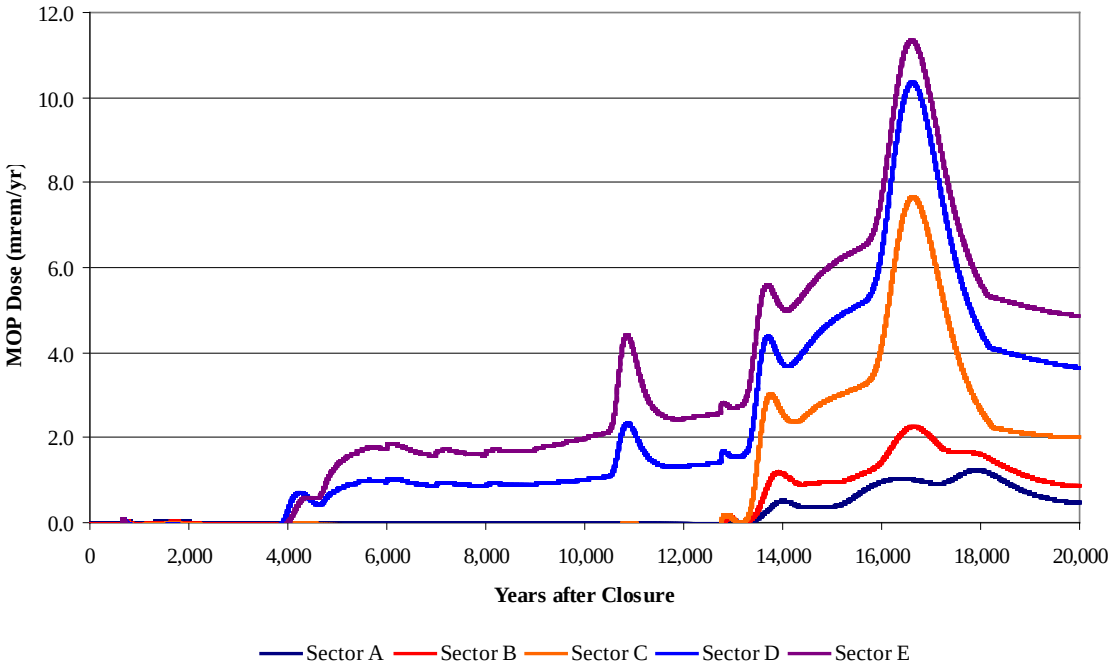


Figure 6.3-19: 100-Meter MOP Peak Vegetable Ingestion Dose Results within 10,000 Years for the Five 100-Meter Sectors

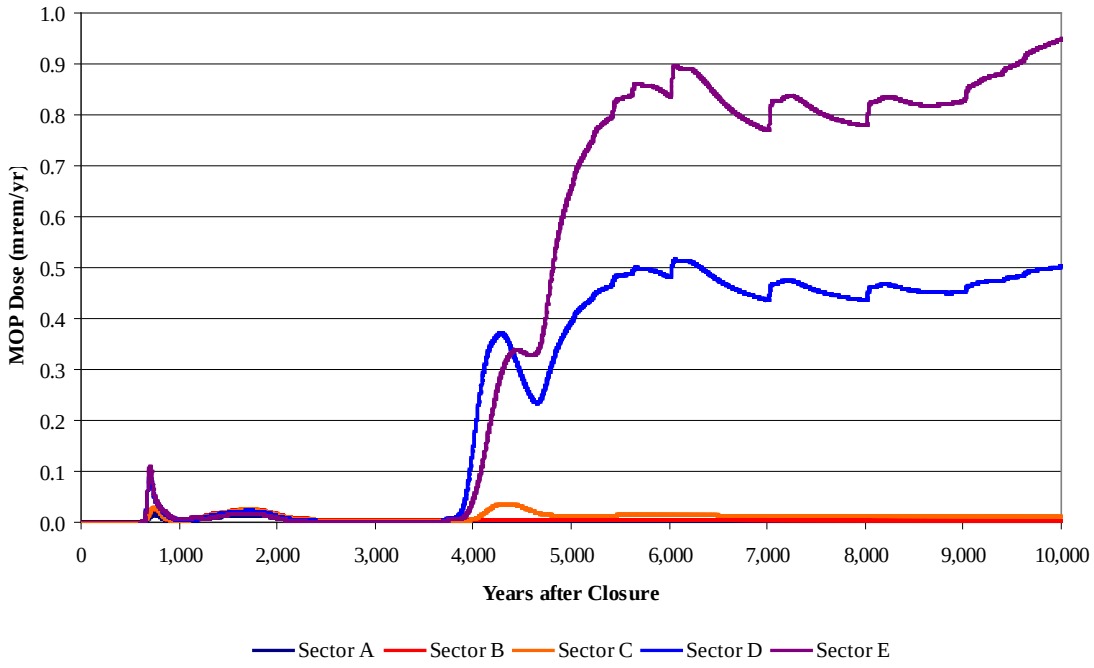
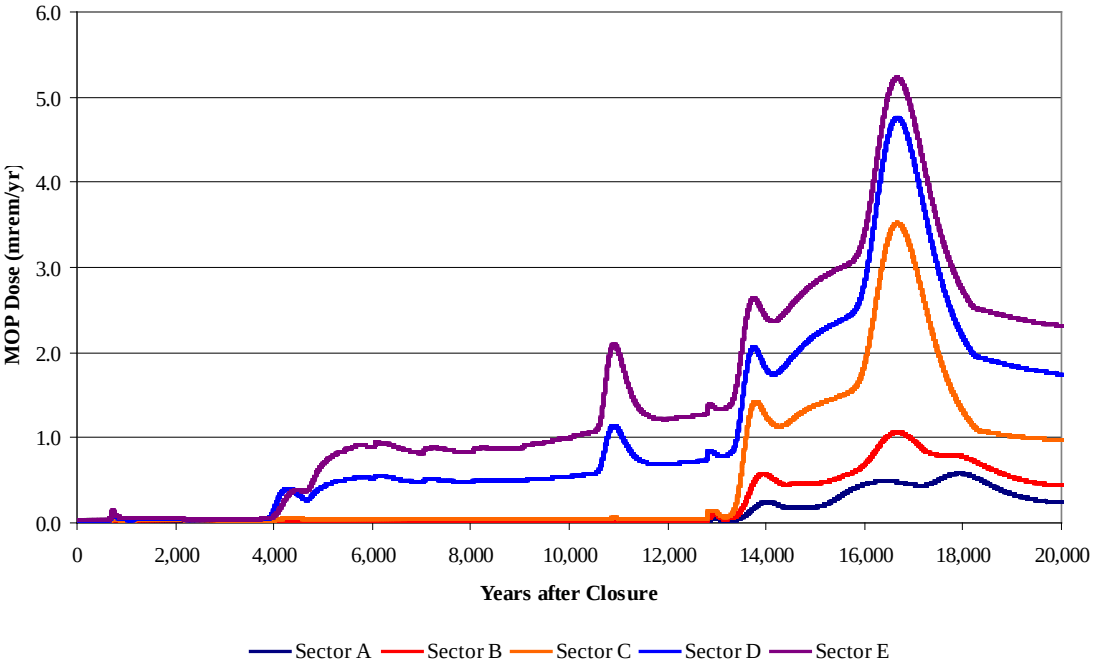


Figure 6.3-20: 100-Meter MOP Peak Vegetable Ingestion Dose Results within 20,000 Years for the Five 100-Meter Sectors



6.3.5.5 Peak Annual MOP Dose at the Stream

The peak groundwater pathway doses for the two stream seeplines (Fourmile Branch and UTR) have been recalculated using the highest concentration for each radionuclide in the sector. Table 6.3-14 shows a comparison of the MOP, stream peak groundwater pathway doses for the two stream sectors. The highest peak groundwater pathway dose in the 10,000-year performance period is associated with UTR. Figure 6.3-21 shows the peak groundwater pathway doses over time during the performance period (10,000 years) for the two streams (UTR and Fourmile Branch). The stream peak groundwater pathway dose for a MOP in the 10,000-year performance period is 0.07 mrem/yr. Figure 6.3-22 shows the peak groundwater pathway stream doses within 20,000 years.

Table 6.3-14: Peak Groundwater Pathway MOP Doses at the Stream by Sector

Sector	Peak Dose in 10,000 Years	Peak Dose in 20,000 Years
Fourmile Branch	**0.015 mrem/yr (year 824)** Principal Pathways: Dust Inhalation Water Ingestion Principal Radionuclides: Am-241, Tc-99	**0.85 mrem/yr (year 20,000)** Principal Pathway: Finfish Ingestion Principal Radionuclide: Cs-135
UTR	**0.07 mrem/yr (year 5,564)** Principal Pathway: Water Ingestion Principal Radionuclides: Ra-226, Pa-231	**0.90 mrem/yr (year 20,000)** Principal Pathway: Finfish Ingestion Principal Radionuclide: Cs-135

Figure 6.3-21: Peak Groundwater Pathway MOP Dose at the Stream Results within 10,000 Years for the Two Stream Sectors

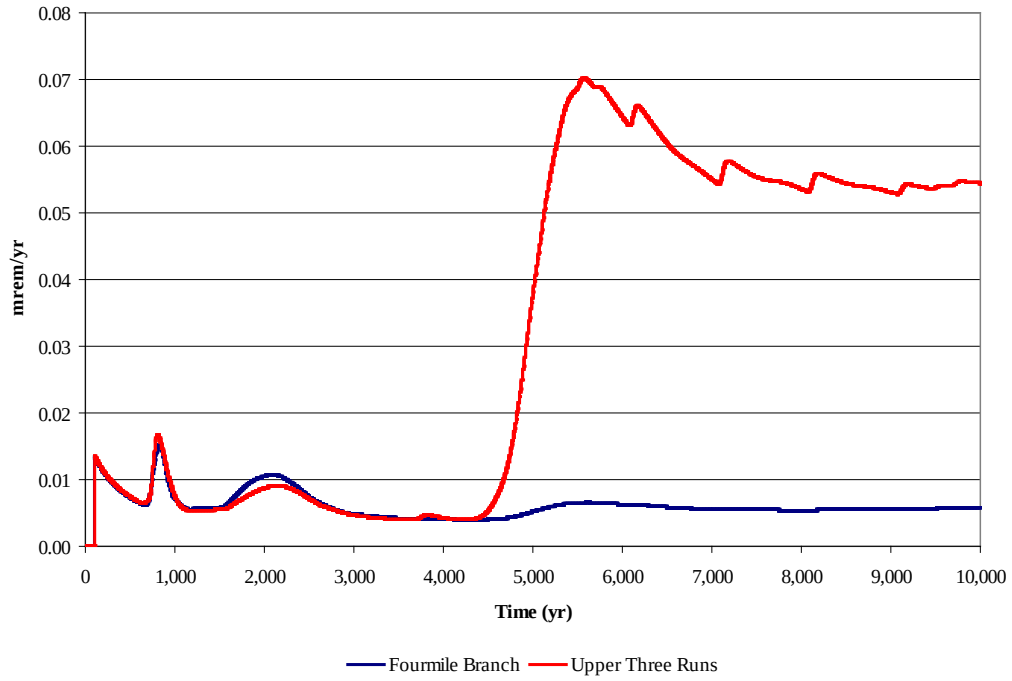
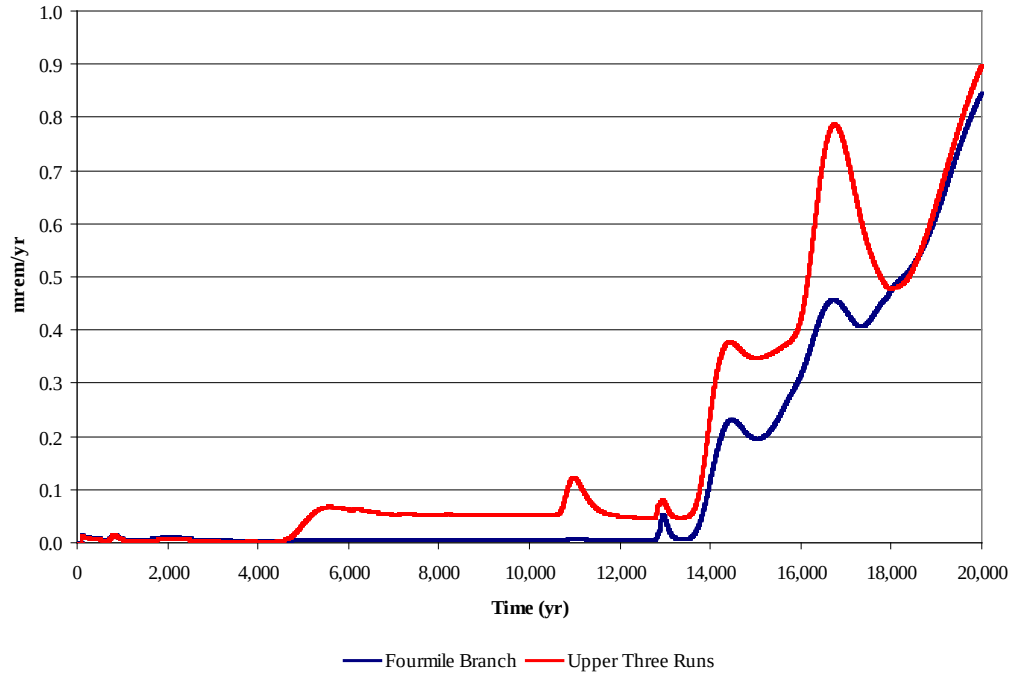


Figure 6.3-22: Peak Groundwater Pathway MOP Dose at the Stream Results within 20,000 Years for the Two Stream Sectors



6.3.5.6 Individual Pathway MOP Contributors at Stream

Table 6.3-15 shows the relative contributions from the individual groundwater pathways to the UTR MOP receptor dose at year 5,600 (the year of the peak UTR dose within 10,000 years). The primary contributor to the UTR peak is water ingestion, with additional contribution from vegetable ingestion. Table 6.3-16 shows the relative contributions from the individual groundwater pathways to the Fourmile Branch MOP receptor dose at 824 years (the year of the peak Fourmile Branch dose). The primary contributors are dust inhalation (34 % of peak dose) and water ingestion (32 % of peak dose).

Table 6.3-15: Individual MOP Peak Dose at the Stream Groundwater Pathway Contributions for UTR

Pathway	Associated Contribution at year 5,600 (mrem/yr)	Total Peak Dose	Principal Radionuclide Pathway Dose
Water Ingestion	0.04	64 %	Pa-231
Vegetable Ingestion	0.02	29 %	Pa-231
All Others	< 0.01	7 %	- -
Total	**0.07**	**100** %	

Table 6.3-16: Individual Peak MOP Dose at the Stream Groundwater Pathway Contributions for Fourmile Branch

Pathway	Associated Contribution at year 824 (mrem/yr)	Total Peak Dose	Principal Radionuclide Pathway Dose
Dust Inhalation	0.005	34 %	Am-241
Water Ingestion	0.005	32 %	Tc-99
Finfish Ingestion	0.003	17 %	Tc-99
Vegetable Ingestion	0.002	15 %	Tc-99
All Others	<0.001	2 %	- -
Total	**0.015**	**100** %	

6.3.5.7 Member of the Public at 100-Meter Peak Annual All-Pathway Dose

The peak all-pathways annual dose for the MOP at 100-meters is calculated using the recalculated peak 100-meter groundwater pathway dose results during the 10,000-year performance period in combination with the recalculated air pathway results. The peak all-pathways annual dose for the MOP is 3.4 mrem/yr and is associated with Sector E. The breakdown of the individual dose contributors is provided in Table 6.3-17.

Table 6.3-17: 100-Meter Peak Annual MOP All-Pathways Dose Contributors

Pathway	Associated Contribution at year 10,000 (mrem/yr)	Percentage of Total Peak Dose	Principal Radionuclide Pathway Dose
Water Ingestion	2.1	62 %	Ra-226
Vegetable Ingestion	1.0	29 %	Ra-226
Air Pathway	0.2	6 %	Sn-126
Finfish Ingestion	<0.1	1 %	Ra-226
Milk Ingestion	<0.1	1 %	Ra-226
Beef Ingestion	<0.1	1 %	Ra-226
Total	**3.4**	**100** %	

6.3.5.8 MOP at Stream Peak Annual All-Pathways Dose

The peak all-pathways annual dose for the MOP at the stream is calculated using the recalculated peak stream groundwater pathway dose results during the 10,000-year performance period in combination with the air pathway results. The peak all-pathways annual dose for the MOP within 10,000 years is 0.1 mrem/yr and is associated with UTR. The breakdown of the individual dose contributors is provided in Table 6.3-18.

Table 6.3-18: Peak Annual MOP at the Stream All-Pathways Dose Individual Contributions

Pathway	Associated Contribution at Year 5,600 (mrem/yr)	Percentage of Total Peak Dose	Principal Radionuclide Pathway Dose
Air Pathway	0.05	42 %	Sn-126
Water Ingestion	0.04	42 %	Pa-231
Vegetable Ingestion	0.02	16 %	Pa-231
Total	**0.1**	**100** %	

6.3.6 Uncertainty and Sensitivity Analysis

Section 5.6 of the FTF PA considers the effects of uncertainties in the conceptual models used and sensitivities in the parameters used in the mathematical models. The uncertainty analyses and sensitivity analyses were primarily performed using a probabilistic model (i.e., the GoldSim FTF model), but some additional single parameter sensitivity analyses were performed through deterministic modeling using both the PORFLOW and GoldSim models.

The probabilistic model varies multiple parameters simultaneously, so concurrent effects of changes in the model can be analyzed, and the potential impact of changes can be assessed. This assessment allows for identification of parameters that are only of significance when varied simultaneously with another parameter. The deterministic model single parameter analysis provides a method to evaluate parametric effects in isolation, so the importance of the uncertainty around a parameter of concern can be more effectively evaluated. Using both probabilistic and deterministic models for sensitivity analysis versus a single approach provides additional information concerning which parameters are of most importance to the FTF PA modeling.

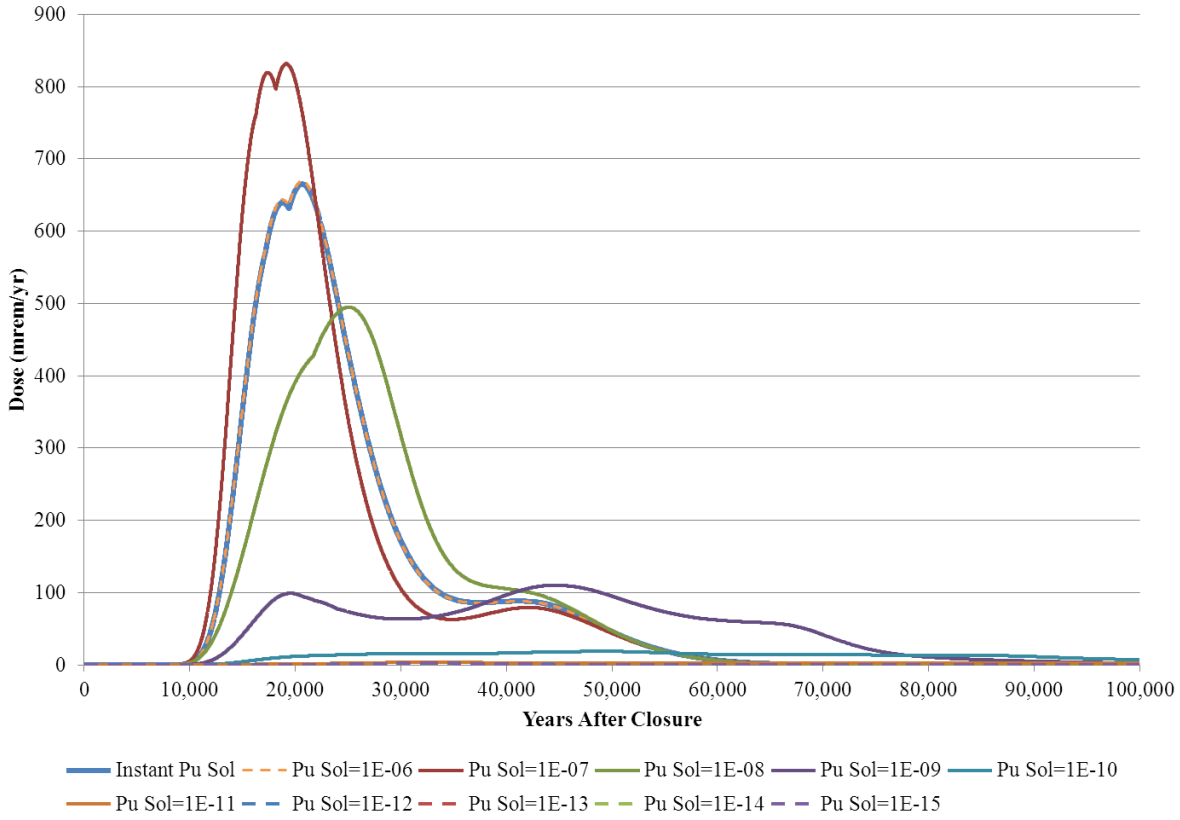
In general, the uncertainty analyses and sensitivity analyses information presented in FTF PA is not affected by the new residual waste information, and the uncertainty analyses and sensitivity analyses insights remain unaffected. The Section 5.6.1 uncertainty analyses and sensitivity analyses approach, and Section 5.6.2, GoldSim Benchmarking discussions of FTF PA are not impacted by a change in the FTF PA Base Case inventories (i.e., using the Tanks 18 and 19 residual inventories at operational closure). With respect to the of FTF PA parameters presented in Section 5.6.3 of FTF PA, the parameter impacted by the residual inventories at operational closure is the radiological inventory, discussed in the Section 5.6.3.2 of FTF PA. Most of the Tanks 18 and 19 residual inventories when operationally closed are within the inventory distributions used in the probabilistic model (documented in the FTF PA Table 5.6-3, Inventory Multipliers), with the exceptions being Am-243, C-14, Nb-93m, Pa-231, Pu-238, Ra-226, and Zr-93. The following sections describe some additional uncertainty analyses and sensitivity analyses activities that were performed utilizing the Tanks 18 and 19 residual inventories at operational closure.

6.3.6.1 Deterministic Model Barrier Analysis

The impact of input variability on the Tank 18 peak dose was further evaluated in this Special Analysis by performing several barrier (single parameter) sensitivity analyses using the Base Case PORFLOW FTF model with changes to select parameters made (a detailed discussion of the PORFLOW FTF model and the individual Base Case parameters are provided in the FTF PA). [SRNL-L4221-2012-00001] These barrier analyses were performed with the specific intent of investigating the uncertainty surrounding the timing of Pu-239 associated dose peaks beyond the 10,000-year performance period. Plutonium solubility sensitivity analyses were performed by calculating the 100-meter MOP peak groundwater pathway Pu-239 doses over a range of plutonium solubility values (from 1.0E-06 mL/g to 1.0E-15 mL/g, and instantaneous release), with the same plutonium solubility value assumed for all waste tank conditions (i.e., no change in plutonium solubility associated with E_h or pH changes). The results of this PORFLOW parametric study for all of the FTF waste tanks within 100,000 years are shown in Figure 6.3-23. This sensitivity study shows that the peak doses associated with Pu-239 are very sensitive to the solubility, with the peak doses associated with Pu-239 tending to decrease as the solubility limit decreases. In general, as plutonium solubility decreases the peak doses also decrease, since less plutonium is being released over time from the CZ. At very high solubilities (e.g., 1.0E-06), however, the peak dose decreases slightly in comparison to the worst-case solubility studied (i.e., 1.0E-07). This effect is due to the plutonium that is released relatively early migrating upward into the grout above the CZ prior to liner failure. At higher or no solubility limit essentially the entire waste inventory diffuses into the overlying waste tank-reducing grout before complete corrosion of the steel waste tank. When the primary steel liner fails, plutonium is held up by the high sorptive property of the grout. At lower values, solubility limits the release concentration to lower values. At 1.0E-7 mol/L some waste diffuses into the waste tank grout, but not all, thus allowing contamination to release at a relatively high concentration of 1.0E-7 mol/L after the liner is assumed to fail (after liner failure there is downward flow of water through the grout and out of the waste tank). As discussed in Section 4.4.3.4 of the FTF PA, the only modeling period in which upward contaminant transfer is significant is early on for the Type IV tanks. Because the Type IV tanks do not

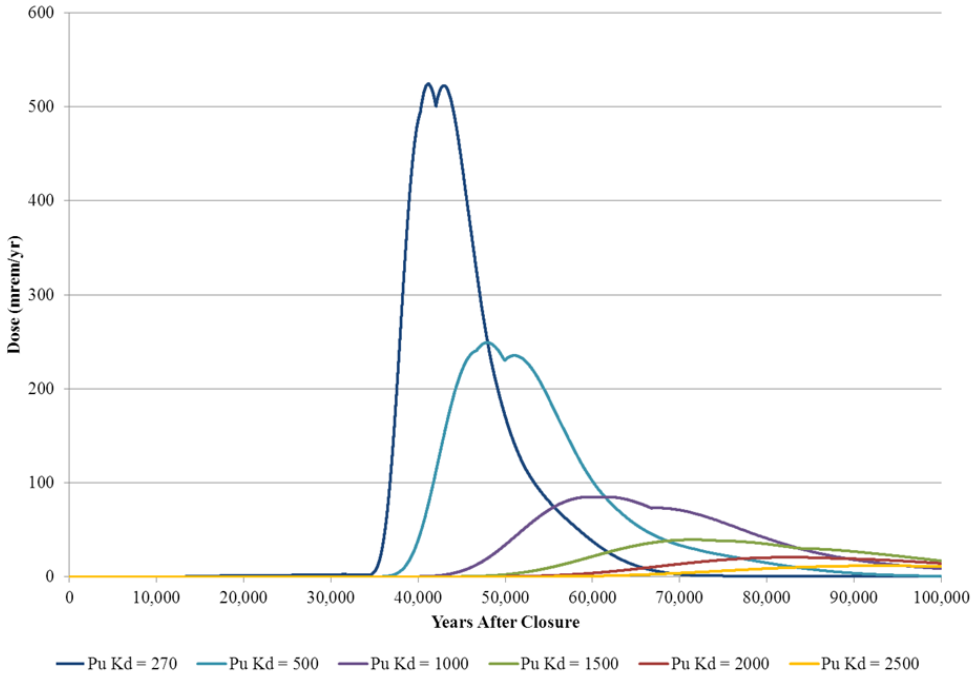
have a top steel liner, flow into the Type IV tanks may be contained prior to liner failure, forcing contaminants to flow upwards into the grout. It should be noted that irrespective of the plutonium solubility value, the peak doses associated with Pu-239 are always below the 25 mrem/yr performance objective within the 10,000-year performance period. This sensitivity study also shows that the multiple barriers to Pu-239 release are effective and can prevent a significant release in the 10,000-year time period regardless of the Pu-239 solubility limits.

Figure 6.3-23: 100-Meter MOP Peak Groundwater Pathway Pu-239 Dose within 100,000 Years – Variable Plutonium Solubility



Sandy soil K_d sensitivity analyses were also performed by looking at the 100-meter MOP peak groundwater pathway doses over a range of plutonium sandy soil K_d values (from 500 mL/g to 2,500 mL/g). The results of this PORFLOW parametric study for Pu-239 within 100,000 years are shown in Figure 6.3-24. This sensitivity study shows that the peak doses associated with Pu-239 can be particularly sensitive to the plutonium sandy soil K_d values with the FTF PA Base Case peak doses associated with Pu-239 being conservative since the plutonium sandy soil K_d value used in the FTF PA Base Case (270 mL/g) is less than the values used in this parametric study.

Figure 6.3-24: 100-Meter MOP Peak Groundwater Pathway Pu-239 Dose within 100,000 Years – Variable Plutonium Sandy Soil K_d Values



6.3.6.2 Deterministic Model Single Parameter Sensitivity Analysis

The impact of input variability on the peak dose was further evaluated in this Special Analysis by performing several single parameter sensitivity analyses using the Base Case PORFLOW FTF model with changes to select parameters made (a detailed discussion of the PORFLOW FTF model and the individual FTF PA Base Case parameters is provided in the FTF PA). Additional inventory sensitivity analyses were performed by comparing the FTF PA Base Case Tank 18 inventory and one-half of the FTF PA Base Case Tank 18 inventory (these results are for Tank 18 only). Results are shown for the 100-meter MOP, peak groundwater pathway dose within 20,000 years (Figure 6.3-25) and within 100,000 years (Figure 6.3-26). This sensitivity study shows that the Tank 18 peak doses (primarily due to Pu-239) can be reduced by reducing the total curies of Pu-239 in Tank 18 and that this reduction approaches a linear function. Figures 6.3-25 and 6.3-26 also show the doses excluding Tank 18 for comparison.

The impact of the FTF point of assessment used was investigated by analyzing the Tank 18 groundwater pathway dose assuming the resident MOP was dwelling at the seepline rather than at 100-meters. The seepline, peak groundwater pathway dose from Tank 18 only for 100,000 years is shown in Figure 6.3-27. Comparison of the seepline, peak groundwater pathway dose from all sources (SRS-REG-2007-00002) and from Tank 18 only (Special Analysis) is shown in Figure 6.3-28 (20,000 years) and Figure 6.3-29 (100,000 years). This sensitivity study shows that the Tank 18 peak doses (primarily due to Pu-239) are very sensitive to the travel distance, which is in turn due to the effectiveness of the natural barrier (i.e., soil) as a retardant to Pu-239 mobility.

Figure 6.3-25: 100-Meter MOP Peak Groundwater Pathway Dose within 20,000 Years for Tank 18 Only (Tank 18 Base Case and One-half Inventory)

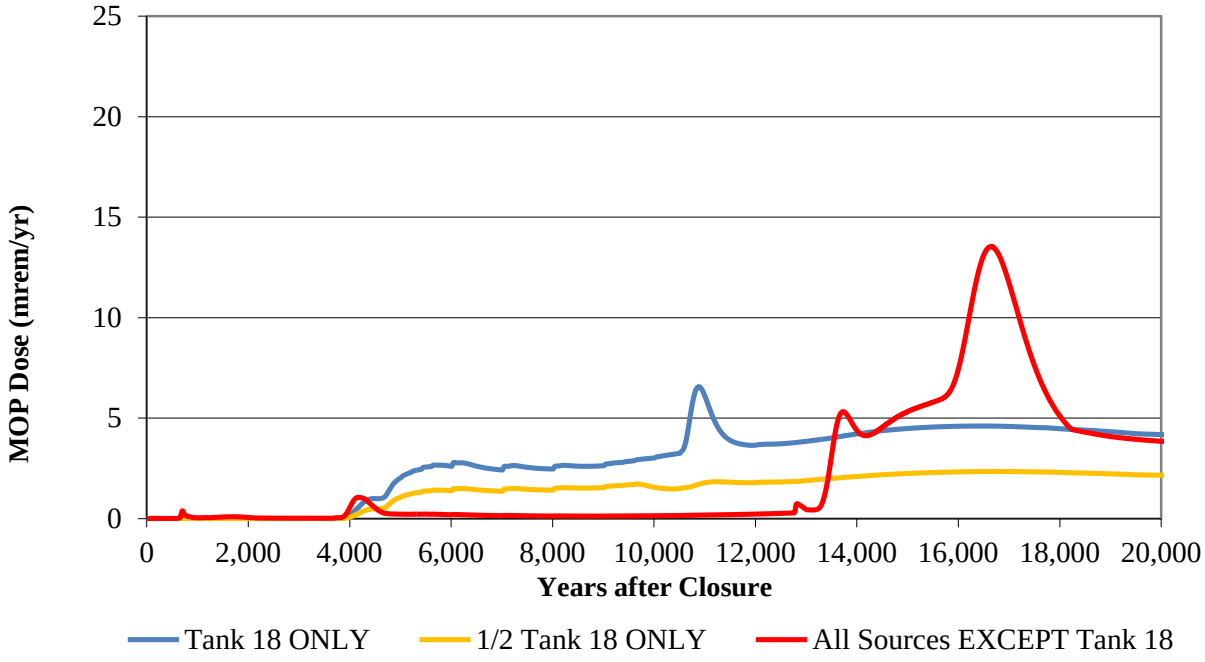


Figure 6.3-26: 100-Meter MOP Peak Groundwater Pathway Dose within 100,000 Years for Tank 18 Only (Tank 18 Base Case and One-half Inventory)

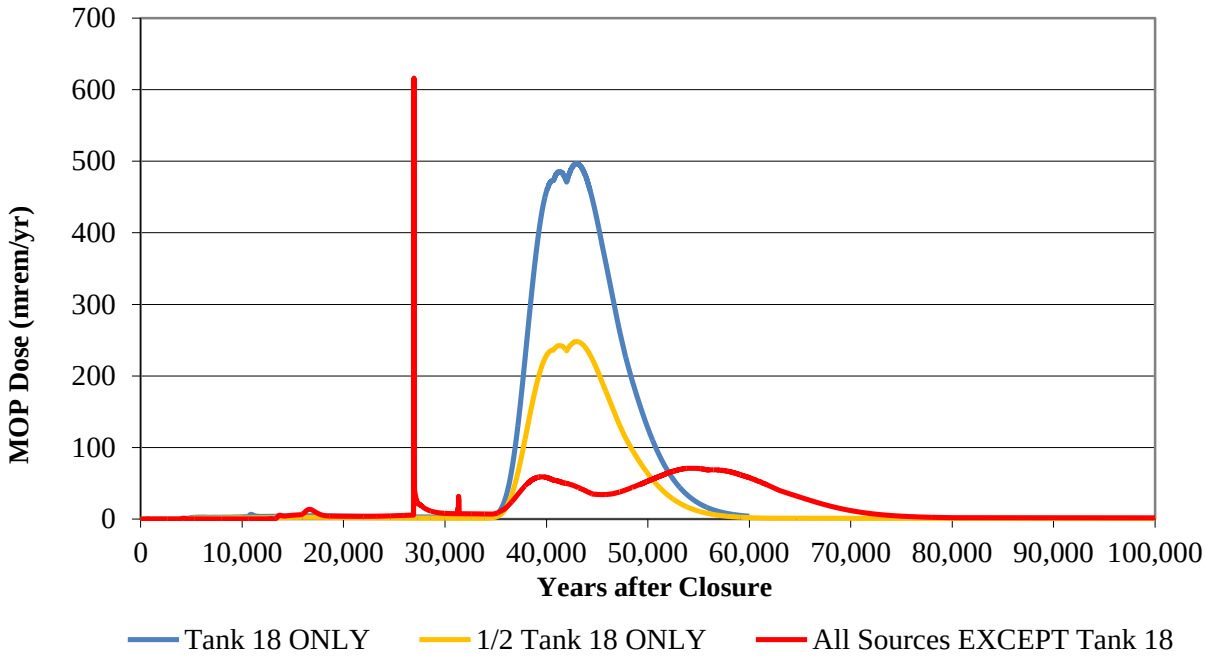


Figure 6.3-27: Seepline Peak Groundwater Pathway Dose within 100,000 Years from Tank 18 Only

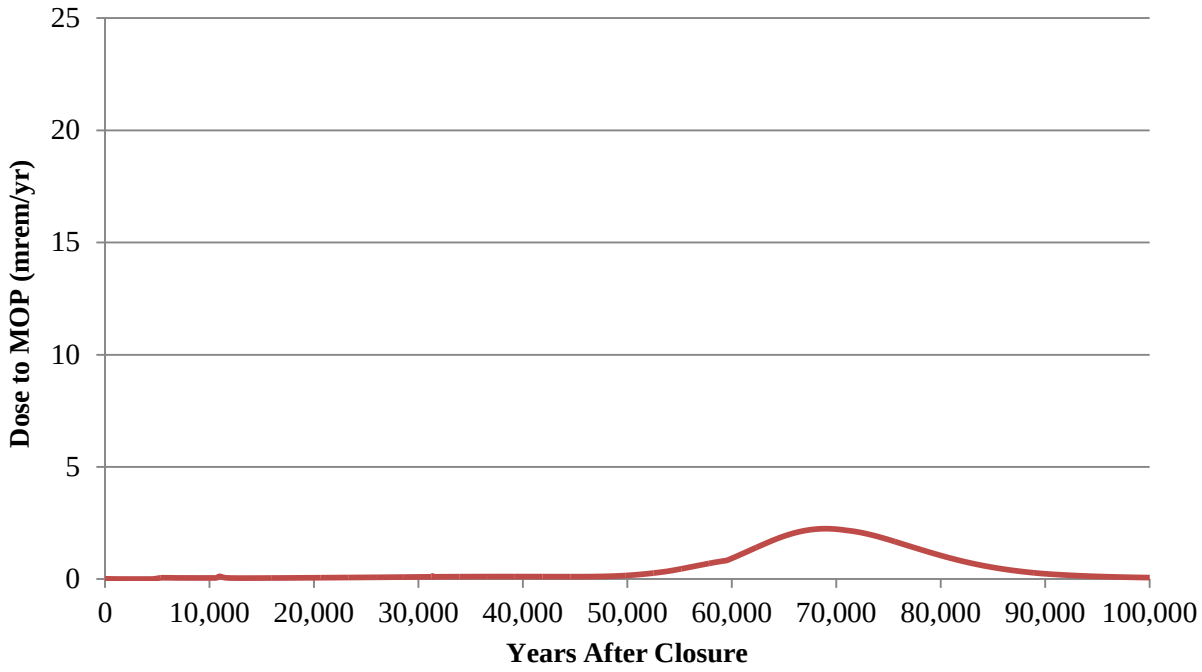


Figure 6.3-28: Seepline Peak Groundwater Pathway Dose within 20,000 Years from All Sources and from Tank 18 Only

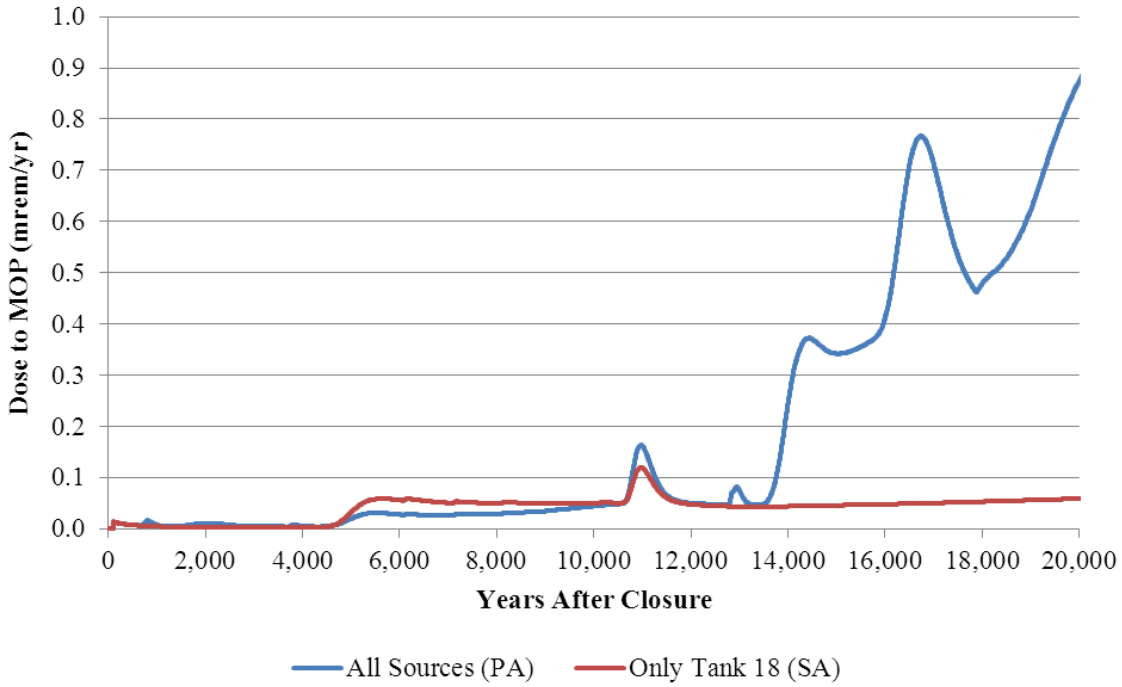
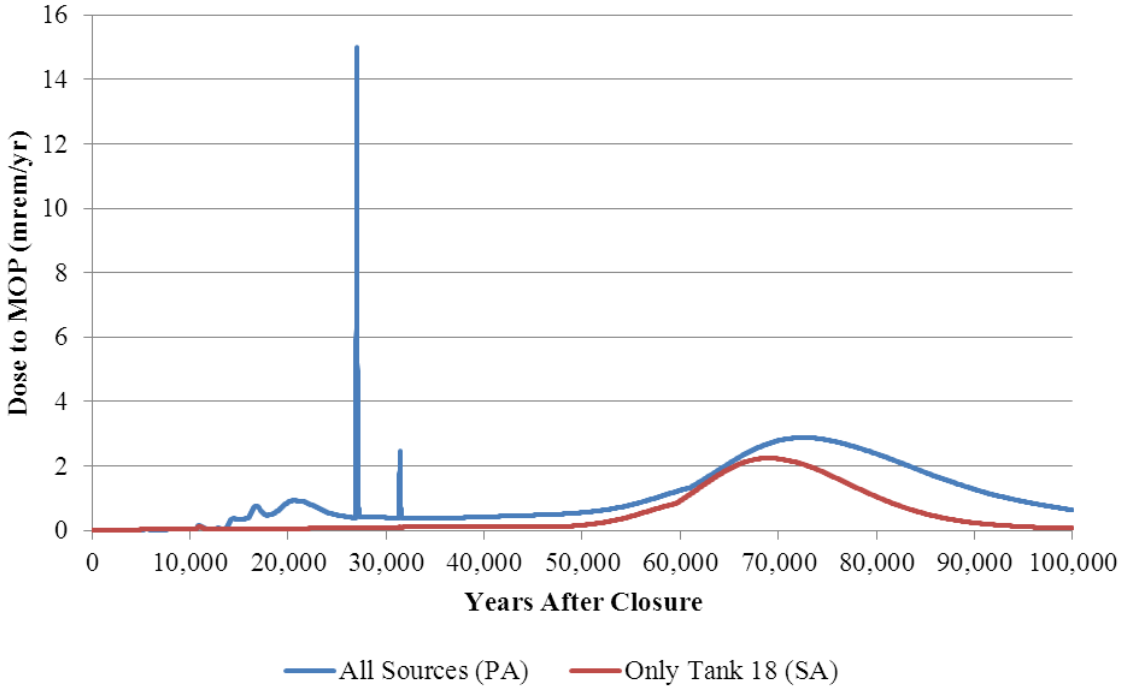


Figure 6.3-29: Seepline Peak Groundwater Pathway Dose within 100,000 Years from All Sources and from Tank 18 Only



6.3.6.3 Deterministic Model Composite Sensitivity Analyses

As discussed in Section 6.3.5.3, the FTF PA Base Case models Pu-239 conservatively with respect to both solubility and sandy soil K_d values. To evaluate the impact of uncertainty surrounding Pu-239 solubility and sandy soil K_d values simultaneously, several new PORFLOW sensitivity analyses were performed substituting variable Pu-239 solubility and Pu-239 sandy soil K_d values into the FTF PA Base Case. Values of 650 mL/g and 1,300 mL/g were used for the plutonium soil sorption coefficients in sandy soil in the new sensitivity studies, with 650 mL/g used for Region III conditions and 1,300 mL/g is used for Region II conditions. These values are based on a combination of the FTF soil conditions (considering current SRS lysimeter testing and literature reviews (SRNL-STI-2011-00672) and the fact that high pH leachate exiting the waste tank will cause increased adsorption (a factor of two per SRNL-STI-2009-00473). With respect to waste release modeling, the sensitivity studies incorporated the new data. This new waste release modeling information was used to develop the Alternative Sensitivity Case K plutonium solubility limits under various conditions.

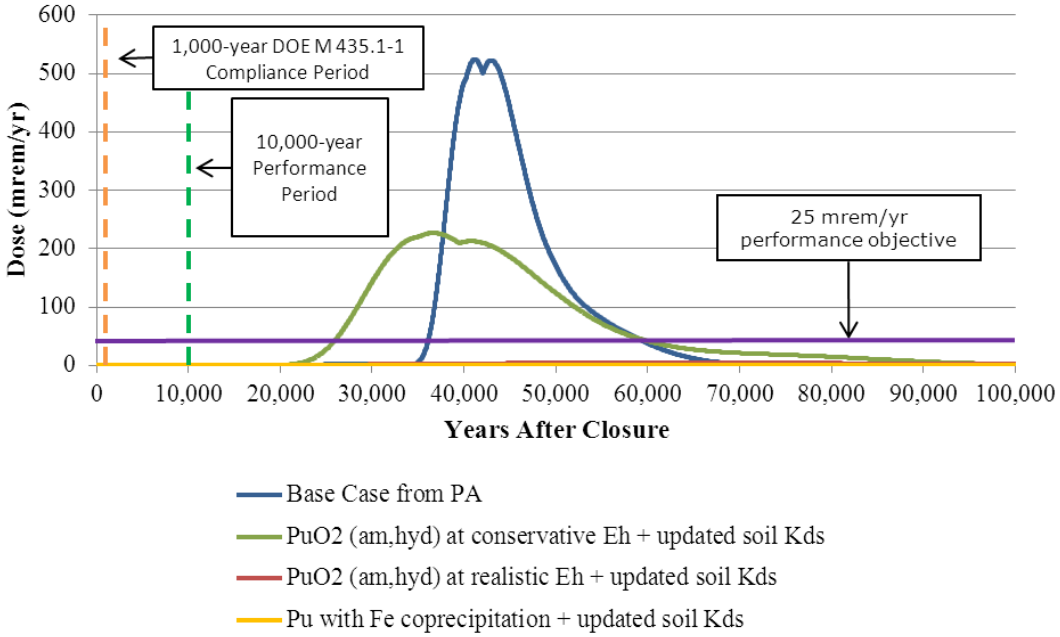
The new data from Tables 6.3-10 and 6.3-11 was used to run three different sensitivity studies, for comparison to the FTF PA Base Case:

1) $PuO_{2(am,hyd)}$ at a "conservative E_h" with updated sandy soil K_d values
2) $PuO_{2(am,hyd)}$ at a "realistic E_h" with updated sandy soil K_d values
3) Co-precipitated plutonium with updated sandy soil K_d values

Two of these sensitivity studies utilized amorphous $PuO_2 \cdot xH_2O_{(am)}$ as the solubility controlling phase for plutonium, as recommended by the expert panel (LA-UR-12-00079) and discussed in detail in the new plutonium solubility analyses (SRNL-STI-2012-00106, SRNL-STI-2012-00087). Because waste tank pore water characteristics (e.g., E_h) changing over time could impact the plutonium solubility values, E_h variability was considered when determining the $PuO_{2(am,hyd)}$ solubilities over time, with both realistic and "conservative" waste tank conditions evaluated. The methodology behind determining the "realistic" and "conservative" E_h is described in Section 6.3.5.3.5. [SRNL-STI-2012-00087]

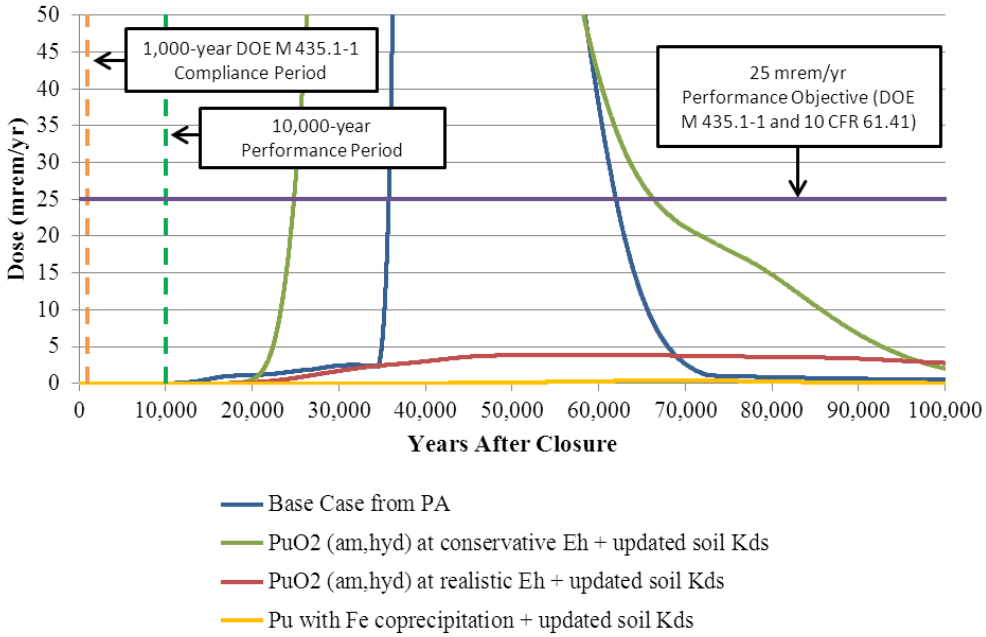
As shown in Figures 6.3-30 and 6.3-31, doses associated with Pu-239 can be expected to occur later than currently reflected in the FTF PA Base Case deterministic model as additional conservatisms are removed. These figures highlight the fact that the peak dose associated with Pu-239 occurs well beyond the 10,000-year performance period for all of the Special Analysis Base Case sensitivity studies performed, and in most cases, the peak dose occurs much later, and is significantly attenuated, when compared to FTF modeling Base Case results. These sensitivity analyses confirm the uncertainty surrounding the doses associated with Tank 18 Pu-239 can be bound, and that waste release experiments to increase support for key modeling assumptions related to Pu-239 waste release, are not required in the short term in order to provided reasonable assurance that the peak doses associated with Tank 18 Pu-239 will not move forward in time into the 10,000-year performance period. While there is uncertainty around the peak dose associated with the residual Pu-239 in Tank 18, the timing associated with the Pu-239 peak dose is understood and under both expected and reasonably bounding conditions there is reasonable assurance that the Pu-239 peak dose will not move forward into the 10,000-year performance period. While the testing in this area might be useful in better defining the precise timing of the peak doses associated with Tank 18 Pu-239, these tests are not required to provide reasonable assurance that the peak dose associated with Pu-239 will not occur within the 10,000-year performance period.

Figure 6.3-30: Composite Sensitivity Study of 100-Meter Peak All Pathways Dose Pu-239 within 100,000 Years for Sector E – All Waste Tanks



Note: Modeling cases defined in Section 6.3.6.3

Figure 6.3-31: Composite Sensitivity Study of 100-Meter Peak All Pathways Pu-239 Dose within 100,000 Years for Sector E – All Waste Tanks (Expanded View)



6.3.6.4 Probabilistic Model Sensitivity Analysis

The Tanks 18 and 19 inventory distributions used in the probabilistic model have been revised to reflect the inventory uncertainty associated with the actual inventory information at operational closure (SRR-CWDA-2010-00117, SRR-CWDA-2010-00118), as shown in the Revised Inventory Multipliers table (Table 6.3-19). A new probabilistic uncertainty analysis has been performed (using the GoldSim FTF model version "SRS FTF v2.5") to assess the impact of the revised Tanks 18 and 19 inventory distributions (with the revised inventories and inventory distributions being the only change to the GoldSim FTF model from the FTF PA). Statistical data associated with the SRS FTF v2.5 probabilistic peak dose results for 1,000 All Cases realizations is shown in Figure 6.3-32 (10,000 years linear scale), Figure 6.3-33 (10,000 years log scale), Figure 6.3-34 (100,000 years linear scale), and Figure 6.3-35 (100,000 years log scale).

Table 6.3-19: Revised Inventory Multipliers

Isotope	FTF PA Tank 18		Revised for Special Analysis Tank 18		FTF PA Tank 19		Revised for Special Analysis Tank 19	
	Uniform Distribution		Normal Distribution		Uniform Distribution		Normal Distribution	
	Min	Max	Average	Standard Deviation	Min	Max	Average	Standard Deviation
Ac-227	0.01	1	1	0.5	0.01	1	1	0.5
Al-26	0.01	1	1	0.5	0.01	1	1	0.5
Am-241	0.5	2	0.68	0.22	0.5	2	0.81	0.31
Am-242m	0.01	1	0.45	0.29	0.01	1	1	0.5
Am-243	0.01	1	0.56	0.38	0.01	1	0.77	0.35
C-14	0.01	1	0.69	0.44	0.01	1	0.71	0.44
Cf-249	0.01	1	1	0.5	0.01	1	1	0.5
Cl-36	0.01	1	1	0.5	0.01	1	1	0.5
Cm-243	0.01	1	1	0.5	0.01	1	1	0.5
Cm-244	0.5	2	0.74	0.51	0.01	1	0.84	0.32
Cm-245	0.01	1	1	0.5	0.01	1	1	0.5
Cm-247	0.01	1	1	0.5	0.01	1	1	0.5
Cm-248	0.01	1	1	0.5	0.01	1	1	0.5
Co-60	0.01	1	0.60	0.17	0.01	1	0.89	0.23
Cs-135	0.01	1	0.79	0.28	0.01	1	0.93	0.32
Cs-137	0.5	2	0.63	0.17	0.5	2	0.95	0.22
Eu-152	0.01	1	1	0.5	0.01	1	1	0.5
Eu-154	0.5	2	0.94	0.21	0.01	1	0.88	0.29
H-3	0.01	1	1	0.5	0.01	1	1	0.5
I-129	0.01	1	0.84	0.25	0.01	1	0.41	0.22
K-40	0.01	1	0.87	0.21	0.01	1	1	0.5
Nb-93m	0.01	1	1	0.5	0.01	1	1	0.5
Nb-94	0.01	1	1	0.5	0.01	1	1	0.5
Ni-59	0.01	1	0.71	0.26	0.01	1	1	0.5
Ni-63	0.5	2	0.82	0.27	0.01	1	1	0.5
Np-237	0.5	2	0.64	0.25	0.01	1	0.92	0.21
Pa-231	0.01	1	0.24	0.14	0.01	1	1	0.5
Pd-107	0.01	1	0.79	0.30	0.01	1	1	0.5
Pu-238	0.5	2	0.40	0.19	0.5	2	0.96	0.23
Pu-239	0.5	2	0.72	0.27	0.5	2	0.90	0.25

Table 6.3-19: Revised Inventory Multipliers (Continued)

Isotope	FTF PA Tank 18		Revised for Special Analysis Tank 18		FTF PA Tank 19		Revised for Special Analysis Tank 19	
	Uniform Distribution		Normal Distribution		Uniform Distribution		Normal Distribution	
	Min	Max	Average	Standard Deviation	Min	Max	Average	Standard Deviation
Pu-240	0.5	2	0.71	0.26	0.5	2	0.88	0.26
Pu-241	0.5	2	0.67	0.18	0.5	2	0.93	0.25
Pu-242	0.01	1	1	0.5	0.01	1	1	0.5
Pu-244	0.01	1	1	0.5	0.01	1	1	0.5
Ra-226	0.01	1	1	0.5	0.01	1	1	0.5
Se-79	0.01	1	1	0.5	0.01	1	1	0.5
Sm-151	0.5	2	0.84	0.25	0.01	1	0.91	0.23
Sn-126	0.01	1	0.92	0.20	0.01	1	0.99	0.23
Sr-90	0.5	2	0.60	0.15	0.5	2	0.78	0.35
Tc-99	0.01	1	0.87	0.23	0.5	2	0.87	0.26
Th-229	0.01	1	0.66	0.35	0.01	1	0.65	0.26
Th-230	0.01	1	0.68	0.37	0.01	1	0.59	0.16
U-232	0.01	1	0.70	0.38	0.01	1	0.88	0.26
U-233	0.01	1	0.75	0.16	0.01	1	0.94	0.23
U-234	0.5	2	0.81	0.36	0.5	2	0.92	0.23
U-235	0.01	1	0.68	0.38	0.01	1	0.90	0.23
U-236	0.01	1	0.74	0.29	0.01	1	0.94	0.23
U-238	0.01	1	0.68	0.39	0.01	1	0.93	0.22
Zr-93	0.01	1	0.66	0.36	0.01	1	0.73	0.40

Figure 6.3-32: FTF Special Analysis (Tanks 18 & 19) "All Cases" Probabilistic Results (10,000 yr) Linear Scale

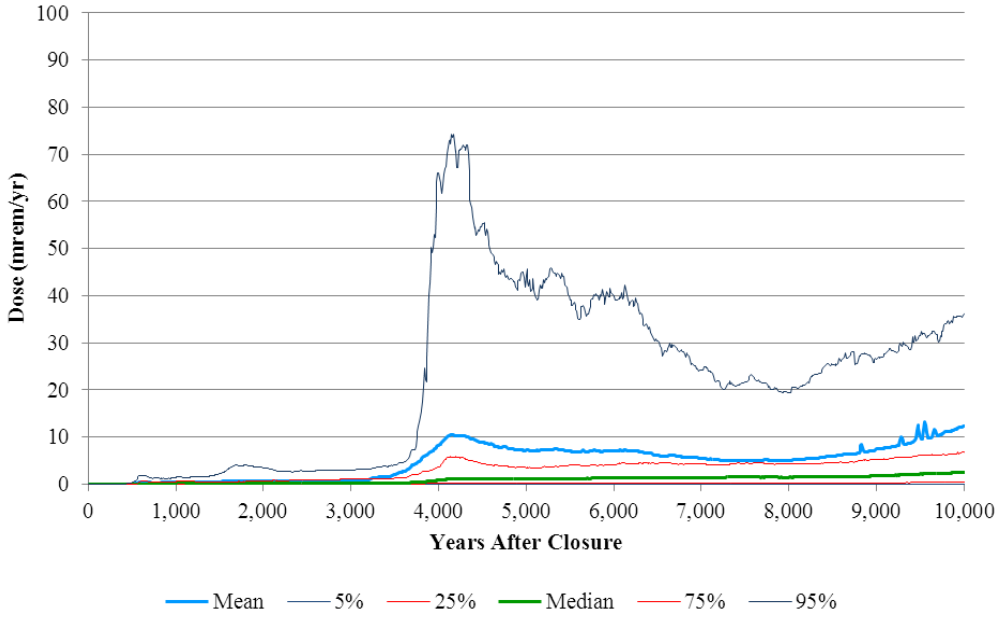


Figure 6.3-33: FTF Special Analysis (Tanks 18 & 19) "All Cases" Probabilistic Results (10,000 yr) Log Scale

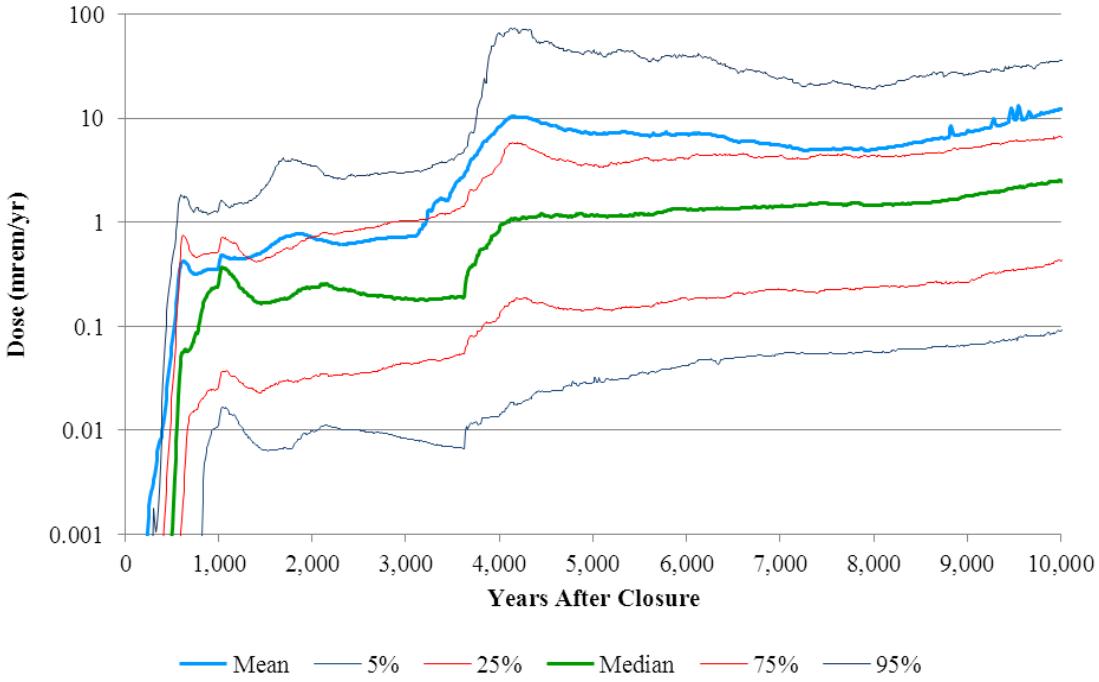


Figure 6.3-34: FTF Special Analysis (Tank 18 & 19) "All Cases" Probabilistic Results (100,000 yr) Linear Scale

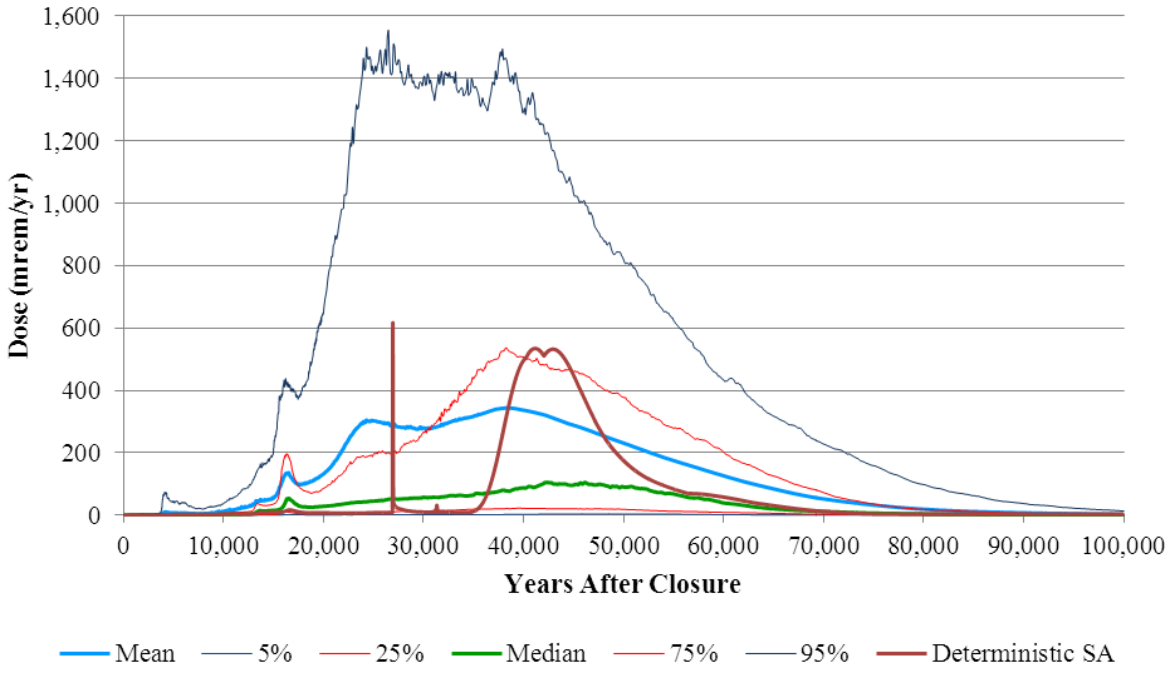
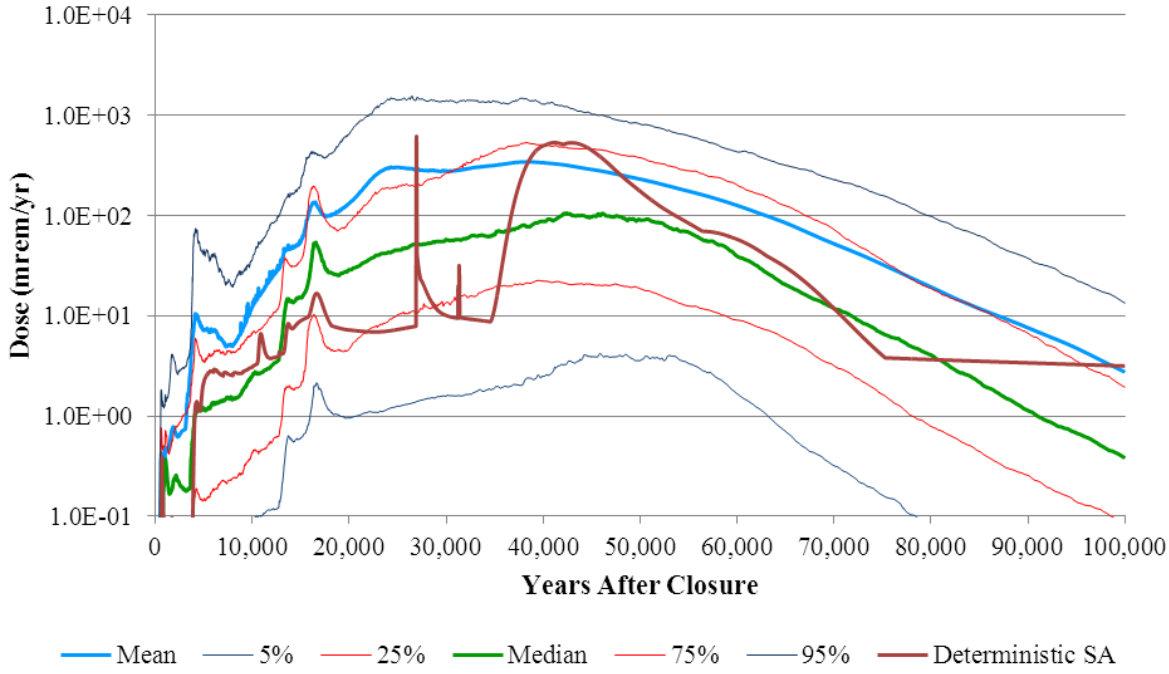


Figure 6.3-35: FTF Special Analysis (Tank 18 & 19) "All Cases" Probabilistic Results (100,000 yr) Log Scale



The probabilistic peak dose results (using "SRS FTF v2.5") for the 1,000 Case A (Base Case) realizations in 10,000 years showed the peak of the means to be 4 mrem/yr and the 95th percentile of the doses to be 35 mrem/yr. The probabilistic peak dose results for 1,000 All Cases realizations showed the 95th percentile of the peak dose in 10,000 years to be 74 mrem/yr (vs 77 mrem/yr in the FTF PA). The All Cases peak of the means in 10,000 years was 13 mrem/yr. The fact that the 95th percentile value is lower than calculated previously is not unexpected, since many of the reasonably conservative stochastic inventory distributions used in the FTF PA, Rev, 1 were tightened (as shown in Table 6.3-19) when the actual waste tank residual characterization data was utilized. The All Cases GoldSim FTF Special Analysis model utilizes all six waste tank configurations postulated in FTF PA, and therefore addresses a wider range of scenarios than is covered by the FTF PA Base Case model.

An additional probabilistic uncertainty analysis has been performed (using the GoldSim FTF model version "SRS FTF v2.6") to assess the impact of new modeling information associated with Pu-239 in conjunction with the revised Tanks 18 and 19 inventory distributions. The changes made in "SRS FTF v2.6" reflect the new plutonium solubility and sandy soil K_d data discussed previously in Section 6.3.6.3 of this Special Analysis (Deterministic Model Composite Sensitivity Analysis) and are documented in *Tank 18 Plutonium Enhanced Probabilistic Analysis - GoldSim FTF Version 2.6* (SRR-CWDA-2012-00019).

Statistical data associated with the probabilistic peak dose results for 1,000 "SRS FTF v2.6" realizations is shown in Figure 6.3-36 (10,000 years linear scale), Figure 6.3-37 (10,000 years log scale), Figure 6.3-38 (100,000 years linear scale), and Figure 6.3-39 (100,000 years log scale). Table 6.3-20 presents a comparison of the dose results generated using the GoldSim "SRS FTF v2.5" and "SRS FTF v2.6" models. Peak of the mean values for the 10,000-year performance period and a 100,000-year period are presented for comparison. Peak of the mean values were chosen as a metric because they represent the peak of the expected value of dose (over time) and are the same metric as used to determine compliance associated with the Yucca Mountain PA (MDL-WIS-PA-000005). As can be seen in the figures presented, the revised probabilistic results ("SRS FTF v2.6") show that the plutonium related changes have a general trend that moderately reduces the annual doses over both the 10,000 and 100,000-year periods. This trend is also reflected in the peak of the mean results over time (Table 6.3-20), where the peak value for "SRS FTF v2.5" is 13 mrem/yr and the peak value for "SRS FTF v2.6" is only 9 mrem/yr.

Table 6.3-20: Comparison of Peak of the Mean Values from Annual Dose Curves Generated Using GoldSim FTF Model Versions 2.5 and 2.6

FTF SRS GoldSim Model Version	Peak of the Mean over 10,000 years (mrem/yr)	Peak of the Mean over 100,000 years (mrem/yr)
Version 2.5	13	344
Version 2.6	9	108

Figure 6.3-36: FTF Special Analysis (Tanks 18 & 19) "v2.6" Probabilistic Results (10,000 yr) Linear Scale

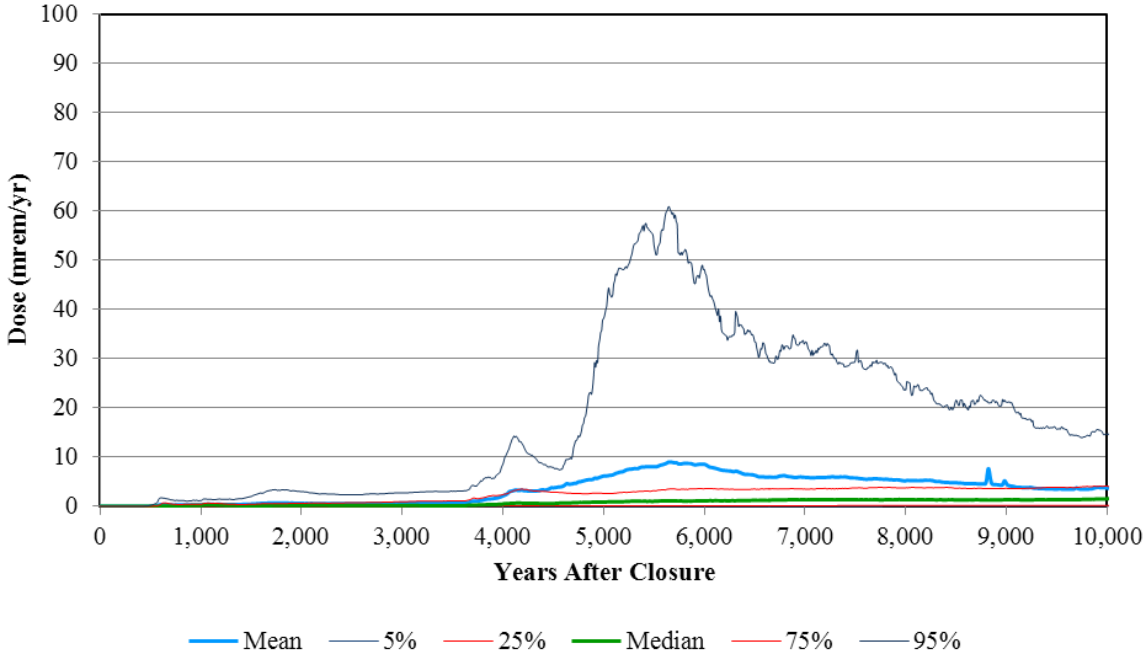


Figure 6.3-37: FTF Special Analysis (Tanks 18 & 19) "v2.6" Probabilistic Results (10,000 yr) Log Scale

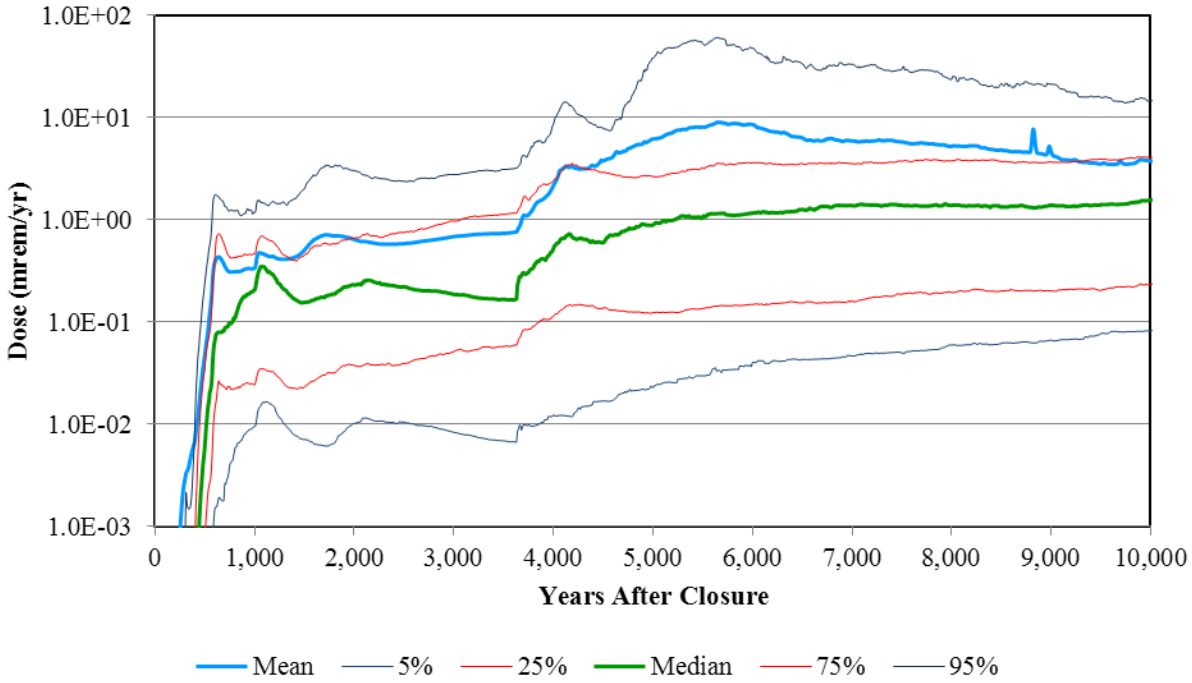


Figure 6.3-38: FTF Special Analysis (Tanks 18 & 19) "v2.6" Probabilistic Results (100,000 yr) Linear Scale

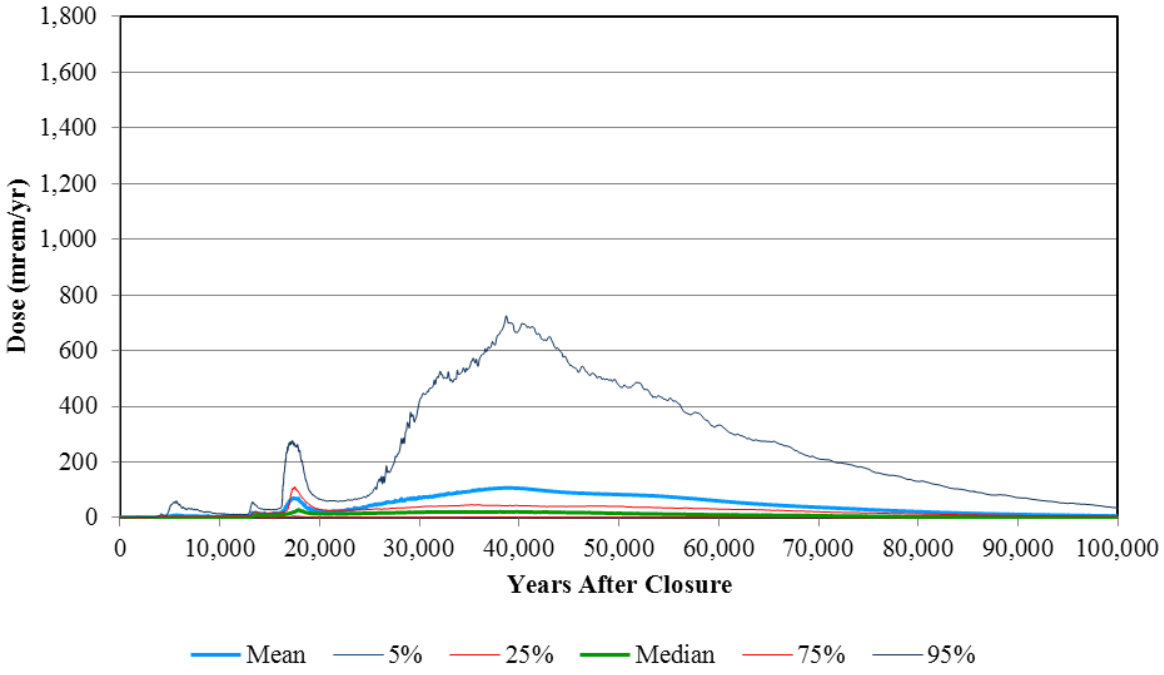
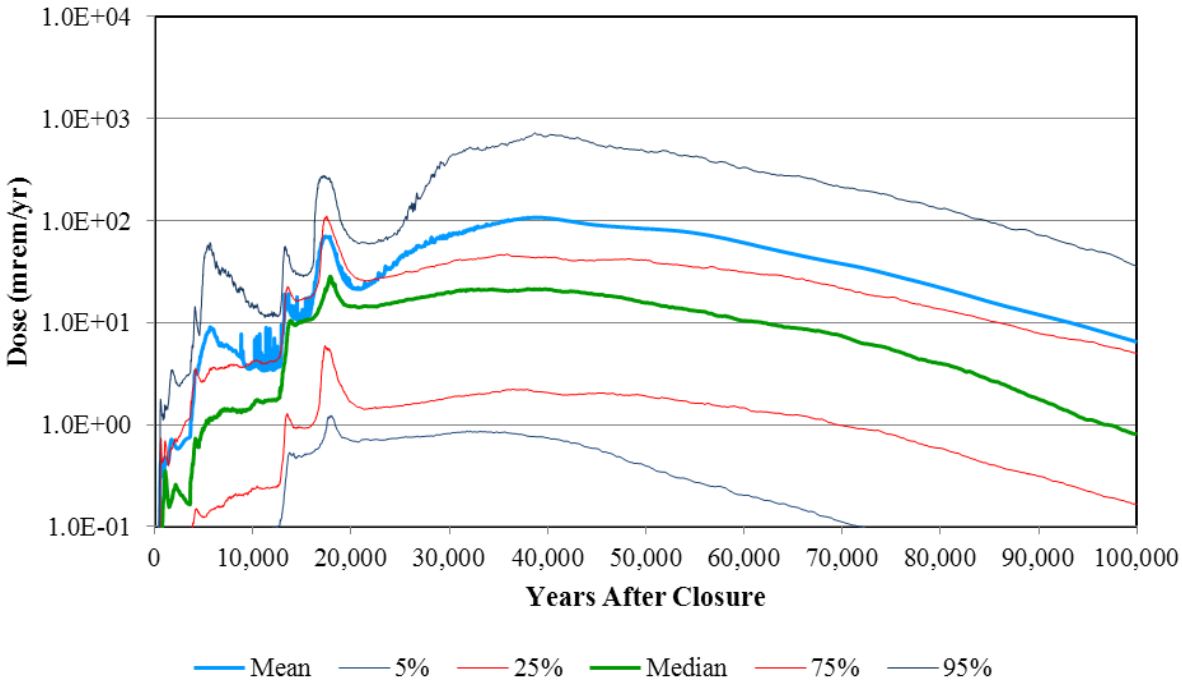


Figure 6.3-39: FTF Special Analysis (Tanks 18 & 19) "v2.6" Probabilistic Results (100,000 yr) Log Scale



The other modeling parameters described in the FTF PA Section 5.6.3 are unaffected by the residual inventories at operational closure. The uncertainty and sensitivity analyses results described in the remainder of FTF PA Section 5.6 (i.e., probabilistic uncertainty and sensitivity analyses results in Sections 5.6.4 through 5.6.6 and deterministic sensitivity analyses results in Section 5.6.7 of this Special Analysis) remain valid irrespective of the revised Tanks 18 and 19 residual inventories and do not require further analysis.

The uncertainty and sensitivity analyses evaluates the response of the FTF models to changes such as inventory variability (inventory sensitivity analysis using the PORFLOW Deterministic Model, Section 5.6.7.1 of FTF PA) and barrier degradation (barrier analyses using the PORFLOW Deterministic Model, Section 5.6.7.3 of FTF PA). The waste-tank inventory sensitivity analysis in FTF PA Section 5.6.7.1 used the PORFLOW FTF PA Base Case modeling, and increased and decreased the waste tank inventories. For Tanks 18 and 19 analyses, the FTF PA Base Case modeling inventory was first increased by 1.5 times and then decreased by 0.5 times. The barrier analysis was carried out using the PORFLOW FTF PA model for 15 different cases for three waste tanks (Tanks 5, 18, and 33, representing each tank type) using the FTF PA Base Case inventories. The sensitivity analyses such as the inventory sensitivity analysis and the barrier analyses provide insight into the relative importance of various parameters of concern without regard to the absolute dose.

The impact of inventory variability on the peak dose was further evaluated in this Special Analysis by performing single parameter sensitivity analyses using the GoldSim FTF modeling (a discussion of the GoldSim FTF modeling and the individual parameters modeled in the GoldSim FTF modeling is provided in FTF PA). A baseline peak dose was determined with the actual Tanks 18 and 19 inventories at operational closure using the GoldSim FTF modeling ("SRS FTF v2.5") in deterministic mode utilizing the SRS FTF modeling Base Case input parameters. To assess the impact of inventory variability the peak dose was recalculated using higher and lower inventory projections. The lower inventory was set at 50 % of the actual Tanks 18 and 19 inventories at operational closure. The higher inventory was set by using the reasonably conservative uncertainty values for Tanks 18 and 19 inventories at operational closure from the waste characterization reports (SRR-CWDA-2010-00117 and SRR-CWDA-2010-00118). The lower inventory peak dose is 55 % of the baseline peak dose in 10,000 years and is 92 % of the baseline peak dose in 20,000 years. The higher (e.g., reasonably conservative) inventory peak dose is 107 % of the baseline peak dose in both 10,000 and 20,000 years.

It should be noted that the GoldSim baseline peak dose typically differs slightly from the PORFLOW FTF model peak dose due to the inherent differences between the models (discussed in the benchmarking section of FTF PA). However, magnitude and timing of the peak doses are similar such that valid sensitivity trends can be analyzed using only the GoldSim FTF model in deterministic mode.

6.3.7 RCRA/CERCLA Risk Analysis

Section 5.7 (RCRA/CERCLA Risk Analysis) of FTF PA contains the RCRA/CERCLA risk assessment for the FTF final facility closure, following the current Area Completion Project protocols for human health and ecological risk assessments. The FTF Contaminant Migration Constituents of Concern (CMCOC) were identified through a system that is consistent with both the Area Completion Project protocols and FTF PA. The CMCOC were identified by modeling the release of contaminants and their travel through the vadose zone. The concentrations of contaminants that are modeled to reach the water table are compared to MCL, RSLs, PRGs, or other appropriate standards in cases where the constituent does not have an MCL. Any constituents that are predicted to exceed these standards (i.e., fraction greater than 1.0) in the groundwater directly beneath FTF (1 meter from boundary) are identified as CMCOC as shown in Tables 6.3-21 and 6.3-22, which reflects concentrations calculated using the Tanks 18 and 19 residual inventories at operational closure (i.e., updated from FTF PA). The CMCOC identified using the described protocols are: C-14, K-40, Nb-93m, Np-237, Pa-231, Pd-107, Pu-239, Pu-240, Ra-226 + Ra-228, Tc-99, Th-229, Th-230, U-233, U-234, U-236, cadmium, and manganese.

Table 6.3-21: Groundwater Radionuclide Concentrations at 1 Meter from FTF[(a)]

Radionuclide	MCL (pCi/L)	Residential Tap Water PRG** (pCi/L)	Peak Concentration (pCi/L) 1 to 10,000 Years	Fraction of MCL or PRG at 1 meter
Ac-227	N/A	2.4E-01	3.4E-03	1.4E-02
Al-26	N/A	2.8E+00	2.2E-06	7.9E-07
Am-241	N/A	4.6E-01	6.1E-04	1.3E-03
Am-242m	N/A	6.7E-01	2.9E-21	4.3E-21
Am-243	N/A	4.6E-01	7.0E-02	1.5E-01
Ba-137m*	N/A	Cs-137 daughter	b	N/A
Bk-249	N/A	4.3E+01	b	N/A
C-14	2.0E+03	MCL used***	3.5E+03	1.8E+00
Ce-144	N/A	1.4E+00	b	N/A
Cf-249	N/A	3.8E-01	1.0E-12	2.6E-12
Cl-36	7.0E+02	MCL used***	1.3E+00	1.9E-03
Cm-242	N/A	1.2E+00	b	N/A
Cm-243	N/A	5.0E-01	b	N/A
Cm-244	N/A	5.7E-01	b	N/A
Cm-245	N/A	4.6E-01	5.2E-04	1.1E-03
Cm-247	N/A	4.8E-01	5.1E-07	1.1E-06
Cm-248	N/A	5.0E-03	2.2E-05	4.4E-03
Co-60	1.0E+02	MCL used***	b	N/A
Cs-134	N/A	1.1E+00	b	N/A
Cs-135	9.0E+02	MCL used***	3.0E+01	3.3E-02
Cs-137	2.0E+02	MCL used***	2.0E-11	1.0E-13
Eu-152	2.0E+02	MCL used***	b	N/A
Eu-154	6.0E+01	MCL used***	b	N/A
Eu-155	6.0E+02	2.5E+01	b	N/A
Gd-152	N/A	1.6E+00	b	N/A
H-3	2.0E+04	MCL used	1.9E-08	9.5E-13
I-129	1.0E+00	MCL used***	4.6E-01	4.6E-01
K-40	N/A	1.9E+00	2.9E+01	1.5E+01
Mo-93m	N/A	1.5E+02	b	N/A
Na-22	N/A	5.0E+00	b	N/A
Nb-93m	1.0E+03	MCL used***	1.1E+03	1.1E+00
Nb-94	N/A	6.1E+00	2.0E+00	3.3E-01
Ni-59	N/A	1.7E+02	7.7E+01	4.5E-01
Ni-63	N/A	7.1E+01	2.5E-01	3.5E-03
Np-237	N/A	7.7E-01	1.7E+01	2.2E+01
Pa-231	N/A	2.8E-01	4.6E+00	1.6E+01
Pb-210	N/A	5.4E+02	3.8E-02	7.0E-05
Pd-107	N/A	1.9E+02	2.9E+02	1.5E+00
Pm-147	N/A	2.8E+01	b	N/A

Table 6.3-21: Groundwater Radionuclide Concentrations at 1 Meter from FTF (Continued)

Radionuclide	MCL (pCi/L)	Residential Tap Water PRG** (pCi/L)	Peak Concentration (pCi/L) 1 to 10,000 Years	Fraction of MCL or PRG at 1m
Pr-144	N/A	5.9E+02	b	N/A
Pu-238	N/A	3.6E-01	5.1E-18	1.4E-17
Pu-239	N/A	3.5E-01	5.2E+00	1.5E+01
Pu-240	N/A	3.5E-01	4.0E+00	1.1E+01
Pu-241	N/A	2.7E+01	2.3E-03	8.5E-05
Pu-242	N/A	3.7E-01	8.8E-02	2.4E-01
Pu-244	N/A	3.5E-01	1.5E-04	4.3E-04
Ra-226 + Ra-228	5.0E+00	MCL used	1.5E+01	3.0E+00
Ra-228	N/A	4.6E-02	1.3E-05	2.8E-04
Rh-106*	N/A	Ru-106 daughter	b	N/A
Ru-106 + D	N/A	1.1E+00	b	N/A
Sb-125	N/A	1.1E+01	b	N/A
Sb-126	N/A	4.3E+00	b	N/A
Sb-126m	N/A	7.2E+02	b	N/A
Se-79	N/A	6.5E+00	2.9E-01	4.5E-02
Sm-147	N/A	1.3E+00	b	N/A
Sm-151	1.0E+03	MCL used	1.0E-24	1.0E-27
Sn-126	N/A	1.9E+00	5.0E-04	2.6E-04
Sr-90	8.0E+00	MCL used	4.0E-05	5.0E-06
Tc-99	9.0E+02	MCL used	1.1E+03	1.2E+00
Te-125m	N/A	1.4E+01	b	N/A
Th-228	N/A	4.5E-01	1.3E-05	2.9E-05
Th-229	N/A	2.1E-01	2.9E-01	1.4E+00
Th-230	N/A	5.2E-01	6.4E-01	1.2E+00
Th-232	N/A	4.7E-01	4.9E-08	1.0E-07
U-232	N/A	1.6E-01	1.3E-19	8.1E-19
U-233	N/A	6.6E-01	4.7E+00	7.1E+00
U-234	N/A	6.7E-01	9.5E+01	1.4E+02
U-235	N/A	6.8E-01	9.8E-02	1.4E-01
U-236	N/A	7.1E-01	1.7E+00	2.4E+00
U-238	N/A	7.4E-01	2.5E-02	3.4E-02
Y-90*	N/A	2.6E+00	b	N/A
Zr-93	2.0E+03	MCL used***	2.7E-02	1.4E-05

(a) = CMCOC are shaded gray in the table.
* = Daughters are assumed to be in equilibrium with the parent nuclide.
** = Residential tap water PRGs are calculated at http://epa-prgs.ornl.gov/radionuclides/, based on a target cancer risk of 1.0E-06.
*** = MCL values for beta and photon emitters are calculated in Table II-3 of FR-00-9654 based on a beta-gamma dose of 4 mrem/yr.
N/A = Not Available
(b) = Values < 1.0E-30

Table 6.3-22: Groundwater Chemical Concentrations at 1 Meter from FTF

Chemical	MCL (µg/L)	Tap Water RSLs* (µg/L)	Peak Concentration (µg/L) 1 to10,000 Yrs	Fraction of MCL or RSL at 1 meter
Ag	N/A	7.1E+01	5.1E+00	7.2E-02
As	1.0E+01	MCL used	1.5E-02	1.5E-03
Ba	2.0E+03	MCL used	1.6E+00	7.9E-04
Cd	5.0E+00	MCL used	1.7E+01	3.5E+00
Total Chromium	1.0E+02	MCL used	2.8E+00	2.8E-02
Cu	1.0E+03	MCL used	2.9E+00	2.9E-03
F	2.0E+03	MCL used	3.6E+01	1.8E-02
Fe	3.0E+02	MCL used	2.1E+02	7.1E-01
Hg	2.0E+00	MCL used	6.9E-02	3.5E-02
Mn	5.0E+01	MCL used	2.5E+02	4.9E+00
Ni	N/A	3.0E+02	4.0E+00	1.3E-02
$NO_2 + NO_3$	1.0E+04	MCL used	5.3E+02	5.3E-02
Pb	1.5E+01	MCL used	5.5E-03	3.6E-04
Sb	6.0E+00	MCL used	2.7E-05	4.4E-06
Se	5.0E+01	MCL used	2.1E-04	4.3E-06
U	3.0E+01	MCL used	1.4E-01	4.8E-03
Zn	5.0E+03	MCL used	2.9E+00	5.9E-04

* = RSLs are obtained February 22, 2012 at: http://www.epa.gov/region9/superfund/prg/ (EPA_RSL Tbl_11-2011) based on a target cancer risk of 1.0E-06.
N/A = Not Available

6.3.7.1 Carbon-14

Carbon-14 has a peak concentration of 3,500 pCi/L at 1 meter compared to the MCL of 2,000 pCi/L. This peak concentration occurs approximately 4,016 years following FTF final facility closure. As shown in Table 6.3-23, the peak concentration drops to 780 pCi/L at 100 meters, that is below the MCL value.

6.3.7.2 Potassium-40

Potassium-40 does not have an MCL so the peak concentration of 29.0 pCi/L at 1 meter is compared to the calculated PRG of 1.9 pCi/L. This peak concentration occurs approximately 3,924 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 4.5 pCi/L at 100 meters and drops to a peak concentration of 5.2E-02 pCi/L at the seepline, this is below the PRG value.

6.3.7.3 Niobium-93m

Niobium-93m has a peak concentration of 1,100 pCi/L at 1 meter compared to the MCL of 1,000 pCi/L. This peak concentration occurs approximately 10,000 years following FTF final facility closure. As shown in Table 6.3-23, the peak concentration drops to 190 pCi/L at 100 meters, that is below the MCL value.

6.3.7.4 Neptunium-237

Neptunium-237 does not have an MCL so the peak concentration of 17 pCi/L at 1 meter is compared to the calculated PRG of 7.7E-01 pCi/L. This peak concentration occurs 6,034 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 3.7 pCi/L at 100 meters and drops to a peak concentration of 8.1E-02 pCi/L at the seepline, that is below the PRG value.

6.3.7.5 Protactinium-231

Protactinium-231 does not have an MCL so the peak concentration of 4.6 pCi/L at 1 meter is compared to the calculated PRG of 2.8E-01 pCi/L. This peak concentration occurs 6,038 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 9.6E-01 pCi/L at 100 meters and drops to a peak concentration of 2.1E-02 pCi/L at the seepline, which is below the PRG value.

6.3.7.6 Palladium-107

Palladium-107 does not have an MCL so the peak concentration of 290 pCi/L at 1 meter is compared to the calculated PRG of 190 pCi/L. This peak concentration occurs approximately 4,686 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 64 pCi/L at 100 meters, that is below the PRG value.

6.3.7.7 Plutonium-239

Plutonium-239 does not have an MCL so the peak concentration of 5.2 pCi/L at 1 meter is compared to the calculated PRG of 3.5E-01 pCi/L. This peak concentration occurs approximately 10,000 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 9.4E-03 pCi/L at 100 meters, that is below the PRG value.

6.3.7.8 Plutonium-240

Plutonium-240 does not have an MCL so the peak concentration of 4.0 pCi/L at 1 meter is compared to the calculated PRG of 3.5E-01 pCi/L. This peak concentration occurs approximately 10,000 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 1.0E-02 pCi/L at 100 meters, that is below the PRG value.

6.3.7.9 Radium-226 + Radium-228

Radium-226, combined with Radium-228, has a peak concentration of 15.0 pCi/L compared to the MCL of 5.0 pCi/L for total radium. This peak concentration occurs approximately 10,000 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 3.1 pCi/L at 100 meters, that is below the MCL value.

6.3.7.10 Technetium-99

Technetium-99 has a peak concentration of 1,100 pCi/L at 1 meter compared to the MCL of 900 pCi/L. This peak concentration occurs approximately 678 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 270 pCi/L at 100 meters, that is below the MCL value.

6.3.7.11 Thorium-229

Thorium-229 does not have an MCL so the peak concentration of 2.9E-01 pCi/L at 1 meter is compared to the calculated PRG of 2.1E-01 pCi/L. This peak concentration occurs approximately 10,000 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 5.5E-03 pCi/L at 100 meters, that is below the PRG value.

6.3.7.12 Thorium-230

Thorium-230 does not have an MCL so the peak concentration of 6.4E-01 pCi/L at 1 meter is compared to the calculated PRG of 5.2E-01 pCi/L. This peak concentration occurs approximately 10,000 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 1.0E-02 pCi/L at 100 meters, that is below the PRG value.

6.3.7.13 Uranium-233

Uranium-233 does not have an MCL so the peak concentration of 4.7 pCi/L at 1 meter is compared to the calculated PRG of 6.6E-01 pCi/L. This peak concentration occurs approximately 9,138 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 2.5E-01 pCi/L at 100 meters, that is below the PRG value.

6.3.7.14 Uranium-234

Uranium-234 does not have an MCL so the peak concentration of 95 pCi/L at 1 meter is compared to the calculated PRG of 6.7E-01 pCi/L. This peak concentration occurs approximately 9,122 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 4.6 pCi/L at 100 meters and drops to a peak concentration of 7.7E-10 pCi/L at the seepline, that is below the PRG value.

6.3.7.15 Uranium-236

Uranium-236 does not have an MCL so the peak concentration of 1.7 pCi/L at 1 meter is compared to the calculated PRG of 7.1E-01 pCi/L. This peak concentration occurs approximately 10,000 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 5.6E-02 pCi/L at 100 meters, that is below the PRG value.

6.3.7.16 Cadmium

Cadmium has a peak concentration of 17 μg/L at 1 meter compared to the MCL of 5.0 μg/L. This peak concentration occurs approximately 7,146 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 3.7 μg/L at 100 meters, that is below the MCL value.

6.3.7.17 Manganese

Manganese has a peak concentration of 250 μg/L at 1 meter compared to the MCL of 50 μg/L. This peak concentration occurs approximately 4,804 years following FTF facility closure. As shown in Table 6.3-23, the peak concentration drops to 41 μg/L at 100 meters, this is below the MCL value.

Table 6.3-23: Groundwater Concentrations of CMCOC at 100 Meters and Seepline

Contaminant	MCL (pCi/L or µg/L)	Residential Tap Water PRG (pCi/L)	Peak Concentration at 100 meters (pCi/L or µg/L) 1 to 10,000 Yrs	Fraction of MCL or PRG at 100 meters	Peak Concentration at UTR Seepline (pCi/L) 1 to 10,000 Yrs	Fraction of MCL or PRG at UTR Seepline
C-14	2.0E+03[1]	MCL used	7.8E+02	3.9E-01	NC	NC
K-40	N/A	1.9E+00	4.5E+00	2.4E+00	5.2E-02	2.7E-02
Nb-93m	1.0E+03[1]	MCL used	1.9E+02	1.9E-01	NC	NC
Np-237	N/A	7.7E-01	3.7E+00	4.8E+00	8.1E-02	1.1E-01
Pa-231	N/A	2.8E-01	9.6E-01	3.4E+00	2.1E-02	7.5E-02
Pd-107	N/A	1.9E+02	6.4E+01	3.4E-01	NC	NC
Pu-239	N/A	3.5E-01	9.4E-03	2.7E-02	NC	NC
Pu-240	N/A	3.5E-01	1.0E-02	2.9E-02	NC	NC
Ra-226 + Ra-228	5.0E+00[1]	MCL used	3.1E+00	6.2E-01	NC	NC
Tc-99	9.0E+02[1]	MCL used	2.7E+02	3.0E-01	NC	NC
Th-229	N/A	2.1E-01	5.5E-03	2.6E-02	NC	NC
Th-230	N/A	5.2E-01	1.0E-02	1.9E-02	NC	NC
U-233	N/A	6.6E-01	2.5E-01	3.8E-01	NC	NC
U-234	N/A	6.7E-01	4.6E+00	6.9E+00	7.7E-10	1.1E-09
U-236	N/A	7.1E-01	5.6E-02	7.9E-02	NC	NC
Cadmium	5.0E+00[2]	MCL used	3.7E+00[2]	7.4E-01	NC	NC
Manganese	5.0E+01[2]	MCL used	4.1E+01[2]	8.2E-01	NC	NC

[1] pCi/L

[2] µg/L

N/A = Not Available

NC = Not Calculated

Note: Contaminants shaded in gray exceed the PRG at 100 meters

6.3.8 ALARA Analysis

Section 5.8 of the FTF PA describes how the ALARA (*as low as reasonably achievable)* requirement of DOE O 435.1, Chg 1 and 10 CFR 61.41 are implemented for FTF. The ALARA information presented in the FTF PA is not affected by the new residual waste information.

6.4 FTF Inadvertent Intruder Analysis

This section will discuss the impact of the new residual waste information on the FTF inadvertent intruder analysis information presented in Section 6.0 of the FTF PA.

6.4.1 Groundwater Concentrations at 1 Meter

Section 6.1 (Groundwater Concentrations at 1 Meter) of the FTF PA presents the 1-meter groundwater concentrations for the FTF radionuclides and chemicals. Maximum groundwater concentrations are given for the modeling cell adjoining the analyzed source terms. Results are presented for the three distinct aquifers modeled (UTR-UZ, UTR-LZ, and Gordon Aquifer).

These groundwater concentrations were recalculated using the PORFLOW FTF model for the FTF PA Base Case using the Tanks 18 and 19 residual inventories when operationally closured presented in Section 6.3.1. Tables A-9 through A-11 (see Appendix A) show peak 1-meter radionuclides concentrations for the three aquifers in the 10,000-year performance period. These radionuclide concentrations reflect the peak concentrations for each radionuclide in the highest sector. Tables A-12 through A-14 (see Appendix A) show peak 1-meter chemical concentrations for the three aquifers in the 10,000-year performance period. These chemical concentrations also reflect the peak concentrations for the sector.

6.4.2 Acute Exposure Scenarios

Section 6.2 (Acute Exposure Scenarios) of the FTF PA describes how the biotic pathways doses are calculated for the Acute Exposure Scenarios. The acute exposure scenarios information presented in the FTF PA is not affected by the new residual waste information.

6.4.3 Chronic Exposure Scenarios

Section 6.3 (Chronic Exposure Scenarios) of FTF PA describes how the biotic pathways doses are calculated for the chronic exposure scenarios. The chronic exposure scenarios information presented in the FTF PA is not affected by the new residual waste information.

6.4.4 Groundwater Doses at 1-Meter

Section 6.4 (Intruder Analysis Results) of FTF PA contains calculations of the peak total intruder doses for the acute intruder scenario and for the chronic intruder agricultural (post-drilling) scenario. For the acute intruder, doses were calculated assuming the acute intruder drills into a three-inch diameter transfer line at any time after the 100-year period of institutional control following FTF facility closure. For the chronic intruder, annual doses were calculated assuming contamination from the drill cuttings, as well as from the use of water obtained from a well.

The acute intruder scenario is dependent on the transfer line inventory (i.e., it does not include a groundwater contribution) and therefore is not affected by a revision to the Tanks 18 and 19 inventories. The peak dose for the acute intruder in the 10,000-year performance period therefore remains 1.6 millirem at year 100, primarily due to exposure to drill cuttings.

The peak chronic doses have been recalculated using the peak groundwater concentrations identified in Section 6.3.2 of this Special Analysis (i.e., groundwater concentrations at 1-meter and at the seepline recalculated using the PORFLOW FTF model for the FTF PA Base Case using the Tanks 18 and 19 residual inventories at operational closure).

For the chronic intruder, the contributions to the peak doses from the four 1-meter sectors were recalculated using the highest concentration for each radionuclide in the sector, with the recalculation based on the Tanks 18 and 19 residual inventories at operational closure. These peak doses were the total dose associated with drill cuttings and all the individual 1-meter well pathways. Figure 6.4-1 graphically presents the annual dose to the chronic intruder for each of the four 1-meter sectors for the 10,000-year performance period after FTF facility closure. As shown in Figure 6.4-1, the dose to the chronic intruder, within the 10,000-year period, is highest at 100 years after FTF final facility closure and is attributed to the earliest time after FTF final facility closure that an intruder is assumed to drill into the closure area.

Figure 6.4-1: Annual Dose to the Chronic Intruder within 10,000 Years

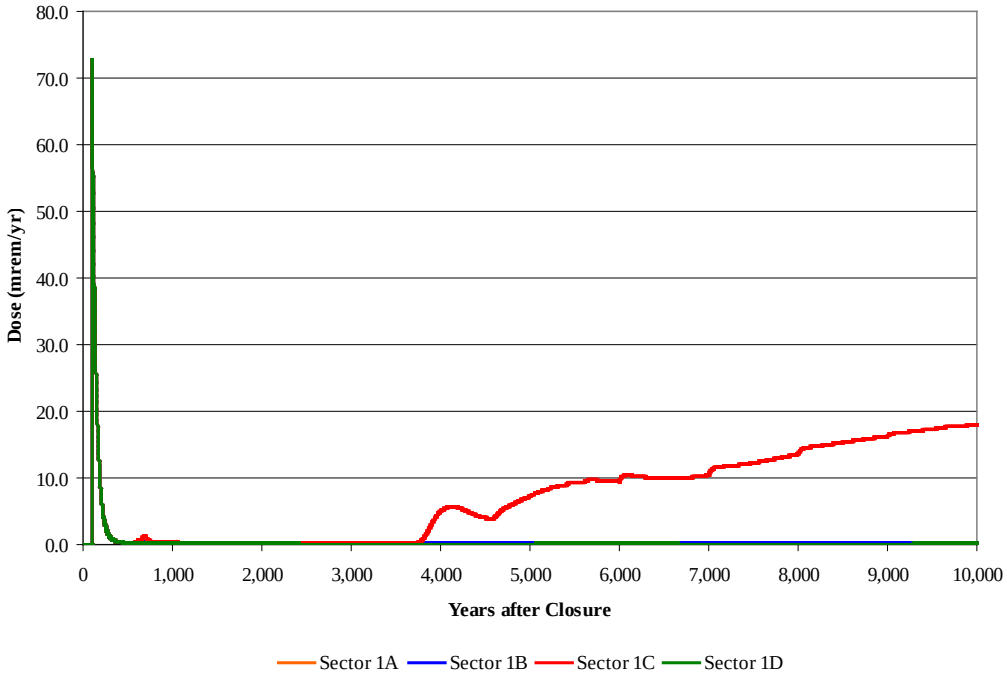


Table 6.4-1 presents the chronic intruder peak dose within the 10,000-year performance period and identifies the contribution from the significant pathways and their contributing radionuclides. The peak dose for the chronic intruder scenario in the 10,000-year performance period was 72.7 mrem/yr at year 100. This peak dose was almost entirely due to ingestion of vegetables contaminated with drill cuttings, with 71.6 of the 72.7 mrem/yr being due to vegetable ingestion. The principal radionuclide contributors to this vegetable dose were the short-lived isotopes Sr-90/Y-90 and Cs-137/Ba-137m.

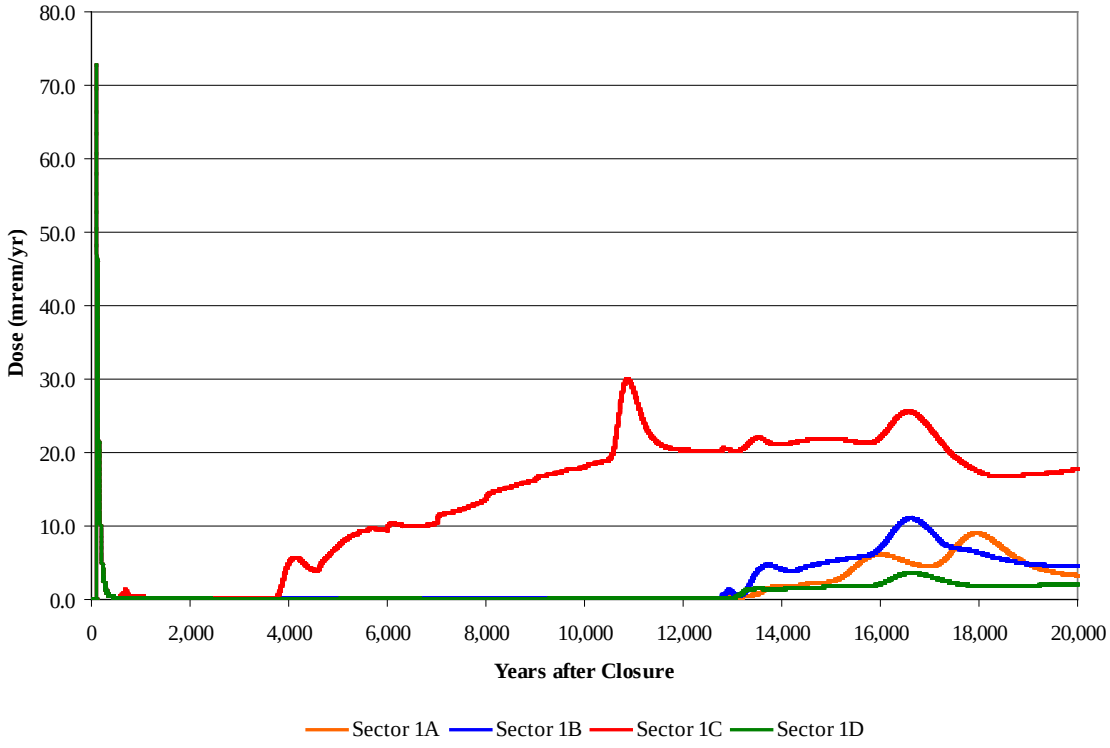
The chronic intruder-scenario peak dose (at year 100) within the 10,000-year period of performance does not include a groundwater contribution because no liner failures are assumed to occur until approximately 500 years after facility closure (which are associated with the ancillary equipment and transfer lines). Thus, the peak dose to the chronic intruder during the 10,000-year performance period does not vary by FTF sector. Because chronic intruder peak dose in 10,000 years is associated with transfer-line drill cuttings, it is not impacted by utilizing the actual residual inventories at operational closure for Tanks 18 and 19.

Table 6.4-1: Chronic Intruder Peak Dose Contributors within 10,000 Years

Chronic Intruder Pathway Contributors	Contribution to Peak (mrem/yr)	Principal Radionuclide Pathway Dose (%)
Vegetable Ingestion	71.6	Sr-90 / Y-90 (56 %) Cs-137 / Ba-137m (44 %)
Soil Ingestion	0.7	Am-241 (42 %) Sr-90 / Y-90 (37 %)
External Exposure	0.4	Cs-137 / Ba-137m (94 %)
Total	**72.7**	

As illustrated in Figure 6.4-2, the year 100 peak dose to the chronic intruder (72.7 mrem/yr) is the peak dose within the 20,000-year period after FTF facility closure. Utilizing the actual residual inventories at closure for Tanks 18 and 19 resulted in a decrease in the chronic intruder peak dose in 20,000 years due to a decrease in the Tanks 18 and 19 dose contribution associated with the groundwater pathway. The groundwater pathway contribution to the peak dose decreased from approximately 75 mrem/yr in FTF PA, to approximately 30 mrem/yr.

Figure 6.4-2: Annual Dose to the Chronic Intruder within 20,000 Years



6.4.5 Intruder Uncertainty/Sensitivity Analysis

Section 6.5 of the FTF PA considers the effects on the intruder analysis of uncertainties in the conceptual models used and sensitivities in the parameters used in the mathematical models. In general, the intruder uncertainty and sensitivity analyses information presented in the FTF PA is not affected by the new residual waste information and the uncertainty and sensitivity analyses insights remain unaffected. The FTF PA sensitivity analysis most affected is the evaluation performed to investigate the effect of an intruder drilling into a waste tank (which is not considered a credible scenario). In this intruder drilling sensitivity analysis, a Tank 18 drilling inventory was substituted for the transfer line-drilling inventory. The dose results for this scenario would have been slightly altered due to the minor changes in the Tank 18 residual inventory at operational closure, but the dose was not recalculated since the scenario is not credible. For the other intruder uncertainty and sensitivity analyses, the Tanks 18 and 19 residual inventories at operational closure are within the inventory distributions documented in the FTF PA and used in the probabilistic model. The other modeling parameters described in SRS-REG-2007-00002 Section 5.6.3 are unaffected by the residual inventories at facility closure. The uncertainty and sensitivity analyses results, described in the remainder of FTF PA Section 6.5, remains valid regardless of the revised Tanks 18 and 19 residual inventories, and has not been recalculated.

6.5 F-Tank Farm Interpretation of Results

Section 7.0 of FTF PA summarizes the conservatisms used in modeling and provides a summary and interpretation of the results presented in Section 5.0 and Section 6.0 of the FTF PA, Rev.1. The FTF PA conservatisms information presented in the FTF PA is not affected by the new residual waste information. The integrated system behavior discussion provided in the Section 7.1.1 of FTF PA remains valid irrespective of the revised Tanks 18 and 19 residual inventories. The individual doses results provided in the Section 7.1.2 of FTF PA have been updated based on the revised calculation using the Tanks 18 and 19 residual inventories at closure, and are summarized as follows:

6.5.1 100-Meter (Water from Well) Groundwater Pathways Doses

The peak 100-meter groundwater pathway doses in the 10,000-year performance period are in Sector E (3.2 mrem/yr) and Sector D (1.7 mrem/yr), as expected, because these sectors are closest to the Type IV tanks, which are the only waste tanks considered to have their liner fail in less than 10,000 years. The primary pathway contributors to the peak 100-meter groundwater dose are water ingestion and vegetable ingestion. The 100-meter groundwater-pathway peak doses during the 10,000-year performance period are primarily associated with Ra-226 and Np-237. The peak 100-meter groundwater pathway doses within 20,000 years are also in Sectors D and E. The peak 100-meter groundwater pathway dose in 10,000 years increased relative to FTF PA when the actual residual inventories at facility closure are utilized for Tanks 18 and 19. The increase in peak dose in 10,000 years is associated with Ra-226 (increased due to an increase in the Pu-238 inventory in Tank 18) and Pa-231 (increased due to an increase in the Pa-231 inventory in Tank 18).

6.5.2 Water at the Stream Groundwater Pathways Doses

The peak-groundwater pathway dose at the stream in the 10,000-year performance period is associated with UTR. The MOP at the stream peak-groundwater pathway dose in the 10,000-year performance period is 0.07 mrem/yr at year 10,000. The primary contributor to the UTR peak dose is water ingestion.

6.5.3 All-Pathways Dose

The peak all-pathways annual dose for the MOP at 100 meters is calculated using the highest 100-meter groundwater-pathway dose results during the 10,000-year performance period in combination with the air pathway results. The peak all-pathways annual dose for the MOP is 3.4 mrem/yr and is associated with Sector E at 100 meters. The all-pathways dose was dominated by the groundwater pathway, with the airborne pathway adding an additional 0.2 mrem/yr to the MOP. The peak all-pathways annual dose for the MOP at 100 meters increased relative to the FTF PA when the actual residual inventories at facility closure are utilized for Tanks 18 and 19, with the dose increasing from 2.5 mrem/yr to 3.4 mrem/yr.

6.5.4 Intruder Dose

The peak dose for the acute intruder in the 10,000-year performance period is 1.6 millirem primarily due to exposure to drill cuttings. The acute intruder scenario does not include a groundwater contribution and therefore does not vary by FTF sector. The peak dose for the chronic intruder scenario in the 10,000-year performance period is 73 mrem/yr. This peak dose was almost entirely due to ingestion of vegetables contaminated with drill cuttings. The chronic intruder scenario peak dose is also driven by the drill cutting contributions and does not vary by FTF sector. The peak intruder doses in 10,000 years were not impacted when the actual residual inventories at facility closure are utilized for Tanks 18 and 19 and are not changed from FTF PA.

6.5.5 Airborne Dose / Radon Flux

The annual dose from airborne releases resulted in a total dose 0.2 mrem/yr (principally from Sn-126) at 100 meters from the FTF in the 10,000-year performance period. These results were very conservative because the flux rates are based on simplified models. The peak airborne dose was not impacted when the actual residual inventories at facility closure are utilized for Tanks 18 and 19. These simplified models also resulted in a peak flux of radon at the ground surface of 3.8E-08 $pCi/m^2/s$.

6.6 FTF Performance Evaluation

Section 8.0 of the FTF PA describes intended use and future work to be done to support its maintenance. The FTF PA use and future work information presented in the FTF PA are not negatively impacted by the new residual waste information, and the new information documented in this Special Analysis will be used to further inform FTF PA future work.

7.0 CONCLUSION

The FTF PA provides groundwater radionuclide concentrations at 1 meter, 100 meters, and exposure points at the two seeplines approximately 1,600 meters from FTF. The groundwater concentrations are provided for each of the three aquifers as applicable as a part of the FTF groundwater modeling. The FTF PA also provides groundwater concentrations for chemical contaminants at 1 meter and 100 meters. In addition, FTF PA provides intruder doses as well as analyses for the air pathways and radon ground surface flux. The FTF PA results can be used in subsequent documents to demonstrate compliance with the pertinent requirements identified below for final facility closure of FTF as indicated in Table 7.0-1.

Table 7.0-1: Key Limits from Regulatory Requirements

Requirement	All-Pathways Dose	Intruder Dose	Air Pathway Dose	Radon Flux	Groundwater Protection
NDAA Section 3116: 10 CFR 61.41 and 61.42	25 mrem/yr	500 mrem/yr	N/A	N/A	N/A
DOE M 435.1-1	25 mrem/yr	500 mrem – acute 100 mrem/yr – chronic	10 mrem/yr	20 pCi/m^2/s at ground surface	< MCL
SCDHEC Primary Drinking Water Regulations	N/A	N/A	N/A	N/A	< MCL

This Special Analysis results can be evaluated versus the assumptions and results in FTF PA. The key radiological results from the FTF PA and this Special Analysis are shown in Table 7.0-2.

Table 7.0-2: Summary Radiological Results for F-Tank Farm

Location	FTF PA Peak Within 10,000 Years (projected Tanks 18/ Tank 19 inventories)			Special Analysis Peak Within 10,000 Years (actual Tanks 18/ Tank 19 inventories)		
	All-Pathways Dose (mrem/yr)	Groundwater Pathway Dose (mrem/yr)	Air Pathway Dose (mrem/yr)	All-Pathways Dose (mrem/yr)	Groundwater Pathway Dose (mrem/yr)	Air Pathway Dose (mrem/yr)
100 meters from FTF	2.5 at ~ year 10,000	2.3 at ~ year 10,000	0.2	3.4 at ~ year 10,000	3.2 at ~ year 10,000	0.2
At Seepline	0.09 at ~ year 10,000	0.04 at ~ year 10,000	0.05	0.12 at ~ year 5,600	0.07 at ~ year 5,600	0.05

Note 1: The FTF PA, Rev.1 peak intruder dose is 73 mrem/yr at year 101 from a chronic scenario, drilling through a transfer line and using groundwater concentrations at the maximum 1-meter FTF location. This value is unchanged in this Special Analysis.

Note 2: The FTF PA peak radon flux at the ground surface is 3.6E-08 pCi/m^2/s and the Special Analysis peak radon flux is slightly increased to 3.8E-08 pCi/m^2/s.

In addition to evaluating the impact of the final Tanks 18 and 19 inventories on peak doses within the 10,000-year performance period, additional sensitivity analyses were performed as listed above. The results of these sensitivity analyses are used to assess the potential dose

impacts from the final inventory, including evaluating an additional 90,000 years beyond the performance period for the purposes of "chasing the peaks" to further understand system performance and inform the final facility closure decision process. These additional sensitivity analyses placed emphasis on understanding releases associated with the Pu-239 inventory remaining in Tank 18 at operational closure and on the barriers to Pu-239 release. There are multiple barriers to Pu-239 release and transport that prevent the Pu-239-related peak near year 40,000 from occurring significantly earlier (i.e., within or close to year 10,000, the outer bound of the performance period). These barriers are discussed within Section 6.3.5.3 of this Special Analysis. Given the multiple barriers to early release and transport of Pu-239, it is reasonable to conclude that the uncertainty surrounding the factors driving the Pu-239 peak dose is not sufficient to impact demonstration of performance objective compliance within the 10,000-year performance period.

The additional sensitivity analyses regarding Pu-239 that were performed show that for several of the barriers to Pu-239 release and transport the FTF PA Base Case model incorporates conservative approaches/inputs and the peak doses associated with Pu-239 would likely occur even farther beyond the 10,000-year performance period if these conservative approaches/inputs are eliminated. The sensitivity analyses documented in Section 6.3.6 of this Special Analysis highlight the fact that doses associated with Pu-239 can be expected to occur later than currently reflected in the FTF PA Base Case deterministic model as additional conservatisms are removed. Figure ES-3 shows that the peak dose associated with Pu-239 occurs well beyond the 10,000-year performance period for all of the FTF PA Base Case sensitivity studies performed, and in most cases, the peak dose occurs much later, and is significantly attenuated when compared to FTF PA Base Case results. These sensitivity analyses confirm that the uncertainty surrounding the doses associated with Tank 18 Pu-239 can be bound and that waste release experiments to increase support for key modeling assumptions related to Pu-239 waste release are not required in the short term to provided reasonable assurance that the peak doses associated with Tank 18 Pu-239 will not move forward in time into the 10,000-year performance period. While there is uncertainty around the peak dose associated with the residual Pu-239 in Tank 18, the timing associated with the Pu-239 peak dose is understood and under both expected and reasonably bounding conditions there is reasonable assurance that the Pu-239 peak dose will not move forward into the 10,000-year performance period. While the testing in this area might be useful in better defining the precise timing of the peak doses associated with Tank 18 Pu-239, these tests are not required to provide reasonable assurance that the peak dose associated with Pu-239 will not occur within the 10,000-year performance period.

The peak groundwater radionuclide concentrations were calculated and only K-40, Np-237, Pa-231, and U-234 were above the PRG at 100 meters; no MCLs were exceeded at 100 meters. All radionuclides were well below the MCL or PRG at the seepline. The peak concentrations for the chemicals of concern were also calculated, and all were less than the MCL or RSL at a distance of 100 meters from FTF.

Based on the above, the Special Analysis results provide reasonable assurance that compliance is maintained with the specific requirements of NDAA Section 3116, DOE M 435.1-1, and the MCLs. The conclusions made in the FTF PA regarding Tanks 18 and 19 final operational closure are not significantly impacted by new information regarding the final residual inventories that are planned to be grouted in-place in Tanks 18 and 19.

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APPENDIX A

RADIOLOGICAL AND CHEMICAL CONCENTRATION TABLES

Table A-1: Radiological 100-Meter Concentrations for UTR-UZ

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Ac-227	N/A	3.0E-08	1,740	5.8E-08	6,144	9.4E-06	6,130	4.0E-04	6,122	5.9E-04	6,116
Al-26	N/A	<1.0E-30	10,000	2.3E-29	10,000	2.3E-18	10,000	2.4E-12	10,000	1.5E-13	10,000
Am-241	Total α	5.7E-28	10,000	2.9E-25	10,000	5.5E-15	10,000	1.7E-09	10,000	2.7E-10	10,000
Am-242m	Total α	<1.0E-30	9,424	<1.0E-30	9,874	<1.0E-30	8,476	5.8E-30	7,544	5.1E-30	7,960
Am-243	Total α	8.6E-28	10,000	4.1E-25	10,000	9.7E-15	10,000	3.6E-09	10,000	2.4E-08	10,000
C-14	2,000	2.3E-03	4,654	1.7E-01	4,500	9.4E+01	4,300	7.8E+02	4,172	1.3E+02	4,222
Cf-249	Total α	<1.0E-30	10,000	<1.0E-30	10,000	8.2E-24	10,000	2.8E-18	10,000	2.5E-19	10,000
Cl-36	N/A	6.9E-06	10,000	4.3E-05	3,692	1.8E-02	3,684	1.9E-01	3,682	2.3E-01	3,682
Cm-243	Total α	<1.0E-30	1,900	<1.0E-30	1,898	<1.0E-30	1,618	<1.0E-30	1,420	<1.0E-30	1,490
Cm-244	Total α	<1.0E-30	1,342	<1.0E-30	1,348	<1.0E-30	1,172	<1.0E-30	1,048	<1.0E-30	1,092
Cm-245	Total α	3.9E-28	10,000	1.9E-25	10,000	4.1E-15	10,000	1.4E-09	10,000	2.1E-10	10,000
Cm-247	Total α	<1.0E-30	10,000	3.5E-28	10,000	7.4E-18	10,000	2.5E-12	10,000	8.3E-14	10,000
Cm-248	Total α	3.1E-29	10,000	1.5E-26	10,000	3.3E-16	10,000	1.1E-10	10,000	3.7E-12	10,000
Co-60	100	<1.0E-30	384	<1.0E-30	432	<1.0E-30	398	<1.0E-30	168	<1.0E-30	166
Cs-135	900	8.1E-04	8,808	2.3E-03	7,524	6.7E-01	6,148	6.0E+00	5,552	2.1E+00	5,796
Cs-137	200	5.0E-29	2,076	3.6E-26	1,370	2.9E-19	1,152	1.5E-15	1,000	2.7E-16	1,048
Eu-152	200	<1.0E-30	1,034	<1.0E-30	1,038	<1.0E-30	918	<1.0E-30	832	<1.0E-30	864
Eu-154	60	<1.0E-30	482	<1.0E-30	486	<1.0E-30	390	<1.0E-30	326	<1.0E-30	324

Table A-1: Radiological 100-Meter Concentrations for UTR-UZ (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs
H-3	20,000	1.8E-12	558	3.2E-12	558	1.8E-11	208	2.1E-09	202	3.3E-09	202
I-129	1	3.1E-04	584	5.3E-04	584	1.4E-02	3,792	1.3E-01	3,788	8.2E-02	3,792
K-40	N/A	3.2E-06	4,640	2.2E-04	4,552	9.4E-02	4,266	2.7E+00	4,152	4.0E+00	4,128
Nb-93m	1,000	1.8E-04	10,000	1.6E-02	9,998	8.4E+00	10,000	1.2E+02	9,998	1.6E+02	9,998
Nb-94	N/A	4.3E-01	564	7.4E-01	562	7.1E-01	560	6.4E-01	560	3.9E-01	560
Ni-59	300	5.8E-01	2,060	9.9E-01	2,036	9.5E-01	2,002	1.2E+01	7,306	1.7E+01	7,288
Ni-63	50	5.2E-04	1,502	1.1E-03	1,468	1.2E-03	1,428	1.0E-03	1,478	3.3E-03	1,208
Np-237	Total α	5.7E-02	1,594	9.8E-02	1,594	9.4E-02	1,586	2.2E+00	6,054	3.3E+00	6,056
Pa-231	Total α	4.0E-05	1,712	7.6E-05	6,102	1.2E-02	6,076	5.3E-01	6,060	7.8E-01	6,060
Pb-210	N/A	1.6E-04	1,748	2.7E-04	1,730	2.7E-04	1,728	4.6E-03	10,000	6.8E-03	10,000
Pd-107	N/A	1.3E-04	5,106	1.4E-02	5,052	7.4E+00	4,872	6.4E+01	4,788	2.4E+01	4,822
Pu-238	Total α	<1.0E-30	5,310	<1.0E-30	7,998	1.3E-29	7,282	6.9E-25	6,744	3.7E-24	6,952
Pu-239	Total α	1.5E-07	10,000	4.2E-09	10,000	5.4E-06	10,000	3.6E-03	10,000	9.4E-03	10,000
Pu-240	Total α	2.5E-08	10,000	7.2E-10	10,000	9.9E-06	10,000	7.1E-03	10,000	1.0E-02	10,000
Pu-241	300	2.2E-27	10,000	1.1E-24	10,000	2.1E-14	10,000	6.6E-09	10,000	1.1E-09	10,000
Pu-242	Total α	5.7E-10	10,000	1.7E-11	10,000	3.1E-07	10,000	2.1E-04	10,000	2.8E-04	10,000
Pu-244	Total α	2.8E-13	10,000	8.2E-15	10,000	1.3E-09	10,000	8.8E-07	10,000	1.5E-07	10,000
Ra-226	Total α/Ra	6.0E-02	1,720	1.0E-01	1,702	1.0E-01	1,694	1.8E+00	10,000	2.6E+00	10,000
Ra-228	Total Ra	9.8E-14	10,000	8.7E-14	10,000	3.3E-10	10,000	6.4E-08	10,000	1.7E-07	10,000
Rn-222	N/A	6.0E-02	1,720	1.0E-01	1,702	1.0E-01	1,694	1.8E+00	10,000	2.6E+00	10,000

Table A-1: Radiological 100-Meter Concentrations for UTR-UZ (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs	Concen-tration (pCi/L)	Year Peak Contri-bution Occurs
Se-79	N/A	1.7E-24	10,000	1.2E-22	10,000	4.9E-13	10,000	3.5E-07	10,000	2.6E-06	10,000
Sm-151	1,000	<1.0E-30	6,674	<1.0E-30	4,550	<1.0E-30	3,646	<1.0E-30	3,032	<1.0E-30	3,238
Sn-126	N/A	<1.0E-30	10,000	<1.0E-30	10,000	1.6E-20	10,000	1.7E-13	10,000	2.2E-12	10,000
Sr-90	8	9.9E-10	1,108	3.1E-09	1,084	1.4E-08	1,026	7.1E-09	1,048	1.2E-07	990
Tc-99	900	3.5E+01	746	6.0E+01	744	5.8E+01	740	2.0E+02	694	1.6E+02	694
Th-228	Total α	9.8E-14	10,000	8.7E-14	10,000	3.3E-10	10,000	6.4E-08	10,000	1.7E-07	10,000
Th-229	Total α	1.8E-07	10,000	2.7E-07	10,000	1.8E-05	10,000	2.1E-03	10,000	5.5E-03	10,000
Th-230	Total α	2.8E-09	10,000	1.4E-09	10,000	3.7E-06	10,000	2.9E-03	10,000	1.0E-02	10,000
Th-232	Total α	2.9E-16	10,000	1.4E-16	10,000	1.1E-12	10,000	2.4E-10	10,000	6.7E-10	10,000
U-232	Total U*	<1.0E-30	4,274	<1.0E-30	2,992	2.5E-30	2,414	1.1E-25	2,020	9.7E-26	2,052
U-233	Total U*	3.6E-06	10,000	4.0E-06	10,000	1.2E-03	10,000	1.0E-01	10,000	2.5E-01	10,000
U-234	Total U*	2.0E-06	10,000	1.5E-06	10,000	2.6E-03	10,000	1.6E+00	10,000	4.6E+00	10,000
U-235	Total U*	1.9E-08	10,000	1.4E-08	10,000	4.8E-05	10,000	4.3E-03	10,000	6.1E-03	10,000
U-236	Total U*	3.7E-08	10,000	2.7E-08	10,000	1.3E-04	10,000	2.2E-02	10,000	5.6E-02	10,000
U-238	Total U*	9.1E-07	10,000	6.8E-07	10,000	1.5E-05	10,000	5.3E-04	10,000	5.6E-04	10,000
Zr-93	N/A	7.3E-25	10,000	4.7E-22	10,000	2.4E-12	10,000	2.9E-07	10,000	4.4E-08	10,000

Table A-1: Radiological 100-Meter Concentrations for UTR-UZ (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Sum of beta-gamma MCL fractions		4.1E-02	N/A	7.1E-02	N/A	1.4E-01	N/A	9.1E-01 ***	N/A	5.5E-01 ****	N/A
Total alpha	15	1.2E-01	N/A	2.0E-01	N/A	2.1E-01	N/A	4.6E+00	N/A	6.7E+00	N/A
Total Ra	5	6.0E-02	N/A	1.0E-01	N/A	1.0E-01	N/A	1.8E+00	N/A	2.6E+00	N/A

* Total uranium is evaluated in Tables A-4 through A-6.

** MCL values for beta and photon emitters are calculated in Table II-3 of FR-00-9654 based on a beta-gamma dose of 4 mrem/yr.

*** Actual Sector D Peak Concentration (pCi/L) is 4.1E-01 (documented in Appendix B) based on analysis of individual radionuclide contributions at time of occurrence rather than bounding approach of summing peak concentrations in 10,000 years, regardless of timing.

**** Actual Sector E Peak Concentration (pCi/L) is 1.8E-01 (documented in Appendix B) based on analysis of individual radionuclide contributions at time of occurrence rather than bounding approach of summing peak concentrations in 10,000 years, regardless of timing.

Table A-2: Radiological 100-Meter Concentrations for UTR-LZ

Radionuclide	MCL (pCi/L) **	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Ac-227	N/A	4.2E-08	10,000	1.2E-07	10,000	6.4E-06	6,136	2.7E-04	6,124	7.3E-04	6,116
Al-26	N/A	<1.0E-30	10,000	<1.0E-30	10,000	2.5E-22	10,000	4.4E-16	10,000	1.0E-16	10,000
Am-241	Total α	<1.0E-30	10,000	4.7E-29	10,000	1.5E-18	10,000	9.5E-13	10,000	4.2E-13	10,000
Am-242m	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	9,268	<1.0E-30	8,440	<1.0E-30	8,628
Am-243	Total α	<1.0E-30	10,000	6.1E-29	10,000	2.4E-18	10,000	1.7E-12	10,000	3.4E-11	10,000
C-14	2,000	2.7E-03	4,750	2.2E-01	4,662	5.8E+01	4,396	6.7E+02	4,264	2.6E+02	4,310
Cf-249	Total α	<1.0E-30	10,000	<1.0E-30	10,000	2.1E-27	10,000	1.4E-21	10,000	3.7E-22	10,000
Cl-36	N/A	7.1E-06	10,000	5.9E-05	3,694	1.2E-02	3,686	1.7E-01	3,682	2.9E-01	3,682
Cm-243	Total α	<1.0E-30	2,058	<1.0E-30	2,116	<1.0E-30	1,840	<1.0E-30	1,650	<1.0E-30	1,688
Cm-244	Total α	<1.0E-30	1,458	<1.0E-30	1,492	<1.0E-30	1,314	<1.0E-30	1,192	<1.0E-30	1,218
Cm-245	Total α	<1.0E-30	10,000	3.0E-29	10,000	1.1E-18	10,000	7.2E-13	10,000	3.1E-13	10,000
Cm-247	Total α	<1.0E-30	10,000	<1.0E-30	10,000	2.0E-21	10,000	1.3E-15	10,000	1.2E-16	10,000
Cm-248	Total α	<1.0E-30	10,000	2.3E-30	10,000	8.5E-20	10,000	5.7E-14	10,000	5.5E-15	10,000
Co-60	100	<1.0E-30	402	<1.0E-30	448	<1.0E-30	416	<1.0E-30	184	<1.0E-30	182
Cs-135	900	8.8E-04	9,034	2.9E-03	7,844	4.0E-01	6,600	4.8E+00	5,976	2.6E+00	6,188
Cs-137	200	<1.0E-30	1,530	4.4E-28	1,470	2.7E-21	1,250	1.7E-17	1,106	6.2E-18	1,142
Eu-152	200	<1.0E-30	1,116	<1.0E-30	1,132	<1.0E-30	1,016	<1.0E-30	932	<1.0E-30	950
Eu-154	60	<1.0E-30	542	<1.0E-30	558	<1.0E-30	472	<1.0E-30	404	<1.0E-30	392

Table A-2: Radiological 100-Meter Concentrations for UTR-LZ (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
H-3	20,000	1.6E-12	562	3.1E-12	560	8.7E-12	210	1.0E-09	204	2.1E-09	204
I-129	1	3.4E-04	586	6.4E-04	586	9.7E-03	3,794	1.1E-01	3,790	1.1E-01	3,788
K-40	N/A	4.1E-06	4,738	3.0E-04	4,648	5.9E-02	4,362	1.8E+00	4,238	4.5E+00	4,200
Nb-93m	1,000	2.1E-04	10,000	2.0E-02	10,000	5.1E+00	10,000	9.4E+01	10,000	1.9E+02	9,998
Nb-94	N/A	4.6E-01	564	8.6E-01	564	8.9E-01	564	8.4E-01	564	7.1E-01	564
Ni-59	300	6.3E-01	2,098	1.2E+00	2,100	1.2E+00	2,090	7.8E+00	7,358	1.6E+01	7,354
Ni-63	50	2.9E-04	1,578	6.9E-04	1,530	9.9E-04	1,358	6.7E-04	1,554	3.2E-03	1,274
Np-237	Total α	6.2E-02	1,598	1.2E-01	1,600	1.2E-01	1,600	1.5E+00	6,062	3.7E+00	6,058
Pa-231	Total α	4.3E-05	1,714	1.0E-04	6,112	8.5E-03	6,084	3.6E-01	6,068	9.6E-01	6,062
Pb-210	N/A	1.7E-04	1,790	3.1E-04	1,782	3.3E-04	1,772	3.1E-03	9,998	8.2E-03	10,000
Pd-107	N/A	1.7E-04	5,176	1.8E-02	5,110	4.6E+00	4,934	5.4E+01	4,846	3.0E+01	4,874
Pu-238	Total α	<1.0E-30	5,666	<1.0E-30	8,322	<1.0E-30	7,638	1.4E-27	7,160	2.0E-26	7,270
Pu-239	Total α	1.7E-09	10,000	8.2E-11	10,000	1.8E-07	10,000	1.7E-04	10,000	6.6E-04	10,000
Pu-240	Total α	2.9E-10	10,000	1.4E-11	10,000	2.2E-07	10,000	3.6E-04	10,000	6.5E-04	10,000
Pu-241	300	<1.0E-30	10,000	1.8E-28	10,000	5.9E-18	10,000	3.7E-12	10,000	1.6E-12	10,000
Pu-242	Total α	6.7E-12	10,000	3.3E-13	10,000	6.8E-09	10,000	1.1E-05	10,000	1.8E-05	10,000
Pu-244	Total α	3.2E-15	10,000	1.6E-16	10,000	2.9E-11	10,000	4.7E-08	10,000	1.2E-08	10,000
Ra-226	Total α/Ra	6.4E-02	1,762	1.2E-01	1,752	1.3E-01	1,746	1.2E+00	10,000	3.1E+00	10,000
Ra-228	Total Ra	4.0E-15	10,000	5.3E-15	10,000	3.0E-11	10,000	9.7E-09	10,000	4.6E-08	10,000

Table A-2: Radiological 100-Meter Concentrations for UTR-LZ (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Rn-222	N/A	6.4E-02	1,762	1.2E-01	1,752	1.3E-01	1,746	1.2E+00	10,000	3.1E+00	10,000
Se-79	N/A	2.5E-28	10,000	4.2E-26	10,000	3.1E-16	10,000	7.5E-10	10,000	8.2E-09	10,000
Sm-151	1,000	<1.0E-30	7,210	<1.0E-30	5,038	<1.0E-30	4,220	<1.0E-30	3,650	<1.0E-30	3,780
Sn-126	N/A	<1.0E-30	10,000	<1.0E-30	10,000	2.4E-25	10,000	1.0E-17	10,000	2.4E-16	10,000
Sr-90	8	3.4E-10	1,142	1.7E-09	1,116	1.0E-08	1,060	2.0E-09	1,082	6.6E-08	1,026
Tc-99	900	3.8E+01	750	7.2E+01	752	7.5E+01	738	2.2E+02	704	2.7E+02	702
Th-228	Total α	4.0E-15	10,000	5.3E-15	10,000	3.0E-11	10,000	9.7E-09	10,000	4.6E-08	10,000
Th-229	Total α	7.0E-07	10,000	1.3E-06	10,000	2.9E-06	10,000	3.6E-04	10,000	1.3E-03	10,000
Th-230	Total α	9.2E-11	10,000	6.1E-11	10,000	2.5E-07	10,000	3.2E-04	10,000	2.3E-03	10,000
Th-232	Total α	9.1E-18	10,000	6.0E-18	10,000	7.6E-14	10,000	3.1E-11	10,000	1.5E-10	10,000
U-232	Total U*	<1.0E-30	4,546	<1.0E-30	3,254	<1.0E-30	2,690	2.7E-28	2,330	4.9E-28	2,320
U-233	Total U*	1.3E-05	10,000	2.4E-05	10,000	1.5E-04	10,000	2.1E-02	10,000	8.2E-02	10,000
U-234	Total U*	7.9E-08	10,000	7.4E-08	10,000	2.2E-04	10,000	2.2E-01	10,000	1.4E+00	10,000
U-235	Total U*	7.7E-10	10,000	7.3E-10	10,000	4.3E-06	10,000	9.1E-04	10,000	1.7E-03	10,000
U-236	Total U*	1.5E-09	10,000	1.4E-09	10,000	1.2E-05	10,000	3.7E-03	10,000	1.7E-02	10,000
U-238	Total U*	3.7E-08	10,000	3.4E-08	10,000	3.1E-06	10,000	1.2E-04	10,000	1.5E-04	10,000
Zr-93	N/A	1.0E-28	10,000	1.5E-25	10,000	1.3E-15	10,000	3.6E-10	10,000	1.2E-10	10,000

Table A-2: Radiological 100-Meter Concentrations for UTR-LZ (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Sum of beta-gamma MCL fractions		4.5E-02	N/A	8.5E-02	N/A	1.3E-01	N/A	8.1E-01 ***	N/A	7.8E-01 ****	N/A
Total alpha	15	1.3E-01	N/A	2.4E-01	N/A	2.6E-01	N/A	3.1E+00	N/A	7.8E+00	N/A
Total Ra	5	6.4E-02	N/A	1.2E-01	N/A	1.3E-01	N/A	1.2E+00	N/A	3.1E+00	N/A

* Total uranium is evaluated in Tables A-4 through A-6.

** MCL values for beta and photon emitters are calculated in Table II-3 of FR-00-9654 based on a beta-gamma dose of 4 mrem/yr.

*** Actual Sector D Peak Concentration (pCi/L) is 3.5E-01 (documented in Appendix B) based on analysis of individual radionuclide contributions at time of occurrence rather than bounding approach of summing peak concentrations in 10,000 years, regardless of timing.

**** Actual Sector E Peak Concentration (pCi/L) is 3.0E-01 (documented in Appendix B) based on analysis of individual radionuclide contributions at time of occurrence rather than bounding approach of summing peak concentrations in 10,000 years, regardless of timing.

Table A-3: Radiological 100-Meter Concentrations for Gordon Aquifer

Radionuclide	MCL (pCi/L) **	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Ac-227	N/A	3.6E-12	10,000	2.3E-11	10,000	3.8E-10	10,000	1.4E-08	10,000	8.1E-08	10,000
Al-26	N/A	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	1.2E-29	10,000	6.4E-29	10,000
Am-241	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	1.9E-27	10,000	1.6E-26	10,000
Am-242m	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	9,782	<1.0E-30	9,710
Am-243	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	3.4E-27	10,000	1.1E-24	10,000
C-14	2,000	1.6E-09	10,000	4.7E-08	9,998	6.0E-06	10,000	9.1E-05	9,998	9.8E-05	10,000
Cf-249	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000
Cl-36	N/A	3.6E-09	10,000	1.6E-08	9,998	1.9E-06	3,792	4.1E-05	3,792	1.3E-04	3,794
Cm-243	Total α	<1.0E-30	2,358	<1.0E-30	2,406	<1.0E-30	2,132	<1.0E-30	1,936	<1.0E-30	1,938
Cm-244	Total α	<1.0E-30	1,642	<1.0E-30	1,674	<1.0E-30	1,498	<1.0E-30	1,374	<1.0E-30	1,352
Cm-245	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	1.4E-27	10,000	1.1E-26	10,000
Cm-247	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	2.5E-30	10,000	4.4E-30	10,000
Cm-248	Total α	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	1.1E-28	10,000	1.9E-28	10,000
Co-60	100	<1.0E-30	452	<1.0E-30	476	<1.0E-30	448	<1.0E-30	218	<1.0E-30	218
Cs-135	900	1.4E-09	10,000	9.1E-09	10,000	3.7E-07	10,000	6.8E-06	10,000	8.8E-06	10,000
Cs-137	200	<1.0E-30	1,720	<1.0E-30	1,648	<1.0E-30	1,434	1.3E-28	1,310	1.8E-28	1,340
Eu-152	200	<1.0E-30	1,240	<1.0E-30	1,262	<1.0E-30	1,138	<1.0E-30	1,058	<1.0E-30	1,042
Eu-154	60	<1.0E-30	634	<1.0E-30	648	<1.0E-30	560	<1.0E-30	498	<1.0E-30	474

Table A-3: Radiological 100-Meter Concentrations for Gordon Aquifer (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
H-3	20,000	2.7E-17	580	1.4E-16	190	4.9E-16	188	1.1E-14	226	5.0E-14	226
I-129	1	2.4E-08	732	1.3E-07	730	1.4E-06	4,080	2.6E-05	4,088	5.1E-05	4,098
K-40	N/A	3.0E-11	10,000	2.4E-09	9,996	2.8E-07	9,998	8.5E-06	10,000	4.2E-05	9,998
Nb-93m	1,000	7.6E-09	10,000	9.6E-07	10,000	1.6E-04	10,000	4.1E-03	10,000	1.4E-02	10,000
Nb-94	N/A	3.8E-05	614	2.1E-04	614	3.5E-04	614	3.8E-04	614	3.8E-04	614
Ni-59	300	1.6E-05	6,440	8.8E-05	6,394	1.5E-04	7,406	5.5E-04	10,000	1.8E-03	10,000
Ni-63	50	5.1E-11	1,886	3.1E-10	1,852	7.1E-10	1,730	7.1E-10	1,768	1.7E-09	1,496
Np-237	Total α	1.7E-06	6,826	9.4E-06	6,866	1.7E-05	8,864	9.5E-05	10,000	4.3E-04	10,000
Pa-231	Total α	4.5E-09	10,000	2.9E-08	10,000	4.7E-07	10,000	1.8E-05	10,000	1.0E-04	10,000
Pb-210	N/A	3.7E-09	10,000	2.0E-08	10,000	3.8E-08	10,000	1.8E-07	10,000	8.4E-07	10,000
Pd-107	N/A	2.5E-09	9,866	3.5E-07	9,806	5.2E-05	9,718	8.8E-04	9,952	1.2E-03	9,990
Pu-238	Total α	<1.0E-30	6,390	<1.0E-30	8,890	<1.0E-30	8,298	<1.0E-30	7,940	<1.0E-30	7,806
Pu-239	Total α	1.6E-22	10,000	1.3E-22	10,000	6.6E-19	10,000	4.7E-16	10,000	3.2E-15	10,000
Pu-240	Total α	2.7E-23	10,000	2.1E-23	10,000	2.7E-19	10,000	9.9E-16	10,000	3.0E-15	10,000
Pu-241	300	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	7.0E-27	10,000	6.3E-26	10,000
Pu-242	Total α	6.3E-25	10,000	5.0E-25	10,000	7.8E-21	10,000	3.1E-17	10,000	8.3E-17	10,000
Pu-244	Total α	3.0E-28	10,000	2.4E-28	10,000	2.5E-23	10,000	9.7E-20	10,000	8.7E-20	10,000
Ra-226	Total α/Ra	1.4E-06	10,000	7.8E-06	10,000	1.4E-05	9,998	6.8E-05	10,000	3.2E-04	10,000
Ra-228	Total Ra	6.4E-25	10,000	5.9E-24	10,000	4.5E-20	10,000	4.6E-17	10,000	5.8E-16	10,000
Rn-222	N/A	1.4E-06	10,000	7.8E-06	10,000	1.4E-05	9,998	6.8E-05	10,000	3.2E-04	10,000

Table A-3: Radiological 100-Meter Concentrations for Gordon Aquifer (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Se-79	N/A	<1.0E-30	10,000	<1.0E-30	10,000	1.1E-28	10,000	7.9E-22	10,000	1.2E-20	10,000
Sm-151	1,000	<1.0E-30	5,750	<1.0E-30	5,882	<1.0E-30	5,080	<1.0E-30	4,514	<1.0E-30	4,526
Sn-126	N/A	<1.0E-30	10,000	<1.0E-30	10,000	<1.0E-30	10,000	3.8E-33	10,000	<1.0E-30	10,000
Sr-90	8	1.4E-17	1,240	1.5E-16	1,218	1.5E-15	1,152	1.5E-15	1,142	1.2E-14	1,088
Tc-99	900	2.2E-03	1,078	1.2E-02	1,074	2.0E-02	1,080	2.6E-02	1,078	3.1E-02	1,076
Th-228	Total α	6.4E-25	10,000	5.9E-24	10,000	4.5E-20	10,000	4.6E-17	10,000	5.8E-16	10,000
Th-229	Total α	3.2E-10	9,998	1.8E-09	10,000	2.8E-09	10,000	5.0E-09	10,000	1.2E-08	10,000
Th-230	Total α	2.2E-20	10,000	9.8E-20	10,000	4.9E-16	10,000	1.3E-12	10,000	2.8E-11	10,000
Th-232	Total α	2.1E-27	10,000	9.6E-27	10,000	1.4E-22	10,000	1.8E-19	10,000	1.8E-18	10,000
U-232	Total U*	<1.0E-30	5,108	<1.0E-30	3,742	<1.0E-30	3,198	<1.0E-30	2,860	<1.0E-30	2,814
U-233	Total U*	6.2E-09	10,000	3.2E-08	10,000	5.1E-08	10,000	1.3E-07	10,000	4.1E-07	10,000
U-234	Total U*	3.0E-17	10,000	1.5E-16	10,000	6.4E-13	10,000	1.4E-09	10,000	2.8E-08	10,000
U-235	Total U*	2.9E-19	10,000	1.5E-18	10,000	1.3E-14	10,000	1.0E-11	10,000	3.5E-11	10,000
U-236	Total U*	5.5E-19	10,000	2.8E-18	10,000	3.5E-14	10,000	3.6E-11	10,000	3.4E-10	10,000
U-238	Total U*	1.4E-17	10,000	7.1E-17	10,000	4.0E-14	10,000	1.5E-12	10,000	6.8E-12	10,000
Zr-93	N/A	<1.0E-30	10,000	<1.0E-30	10,000	7.5E-29	10,000	3.5E-23	10,000	1.7E-22	10,000

Table A-3: Radiological 100-Meter Concentrations for Gordon Aquifer (Continued)

Radionuclide	MCL (pCi/L)**	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Sum of beta-gamma MCL fractions		2.5E-06	N/A	1.4E-05	N/A	2.4E-05	N/A	6.0E-05	N/A	1.1E-04	N/A
Total Alpha	15	3.1E-06	N/A	1.7E-05	N/A	3.1E-05	N/A	1.8E-04	N/A	8.6E-04	N/A
Total Ra	5	1.4E-06	N/A	7.8E-06	N/A	1.4E-05	N/A	6.8E-05	N/A	3.2E-04	N/A

* Total uranium is evaluated in Tables A-4 through A-6.

** MCL values for beta and photon emitters are calculated in Table II-3 of FR-00-9654 based on a beta-gamma dose of 4 mrem/yr.

Table A-4: Chemical 100-Meter Concentrations for UTR-UZ

Chemical	MCL (μg/L)	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs
Ag	N/A	5.96E-04	8,898	1.13E-03	8,538	4.23E-02	6,784	6.95E-01	5,916	9.08E-01	5,776
As	1.0E+01	8.14E-06	10,000	1.63E-05	10,000	1.73E-04	10,000	1.84E-03	9,452	2.23E-03	9,232
Ba	2.0E+03	5.39E-03	1,714	9.39E-03	1,690	5.02E-02	4,974	3.95E-01	4,910	3.76E-01	6,408
Cd	5.0E+00	2.30E-02	1,414	3.94E-02	1,394	5.48E-02	7,326	2.19E+00	7,250	3.20E+00	7,258
Cr	1.0E+02	8.71E-03	1,416	1.53E-02	1,406	3.12E-02	4,740	4.04E-01	4,694	5.11E-01	4,686
Cu	1.0E+03	6.47E-04	6,342	1.14E-03	6,226	2.74E-02	6,246	4.17E-01	5,536	5.31E-01	5,418
F	2.0E+03	8.60E-02	564	1.48E-01	562	1.62E+00	3,842	1.01E+01	3,838	3.48E+00	3,840
Fe	3.0E+02	6.57E-06	10,000	4.47E-06	10,000	7.28E-03	10,000	1.45E+00	10,000	2.78E+00	10,000
Hg	2.0E+00	7.86E-23	10,000	5.72E-20	10,000	4.80E-11	10,000	1.66E-06	10,000	1.31E-06	10,000
Mn	5.0E+01	1.29E-02	5,236	2.38E-02	5,636	1.07E+00	5,276	2.73E+01	5,110	3.90E+01	5,076
$NO_2 + NO_3$	1.0E+04	3.31E+00	564	5.72E+00	562	1.60E+01	3,658	1.23E+02	3,654	9.82E+00	3,656
Ni	N/A	2.99E-01	2,066	5.11E-01	2,036	4.90E-01	2,008	4.43E-01	1,876	2.91E-01	1,668
Pb	1.5E+01	1.25E-31	10,000	2.72E-29	10,000	2.31E-17	10,000	8.87E-11	10,000	2.03E-10	10,000
Sb	6.0E+00	4.44E-35	10,000	9.41E-33	10,000	7.36E-20	10,000	1.35E-12	10,000	6.27E-15	10,000
Se	5.0E+01	3.23E-27	10,000	2.18E-24	10,000	8.92E-15	10,000	8.39E-10	10,000	5.70E-10	10,000
U	3.0E+01	2.98E-06	10,000	2.24E-06	10,000	4.69E-05	10,000	1.57E-03	10,000	1.70E-03	10,000
Zn	5.0E+03	3.02E-04	10,000	6.37E-04	10,000	2.50E-02	9,478	4.05E-01	8,002	5.26E-01	7,762

Table A-5: Chemical 100-Meter Concentrations for UTR-LZ

Chemical	MCL (μg/L)	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs
Ag	N/A	6.46E-04	9,210	1.41E-03	9,016	3.06E-02	7,356	4.77E-01	6,454	7.16E-01	6,290
As	1.0E+01	3.67E-06	10,000	9.23E-06	10,000	9.06E-05	10,000	1.55E-03	10,000	2.51E-03	9,932
Ba	2.0E+03	5.84E-03	1,736	1.11E-02	1,724	3.85E-02	5,026	3.61E-01	4,950	3.64E-01	4,946
Cd	5.0E+00	2.50E-02	1,434	4.64E-02	1,440	4.81E-02	1,432	1.47E+00	7,282	3.69E+00	7,266
Cr	1.0E+02	9.46E-03	1,436	1.82E-02	1,446	2.24E-02	4,780	3.25E-01	4,728	5.20E-01	4,720
Cu	1.0E+03	6.72E-04	7,132	1.33E-03	7,272	1.99E-02	6,728	2.94E-01	5,988	4.09E-01	5,852
F	2.0E+03	9.27E-02	564	1.72E-01	564	1.31E+00	3,842	1.04E+01	3,840	6.49E+00	3,840
Fe	3.0E+02	2.62E-07	10,000	2.26E-07	10,000	3.82E-04	10,000	1.77E-01	10,000	4.74E-01	10,000
Hg	2.0E+00	2.61E-26	10,000	4.38E-23	10,000	6.64E-14	10,000	5.57E-09	10,000	8.26E-09	10,000
Mn	5.0E+01	1.41E-02	5,340	3.10E-02	5,720	7.35E-01	5,414	1.84E+01	5,228	4.07E+01	5,182
$NO_2 + NO_3$	1.0E+04	3.59E+00	564	6.68E+00	564	1.06E+01	3,660	1.12E+02	3,656	3.83E+01	3,658
Ni	N/A	3.26E-01	2,102	6.10E-01	2,118	6.32E-01	2,102	5.95E-01	2,098	4.99E-01	2,048
Pb	1.5E+01	1.56E-36	10,000	7.07E-34	10,000	6.95E-22	10,000	4.66E-15	10,000	5.28E-14	10,000
Sb	6.0E+00	1.64E-40	10,000	5.28E-38	10,000	4.97E-25	10,000	1.42E-17	10,000	4.45E-19	10,000
Se	5.0E+01	5.14E-31	10,000	7.74E-28	10,000	5.61E-18	10,000	1.28E-12	10,000	1.84E-12	10,000
U	3.0E+01	1.20E-07	10,000	1.12E-07	10,000	9.81E-06	10,000	3.46E-04	10,000	4.45E-04	10,000
Zn	5.0E+03	1.36E-04	10,000	3.58E-04	10,000	1.73E-02	10,000	2.79E-01	8,926	4.07E-01	8,620

Table A-6: Chemical 100-Meter Concentrations for Gordon Aquifer

Chemical	MCL (μg/L)	Sector A		Sector B		Sector C		Sector D		Sector E	
		Concen-tration (μg/L)	Year Peak Contri-bution Occurs	Concen-tration (μg/L)	Year Peak Contri-bution Occurs	Concen-tration (μg/L)	Year Peak Contri-bution Occurs	Concen-tration (μg/L)	Year Peak Contri-bution Occurs	Concen-tration (μg/L)	Year Peak Contri-bution Occurs
Ag	N/A	1.46E-09	10,000	8.53E-09	10,000	9.93E-08	10,000	1.78E-06	10,000	4.19E-06	10,000
As	1.0E+01	2.37E-13	10,000	1.75E-12	10,000	1.57E-11	10,000	6.13E-10	10,000	1.84E-09	10,000
Ba	2.0E+03	1.76E-07	4,324	9.79E-07	4,308	5.22E-06	9,996	7.14E-05	10,000	1.15E-04	9,996
Cd	5.0E+00	8.41E-07	3,038	4.66E-06	3,018	9.30E-06	10,000	2.77E-04	10,000	1.58E-03	10,000
Cr	1.0E+02	3.17E-07	3,038	1.77E-06	3,006	4.39E-06	8,930	6.44E-05	9,766	1.77E-04	9,892
Cu	1.0E+03	1.16E-08	10,000	6.50E-08	10,000	3.29E-07	10,000	4.16E-06	10,000	9.02E-06	10,000
F	2.0E+03	7.69E-06	614	4.25E-05	614	4.96E-04	3,998	6.23E-03	3,994	7.53E-03	3,994
Fe	3.0E+02	5.47E-17	10,000	2.71E-16	10,000	3.59E-13	10,000	3.76E-10	10,000	1.66E-09	10,000
Hg	2.0E+00	9.83E-40	10,000	3.77E-35	10,000	7.01E-26	10,000	1.24E-20	10,000	4.34E-20	10,000
Mn	5.0E+01	1.23E-07	10,000	7.07E-07	10,000	2.06E-06	10,000	2.35E-05	10,000	8.93E-05	10,000
$NO_2 + NO_3$	1.0E+04	2.99E-04	614	1.65E-03	614	2.75E-03	614	1.05E-02	3,716	1.11E-02	3,716
Ni	N/A	8.47E-06	6,746	4.69E-05	6,666	7.81E-05	6,714	8.52E-05	6,760	8.82E-05	6,880
Pb	1.5E+01	2.57E-53	10,000	4.07E-49	10,000	2.37E-37	10,000	4.82E-30	10,000	7.08E-29	10,000
Sb	6.0E+00	5.73E-58	10,000	5.37E-54	10,000	9.29E-41	10,000	4.91E-33	10,000	6.08E-33	10,000
Se	5.0E+01	6.56E-45	10,000	2.69E-40	10,000	1.97E-30	10,000	7.88E-25	10,000	1.49E-23	10,000
U	3.0E+01	4.59E-17	10,000	2.32E-16	10,000	1.31E-13	10,000	4.51E-12	10,000	3.86E-11	10,000
Zn	5.0E+03	8.79E-12	10,000	6.65E-11	10,000	3.21E-09	10,000	2.06E-07	10,000	5.68E-07	10,000

Table A-7: Upper Three Runs Seepline Sensitivity Run Radionuclide Concentrations

Radionuclide	Peak Seepline Concentration in 10,000 Yrs (pCi/L)	Location of Largest Contributor (Sector)	Year Largest Contribution in 10,000 Years Occurs
Ac-227	1.6E-05	UTR-LZ	6,220
Am-241	<1.0E-30	UTR-LZ	10,000
Am-243	1.4E-29	UTR-LZ	10,000
C-14	5.1E+00	UTR-LZ	5,500
Cm-244	<1.0E-30	UTR-LZ	1,452
Cs-135	2.1E-02	UTR-LZ	10,000
I-129	3.4E-03	UTR-LZ	3,820
Np-237	8.1E-02	UTR-LZ	6,166
Pa-231	2.1E-02	UTR-LZ	6.176
Pb-210	1.4E-04	UTR-LZ	10,000
Pu-238	<1.0E-30	UTR-LZ	8,060
Pu-239	1.8E-15	UTR-LZ	10,000
Pu-240	1.1E-15	UTR-LZ	10,000
Ra-226	5.3E-02	UTR-LZ	10,000
Ra-228	3.4E-17	UTR-LZ	10,000
Rn-222	5.3E-02	UTR-LZ	10,000
Tc-99	5.9E+00	UTR-LZ	798
Th-228	3.4E-17	UTR-LZ	10,000
Th-229	2.8E-07	UTR-LZ	10,000
Th-230	5.4E-13	UTR-LZ	10,000
Th-232	2.4E-20	UTR-LZ	10,000
U-233	5.8E-06	UTR-LZ	10,000
U-234	7.7E-10	UTR-LZ	10,000
U-235	1.4E-12	UTR-LZ	10,000
U-236	6.3E-12	UTR-LZ	10,000

Table A-8: Fourmile Branch Seepline Sensitivity Run Radionuclide Concentrations

Radionuclide	Peak Seepline Concentration in 10,000 Yrs (pCi/L)	Location of Largest Contributor (Sector)	Year Largest Contribution in 10,000 Years Occurs
Ac-227	3.3E-07	UTR-UZ	6,266
Am-241	2.7E-30	UTR-UZ	10,000
Am-243	6.8E-26	UTR-UZ	10.000
C-14	6.2E-01	UTR-UZ	5,582
Cm-244	<1.0E-30	UTR-UZ	1,296
Cs-135	2.4E-03	UTR-UZ	10,000
I-129	2.7E-04	UTR-UZ	3,828
Np-237	9.5E-03	UTR-UZ	1,694
Pa-231	4.3E-04	UTR-UZ	6,228
Pb-210	1.8E-05	UTR-UZ	2,200
Pu-238	<1.0E-30	UTR-UZ	5,934
Pu-239	1.0E-12	UTR-UZ	10,000
Pu-240	1.8E-13	UTR-UZ	10,000
Ra-226	7.1E-03	UTR-UZ	2,172
Ra-228	8.2E-18	UTR-UZ	10,000
Rn-222	7.1E-03	UTR-UZ	2,172
Tc-99	5.4E+00	UTR-UZ	826
Th-228	8.2E-18	UTR-UZ	10,000
Th-229	2.8E-08	UTR-UZ	10,000
Th-230	3.0E-13	UTR-UZ	10,000
Th-232	1.3E-20	UTR-UZ	10,000
U-233	2.9E-07	UTR-UZ	10,000
U-234	3.3E-10	UTR-UZ	10,000
U-235	2.3E-12	UTR-UZ	10,000
U-236	2.6E-12	UTR-UZ	10,000

Table A-9: Radiological 1-Meter Concentrations for UTR-UZ

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Ac-227	8.0E-08	1,714	1.4E-05	6,122	3.4E-03	6,098	1.2E-08	6,106
Al-26	1.7E-25	10,000	8.8E-11	10,000	2.2E-06	10,000	5.3E-18	10,000
Am-241	3.5E-25	10,000	3.1E-08	10,000	6.1E-04	10,000	9.8E-15	10,000
Am-242m	<1.0E-30	8,290	8.8E-28	7,020	2.9E-21	6,626	<1.0E-30	7,990
Am-243	4.8E-23	10,000	7.1E-08	10,000	7.0E-02	10,000	8.7E-13	10,000
C-14	2.6E-03	2,178	1.7E+02	4,142	3.5E+03	4,016	1.9E-03	4,214
Cf-249	<1.0E-30	10,000	5.3E-17	9,786	1.0E-12	8,496	9.1E-24	10,000
Cl-36	2.2E-05	10,000	3.1E-02	3,680	1.3E+00	3,676	4.1E-06	3,680
Cm-243	<1.0E-30	1,828	<1.0E-30	1,302	<1.0E-30	1,188	<1.0E-30	1,416
Cm-244	<1.0E-30	1,294	<1.0E-30	978	<1.0E-30	928	<1.0E-30	1,048
Cm-245	2.0E-25	10,000	2.6E-08	10,000	5.2E-04	10,000	7.6E-15	10,000
Cm-247	1.5E-29	10,000	4.7E-11	10,000	5.1E-07	10,000	3.0E-18	10,000
Cm-248	6.5E-28	10,000	2.1E-09	10,000	2.2E-05	10,000	1.3E-16	10,000
Co-60	<1.0E-30	358	<1.0E-30	370	<1.0E-30	126	<1.0E-30	326
Cs-135	2.1E-03	6,902	1.3E+00	5,388	3.0E+01	4,826	7.8E-05	6,590
Cs-137	1.3E-24	1,918	5.6E-15	918	2.0E-11	786	7.9E-21	1,040
Eu-152	<1.0E-30	1,002	<1.0E-30	782	<1.0E-30	728	<1.0E-30	832
Eu-154	<1.0E-30	420	<1.0E-30	288	<1.0E-30	236	<1.0E-30	324

Table A-9: Radiological 1-Meter Concentrations for UTR-UZ (Continued)

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
H-3	7.1E-12	552	1.7E-11	204	1.9E-08	196	2.8E-12	158
I-129	8.2E-04	576	2.4E-02	3,790	4.6E-01	3,786	3.8E-05	536
K-40	5.0E-06	10,000	1.6E-01	4,104	2.9E+01	3,924	7.0E-05	4,112
Nb-93m	1.5E-06	10,000	1.6E+01	10,000	1.1E+03	9,994	2.9E-03	10,000
Nb-94	1.2E+00	556	2.0E+00	556	1.9E+00	556	4.6E-02	554
Ni-59	1.6E+00	1,792	2.7E+00	1,884	7.7E+01	7,188	5.8E-02	1,692
Ni-63	4.3E-03	1,378	7.6E-03	1,178	2.5E-01	1,056	1.6E-03	1,102
Np-237	1.5E-01	1,564	2.6E-01	1,574	1.7E+01	6,034	5.6E-03	1,556
Pa-231	1.1E-04	1,684	1.9E-02	6,062	4.6E+00	6,038	1.6E-05	6,052
Pb-210	4.6E-04	1,634	7.7E-04	1,650	3.8E-02	10,000	1.8E-05	1,592
Pd-107	3.0E-07	4,962	1.4E+01	4,764	2.9E+02	4,686	3.9E-04	4,810
Pu-238	3.6E-28	4,738	9.9E-24	6,452	5.1E-18	6,214	3.5E-24	4,178
Pu-239	3.3E-04	10,000	3.0E-03	10,000	5.2E+00	10,000	2.1E-03	10,000
Pu-240	5.6E-05	10,000	6.9E-03	10,000	4.0E+00	10,000	2.4E-04	10,000
Pu-241	1.0E-24	10,000	1.2E-07	10,000	2.3E-03	10,000	3.8E-14	10,000
Pu-242	1.3E-06	10,000	2.1E-04	10,000	8.8E-02	10,000	8.1E-07	10,000
Pu-244	6.2E-10	10,000	7.7E-07	10,000	1.5E-04	10,000	3.8E-09	10,000
Ra-226	1.8E-01	1,606	3.0E-01	1,624	1.5E+01	10,000	6.9E-03	1,560
Ra-228	3.4E-11	10,000	9.4E-09	10,000	1.3E-05	10,000	2.9E-11	10,000
Rn-222	1.8E-01	1,606	3.0E-01	1,624	1.5E+01	10,000	6.9E-03	1,560

Table A-9: Radiological 1-Meter Concentrations for UTR-UZ (Continued)

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Se-79	2.2E-19	10,000	4.5E-07	10,000	2.9E-01	10,000	5.5E-14	10,000
Sm-151	<1.0E-30	5,942	<1.0E-30	2,688	1.0E-24	2,422	<1.0E-30	3,356
Sn-126	1.7E-29	10,000	2.5E-11	10,000	5.0E-04	10,000	9.6E-20	10,000
Sr-90	6.4E-08	954	4.3E-07	958	4.0E-05	898	1.8E-07	912
Tc-99	9.3E+01	714	1.6E+02	728	1.1E+03	678	3.4E+00	708
Th-228	3.4E-11	10,000	9.4E-09	10,000	1.3E-05	10,000	2.9E-11	10,000
Th-229	1.4E-05	10,000	6.1E-04	10,000	2.9E-01	10,000	4.0E-06	10,000
Th-230	1.2E-06	10,000	2.1E-04	10,000	6.4E-01	10,000	1.6E-06	10,000
Th-232	1.2E-13	10,000	4.2E-11	10,000	4.9E-08	10,000	1.4E-13	10,000
U-232	<1.0E-30	3,828	1.4E-24	1,764	1.3E-19	1,470	1.7E-28	3,416
U-233	6.7E-04	10,000	1.9E-02	10,000	4.7E+00	9,138	9.0E-05	9,912
U-234	5.6E-04	10,000	8.4E-02	10,000	9.5E+01	9,122	3.6E-04	10,000
U-235	5.5E-06	10,000	9.1E-04	10,000	9.8E-02	10,000	4.4E-06	9,864
U-236	1.1E-05	10,000	2.4E-03	10,000	1.7E+00	10,000	6.1E-06	10,000
U-238	2.6E-04	10,000	1.1E-03	10,000	2.5E-02	8,484	1.9E-04	9,762
Zr-93	2.6E-23	10,000	3.2E-06	10,000	2.7E-02	10,000	1.5E-12	10,000

Table A-10: Radiological 1-Meter Concentrations for UTR-LZ

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Ac-227	2.7E-08	1,722	6.6E-06	6,122	1.6E-03	6,104	2.1E-07	6,108
Al-26	3.5E-30	10,000	1.3E-14	10,000	1.1E-09	10,000	8.8E-16	10,000
Am-241	1.7E-29	10,000	1.5E-11	10,000	9.1E-07	10,000	1.3E-12	10,000
Am-242m	<1.0E-30	9,182	<1.0E-30	7,940	1.1E-25	7,422	<1.0E-30	7,814
Am-243	2.2E-27	10,000	3.0E-11	10,000	9.0E-05	10,000	1.2E-10	10,000
C-14	8.8E-04	2,284	6.6E+01	4,224	1.0E+03	4,100	3.5E-02	4,202
Cf-249	<1.0E-30	10,000	2.4E-20	10,000	8.9E-16	10,000	1.2E-21	10,000
Cl-36	7.1E-06	10,000	1.3E-02	3,682	6.1E-01	3,678	7.8E-05	3,680
Cm-243	<1.0E-30	1,996	<1.0E-30	1,532	<1.0E-30	1,378	<1.0E-30	1,494
Cm-244	<1.0E-30	1,416	<1.0E-30	1,120	<1.0E-30	1,024	<1.0E-30	1,098
Cm-245	9.0E-30	10,000	1.2E-11	10,000	7.4E-07	10,000	9.9E-13	10,000
Cm-247	<1.0E-30	10,000	2.1E-14	10,000	2.9E-10	10,000	3.9E-16	10,000
Cm-248	<1.0E-30	10,000	9.4E-13	10,000	1.3E-08	10,000	1.7E-14	10,000
Co-60	<1.0E-30	376	<1.0E-30	386	<1.0E-30	354	<1.0E-30	350
Cs-135	7.2E-04	7,608	4.7E-01	5,780	8.1E+00	5,216	8.1E-04	5,696
Cs-137	4.6E-27	2,026	3.2E-17	1,028	9.4E-14	946	4.8E-19	1,008
Eu-152	<1.0E-30	1,088	<1.0E-30	882	<1.0E-30	814	<1.0E-30	866
Eu-154	<1.0E-30	496	<1.0E-30	364	<1.0E-30	300	<1.0E-30	352

Table A-10: Radiological 1-Meter Concentrations for UTR-LZ (Continued)

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
H-3	2.1E-12	554	1.0E-11	164	3.7E-09	200	1.6E-11	158
I-129	2.8E-04	578	9.9E-03	3,790	2.1E-01	3,786	2.3E-04	536
K-40	1.5E-06	10,000	6.6E-02	4,190	1.2E+01	4,006	1.3E-03	4,094
Nb-93m	7.6E-07	10,000	6.2E+00	10,000	4.8E+02	10,000	5.6E-02	10,000
Nb-94	4.1E-01	558	1.1E+00	560	1.1E+00	560	1.4E-01	558
Ni-59	5.3E-01	1,874	1.5E+00	1,970	2.8E+01	7,250	3.1E-01	1,172
Ni-63	8.7E-04	1,446	4.4E-03	1,212	5.3E-02	1,104	9.5E-03	1,108
Np-237	5.1E-02	1,570	1.5E-01	1,582	7.4E+00	6,038	2.1E-02	686
Pa-231	3.6E-05	1,688	8.8E-03	6,066	2.1E+00	6,038	2.8E-04	6,052
Pb-210	1.5E-04	1,674	4.2E-04	1,702	1.8E-02	10,000	8.6E-05	1,034
Pd-107	1.9E-07	5,024	5.2E+00	4,818	8.4E+01	4,740	7.3E-03	4,800
Pu-238	<1.0E-30	5,142	8.8E-27	6,900	6.3E-21	6,622	4.1E-26	4,612
Pu-239	8.6E-06	10,000	1.4E-04	10,000	3.5E-01	10,000	5.4E-03	10,000
Pu-240	1.5E-06	10,000	2.5E-04	10,000	2.1E-01	10,000	6.3E-04	10,000
Pu-241	5.1E-29	10,000	5.8E-11	10,000	3.5E-06	10,000	4.8E-12	10,000
Pu-242	3.4E-08	10,000	7.8E-06	10,000	4.6E-03	10,000	2.1E-06	10,000
Pu-244	1.6E-11	10,000	2.8E-08	10,000	8.1E-06	10,000	9.8E-09	10,000
Ra-226	5.9E-02	1,650	1.6E-01	1,672	6.8E+00	10,000	3.6E-02	1,004
Ra-228	2.3E-12	10,000	1.2E-09	10,000	1.9E-06	10,000	2.2E-10	10,000
Rn-222	5.9E-02	1,650	1.6E-01	1,672	6.8E+00	10,000	3.6E-02	1,004

Table A-10: Radiological 1-Meter Concentrations for UTR-LZ (Continued)

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Se-79	1.6E-23	10,000	7.0E-10	10,000	7.4E-04	10,000	5.5E-12	10,000
Sm-151	<1.0E-30	6,570	<1.0E-30	3,324	6.3E-30	2,892	<1.0E-30	3,242
Sn-126	<1.0E-30	10,000	3.5E-16	10,000	1.1E-08	10,000	2.5E-17	10,000
Sr-90	9.2E-09	986	1.6E-07	986	5.5E-06	926	9.4E-07	928
Tc-99	3.2E+01	724	9.2E+01	728	5.7E+02	686	2.0E+01	616
Th-228	2.3E-12	10,000	1.2E-09	10,000	1.9E-06	10,000	2.2E-10	10,000
Th-229	1.0E-06	10,000	7.1E-05	10,000	6.4E-02	10,000	2.4E-05	10,000
Th-230	7.8E-08	10,000	2.2E-05	10,000	1.3E-01	10,000	1.2E-05	10,000
Th-232	8.0E-15	10,000	4.6E-12	10,000	8.3E-09	10,000	1.0E-12	10,000
U-232	<1.0E-30	4,132	1.5E-27	2,112	7.5E-23	1,844	9.8E-29	2,068
U-233	5.3E-05	10,000	3.2E-03	10,000	1.8E+00	10,000	6.2E-04	10,000
U-234	4.2E-05	10,000	1.1E-02	10,000	3.5E+01	10,000	3.5E-03	10,000
U-235	4.2E-07	10,000	1.4E-04	10,000	2.3E-02	10,000	2.7E-05	10,000
U-236	8.2E-07	10,000	3.8E-04	10,000	4.7E-01	10,000	5.3E-05	10,000
U-238	2.0E-05	10,000	3.1E-04	10,000	6.5E-03	9,836	1.2E-03	9,950
Zr-93	8.3E-27	10,000	3.5E-09	10,000	8.0E-05	10,000	1.6E-10	10,000

Table A-11: Radiological 1-Meter Concentrations for Gordon Aquifer

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Ac-227	8.1E-13	10,000	2.2E-10	10,000	2.7E-08	10,000	5.8E-11	10,000
Al-26	<1.0E-30	10,000	6.7E-29	10,000	2.9E-23	10,000	9.3E-28	10,000
Am-241	<1.0E-30	10,000	6.0E-27	10,000	1.7E-21	10,000	9.8E-26	10,000
Am-242m	<1.0E-30	10,000	<1.0E-30	9,260	<1.0E-30	8,584	<1.0E-30	9,044
Am-243	<1.0E-30	10,000	1.1E-26	10,000	1.5E-19	10,000	8.0E-24	10,000
C-14	2.9E-10	9,998	2.8E-06	9,998	2.5E-05	9,990	2.3E-08	9,990
Cf-249	<1.0E-30	10,000	<1.0E-30	10,000	1.7E-30	10,000	<1.0E-30	10,000
Cl-36	1.2E-09	10,000	8.5E-07	3,784	3.2E-05	3,778	6.4E-08	3,778
Cm-243	<1.0E-30	2,284	<1.0E-30	1,818	<1.0E-30	1,662	<1.0E-30	1,776
Cm-244	<1.0E-30	1,598	<1.0E-30	1,300	<1.0E-30	1,200	<1.0E-30	1,274
Cm-245	<1.0E-30	10,000	4.7E-27	10,000	1.4E-21	10,000	7.7E-26	10,000
Cm-247	<1.0E-30	10,000	8.5E-30	10,000	5.6E-25	10,000	3.0E-29	10,000
Cm-248	<1.0E-30	10,000	3.7E-28	10,000	2.5E-23	10,000	1.3E-27	10,000
Co-60	<1.0E-30	418	<1.0E-30	420	<1.0E-30	190	<1.0E-30	392
Cs-135	4.9E-10	10,000	2.1E-07	10,000	2.5E-06	10,000	6.0E-09	10,000
Cs-137	<1.0E-30	2,288	2.4E-29	1,242	5.8E-26	1,142	2.9E-29	1,200
Eu-152	<1.0E-30	1,204	<1.0E-30	1,004	<1.0E-30	936	<1.0E-30	986
Eu-154	<1.0E-30	586	<1.0E-30	460	<1.0E-30	392	<1.0E-30	446

Table A-11: Radiological 1-Meter Concentrations for Gordon Aquifer (Continued)

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
H-3	8.1E-18	576	3.7E-16	184	7.7E-15	222	1.1E-16	178
I-129	5.5E-09	746	6.1E-07	4,070	1.1E-05	4,054	2.2E-08	4,052
K-40	2.6E-12	10,000	1.4E-07	10,000	1.3E-05	9,990	2.8E-08	10,000
Nb-93m	1.2E-11	9,998	8.5E-05	10,000	4.9E-03	10,000	1.0E-05	9,996
Nb-94	8.9E-06	612	2.2E-04	610	2.1E-04	608	2.5E-05	604
Ni-59	3.6E-06	6,830	9.2E-05	7,200	4.8E-04	10,000	1.1E-05	5,790
Ni-63	3.2E-11	1,744	8.2E-10	1,558	1.3E-09	1,414	3.5E-10	1,374
Np-237	3.9E-07	7,554	1.0E-05	8,268	1.3E-04	10,000	1.3E-06	10,000
Pa-231	1.0E-09	10,000	2.7E-07	10,000	3.4E-05	10,000	7.5E-08	10,000
Pb-210	8.8E-10	10,000	2.4E-08	10,000	2.8E-07	10,000	3.3E-09	10,000
Pd-107	1.5E-12	9,966	2.3E-05	9,346	2.6E-04	9,246	4.3E-07	9,132
Pu-238	<1.0E-30	5,942	<1.0E-30	7,612	<1.0E-30	7,250	<1.0E-30	7,490
Pu-239	4.8E-18	10,000	3.6E-16	10,000	2.7E-13	10,000	1.3E-14	10,000
Pu-240	8.2E-19	10,000	1.7E-16	10,000	1.4E-13	10,000	1.5E-15	10,000
Pu-241	<1.0E-30	10,000	2.1E-26	10,000	6.6E-21	10,000	4.0E-25	10,000
Pu-242	1.9E-20	10,000	4.9E-18	10,000	3.1E-15	10,000	6.0E-18	10,000
Pu-244	9.2E-24	10,000	1.3E-20	10,000	7.1E-18	10,000	2.8E-20	10,000
Ra-226	3.3E-07	10,000	9.1E-06	10,000	1.1E-04	10,000	1.3E-06	9,998
Ra-228	1.6E-21	10,000	1.5E-18	10,000	3.4E-15	10,000	5.9E-18	10,000
Rn-222	3.3E-07	10,000	9.1E-06	10,000	1.1E-04	10,000	1.3E-06	9,998

Table A-11: Radiological 1-Meter Concentrations for Gordon Aquifer (Continued)

Radionuclide	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs	Concentration (pCi/L)	Year Peak Contribution Occurs
Se-79	<1.0E-30	10,000	1.0E-22	10,000	1.3E-16	10,000	1.3E-22	10,000
Sm-151	<1.0E-30	7,430	<1.0E-30	4,198	<1.0E-30	3,736	<1.0E-30	4,062
Sn-126	<1.0E-30	10,000	<1.0E-30	10,000	3.2E-25	10,000	<1.0E-30	10,000
Sr-90	5.8E-17	1,088	5.0E-15	1,098	1.9E-14	1,056	7.4E-15	1,034
Tc-99	5.0E-04	1,108	1.2E-02	1,056	1.6E-02	1,036	1.5E-03	1,026
Th-228	1.6E-21	10,000	1.5E-18	10,000	3.4E-15	10,000	5.9E-18	10,000
Th-229	7.1E-11	10,000	1.8E-09	10,000	5.0E-09	10,000	2.3E-10	10,000
Th-230	7.7E-17	10,000	3.3E-14	10,000	3.1E-10	10,000	4.6E-13	10,000
Th-232	7.6E-24	10,000	7.1E-21	10,000	1.9E-17	10,000	2.8E-20	10,000
U-232	<1.0E-30	4,756	<1.0E-30	2,678	<1.0E-30	2,396	<1.0E-30	2,572
U-233	1.4E-09	10,000	3.3E-08	10,000	1.7E-07	10,000	4.2E-09	10,000
U-234	8.1E-14	10,000	3.4E-11	10,000	2.6E-07	10,000	3.7E-10	10,000
U-235	7.9E-16	10,000	4.9E-13	10,000	1.5E-10	10,000	6.3E-13	10,000
U-236	1.5E-15	10,000	1.3E-12	10,000	2.9E-09	10,000	4.2E-12	10,000
U-238	3.8E-14	10,000	2.7E-12	10,000	4.2E-11	10,000	2.3E-11	10,000
Zr-93	<1.0E-30	10,000	7.0E-23	10,000	6.5E-18	10,000	5.7E-22	10,000

Table A-12: Chemical 1-Meter Concentrations for UTR-UZ

Chemical	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs
Ag	1.74E-03	6,918	9.69E-02	5,878	5.05E+00	4,712	6.47E-05	3,734
As	4.25E-05	10,000	3.23E-04	8,566	1.51E-02	7,008	1.62E-06	9,474
Ba	1.50E-02	1,586	9.77E-02	4,904	1.57E+00	6,308	6.05E-04	998
Cd	6.48E-02	1,266	1.08E-01	1,302	1.75E+01	7,146	2.40E-03	1,228
Cr	2.43E-02	1,264	6.07E-02	4,678	2.82E+00	4,608	9.00E-04	1,228
Cu	2.16E-03	5,296	6.24E-02	5,498	2.86E+00	4,534	8.55E-05	4,938
F	2.47E-01	556	3.33E+00	3,838	3.60E+01	3,836	9.28E-03	554
Fe	1.85E-03	10,000	6.85E-01	10,000	2.12E+02	10,000	2.86E-03	9,946
Hg	2.79E-18	10,000	9.11E-06	10,000	6.94E-02	10,000	1.23E-11	10,000
Mn	3.42E-02	4,764	1.97E+00	5,052	2.47E+02	4,808	3.71E-03	1,776
$NO_2 + NO_3$	9.63E+00	556	2.88E+01	3,654	5.29E+02	3,650	3.62E-01	554
Ni	8.07E-01	1,800	1.37E+00	1,896	4.01E+00	1,126	3.73E-02	1,166
Pb	1.54E-26	10,000	6.16E-09	10,000	5.45E-03	10,000	7.48E-17	10,000
Sb	2.54E-33	10,000	2.35E-10	10,000	2.66E-05	10,000	1.86E-19	10,000
Se	2.22E-22	10,000	7.47E-09	10,000	2.14E-04	10,000	1.99E-14	10,000
U	8.56E-04	10,000	3.66E-03	10,000	1.43E-01	8,462	1.13E-03	9,784
Zn	1.57E-03	10,000	5.73E-02	7,960	2.93E+00	5,992	5.99E-05	9,488

Table A-13: Chemical 1-Meter Concentrations for UTR-LZ

Chemical	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs
Ag	5.81E-04	7,530	4.53E-02	6,332	1.37E+00	5,244	3.91E-04	3,786
As	1.24E-05	10,000	1.31E-04	9,620	6.30E-03	7,882	8.06E-06	5,572
Ba	5.00E-03	1,636	4.65E-02	4,928	5.47E-01	6,346	3.66E-03	1,002
Cd	2.18E-02	1,310	6.01E-02	1,360	7.66E+00	7,164	1.34E-02	922
Cr	8.17E-03	1,310	2.77E-02	4,710	1.05E+00	4,644	5.00E-03	922
Cu	7.00E-04	5,792	2.91E-02	5,882	7.42E-01	4,980	3.19E-04	3,262
F	8.23E-02	558	1.64E+00	3,838	1.47E+01	3,836	3.03E-02	534
Fe	1.46E-04	10,000	5.79E-02	10,000	3.29E+01	10,000	1.79E-02	10,000
Hg	6.14E-22	10,000	2.73E-08	10,000	4.45E-04	10,000	1.00E-09	10,000
Mn	1.16E-02	4,880	8.91E-01	5,168	9.56E+01	4,928	2.25E-02	1,790
$NO_2 + NO_3$	3.20E+00	558	1.15E+01	3,656	1.63E+02	3,652	1.18E+00	534
Ni	2.73E-01	1,876	7.76E-01	1,976	1.21E+00	1,166	2.26E-01	1,172
Pb	5.39E-31	10,000	2.95E-13	10,000	5.80E-07	10,000	1.60E-14	10,000
Sb	2.20E-38	10,000	2.18E-15	10,000	2.38E-10	10,000	5.59E-17	10,000
Se	1.65E-26	10,000	1.09E-11	10,000	8.63E-07	10,000	2.00E-12	10,000
U	6.43E-05	10,000	1.00E-03	10,000	3.75E-02	9,808	6.80E-03	9,978
Zn	4.59E-04	10,000	2.68E-02	8,722	7.65E-01	6,888	3.00E-04	5,576

Table A-14: Chemical 1-Meter Concentrations for Gordon Aquifer

Chemical	Sector 1A		Sector 1B		Sector 1C		Sector 1D	
	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs	Concentration (μg/L)	Year Peak Contribution Occurs
Ag	6.89E-10	10,000	8.96E-08	10,000	1.24E-06	10,000	4.57E-09	10,000
As	7.53E-13	10,000	3.28E-11	10,000	1.77E-09	10,000	1.22E-11	10,000
Ba	4.05E-08	4,592	2.66E-06	9,632	2.48E-05	9,662	1.26E-07	3,908
Cd	1.93E-07	3,146	5.12E-06	10,000	4.22E-04	10,000	9.70E-07	10,000
Cr	7.25E-08	3,154	2.42E-06	8,516	3.77E-05	9,336	2.27E-07	2,752
Cu	3.36E-09	10,000	2.45E-07	10,000	2.54E-06	10,000	1.52E-08	10,000
F	1.78E-06	612	2.79E-04	3,984	2.19E-03	3,978	5.40E-06	602
Fe	1.52E-13	10,000	3.42E-11	10,000	2.40E-08	10,000	1.91E-10	10,000
Hg	1.47E-35	10,000	1.06E-20	10,000	3.73E-16	10,000	5.87E-20	10,000
Mn	2.68E-08	10,000	1.29E-06	10,000	2.95E-05	10,000	1.63E-07	10,000
$NO_2 + NO_3$	6.92E-05	612	1.70E-03	610	2.55E-03	3,708	2.10E-04	602
Ni	1.95E-06	7,212	4.83E-05	6,500	4.77E-05	6,336	6.03E-06	6,042
Pb	3.19E-47	10,000	3.11E-29	10,000	8.59E-23	10,000	4.12E-28	10,000
Sb	5.75E-55	10,000	1.47E-31	10,000	1.48E-25	10,000	9.34E-31	10,000
Se	5.76E-41	10,000	1.43E-24	10,000	4.74E-19	10,000	4.54E-23	10,000
U	1.23E-13	10,000	8.68E-12	10,000	2.39E-10	10,000	1.33E-10	10,000
Zn	2.78E-11	10,000	9.81E-09	10,000	2.93E-07	10,000	6.89E-10	10,000

APPENDIX B

BETA-GAMMA PEAK CONCENTRATIONS RATIOED TO MCLS FOR INDIVIDUAL CONSTITUENTS RELATED BY TIMING AT THE 100-METER BOUNDARY

Appendix A Tables A-1 and A-2 provide a summary of beta-gamma MCL fractions summed by peak concentration in 10,000 years, regardless of timing. This approach provides conservative results as not all constituents peak at the same time within 10,000 years. Five radionuclides make up approximately 99 % of the beta-gamma inputs for the individual aquifers and sectors (C-14, I-129, Nb-93m, Ni-59, and Tc-99) within 10,000 years.

For this appendix, the peak concentrations for these five radionuclides were analyzed individually by time of occurrence against the concentration at the same time for the remaining radionuclides. For example, C-14 peaked in 10,000 years at 4,172 years. The remaining four radionuclides did not peak in that year, so the beta-gamma value at 4,172 years for each of these remaining radionuclides was added to the beta-gamma value for C-14 to produce an estimated beta-gamma value for the year 4,172, resulting in a beta-gamma MCL fraction of 41 % for the UTR-UZ Sector D (Table B-1).

Tables B-1 and B-2 present the beta-gamma peak concentrations in 10,000 years by aquifer ratio to MCLs for the five radionuclides that comprise the majority of the total beta-gamma contribution utilizing concurrent time for Sectors D and E, respectively.

Table B-1: Beta-Gamma Peak Concentrations in 10,000 Years Ratio to MCLs for Selected Individual Constituents Related by Timing for Sector D

Radio-nuclide	MCL (pCi/L)	UTR-LZ			UTR-UZ		
		Conc. (pCi/L)	Beta-gamma fraction	peak (yr)	conc (pCi/L)	Beta-gamma fraction	peak (yr)
C-14	2,000	6.7E+02	3.3E-01	4,264	7.8E+02	3.9E-01	4,172
I-129	1	1.9E-02	1.9E-02	4,264	1.8E-02	1.8E-02	4,172
Nb-93m	1,000	1.9E-06	1.9E-09	4,264	1.2E-06	1.2E-09	4,172
Ni-59	300	6.7E-02	2.2E-04	7,358	1.4E-04	4.5E-07	4,172
Tc-99	900	5.1E-01	5.7E-04	4,264	5.3E-01	5.9E-04	4,172
		Total	**3.5E-01**		**Total**	**4.1E-01**	
C-14	2,000	6.4E-02	3.2E-05	3,790	8.9E-01	4.5E-04	3,788
I-129	1	1.1E-01	1.1E-01	3,790	1.3E-01	1.3E-01	3,788
Nb-93m	1,000	4.9E-08	4.9E-11	3,790	6.3E-08	6.3E-11	3,788
Ni-59	300	7.4E-02	2.5E-04	3,790	1.2E-06	3.9E-09	3,788
Tc-99	900	6.0E-01	6.7E-04	3,790	4.9E-01	5.5E-04	3,788
		Total	**1.1E-01**		**Total**	**1.3E-01**	
C-14	2,000	7.2E-01	3.6E-04	10,000	7.4E-04	3.7E-07	9,998
I-129	1	1.5E-07	1.5E-07	10,000	4.9E-08	4.9E-08	9,998
Nb-93m	1,000	9.4E+01	9.4E-02	10,000	1.2E+02	1.2E-01	9,998
Ni-59	300	1.1E+00	3.8E-03	10,000	1.6E+00	5.4E-03	9,998
Tc-99	900	1.2E+00	1.3E-03	10,000	1.3E+00	1.4E-03	9,998
		Total	**9.9E-02**		**Total**	**1.3E-01**	
C-14	2,000	1.0E+00	5.2E-04	7,358	1.4E-01	6.8E-05	7,306
I-129	1	2.3E-05	2.3E-05	7,358	9.0E-07	9.0E-07	7,306
Nb-93m	1,000	4.1E+01	4.1E-02	7,358	5.1E+01	5.1E-02	7,306
Ni-59	300	7.8E+00	2.6E-02	7,358	1.2E+01	4.0E-02	7,306
Tc-99	900	9.0E-01	1.0E-03	7,358	9.8E-01	1.1E-03	7,306
		Total	**6.8E-02**		**Total**	**9.2E-02**	
C-14	2,000	6.2E-07	3.1E-10	704	2.9E-06	1.4E-09	694
I-129	1	7.8E-05	7.8E-05	704	5.4E-08	5.4E-08	694
Nb-93m	1,000	1.6E-16	1.6E-19	704	1.7E-16	1.7E-19	694
Ni-59	300	7.3E-16	2.4E-18	704	3.0E-15	1.0E-17	694
Tc-99	900	2.2E+02	2.4E-01	704	2.0E+02	2.2E-01	694
		Total	**2.4E-01**		**Total**	**2.2E-01**	

(Peak Radionuclide Indicated in Green Shading)

Table B-2: Beta-Gamma Peak Concentrations in 10,000 Years for Individual Selected Constituents Related by Timing for Sector E

Radio-nuclide	MCL (pCi/L)	UTR-LZ			UTR-UZ		
		Conc. (pCi/L)	Beta-gamma fraction	peak (yr)	conc (pCi/L)	Beta-gamma fraction	peak (yr)
C-14	2,000	2.6E+02	1.3E-01	4,310	1.3E+02	6.5E-02	4,222
I-129	1	2.3E-02	2.3E-02	4,310	9.1E-03	9.1E-03	4,222
Nb-93m	1,000	5.4E-06	5.4E-09	4,310	2.4E-06	2.4E-09	4,222
Ni-59	300	5.8E-02	1.9E-04	4,310	5.1E-04	1.7E-06	4,222
Tc-99	900	5.4E-01	6.0E-04	4,310	4.7E-01	5.2E-04	4,222
		Total	**1.5E-01**		**Total**	**7.4E-02**	
C-14	2,000	1.4E-02	6.9E-06	3,788	4.2E-02	2.1E-05	3,792
I-129	1	1.1E-01	1.1E-01	3,788	8.3E-02	8.3E-02	3,792
Nb-93m	1,000	9.7E-08	9.7E-11	3,788	8.4E-08	8.4E-11	3,792
Ni-59	300	6.4E-02	2.1E-04	3,788	1.9E-06	6.3E-09	3,792
Tc-99	900	7.7E-01	8.5E-04	3,788	4.3E-01	4.8E-04	3,792
		Total	**1.1E-01**		**Total**	**8.3E-02**	
C-14	2,000	4.4E-01	2.2E-04	9,998	3.5E-04	1.8E-07	9,998
I-129	1	5.8E-08	5.8E-08	9,998	2.5E-09	2.5E-09	9,998
Nb-93m	1,000	1.9E+02	1.9E-01	9,998	1.6E+02	1.6E-01	9,998
Ni-59	300	2.5E+00	8.2E-03	9,998	2.2E+00	7.4E-03	9,998
Tc-99	900	1.2E+00	1.3E-03	9,998	1.1E+00	1.2E-03	9,998
		Total	**2.0E-01**		**Total**	**1.7E-01**	
C-14	2,000	6.3E-01	3.2E-04	7,354	2.8E-02	1.4E-05	7,288
I-129	1	2.9E-05	2.9E-05	7,354	6.3E-07	6.3E-07	7,288
Nb-93m	1,000	8.1E+01	8.1E-02	7,354	6.6E+01	6.6E-02	7,288
Ni-59	300	1.6E+01	5.4E-02	7,354	1.7E+01	5.7E-02	7,288
Tc-99	900	9.1E-01	1.0E-03	7,354	8.5E-01	9.5E-04	7,288
		Total	**1.4E-01**		**Total**	**1.2E-01**	
C-14	2,000	1.1E-07	5.4E-11	702	1.8E-07	9.0E-11	694
I-129	1	7.0E-05	7.0E-05	702	3.5E-08	3.5E-08	694
Nb-93m	1,000	3.0E-16	3.0E-19	702	2.2E-16	2.2E-19	694
Ni-59	300	2.1E-13	6.9E-16	702	1.4E-12	4.8E-15	694
Tc-99	900	2.7E+02	3.0E-01	702	1.6E+02	1.8E-01	694
		Total	**3.0E-01**		**Total**	**1.8E-01**	

(Peak Radionuclide Indicated in Green Shading)