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Revision 0

Response to Continued Discussion between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy Pertaining to Tc-99 Solubility Limits
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS/ABBREVIATIONS

AGW	Artificial Groundwater
DLM	Dynamic Leaching Method
DOE	U.S. Department of Energy
FDC	Future Disposal Cell
MOP	Member of the Public
N/A	Not Applicable or Not Available
NRC	U.S. Nuclear Regulatory Commission
RAI	Request for Additional Information
SA	Special Analysis
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site

1.0 RESPONSE TO CONTINUED DISCUSSION BETWEEN DOE AND NRC WITH RESPECT TO TC-99 SOLUBILITY LIMITS

Following their review of DOE's *FY2014 Special Analysis for the Saltstone Disposal Facility at the Savannah River Site* (SRR-CWDA-2014-00006), the United Stated Nuclear Regulatory Commission (NRC) issued a request for additional information (RAI) concerning Tc-99 release from young cementitious materials (RAI SP-12). [ML15161A541] In developing the response to this request, the Department of Energy (DOE) updated the GoldSim models for the Saltstone Disposal Facility (SDF) Special Analysis (SA) and a set of simulations was performed to illustrate how consideration of this early stage (Reduced Region I or young/reduced stage) would influence the final dose results. [SRR-CWDA-2016-00004]

The update was needed because the GoldSim (and PORFLOW) SDF models do not consider the chemical environment defined as Reduced Region I (or the young/reduced stage). The lack of consideration of the young/reduced stage in the previous SDF models was based on initial calculations for the SDF model, performed using the Geochemist's Workbench® thermodynamic model. These calculations indicated that the Region I (young) cementitious stage was not important due to its relatively short duration. [SRNL-STI-2009-00473; SRNL-STI-2009-00544] Therefore, the initial chemical environment stage found in GoldSim and PORFLOW SDF model simulations was the Reduced Region II (middle/reduced stage) and its longevity was dependent on the time needed for the infiltrating groundwater to consume the reduction capacity inherent to the original saltstone. More specifically, the saltstone aging process and associated transitions of chemical environments simulated in previous versions of the GoldSim SDF model assumed the progression of saltstone aging as follows: Reduced Region II → Oxidized Region II → Oxidized Region III. In the updated version of the GoldSim SDF model developed in response to RAI SP-12, the saltstone aging process and associated transitions of chemical environments simulated assumes that the progression of saltstone aging as follows: Reduced Region I → Reduced Region II → Oxidized Region II → Oxidized Region III.

In the time following the publishing of DOE's response to NRC's RAI SP-12, DOE has presented to the NRC additional information regarding studies related to Tc-99 solubility limits. This new information is based on a laboratory study of contaminant leaching from saltstone, performed by the University of Georgia's Savannah River Ecological Laboratory (SREL Doc R-16-0003). The data referred to herein is based on Dynamic Leaching Method tests described in SREL Doc R-16-0003. The ongoing results of this study have been presented for three samples, the first sample is a Tc-99 spiked column developed for the study and the other two samples were taken from saltstone cores extracted from SDU 2A (Samples SDU-A and SDU-B). The two SDU cores were leach-tested using two different leachants (influent solutions). Both leachants were similar artificial groundwater (AGW) simulants, but one was at equilibrium with laboratory air (sample SDU-A) and the other was a degassed permeant (SDU-B). The Tc-99 spiked column was also evaluated using a degassed permeant (SDU-B). Because of its greater O_2 content, the transition to oxidized conditions will proceed faster with the AGW that is at equilibrium with laboratory air.

The continued discussions between the DOE and the NRC are based on NRC concerns regarding Tc-99 concentrations of the effluent from the core samples, especially Sample SDU-B where the

effluent concentration approached 5.0E-07 mol/L (see Table 1). To illustrate how a potentially higher Tc-99 solubility limit and/or the implementation of the Reduced Region I chemical environment into the SDF modeling efforts influences the dose results calculated by the model, a series of supplemental simulations was performed using the updated GoldSim models. Because the early dose results are dominated by the sum of the Tc-99 and I-129 dose contributions, the supplemental simulations presented in this report consider both the I-129 K_d values used in the FY2014 SDF SA and a more conservative value (the K_d of iodine = 0 ml/g for cementitious materials) presently under consideration.

Table 1: Technetium-99 leaching from the Sample SDU-B[1]

Pore Volumes	Concentration (mol/L)	pH[2]	Hydraulic Conductivity (cm/s)
0.08	2.07E-07	-	2.3E-09
0.11	2.61E-07	12.4	7.5E-10
0.13	2.70E-07	12.2	3.4E-10
0.13	3.36E-07	12.2	2.2E-10
0.17	2.72E-07	12.4	4.7E-10
0.26	3.28E-07	12.4	4.6E-10
0.28	2.71E-07	-	1.3E-10
0.29	2.54E-07	12.0	7.2E-11
0.30	2.37E-07	12.2	7.3E-11
0.31	4.48E-07	-	4.5E-11
0.32	2.64E-07	-	6.7E-11
0.34	3.52E-07	12.0	1.3E-10
0.39	3.72E-07	11.6	1.30E-10
0.41	3.63E-07	-	1.23E-10
0.46	3.79E-07	-	1.08E-10
0.48	4.12E-07	11.3	1.01E-10
0.51	4.34E-07	11.2	9.34E-11
0.54	4.89E-07	-	7.72E-11
0.55	4.93E-07	10.8	8.73E-11
0.58	4.67E-07	10.8	8.3E-11
0.60	4.76E-07	10.6	7.6E-11

[1]From SREL Doc R-16-0003 source file *SREL DLM Tc Data_090616.xlsx*.
[2]A dash indicates that pH was not measured.

2.0 SENSITIVITY SIMULATIONS BASES ON THE SREL DYNAMIC LEACHING STUDY

In this study, intended to supplement the information presented in the response to FY2014 SDF SA RAI SP-12, a set of additional simulations was performed. These simulations are based on the initial findings of SREL's dynamic leaching method (DLM) study. The results were then compared to the FY2014 SDF SA Evaluation Case and the FY2014 SDF SA sensitivity simulation where the Reduced Region II Tc-99 solubility limit was increased from 1.0 E-8 mol/L to 1.0 E-7 mol/L. [SRR-CWDA-2014-00006] The supplemental simulations listed in Table 2 considered the influence of adding the Reduced Region I Tc-99 solubility limit to the SDF model, and variations in the solubility limits controlling the release of Tc-99 from saltstone and its surrounding cementitious material. The supplemental runs performed for this analysis are the same as the FY2014 SDF SA Evaluation Case except for changes listed in Table 2.

Table 2: Additional Simulations

Simulation	Reduced Region I Solubility Limit (mol/L)	Reduced Region II Solubility Limit (mol/L)	Iodine K_d for Cementitious Materials (ml/g)	Source
A	N/A	1.0E-08	FY2014 SDF SA Values[1]	FY2014 SDF SA Evaluation Case
B	N/A	1.0E-07	FY2014 SDF SA Values[1]	FY2014 SDF SA Sensitivity Case[2]
C[3]	N/A	5.0E-07	FY2014 SDF SA Values[1]	Supplemental Runs
D	1.0E-08	1.0E-07	FY2014 SDF SA Values[1]	Supplemental Runs
E	N/A	1.0E-07	0	Supplemental Runs
F[3]	N/A	5.0E-07	0	Supplemental Runs
G	1.0E-8	1.0E-07	0	Supplemental Runs

[1] The FY2014 SDF SA iodine K_d values are 9.0 ml/g for Reduced Region I, 9.0 ml/g for Reduced Region II, 15.0 ml/g for Oxidized Region II, and 4.0 ml/g for Oxidized Region III.

[2] The FY2014 SDF SA Sensitivity Case is described in Section 5.6.6.1 of the FY2014 SDF SA. [SRR-CWDA-2014-00006]

[3] Uses Flow Case F6 flow data described in Table 4.4-3 of the FY2014 SDF SA. [SRR-CWDA-2014-00006]

To evaluate the potential increase in magnitudes of peak releases and changes in timing of the peak releases, that could occur if the reduced environment solubility limit was underestimated, the SDF GoldSim model used in the FY2014 SDF SA was rerun assuming that the Reduced Region II solubility limit was set to 5.0E-07 mol/L. Note that for this simulation, the Reduced Region II solubility limit extends from the start of the simulation until Oxidized Region II conditions are initiated.

Examination of the hydraulic conductivities measured in the SREL study (SREL Doc R-16-0003) indicates that flow rates based on the FY2014 SDF SA Evaluation Case would be inconsistent with the measured flow rates through the core samples. Specifically, the SDF models assumed an initial saturated hydraulic conductivity for saltstone, which was higher than the measured values (i.e., 6.4E-09 cm/sec versus the values presented in Table 1). [SRR-CWDA-2014-00006] For this reason, sensitivity Flow Case F6 which uses an initial saturated hydraulic

conductivity value of 3.9E-10 cm/sec (SRR-CWDA-2014-00006, Table 4.4-3) is utilized for Simulations C and F.

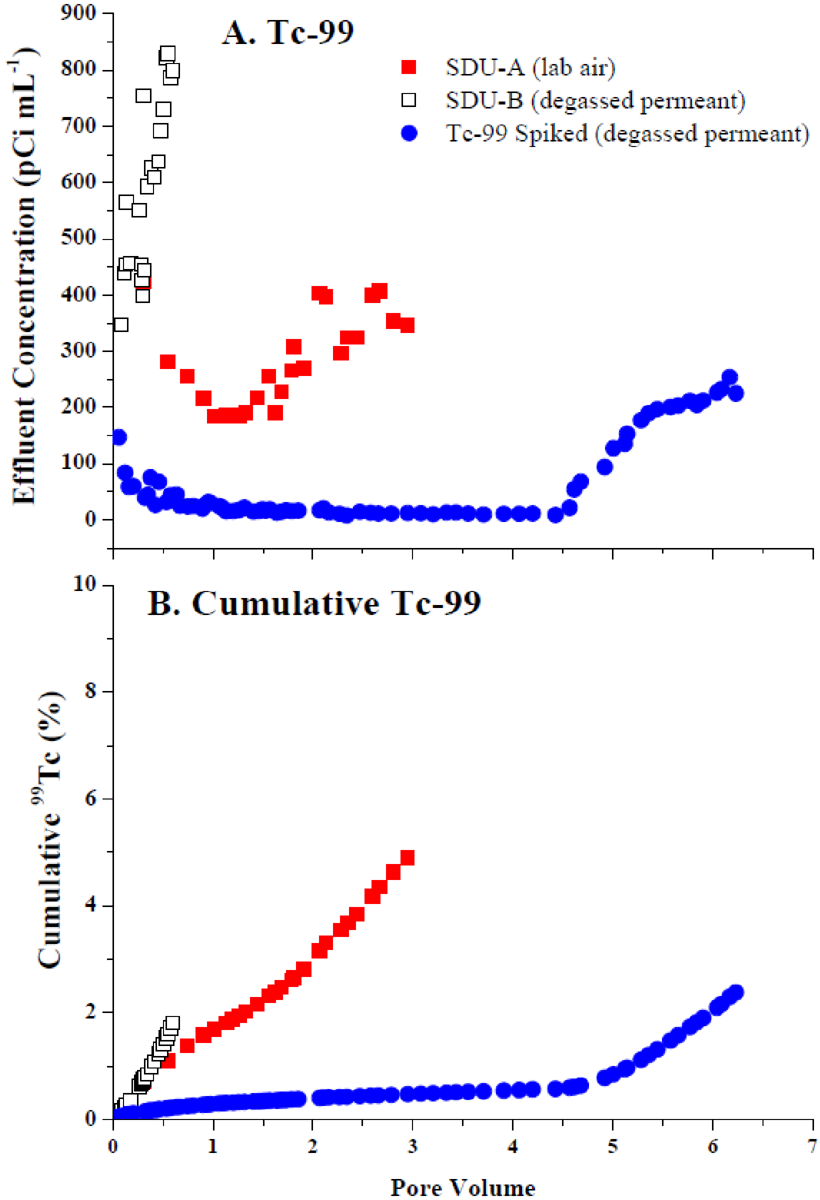
The negative correlation between the hydraulic conductivities presented in Table 1 and the effluent concentrations can be explained by both physical and chemical processes (SREL Doc R-16-0003). Physically, the longer mobile water residence time imposed by lower saltstone hydraulic conductivities allows for a greater degree of diffusional exchange between dead-end (more stagnant) pore space and mobile zones. The existence of less mobile zones would be consistent with the concept of a high-porosity low hydraulic conductivity medium such as saltstone. In addition, chemical processes such as kinetically limited reactions, including desorption and dissolution, can also contribute to the observed phenomenon.

A prior analysis associated with the RAI SP-12 response considered the implications on dose calculations associated with the Reduced Region I chemical environment by assuming three possible transition times based on 10 pore-volume flushes, 25 pore-volume flushes, and 50 pore-volume flushes before reaching the Reduced Region II state. In the present study, the number of pore-volume flushes needed to attain the Reduced Region I → Reduced Region II transition was set to 4.5 pore-volumes to be consistent with the inflection point shown in the SREL dynamic leaching study for the Tc-99-spiked saltstone sample analysis (see Figure 1).

For the Reduced Region I → Reduced Region II simulations, the solubility limit for Reduced Region I was set to 1.0 E-8 mol/L (SRNL-STI-2012-00769) and the solubility limit for Reduced Region II was set to 1.0 E-7 mol/L. Note that in the Reduced Region I → Reduced Region II transition analysis, because the solubility limits and K_ds values for a number of elements within the Reduced Region I chemical environment are considerably different from those in the Reduced Region II chemical environment, this transition timing was also applied to the other radionuclides to determine the impact on total doses to the hypothetical member of the public (MOP) at the 100-meter boundary (i.e., the outer edge of the buffer zone represented by a distance of 100-meters from the disposal units).

Because in the first 10,000 years of the SDF model simulations, the timing and associated overlapping of I-129 and Tc-99 breakthrough curves controls the peak doses, it is important to understand the implications of the chosen iodine K_ds with respect to the dose calculations at the 100-meter MOP boundary. To help understand the degree to which iodine K_ds can influence the overlapping of I-129 and Tc-99 dose contribution breakthrough curves, and total peak dose calculations for the first 10,000 years, the FY2014 SDF SA sensitivity analysis, the FY2014 SDF SA model case with the Reduced Region II solubility limit set to 5.0E-07 mol/L with the flow field set to Flow Case F6, and the Reduced Region I → Reduced Region II transition analysis, were each rerun with the cementitious iodine K_ds set to 0.0 ml/g. The results of these new simulations and there comparisons with the FY2014 SDF SA Evaluation Case and the additional sensitivity simulations are presented below.

Figure 1: Tc-99 Leaching from the two SDU Samples and the Tc-99 Spiked Saltstone Samples: (A) Effluent Tc-99 Concentration, and Cumulative % of Tc-99 Leached.



2.1 MOP Total-Dose Comparison: Supplemental Simulations versus FY2014 SDF SA

As discussed above, this analysis is based upon supplemental simulations (see Table 2, Simulations C and F), performed with the SDF GoldSim models to evaluate the sensitivity of modeling results to increases in the Reduced Region II Tc-99 solubility limits to levels based on effluent concentration levels seen in a laboratory saltstone contaminant leaching study, performed by the University of Georgia's Savannah River Ecological Laboratory (SREL Doc R-16-0003). In addition, Simulations D and G (see Table 2) were designed to evaluate how different the results would be if the transition from Reduced Region I → Reduced Region II was considered. Two sets of supplemental simulations are considered herein, with the first set based on the FY2014 SDF SA cementitious iodine K_ds and the second set based on the assumption that sorption of iodine is negligible in the cementitious materials (the iodine K_d = 0 ml/g). For perspective, the supplemental simulations are compared to the FY2014 SDF SA Evaluation Case (Simulation A in Table 2) and the high technetium solubility-limit sensitivity presented in the FY2014 SDF SA (Simulation B in Table 2) from Section 5.6.6.1 of the FY2104 SDF SA. [SRR-CWDA-2014-00006]

Figures 2, 3, and 4 present comparisons between the FY2014 SDF SA Evaluation Case and high technetium solubility sensitivity case (see Section 5.6.6.1 of SRR-CWDA-2014-00006) with the two sets of supplemental simulations with the first set using the FY2014 SDF SA cementitious iodine K_ds (Simulations C and D in Table 2) and a second set (Simulations E, F, and G in Table 2) which assume that sorption of iodine is negligible in the cementitious materials.

Figure 2 presents the GoldSim 100-Meter MOP total dose results for the first 10,000 years of the simulations. As can be readily discerned from Figure 2, especially comparing the simulations where the Tc-99 solubility limit is set to 1.0E-07 mol/L for Reduced Region II, if iodine sorption is considered to be negligible, the 1,000-year peak total dose is increased reaching almost 5 mrem/yr and the 10,000-year peak total dose is lowered from approximately 28 mrem/yr to approximately 20 mrem/yr. This change occurs because the peak of the I-129 breakthrough curve arrives earlier, increasing the peak total dose for the first 1,000 years but by changing the manner in which the Tc-99 and I-129 breakthrough curves overlap, the two dose contributions no longer reinforce each other to the same degree. Note that when sorption of iodine is handled the same way for the 1.0E-07 mol/L Reduced Region II simulations the difference between the breakthrough curves for the non-transitioning (Simulation B/Simulation E) and transitioning options (Simulation D/Simulation G) is small.

Comparing the 1.0E-07 mol/L Reduced Region breakthrough curves (Simulation B/Simulation E) with the Evaluation Case (Simulation A) breakthrough curve shows that a one order of magnitude change in Reduced Region Tc-99 solubility limits increases the 10,000-year breakthrough curve peak total by a factor of 2 (Table 3).

Figure 2 also shows the influence of the lower flow rate for Simulations C and F in conjunction with the increased solubility limit of 5.0E-07 mol/L for the Reduced Region II (Reduced Region I is not considered in these runs). In Simulation C, the lower flow rate slows down the release of both Tc-99 and I-129. In Simulation F, the lower flow rate slows down the release of Tc-99 but the slowing of the release of I-129 is offset by the lack of sorption and the peak dose at 4,790 years is greater than the peak dose for the Evaluation Case (Simulation A). Note that the peak

dose at 4,790 years (17.0 mrem/yr) is not the 10,000-year peak dose, which occurs at 9,850 years and is 17.1 mrem/yr (Table 3).

Figure 2: GoldSim 100-Meter MOP Total Dose within 10,000 Years, Any Sector, for Select Sensitivity Simulations

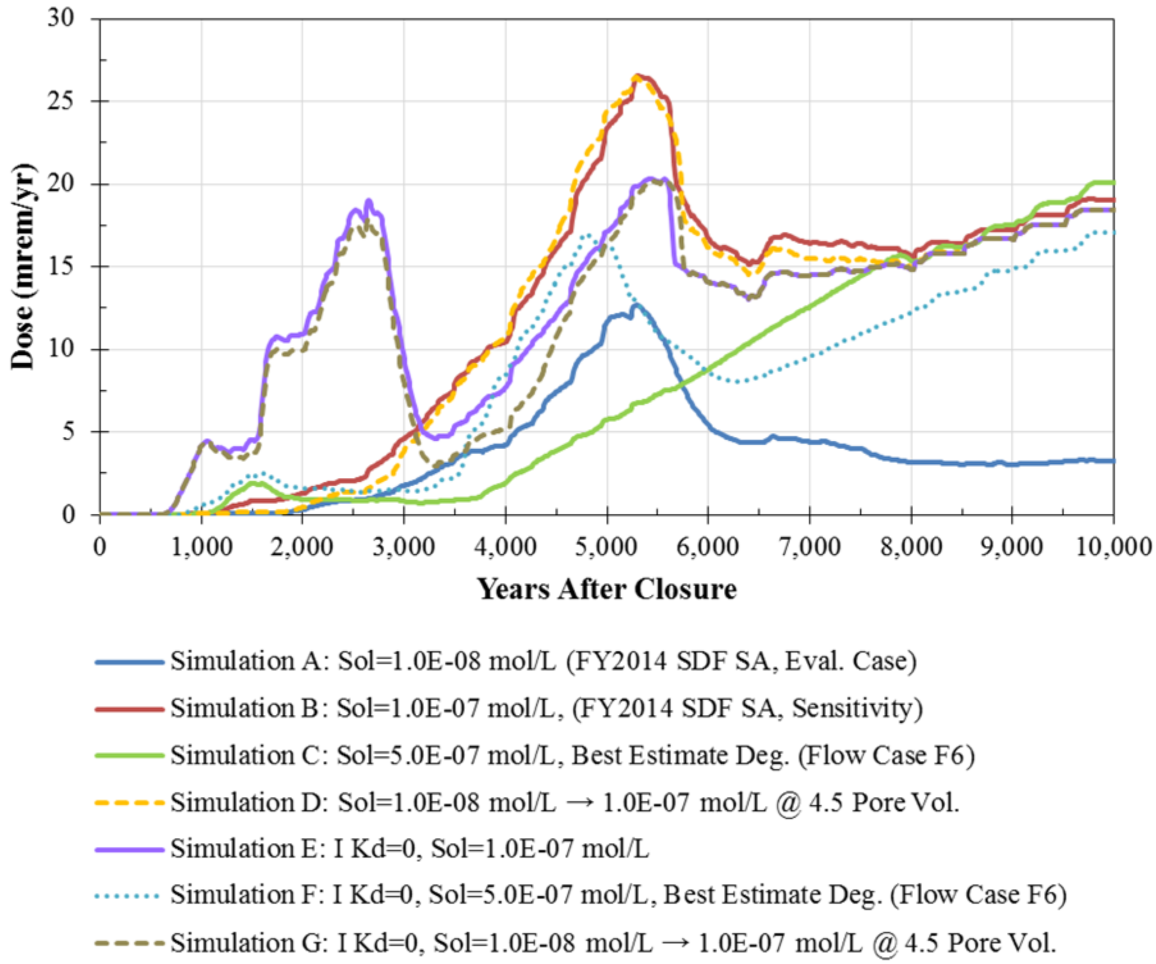


Table 3: Summary of Peak Total Doses from Varying Technetium Solubilities

Time Period (Years)	Evaluation Case		Sensitivity Case		High Solubility		Reduced Region I to II	
	(1.0E-08 mol/L)		**(1.0E-07 mol/L)**		**(5.0E-07 mol/L)**		**1.0E-08 mol/L**	**1.0E-07 mol/L**
	Peak Dose	**Time of Peak Dose**	**Peak Dose**	**Time of Peak Dose**	**Peak Dose**	**Time of Peak Dose**	**Peak Dose**	**Time of Peak Dose**
	(mrem/yr)	**(yr)**	**(mrem/yr)**	**(yr)**	**(mrem/yr)**	**(yr)**	**(mrem/yr)**	**(yr)**
Total Doses (FY2014 SDF SA Iodine Kds)								
0 to 1,000	8.1E-02	1,000	9.2E-02	1,000	8.5E-02	1,000	8.5E-02	1,000
0 to 10,000	1.3E+01	5,290	2.7E+01	5,300	2.0E+01	9,860	2.6E+01	5,280
0 to 50,000	4.8E+02	31,220	5.0E+01	50,000	8.6E+01	19,300	5.0E+01	50,000
Total Doses (Cementitious Iodine Kds = 0 ml/g*)								
0 to 1,000	8.1E-02	1,000	4.2E+00	1,000	5.5E-01	1,000	4.2E-00	1,000
0 to 10,000	1.3E+01	5,290	2.0E+01	5,420	1.7E+01	9,850	2.0E+01	5,560
0 to 50,000	4.8E+02	31,220	5.0E+01	50,000	8.6E+01	19,320	5.0E+01	50,000

* The Evaluation Case does not have a supplemental version

Figure 3 presents the GoldSim 100-Meter MOP total dose results for 50,000 years scaled to allow the spike-mode releases of Tc-99 that occur later in time. These spike-mode releases of Tc-99 are mainly associated with the vertically-downwards transport of Tc-99. In the SDF GoldSim model, as oxygen is transported downwards from mixing cell (i.e., GoldSim cell-pathway element) to mixing cell, the reducing capacity of a cell decreases reflecting the oxidation of precipitated minerals. Since the reaction is modeled as an instantaneous reaction, oxygen entering the cell is continuously used up in a redox reaction until the reducing capacity of the cell is exhausted. At the time that the reducing capacity of a particular mixing cell is exhausted, any solid-phase Tc-99 in that cell is released from the solid phase by dissolution. As the dissolved Tc-99 is transported downwards from that cell, it is re-reduced until the reducing capacity of the mixing cell it has entered has been exhausted. This process continues until the Tc-99 is transported beyond any reducing zones. As this process of dissolution and re-precipitation continues downwards along a front, an extremely large release of Tc-99 occurs from the lowest reducing cementitious cell generating the spike-shaped geometry seen in the 100-meter total dose breakthrough curve (Simulation A). Note that the spike-mode release behavior does not occur in Simulations B through G. This behavior indicates that the higher reduced condition solubility limits allow for a bleed off of enough Tc-99 to prevent the degree of precipitation necessary for the dissolution/re-precipitation process to occur at a noticeable level. Simulations B through G are described in greater detail in the following sections. For a more detailed account of the Evaluation Case (Simulation A) refer to the FY2014 SDF SA. [SRR-CWDA-2014-00006]

Figure 3: GoldSim 100-Meter MOP Total Dose within 50,000 Years, Any Sector, for Select Sensitivity Simulations

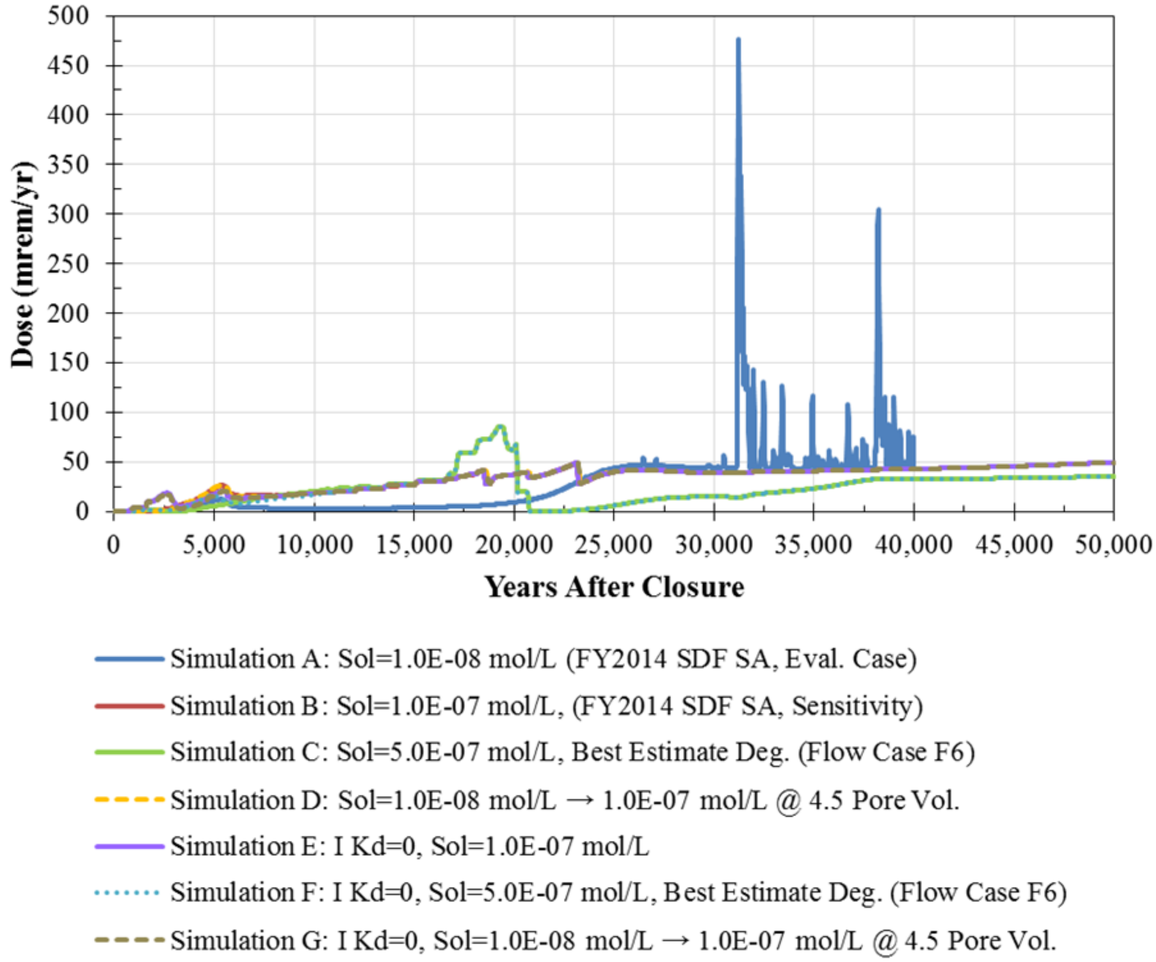
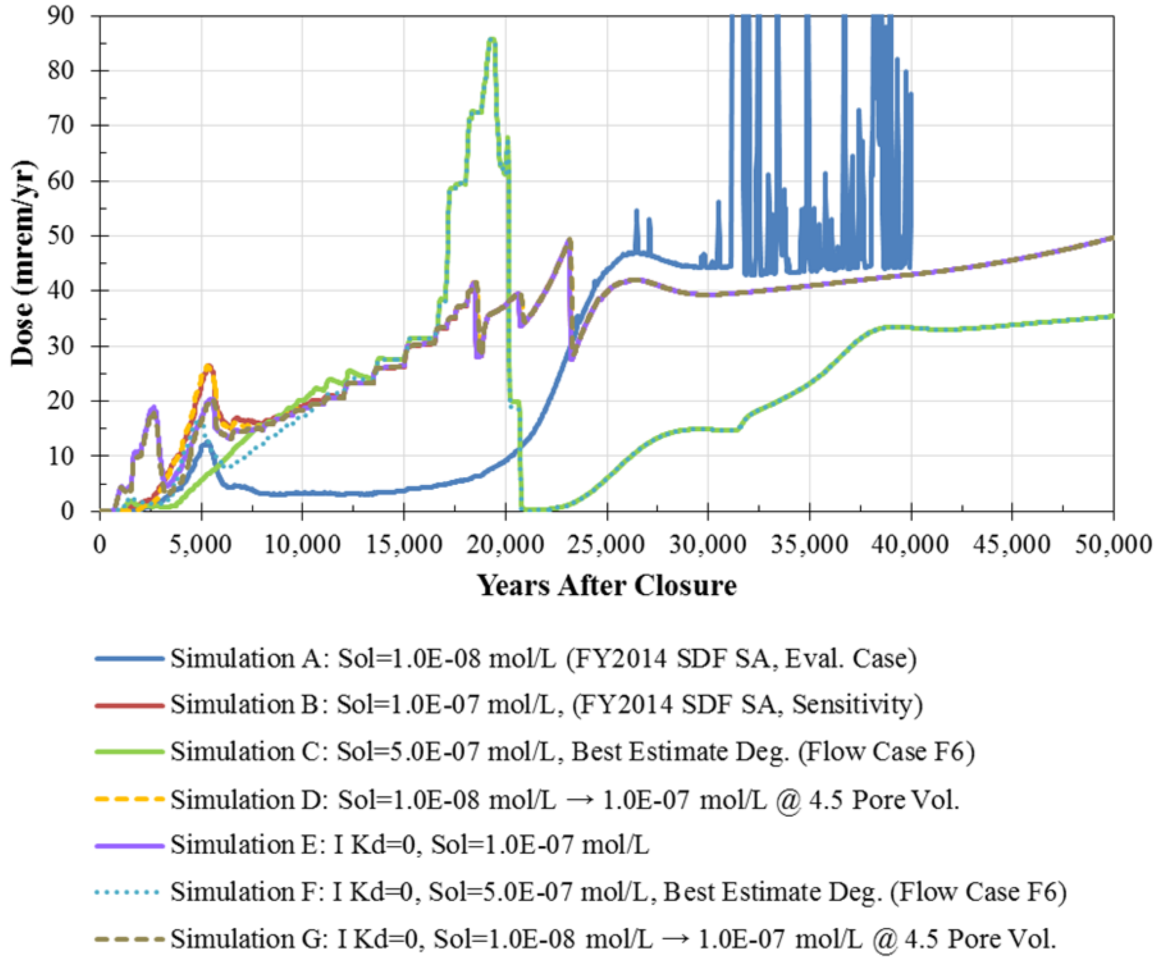


Figure 4 is similar to Figure 3 except that its vertical scale is reset to allow a closer view of the Simulation C breakthrough curve at 19,300 years where it peaks at 86 mrem/yr (Table 3).

Figure 4: GoldSim 100-Meter MOP Total Dose within 50,000 Years, Any Sector, for Select Sensitivity Simulations (Alternative Scale)



2.2 MOP Total-Dose Results for Simulation B

This section provides a more detailed discussion of Simulation B, the FY2014 SDF SA high Tc-99 solubility limit Simulation (see Table 2). In Simulation B the initial chemical environment is Reduced Region II and the Reduced Region II Tc-99 solubility limit is set to 1.0E-07 mol/L. Figure 5, added for clarification purposes, is a map depicting the approximate locations of the saltstone disposal units (SDUs), the 100-meter MOP boundary surrounding the SDU's, and the analysis sectors comprising the boundary. The background reflects the PORFLOW model grid. Note that Figure 5 is consistent with respect to locations planned for future SDUs at the time the FY2014 SDF SA modeling was performed. The same locations are used in the supplemental simulations presented here.

Figure 5: Map of Present and Future SDF Disposal Units with MOP 100-Meter Boundary and Sector Designations (Pre-2016 Design)

Figures 6 through 12 depict the sector-specific results for Simulation B and then go into further detail with respect to Sectors B, J, and K. Due to the generally higher concentration at observation wells along these three sectors, Sectors B, J, and K generally dominate the SDF GoldSim model MOP peak dose results, and are therefore considered representative of the system.

Figure 6 depicts the peak total-dose breakthrough curves for the first 10,000 years of Simulation B for Sectors A through L of the 100-meter MOP boundary (Figure 5). Figure 5 shows where these sectors are located and can be grouped as present SDU (SDUs 2A, 2B, 3A, 3B, 5A, 5B, and 6) locations and future SDU (SDUs 7, 8, 9, 10, 11, and 12) locations. Figure 6 indicates that for Simulation B, over the first 10,000 years, the peak total dose of 27 mrem/yr will occur at 5,300 years (Table 3) along Sector B. This peak value is expected to be dominated by radionuclide releases from SDU 4. The peak 1,000-year dose of 0.092 mrem/yr (at 1,000 years), is derived from Sector C values (Table 3). After the release from SDU 4 no longer controls the dose calculations, peak doses in Sector K dominate the MOP total-dose calculations until about 18,000 years into the simulation. After 18,000 years into the simulation Sector J (or I) total-dose values will dominate the magnitude of the dose calculations (see Figures 6 and 7).

Figure 8 shows that in Sector B for the first 10,000 years, releases of I-129 and Tc-99 dominate the total-dose results with the overlapping I-129 and Tc-99 breakthrough curves contributing the most to peak dose results. Figure 9 shows that for the first 6,000 years I-129 and Tc-99 dose contributions dominate the total dose results, after which until 20,000 years into the simulation, Tc-99 dose contributions dominate the total dose results. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector B.

Figure 10 shows that in Sector J for the first 10,000 years, releases of I-129 and Tc-99 dominate the total-dose results with the overlapping I-129 and Tc-99 breakthrough curves contributing the most to peak dose results. Figure 11 shows that for the first 6,000 years I-129 and Tc-99 dose contributions control the total dose results, after which until 22,000 years into the simulation, Tc-99 dose contributions dominate the total dose results. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector J.

Figure 12 shows that in Sector K for the first 10,000 years, releases of I-129 and Tc-99, dominate the total-dose results with the overlapping I-129 and Tc-99 breakthrough curves contributing the most to peak dose results. Figure 13 shows that for the first 6,000 years I-129 and Tc-99 dose contributions dominate the total dose results, after which until 20,000 years into the simulation, Tc-99 dose contributions dominate the total dose results. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector K. Note that the lower Ra-226 dose contributions in Sector K (Figure 13) versus Sector J (Figure 11) are related to the inventories of the source SDUs. SDUs 2A, 2B, 3A, and 3B (see Figure 5), have much larger ratios of Ra-226 and Th-230 inventories to saltstone volumes than in other SDUs.

Figure 6: GoldSim 100-Meter MOP Dose within 10,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

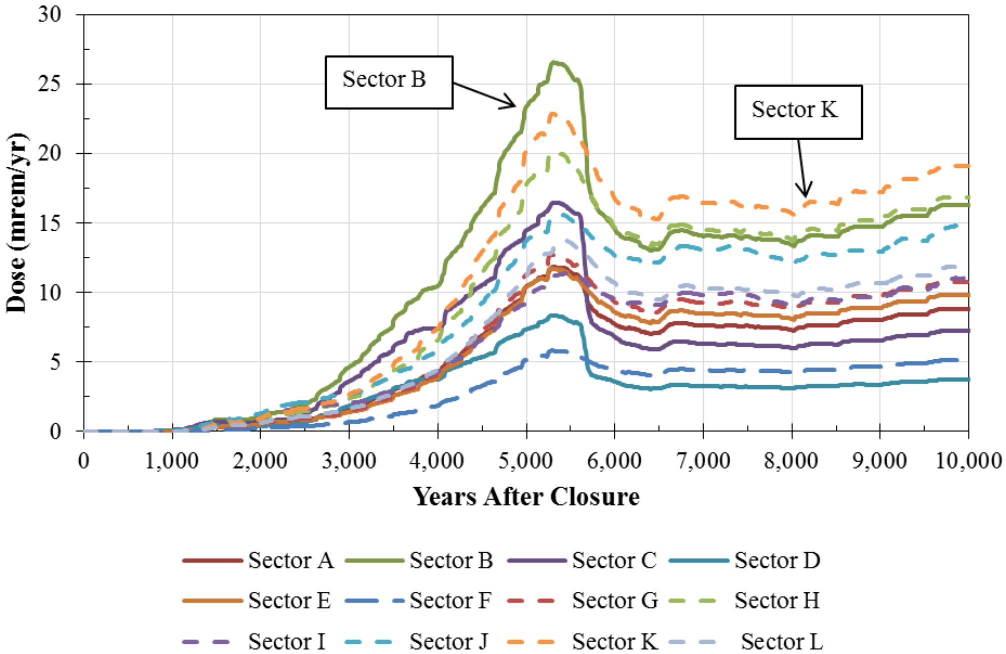


Figure 7: GoldSim 100-Meter MOP Dose within 50,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

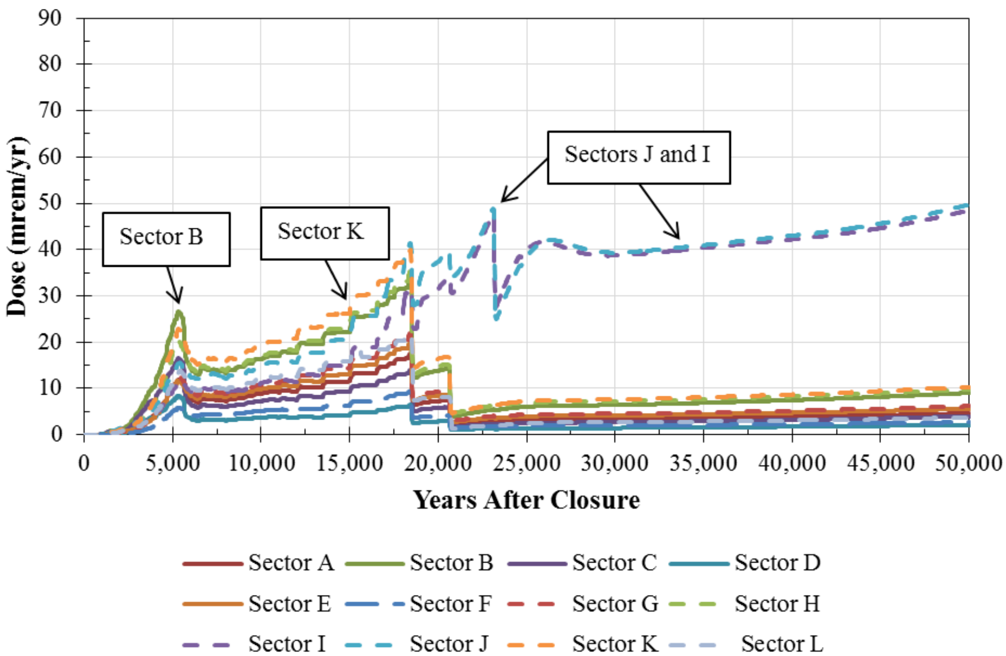


Figure 8: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector B, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

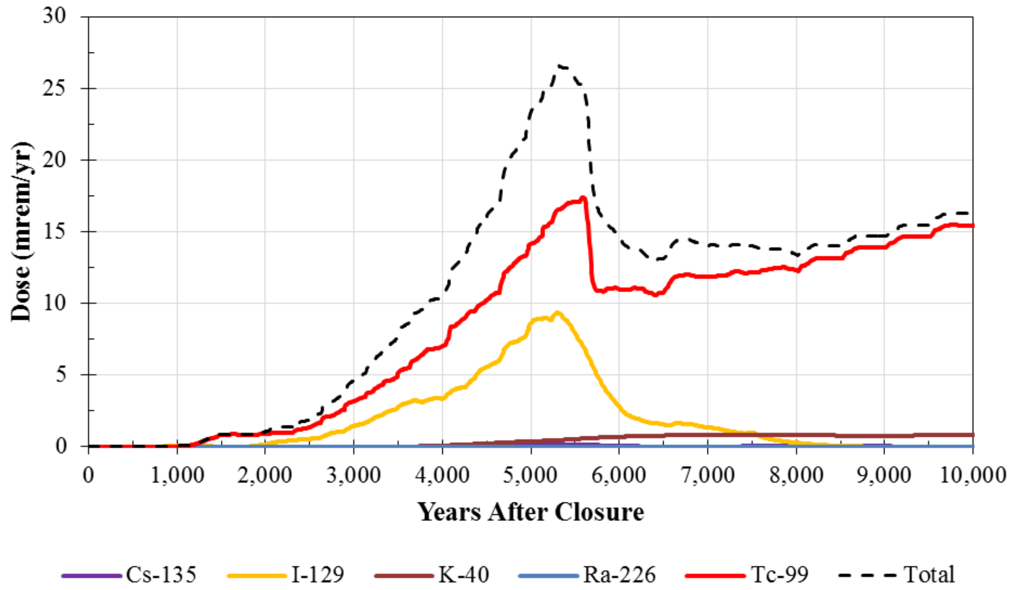


Figure 9: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector B, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

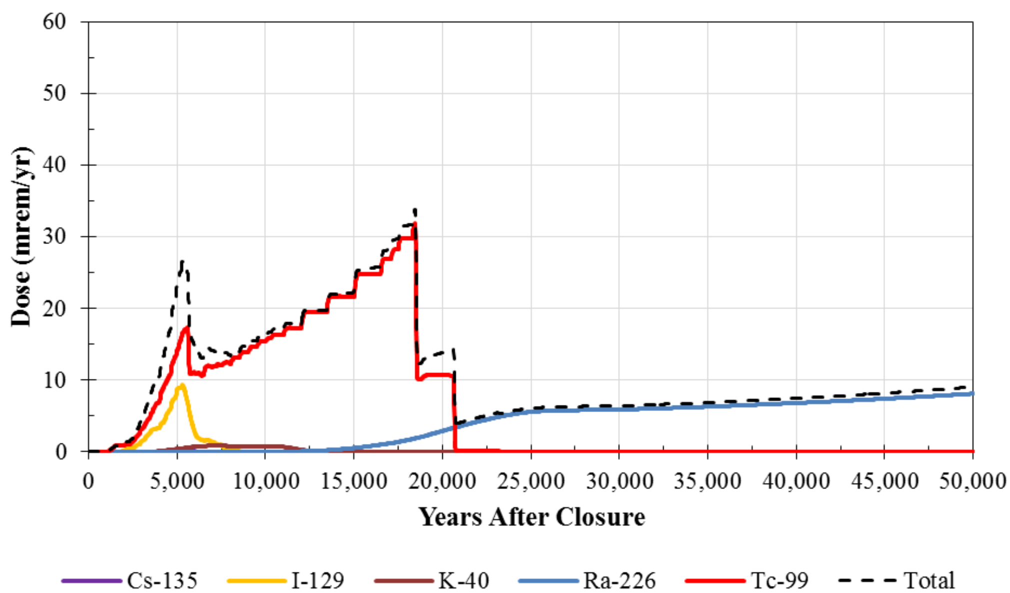


Figure 10: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

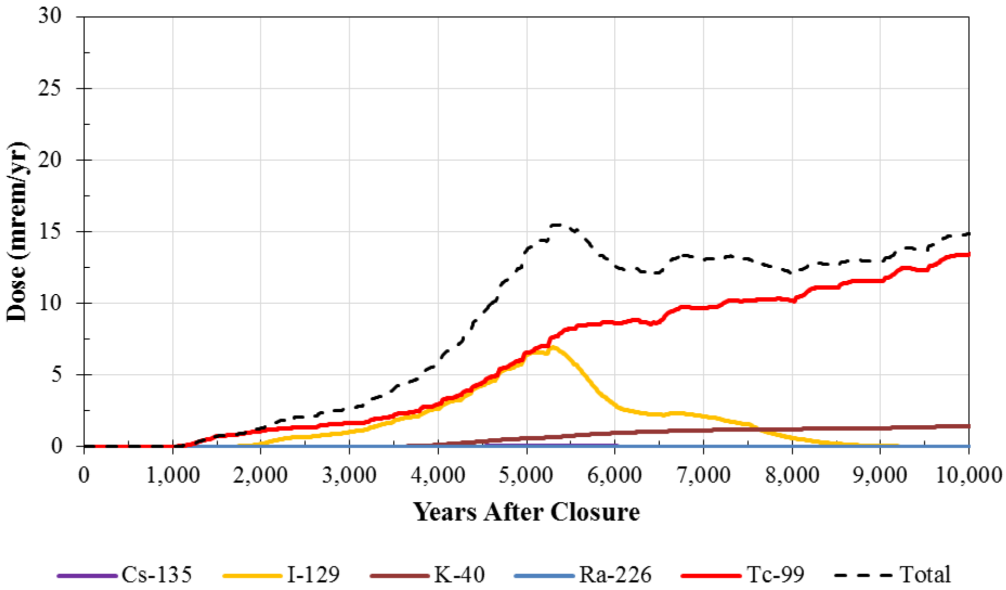


Figure 11: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

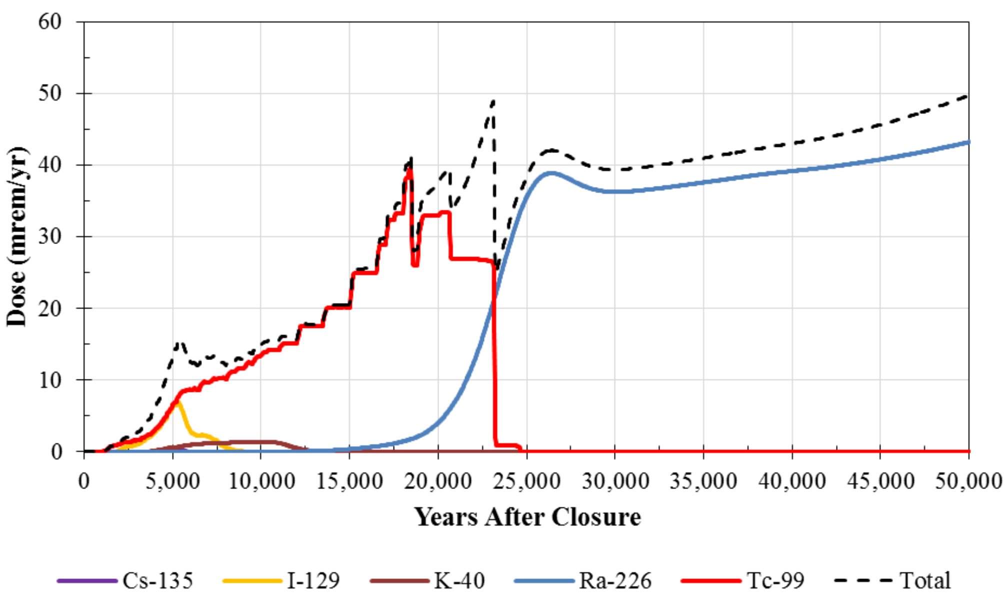


Figure 12: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L

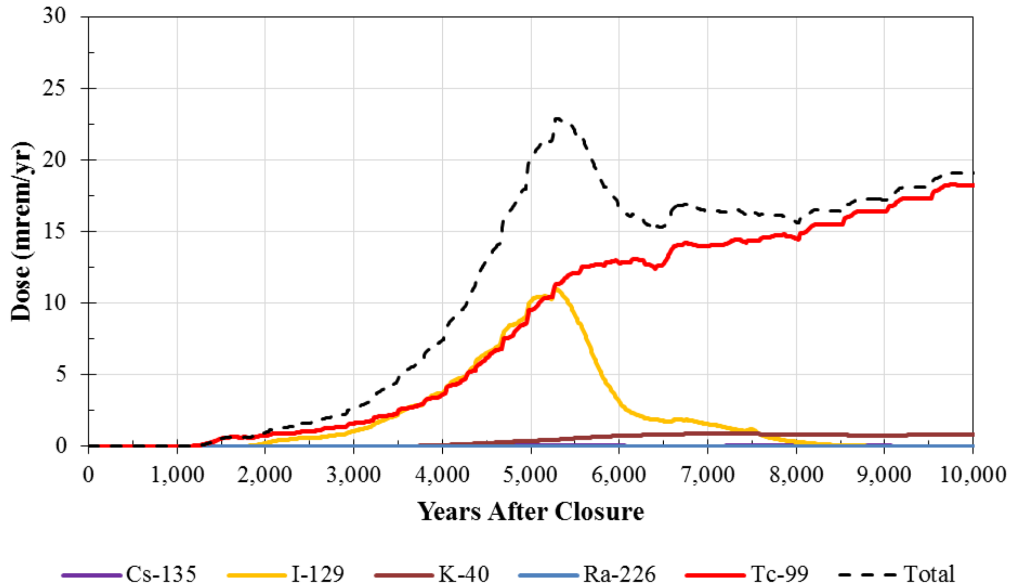
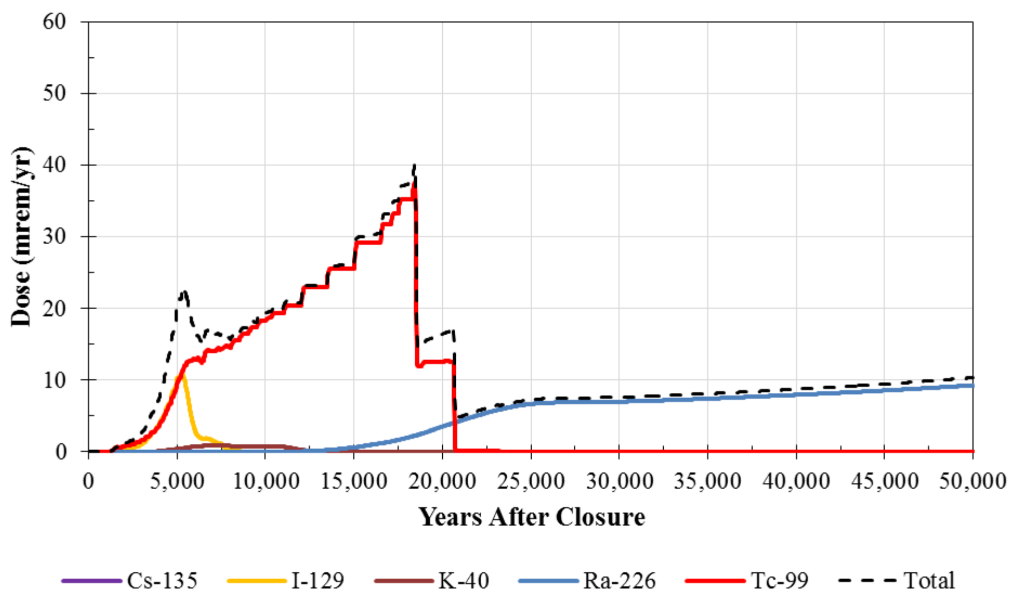


Figure 13: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L



2.3 MOP Total-Dose Results for Simulation C

This section provides a more detailed discussion of Simulation C, the supplemental simulation with the chemical environment condition initiated as Reduced Region II, with a technetium solubility limit of 5.0E-07 mol/L (Table 2). In addition the Evaluation Case flow data (Flow Case F1 of SRR-CWDA-2014-00006, Table 4.4-3) is replaced with the Flow Case F6 (SRR-CWDA-2014-00006, Table 4.4-3) flow data in Simulation C. Figures 14 through 19 depict the Sector specific results for Simulation C and then go into further detail with respect to Sectors J and K (Figure 5). Due to the generally higher dose magnitudes generated at observation wells along these two sectors, Sectors J and K, are therefore considered representative of the system.

Figure 14 depicts the sector-specific peak total-dose breakthrough curves for the first 10,000 years of Simulation C for Sectors A through L of the 100-meter MOP boundary. Figure 14 breakthrough curves indicate that for Simulation C, over the first 10,000 years, the peak total dose of 20 mrem/yr occurs at 9,860 years (see also Table 3) along Sector K. The peak 1,000-year dose of less than 0.1 mrem/yr (at 1,000 years), is derived from Sector C values (Table 3). After about 17,000 years Sector J (or after 20,000 years Sector I dose values) control the magnitude of the MOP total-dose calculations (see Figures 14 and 15).

Figure 16 shows that for the first 10,000 years in Sector J, Tc-99 releases dominate the total-dose results. The relative unimportance of I-129 is a function of the lower flow velocities associated with Flow Case F6. Figure 17 shows that for the first 20,000 years, Tc-99 dose contributions dominate the total dose results in Sector J, after which Ra-226 dose contributions dominate the total dose results in Sector J for the remainder of the 50,000 year simulation.

Figure 18 shows that for the first 10,000 years in Sector K, Tc-99 releases dominate the total-dose results. Again, the relative unimportance of I-129 is a function of the lower flow velocities associated with Flow Case F6. Figure 19 shows that for the first 20,000 years, Tc-99 dose contributions dominate the total dose results in Sector K, after which Ra-226 dose contributions dominate the total dose results in Sector K for the remainder of the 50,000-year simulation. Note that the lower Ra-226 dose contributions in Sector K (Figure 19) versus Sector J (Figure 17) are related to the inventories of the source SDUs. SDUs 2A, 2B, 3A, and 3B (see Figure 5), have much larger ratios of Ra-226 and Th-230 inventories to saltstone volumes than in other SDUs.

Figure 14: GoldSim 100-Meter MOP Dose within 10,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate)

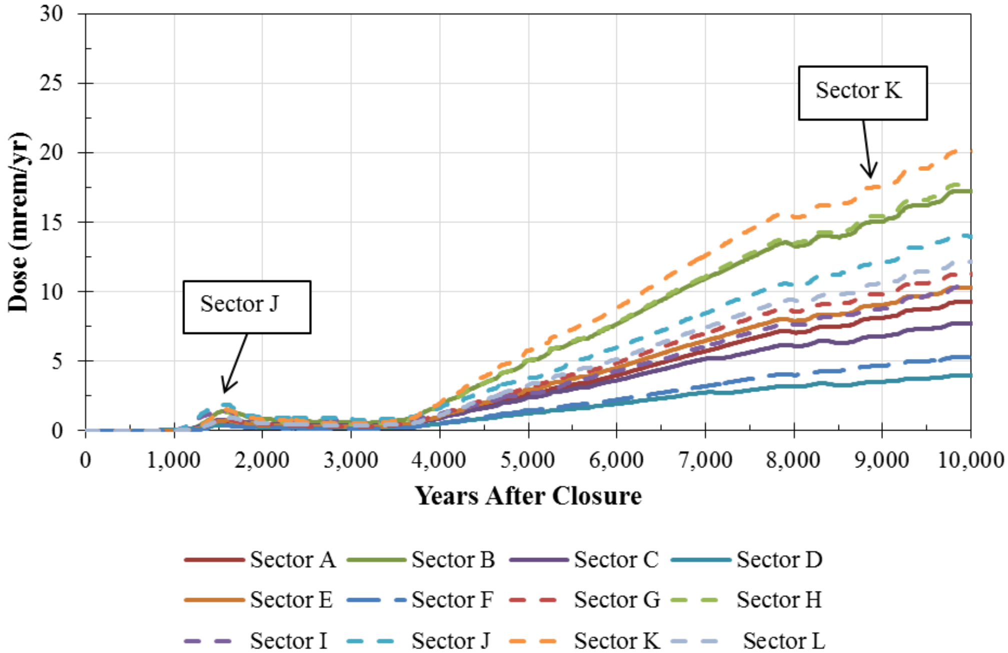


Figure 15: GoldSim 100-Meter MOP Dose within 50,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate)

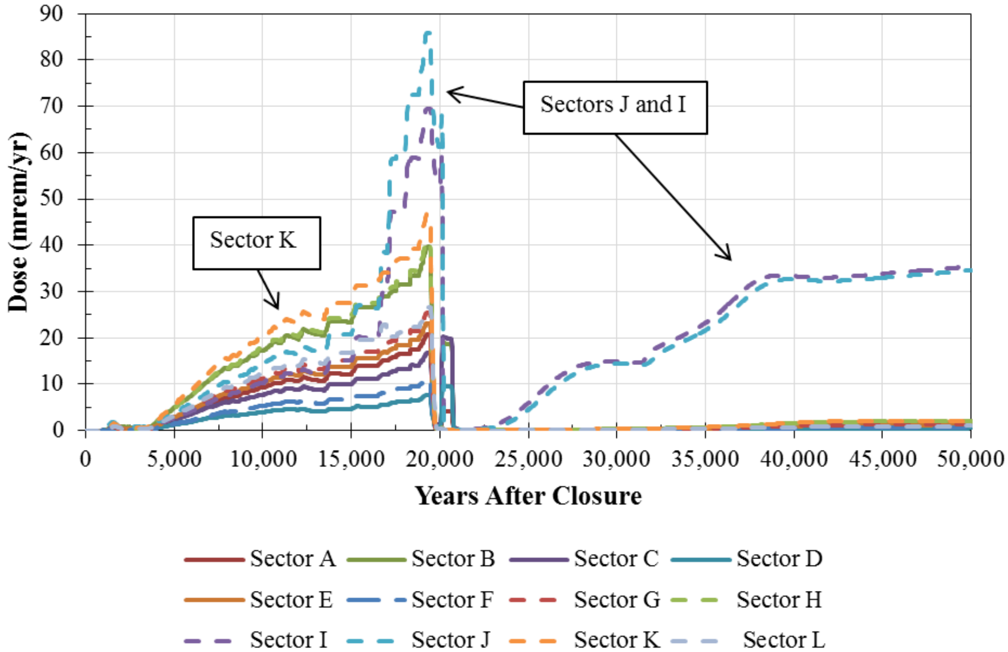


Figure 16: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate)

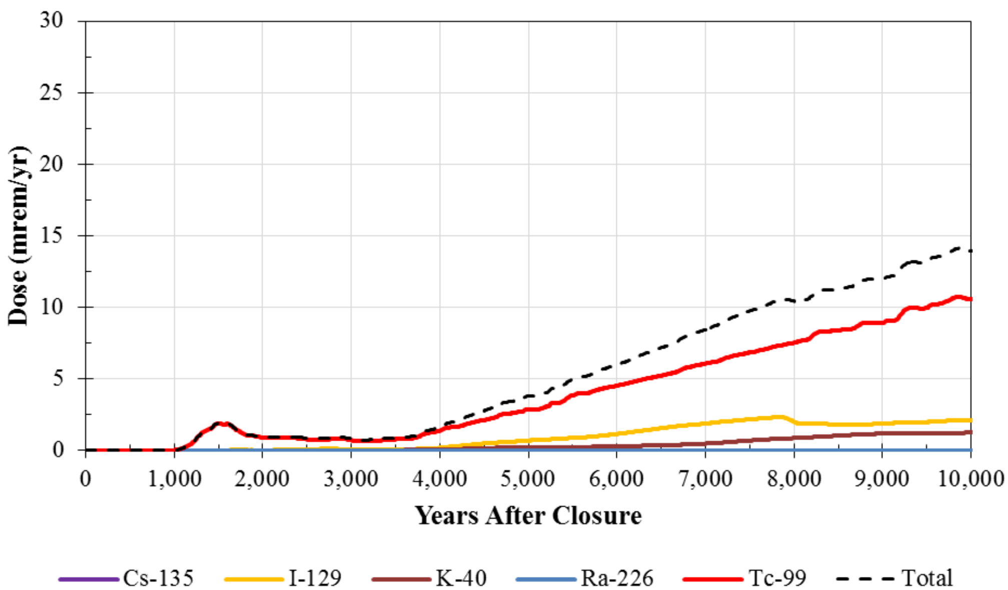


Figure 17: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate)

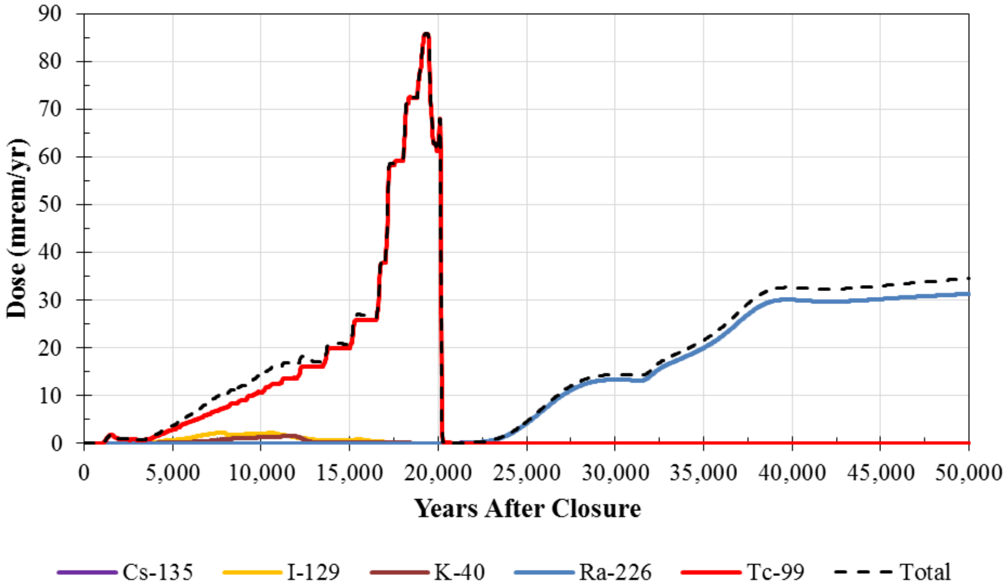


Figure 18: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate)

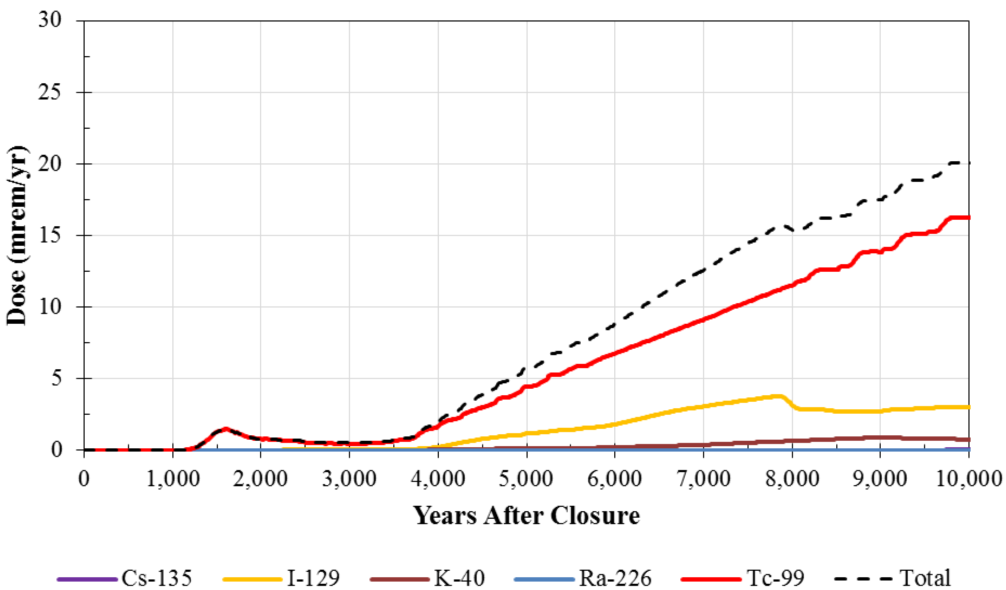
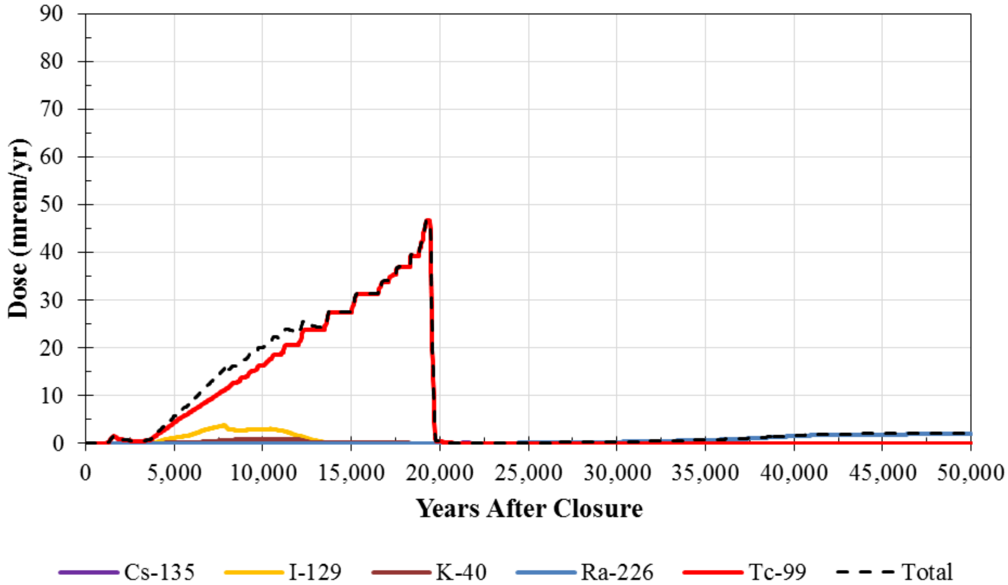


Figure 19: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate)



2.4 MOP Total-Dose Results for Simulation D

This section provides a more detailed discussion of Simulation D, where the Reduced Region I → Reduced Region II transition takes place, with the Reduced Region I technetium solubility limit set to 1.0E-08 mol/L, the Reduced Region II technetium solubility limit set to 1.0E-07 mol/L, and the Reduced Region I → Reduced Region II transition taking place after 4.5 pore-volumes of water has passed through the system (Table 2). Figures 20 through 27 depict the Sector specific results for Simulation D and then go into further detail with respect to Sectors B, J, and K. Due to the generally higher radionuclide concentrations at observation wells along these three sectors, Sectors B, J, and K generally dominate the GoldSim model MOP peak dose results, and are therefore considered representative of the system.

Figure 20 depicts the peak total-dose breakthrough curves for the first 10,000 years of Simulation D for Sectors A through L of the 100-meter MOP boundary (Figure 5). Figure 20 indicates that for Simulation D, over the first 10,000 years, the peak total dose of 26 mrem/yr will occur at 5,280 years (Table 3) along Sector B. This peak value is expected to be dominated by radionuclide releases from SDU 4. The peak 1,000-year dose of less than 0.1 mrem/yr (at 1,000 years), is derived from Sector C values (Table 3). As seen in Figure 21, until about 5,600 years the dose values along Sector B would define the maximum total-dose breakthrough curve. After 5,600 years the dose values along Sector K dominate the total-dose breakthrough curve until 10,000 years (Figure 20). Figure 21 shows that after 10,000 years dose values along Sector K define the total dose values until 18,000 years into the simulation when the total-dose values at observation wells along Sector J (or I) dominate the magnitude of the dose calculations (see Figures 20 and 21).

Figure 22 shows that along Sector B for the first 10,000 years combined releases of I-129, Tc-99, and K-40 control the total dose level. After 6,000 years, Tc-99 releases control the total dose level until 10,000 years have passed. Figure 23 shows that after the first 10,000 years Tc-99 dose contributions dominate the total dose results up until 20,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector B.

Figure 24 shows that along Sector J for the first 10,000 years combined releases of I-129, Tc-99, and K-40 control the total dose level for the first 6,000 years. After 6,000 years, Tc-99 releases control the total dose level until 10,000 years have passed. Figure 25 shows that after the first 10,000 years Tc-99 dose contributions dominate the total dose results up until 23,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector J.

Figure 26 shows that along Sector K for the first 10,000 years combined releases of I-129, Tc-99, and K-40 control the total dose level for the first 6,000 years. After 6,000 years, Tc-99 releases control the total dose level until 10,000 years have passed. Figure 27 shows that after the first 10,000 years Tc-99 dose contributions dominate the total dose results up until 21,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector K. Note that the lower Ra-226 dose contributions in Sector K (Figure 27) versus Sector J (Figure 25) are related to the inventories of the source SDUs. SDUs 2A, 2B, 3A, and 3B (see Figure 5), have much larger ratios of Ra-226 and Th-230 inventories to saltstone volumes than in other SDUs.

Figure 20: GoldSim 100-Meter MOP Dose within 10,000 Years, Sectors A through L, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L

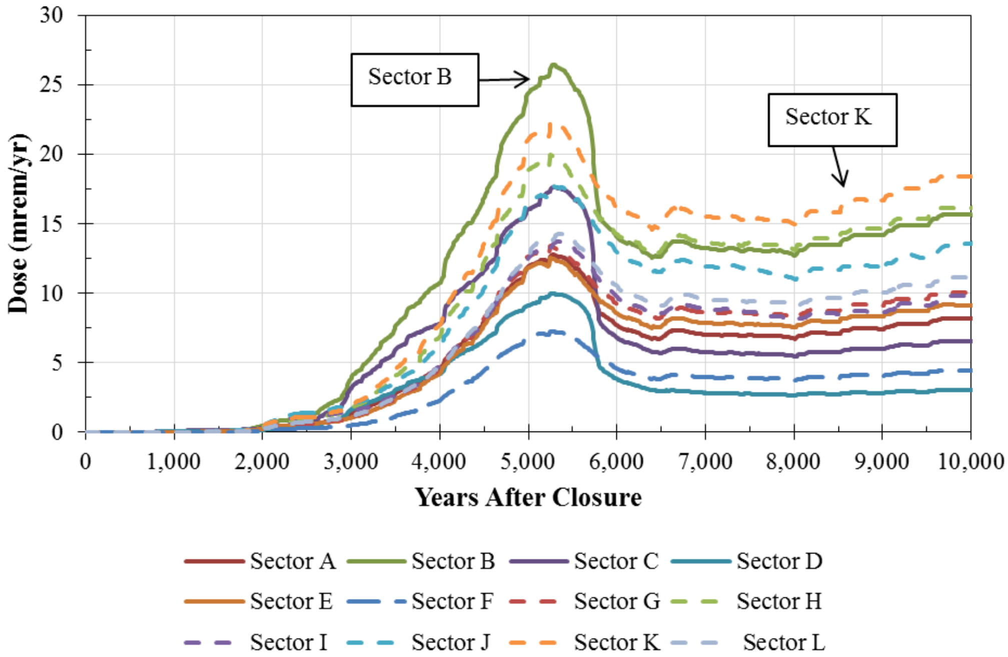


Figure 21: GoldSim 100-Meter MOP Dose within 50,000 Years, Sectors A through L, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L

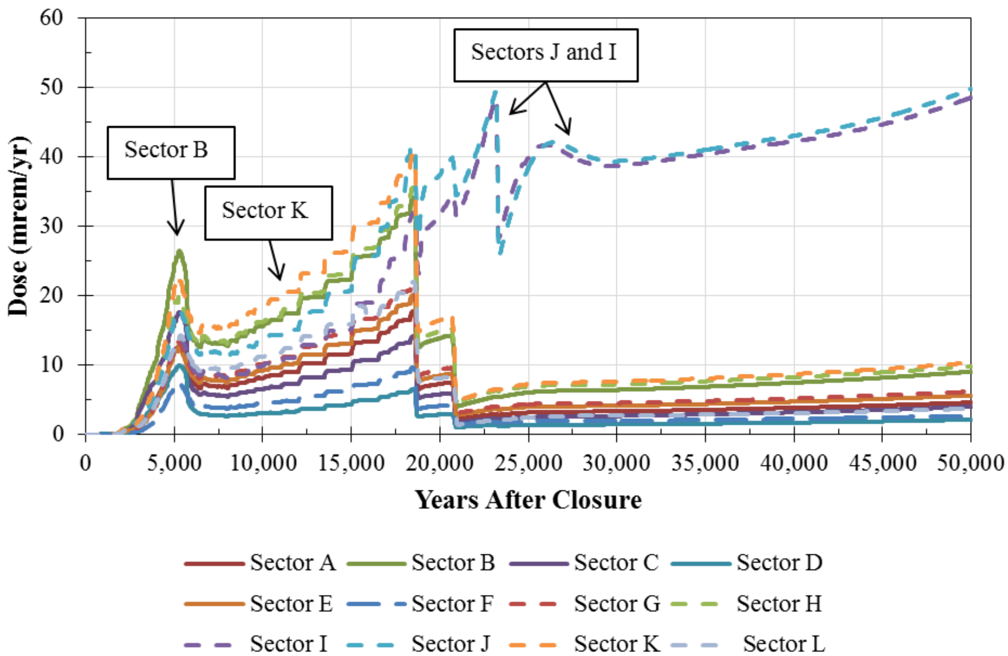


Figure 22: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector B, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L)

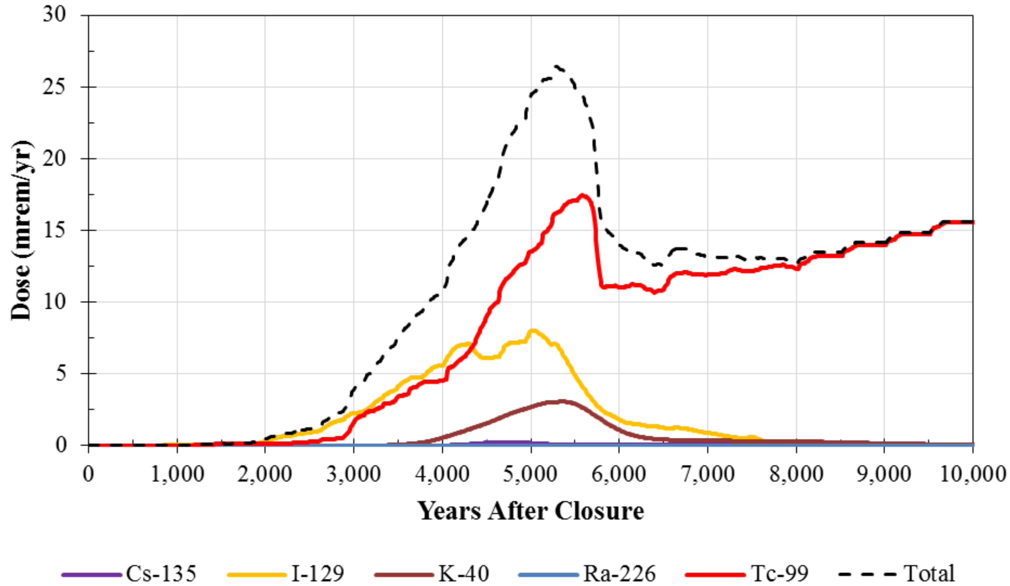


Figure 23: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector B, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L

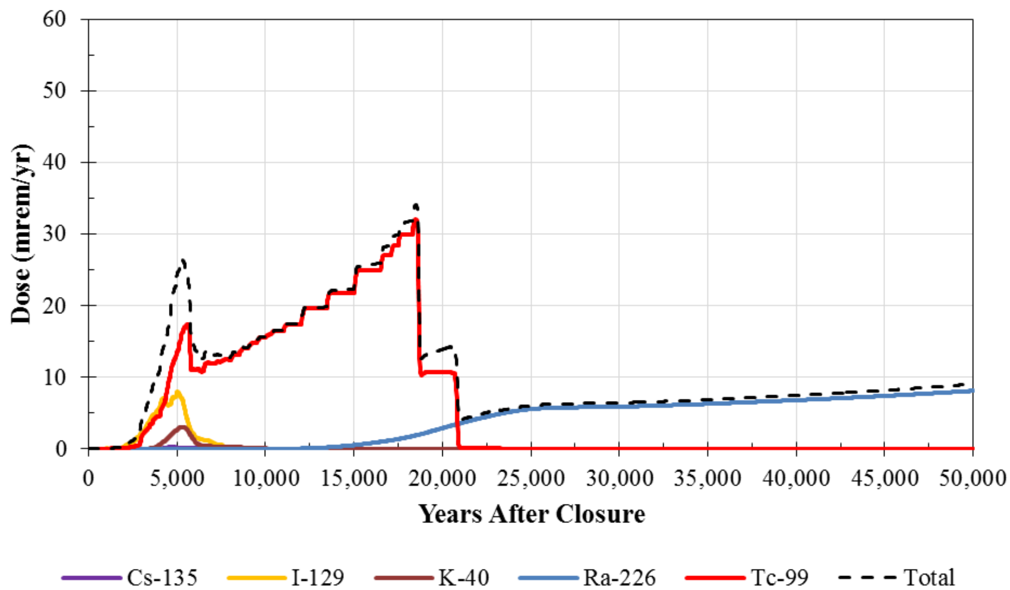


Figure 24: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector J, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L

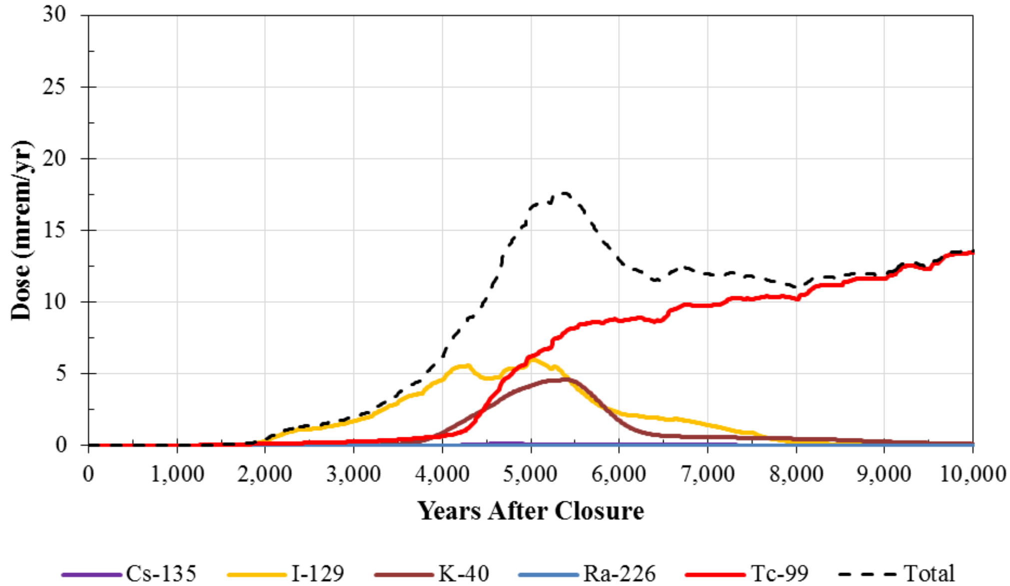


Figure 25: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector J, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L

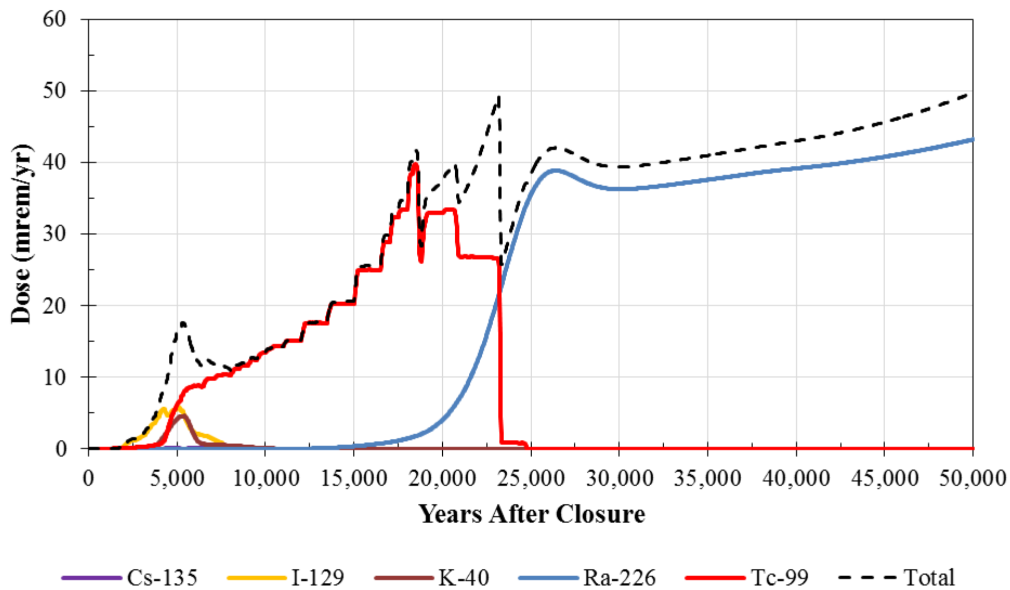


Figure 26: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector K, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L

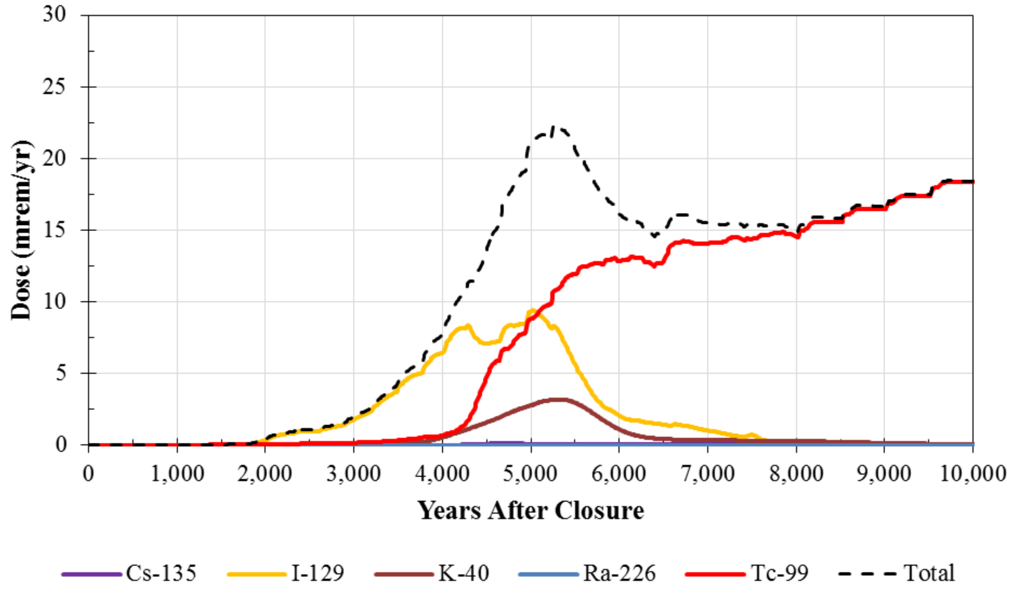
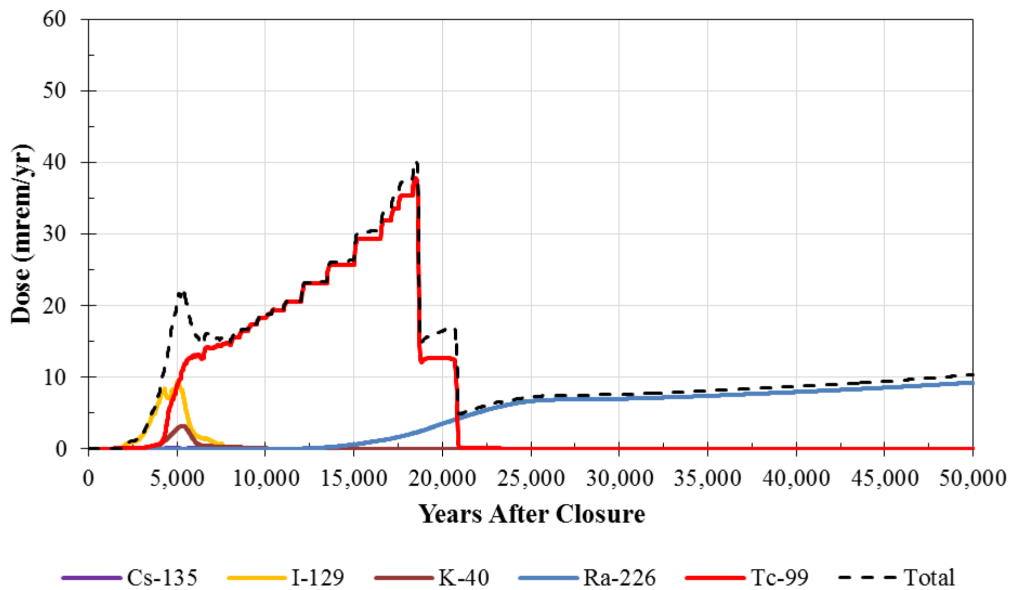


Figure 27: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector K, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L



2.5 MOP Total-Dose Results for Simulation E

This section provides a more detailed discussion of Simulation E, which is consistent with the FY2014 SDF SA high Tc-99 solubility limit case, Simulation B (Table 2) except that sorption of iodine in the cementitious materials is neglected. In Simulation E the initial chemical environment is Reduced Region II and the Reduced Region II Tc-99 solubility limit is set to 1.0E-07 mol/L. Figures 28 through 35 depict the sector-specific total dose results for Simulation E and then go into further detail with respect to Sectors B, J, and K. Due to the generally higher concentration at observation wells along these three sectors, Sectors B, J, and K generally dominate the GoldSim model MOP peak dose results, and are therefore considered representative of the system.

Figure 28 depicts the peak total-dose breakthrough curves for the first 10,000 years of Simulation E for Sectors A through L of the 100-meter MOP boundary (Figure 5). Figure 28 indicates that for Simulation E, over the first 10,000 years, the peak total dose of 20 mrem/yr will occur at 5,420 years (Table 3) along Sector B. This peak value is expected to be dominated by radionuclide releases from SDU 4. The peak 1,000-year dose of 4.2 mrem/yr (at 1,000 years), is also derived from Sector B values (Table 3). As seen in Figure 28, at around 2,500 years, the dose values along Sector K are greater than the dose results along Sector B, but by 3,000 years this trend has reversed. After about 5,600 years the dose values along Sector K dominate the total-dose breakthrough curve until 18,000 years when total-dose values at observation wells along Sector J (or I) will dominate the magnitude of the dose calculations (see Figures 28 and 29).

Figure 30 shows that in Sector B for the first 10,000 years, releases of I-129 control the total dose level for the first 3,000 years, then Tc-99 which peaks at about 5,500 years does. Because the reinforcement associated with overlapping of I-129 and Tc-99 breakthrough curves, does not occur, the 10,000-year peak is not as high as in Simulation B. Figure 31 shows that after the first 3,000 years Tc-99 dose contributions dominate the total dose results, until 20,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector B.

Figure 32 shows that in Sector J for the first 10,000 years, releases of I-129 and Tc-99 dominate the total-dose results with I-129 the controlling species for the first 3,000 years and Tc-99 the controlling species until 10,000 years into the simulation. Figure 33 shows that after 10,000 years Tc-99 dose contributions control the total dose results until 22,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector J.

Figure 34 shows that in Sector K for the first 10,000 years, releases of I-129 and Tc-99 dominate the total-dose results with I-129 the controlling species for the first 3,000 years and Tc-99 the controlling species until 10,000 years into the simulation. Figure 35 shows that after 10,000 years Tc-99 dose contributions control the total dose results until 21,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector K. Note that the lower Ra-226 dose contributions in Sector K (Figure 35) versus Sector J (Figure 33) are related to the inventories of the source SDUs. SDUs 2A, 2B, 3A, and 3B (see Figure 5), have much larger ratios of Ra-226 and Th-230 inventories to saltstone volumes than in other SDUs.

Figure 28: GoldSim 100-Meter MOP Dose within 10,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

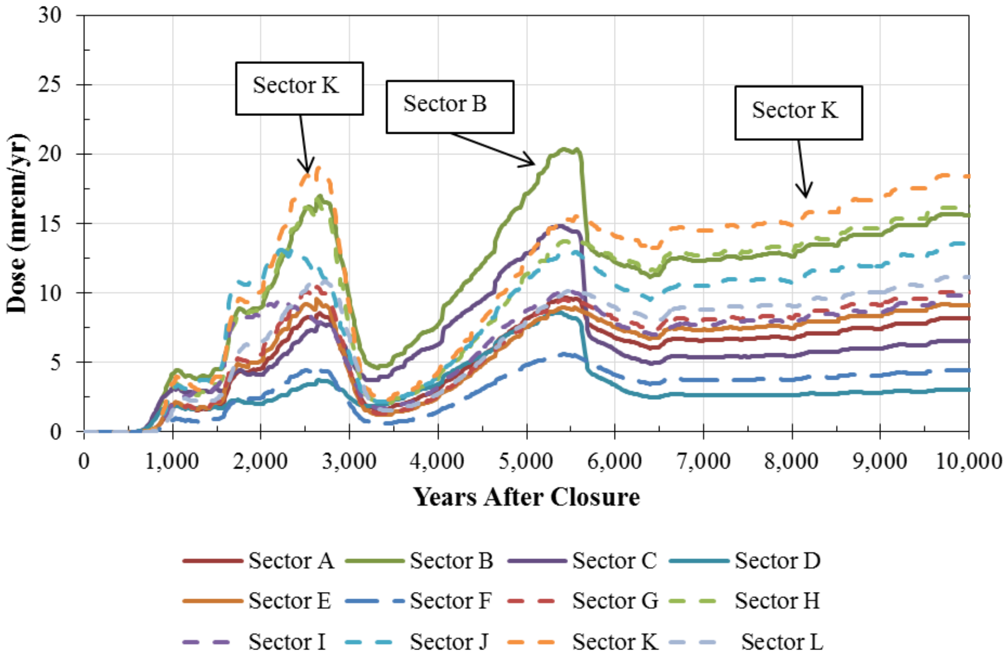


Figure 29: GoldSim 100-Meter MOP Dose within 50,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

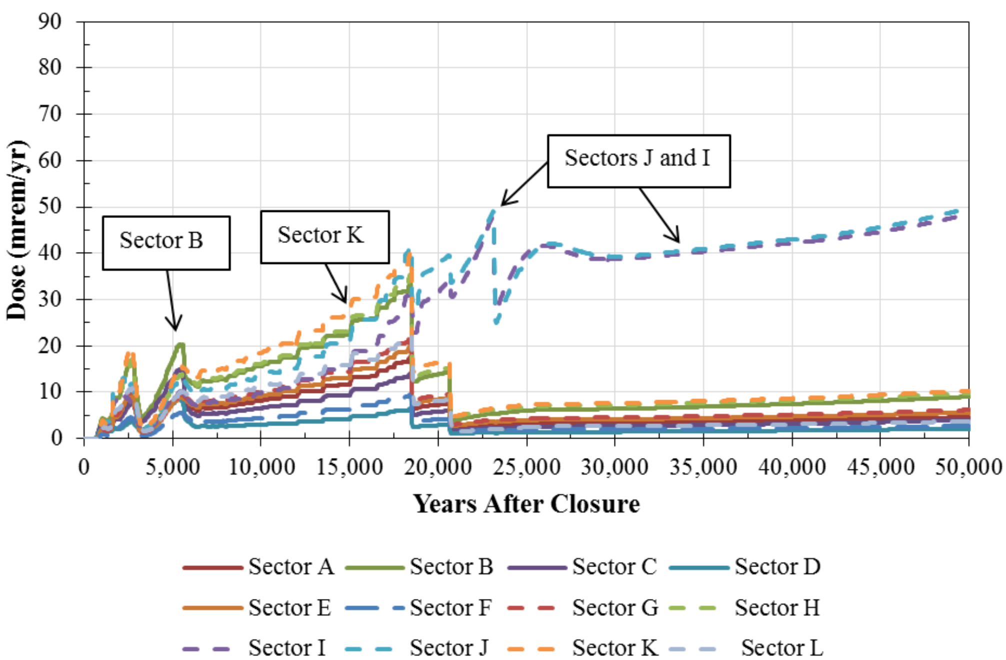


Figure 30: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector B, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

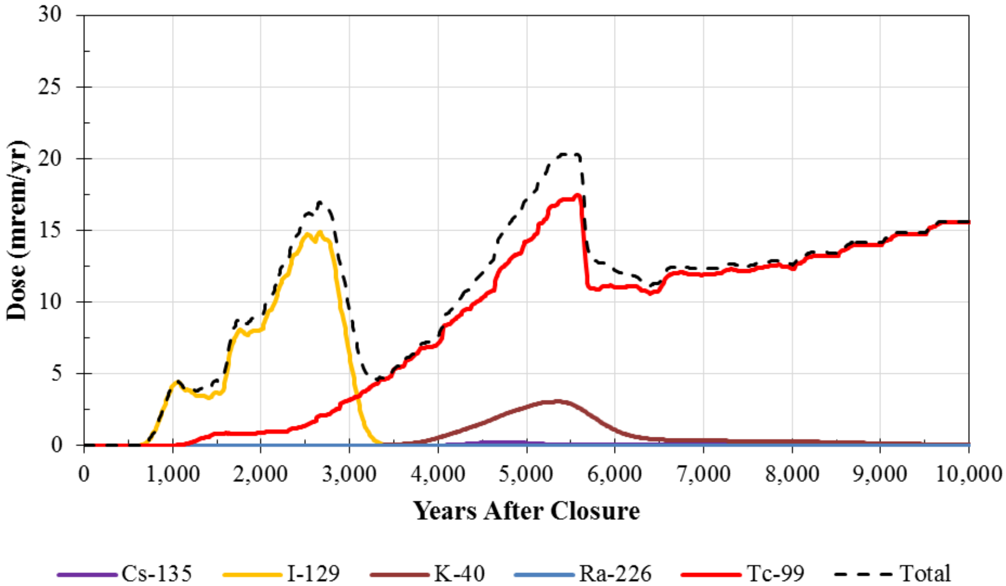


Figure 31: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector B, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

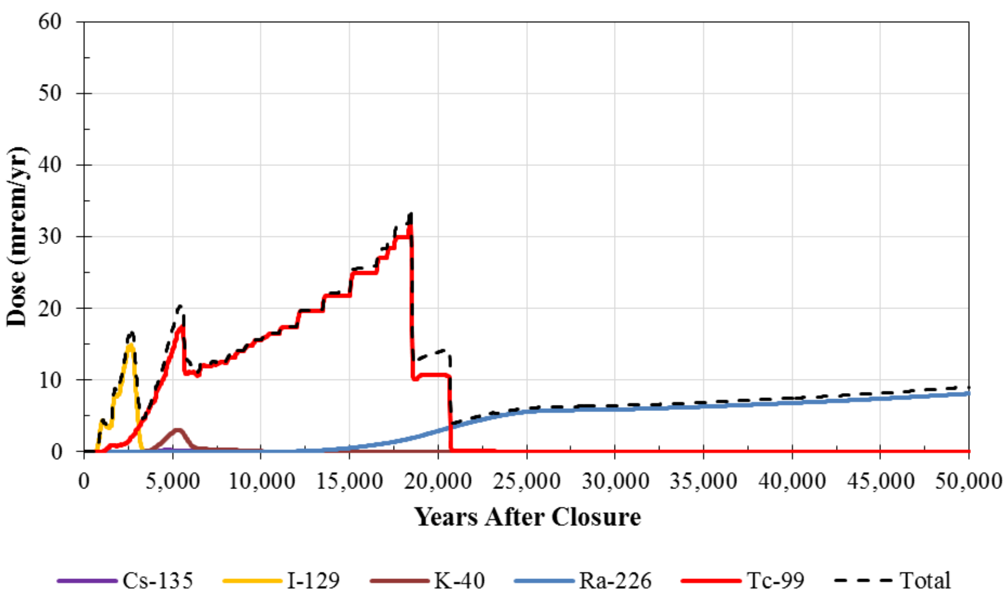


Figure 32: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

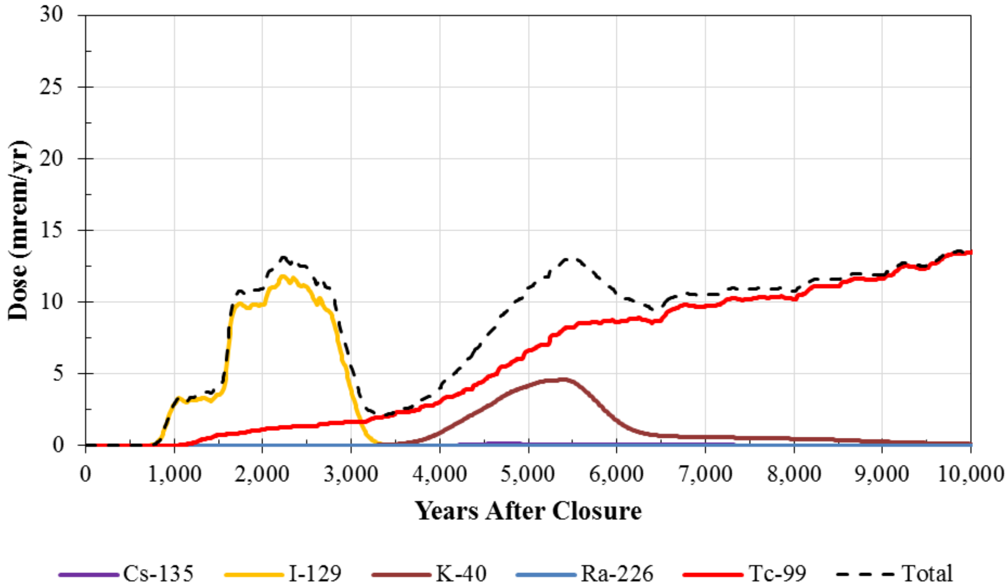


Figure 33: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

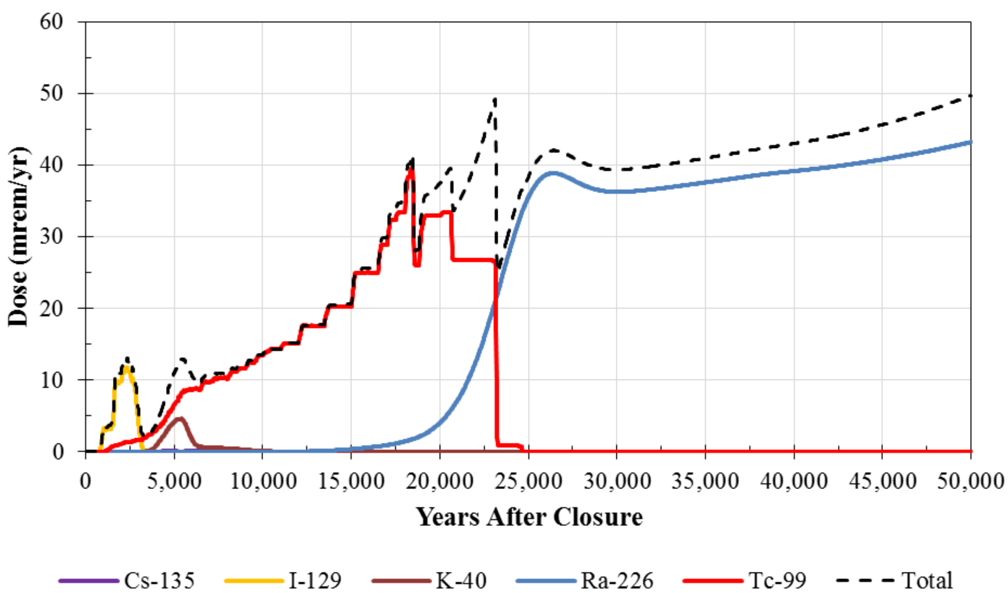


Figure 34: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

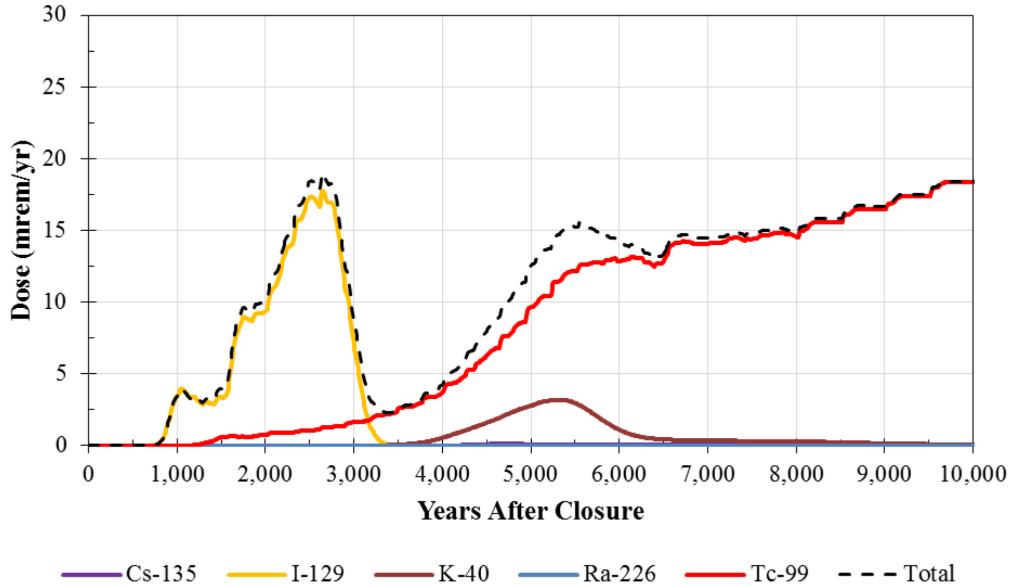
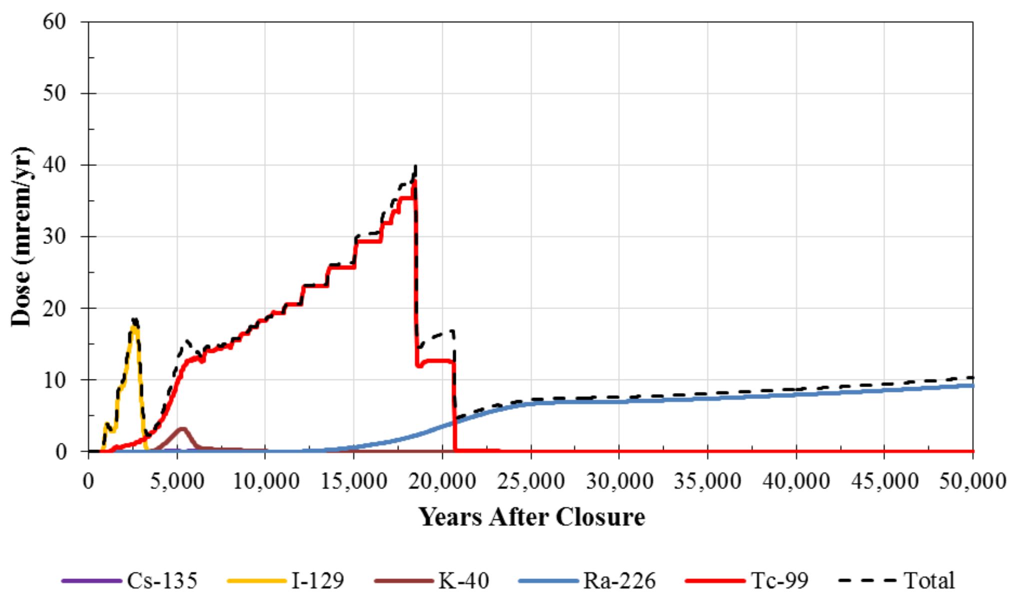


Figure 35: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials



2.6 MOP Total-Dose Results for Simulation F

This section provides a more detailed discussion of Simulation F, the supplemental simulation with the chemical environment condition initiated as Reduced Region II, with a technetium solubility limit of 5.0E-07 mol/L (Table 2). In addition the Evaluation Case flow data (Flow Case F1 of SRR-CWDA-2014-00006, Table 4.4-3) is replaced with the Case F6 (SRR-CWDA-2014-00006, Table 4.4-3) flow data in Simulation F. This simulation is the same as Simulation C (Table 2) except that sorption of iodine in the cementitious materials is neglected. Figures 36 through 41 depict the sector specific results for Simulation F and then go into further detail with respect to Sectors J and K (see Figure 5). Due to the generally higher dose magnitudes generated at observation wells along these two sectors, Sectors J and K are considered representative of the system.

Figure 36 depicts the peak total-dose breakthrough curves for the first 10,000 years of Simulation F for each sector (Sectors A through L) of the 100-meter MOP boundary. Figure 36 breakthrough curves indicate that for Simulation F, over the first 10,000 years the MOP peak total dose of 17 mrem/yr occurs at 9,850 years (see also Table 3) along Sector K. The peak 1,000-year dose of 0.55 mrem/yr (at 1,000 years), is derived from Sector J values (see also Table 3). After about 17,000 years Sector J (or after 20,000 years Sector I dose values) controls the magnitude of the MOP total-dose calculations (see Figures 36 and 37).

Figure 38 shows that in Sector J, for the first 6,000 years, I-129 and Tc-99 releases dominate the total-dose results. The greater importance of I-129 over the first 6,000 years, relative to found in Simulation C, reflects the assumption that iodine sorption is negligible. Neglecting iodine sorption offsets the influence of the lower flow velocities associated with the use of Flow Case F6 data. Figure 39 shows that from 6,000 to 20,000 years, Tc-99 dose contributions dominate the total dose results in Sector J. After 20,000 years, Ra-226 dose contributions control the total dose results for the remainder of the 50,000 year simulation.

Figure 40 shows that in Sector K, for the first 6,000 years, I-129 and Tc-99 releases dominate the total-dose results. Figure 41 shows that after 6,000 years, for the remainder of the first 20,000 years, Tc-99 dose contributions dominate the total dose results in Sector K. After 20,000 years, Ra-226 dose contributions dominate the total dose results in Sector K for the remainder of the 50,000 year simulation. Note that the lower Ra-226 dose contributions in Figure 41 versus Figure 39 are related to the inventories of the source SDUs. SDUs 2A, 2B, 3A, and 3B (see Figure 5), have much larger ratios of Ra-226 and Th-230 inventories to saltstone volumes than in other SDUs.

Figure 36: GoldSim 100-Meter MOP Dose within 10,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate) and an Iodine Kd of 0 in Cementitious Materials

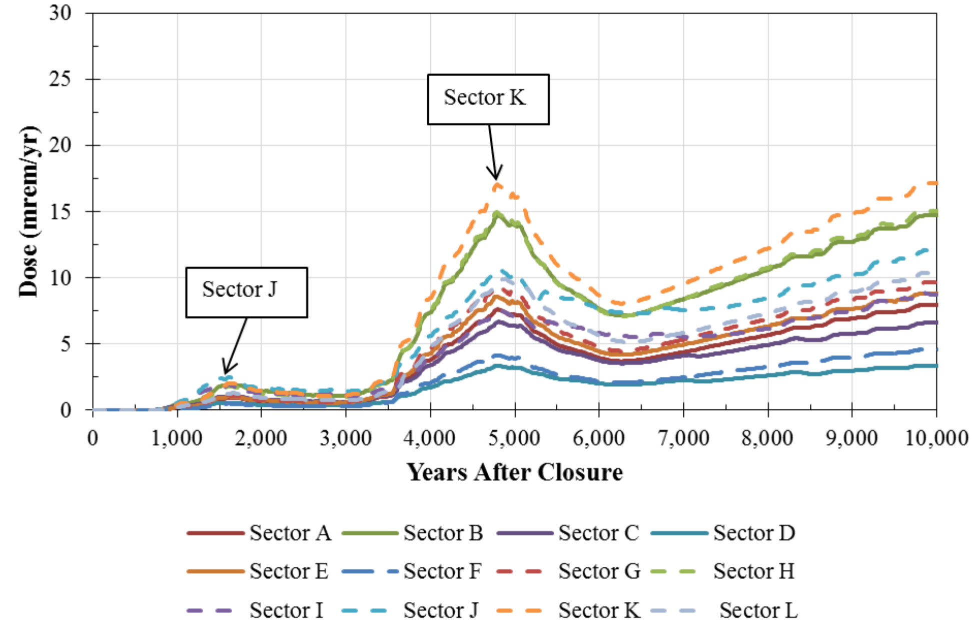


Figure 37: GoldSim 100-Meter MOP Dose within 50,000 Years, Sectors A through L, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate) and an Iodine Kd of 0 in Cementitious Materials

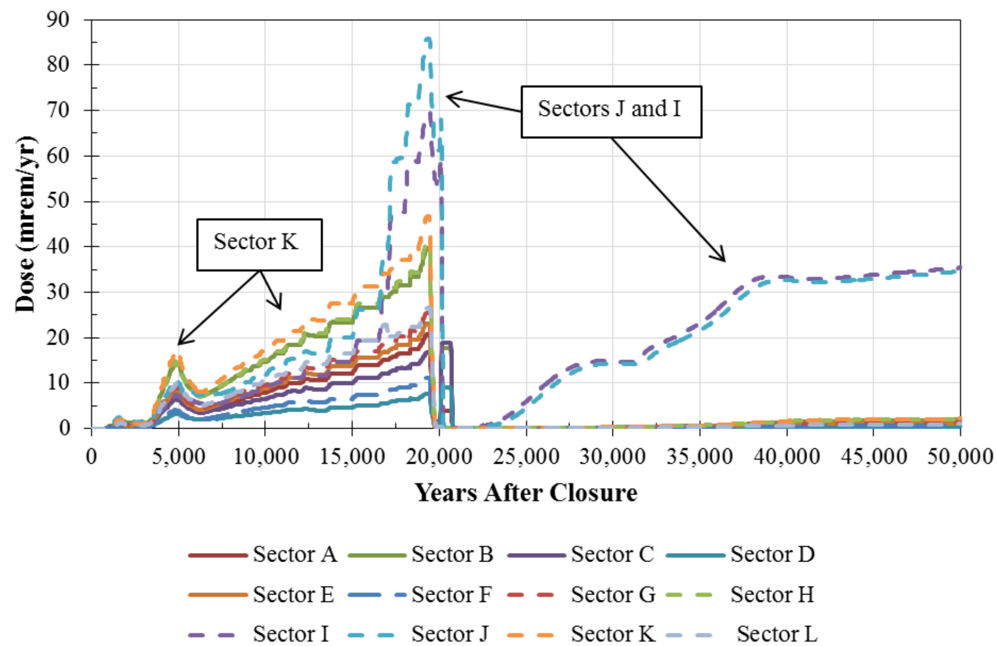


Figure 38: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate) and an Iodine Kd of 0 in Cementitious Materials

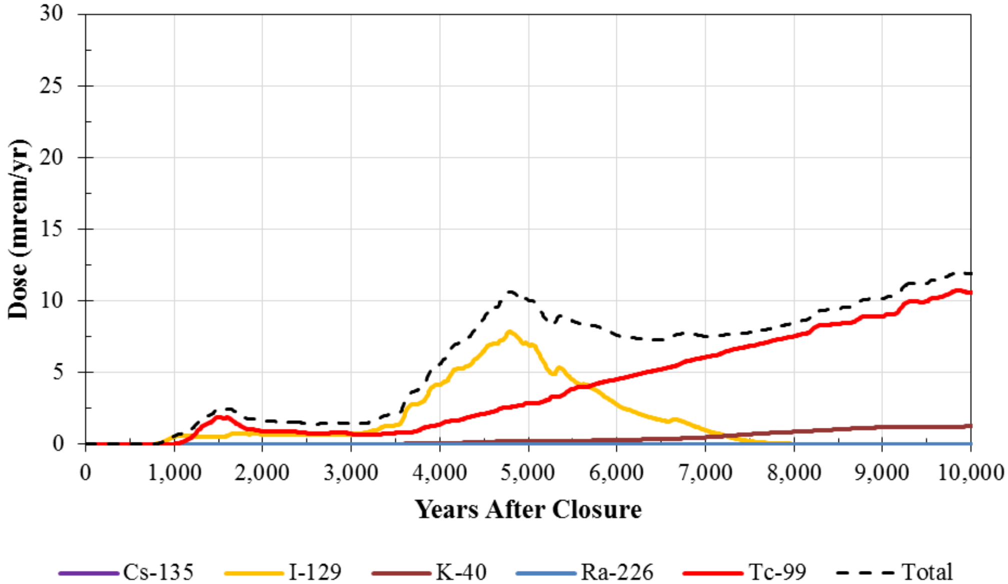


Figure 39: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector J, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate) and an Iodine Kd of 0 in Cementitious Materials

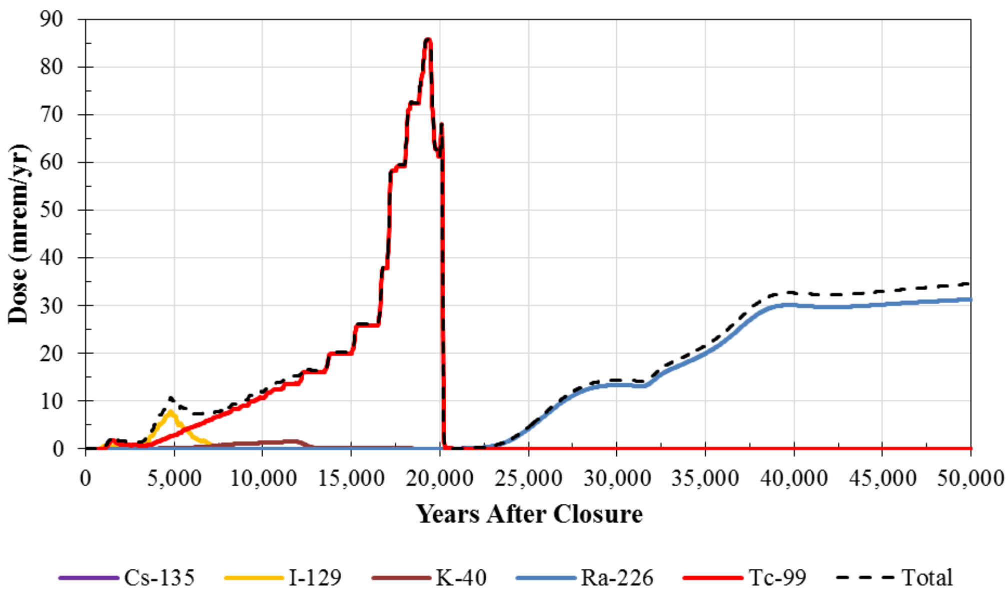


Figure 40: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate) and an Iodine Kd of 0 in Cementitious Materials

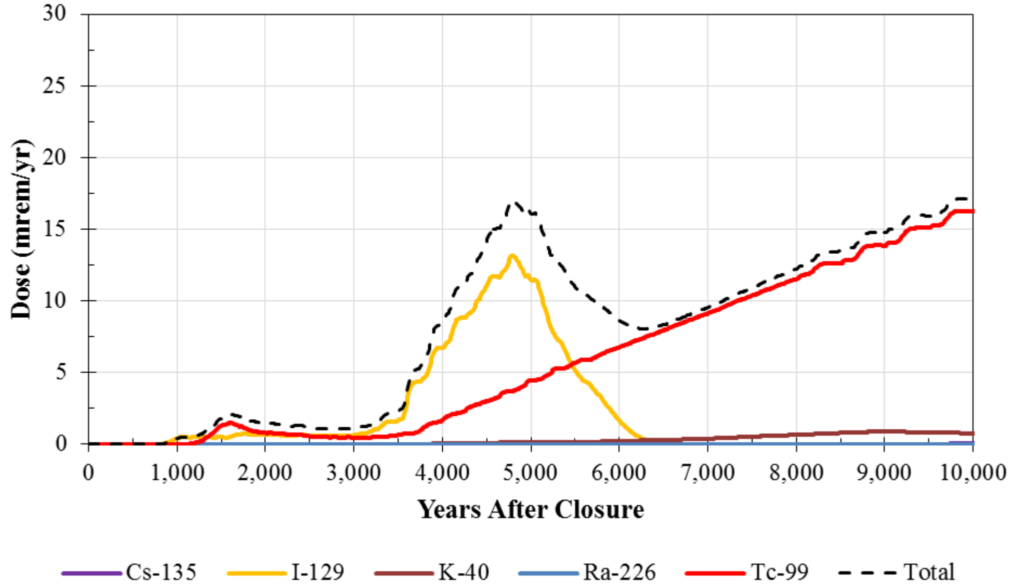
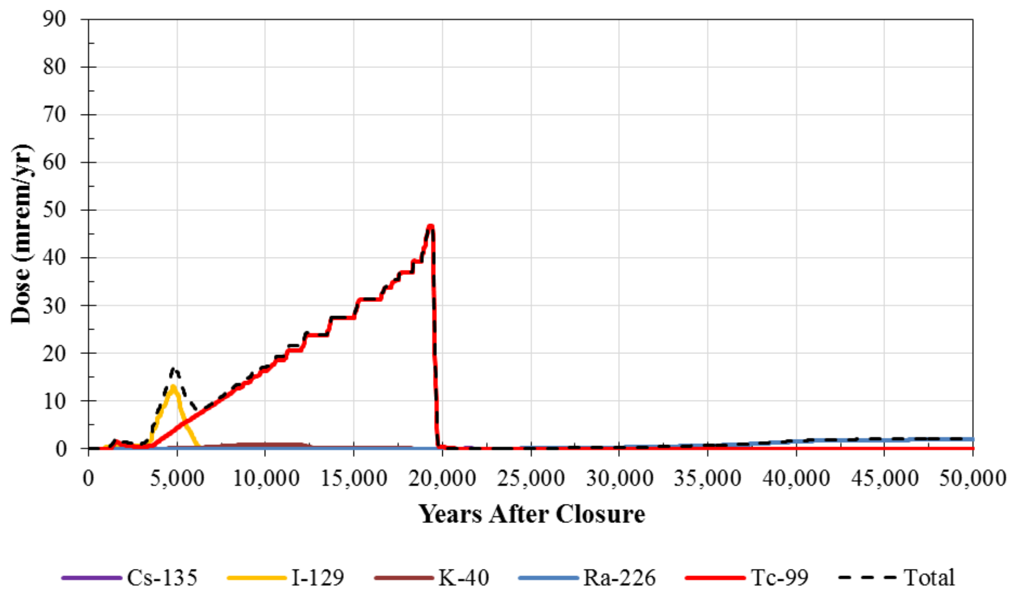


Figure 41: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector K, for Modeling Simulation that Assumes a Continuous Technetium Solubility of 5.0E-07 mol/L and Employs Flow Case F6 (which Includes a Best Estimate Cementitious Degradation Rate) and an Iodine Kd of 0 in Cementitious Materials



2.7 MOP Total-Dose Results for Simulation G

This section provides a more detailed discussion of Simulation G, where the Reduced Region I → Reduced Region II transition takes place, with the Reduced Region I technetium solubility limit set to 1.0E-08 mol/L, the Reduced Region II technetium solubility limit set to 1.0E-07 mol/L, and the Reduced Region I → Reduced Region II transition taking place after 4.5 pore-volumes of water has passed through the system (Table 2). This simulation is the same as Simulation D except that iodine sorption in the cementitious materials has been neglected. Figures 42 through 49 depict the Sector specific results for Simulation G and then go into further detail with respect to Sectors B, J, and K. Due to the generally higher concentration at observation wells along these three sectors, Sectors B, J, and K generally dominate the GoldSim model MOP peak dose results, and are therefore considered representative of the system.

Figure 42 depicts the peak total-dose breakthrough curves for the first 10,000 years of Simulation G for Sectors A through L of the 100-meter MOP boundary (Figure 5). Figure 42 indicates that for Simulation G, over the first 10,000 years, the peak total dose of 20 mrem/yr will occur at 5,560 years (Table 3) along Sector B. This peak value is expected to be dominated by radionuclide releases from SDU 4. The peak 1,000-year dose of 4.2 mrem/yr (at 1,000 years), is also derived from Sector B values (Table 3). As seen in Figure 42, at around 2,500 years, the dose values along Sector K are greater than the dose results along Sector B, but by 3,000 years this trend has reversed. After about 5,600 years the dose values along Sector K dominate the total-dose breakthrough curve until 18,000 years when total-dose values at observation wells along Sector J (or I) will dominate the magnitude of the dose calculations (see Figures 42 and 43).

Figure 44 shows that in Sector B for the first 10,000 years, releases of I-129 controls the total dose level for the first 3,000 years then Tc-99 which peaks at about 5,500 years controls the total dose level. Because the reinforcement associated with overlapping of I-129 and Tc-99 breakthrough curves does not occur, the 10,000-year peak is not as high as in Simulation D. Figure 45 shows that after the first 10,000 years Tc-99 dose contributions dominate the total dose results, until 20,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector B.

Figure 46 shows that in Sector J for the first 10,000 years, releases of I-129 and Tc-99 dominate the total-dose results with I-129 the controlling species for the first 3,000 years and Tc-99 (with some contribution from K-40) the controlling species until 10,000 years into the simulation. Figure 37 shows that after 10,000 years Tc-99 dose contributions control the total dose results until 22,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector J.

Figure 48 shows that in Sector K for the first 10,000 years, releases of I-129 and Tc-99 dominate the total-dose results with I-129 the controlling species for the first 3,000 years and Tc-99 (with some contribution from K-40) the controlling species until 10,000 years into the simulation. Figure 49 shows that after 10,000 years Tc-99 dose contributions control the total dose results until 21,000 years into the simulation. For the remainder of the simulation Ra-226 dose contributions dominate the total dose results in Sector K. Note that the lower Ra-226 dose contributions in Sector K (Figure 49) versus Sector J (Figure 47) are related to the inventories of

the source SDUs. SDUs 2A, 2B, 3A, and 3B (see Figure 5), have much larger ratios of Ra-226 and Th-230 inventories to saltstone volumes than in other SDUs.

Figure 42: GoldSim 100-Meter MOP Dose within 10,000 Years, Sectors A through L, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

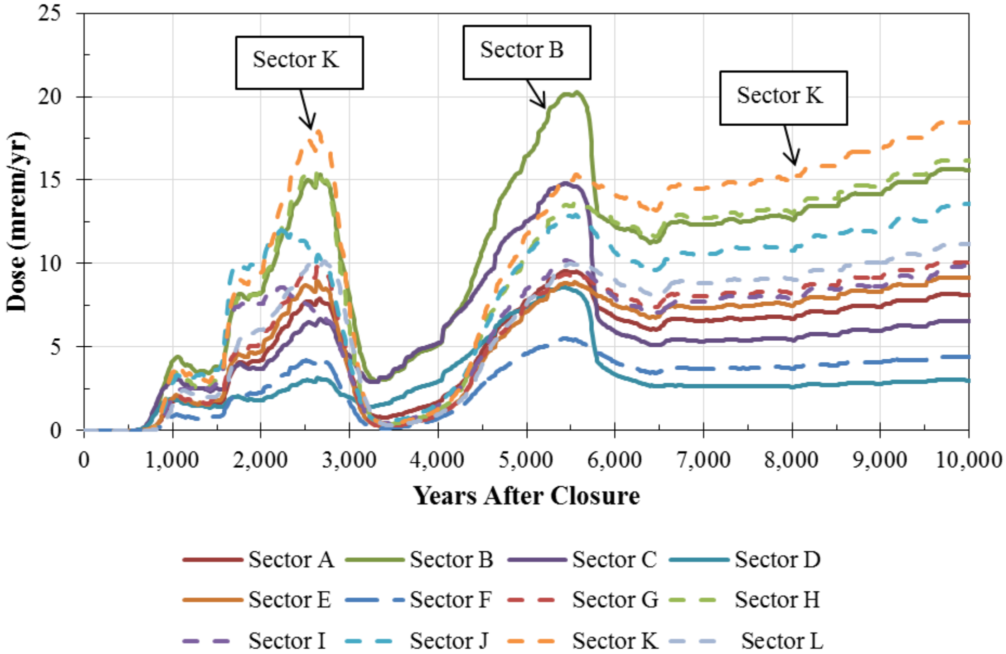


Figure 43: GoldSim 100-Meter MOP Dose within 50,000 Years, Sectors A through L, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

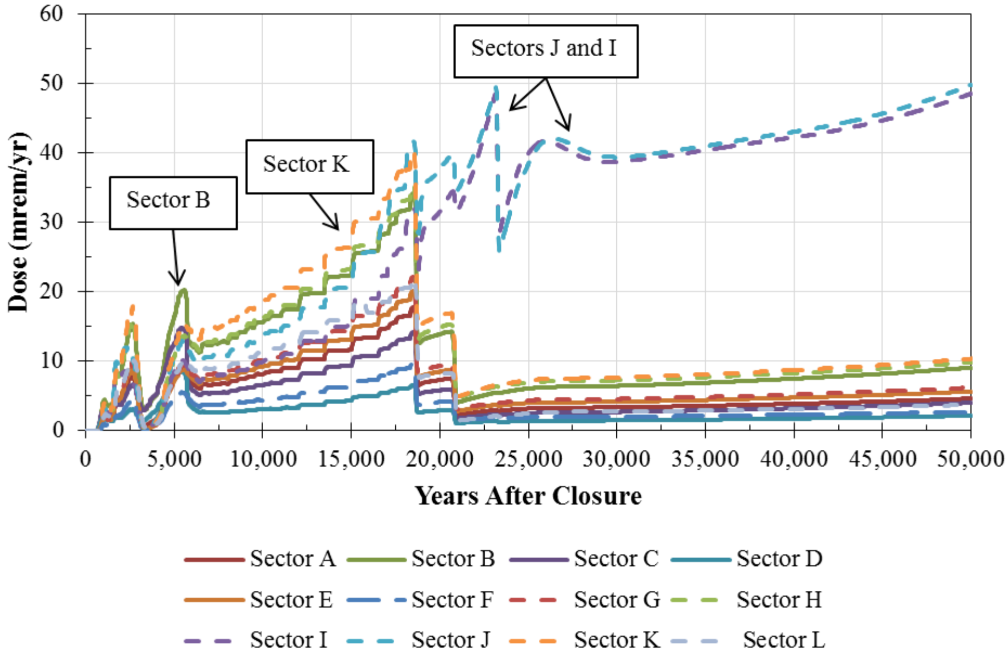


Figure 44: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector B, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

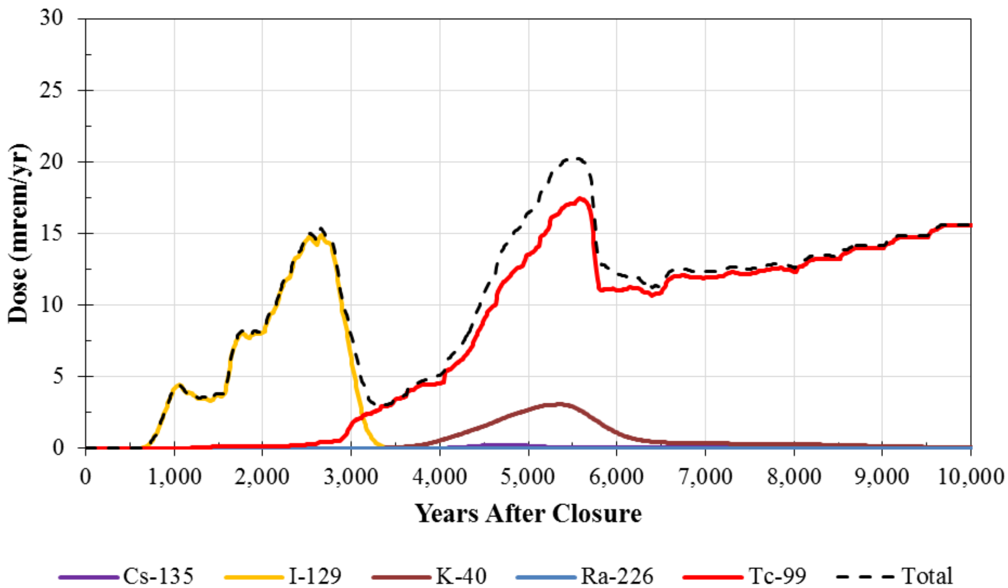


Figure 45: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector B, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

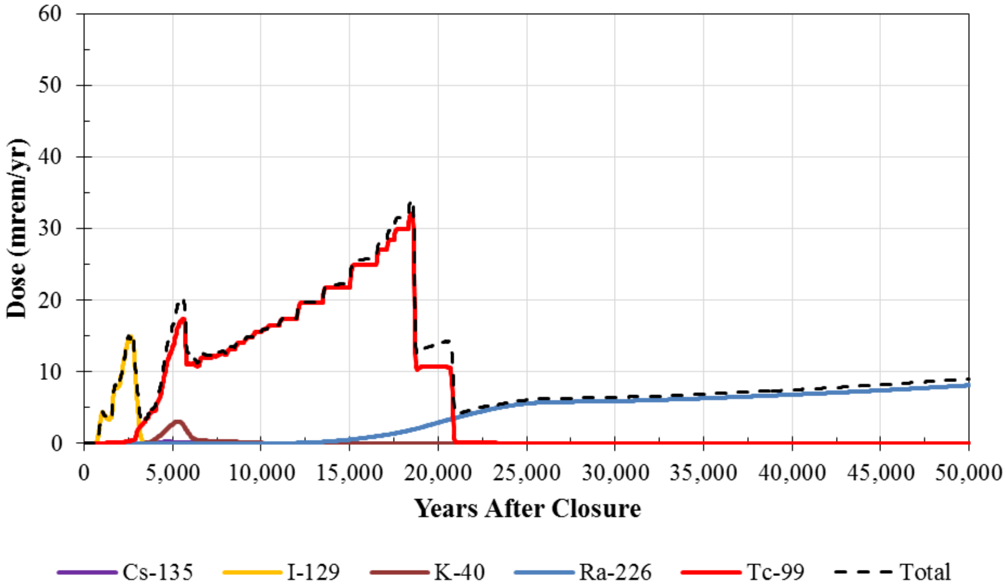


Figure 46: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector J, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

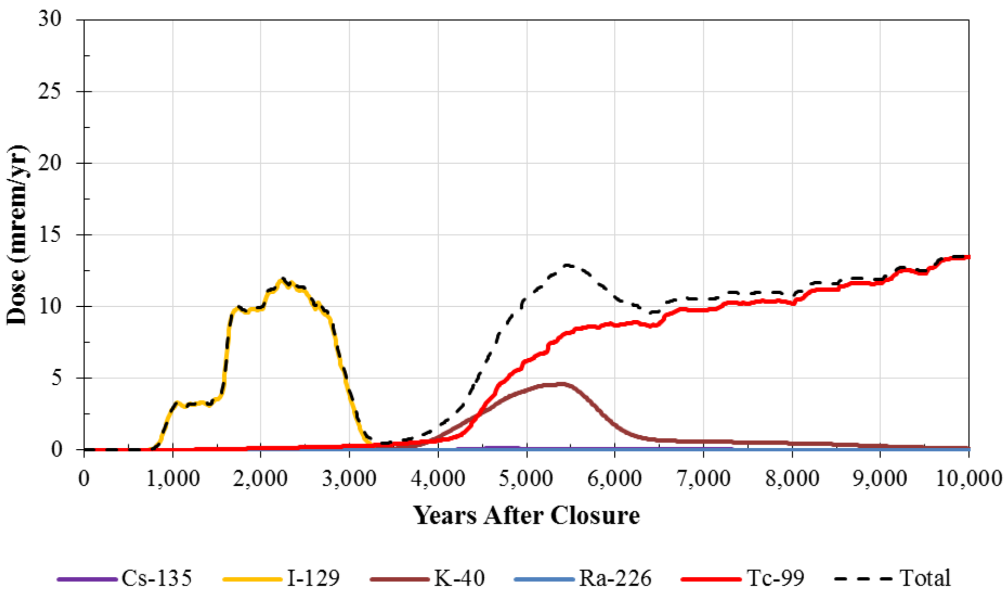


Figure 47: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector J, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

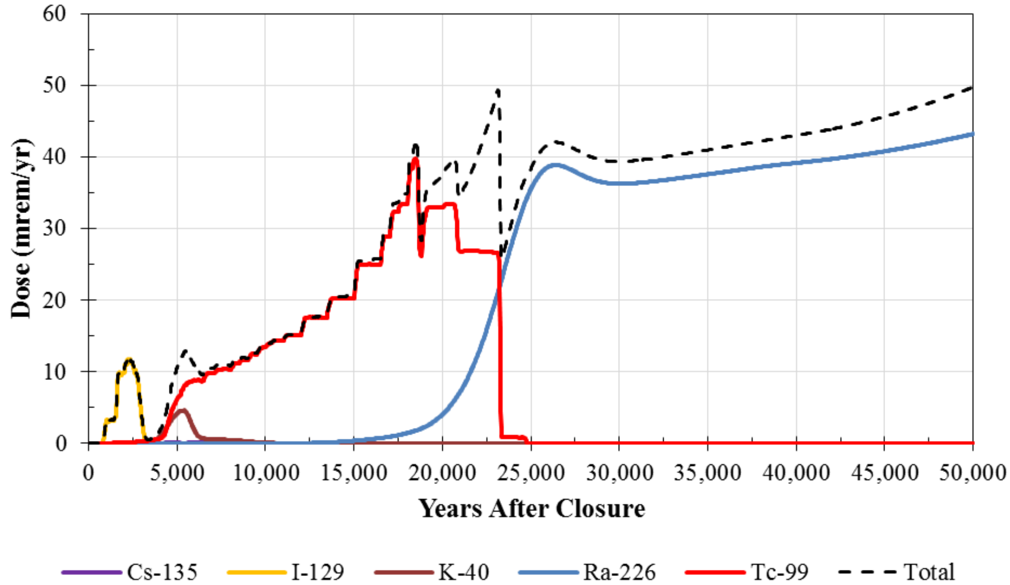


Figure 48: GoldSim 100-Meter MOP Dose Contributors within 10,000 Years, Sector K, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials

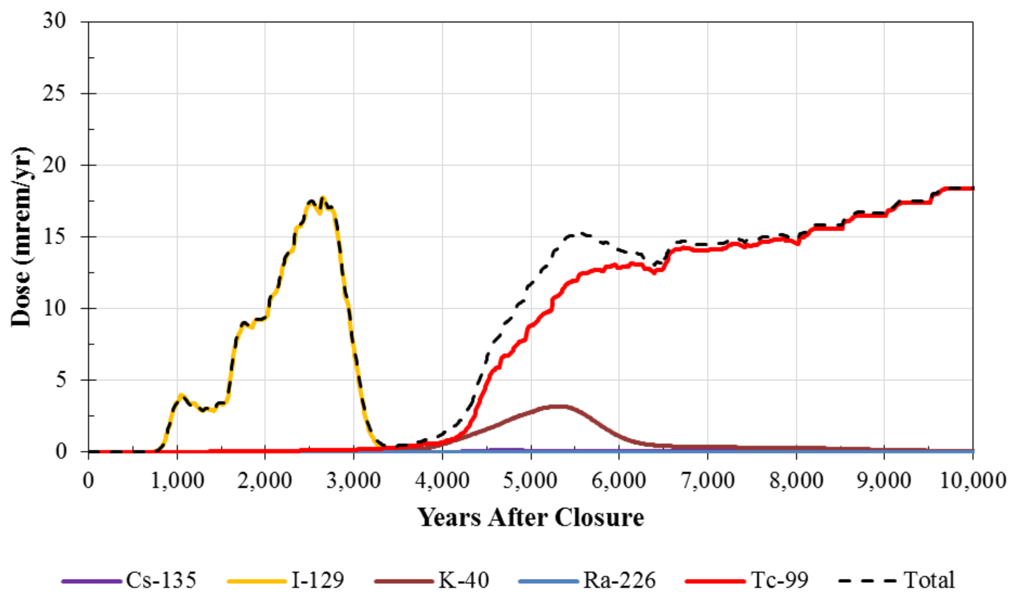
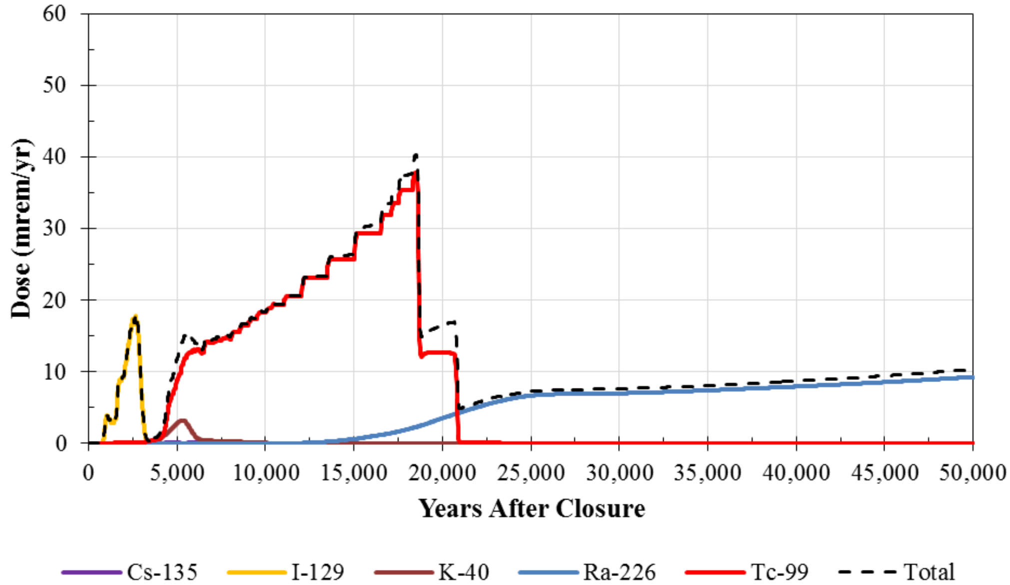


Figure 49: GoldSim 100-Meter MOP Dose Contributors within 50,000 Years, Sector K, for Modeling Simulation that Assumes an Initial Technetium Solubility of 1.0E-08 mol/L then After 4.5 Pore Flushes Assumes a Technetium Solubility of 1.0E-07 mol/L and an Iodine Kd of 0 in Cementitious Materials



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