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Savannah River Remediation
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INTEROFFICE MEMORANDUM

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Impact of GSA2018 Flow Update, Alternative Dispersion Model, and Increased Grid Resolution on Tank Closure Performance Assessments

The F-Area Tank Farm (FTF) and H-Area Tank Farm (HTF) Performance Assessments (PAs) involve simulations of radionuclide and chemical waste migration through groundwater to exposure points. These solute transport simulations are based on a circa 2004 "GSA/PORFLOW" flow model [WSRC-TR-2004-00106]. The GSA/PORFLOW model was significantly updated in 2016-2017 [SRNL-STI-2017-00008 Rev. 1]. Impacts of the "GSA2016" flow model on the F- and H-Tank Farm PAs were assessed in SRNL-STI-2017-00445, *Impacts of Updated GSA Groundwater Flow Models on the FTF, HTF and SDF PAs*. Since then (2018-2019) further revisions resulted in a "GSA2018" flow model [SRNL-STI-2018-00643], which has been adopted for the 2019 Saltstone PA revision [SRR-CWDA-2019-00001 Revision A]. This study assesses the impacts of the GSA2018 flow model on the FTF and HTF PAs. Also assessed are the impacts of an alternative plume dispersion model and increased grid resolution that have been incorporated in the 2019 Saltstone PA.

The effects of the GSA2018 flow field, alternative dispersion model, and increased grid resolution are assessed individually and in combination. The impacts of these updates are assessed through three sets of comparisons based on PORFLOW version 6.42.9 [https://www.acricfd.com/software/porflow/, SRNL-STI-2018-00275] simulations. In the first set, a constant 1.0 mol/yr source of a hypothetical, non-decaying, non-sorbing, "tracer" species is placed in aquifer grid cells near the water table underlying each tank or other PA source (ancillary equipment for example). The general layouts of these source zones, labeled by tank number, are shown in Figures 1 and 2. PORFLOW simulations proceed until the plume emanating from each source zone reaches a steady-state configuration. Steady-state (peak) concentrations at the 100-meter perimeter are compared for the various simulation cases considered. For the second set of simulations, the constant source is replaced with an instantaneous (one-time) source of 1.0 mol of tracer. These "pulse" simulations produce transient concentration breakthrough curves at the 100-meter perimeter. The breakthrough curves and their peak concentrations are compared for the simulation cases considered. Finally, the "Evaluation" (compliance, base) cases from the latest F- and H-Area Special Analyses (SAs) [SRR-CWDA-2012-00106 Rev. 1, SRR-CWDA-2016-00078] are re-simulated with the updated GSA2018 flow field, alternative dispersion model, and/or increased grid resolution.

Figure 1: F-Area waste tanks.

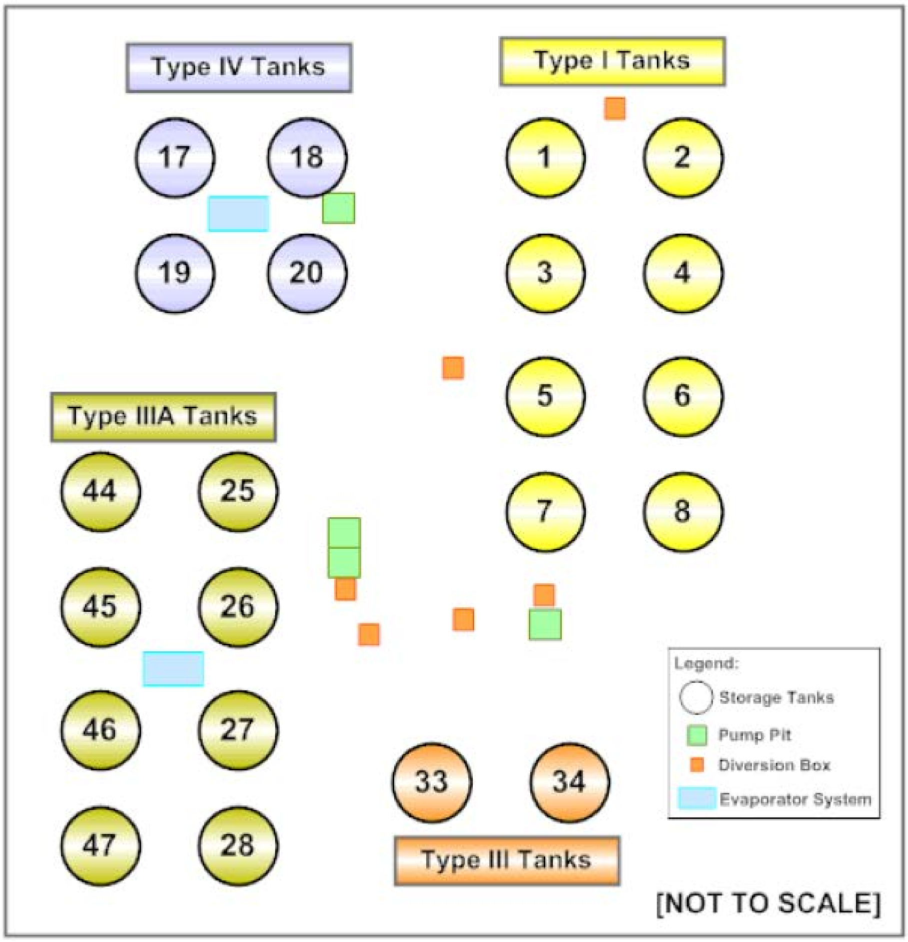


Figure 2: H-Area waste tanks.

The summary phrase "alternative dispersion model" refers to multiple settings in a PORFLOW simulation as summarized on Table 1. Harmonic averaging (PORFLOW HARMonic option) is commonly used in numerical models to assign transport properties associated with grid cells to the interfaces between cells. With this cell face assignment PORFLOW exhibited numerical instabilities when the full dispersion tensor was modeled. To avoid these instabilities, PORFLOW was typically run with only the diagonal terms of the tensor included in the simulation. The diagonal-terms-only setting produces increased numerical dispersion when the flow direction is not aligned with one of the grid axes, and thus is undesirable. More recently, upwinding (PORFLOW UPWInd option) coupled with the full dispersion tensor (PORFLOW TENSor option) was discovered to generally produce stable numerical simulations. As noted in Table 1, the UPWI + TENS settings have been adopted for PORFLOW simulations going forward to avoid unnecessary numerical dispersion. [SRNL-STI-2017-00445]

Table 1. Plume dispersion settings in PORFLOW.

Setting	F-Area Tanks 5 & 6 SA	H-Area Type I/II (Tank 12) SA	Update
Property assignment at cell faces	HARMonic averaging	HARMonic averaging	UPWInd assignment
Dispersion tensor	Diagonal terms only	Diagonal terms only	Full TENSor
Dispersion model	Two-parameter default model	Four-parameter STRAtified model	Four-parameter STRAtified model

Also noted in Table 1 is an update to the dispersion model for the F-Tank Farm. The two- and four-parameter dispersion models are described in SRNL-L6200-2010-00016. The dispersivity values for the four-parameter (STRAtified) model recommended in SRNL-STI-2018-00012 have been proposed for the next tank closure PA revisions. The four-parameter model coupled with the recommended dispersivities produces less vertical dispersion than the two-parameter model, consistent with plume migration through a layered/stratified sedimentary system.

Table 2 summarizes the grid resolution of the F- and H-Tank Farm SA models and planned PA revision models. The updated values follow the recommendations of SRNL-STI-2018-00012, avoid unnecessary numerical dispersion, and have become practicable with current computing capabilities. In previous modeling, solute loss out the prescribed concentration boundary above the water table was occasionally observed. To guard against unintended mass loss, the extent of aquifer grids will be increased through an additional grid layer above the water table as indicated in Table 2.

Table 2. Grid resolution.

Attribute	F-Area Tanks 5 & 6 SA	H-Area Type I/II (Tank 12) SA	Update
Lateral (x,y) grid resolution	4x4 refinement to 50-feet	6x6 refinement to 33-feet	8x8 refinement to 25-feet
Vertical (z) grid resolution	No refinement	2x refinement in Lower Aquifer Zone	3-foot resolution to the extent practicable
Grid extent	Just above water table	Just above water table	Expanded buffer zone above water table

The specific cases considered for this comparative study are:

1. <u>Reference</u>: GSA2004 flow field, original plume dispersion settings (Table 1), and original grid resolution and extent (Table 2).
2. <u>GSA2004+TENSor</u>: GSA2004 flow field, updated dispersion settings
3. <u>GSA2004+TENSor+refinement</u>: GSA2004 flow field, updated dispersion settings, increased horizontal and vertical grid refinement, increased extent above water table
4. <u>GSA2018+TENSor</u>: GSA2018 flow field, updated dispersion settings
5. <u>GSA2018+TENSor+refinement</u>: GSA2018 flow field, updated dispersion settings, increased horizontal and vertical grid refinement, increased extent above water table

The “GSA2018+TENSor+refinement” case (case 5) includes all anticipated updates relative to the “Reference” case (case 1). The other cases are partial updates intended to show the impact of step-by-step updates to the Reference case, for example

- dispersion settings (case 2), then grid resolution (case 3), and finally flow field (case 5)
- dispersion settings (case 2), then flow field (case 4), and finally grid resolution (case 5).

Electronic files are stored under directories \\godzilla-01\hpc_project\projwork53\srr19_cont2\FTF and \\godzilla-01\hpc_project\projwork53\srr19_cont2\HTF. Streamtrace, tracer plume, and SA Evaluation case simulations are described in the following two sections.

Streamtrace simulations

Figures 3 and 4 compare the GSA2004 and GSA2018 groundwater flow fields through streamtrace plots in plan and cross-sectional views centered over the F-Tank Farm. Each streamtrace starts near the water table beneath a tank and extends past the 100-meter perimeter indicated with green diamond symbols. Red circles along each streamtrace denote 10-years of travel time. The cross-sectional cut is shown in the plan view by a light gray line. Two confining zones are shown in the cross-sectional view: the Tan Clay Confining Zone (TCCZ) in tan, and the Gordon Confining Unit (GCU) in green. Kinks in the plan-view streamtraces correspond to passage through the TCCZ and an abrupt change in flow direction. In the context of the model (x,y) coordinate system, both models indicate a southwesterly flow direction in the Upper Aquifer Zone (UAZ). In the Lower Aquifer Zone (LAZ) between the TCCZ and GCU, groundwater flows in a westerly direction on average in the GSA2004 model. In the GSA2018 model the LAZ flow direction is more to the northwest. Groundwater flow rates are slower in the GSA2018 model.

Figures 5 and 6 provide the same comparison of the GSA2004 and GSA2018 models in the context of the H-Tank Farm, except that timing markers are placed every 20-years. Because the H-Tank Farm resides over a groundwater high dividing infiltrating flow between Fourmile Branch, McQueen Branch, and Upper Three Runs, simulated flow directions and rates are more uncertain and variable than beneath F-Tank Farm. The downward component of the flow trajectory is also larger, consistent with the presence of a groundwater divide. In the GSA2004 model, simulated streamtraces travel in directions ranging from west to north to northeast reflecting a groundwater high just south of the H-Tank Farm center. In the GSA2018 model, the collective set of streamtraces radiate in all directions reflecting a simulated groundwater high beneath the center of the facility. As in F-Area, the groundwater travel rates are slower in the GSA2018 model.

Figure 3: Simulated streamtraces from F-Area tanks with 10-year markers: GSA2004 flow field.

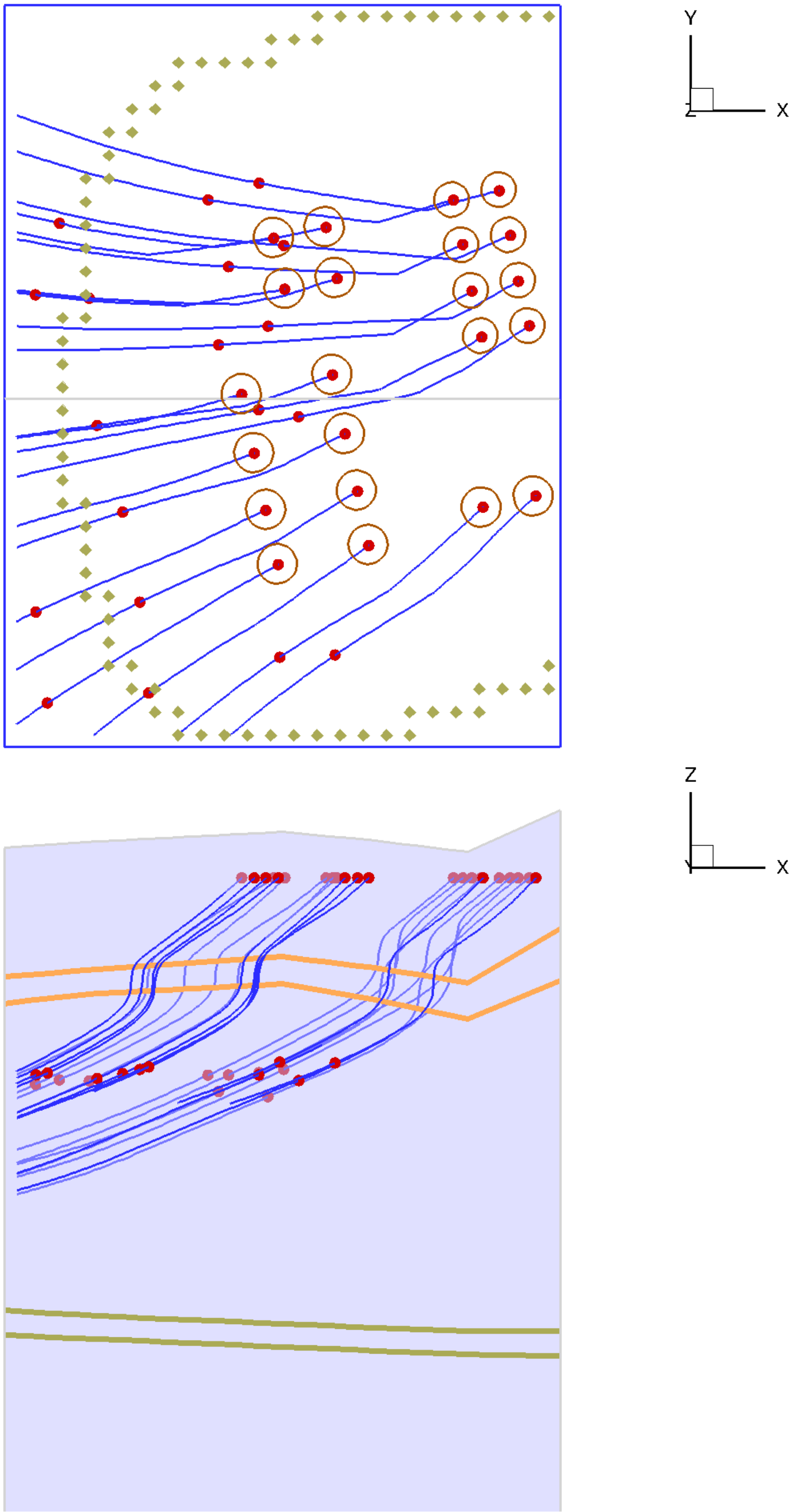


Figure 4: Simulated streamtraces from F-Area tanks with 10-year markers: GSA2018 flow field.

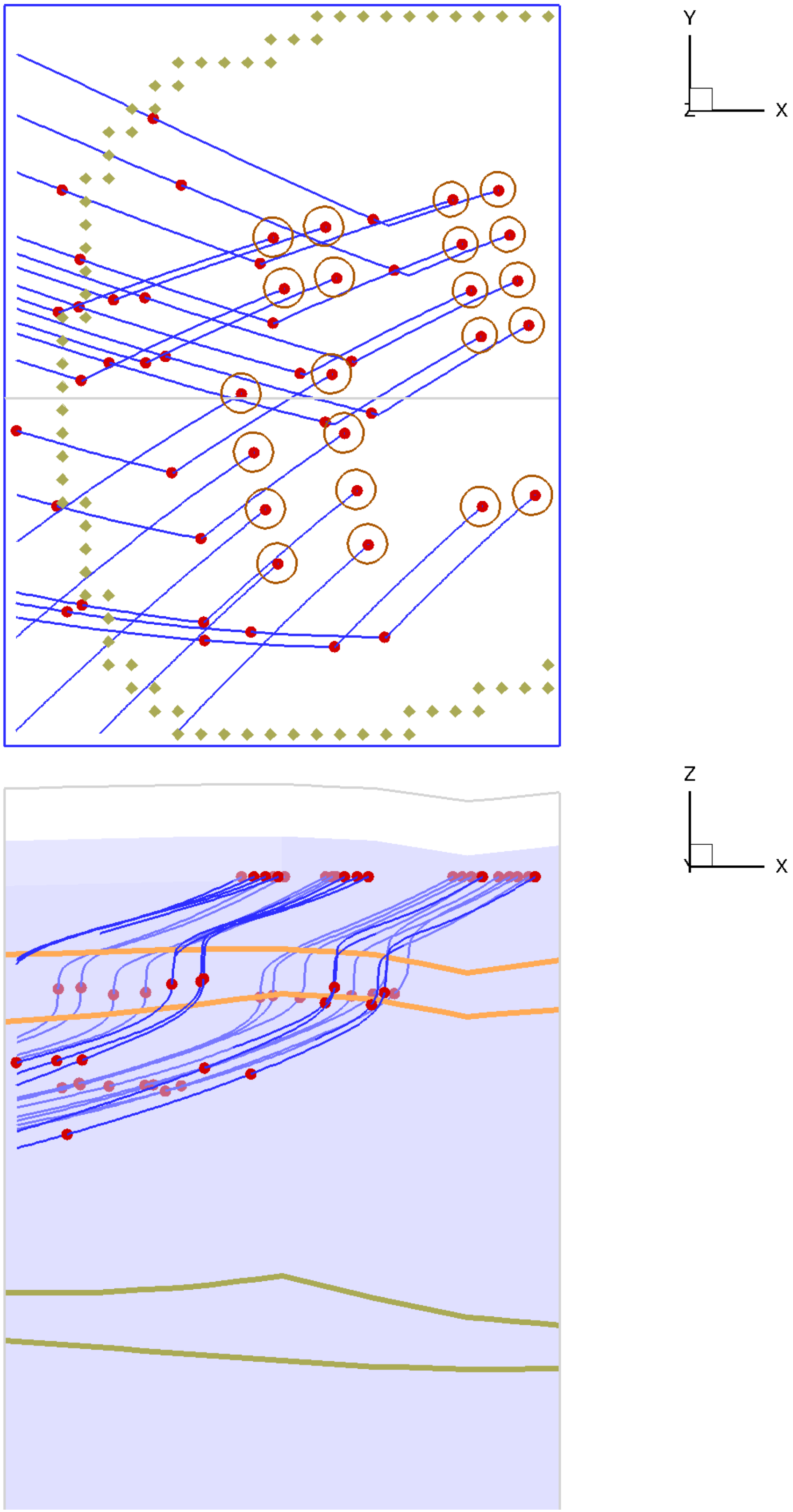


Figure 5: Simulated streamtraces from H-Area tanks with 20-year markers: GSA2004 flow field.

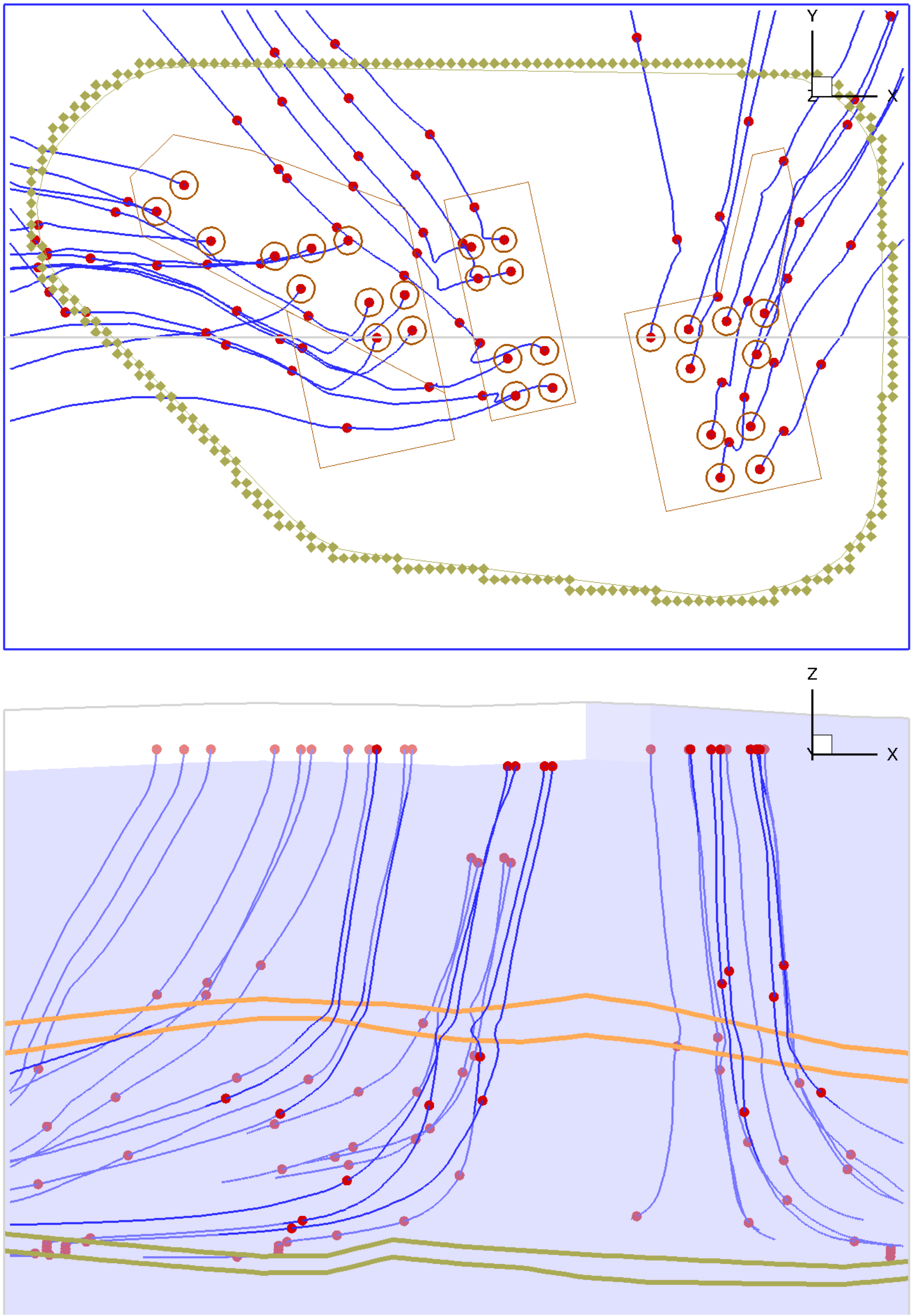
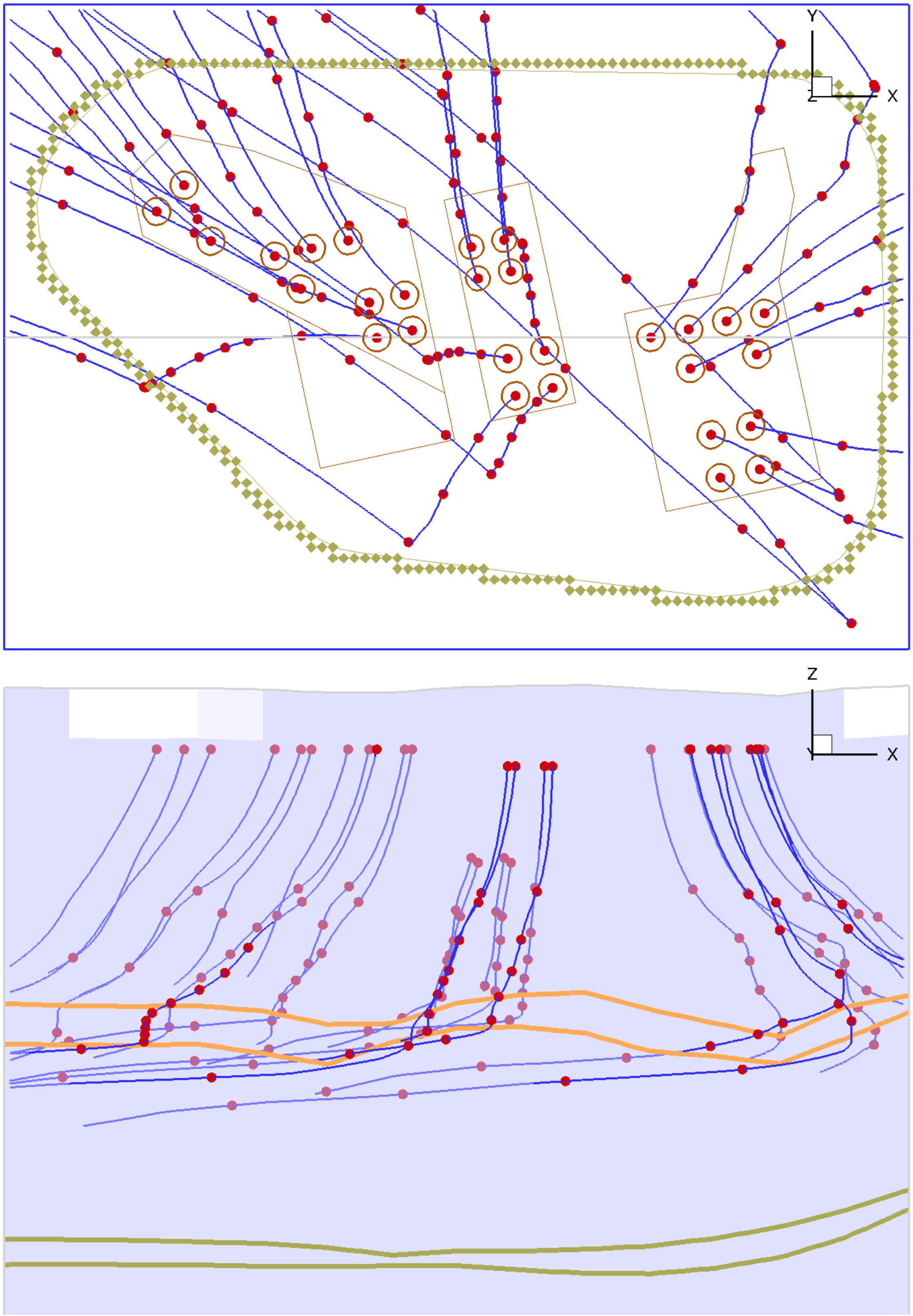


Figure 6: Simulated streamtraces from H-Area tanks with 20-year markers: GSA2018 flow field.



F-Tank Farm tracer plume simulations

Appendix A and B contain transient plots of peak tracer concentration at 100-meters for each tank in F-Area for steady-state and pulsed source simulations, respectively. Tables 3 and 4 summarize the overall peak concentrations observed from the simulations. Also listed in the tables are summary statistics: maximum, mean, median, and minimum concentration. Finally, several relative comparisons are shown based on the median values for each of the five cases.

Regarding the steady-state plume simulations in Table 3, the overall impact of implementing the GSA2018 flow field, alternative dispersion model, and increased grid resolution is projected to be around 10x based on comparing Case 5 to Case 1 (9.9x in Table 3). The largest contributor is the alternative dispersion model (TENSor effect), which constitutes approximately 90% of the overall effect. The refined grid contributes about 10% and the flow model effect is negligible.

Similar impacts are observed from the pulsed plume results in Table 4. The overall impact of the three anticipated updates is about a 12x increase in peak concentrations. Again, the largest contributor is dispersion model followed by mesh refinement and then flow field.

Table 3. Peak concentrations from F-Tank Farm steady-state tracer plume simulations.

Case: Source	(1) Reference	(2) GSA2004 + TENSor	(3) GSA2004 + TENSor + refinement	(4) GSA2018 + TENSor	(5) GSA2018 + TENSor + refinement			
TANK01	6.68E-07	3.69E-06	4.49E-06	2.96E-06	3.21E-06			
TANK02	5.56E-07	3.06E-06	4.05E-06	2.91E-06	3.30E-06			
TANK03	7.20E-07	3.52E-06	4.37E-06	2.63E-06	2.75E-06			
TANK04	5.32E-07	2.93E-06	3.58E-06	2.38E-06	2.63E-06			
TANK05	9.67E-07	3.45E-06	3.96E-06	2.23E-06	2.54E-06			
TANK06	5.60E-07	2.68E-06	3.22E-06	1.93E-06	2.15E-06			
TANK07	7.97E-07	3.41E-06	3.88E-06	2.43E-06	2.54E-06			
TANK08	5.49E-07	2.47E-06	2.86E-06	2.01E-06	2.09E-06			
TANK17	1.48E-06	8.85E-06	1.03E-05	8.31E-06	1.19E-05			
TANK18	1.14E-06	7.09E-06	7.45E-06	6.69E-06	9.09E-06			
TANK19	7.76E-07	6.00E-06	9.50E-06	6.54E-06	9.34E-06			
TANK20	1.03E-06	5.18E-06	7.57E-06	4.82E-06	6.66E-06			
TANK25	3.36E-07	2.64E-06	6.43E-06	4.77E-06	6.35E-06			
TANK26	2.68E-07	2.45E-06	6.38E-06	4.47E-06	5.57E-06			
TANK27	1.96E-07	2.30E-06	5.73E-06	3.68E-06	4.94E-06			
TANK28	1.59E-07	2.25E-06	6.07E-06	4.56E-06	6.49E-06			
TANK33	1.26E-07	1.50E-06	4.13E-06	4.07E-06	5.10E-06			
TANK34	8.87E-08	1.14E-06	3.46E-06	3.10E-06	4.50E-06			
TANK44	4.17E-07	4.13E-06	1.03E-05	6.52E-06	9.82E-06			
TANK45	3.35E-07	4.24E-06	1.01E-05	6.22E-06	8.85E-06			
TANK46	2.56E-07	3.45E-06	9.82E-06	6.25E-06	8.47E-06			
TANK47	4.37E-07	5.17E-06	9.38E-06	6.82E-06	8.91E-06			
Maximum	1.48E-06	8.85E-06	1.03E-05	8.31E-06	1.19E-05			
Mean	5.63E-07	3.71E-06	6.23E-06	4.38E-06	5.78E-06			
Median	5.41E-07	3.43E-06	5.90E-06	4.27E-06	5.33E-06			
Minimum	8.87E-08	1.14E-06	2.86E-06	1.93E-06	2.09E-06			
Relative median	1x	6.3x	10.9x	7.9x	9.9x		**8.87**	
TENSor effect	1x	6.3x				6.35x	5.35	91%
Refinement effect		1x	1.72x	1x	1.25x	1.48x	0.48	8%
Flow field effect		1x		1.24x				
Flow field effect			1x		0.90x	1.07x	0.07	1%
							5.91	100%

Table 4. Peak concentrations from F-Tank Farm pulsed tracer plume simulations.

Case: Source	(1) Reference	(2) GSA2004 + TENSor	(3) GSA2004 + TENSor + refinement	(4) GSA2018 + TENSor	(5) GSA2018 + TENSor + refinement			
TANK01	7.81E-08	4.49E-07	5.43E-07	2.48E-07	2.77E-07			
TANK02	6.11E-08	3.29E-07	4.60E-07	2.42E-07	2.83E-07			
TANK03	7.75E-08	4.12E-07	5.10E-07	2.15E-07	2.25E-07			
TANK04	5.32E-08	3.02E-07	3.86E-07	1.88E-07	2.07E-07			
TANK05	9.98E-08	3.71E-07	4.45E-07	1.79E-07	2.10E-07			
TANK06	5.30E-08	2.74E-07	3.41E-07	1.43E-07	1.64E-07			
TANK07	8.26E-08	3.48E-07	4.15E-07	1.88E-07	2.01E-07			
TANK08	5.27E-08	2.40E-07	2.91E-07	1.45E-07	1.58E-07			
TANK17	2.59E-07	1.47E-06	1.81E-06	1.24E-06	1.95E-06			
TANK18	1.68E-07	1.07E-06	1.18E-06	8.54E-07	1.22E-06			
TANK19	1.18E-07	9.48E-07	1.53E-06	8.61E-07	1.24E-06			
TANK20	1.41E-07	7.39E-07	1.11E-06	5.67E-07	7.75E-07			
TANK25	4.55E-08	3.58E-07	8.67E-07	6.13E-07	7.99E-07			
TANK26	3.71E-08	3.24E-07	8.58E-07	5.84E-07	7.21E-07			
TANK27	2.81E-08	3.12E-07	7.69E-07	4.76E-07	6.74E-07			
TANK28	2.42E-08	3.24E-07	8.93E-07	6.89E-07	1.06E-06			
TANK33	1.60E-08	1.78E-07	5.29E-07	5.55E-07	7.01E-07			
TANK34	1.07E-08	1.44E-07	4.42E-07	4.18E-07	6.22E-07			
TANK44	7.59E-08	7.56E-07	1.89E-06	1.00E-06	1.53E-06			
TANK45	5.98E-08	8.00E-07	1.91E-06	9.34E-07	1.48E-06			
TANK46	5.08E-08	6.22E-07	1.89E-06	1.04E-06	1.49E-06			
TANK47	8.72E-08	8.86E-07	1.74E-06	1.30E-06	1.85E-06			
Maximum	2.59E-07	1.47E-06	1.91E-06	1.30E-06	1.95E-06			
Mean	7.63E-08	5.30E-07	9.46E-07	5.77E-07	8.11E-07			
Median	6.04E-08	3.64E-07	8.14E-07	5.61E-07	7.11E-07			
Minimum	1.07E-08	1.44E-07	2.91E-07	1.43E-07	1.58E-07			
Relative median	1x	6.0x	13.5x	9.3x	11.8x		**10.76**	
TENSor effect	1x	6.0x				6.02x	5.02	84%
Refinement effect		1x	2.24x	1x	1.27x	1.75x	0.75	13%
Flow field effect		1x		1.54x				
Flow field effect			1x		0.87x	1.21x	0.21	3%
							5.98	100%

H-Tank Farm tracer plume simulations

Appendix C and D contain transient plots of peak tracer concentration at 100-meters for each tank in H-Area for steady-state and pulsed source simulations, respectively. Tables 5 and 6 summarize the overall peak concentrations observed during the simulations. Also listed in the tables are summary statistics: maximum, mean, median, and minimum concentration. Finally, several relative comparisons are shown based on the median values for each of the five cases.

Regarding the steady-state plume simulations in Table 5, the overall impact of implementing the GSA2018 flow field, alternative dispersion model, and increased grid resolution is projected to be about 5.8x based on comparing Case 5 to Case 1 (5.84x in Table 5). The relative contributions of flow field, dispersion model, and grid resolution are approximately 60%, 25%, and 15%, respectively. The effect of the alternative dispersion model is much lower than F-Area because the reference simulation already includes the four-parameter STRAtified model. Similarly, the grid refinement effect is much smaller for H-Area compared to F-Area because the H-Tank Farm SA used a higher resolution grid than used in the F-Tank Farm SA (Table 2). On the other hand, much slower groundwater velocities in the GSA2018 model versus the GSA2004 model in the immediate vicinity of H-Area tanks accentuate the contribution of the flow field update.

The general impacts observed from the pulsed plume results in Table 6 are like those of the steady-state plume simulations. The overall impact of the three anticipated updates is about a 2.8x increase in peak concentrations on average. The relative contributions of flow field, dispersion model, and grid resolution are approximately 50%, 25%, and 25%, respectively.

Table 5. Peak concentrations from H-Tank Farm steady-state tracer plume simulations.

Case: Source	(1) Reference	(2) GSA2004 + TENSor	(3) GSA2004 + TENSor + refinement	(4) GSA2018 + TENSor	(5) GSA2018 + TENSor + refinement			
TANK09	6.88E-06	1.63E-05	1.58E-05	3.03E-05	2.96E-05			
TANK10	7.80E-06	2.00E-05	1.94E-05	3.23E-05	3.15E-05			
TANK11	6.18E-06	1.35E-05	1.31E-05	2.55E-05	2.58E-05			
TANK12	6.53E-06	1.52E-05	1.51E-05	2.83E-05	2.95E-05			
TANK13	3.09E-06	4.30E-06	4.70E-06	4.04E-06	4.30E-06			
TANK14	3.47E-06	5.18E-06	5.52E-06	1.05E-05	8.39E-06			
TANK15	3.69E-06	5.13E-06	5.43E-06	1.77E-05	2.17E-05			
TANK16	3.18E-06	4.40E-06	4.51E-06	1.37E-05	1.38E-05			
TANK21	2.51E-06	3.56E-06	4.41E-06	8.65E-06	1.13E-05			
TANK22	2.80E-06	3.80E-06	5.07E-06	2.17E-05	2.54E-05			
TANK23	2.37E-06	3.79E-06	4.92E-06	1.50E-05	1.78E-05			
TANK24	2.83E-06	3.71E-06	4.96E-06	8.17E-06	1.03E-05			
TANK29	3.05E-06	4.14E-06	5.18E-06	1.29E-05	1.60E-05			
TANK30	4.34E-06	6.41E-06	7.67E-06	1.18E-05	1.42E-05			
TANK31	5.51E-06	7.95E-06	1.10E-05	1.02E-05	1.31E-05			
TANK32	5.22E-06	8.38E-06	1.19E-05	8.85E-06	1.11E-05			
TANK35	7.03E-06	1.02E-05	1.40E-05	1.06E-05	1.34E-05			
TANK36	8.07E-06	1.13E-05	1.67E-05	1.17E-05	1.77E-05			
TANK37	6.71E-06	9.98E-06	1.51E-05	1.08E-05	1.71E-05			
TANK38	3.46E-06	5.28E-06	6.06E-06	1.30E-05	1.91E-05			
TANK39	3.09E-06	5.39E-06	7.13E-06	1.09E-05	1.57E-05			
TANK40	2.91E-06	5.80E-06	7.27E-06	1.02E-05	1.84E-05			
TANK41	3.01E-06	6.16E-06	7.97E-06	1.09E-05	2.14E-05			
TANK42	3.14E-06	4.90E-06	6.44E-06	1.71E-05	2.73E-05			
TANK43	2.41E-06	5.12E-06	7.65E-06	1.39E-05	2.64E-05			
TANK48	2.75E-06	4.93E-06	6.62E-06	1.56E-05	2.28E-05			
TANK49	2.56E-06	5.42E-06	8.06E-06	1.70E-05	3.21E-05			
TANK50	2.53E-06	4.99E-06	7.05E-06	1.77E-05	2.91E-05			
TANK51	2.55E-06	5.17E-06	6.87E-06	2.29E-05	2.91E-05			
Maximum	8.07E-06	2.00E-05	1.94E-05	3.23E-05	3.21E-05			
Mean	4.13E-06	7.26E-06	8.82E-06	1.52E-05	1.98E-05			
Median	3.14E-06	5.28E-06	7.13E-06	1.30E-05	1.84E-05			
Minimum	2.37E-06	3.56E-06	4.41E-06	4.04E-06	4.30E-06			
Relative median	1x	1.68x	2.27x	4.14x	5.84x		**4.84**	
TENSor effect	1x	1.68x				1.68x	0.68	26%
Refinement effect		1x	1.35x	1x	1.41x	1.38x	0.38	15%
Flow field effect		1x		2.47x				
Flow field effect			1x		2.57x	2.52x	1.52	59%
							2.58	100%

Table 6. Peak concentrations from H-Tank Farm pulsed tracer plume simulations.

Case: Source	(1) Reference	(2) GSA2004 + TENSor	(3) GSA2004 + TENSor + refinement	(4) GSA2018 + TENSor	(5) GSA2018 + TENSor + refinement			
TANK09	2.48E-07	4.63E-07	5.00E-07	5.84E-07	7.56E-07			
TANK10	2.74E-07	6.11E-07	6.13E-07	6.48E-07	8.79E-07			
TANK11	1.97E-07	3.50E-07	3.43E-07	3.61E-07	3.90E-07			
TANK12	1.85E-07	3.56E-07	3.80E-07	3.87E-07	4.82E-07			
TANK13	1.18E-07	1.22E-07	1.24E-07	2.70E-08	2.94E-08			
TANK14	6.04E-08	5.88E-08	6.27E-08	7.44E-08	5.12E-08			
TANK15	1.92E-07	2.16E-07	2.43E-07	3.68E-07	4.94E-07			
TANK16	1.13E-07	1.24E-07	1.23E-07	1.87E-07	2.01E-07			
TANK21	1.43E-07	1.55E-07	2.32E-07	6.13E-08	8.51E-08			
TANK22	2.04E-07	2.40E-07	3.95E-07	2.30E-07	3.03E-07			
TANK23	1.23E-07	1.42E-07	1.95E-07	2.69E-07	3.10E-07			
TANK24	1.76E-07	1.94E-07	3.08E-07	1.22E-07	1.59E-07			
TANK29	1.45E-07	1.64E-07	2.29E-07	6.72E-07	9.05E-07			
TANK30	2.22E-07	2.87E-07	3.70E-07	5.18E-07	6.81E-07			
TANK31	3.28E-07	4.15E-07	6.21E-07	3.87E-07	4.91E-07			
TANK32	3.21E-07	4.33E-07	7.40E-07	2.01E-07	2.54E-07			
TANK35	5.87E-07	7.56E-07	1.27E-06	6.16E-07	9.00E-07			
TANK36	9.39E-07	1.12E-06	2.10E-06	1.11E-06	1.97E-06			
TANK37	7.06E-07	8.90E-07	1.66E-06	9.89E-07	1.94E-06			
TANK38	1.43E-07	1.94E-07	2.50E-07	1.80E-07	2.43E-07			
TANK39	1.43E-07	2.34E-07	3.13E-07	1.89E-07	3.07E-07			
TANK40	1.76E-07	3.06E-07	4.23E-07	3.78E-07	7.66E-07			
TANK41	2.29E-07	3.87E-07	5.97E-07	6.35E-07	1.35E-06			
TANK42	1.17E-07	1.55E-07	2.07E-07	2.97E-07	4.93E-07			
TANK43	1.34E-07	2.59E-07	4.27E-07	6.62E-07	1.41E-06			
TANK48	7.60E-08	1.22E-07	1.68E-07	4.14E-07	5.91E-07			
TANK49	1.03E-07	1.96E-07	3.08E-07	8.14E-07	1.65E-06			
TANK50	6.40E-08	1.11E-07	1.67E-07	7.38E-07	1.43E-06			
TANK51	9.08E-08	1.69E-07	2.48E-07	1.11E-06	1.75E-06			
Maximum	9.39E-07	1.12E-06	2.10E-06	1.11E-06	1.97E-06			
Mean	2.26E-07	3.18E-07	4.70E-07	4.56E-07	7.34E-07			
Median	1.76E-07	2.34E-07	3.13E-07	3.87E-07	4.94E-07			
Minimum	6.04E-08	5.88E-08	6.27E-08	2.70E-08	2.94E-08			
Relative median	1x	1.33x	1.78x	2.20x	2.81x		**1.81**	
TENSor effect	1x	1.33x				1.33x	0.33	26%
Refinement effect		1x	1.34x	1x	1.28x	1.31x	0.31	25%
Flow field effect		1x		1.65x				
Flow field effect			1x		1.58x	1.62x	0.62	49%
							1.25	100%

PA Evaluation Case simulations

Figure 7 compares peak I-129 concentrations at 100-meters for the Evaluation case from the most recent F-Tank Farm SA [SRR-CWDA-2012-00106]. I-129 was selected for initial comparisons because the nuclide is relatively non-sorbing and slow decaying, and thus responds principally to groundwater flow and dispersion conditions. Figures 8 and 9 show the peaks around 4000 and 13,000 years in more detail. The GSA2018 flow field update + alternative dispersion model + grid refinement update increases the peak flux by 8.5x in the 3500-5000 year period and 6.1x in the 12,700-13,000 year period. Figure 10 focuses on the 0-1000 year compliance period. In this timeframe the updated aquifer inputs lead to a 8.7x increase in I-129 concentration.

From a DOE Order 435.1 compliance perspective, Table 7 reproduced from SRR-CWDA-2012-00106 Table 6.3-7 summarizes the groundwater pathway dose results from the Tank 5 and 6 Special Analysis. Figure 11 reproduced from SRR-CWDA-2012-00106 Figure 6.3-3 plots the groundwater pathway dose results within the 1000-year compliance period. The highest groundwater pathway dose within 1000 years is approximately 0.4 mrem/yr. The primary contributor to dose is Tc-99 (see Figure 6.3-7 of SRR-CWDA-2012-00106 for dose contributions by nuclide). Figure 12 compares Tc-99 concentrations at 100-meters through 1000 years. The GSA2018 flow field update + alternative dispersion model + grid refinement update increases the peak Tc-99 concentration by 6.0x, which would increase the groundwater pathway dose within the compliance period to about 2.4 mrem/yr. This projected dose is well below the 25 mrem/yr performance objective.

Figure 7: F-Tank Farm SA Evaluation case simulation for I-129: 0-20,000 years.

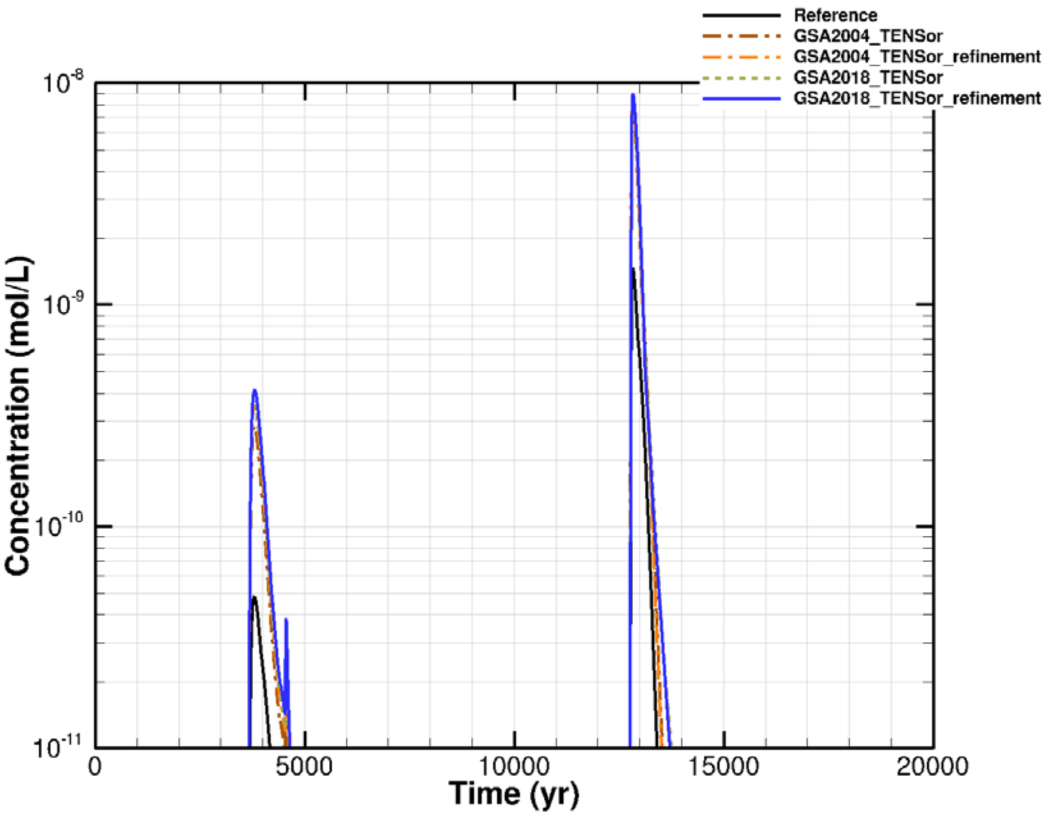


Figure 8: F-Tank Farm SA Evaluation case simulation for I-129: 3500-5000 years.

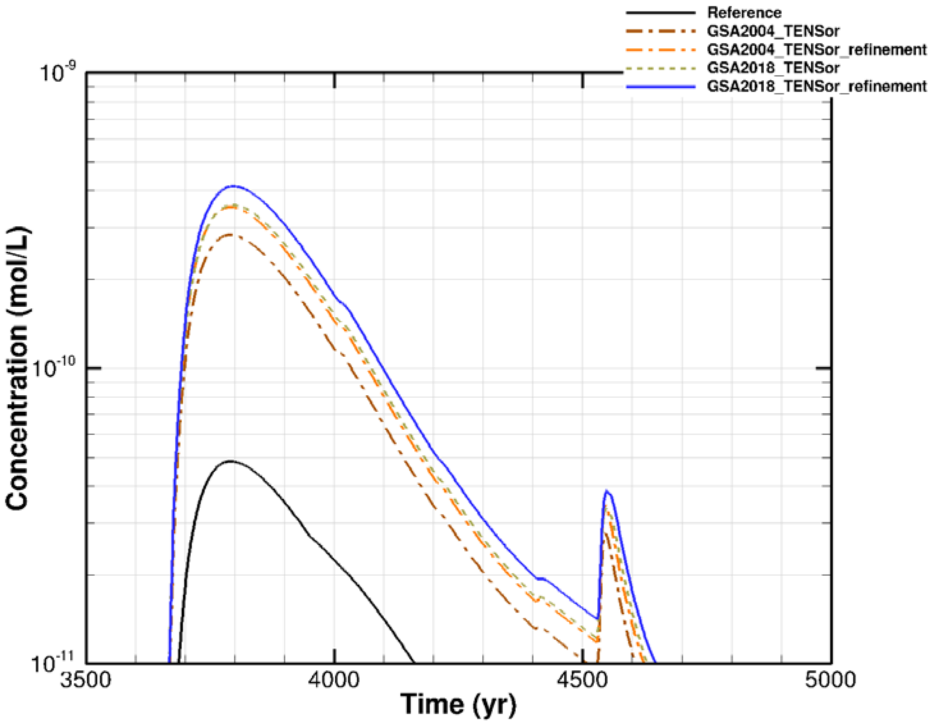


Figure 9: F-Tank Farm SA Evaluation case simulation for I-129: 12,700-13,000 years.

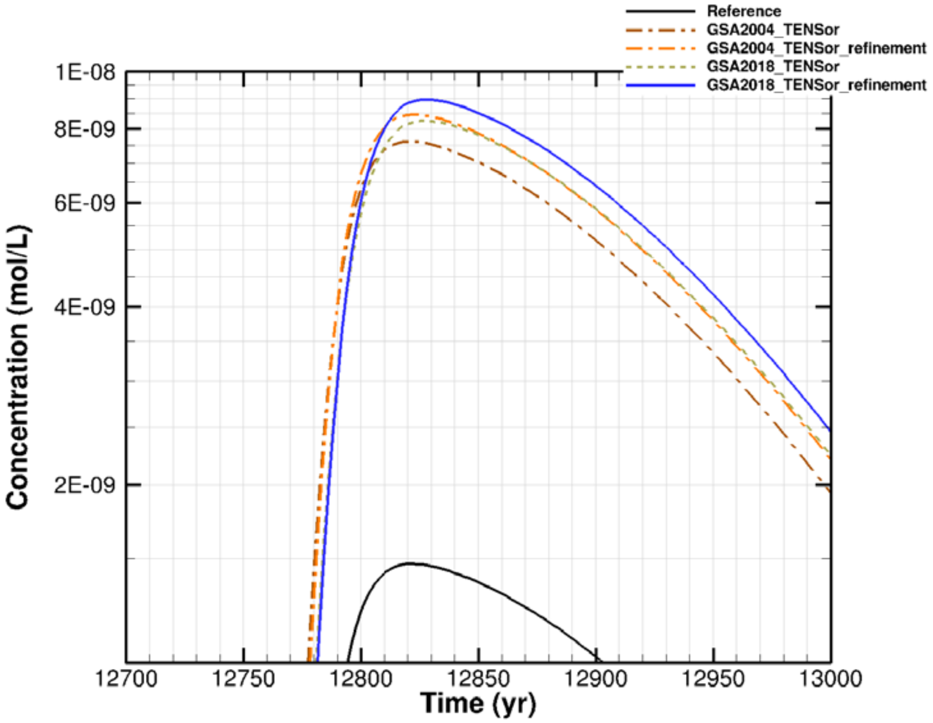


Figure 10: F-Tank Farm SA Evaluation case simulation for I-129: 0-1000 years.

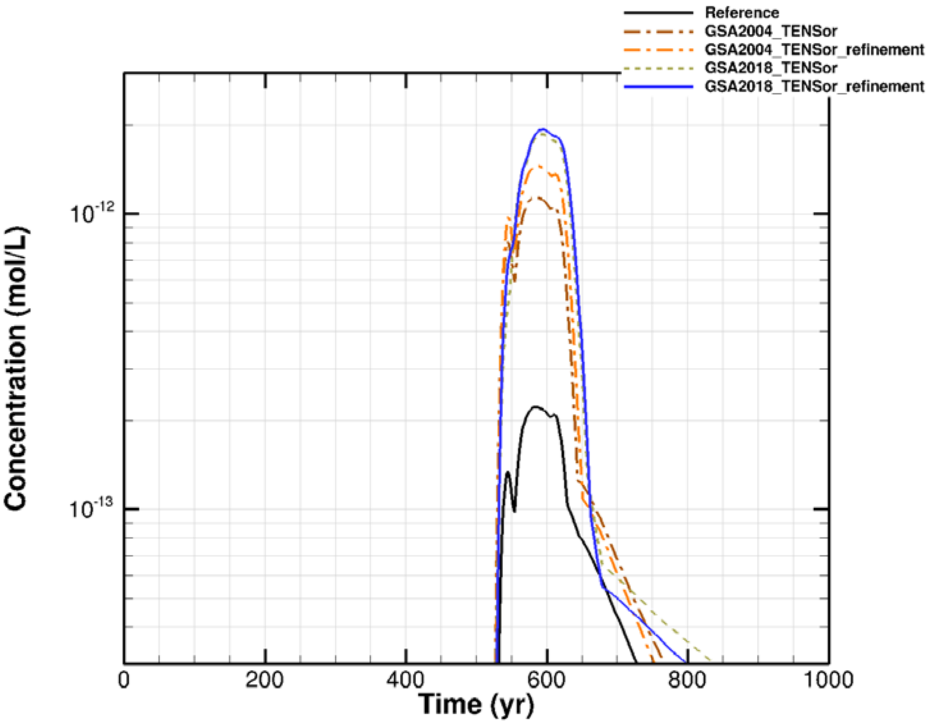
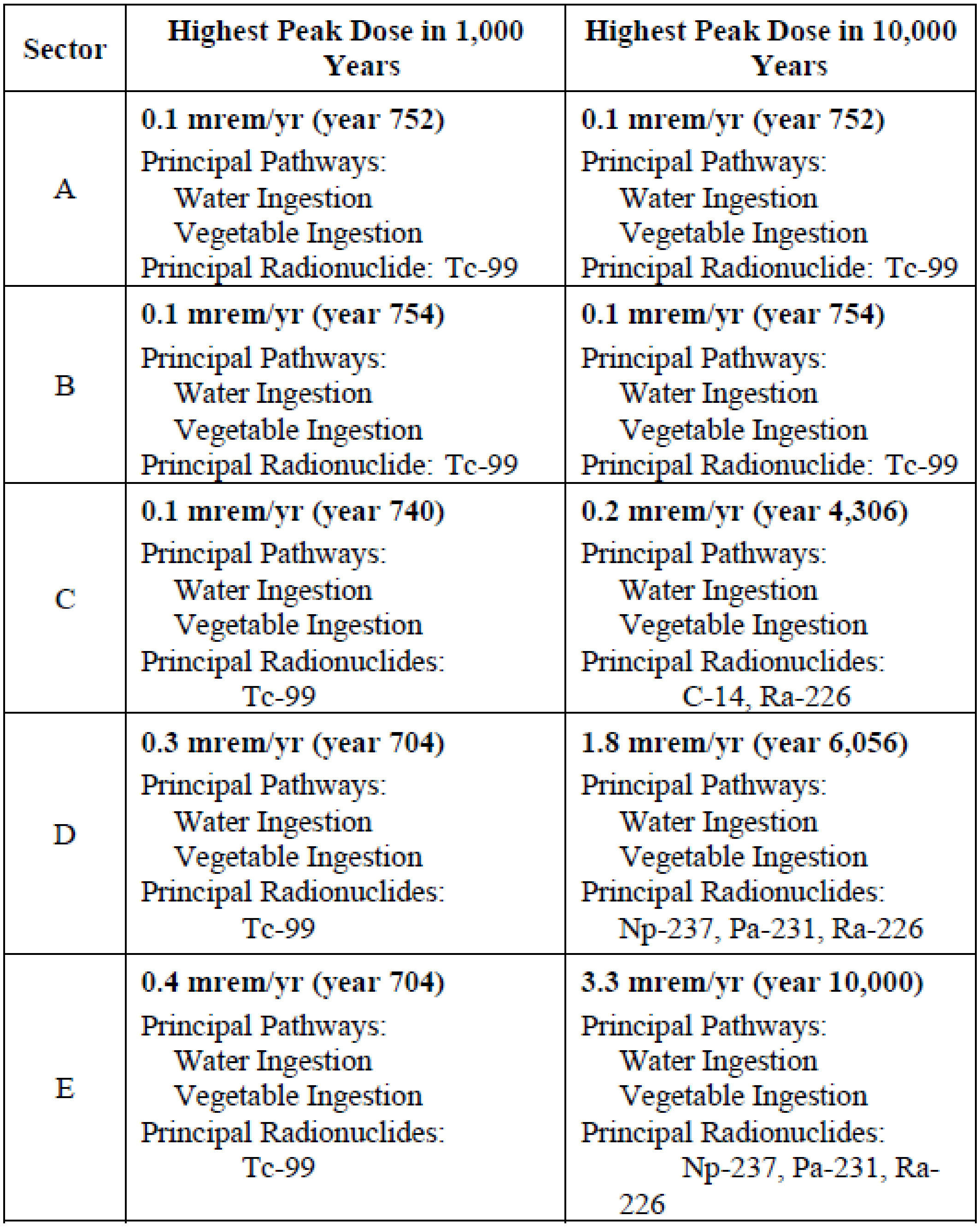


Table 7. 100-meter Member of the Public (MOP) peak groundwater pathways dose by sector; reproduced from SRR-CWDA-2012-00106 Table 6.3-7.



Sector	Highest Peak Dose in 1,000 Years	Highest Peak Dose in 10,000 Years
A	**0.1 mrem/yr (year 752)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclide: Tc-99	**0.1 mrem/yr (year 752)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclide: Tc-99
B	**0.1 mrem/yr (year 754)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclide: Tc-99	**0.1 mrem/yr (year 754)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclide: Tc-99
C	**0.1 mrem/yr (year 740)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Tc-99	**0.2 mrem/yr (year 4,306)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: C-14, Ra-226
D	**0.3 mrem/yr (year 704)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Tc-99	**1.8 mrem/yr (year 6,056)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Pa-231, Ra-226
E	**0.4 mrem/yr (year 704)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Tc-99	**3.3 mrem/yr (year 10,000)** Principal Pathways: Water Ingestion Vegetable Ingestion Principal Radionuclides: Np-237, Pa-231, Ra-226

Figure 11: 100-meter Member of the Public (MOP) peak groundwater pathways dose within 1000 years by sector; reproduced from SRR-CWDA-2012-00106 Figure 6.3-3.

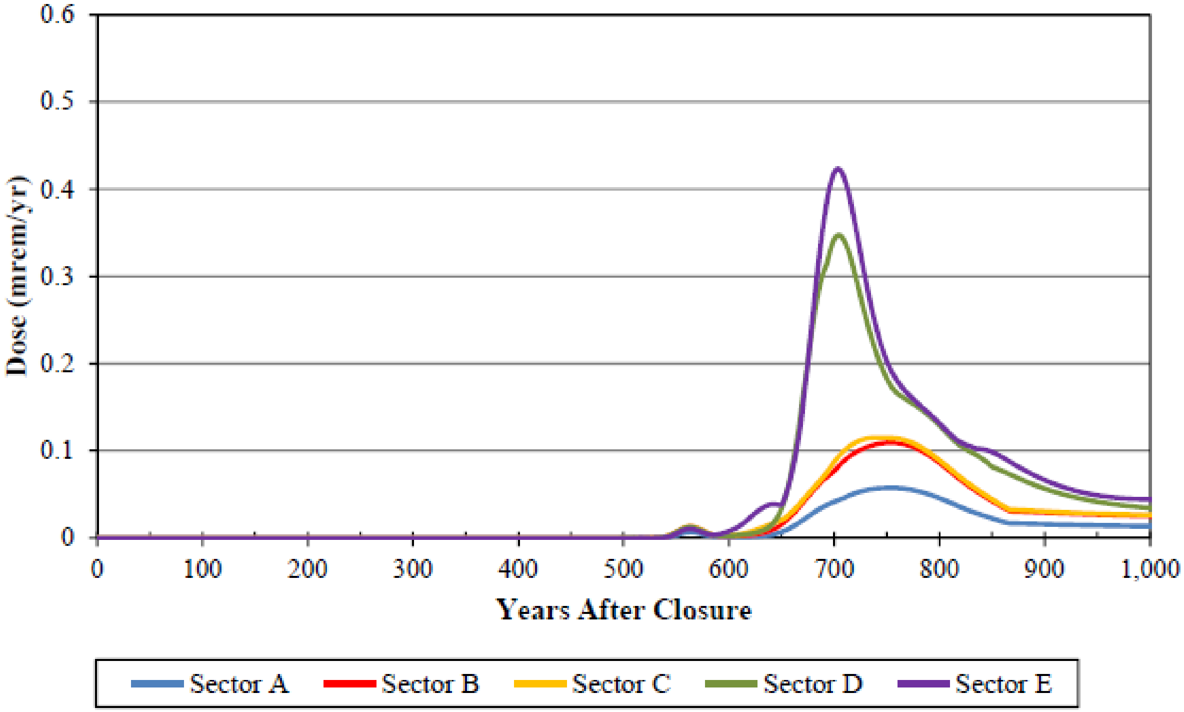
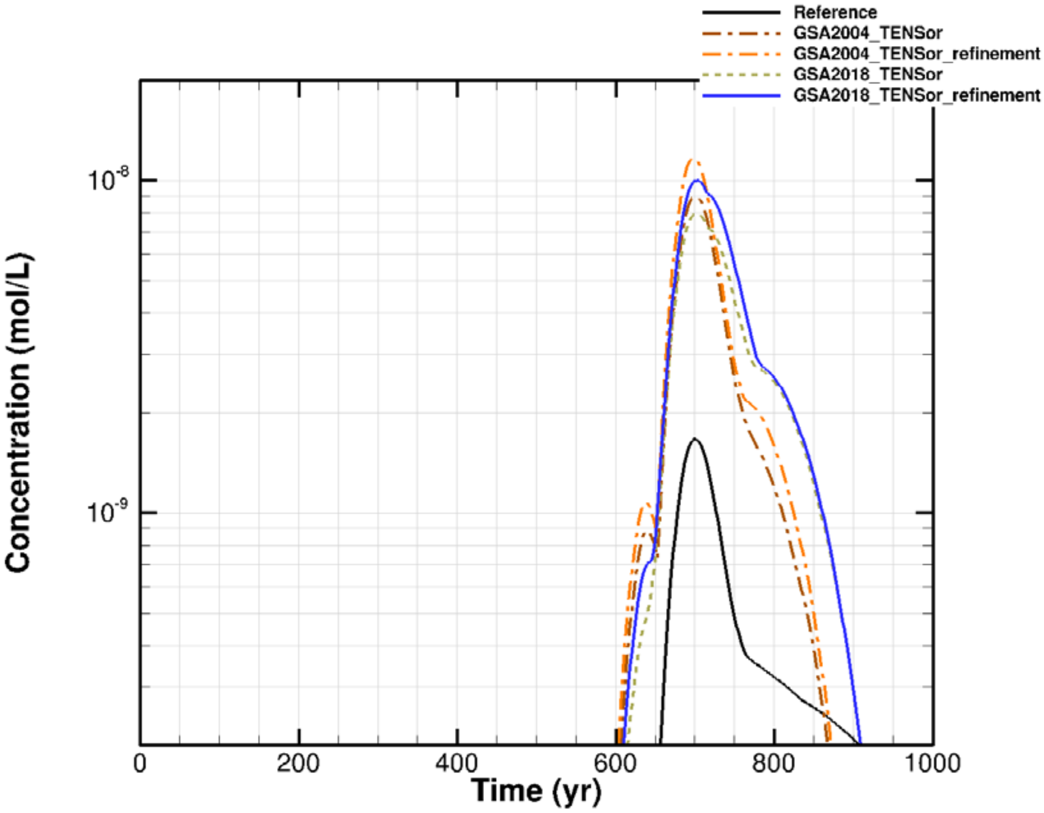


Figure 12: F-Tank Farm SA Evaluation case simulation for Tc-99: 0-1000 years.



Like F-Tank Farm, Figure 13 compares peak I-129 concentration at 100-meters for the Evaluation case from the most recent H-Tank Farm SA [SRR-CWDA-2016-00078]. Figures 14 and 15 show the peaks around 3000 and 12,000 years in more detail. The GSA2018 flow field update + alternative dispersion model + grid refinement update increases the peak flux by 3.74x in the 3500-5000 year period and 2.17x in the 11,000-14,000 year period. Within the 0-1000 year compliance period (Figure 16), the increase in I-129 concentration is 1.89x.

From a DOE Order 435.1 compliance perspective, Table 8 reproduced from SRR-CWDA-2016-00078 Table 5.2-1 summarizes the groundwater pathway dose results from the Tank 5 and 6 Special Analysis. Figure 17 reproduced from SRR-CWDA-2016-00078 Figure 5.2-1 plots the groundwater pathway dose results within the 1000-year compliance period. The highest groundwater pathway dose within 1000 years is approximately 0.2 mrem/yr. The primary contributor to dose is Tc-99 (see Figure 5.2-4 of SRR-CWDA-2016-00078 for dose contributions by nuclide). Figure 18 compares Tc-99 concentrations at 100-meters through 1000 years. The GSA2018 flow field update + alternative dispersion model + grid refinement update increases the peak Tc-99 concentration by 1.99x, which would increase the groundwater pathway dose within the compliance period to about 0.4 mrem/yr. This projected dose is well below the 25 mrem/yr performance objective.

Figure 13: H-Tank Farm SA Evaluation case simulation for I-129: 0-20,000 years.

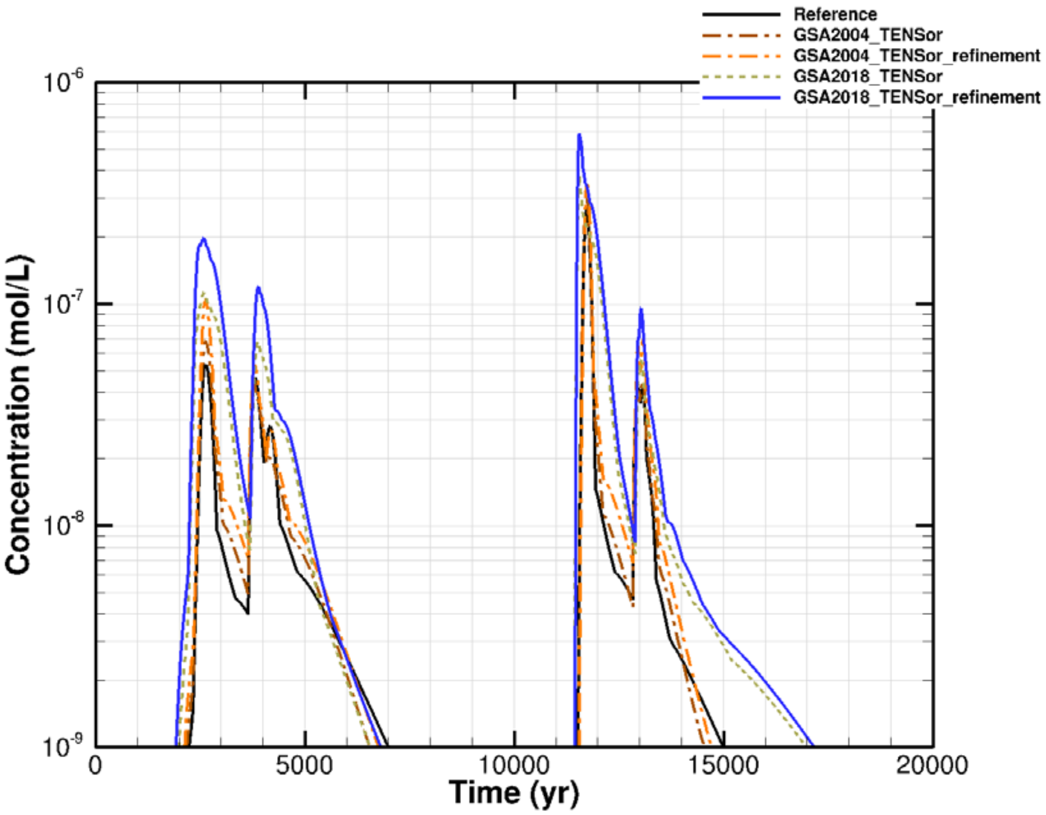


Figure 14: H-Tank Farm SA Evaluation case simulation for I-129: 2000-5000 years.

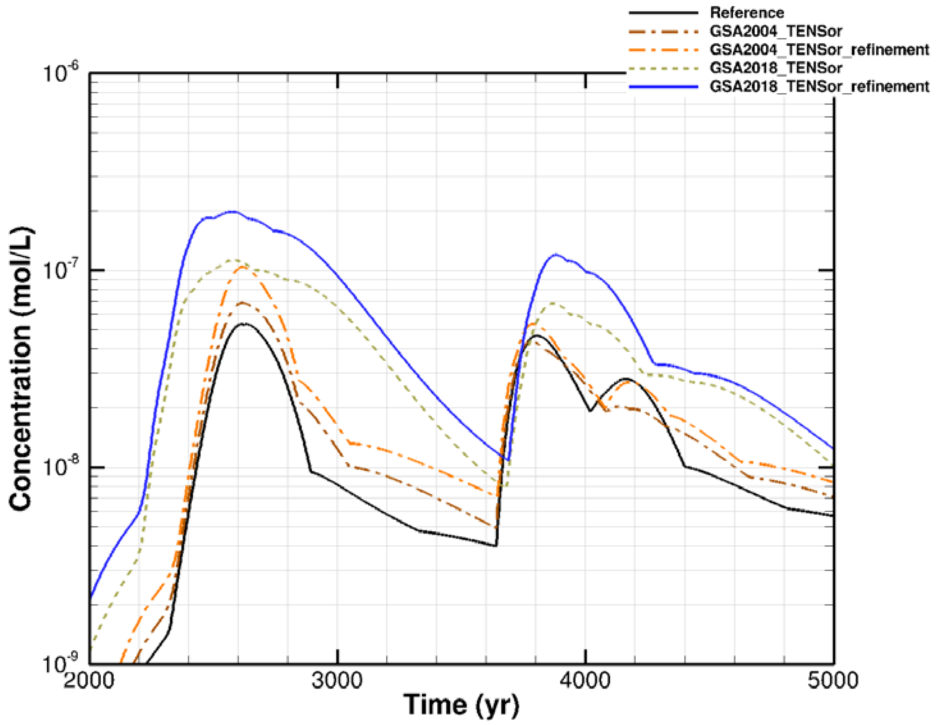


Figure 15: H-Tank Farm SA Evaluation case simulation for I-129: 11,000-14,000 years.

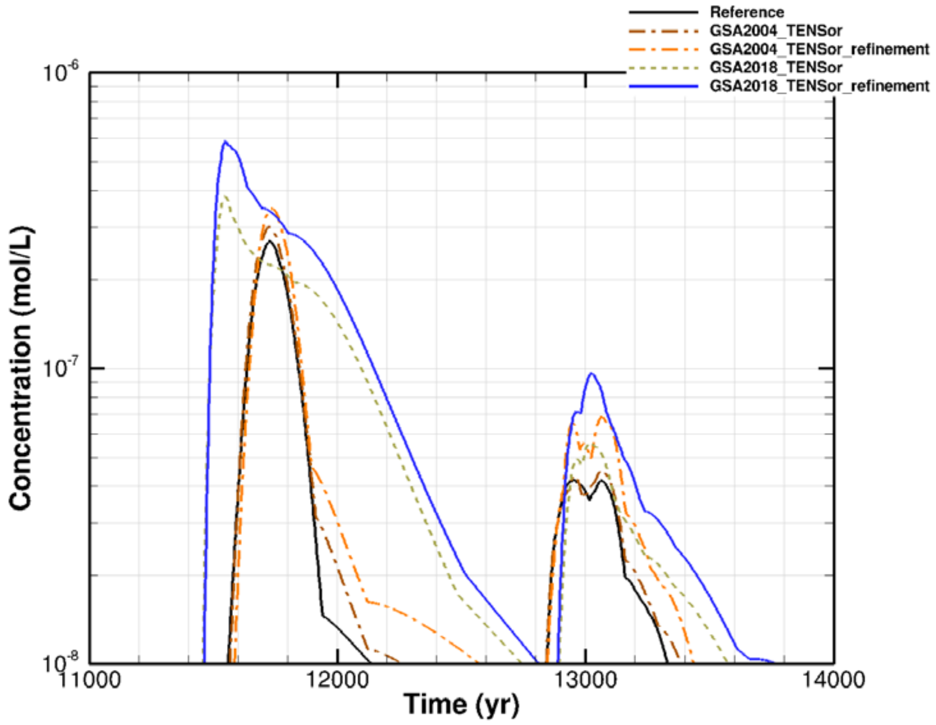


Figure 16: H-Tank Farm SA Evaluation case simulation for I-129: 0-1000 years.

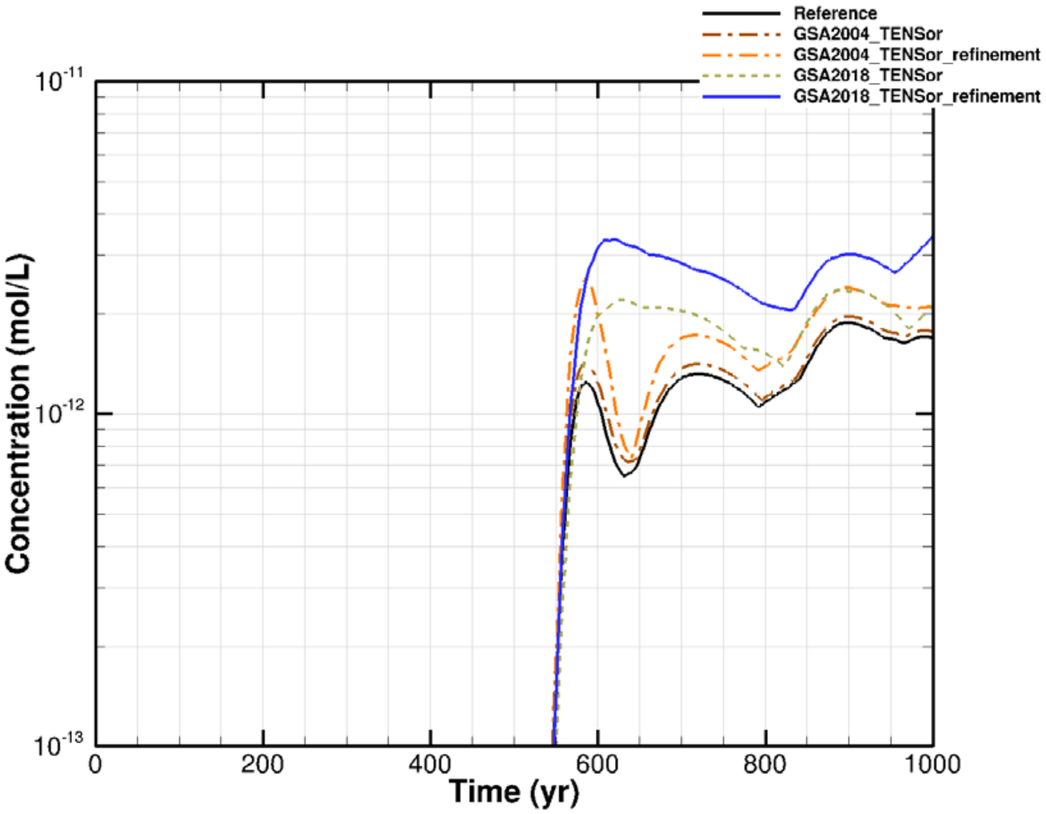


Table 8. 100-meter Member of the Public (MOP) peak groundwater pathways dose by sector; reproduced from SRR-CWDA-2016-00078 Table 5.2-1.

Sector[a]	Peak Dose in 1,000 Years	Peak Dose in 10,000 Years	Peak Dose in 100,000 Years
A	**0.2 mrem/yr (year 780)** Principal Radionuclide: Tc-99	**7 mrem/yr (year 2,620)** Principal Radionuclide: I-129	**81 mrem/yr (year 91,400)** Principal Radionuclide: Ra-226
B	**0.2 mrem/yr (year 780)** Principal Radionuclide: Tc-99	**4 mrem/yr (year 3,880)** Principal Radionuclide: I-129	**163 mrem/yr (year 61,260)** Principal Radionuclide: Ra-226
C	**0.2 mrem/yr (year 820)** Principal Radionuclide: Tc-99	**6 mrem/yr (year 3,800)** Principal Radionuclide: I-129	**103 mrem/yr (year 71,480)** Principal Radionuclide: Ra-226
D	**0.03 mrem/yr (year 880)** Principal Radionuclide: Tc-99	**0.3 mrem/yr (year 3,800)** Principal Radionuclide: I-129	**10 mrem/yr (year 86,440)** Principal Radionuclide: Ra-226
E	**0.1 mrem/yr (year 880)** Principal Radionuclide: Tc-99	**0.1 mrem/yr (year 880)** Principal Radionuclide: Tc-99	**131 mrem/yr (year 85,700)** Principal Radionuclide: Ra-226
F	**0.1 mrem/yr (year 880)** Principal Radionuclide: Tc-99	**0.3 mrem/yr (year 3,940)** Principal Radionuclide: I-129	**141 mrem/yr (year 88,900)** Principal Radionuclide: Ra-226

Figure 17: 100-meter Member of the Public (MOP) peak groundwater pathways dose within 1000 years by sector; reproduced from SRR-CWDA-2016-00078 Figure 5.2-1.

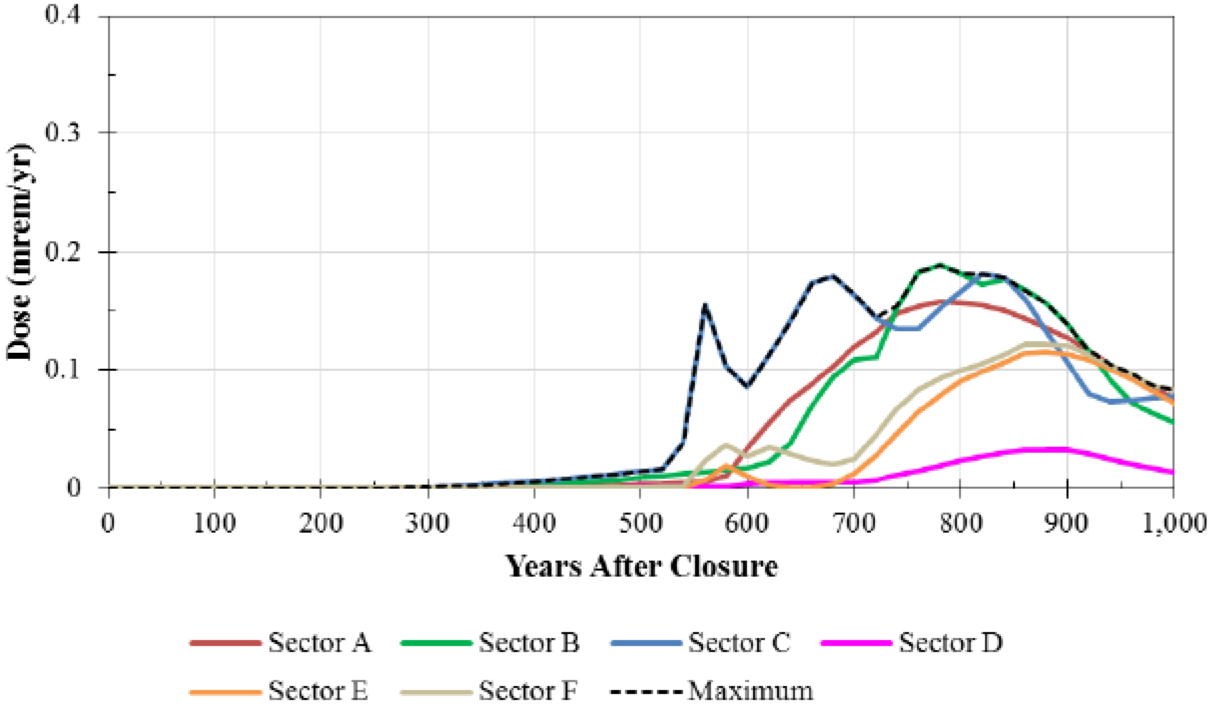
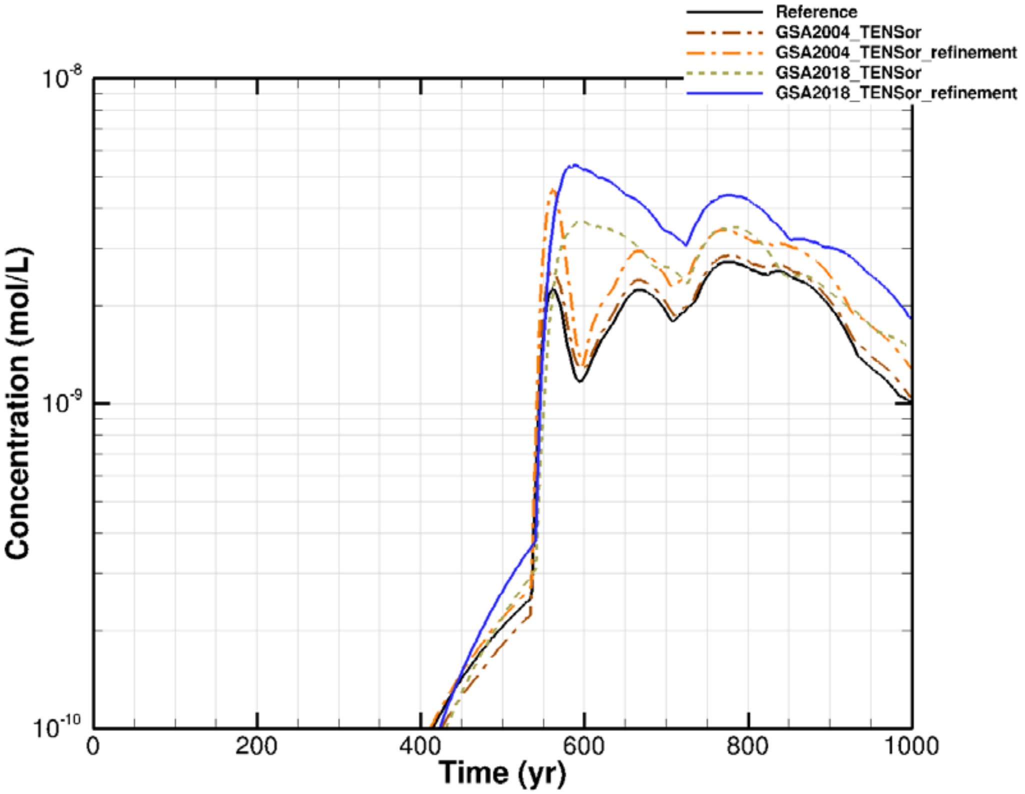


Figure 18: H-Tank Farm SA Evaluation case simulation for Tc-99: 0-1000 years.



Conclusions

Tracer plume and SA Evaluation case simulations for F-Area suggest that the GSA2018 flow field coupled with an alternative dispersion model and increased grid resolution will increase peak 100-meter concentrations by a factor of 5 to 10x. Analogous simulations for H-Area indicate a smaller increase on the order of 2 to 5x. Re-simulation of the Evaluation cases from the most recent F- and H-Tank Special Analyses using the GSA2018 flow field update + alternative dispersion model + grid refinement update indicates Member of the Public (MOP) doses during the 1000-year DOE compliance period that are well below the performance objective of 25 mrem/yr.

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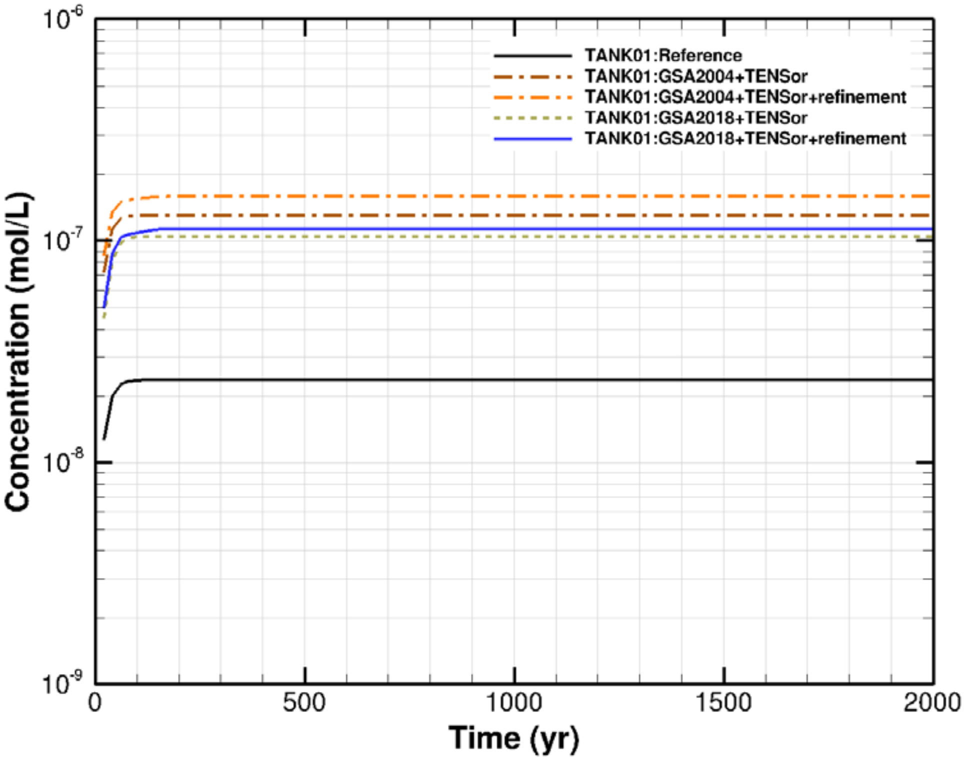
Appendix A: F-Tank Farm Steady-State Tracer Simulations

Figure A-1 shows the highest concentration along the 100-meter perimeter for a constant 1.0 mol/yr source of tracer beneath each waste tank.

Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm.



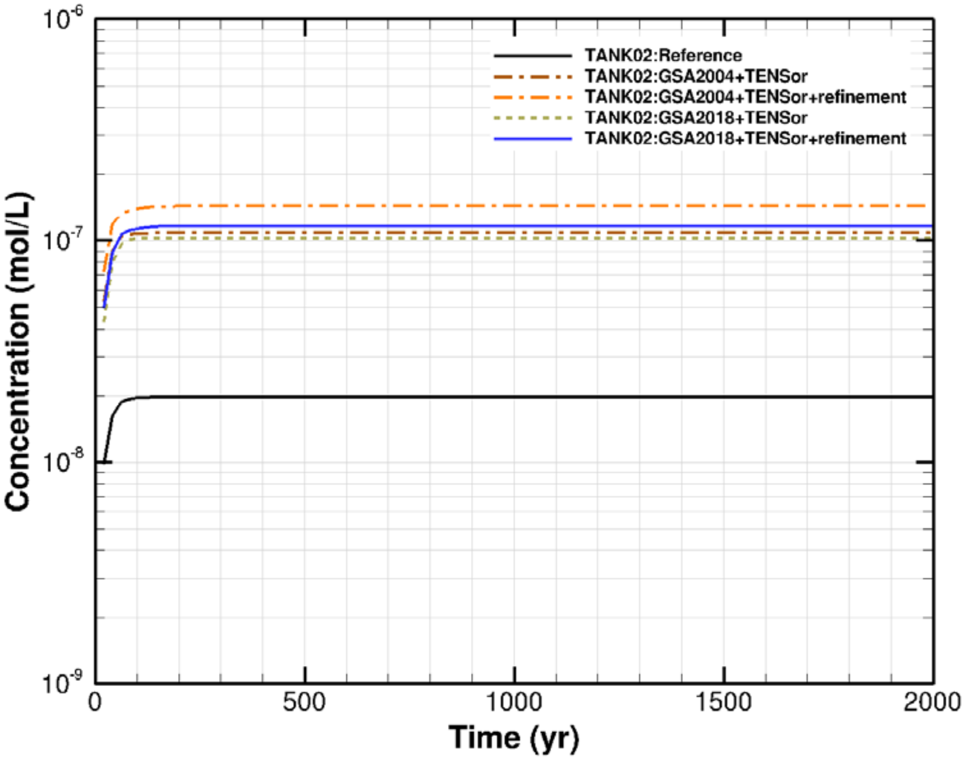
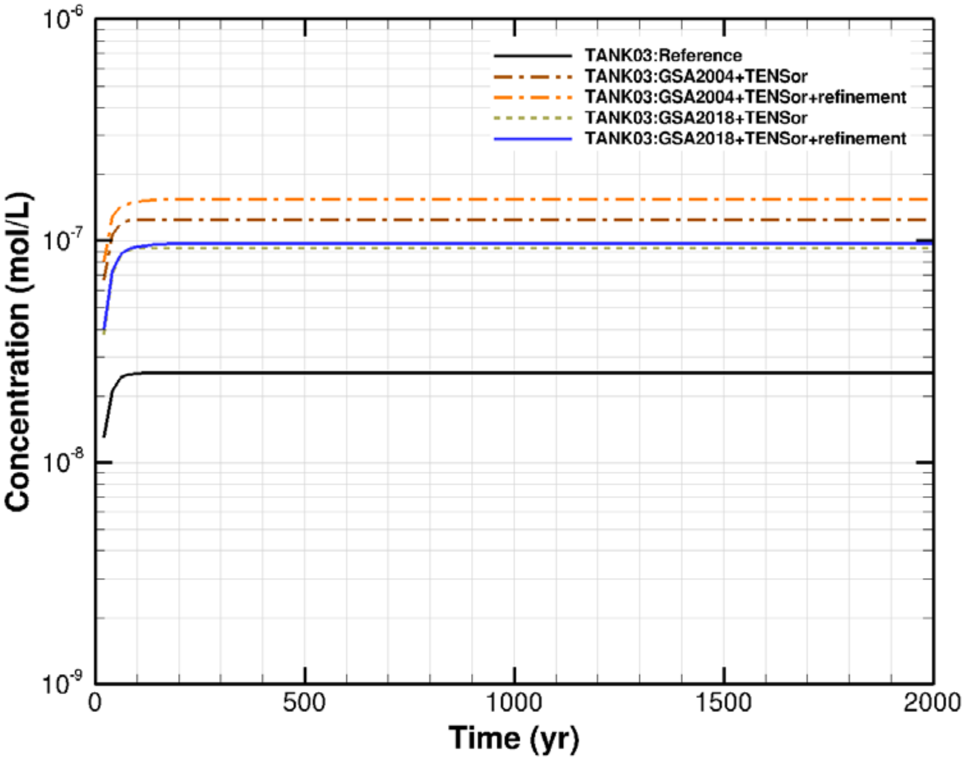


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



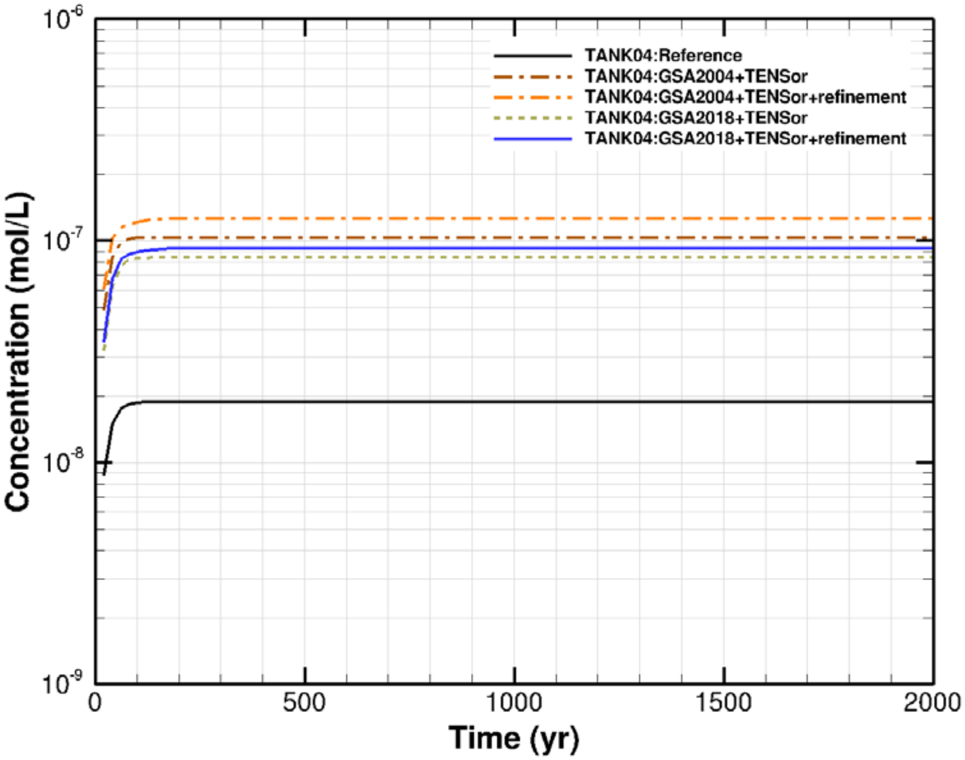
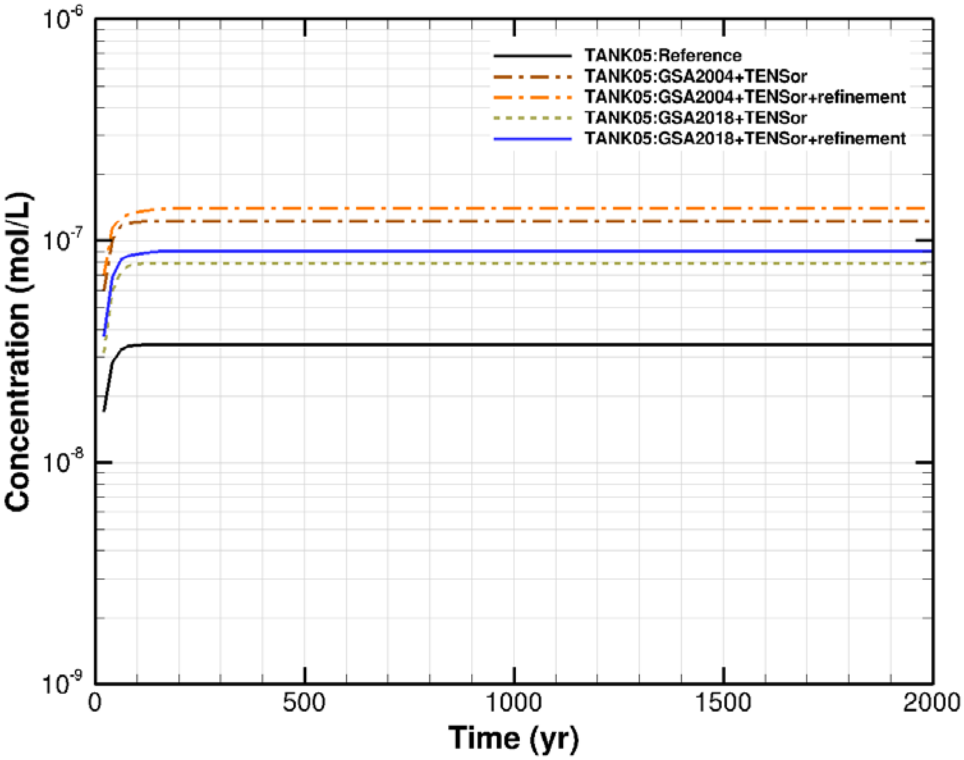


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



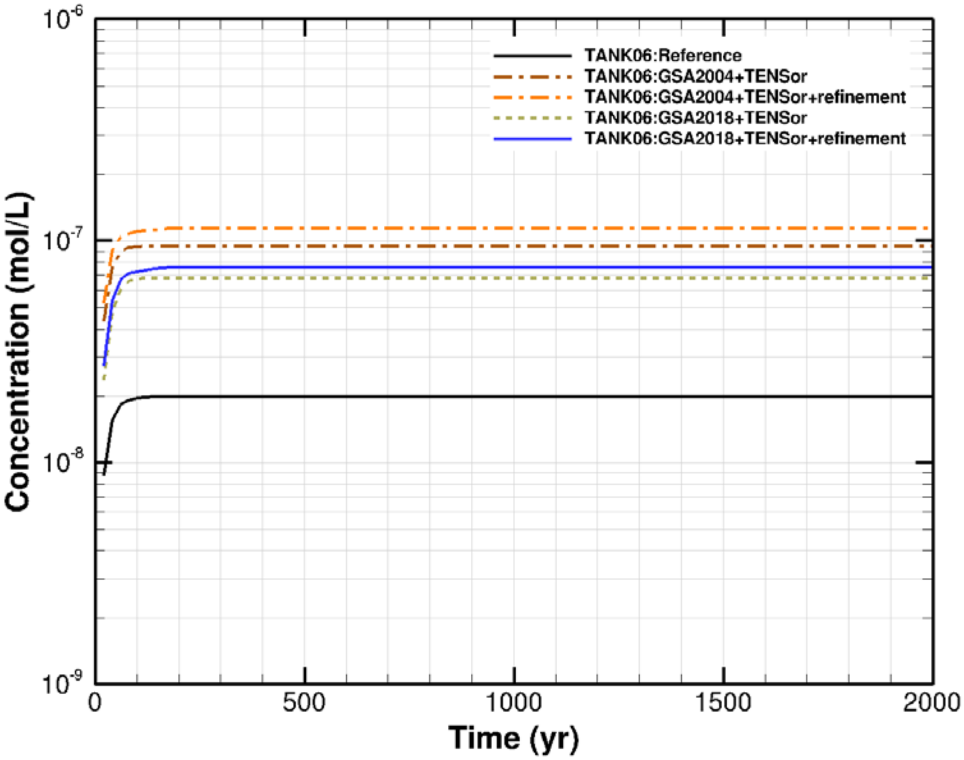
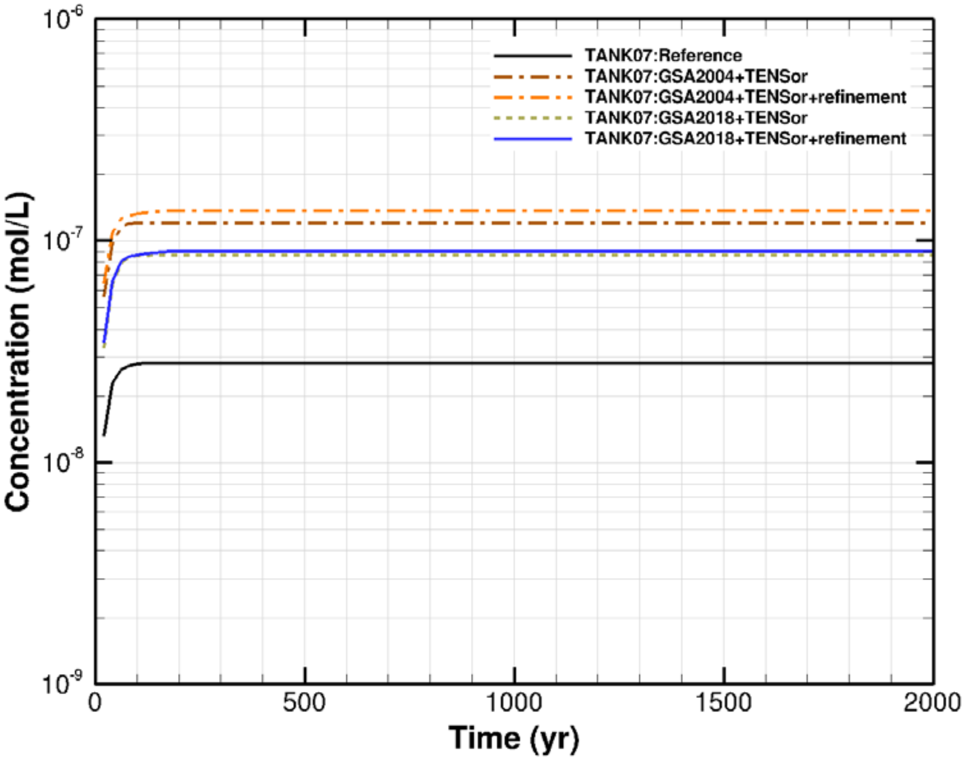


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



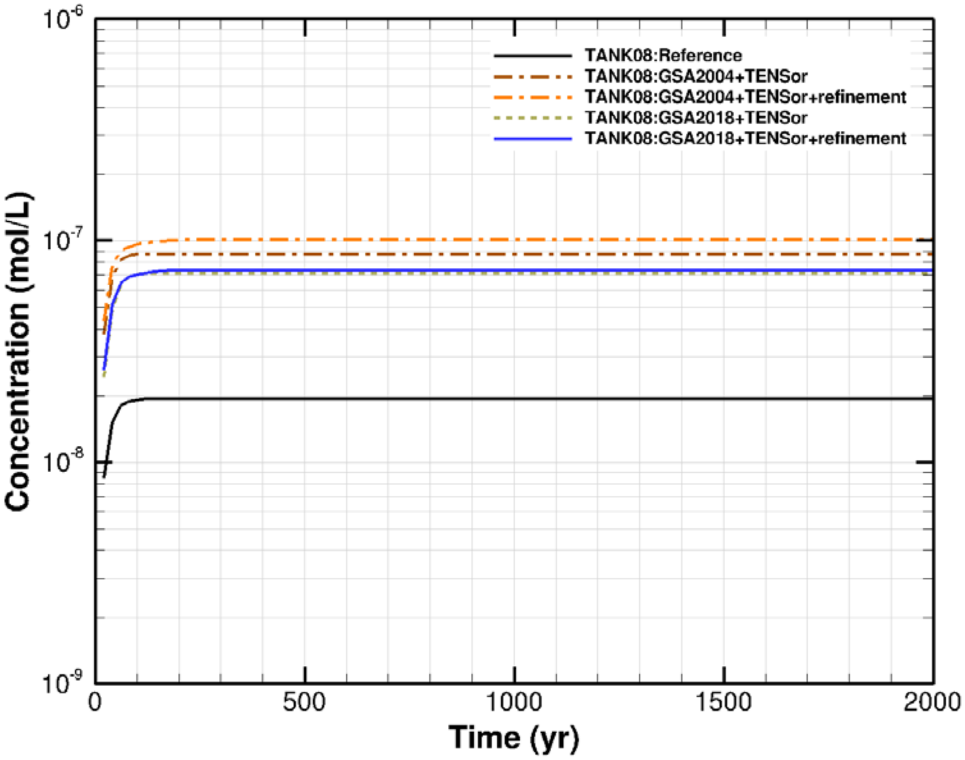
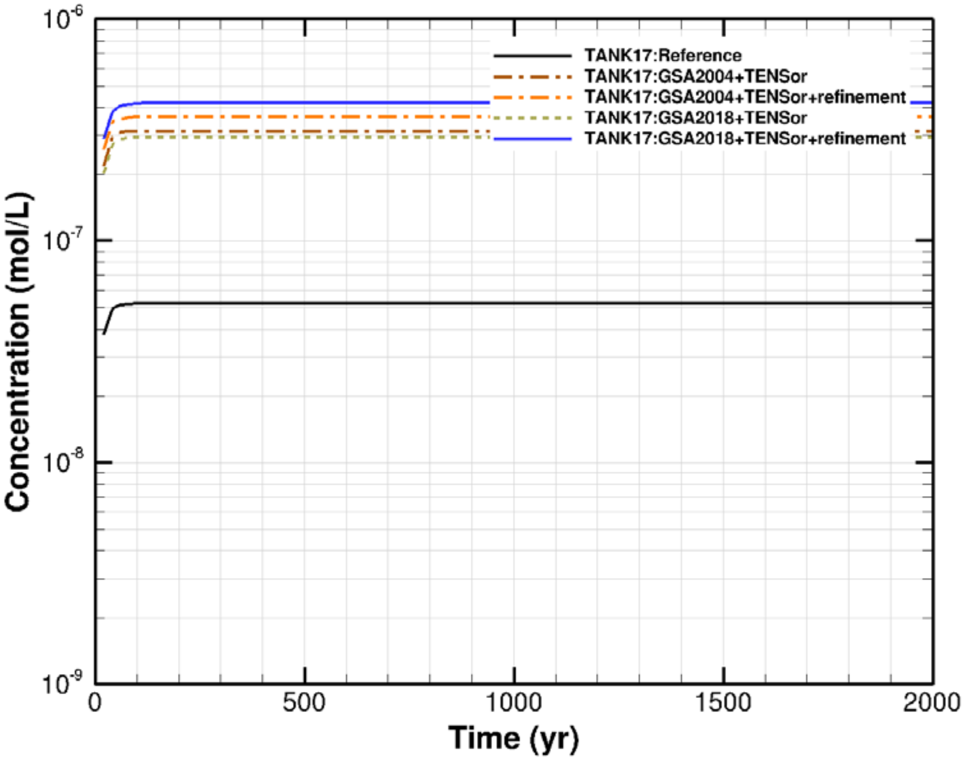


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



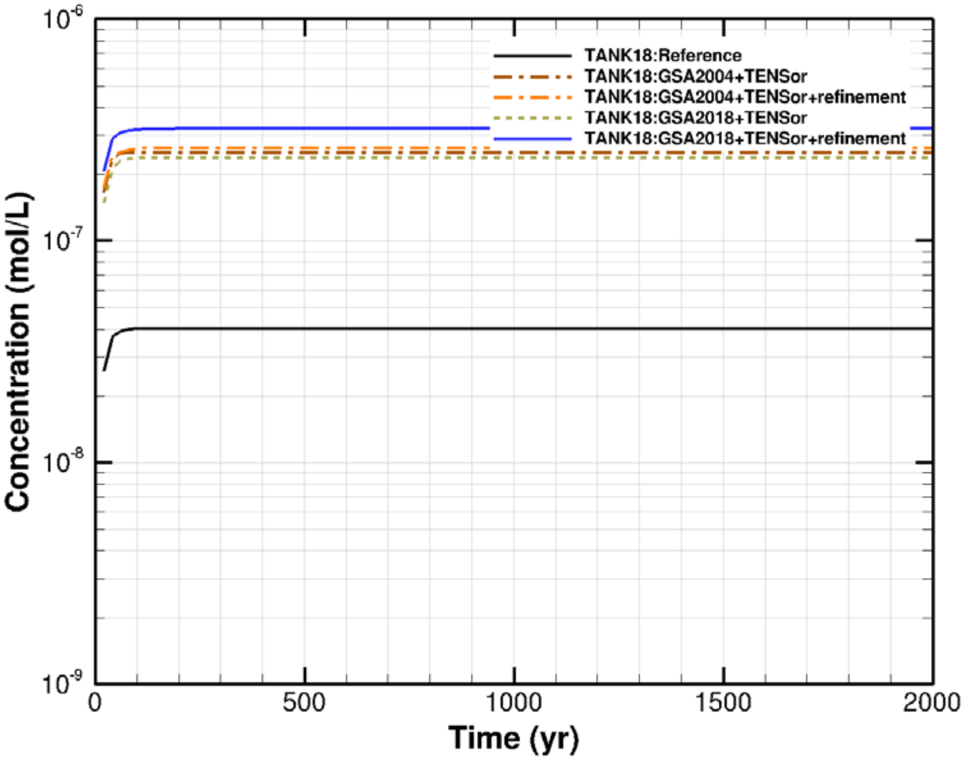
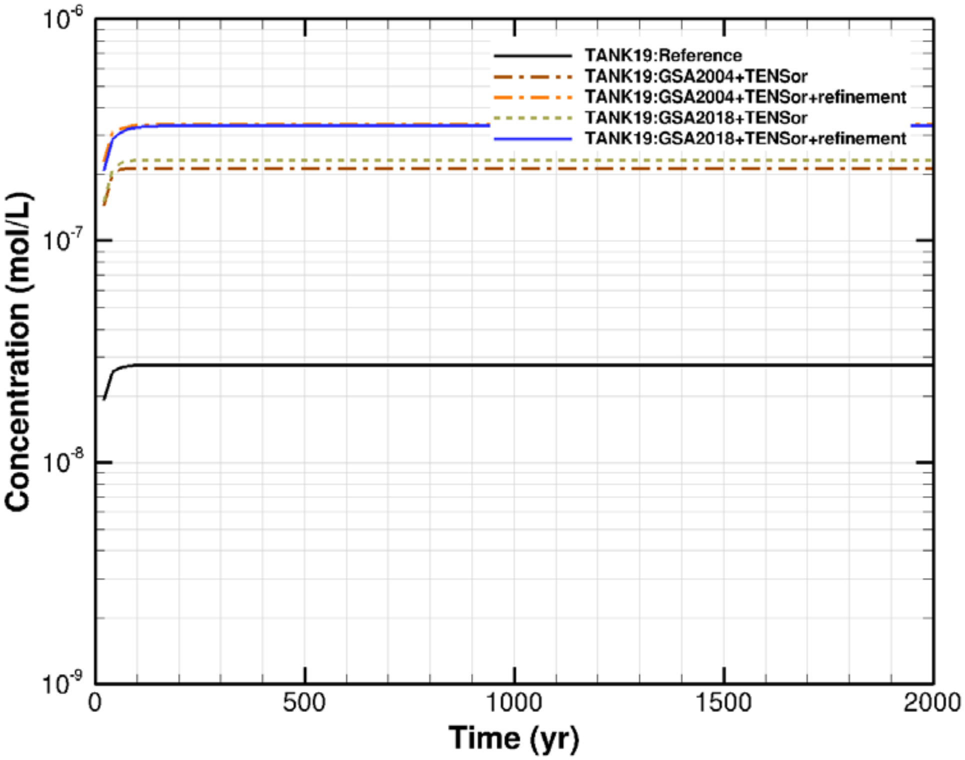


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



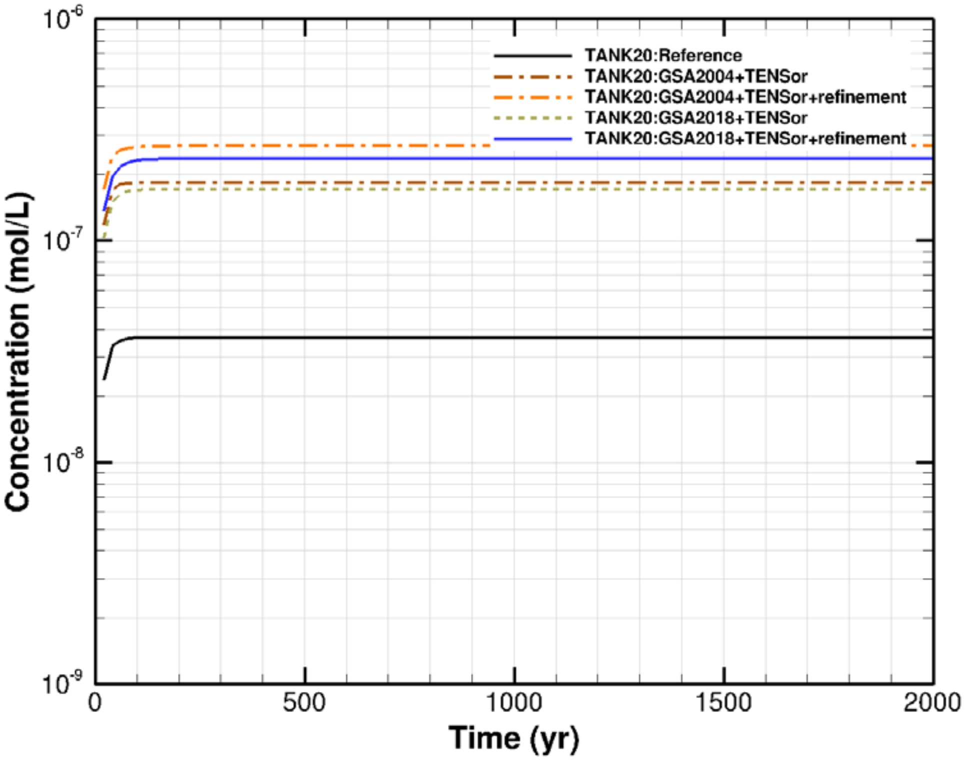
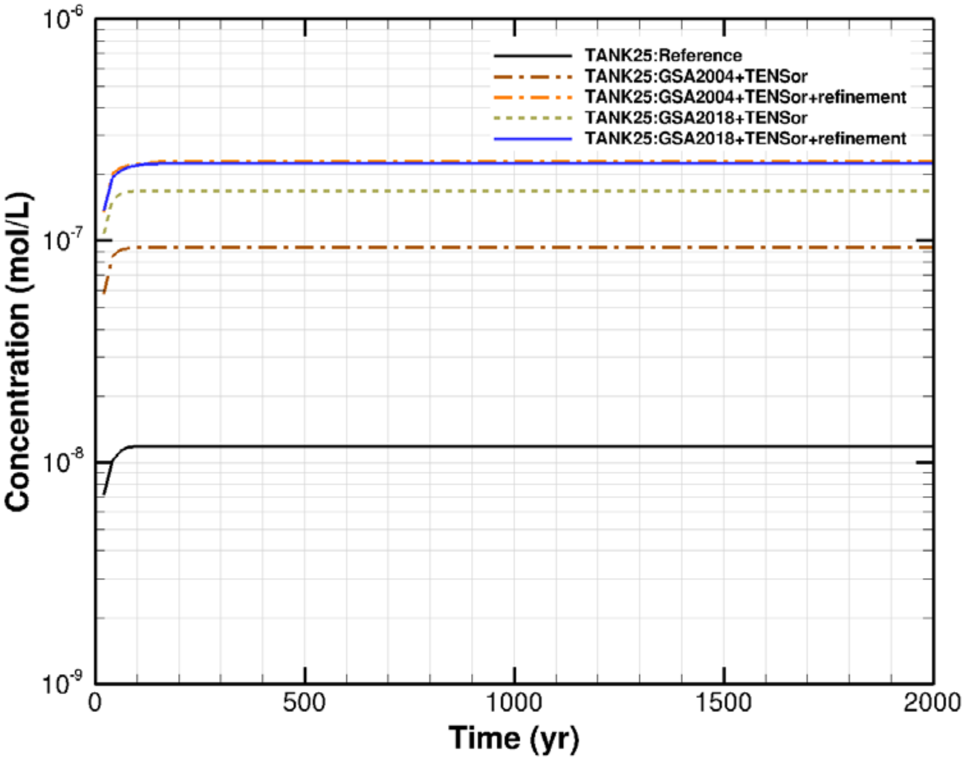


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



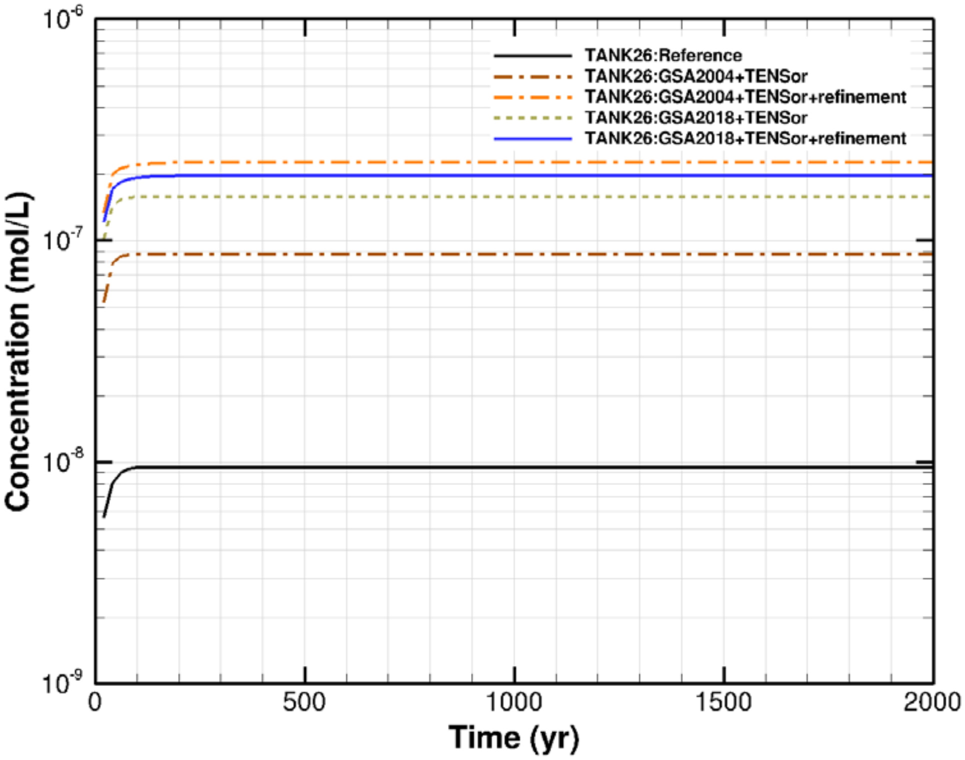
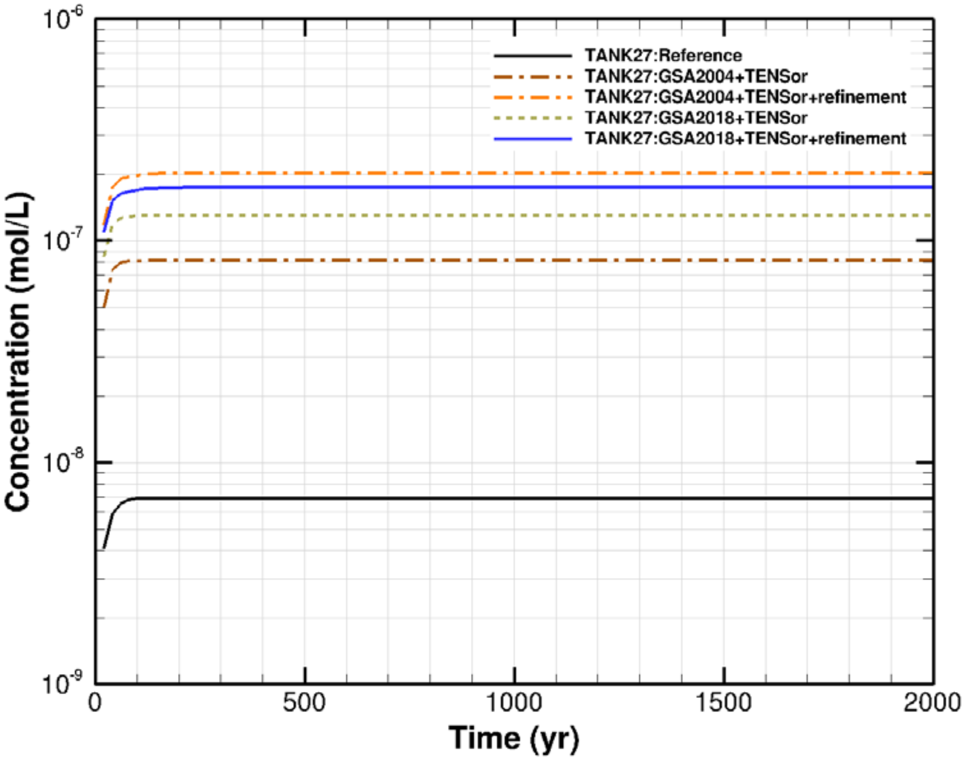


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



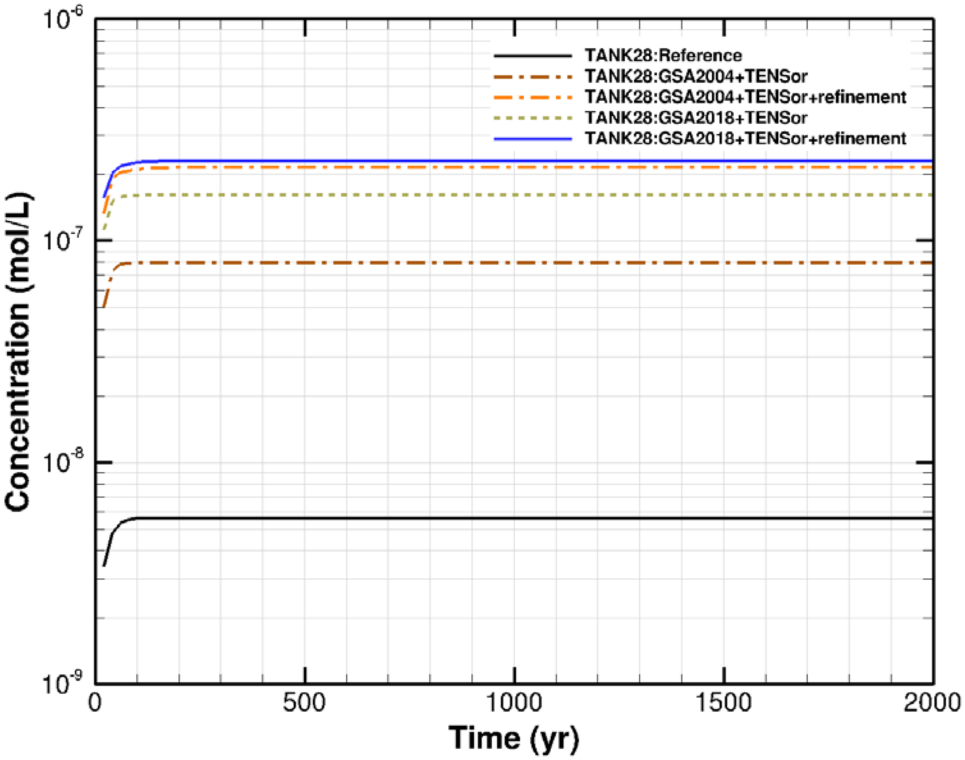
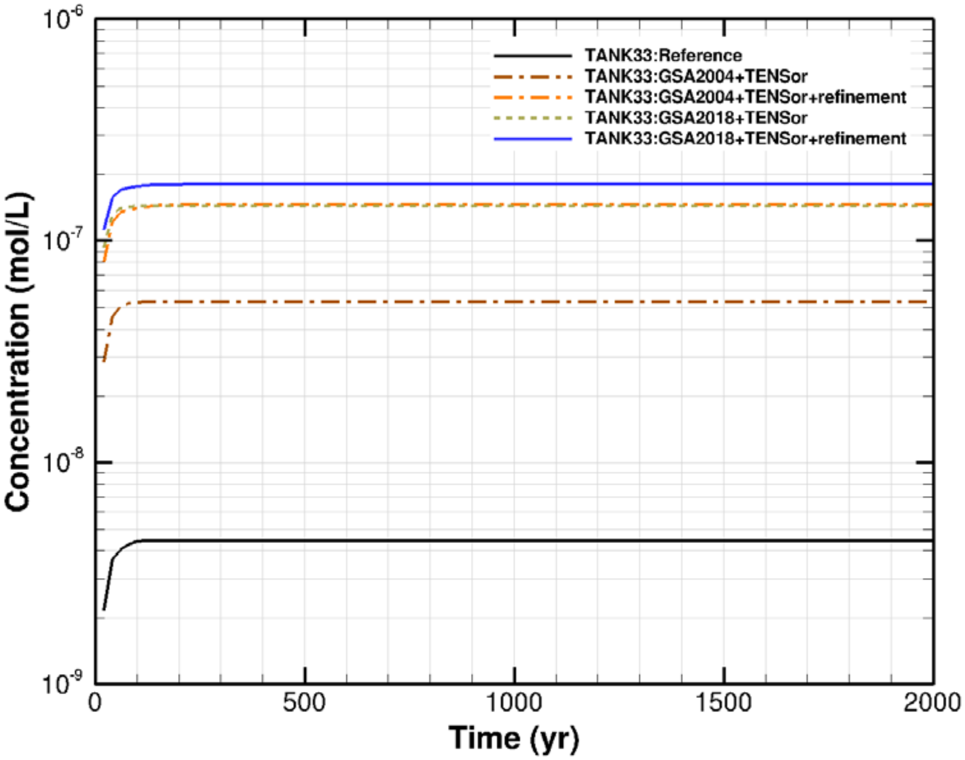


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



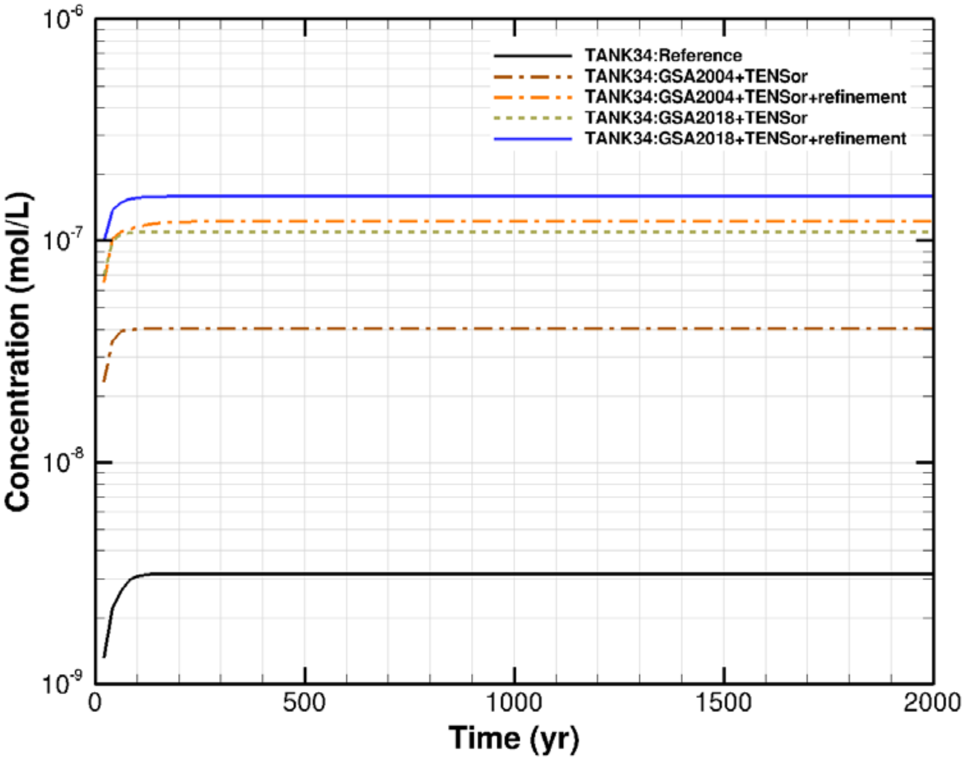
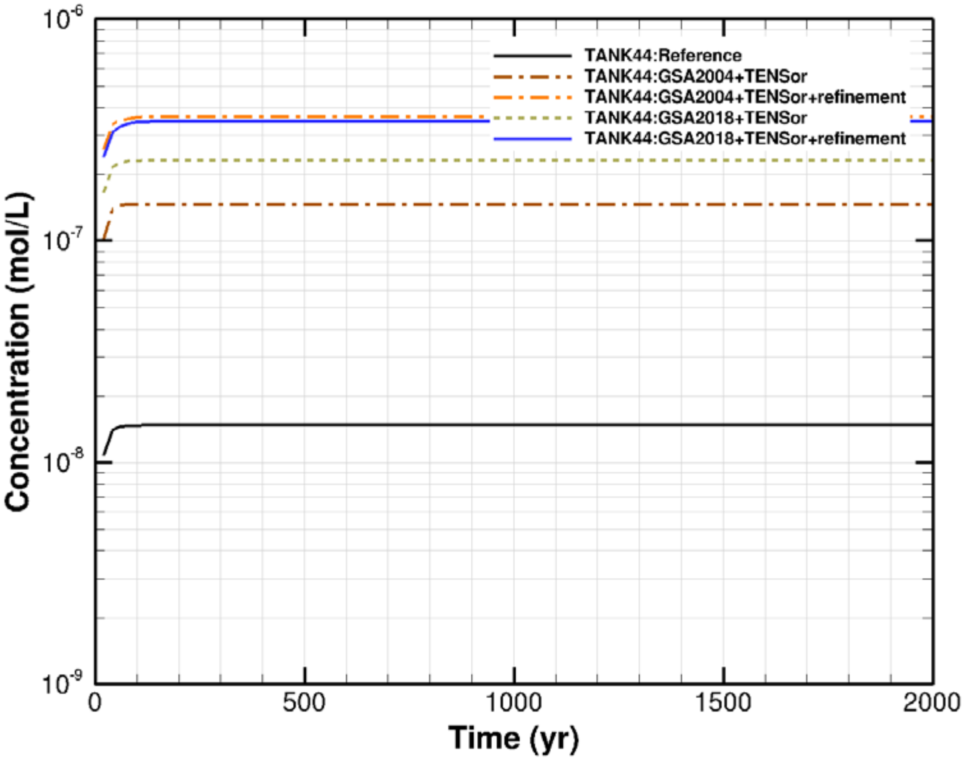


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)



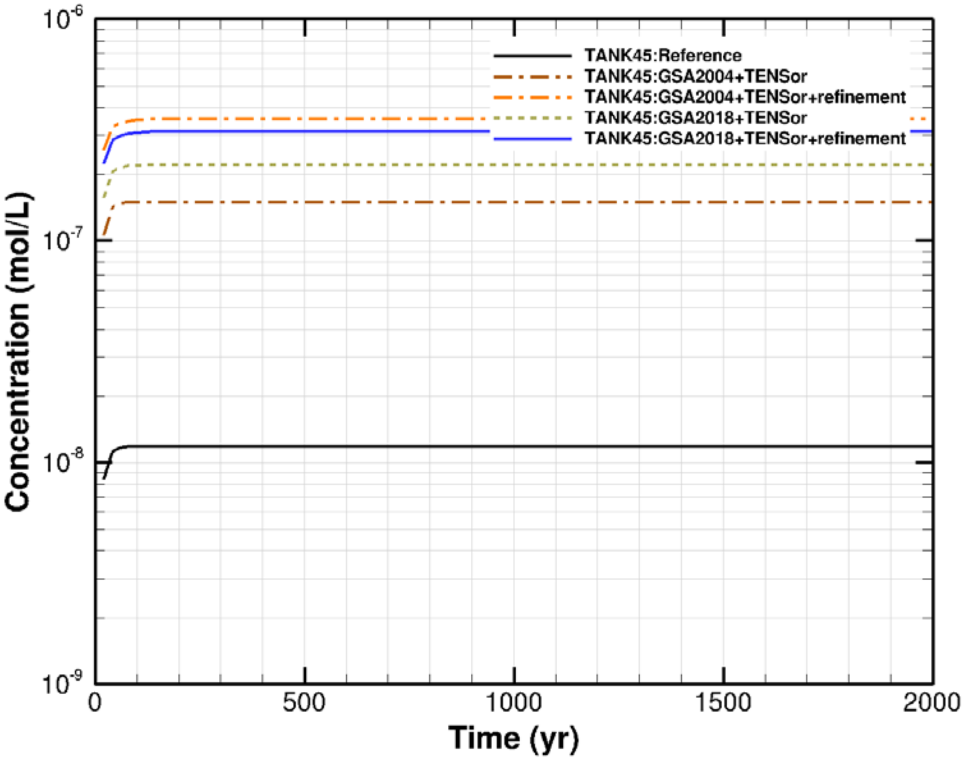
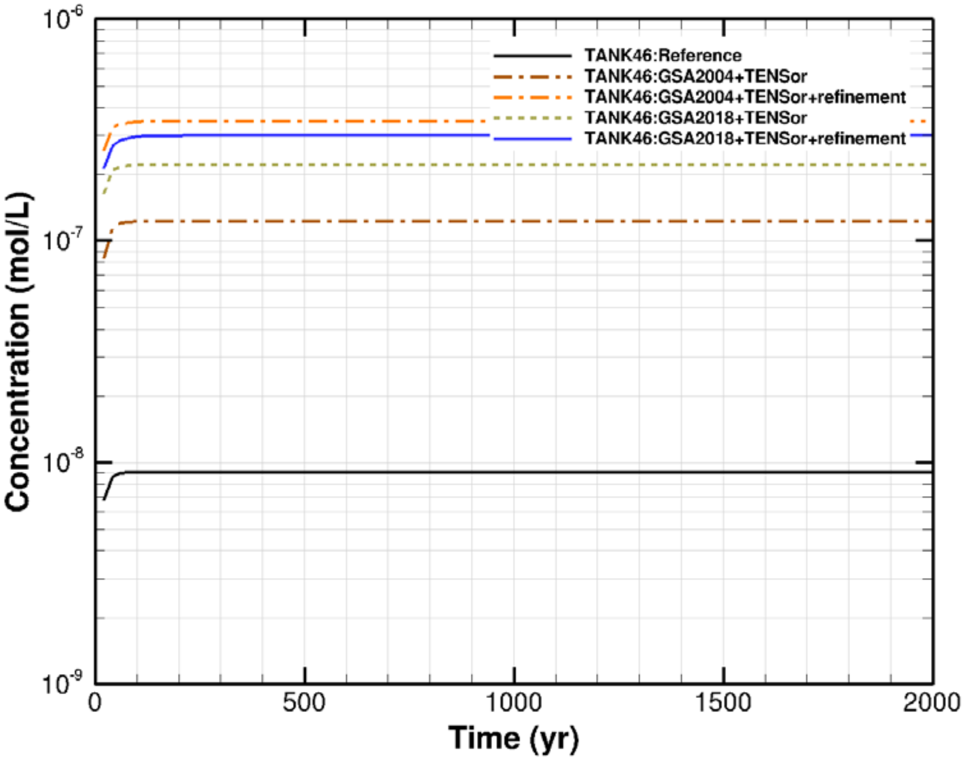
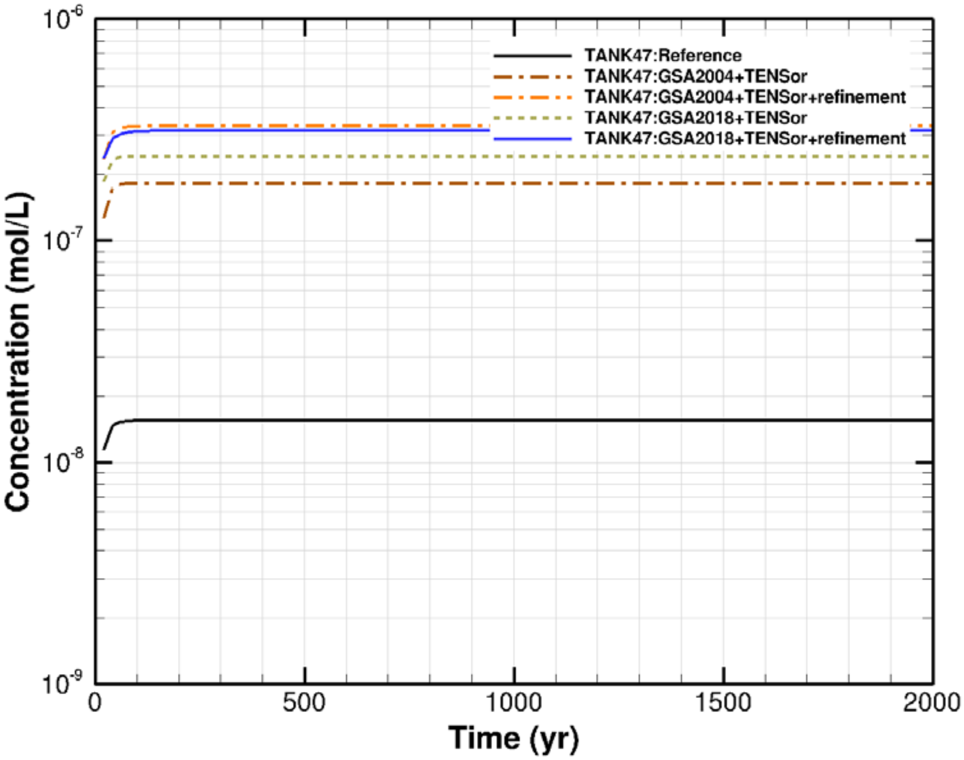


Figure A-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: F-Tank Farm. (continued)

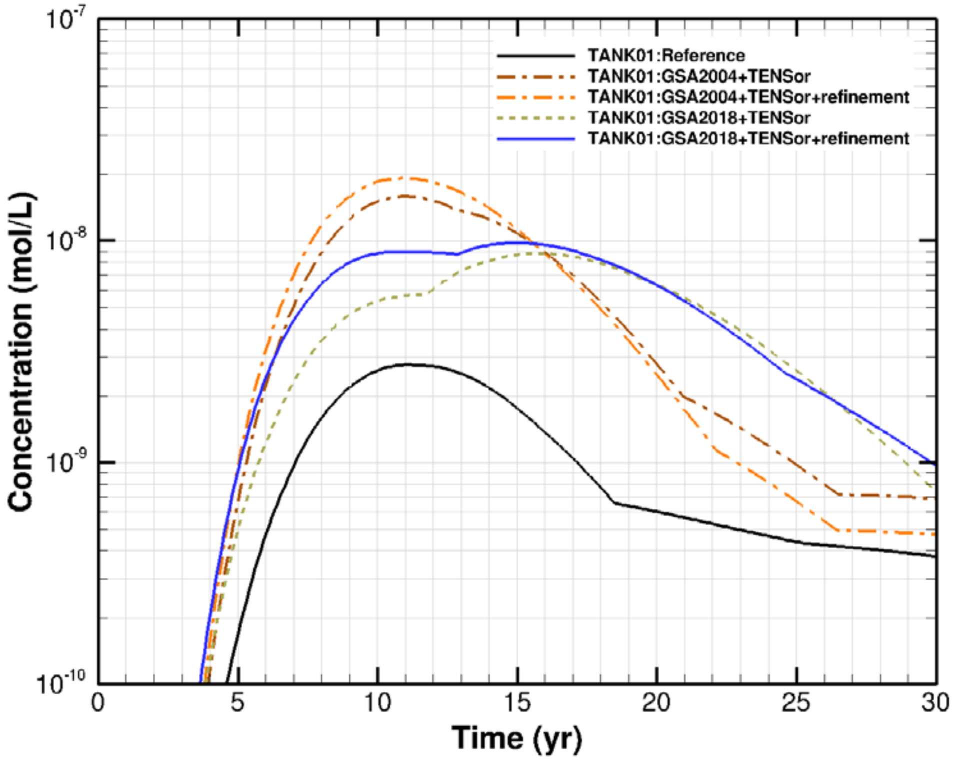




Appendix B: F-Tank Farm Pulsed Tracer Simulations

Figure B-1 shows the highest concentration along the 100-meter perimeter for a one-time 1.0 mol source of tracer beneath each waste tank.

Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm.



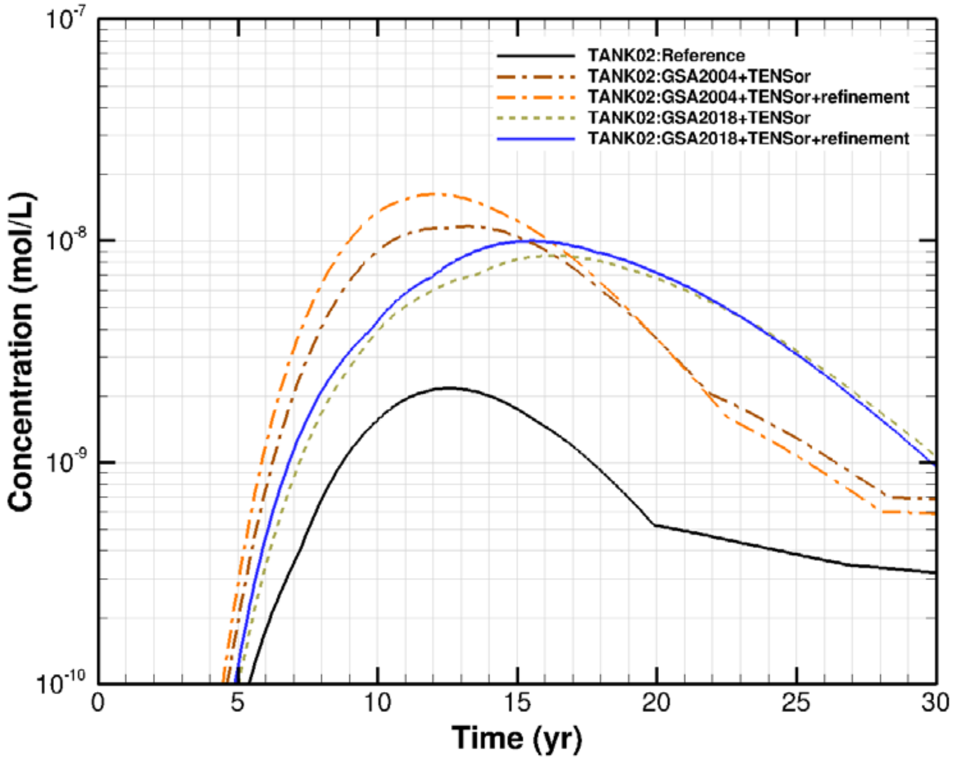
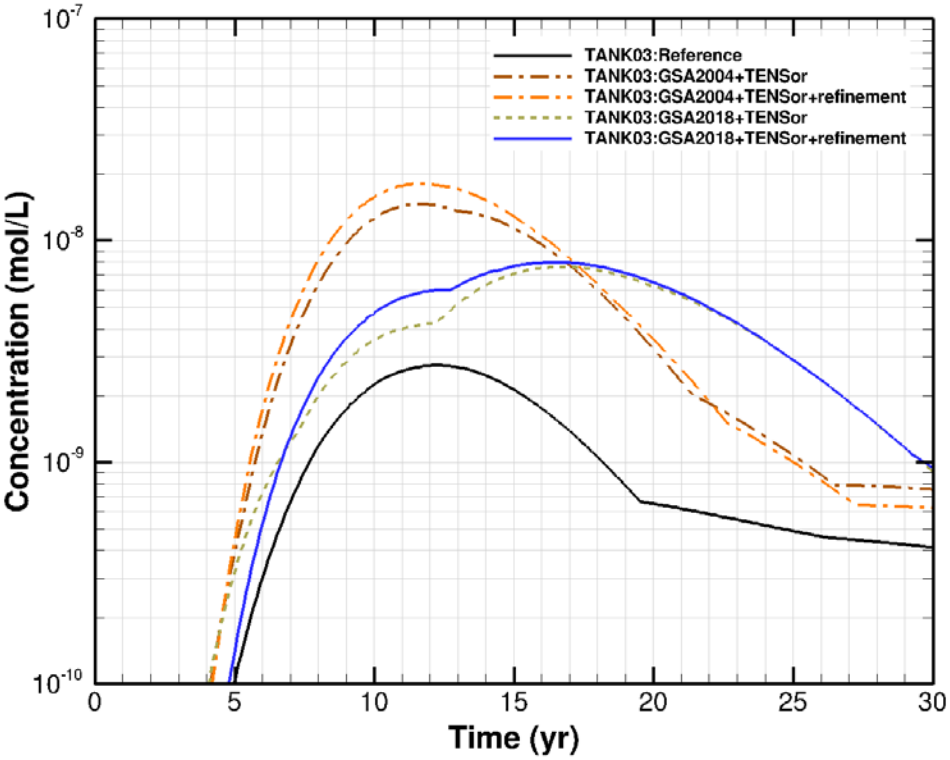


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



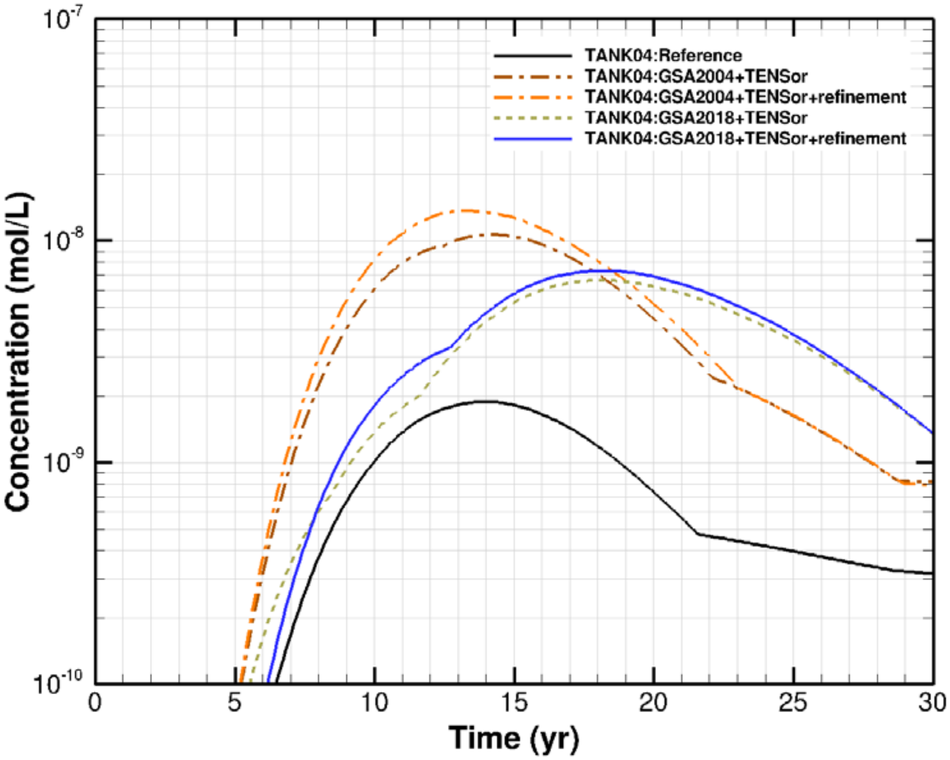
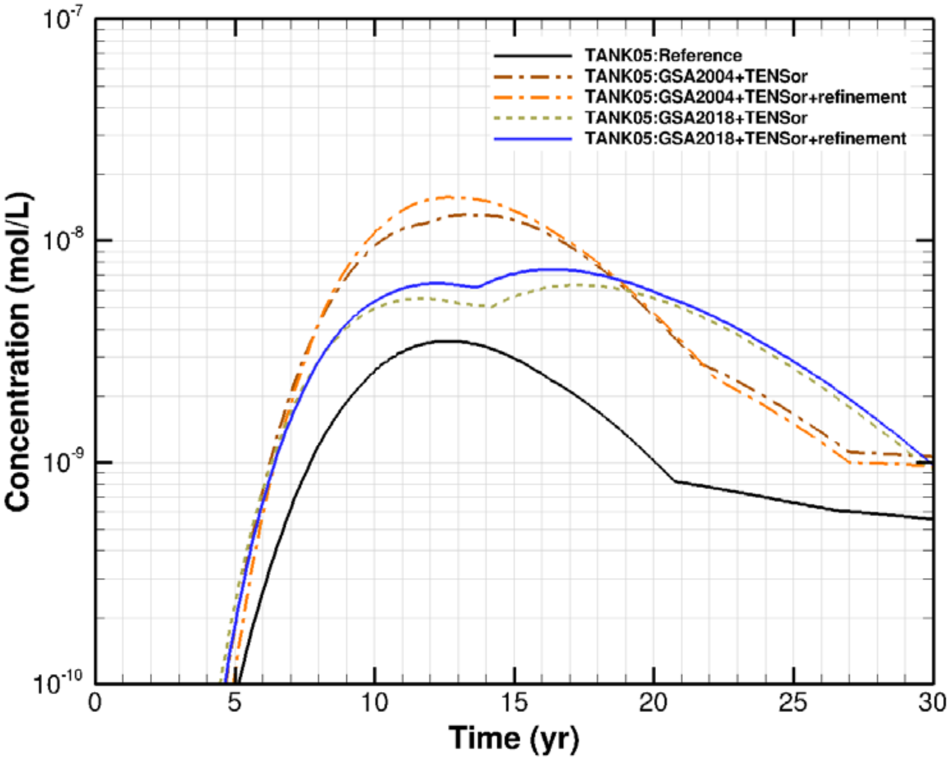


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



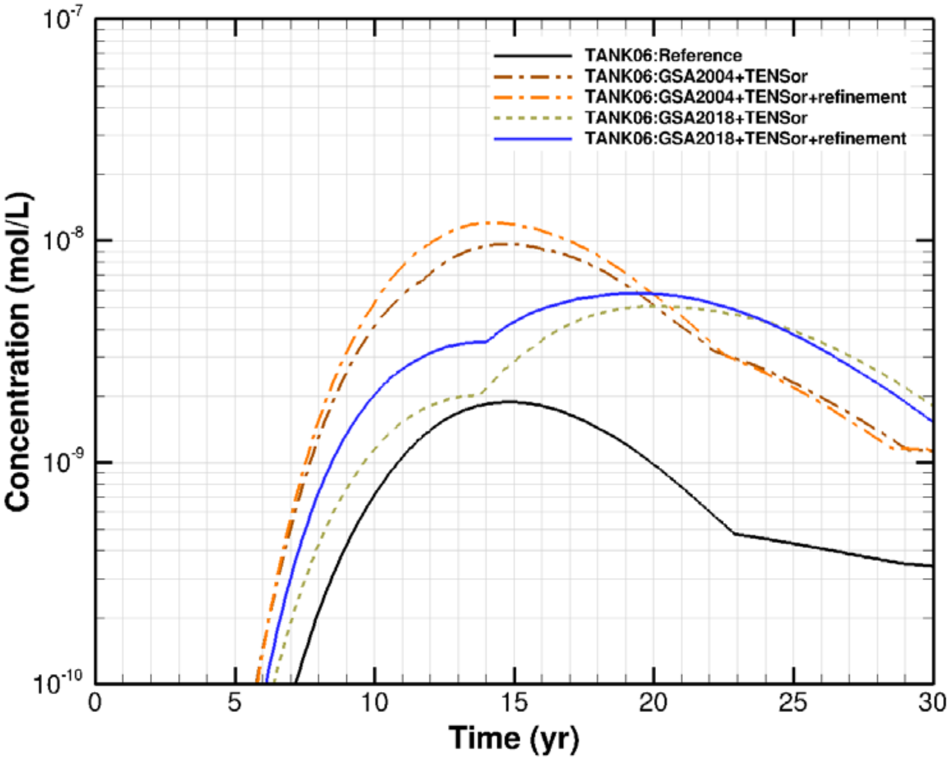
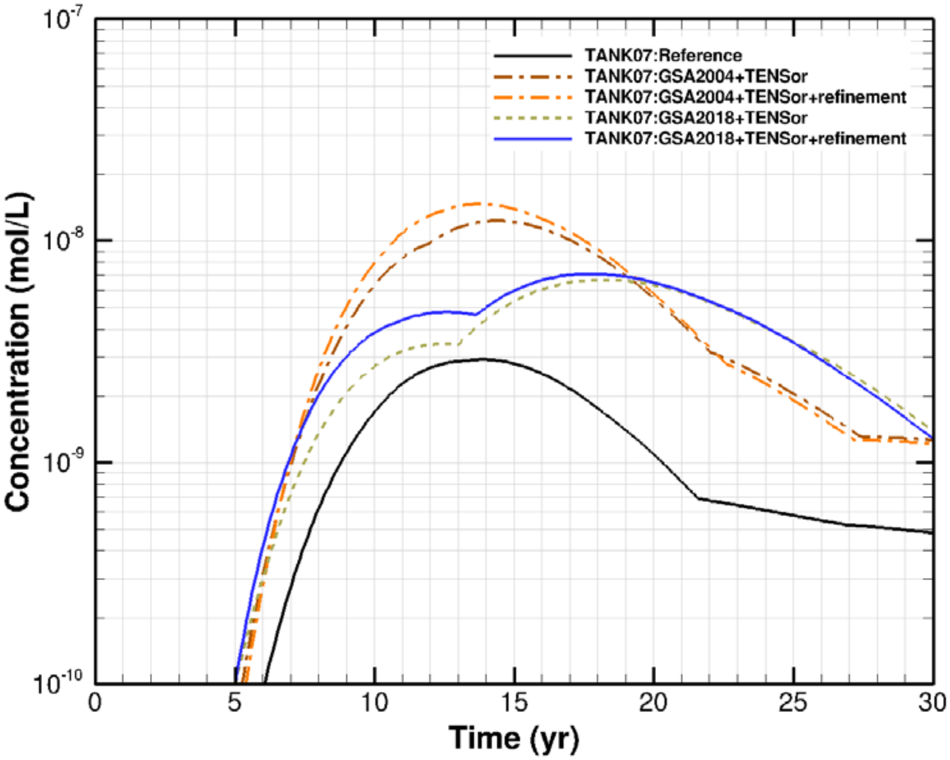


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



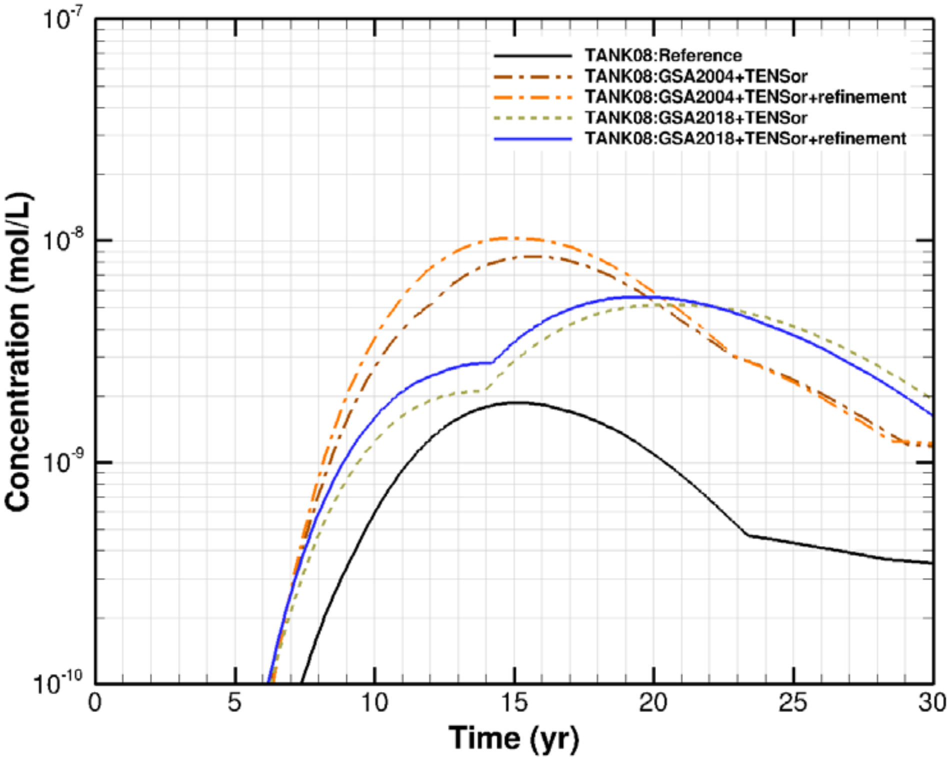
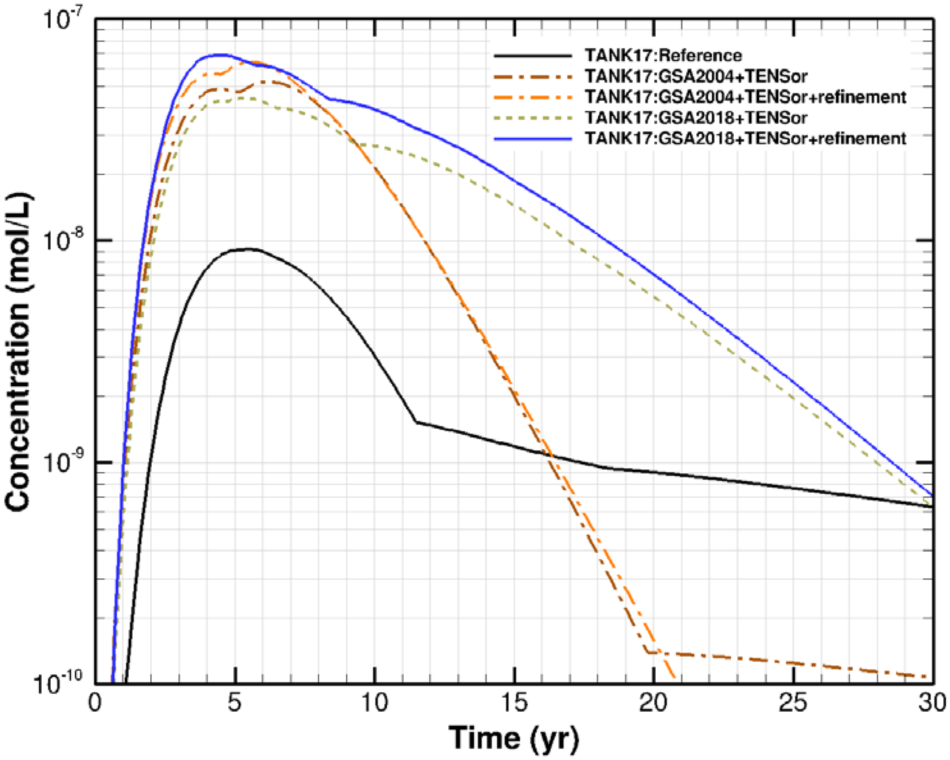


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



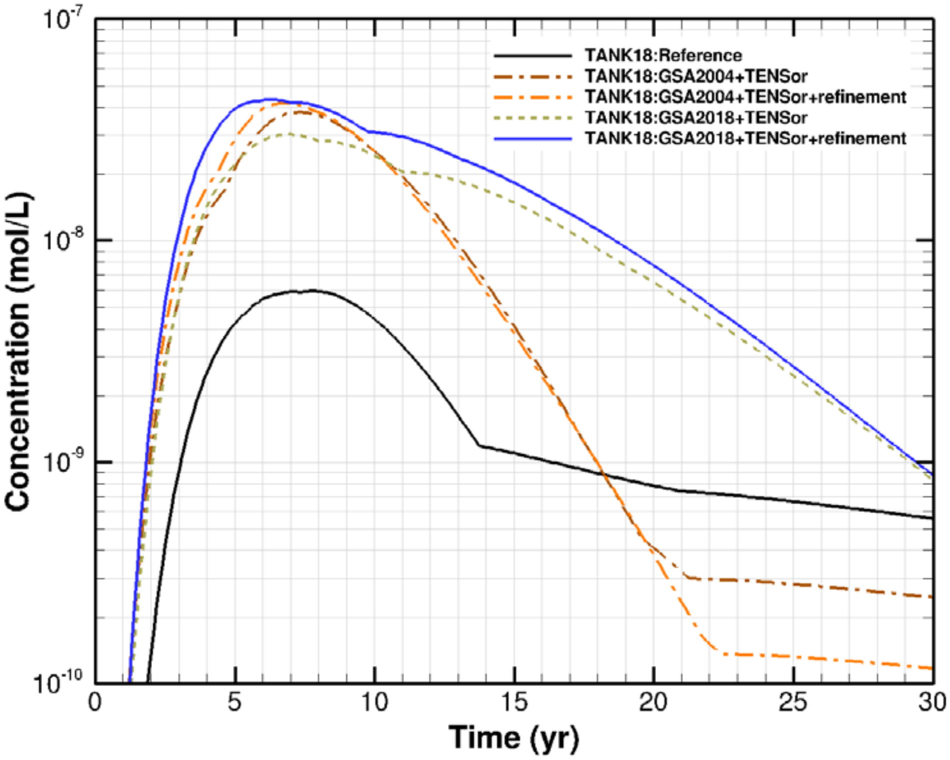
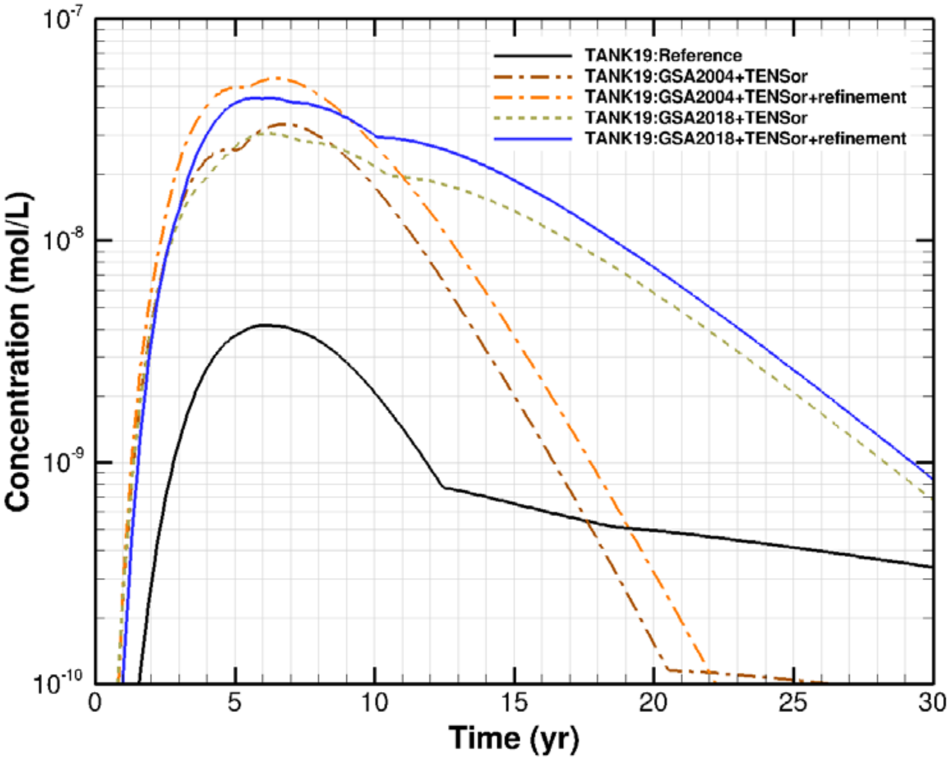


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



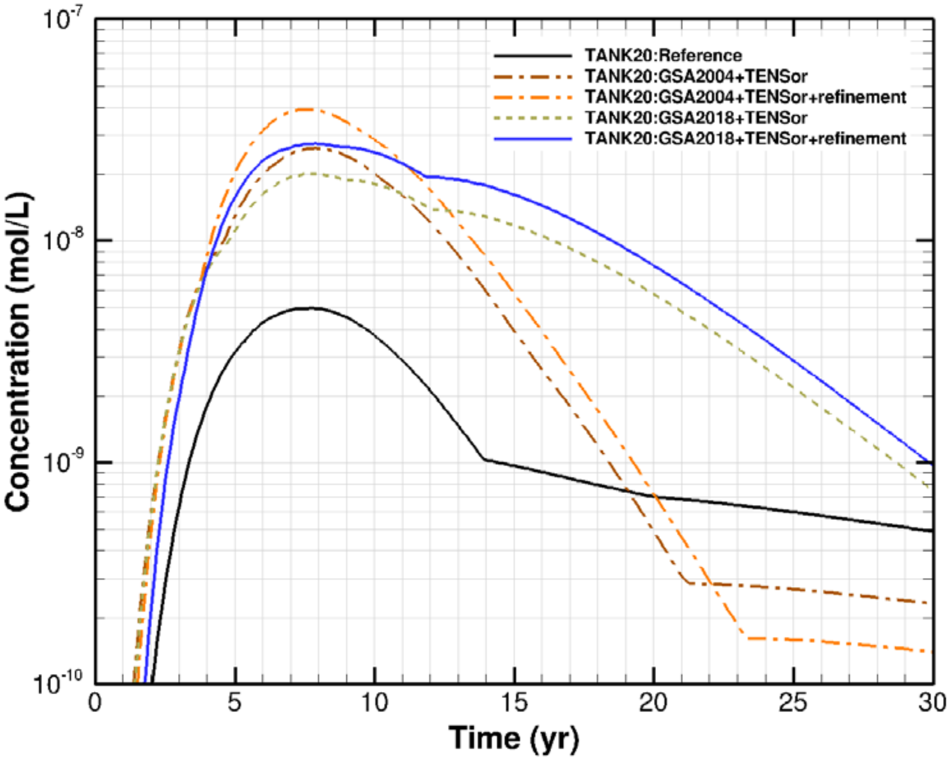
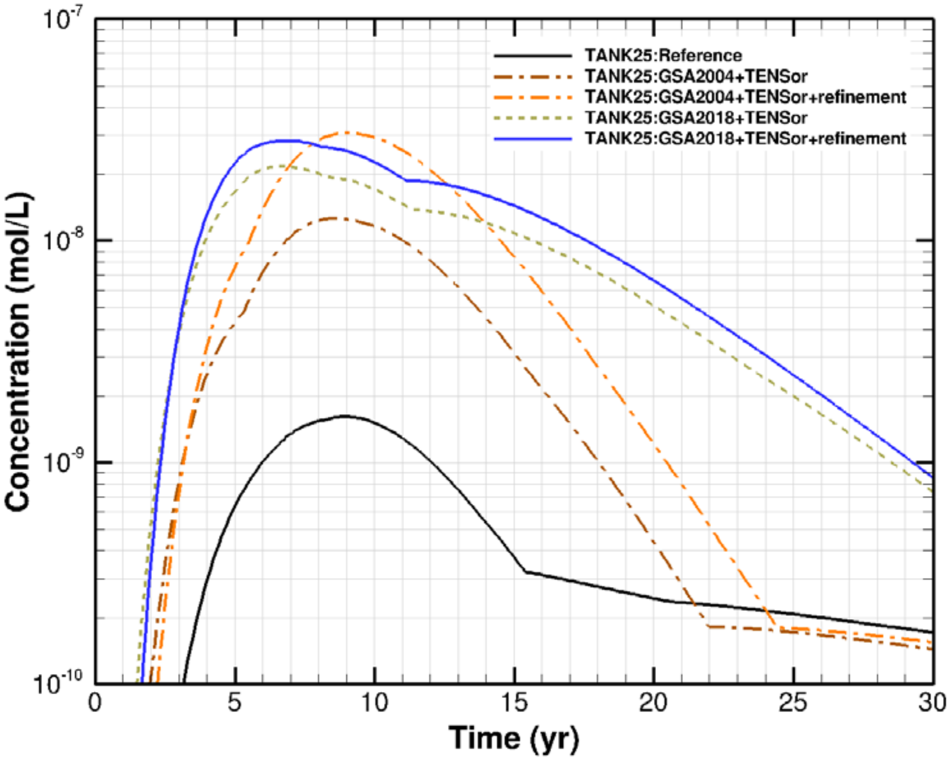


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



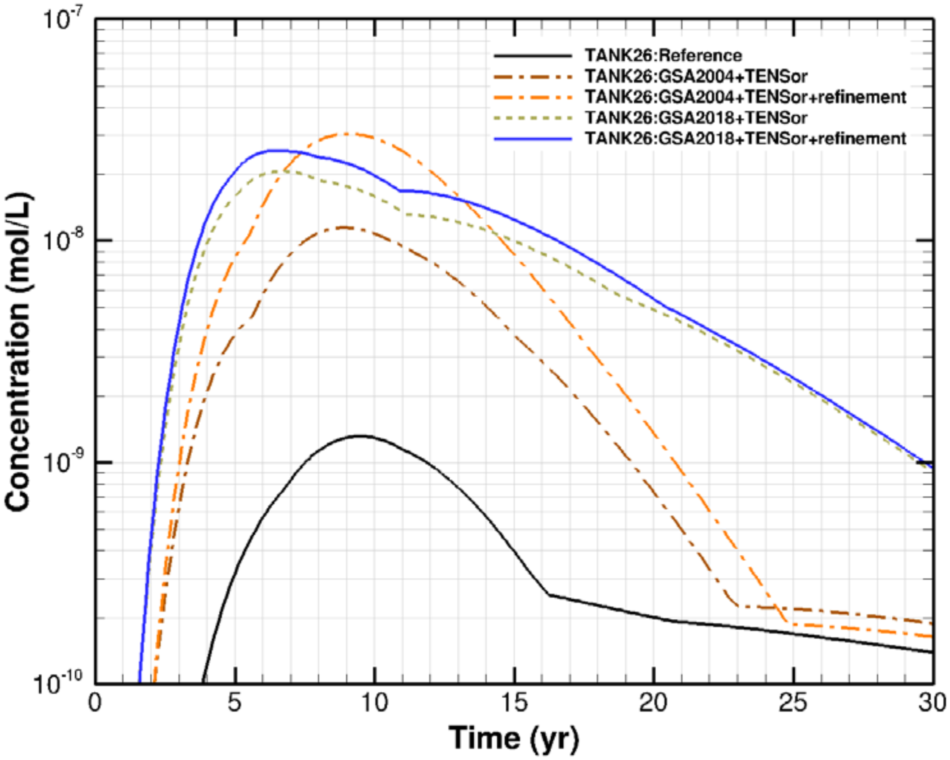
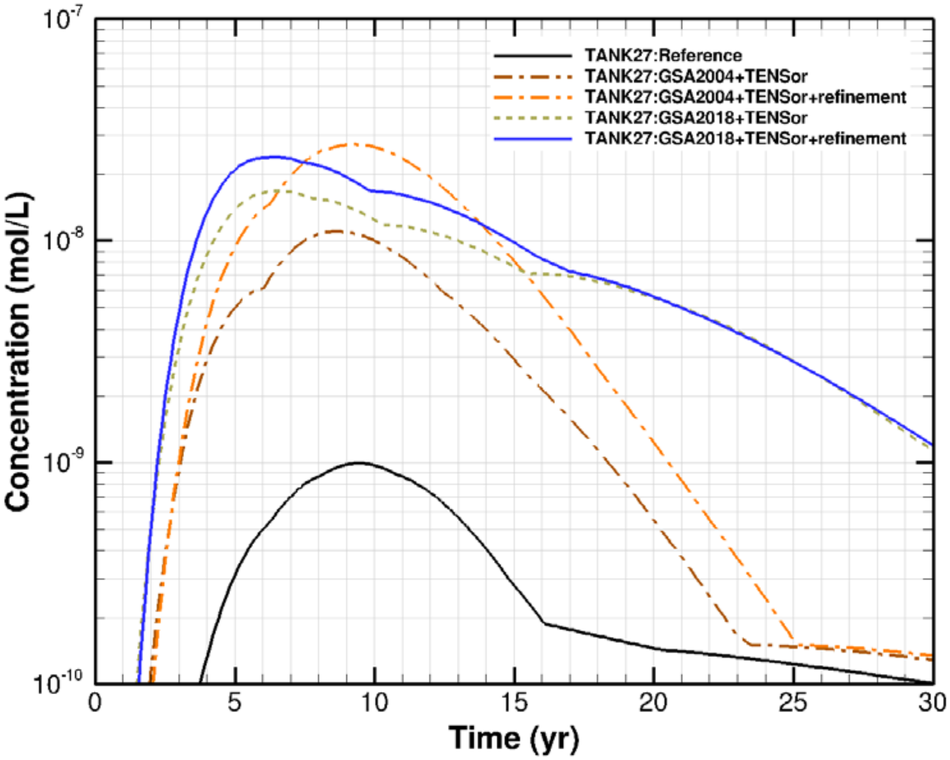


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



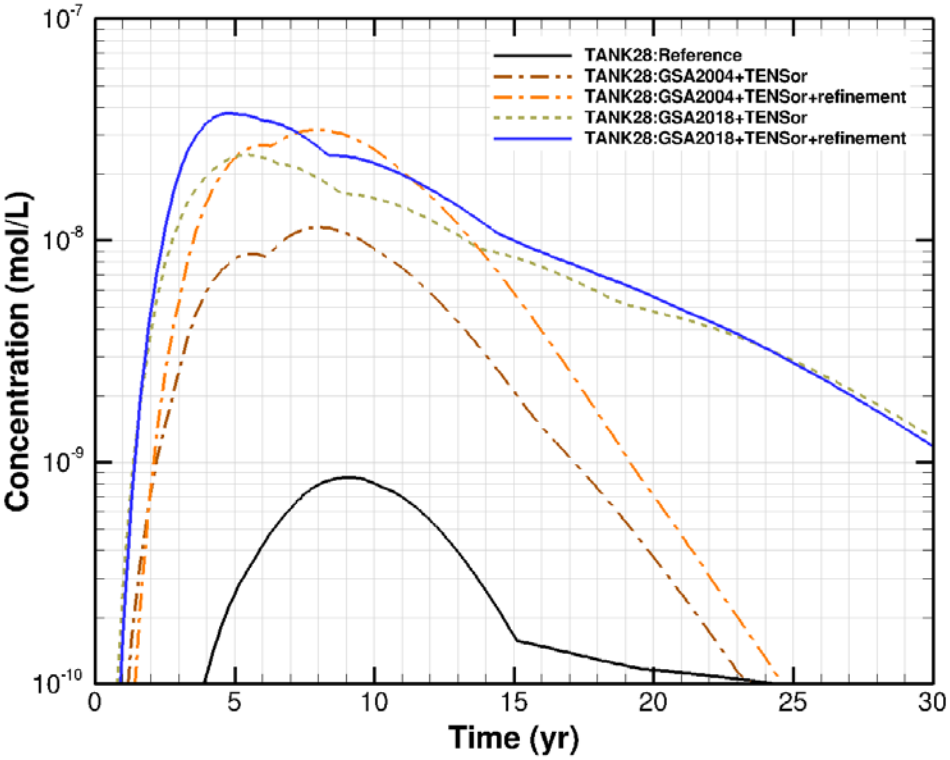
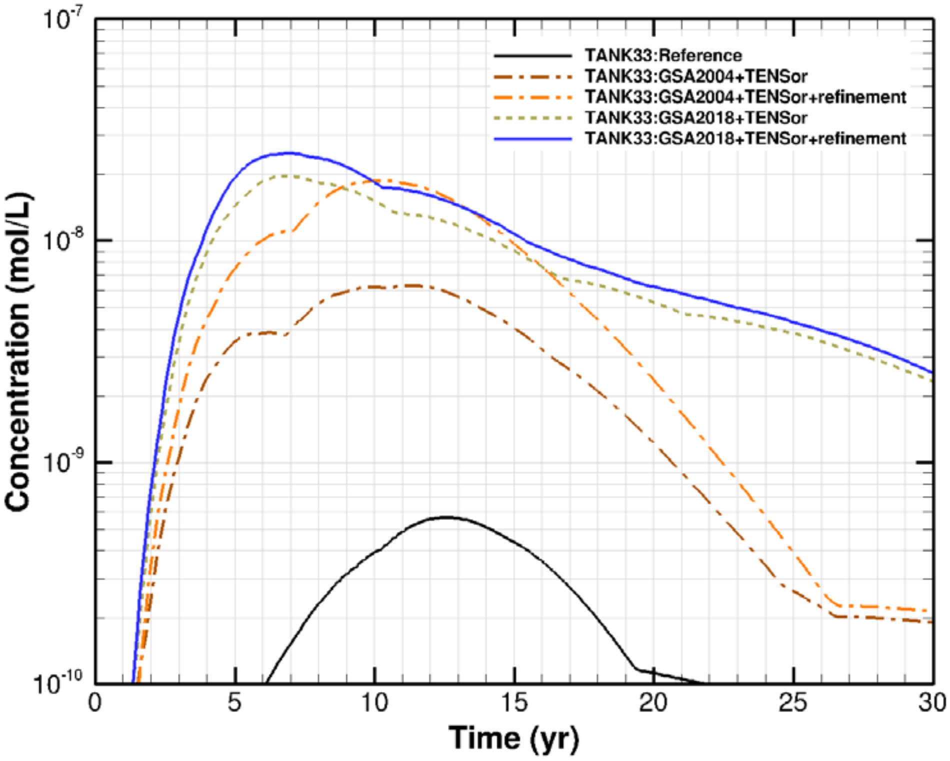


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



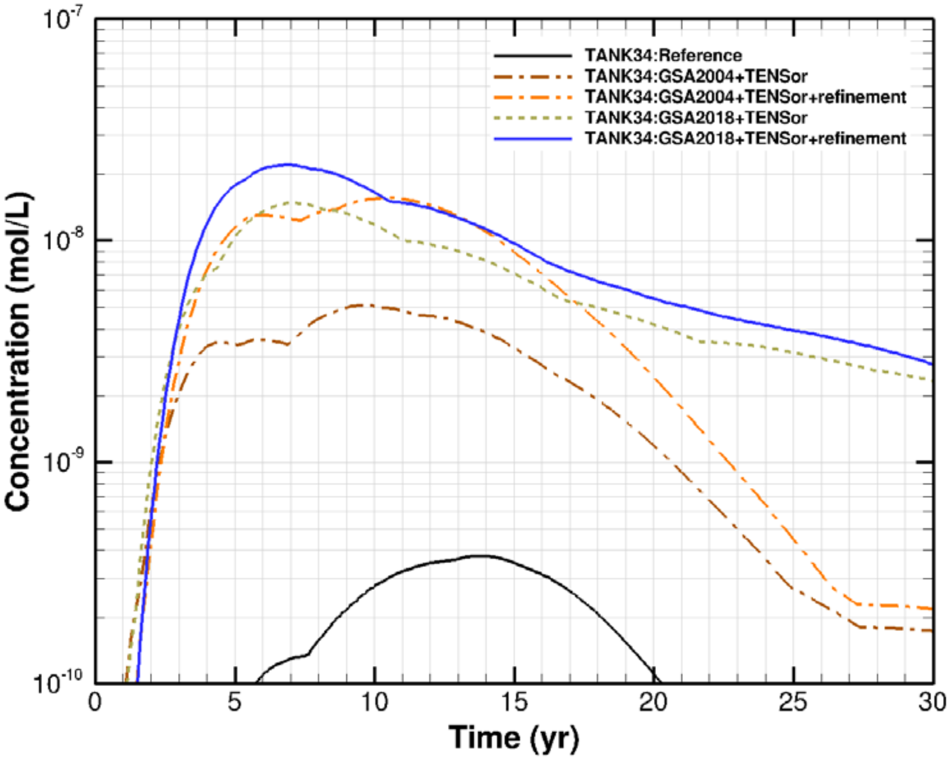
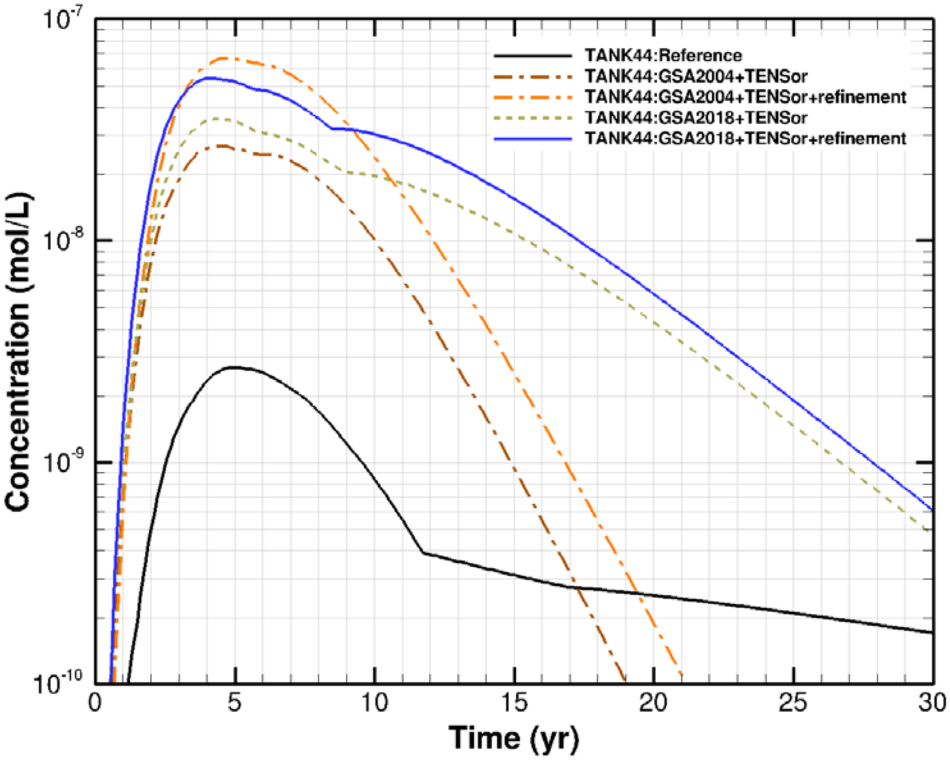


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)



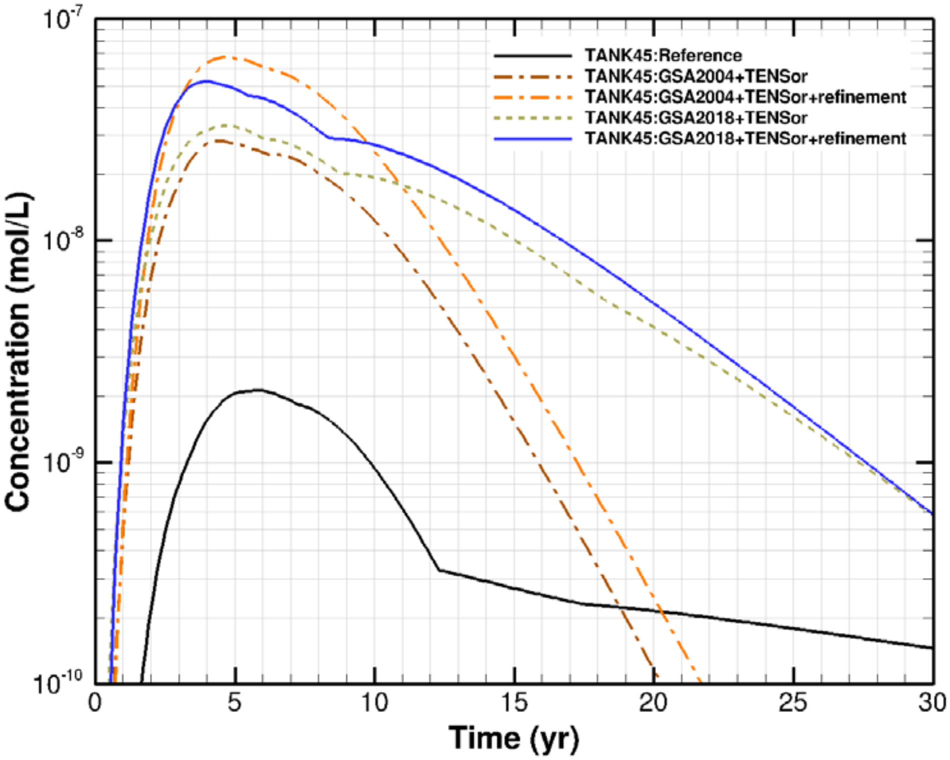
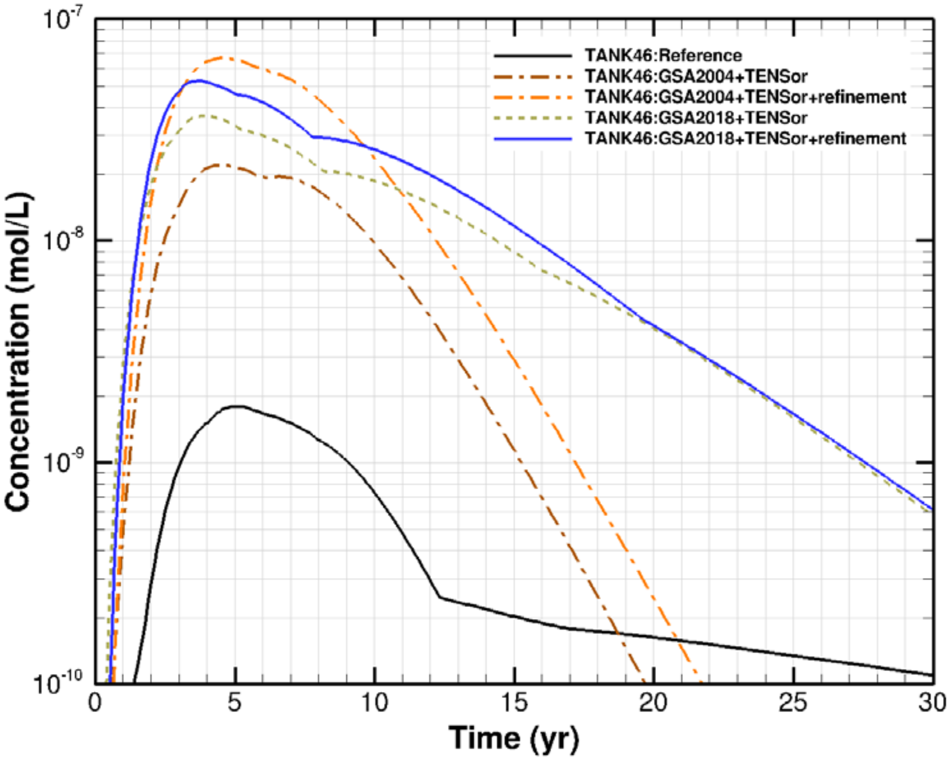
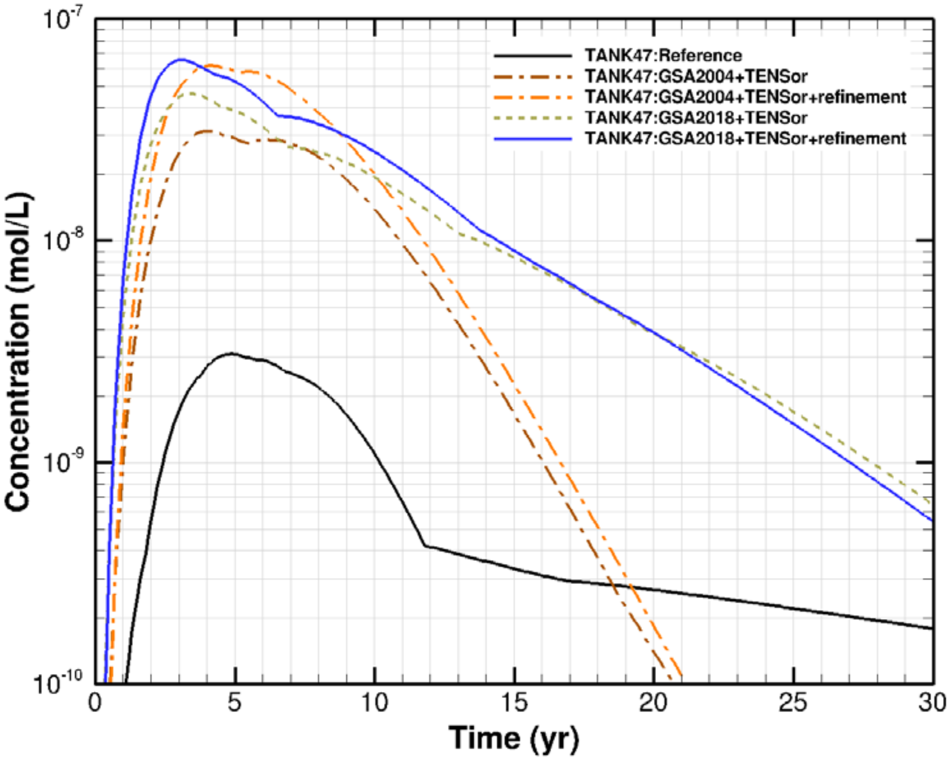


Figure B-1: Transient tracer concentrations at 100-m for a 1.0 mol source: F-Tank Farm. (continued)

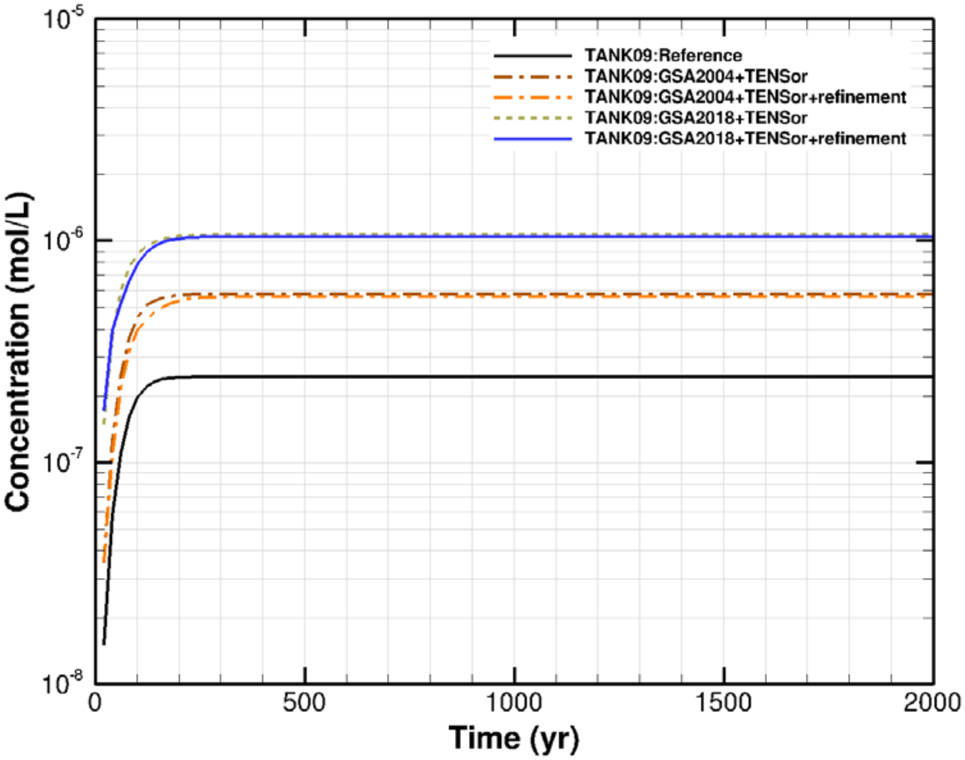




Appendix C: H-Tank Farm Steady-State Tracer Simulations

Figure C-1 shows the highest concentration along the 100-meter perimeter for a constant 1.0 mol/yr source of tracer beneath each waste tank.

Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm.



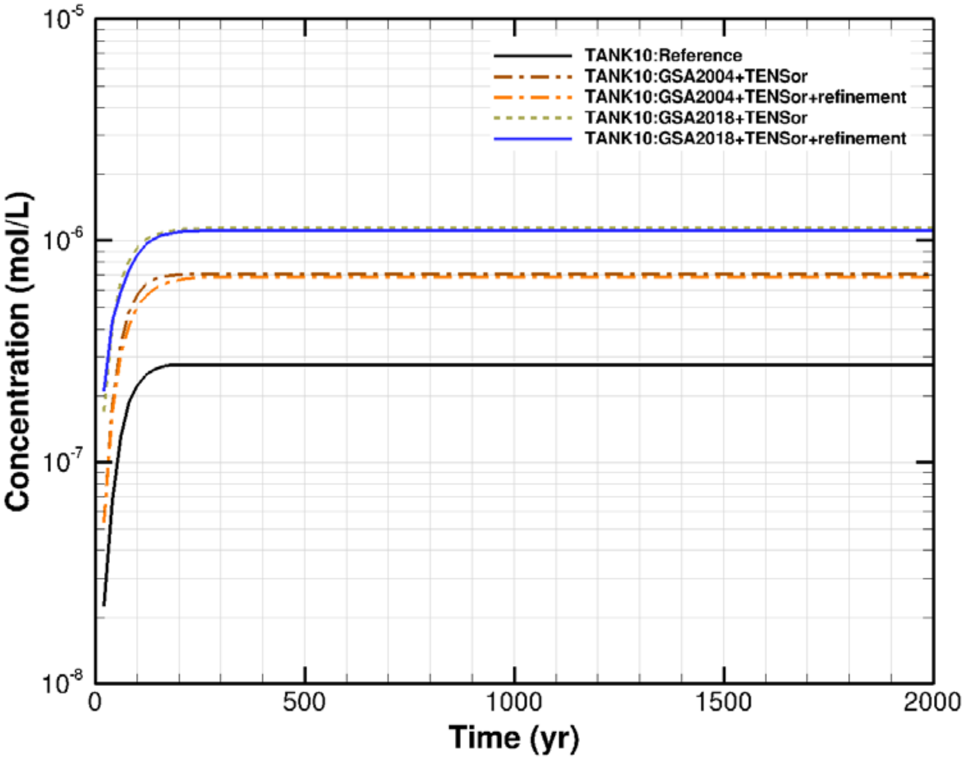
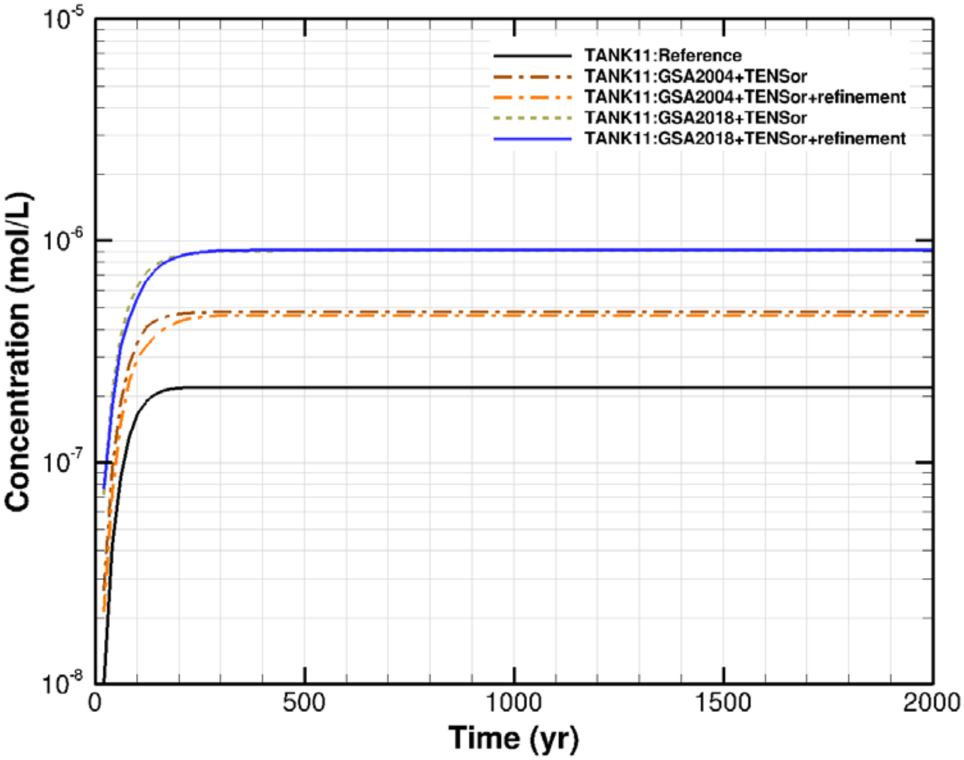


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



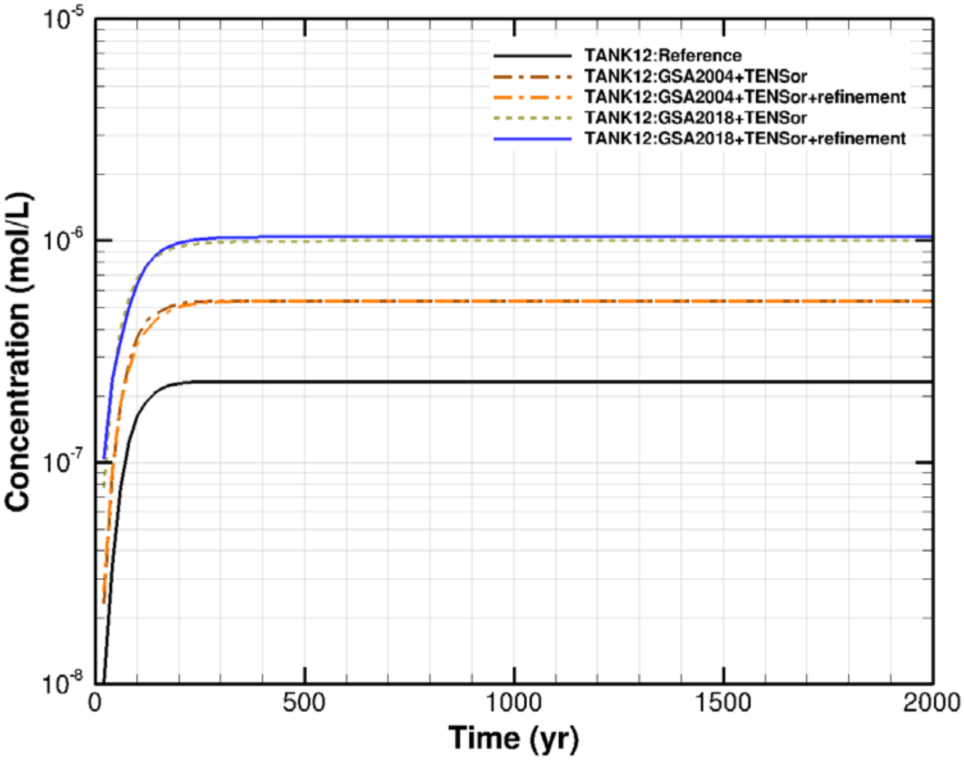
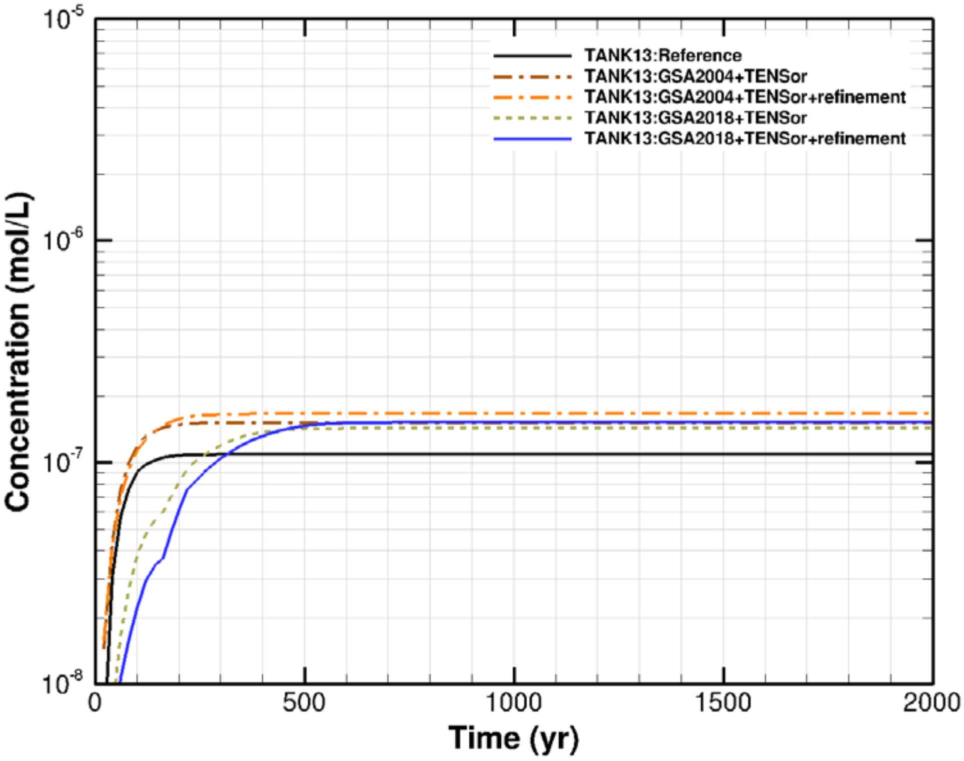


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



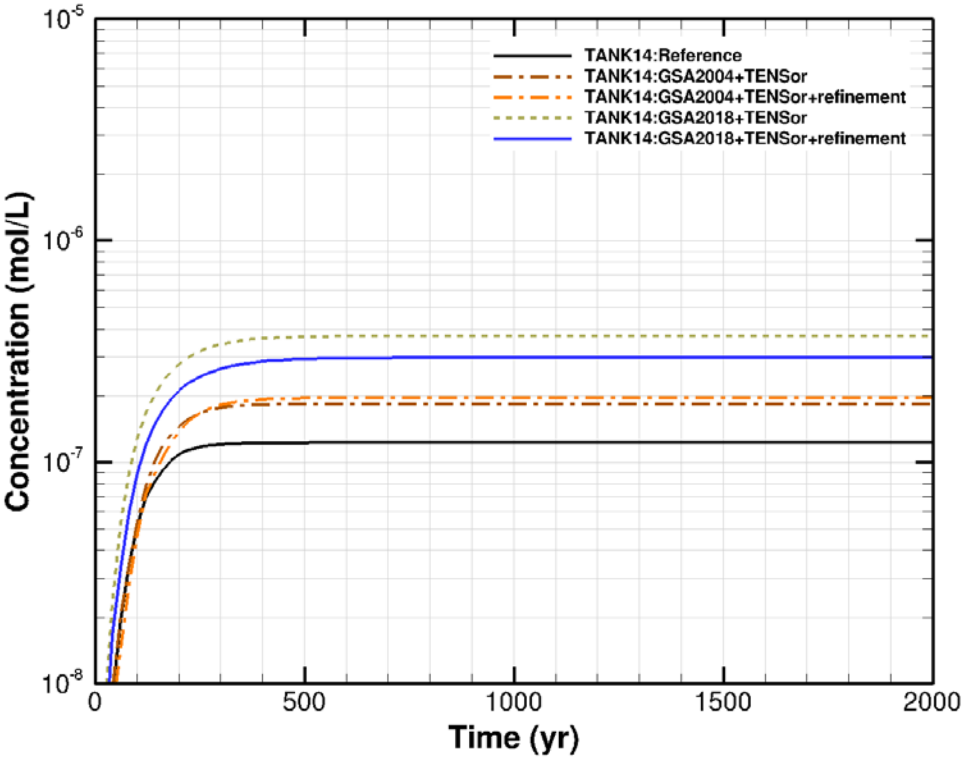
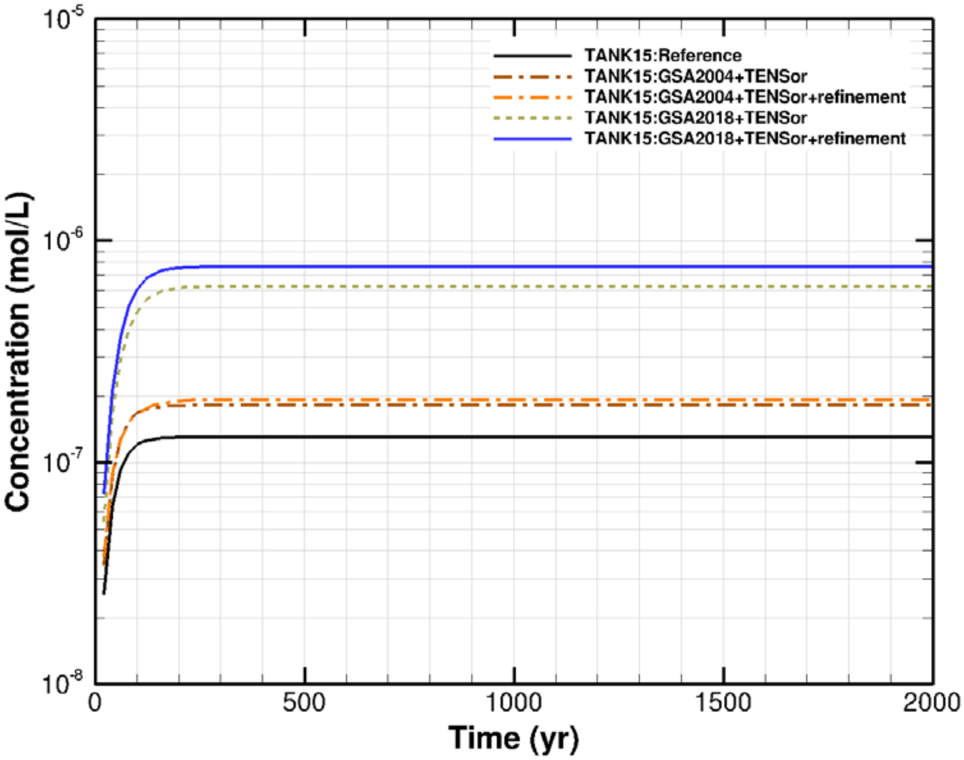


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



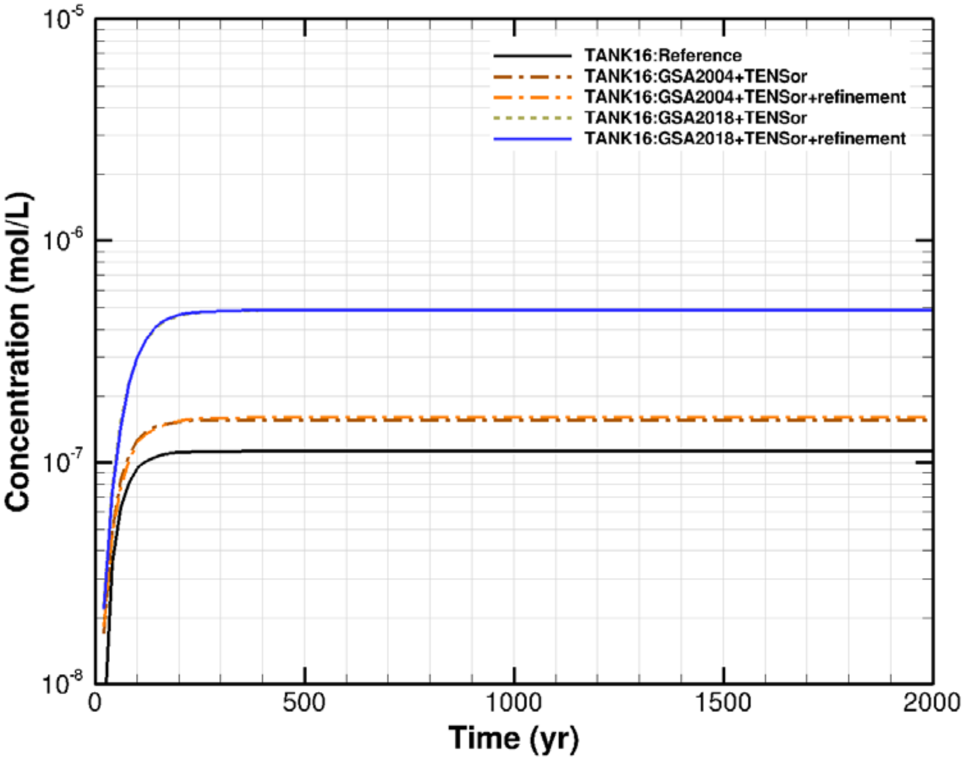
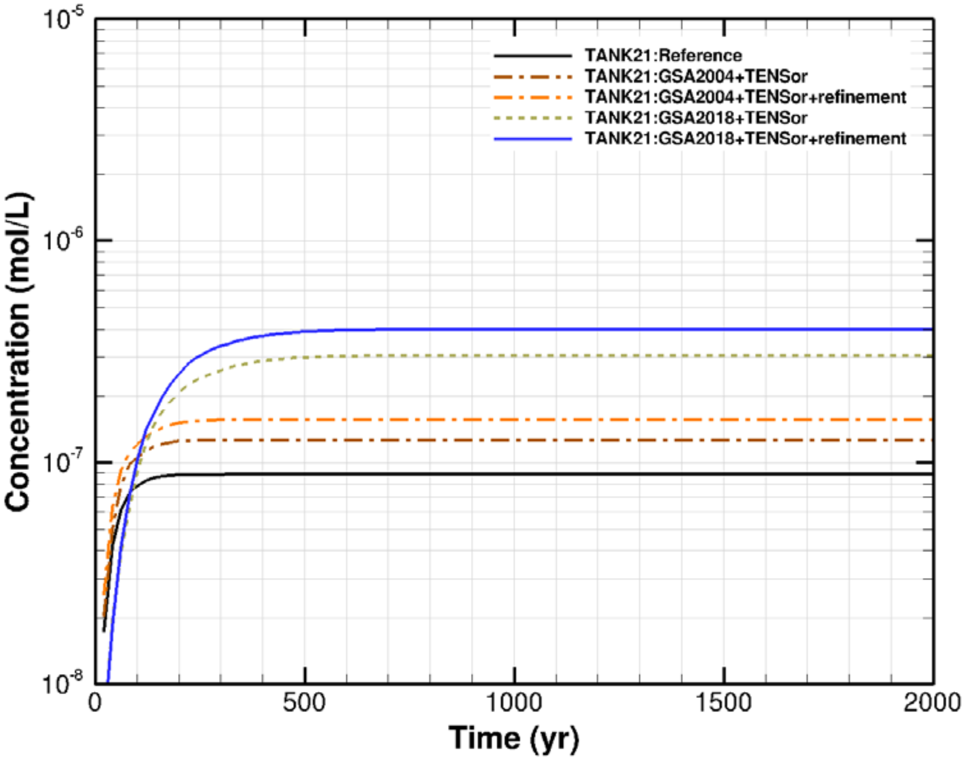


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



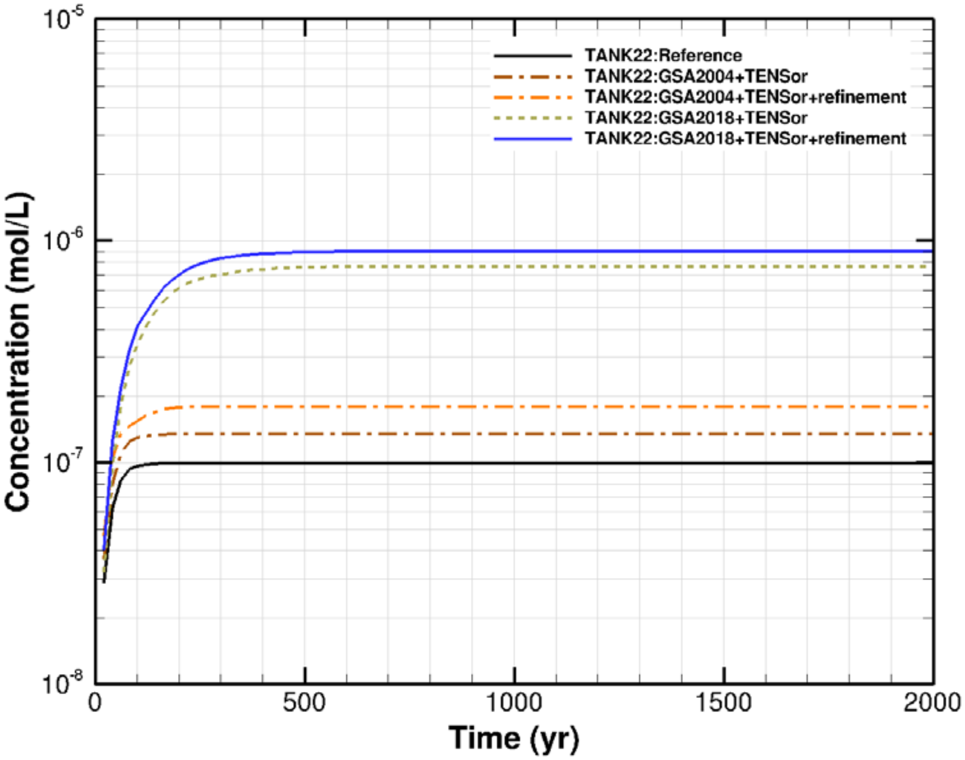
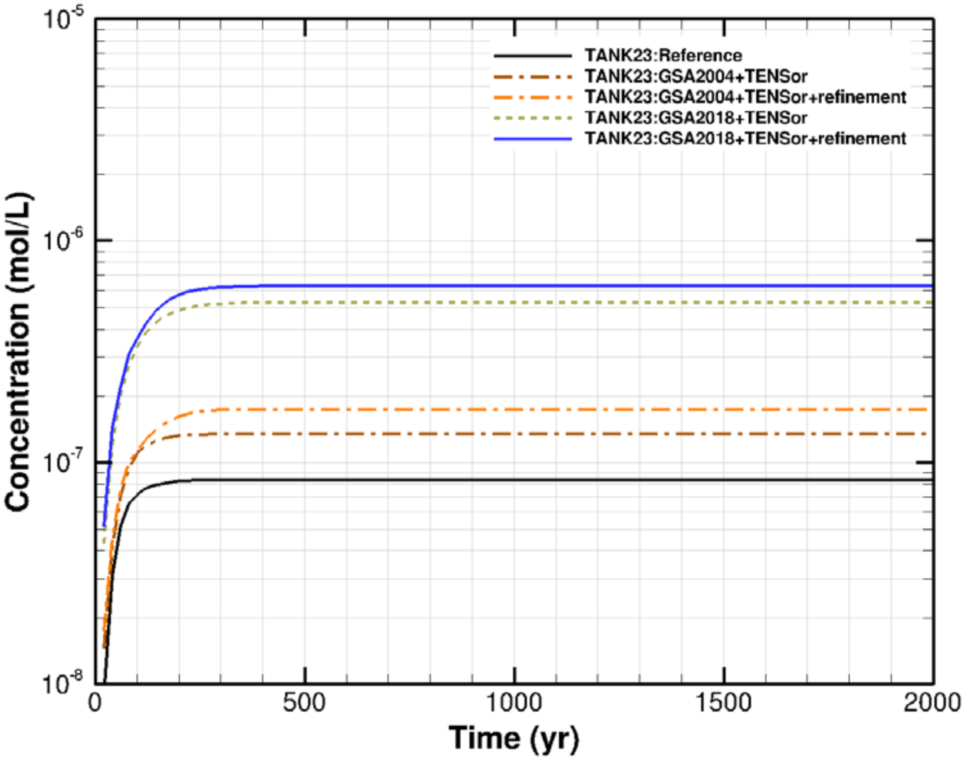


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



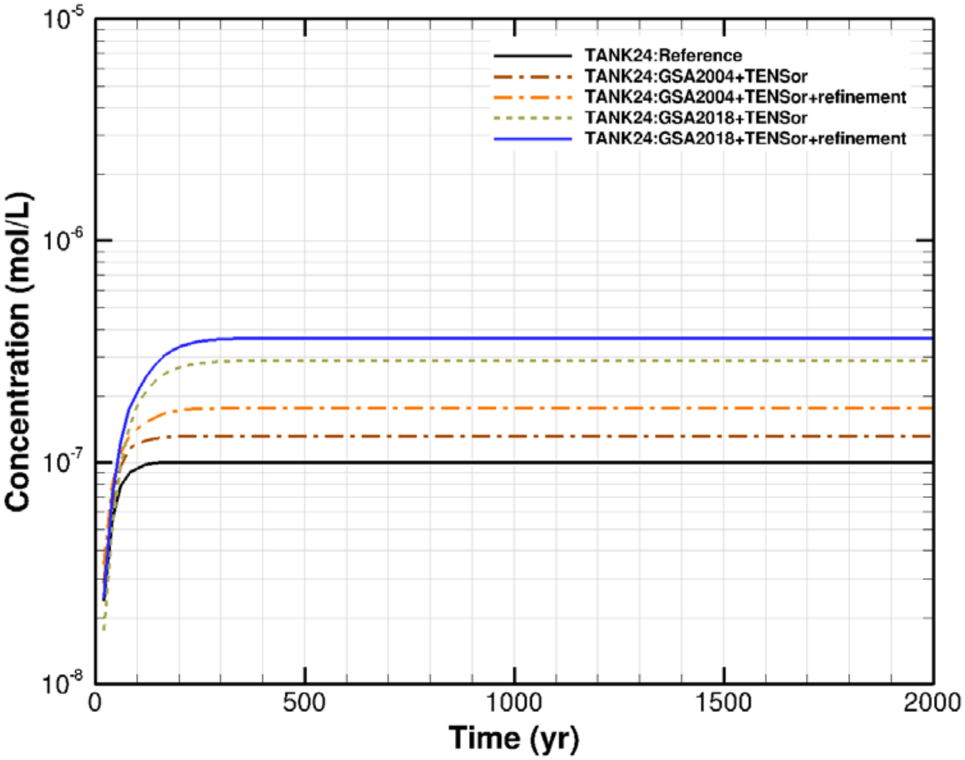
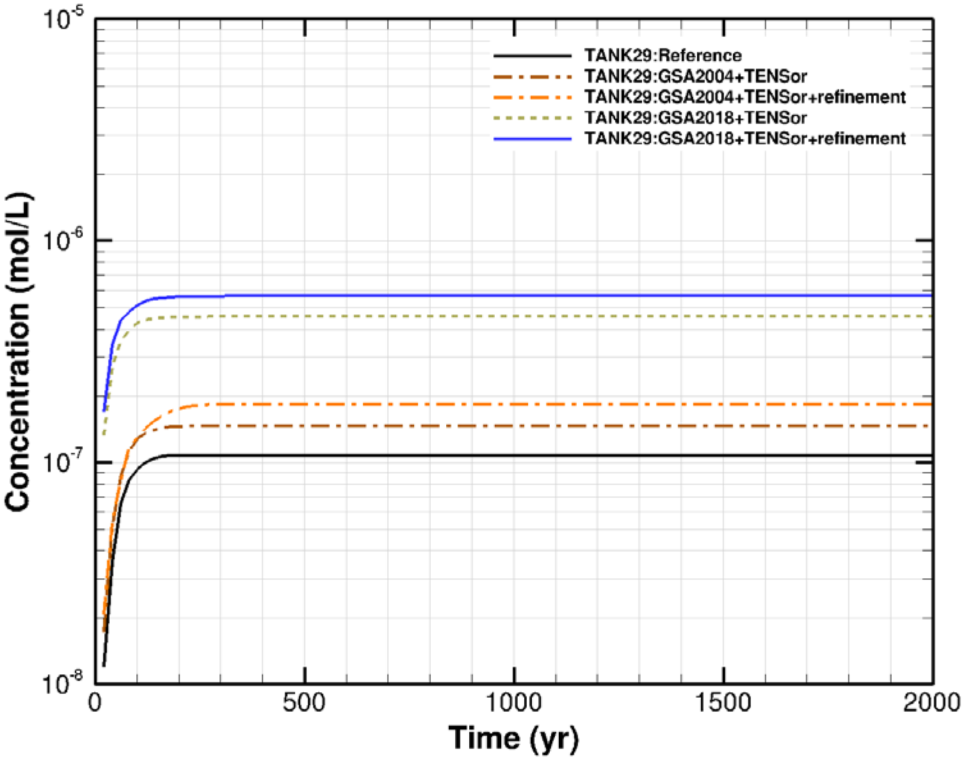


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



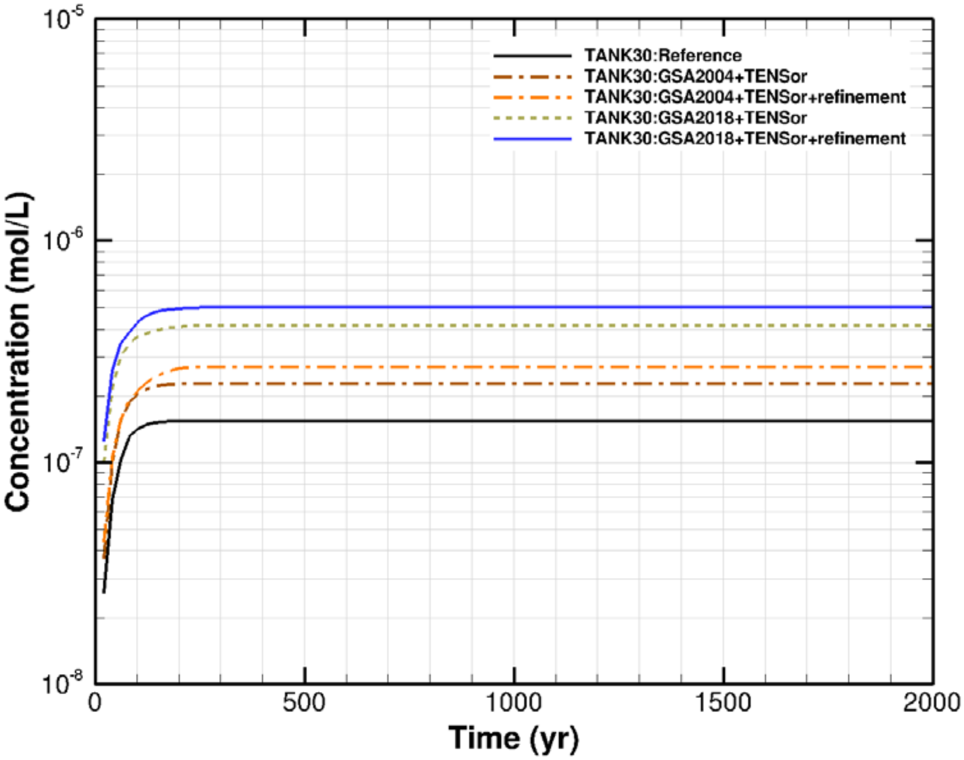
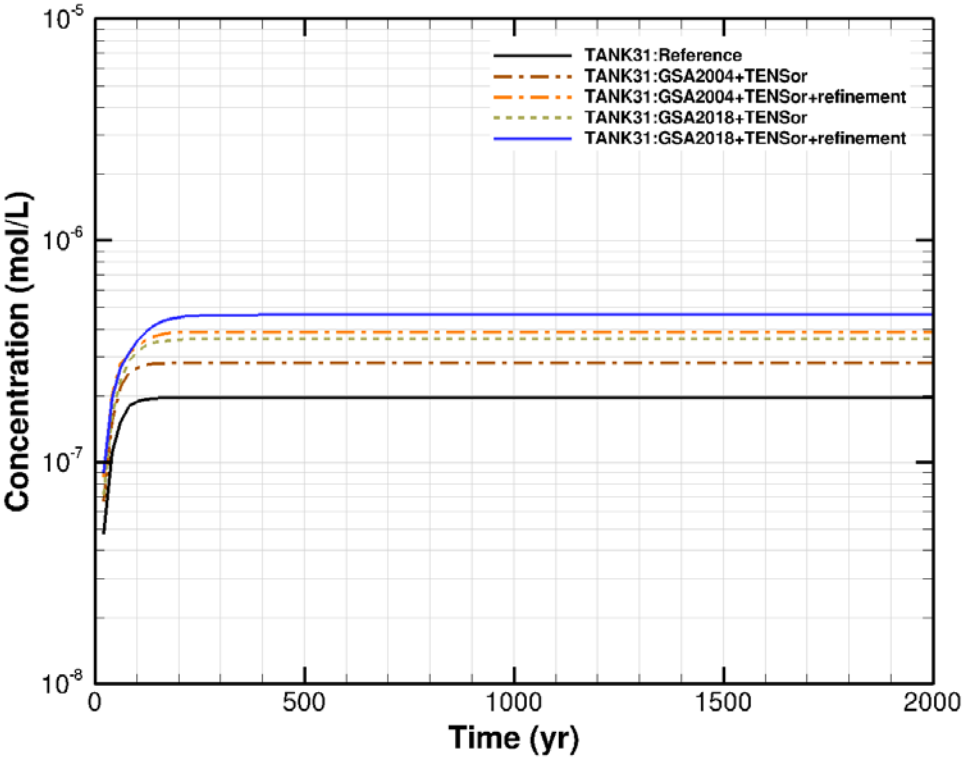


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



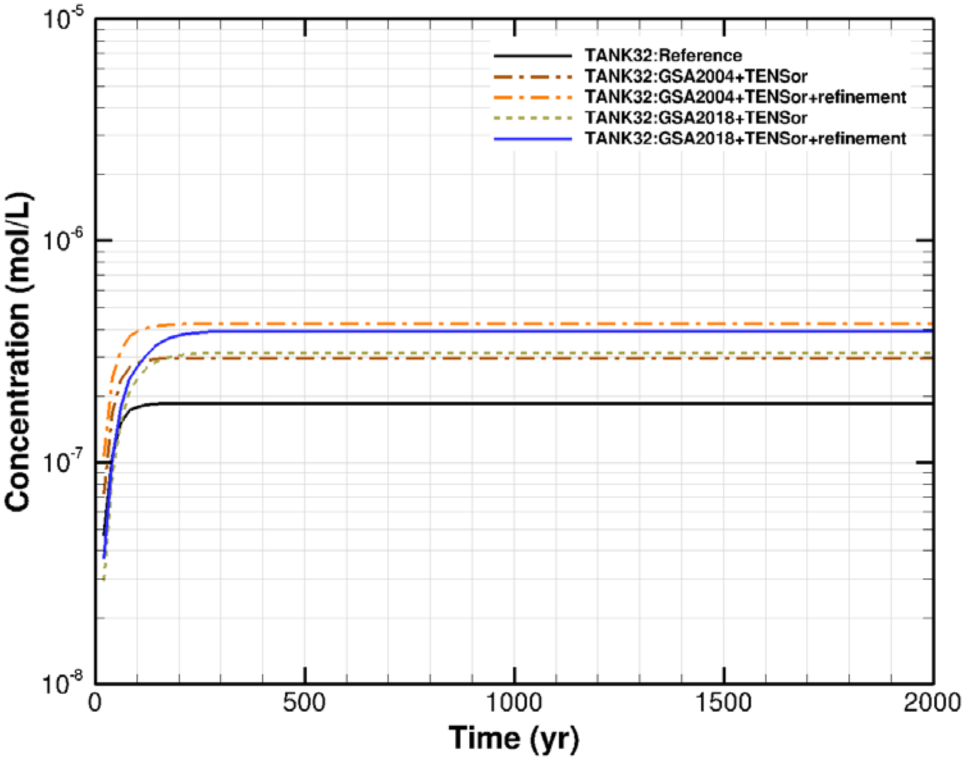
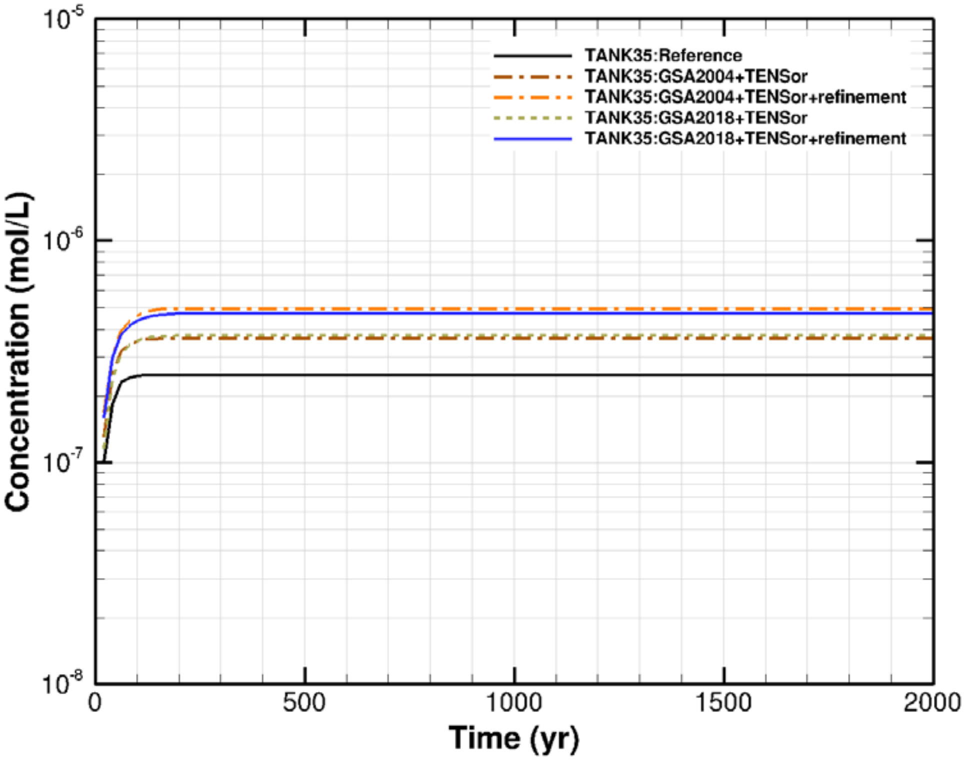


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



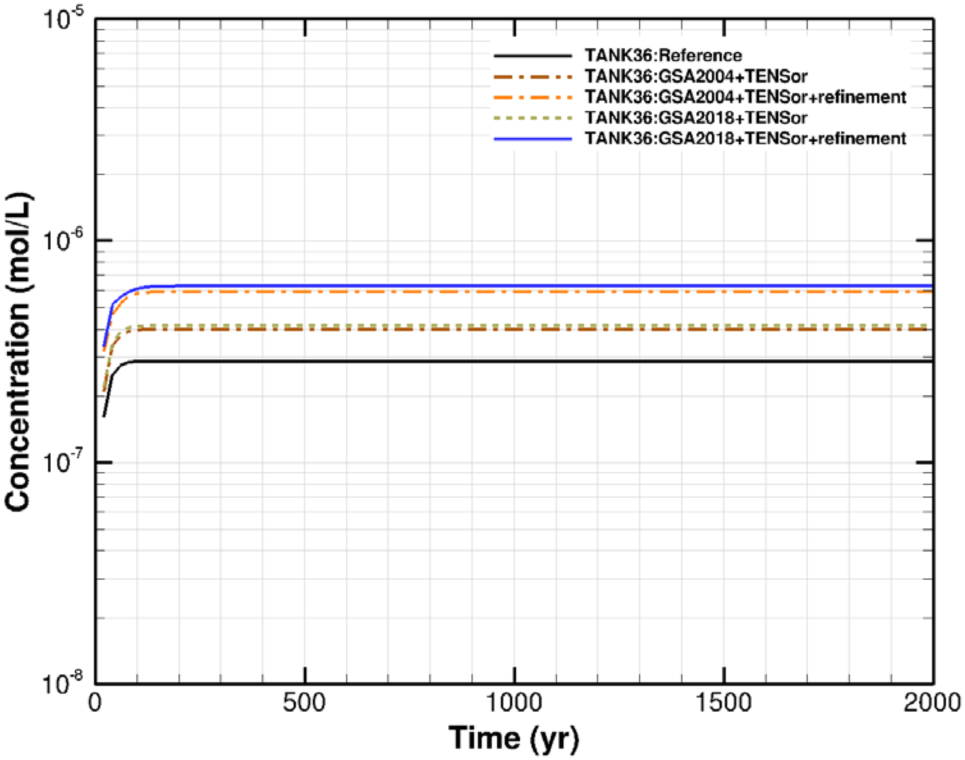
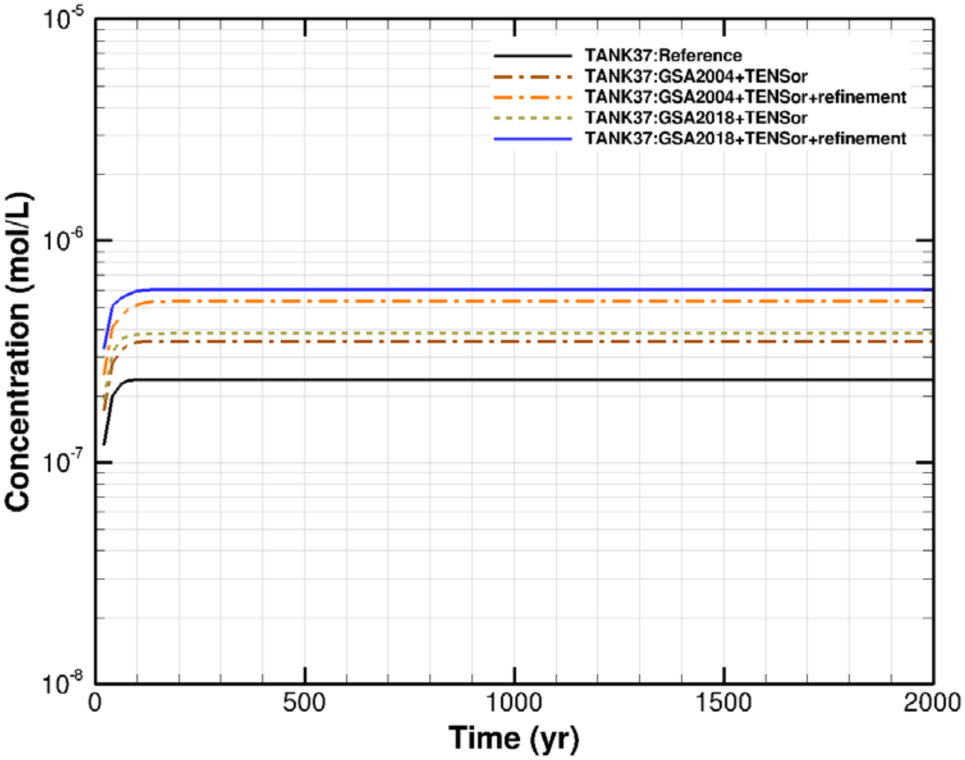


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



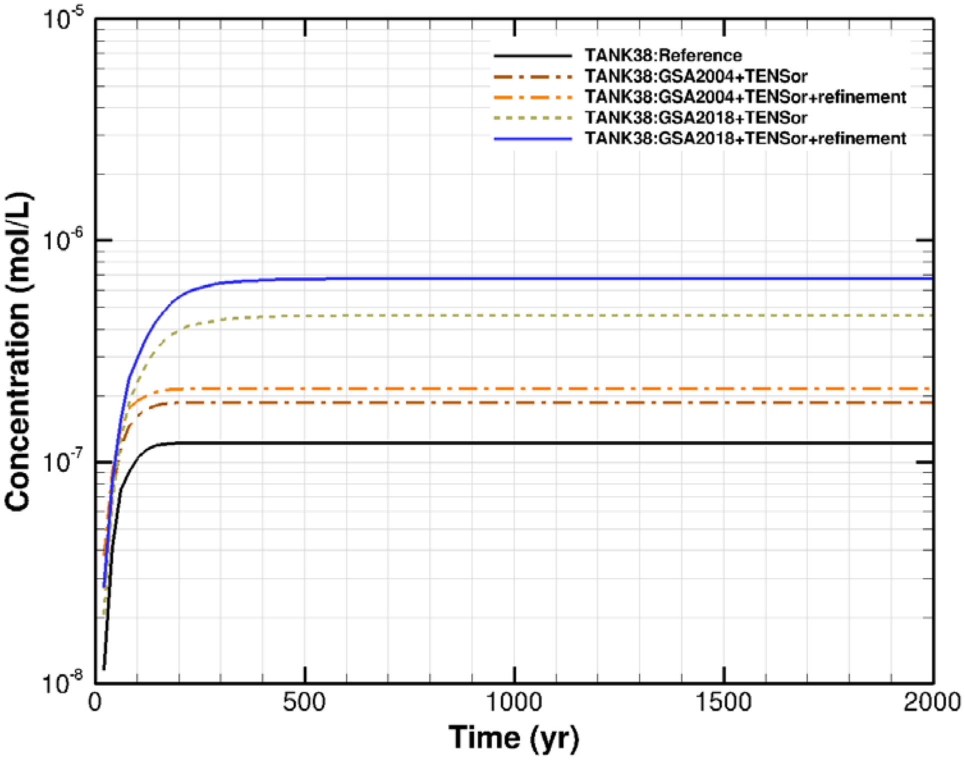
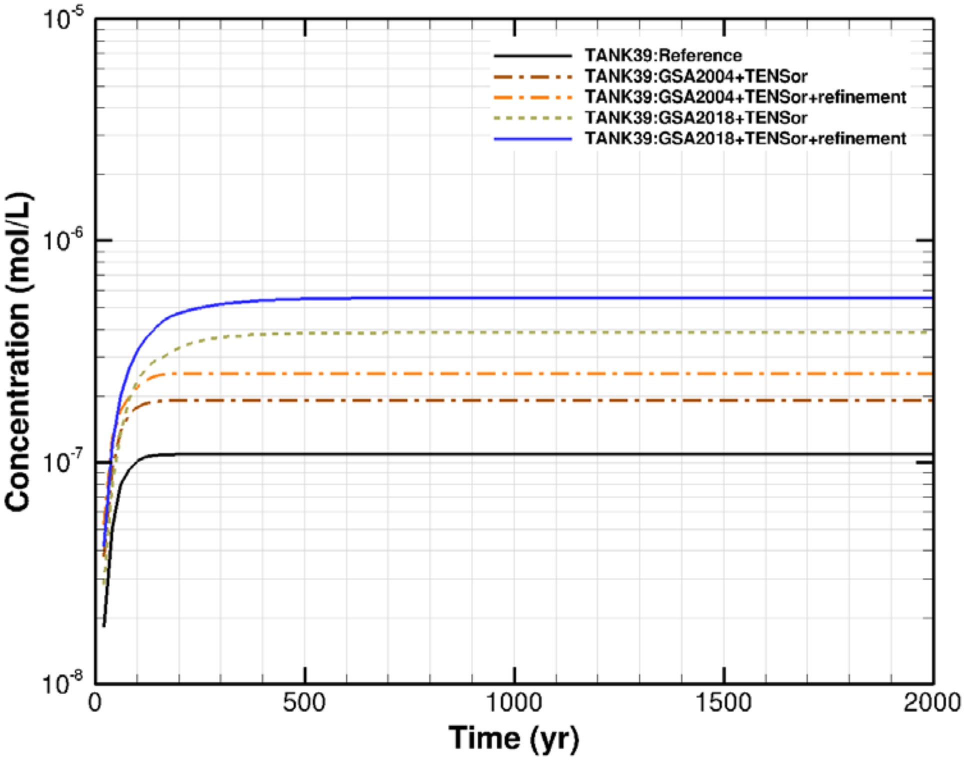


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



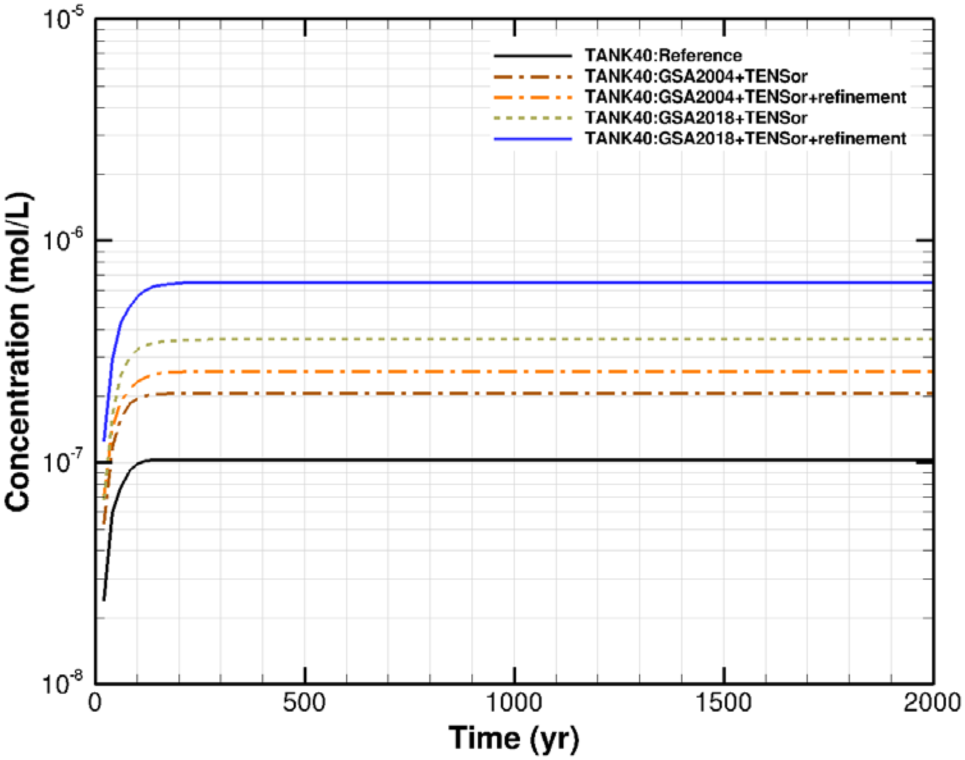
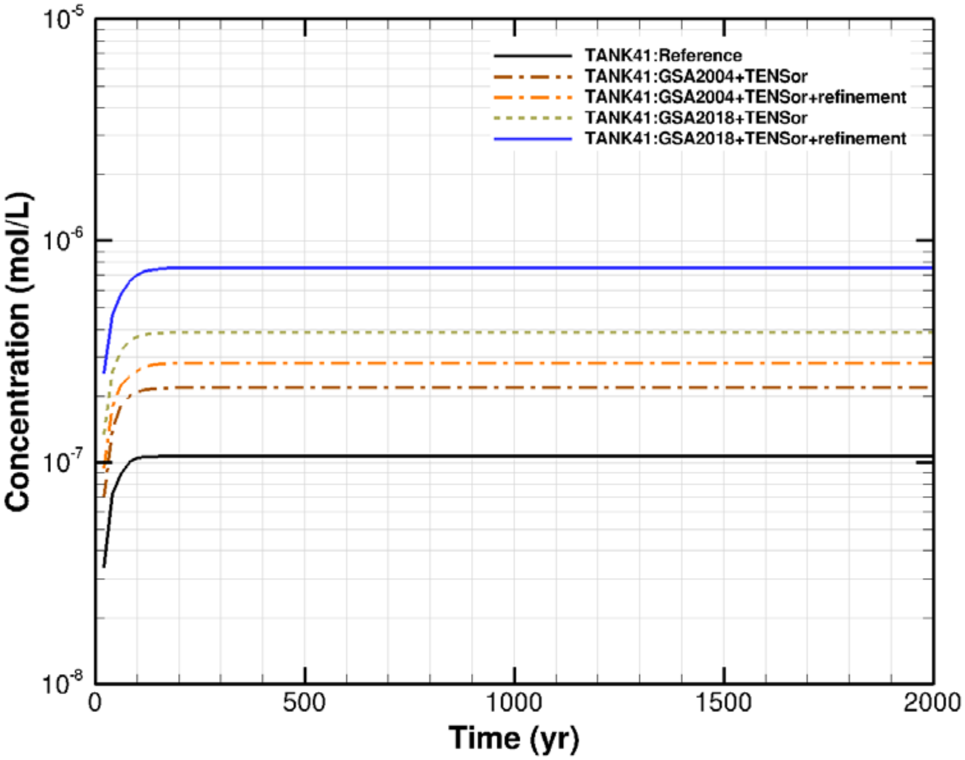


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



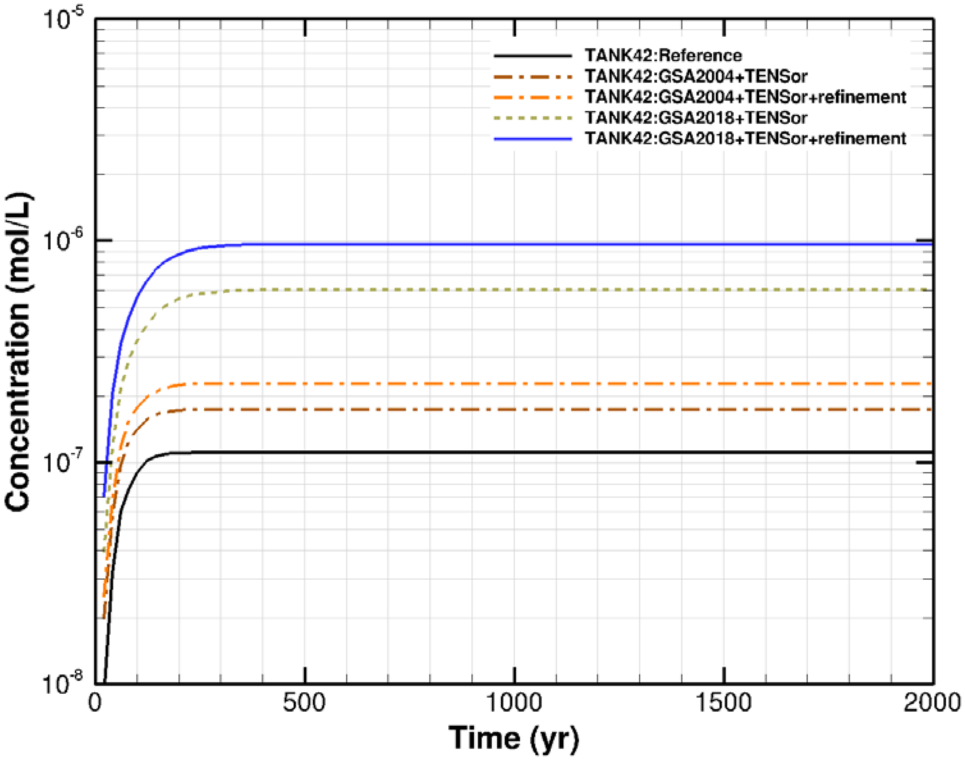
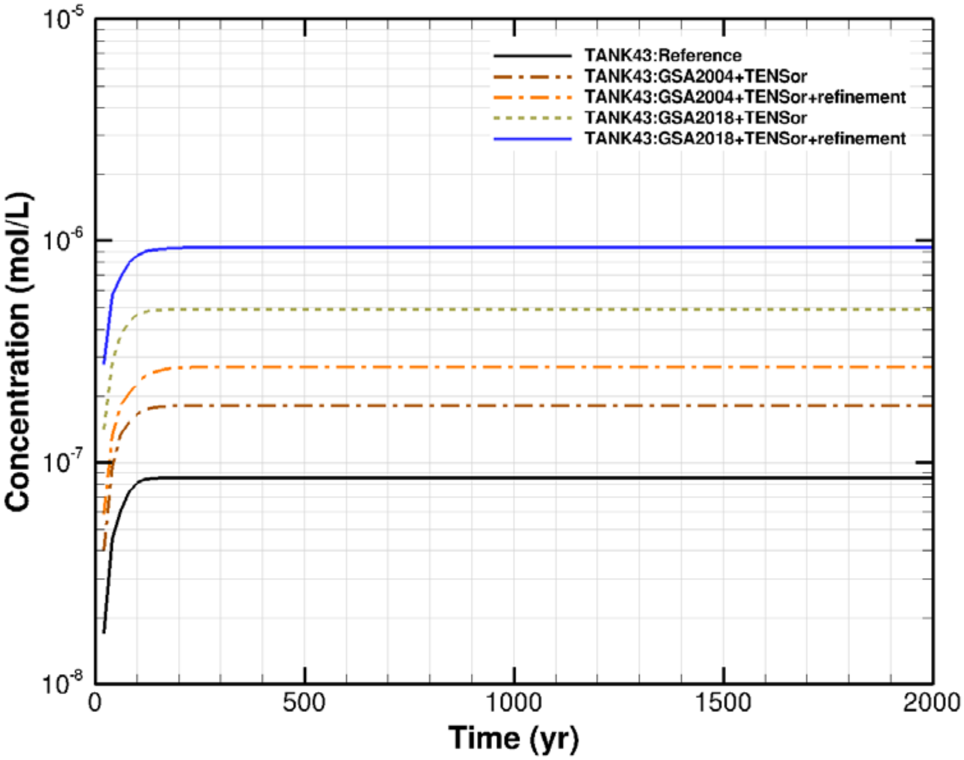


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



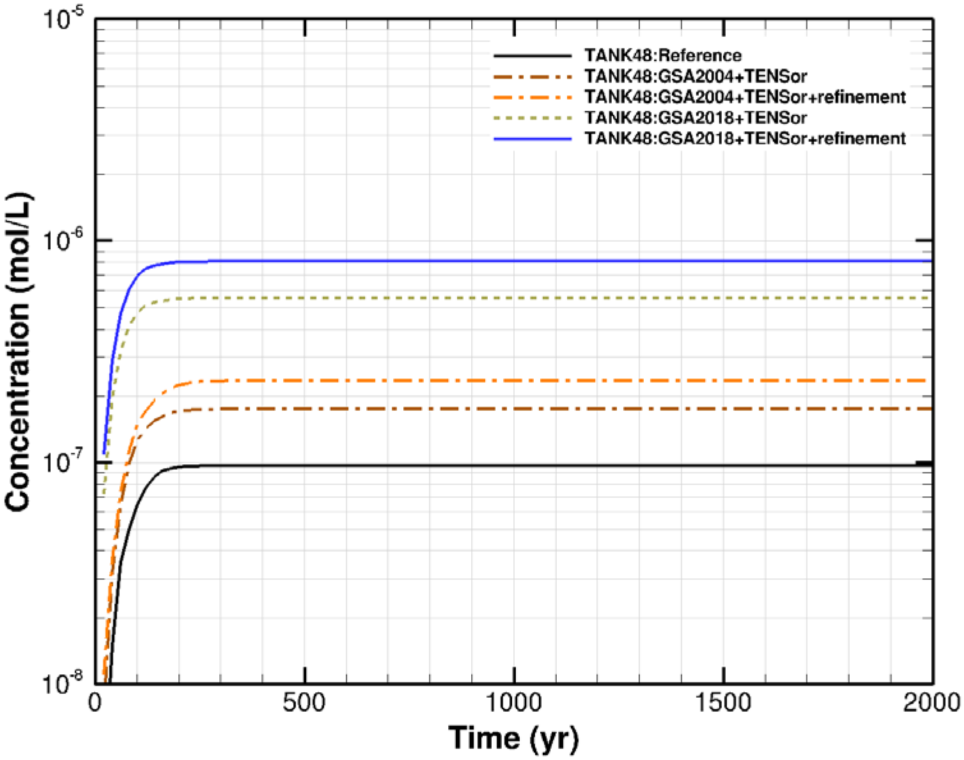
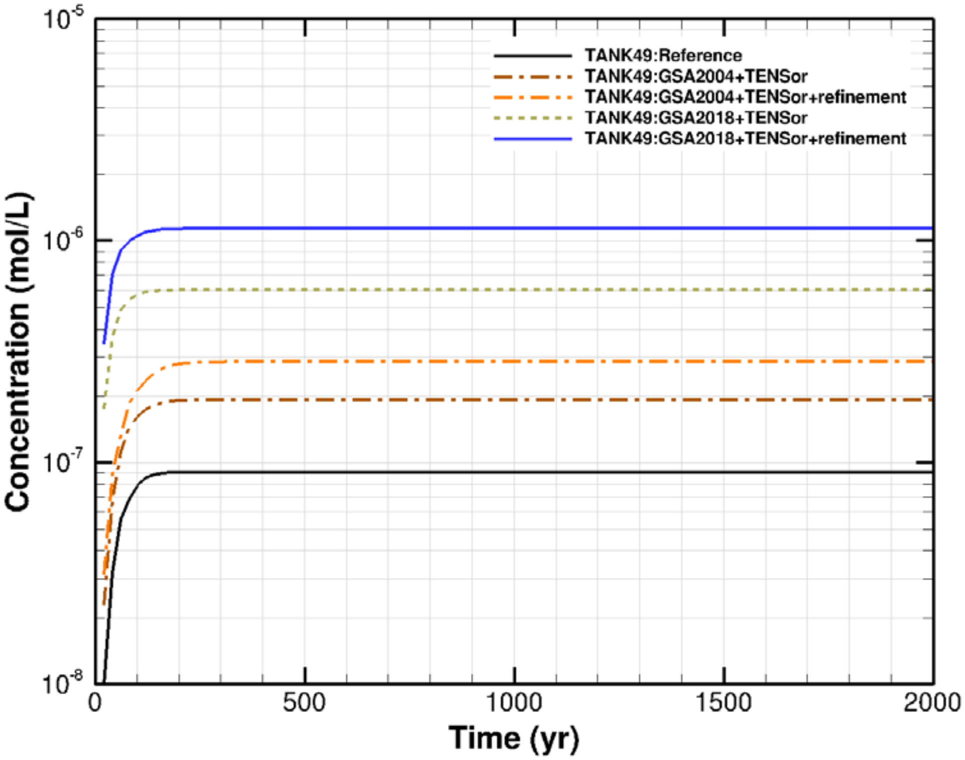


Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



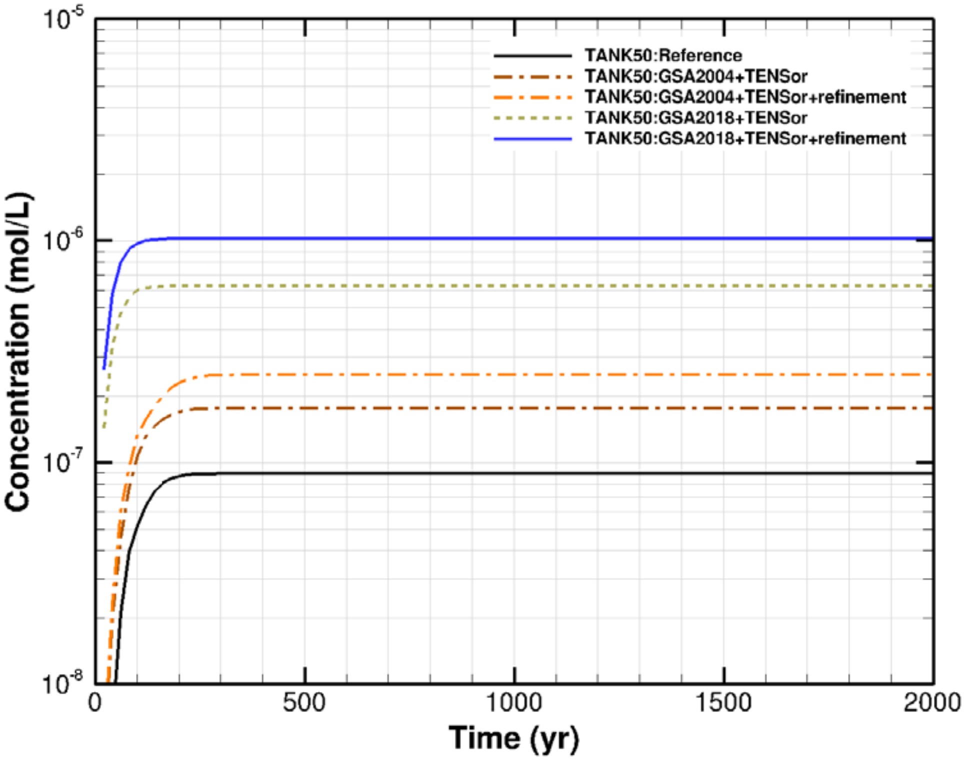
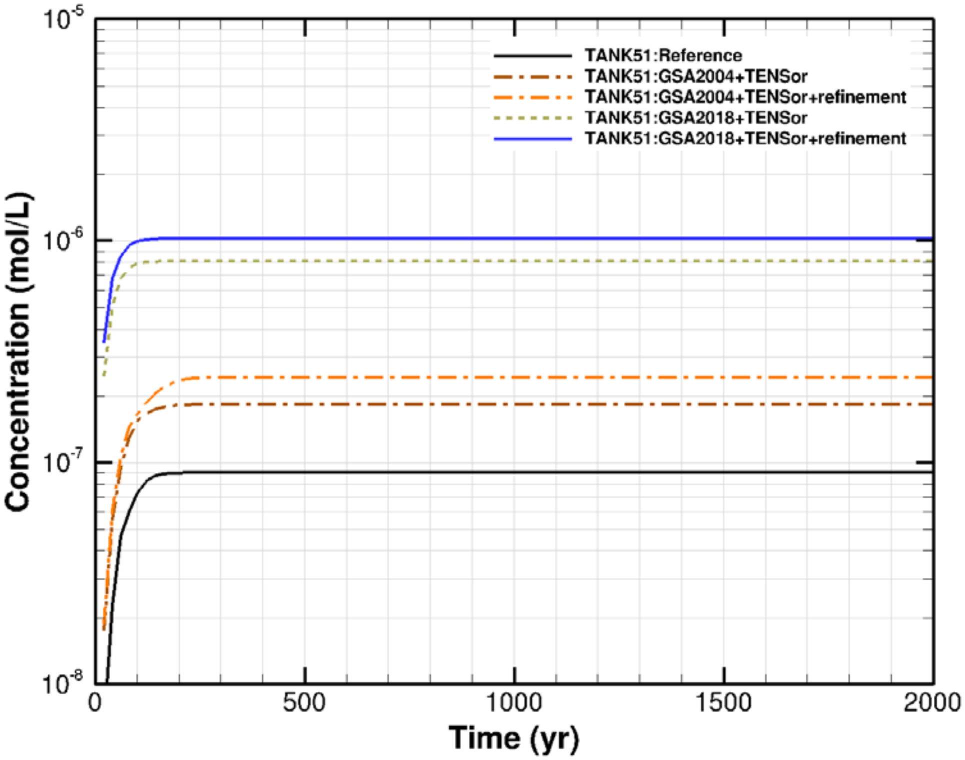


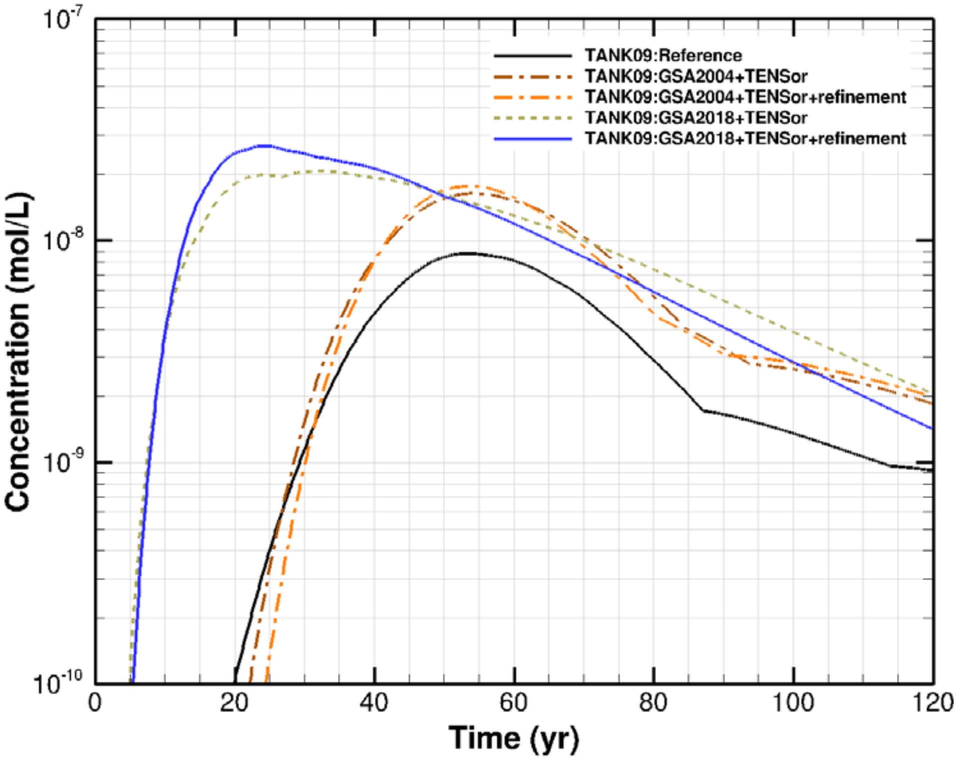
Figure C-1: Peak tracer concentrations at 100-m for a constant 1.0 mol/yr source: H-Tank Farm. (continued)



Appendix D: H-Tank Farm Pulsed Tracer Simulations

Figure D-1 shows the highest concentration along the 100-meter perimeter for a one-time 1.0 mol source of tracer beneath each waste tank.

Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm.



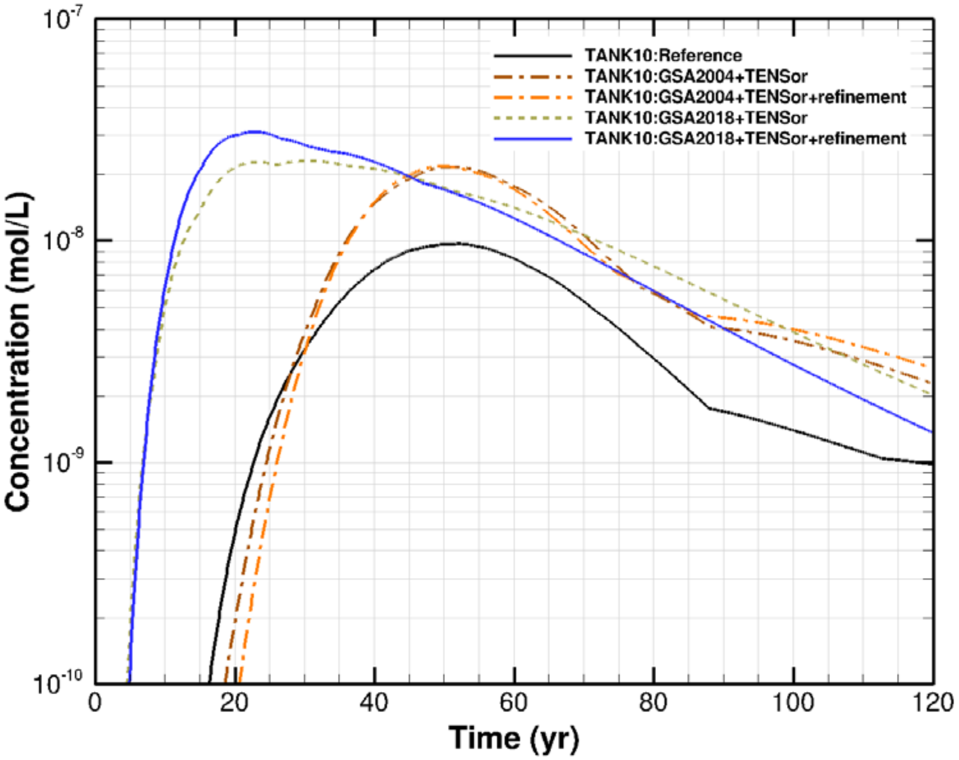
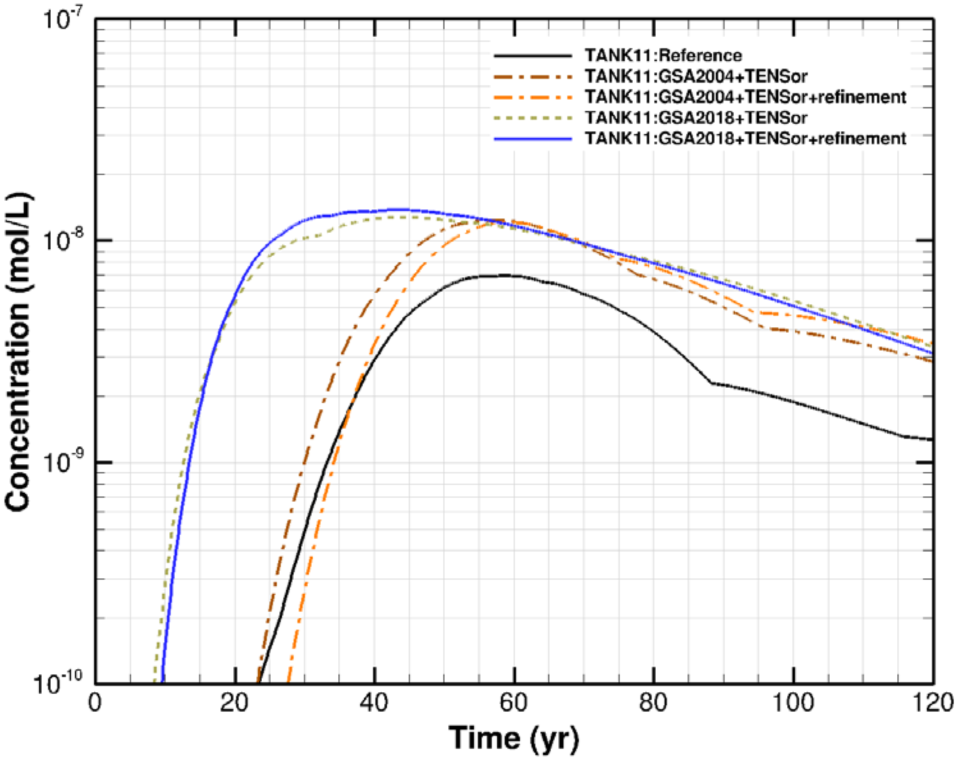


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



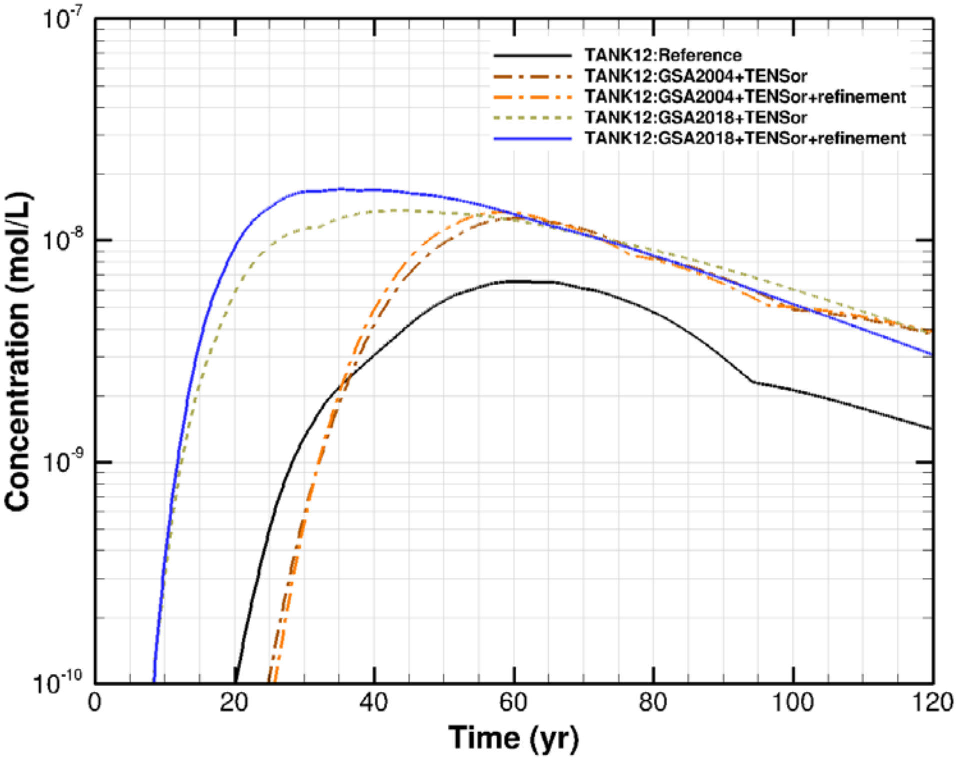
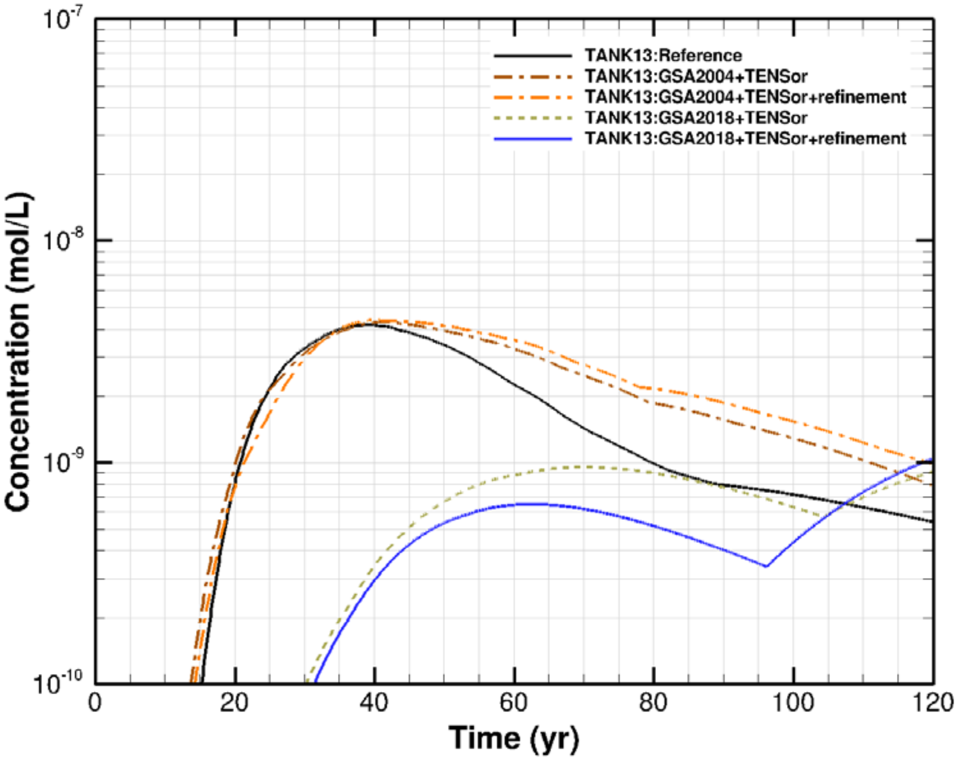


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



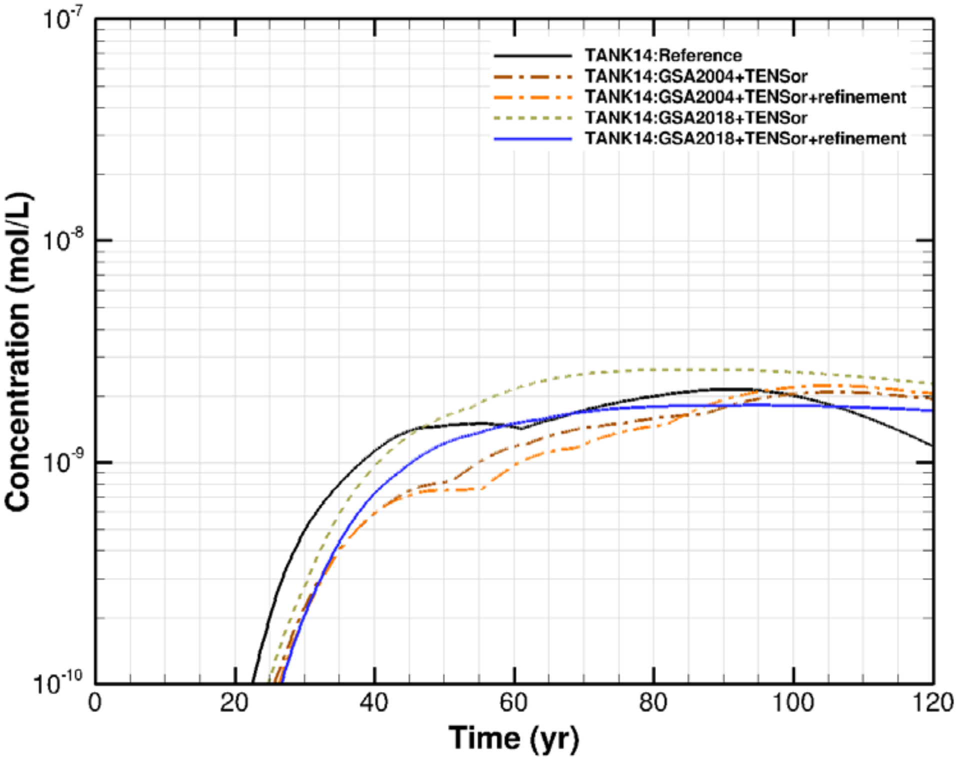
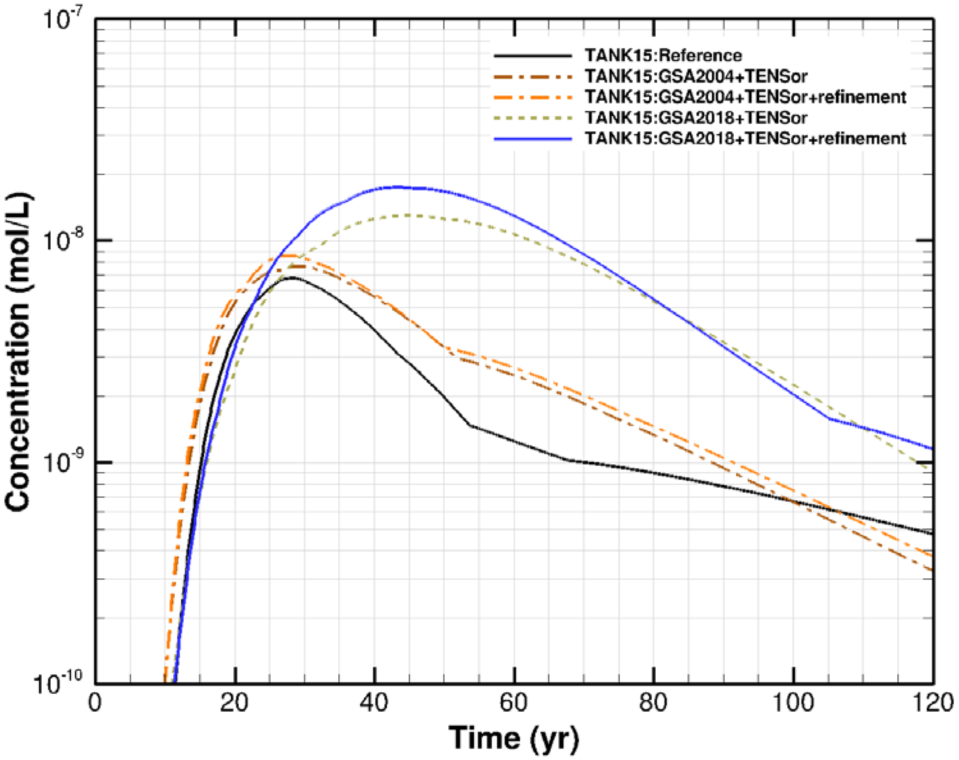


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



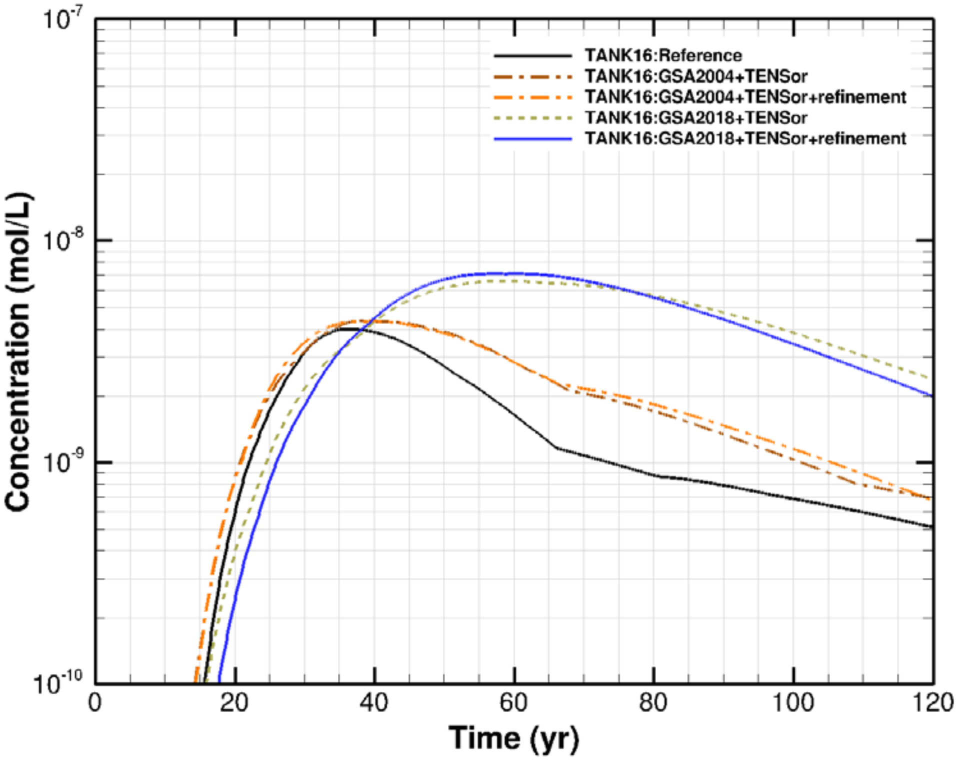
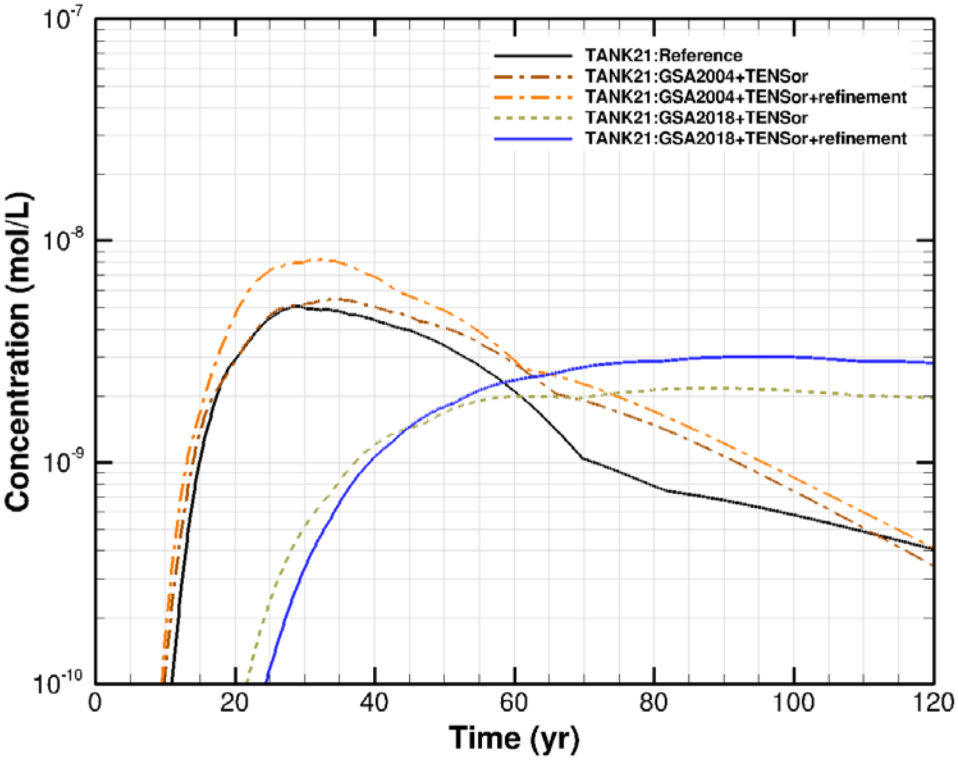


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



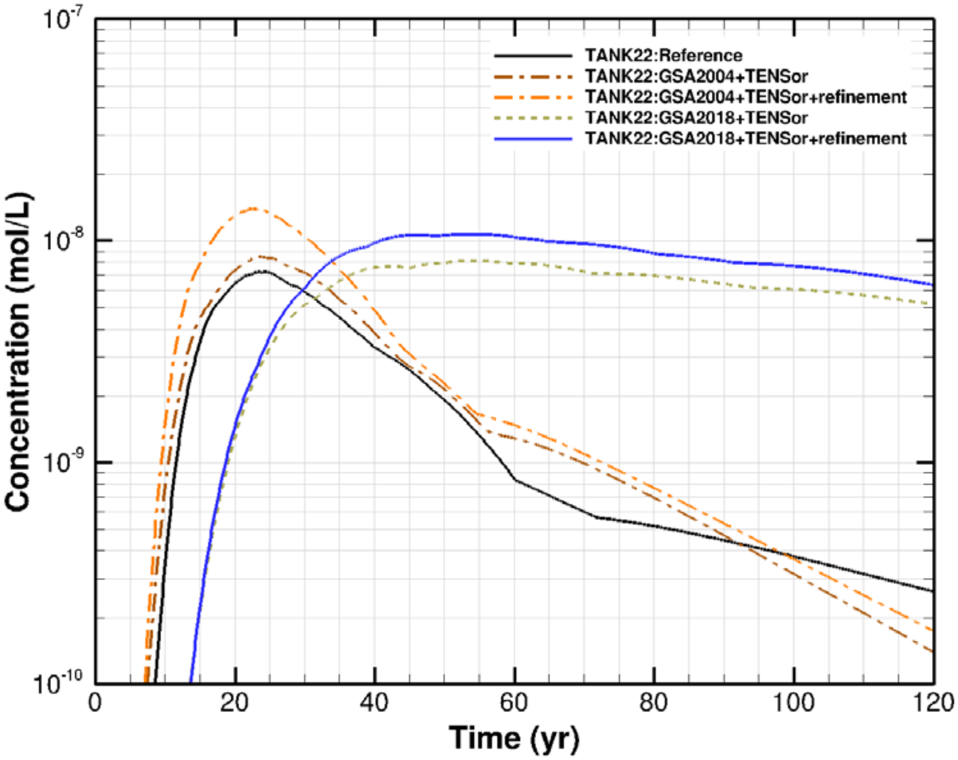
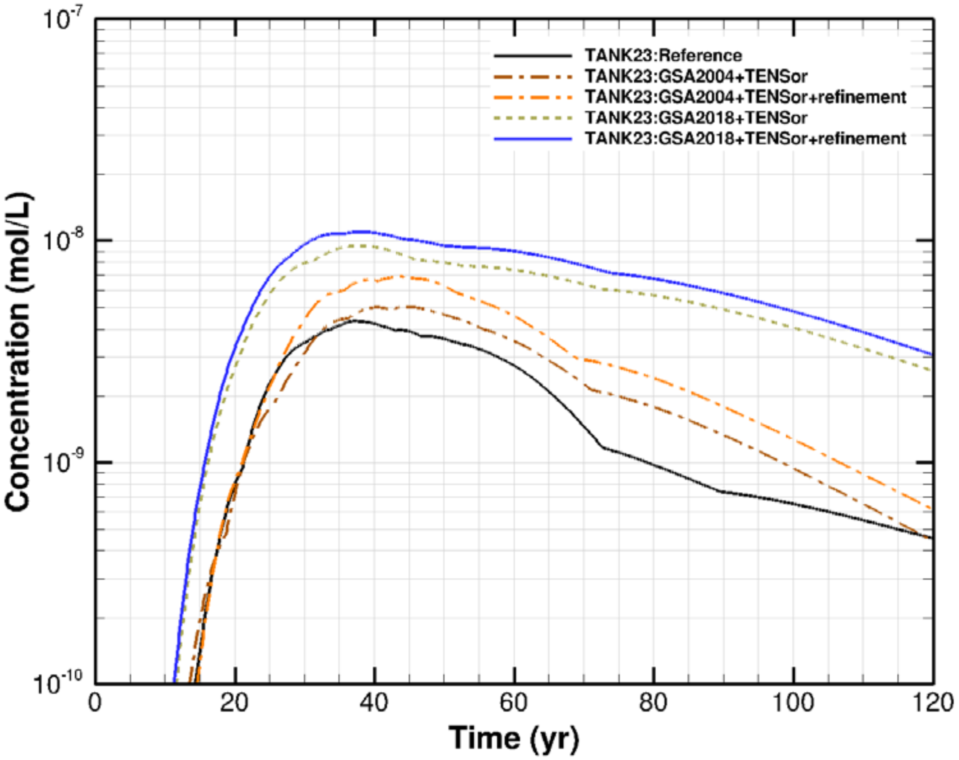


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



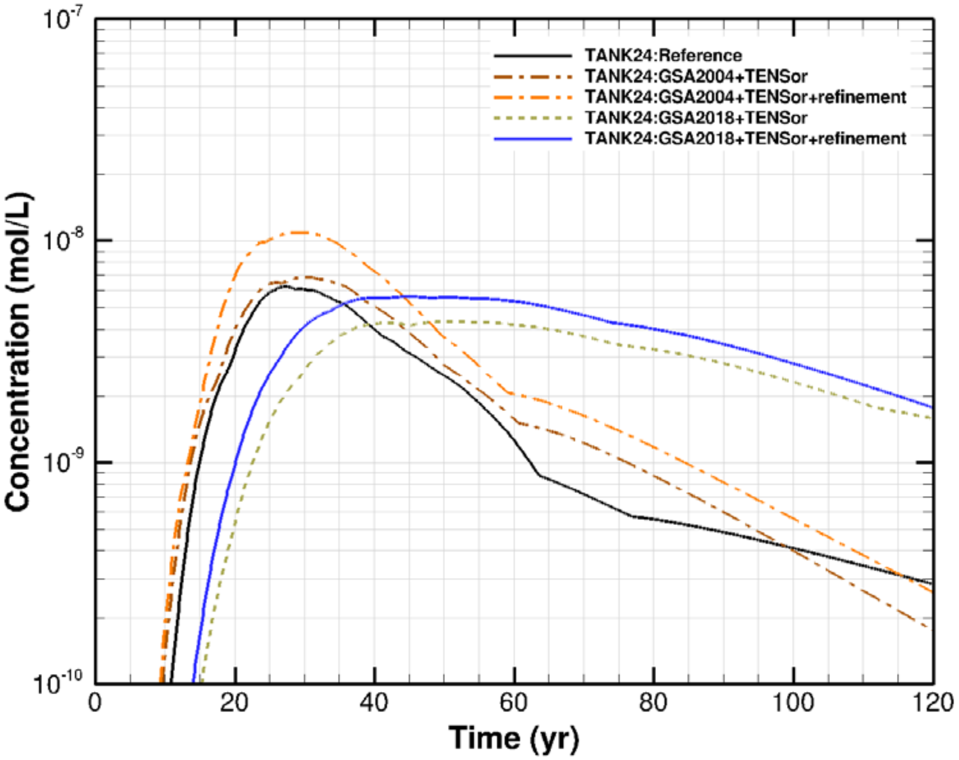
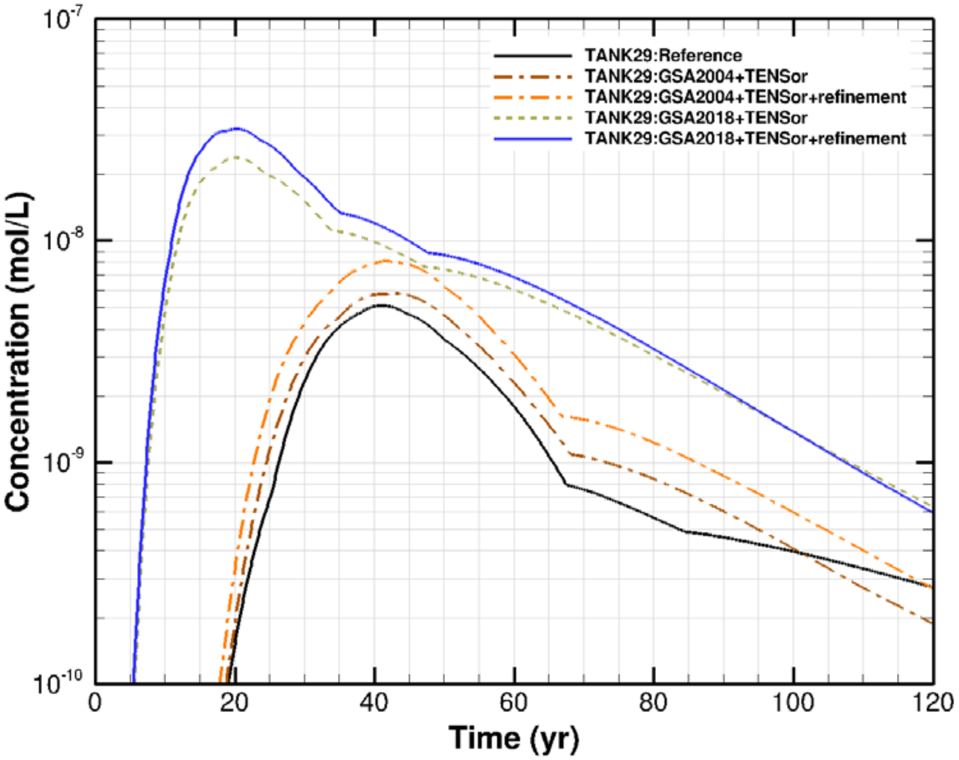


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



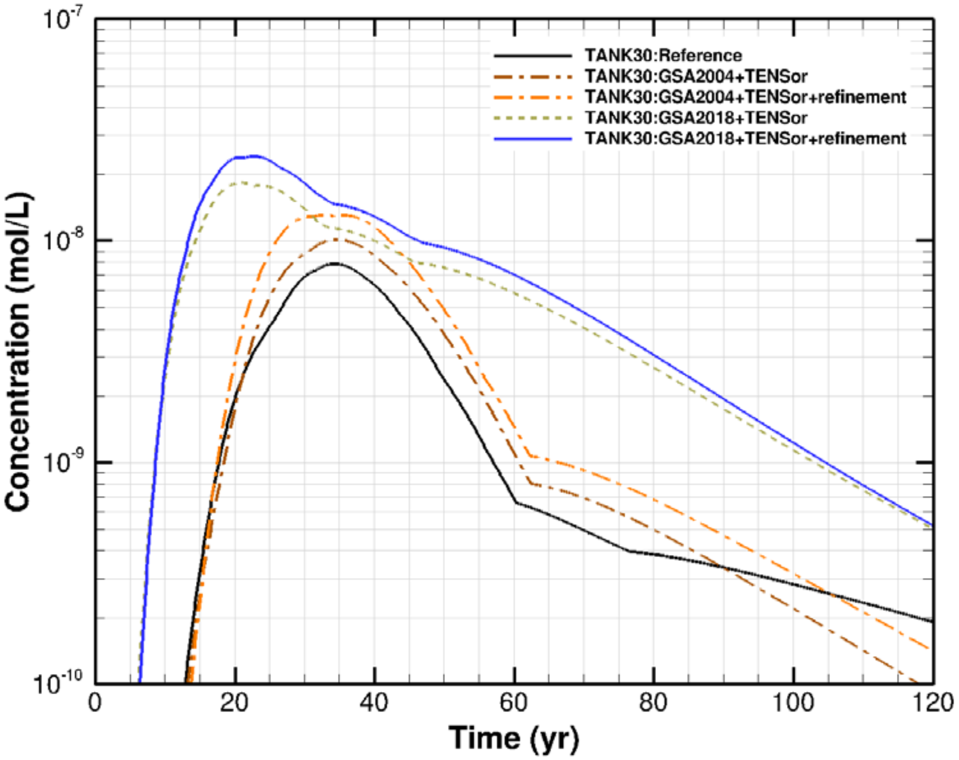
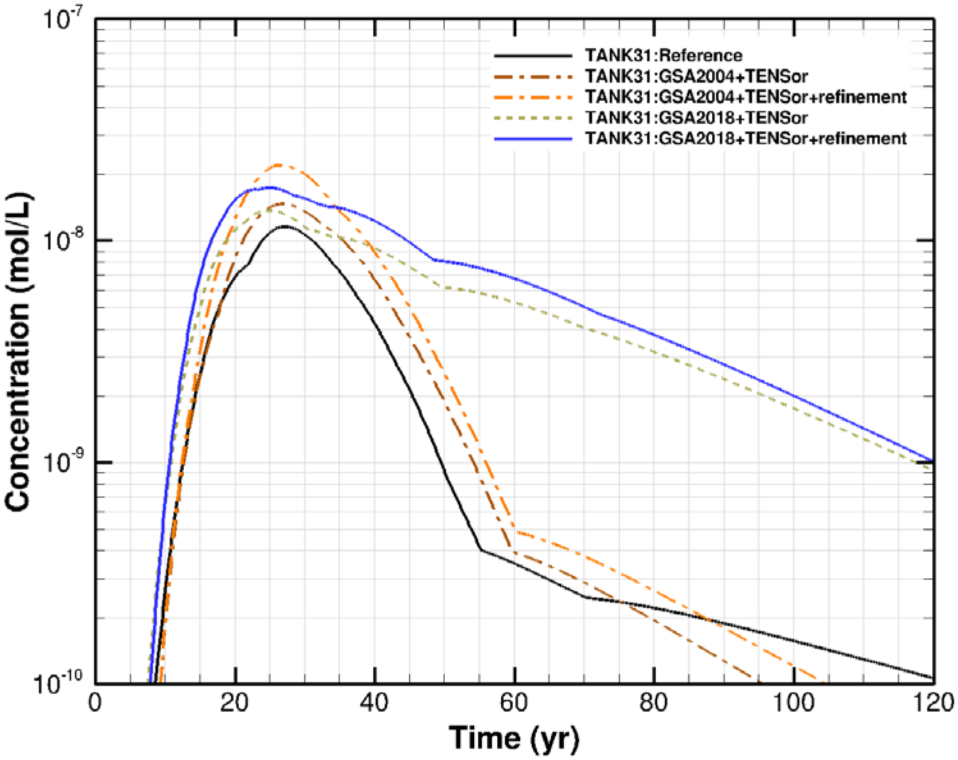


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



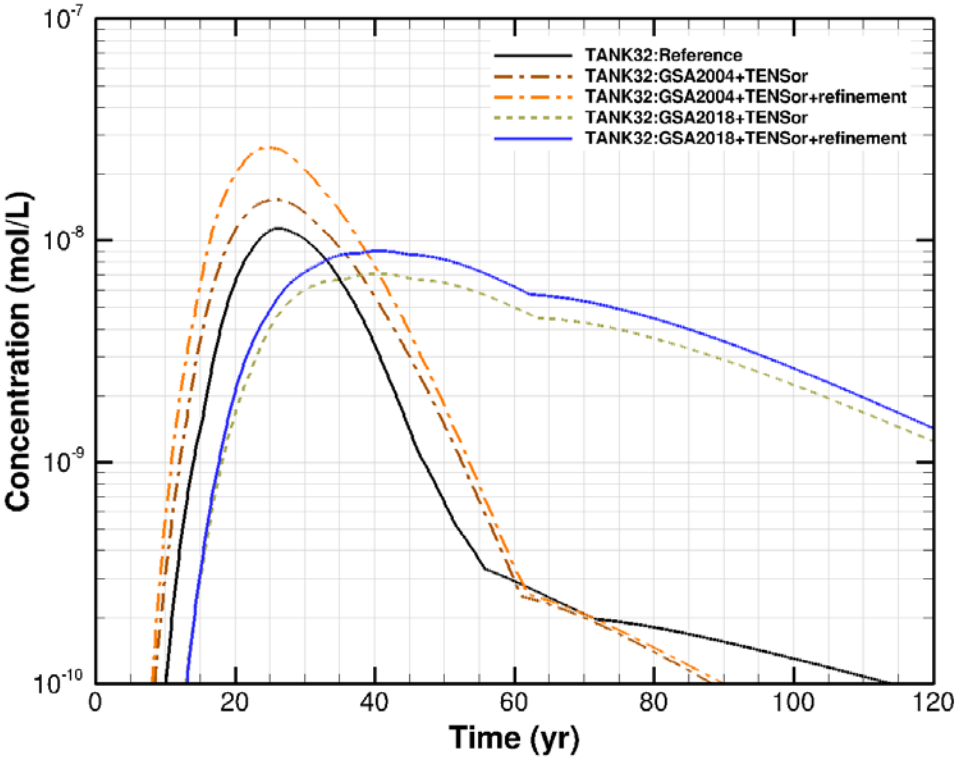
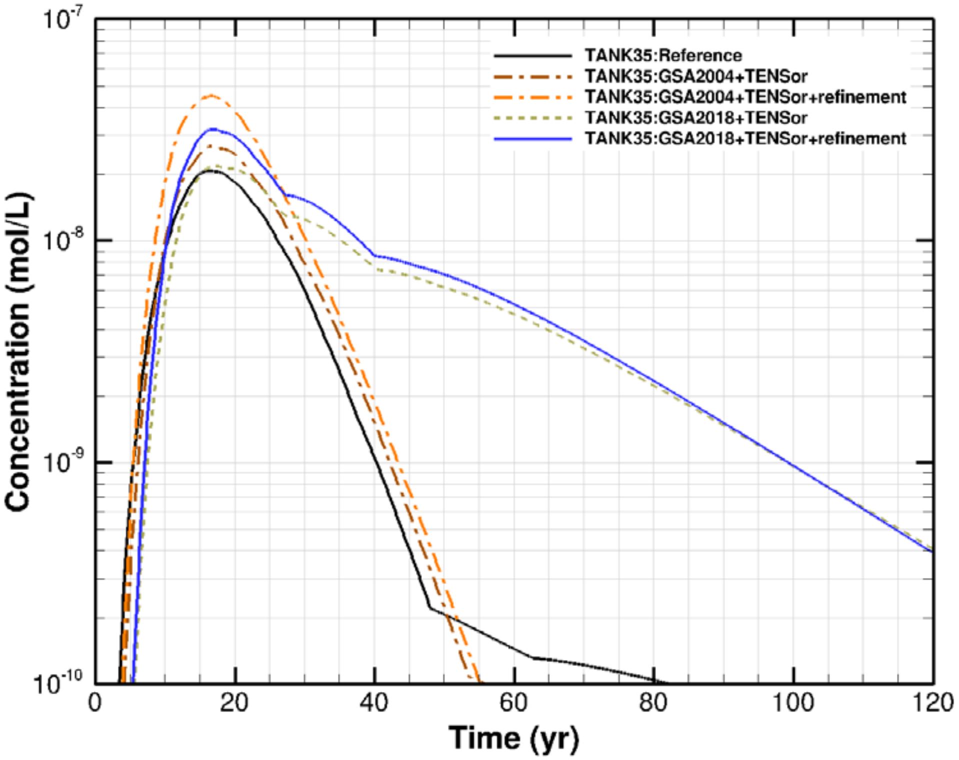


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



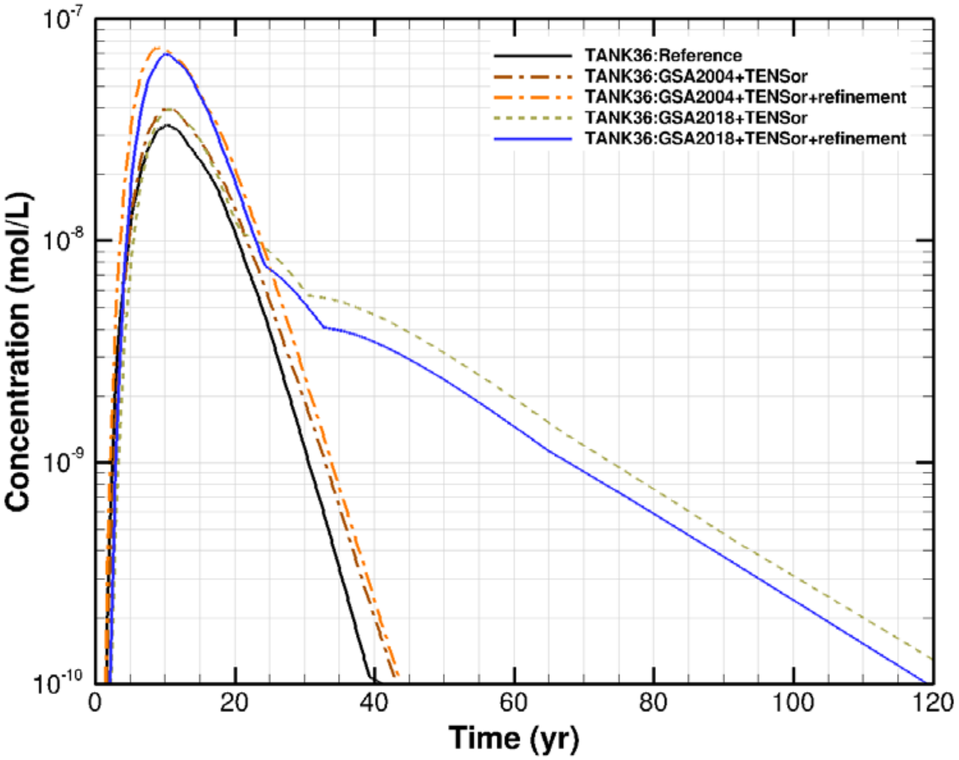
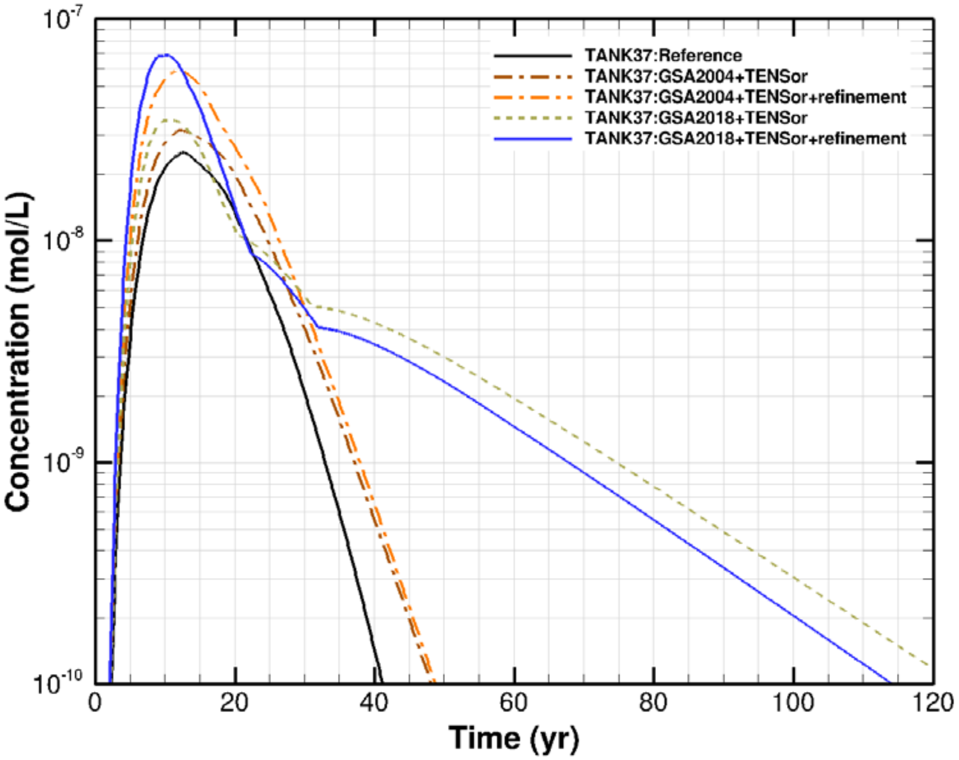


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



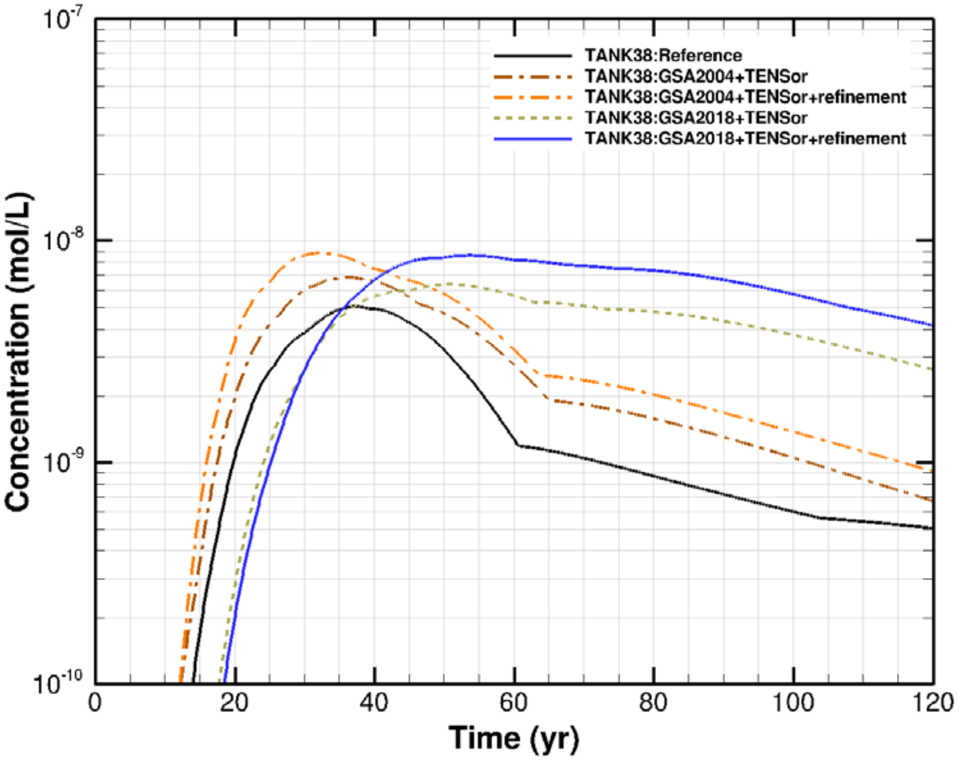
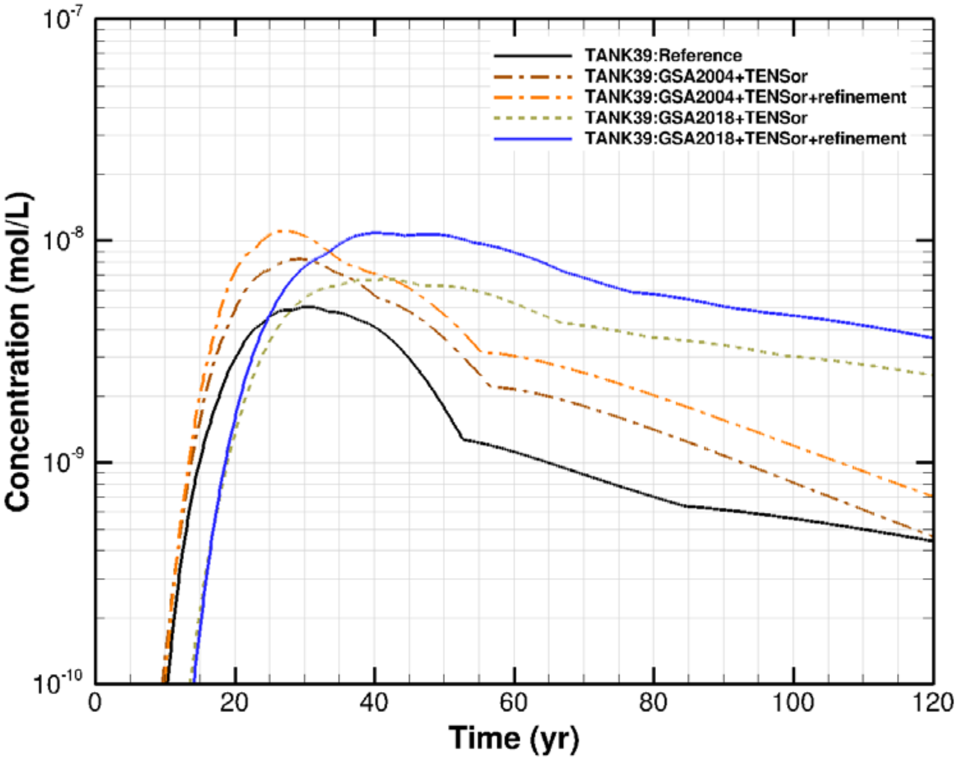


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



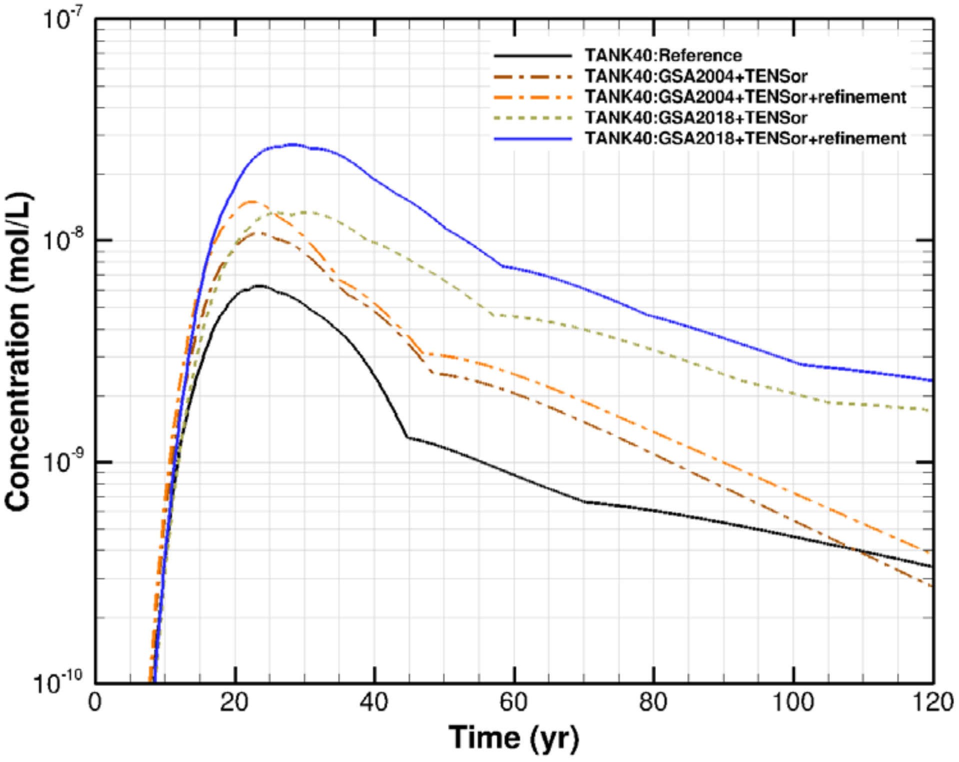
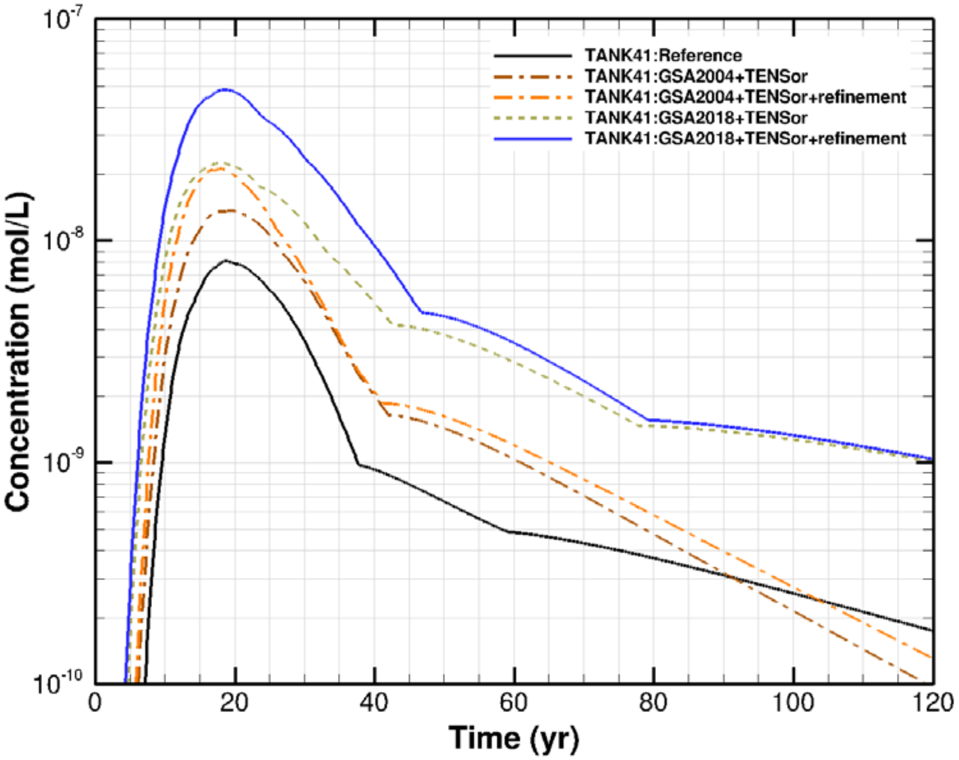


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



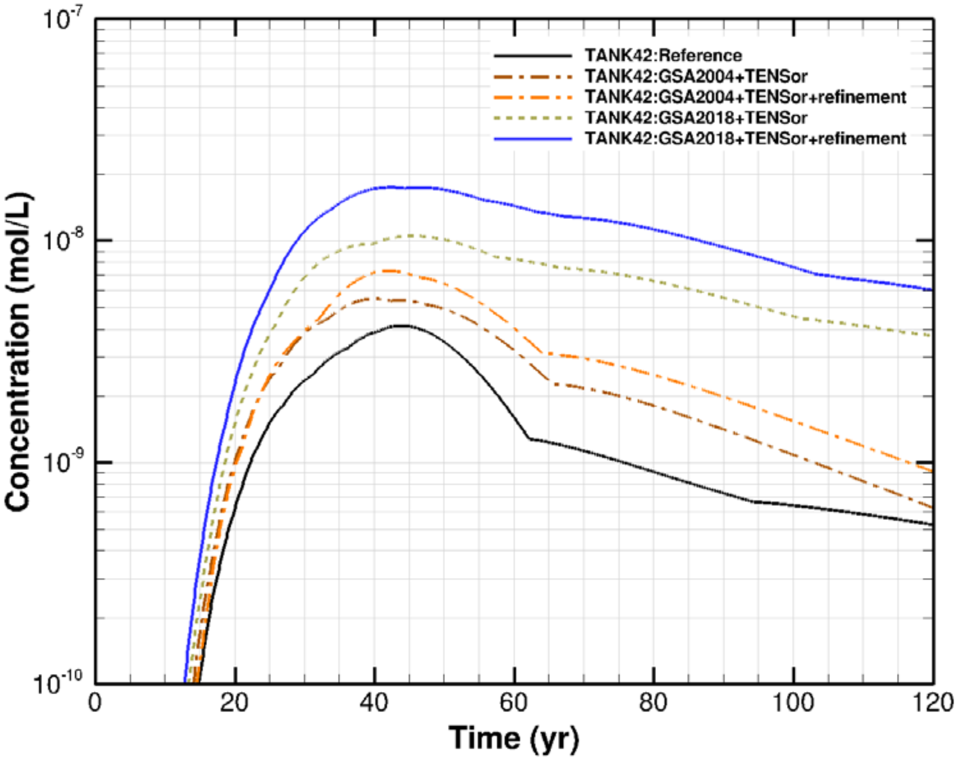
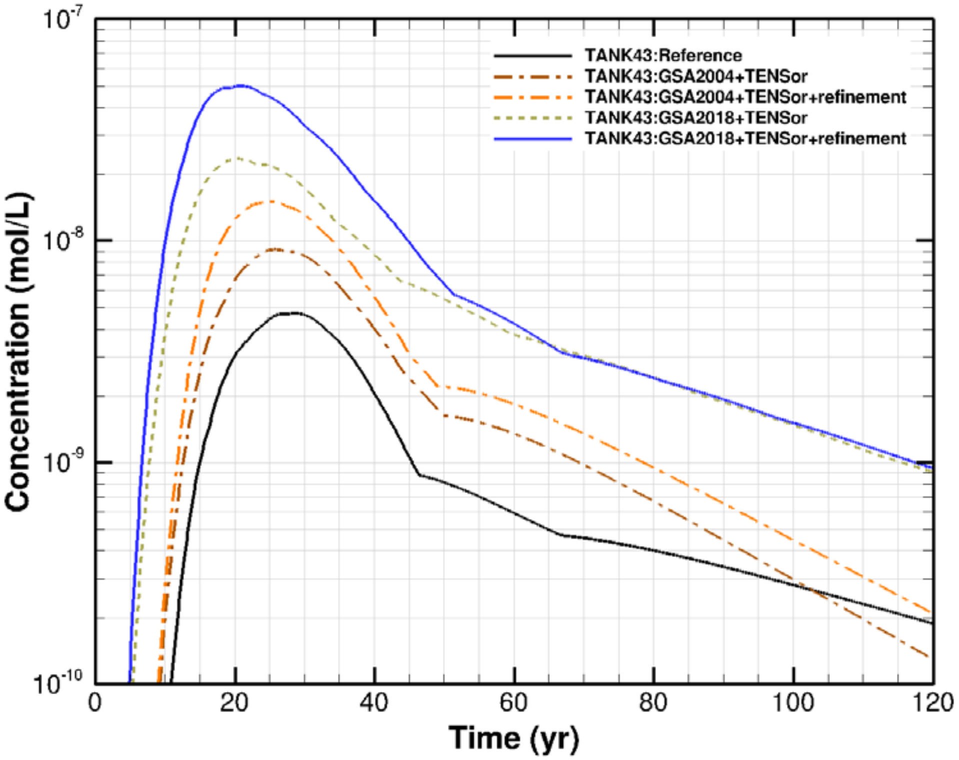


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



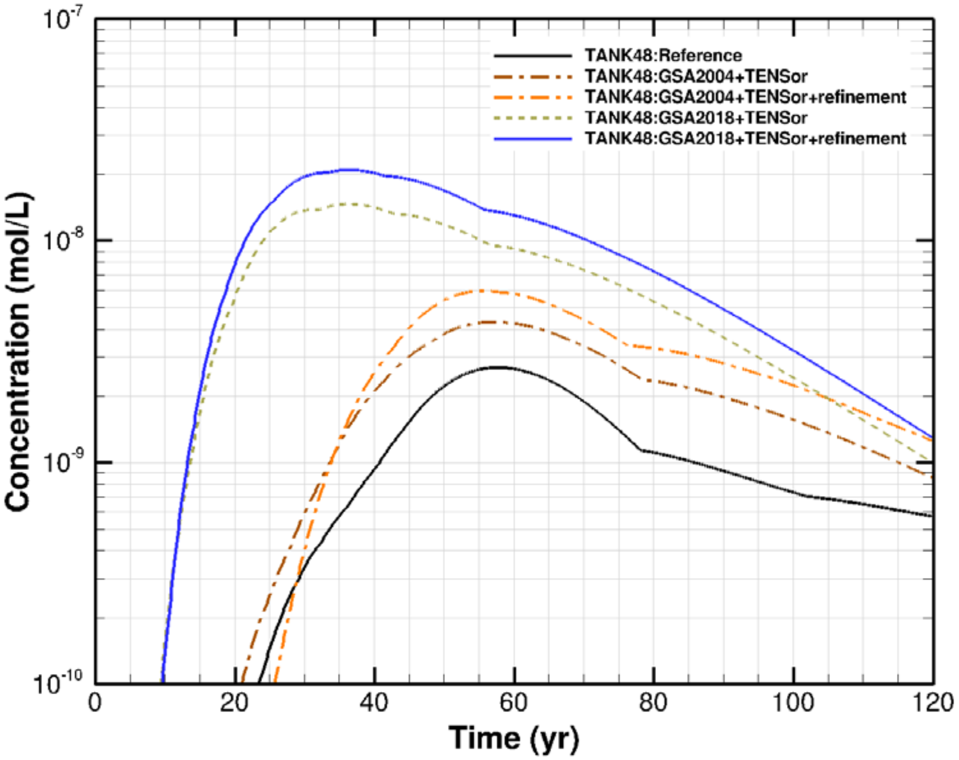
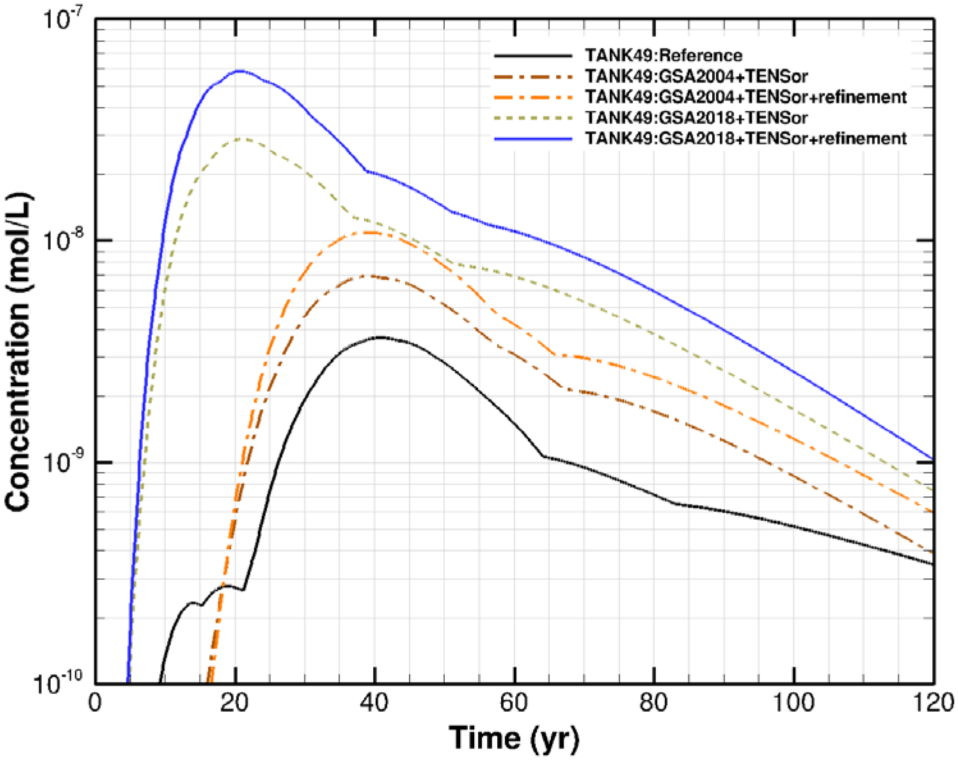


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)



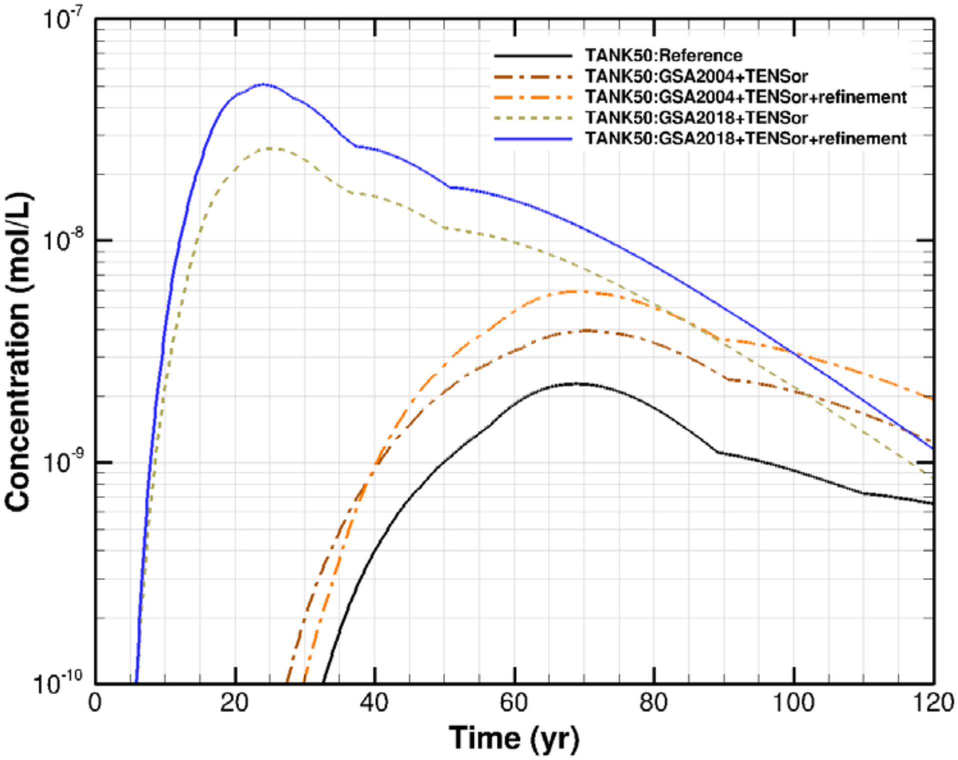


Figure D-1: Transient tracer concentrations at 100-m for a 1.0 mol source: H-Tank Farm. (continued)