Contract No:

This document was prepared in conjunction with work accomplished under Contract No. 89303321CEM000080 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

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APPENDIX C: SUPPORTING INFORMATION: GROUNDWATER FLOW MODEL

This appendix contains information and key data in support of Chapter 3 and Chapter 8. The following topics are addressed:

- PIF aquifer cutouts for ELLWF aquifer flow and transport analyses.
- Limits aquifer cutouts for ELLWF aquifer flow and transport analyses.

C.1 AQUIFER CUTOUTS

Given the grid demands associated with (1) addressing numerical dispersion and (2) model demands encompassing the "at and beyond" POA footprints, multiple aquifer PORFLOW cutouts are required to maintain the total number of nodes within the 3 million node limitation of the current version 6.43.0 of PORFLOW (ACRi, 2018). The methods employed to create the overlapping aquifer cutouts and then to recombine the transport results meet the overall objectives. In effect, the combined transport results are identical to results created if using an overall model that spans the entire required modeling domain.

For use in PORFLOW STAT commands, node location files are generated for each aquifer cutout where all PORFLOW cells within the regions encompassing the "at and beyond" 100-meter POA footprint are included. For every *x-y* location within these regions, every vertically stacked PORFLOW cell is included. The resulting STAT.out files contain maximum, minimum, and average concentrations for (1) every parent radionuclide and its short-chain progeny or tracer at (2) every requested time step, which is generally one-year steps throughout the compliance periods.

Details associated with generating the aquifer cutouts are provided below.

C.1.1 Overview of Cutout Footprints

As shown in Chapter 3, Figure 3-64, the 100-meter POA for the GW aquifer that surrounds the ELLWF is split into two separate sections based on knowledge of the general GW flow field beneath the ELLWF. North and South curtains are generated as discussed below.

C.1.1.1. North Curtain Segments

The four aquifer cutouts that contribute to the North curtain are illustrated in Figure C-1. The composite North curtain is created by stitching together these four curtain segments (Figure C-2). As Figure C-1 and Figure C-2 indicate, the curtain cutouts overlap each other. Using an integer indexing scheme, where $i = 1$ represents the first areal node location of the composite North curtain, the index increments by 1 from the farthest western location toward the opposite end in the southeastern location. The specific start and end indices for each aquifer cutout are provided in Table C-1. The indexing employed represents an arc-length along the curtain that is not a true physical length due to the finite grid aspects; however, the fact that the nodes are 12.5 feet apart provides some measure of distances (i.e., overestimates distance due to the stair-stepping that is occurring).
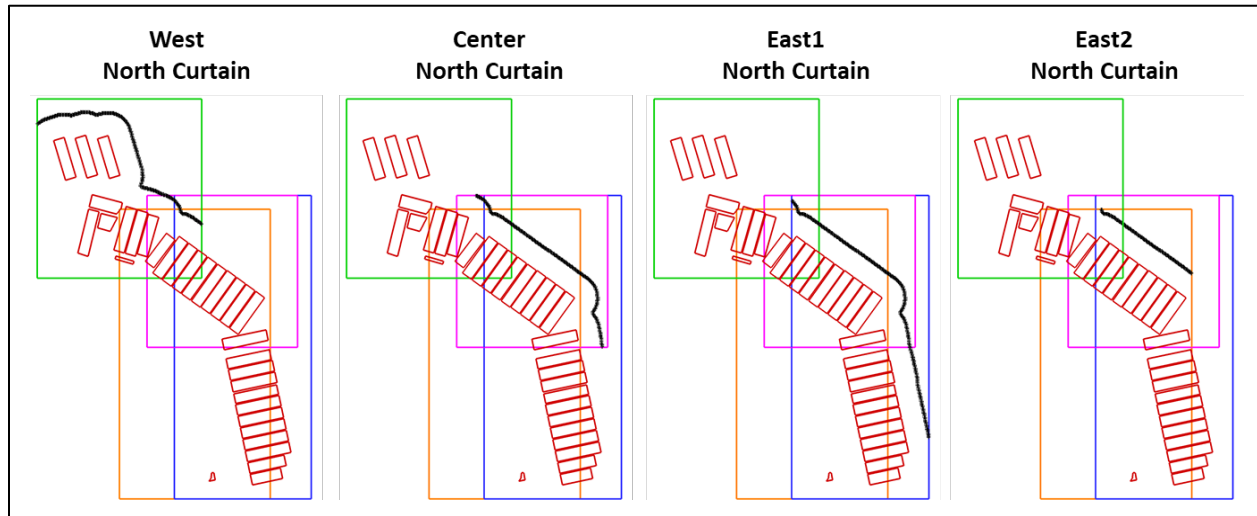
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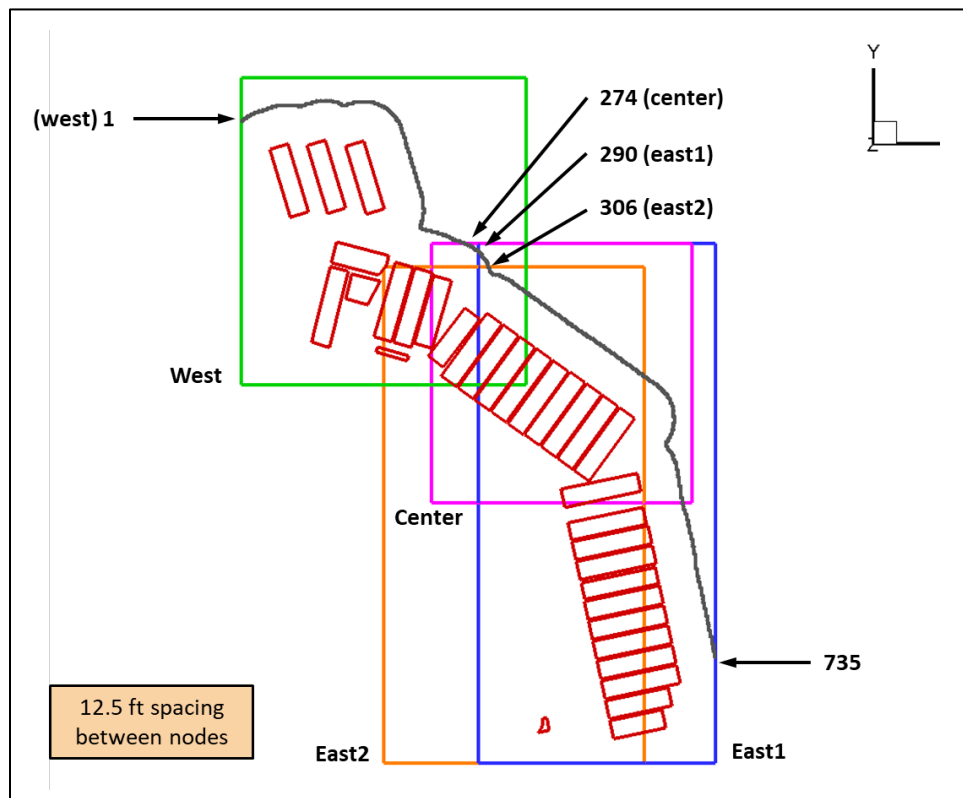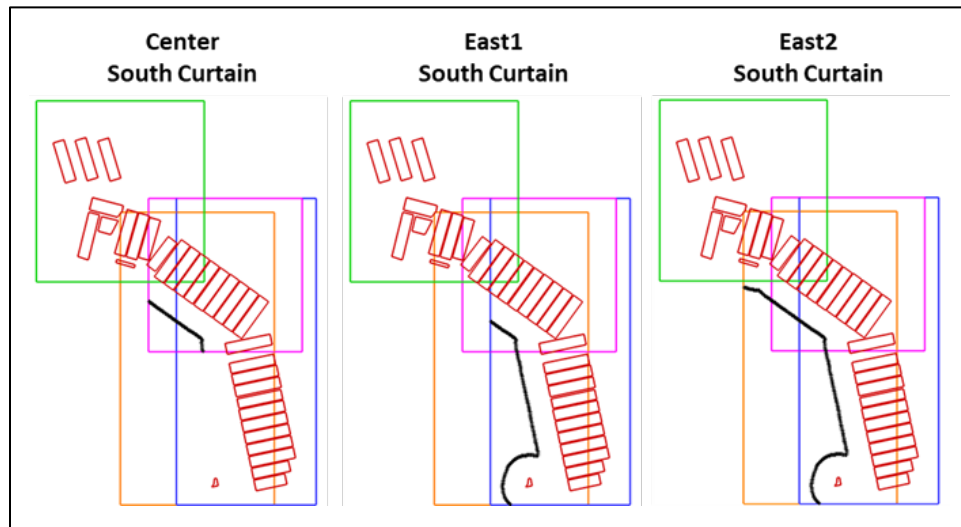**Figure C-1. Overlapping of Four North Curtain Segments**
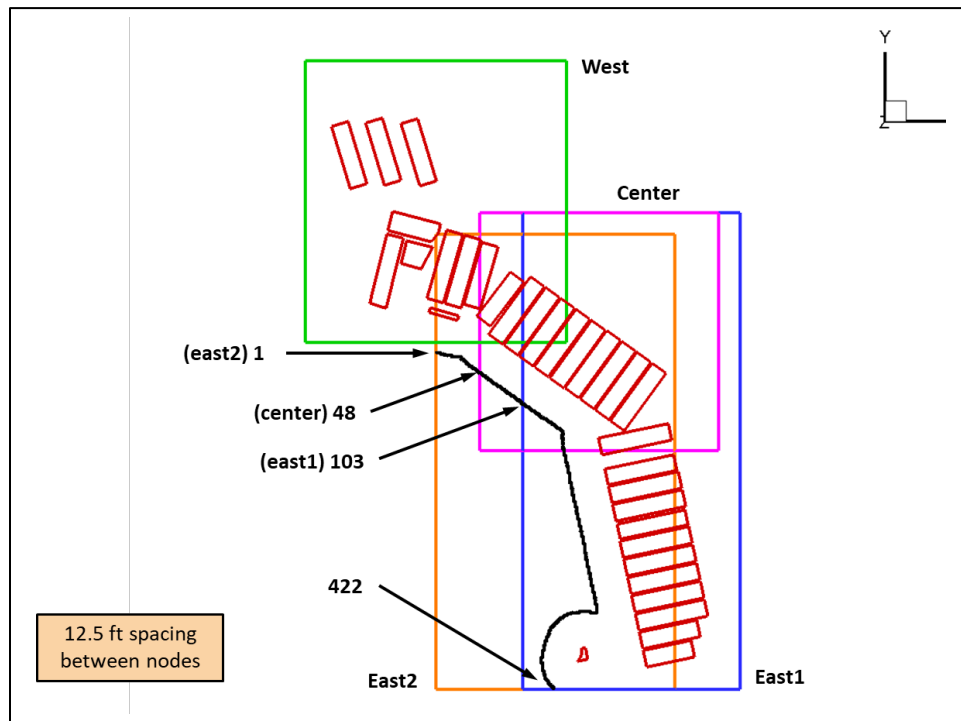

Figure C-2. Composite North Curtain Aquifer Cutout Interfaces

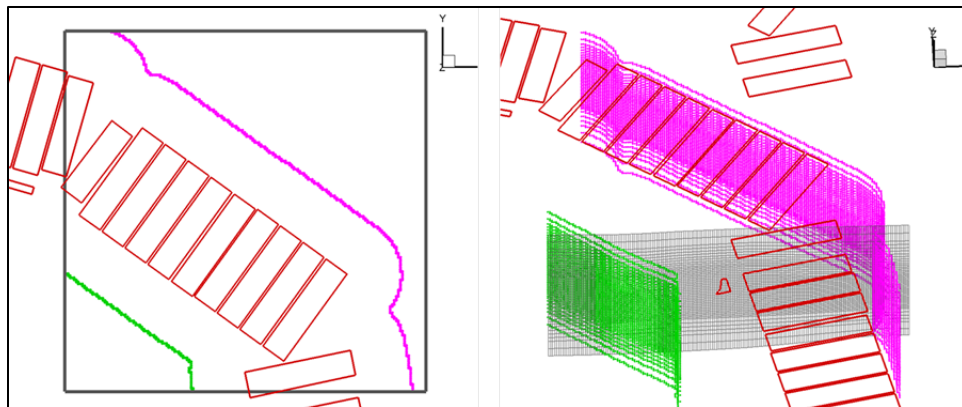**Table C-1. North Curtain Indexing Scheme**

Aquifer Cutout	*i*-start	*i*-end
West	1	348
Center	274	608
East1	290	735
East2	306	485

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C.1.1.2. South Curtain Segments

The three aquifer cutouts contributing to the South curtain are illustrated in Figure C-3. The composite South curtain is created by stitching together these three overlapping curtain segments (Figure C-4). Table C-2 provides the specific start and end indices for each aquifer cutout based on the same integer indexing scheme described for the North curtain in Section C.1.1.1.

Figure C-3. Overlapping of Three South Curtain Segments

Figure C-4. Composite South Curtain Aquifer Cutout Interfaces

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Table C-2. South Curtain Indexing Scheme

Aquifer Cutout	*i*-start	*i*-end
West	N/A	N/A
Center	1	422
East1	48	169
East2	103	422

C.1.1.3. North and South Curtains

The curtains represent 2-D surfaces (i.e., vertical stacks of PORFLOW nodes) that coincide with the location of the 100-meter POA. Figure C-5 through Figure C-9 present 3-D views of the North and South curtains from varying angles, along with a specific vertical slice of the PORFLOW mesh shown in black.
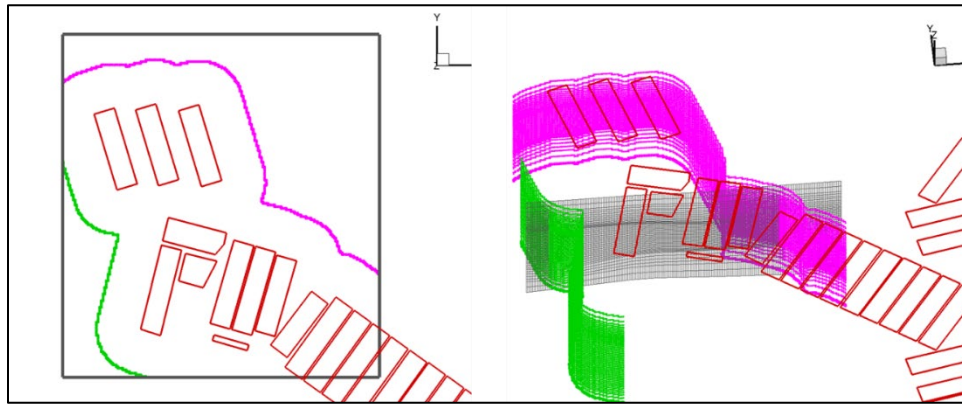
Figure C-5. North and South Curtains Within West Aquifer Cutout

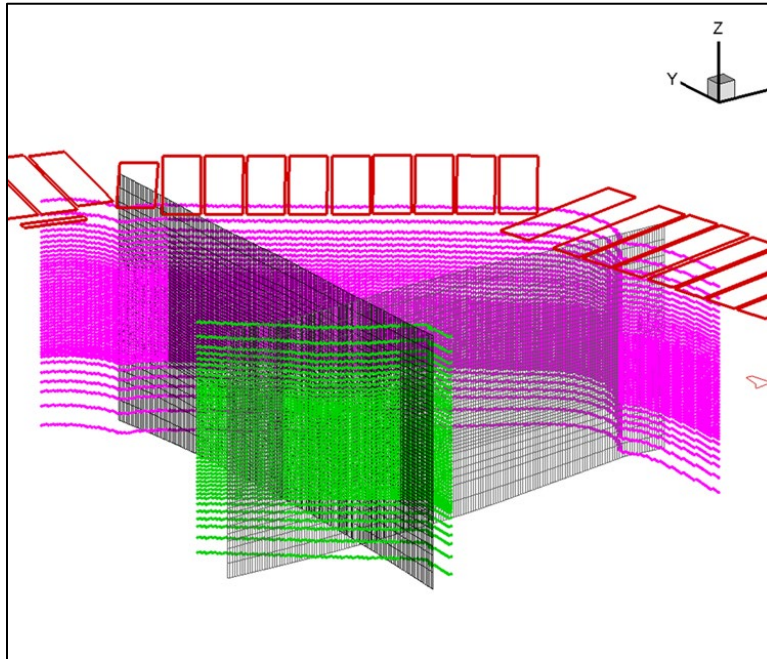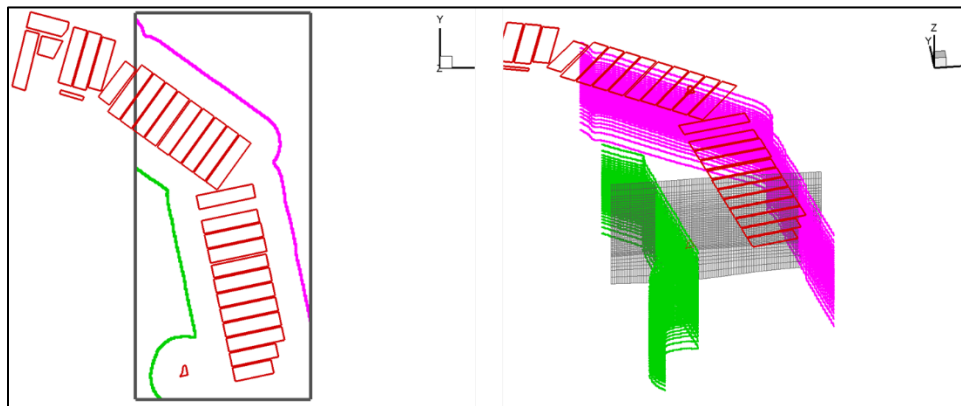**Figure C-6. North and South Curtains Within Center Aquifer Cutout**

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Figure C-7. North and South Curtains Within Center Aquifer Cutout (rotated)

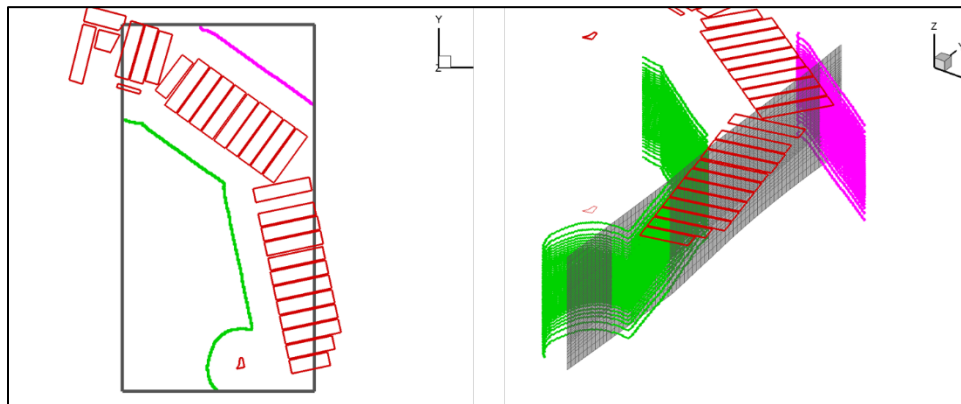**Figure C-8. North and South Curtains Within East1 Aquifer Cutout**

Figure C-9. North and South Curtains Within East2 Aquifer Cutout

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C.1.2 Cutouts for Plume Interaction Factor Analyses

Sections C.1.2.1, C.1.2.2, C.1.2.3, and C.1.2.4 present steady-state tracer concentration profiles for the West, Center, East1, and East2 PIF aquifer cutout footprints, respectively. The left-hand images are based on the TP0 flow field (i.e., uncovered case), while, for comparison purposes, the right-hand images are based on the TP1 flow field (i.e., intact case with minimal closure cap degradation). Only best-estimate flow fields are shown. Because the TP0 and TP1 cases bound the behavior, concentration profiles are not shown for the TP2, TP3, and TP4 periods (i.e., increasing cover degradation).

The 2-D plume concentration profiles shown represent the local maximum tracer concentrations in gmol L^{-1} at each x-y location (i.e., maximum value within the stack of PORFLOW cells at given i and j indices). For some DUs, their contaminant plumes display a shift in the northwestern direction, which results from contaminant migrating into the Gordan Aquifer Unit and traveling directly to Upper Three Runs.
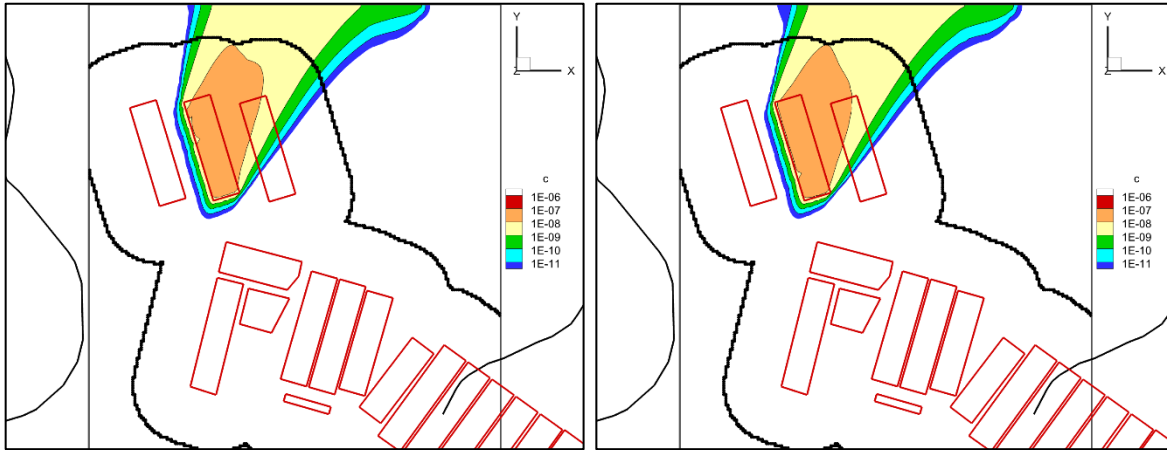
C.1.2.1. West Footprint

The West PIF aquifer cutout footprint contains the following DUs:

ET07, ET08, ET09, ET03, ET04, NR26E, ST08, ST09, ST10, ILV, ST11

As seen by comparing the left-hand (TP0) and right-hand (TP1) concentration profiles in Figure C-10 through Figure C-20, the impact of the final closure cap is marginal. For all cases shown, the West PIF aquifer cutout footprint meets the criteria chosen (Section 3.5.3.2.2) in establishing this footprint.
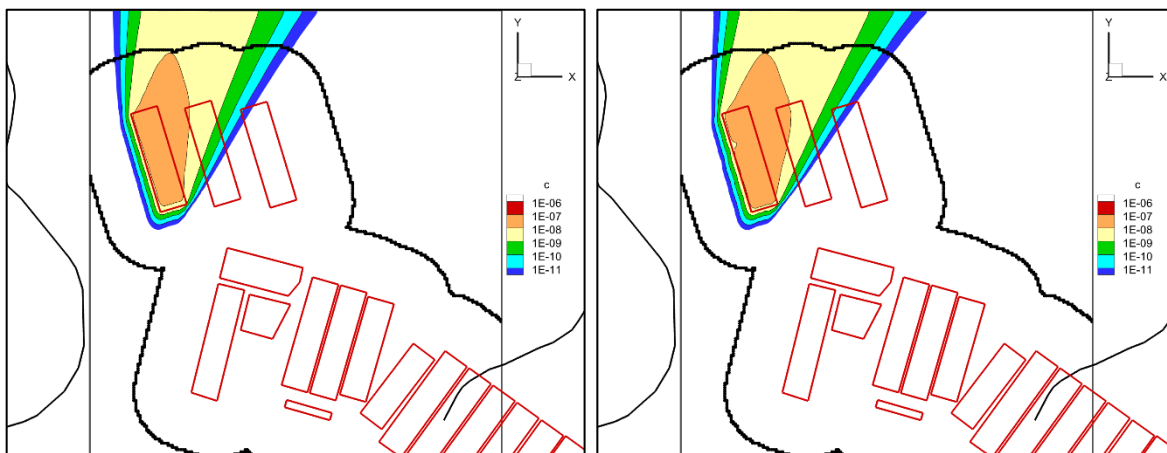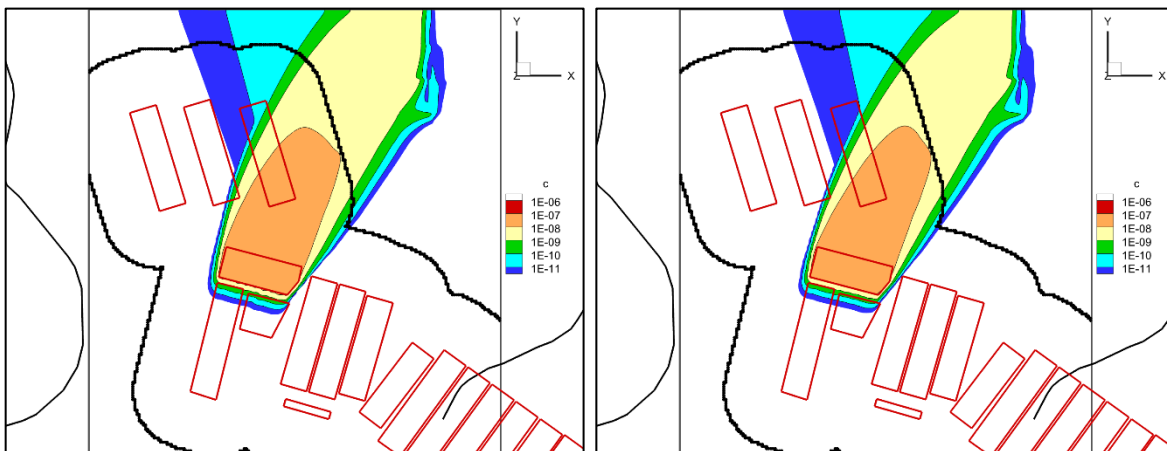

Figure C-10. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ET07)

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Figure C-11. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ET08)

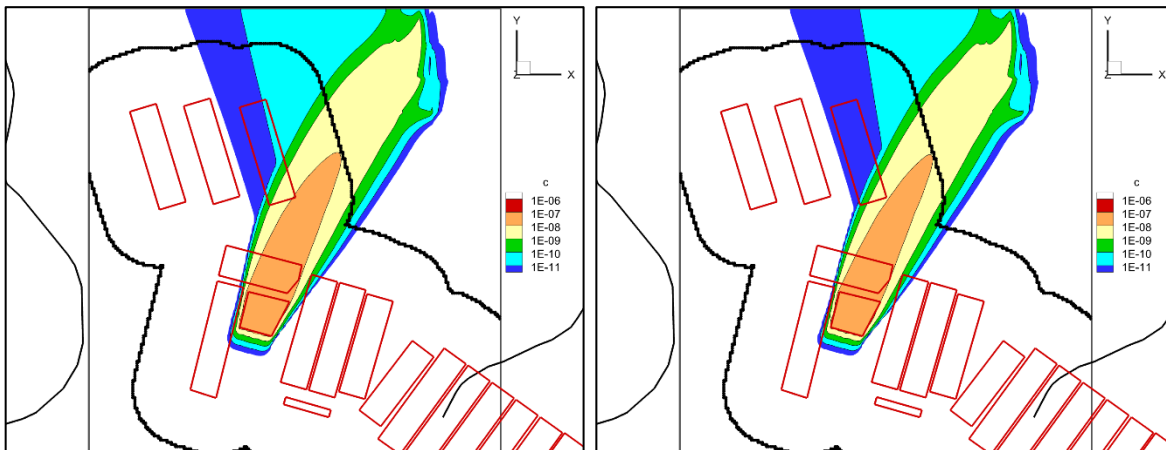**Figure C-12. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ET09)**
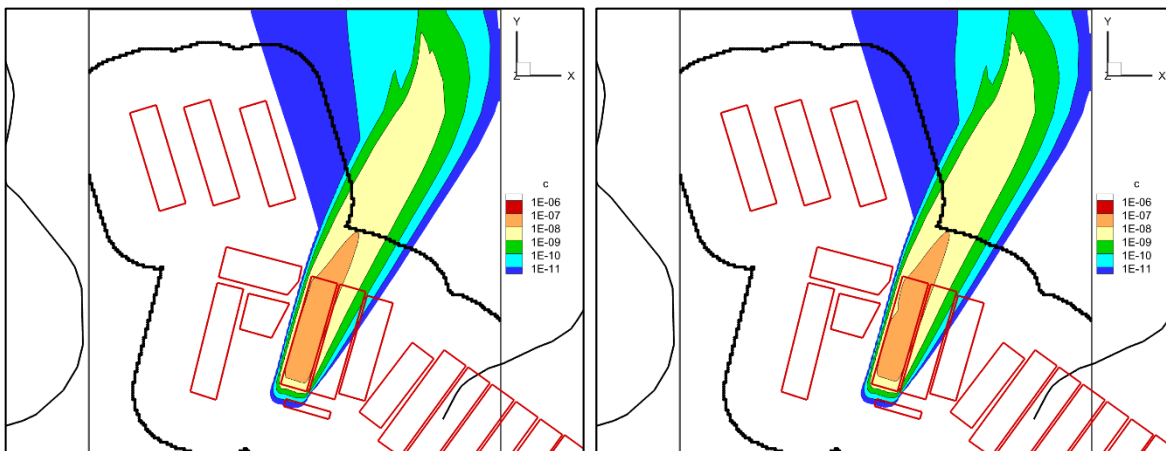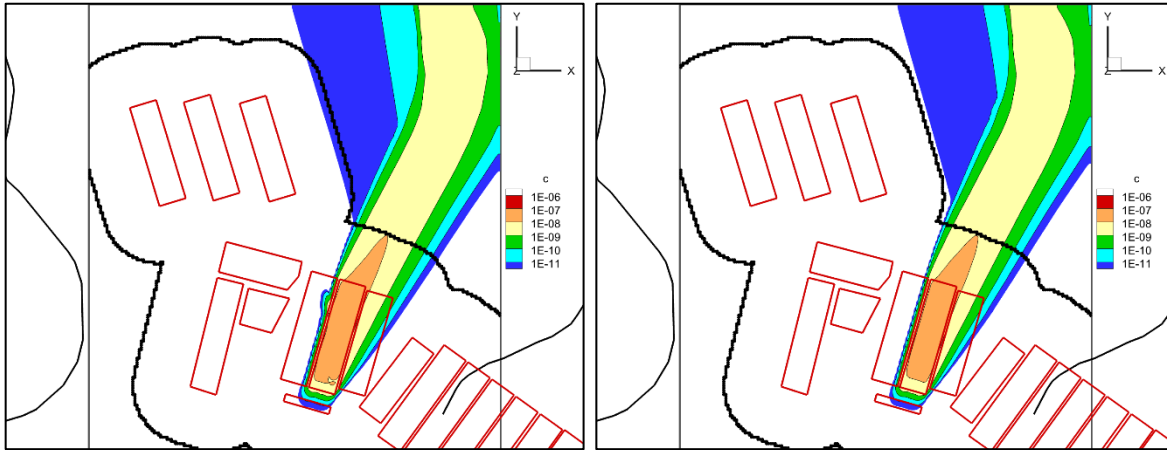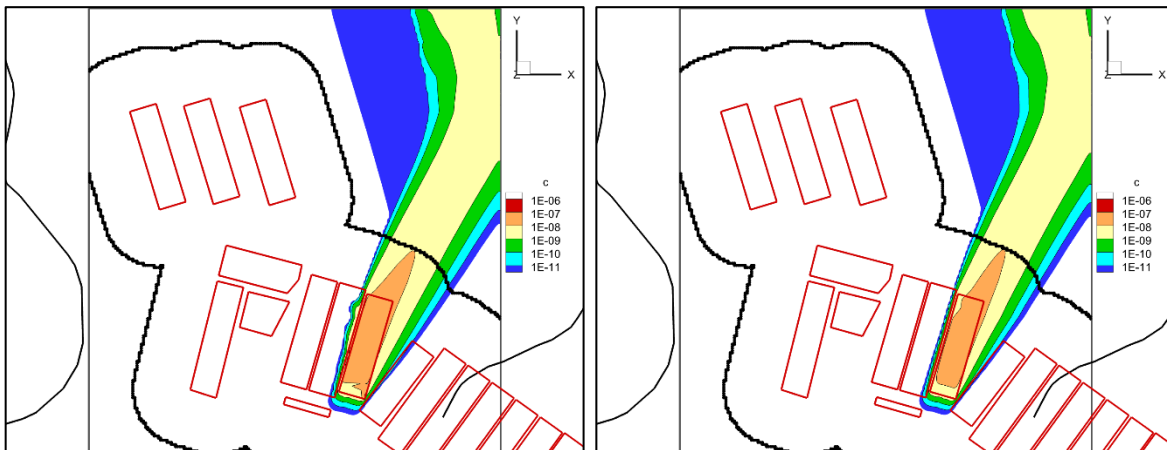

Figure C-13. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ET03)

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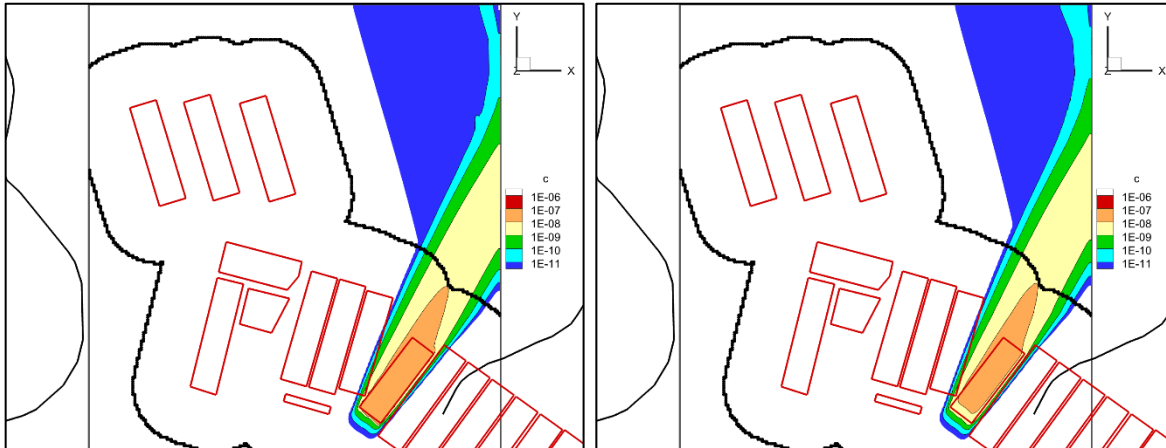at the Savannah River Site

Figure C-14. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ET04)

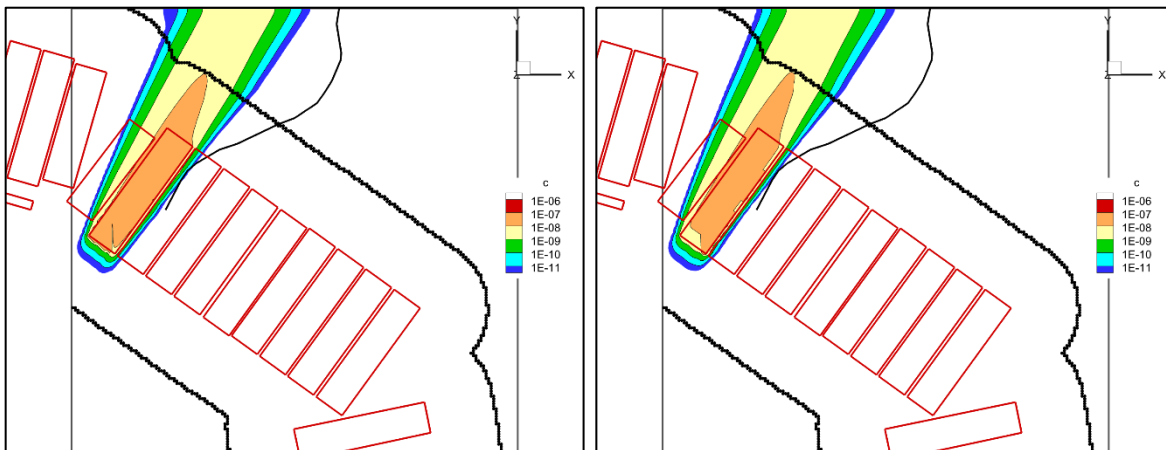**Figure C-15. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (NR26E)**

Figure C-16. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ST08)

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Figure C-17. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ST09)

Figure C-18. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ST10)

Figure C-19. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ILV)

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Figure C-20. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: West PIF Aquifer Cutout (ST11)
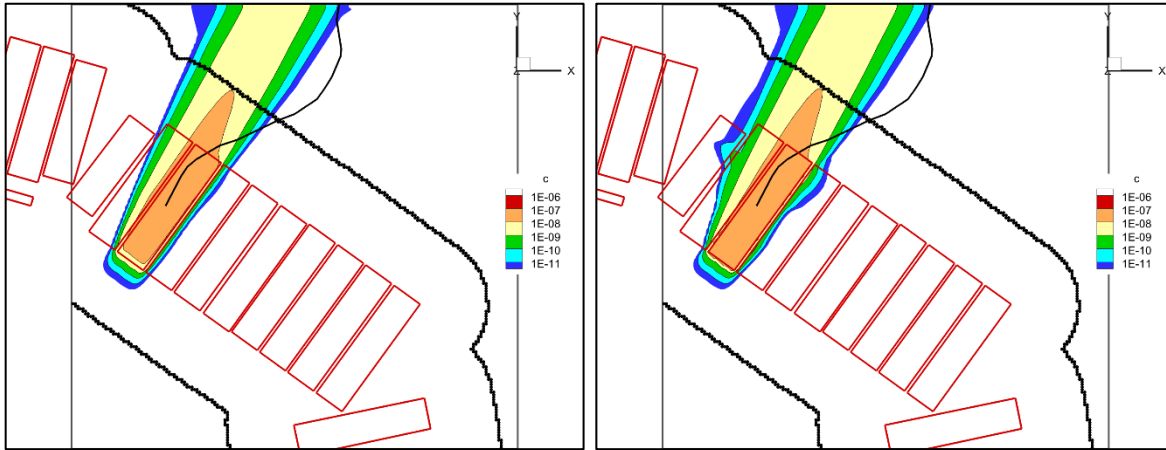
C.1.2.2. Center Footprint

The Center PIF aquifer cutout footprint contains the following DUs:

<div align="center">

ST01, ST02, ST03, ST04, ST23, ST24, ST05, ST06, ST07, ST08, ST09

</div>

As seen by comparing the left-hand (TP0) and right-hand (TP1) concentration profiles in Figure C-21 through Figure C-29, the impact of the final closure cap is marginal. For all cases shown, the Center PIF aquifer cutout footprint meets the criteria chosen (Section 3.5.3.2.2) in establishing this footprint.
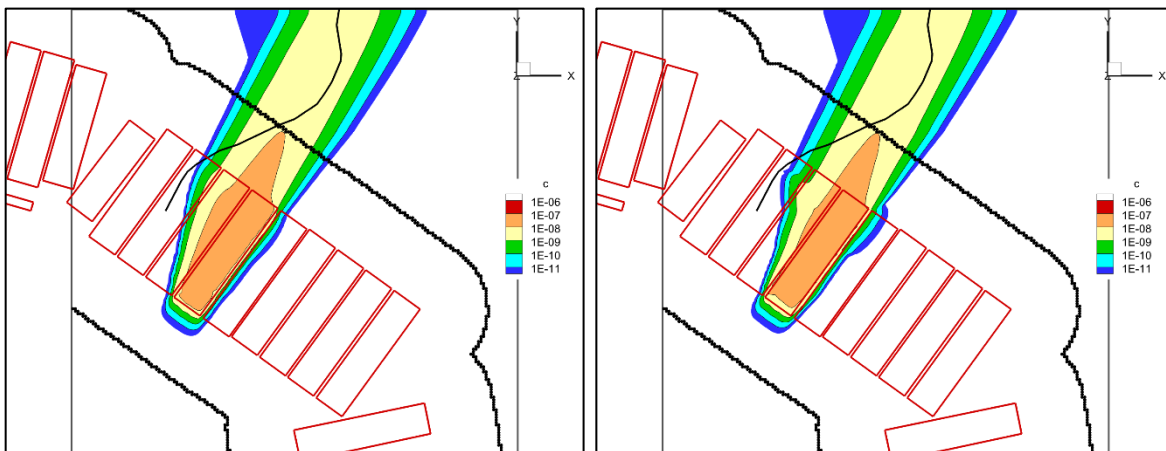

Figure C-21. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST01)

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Figure C-22. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST02)
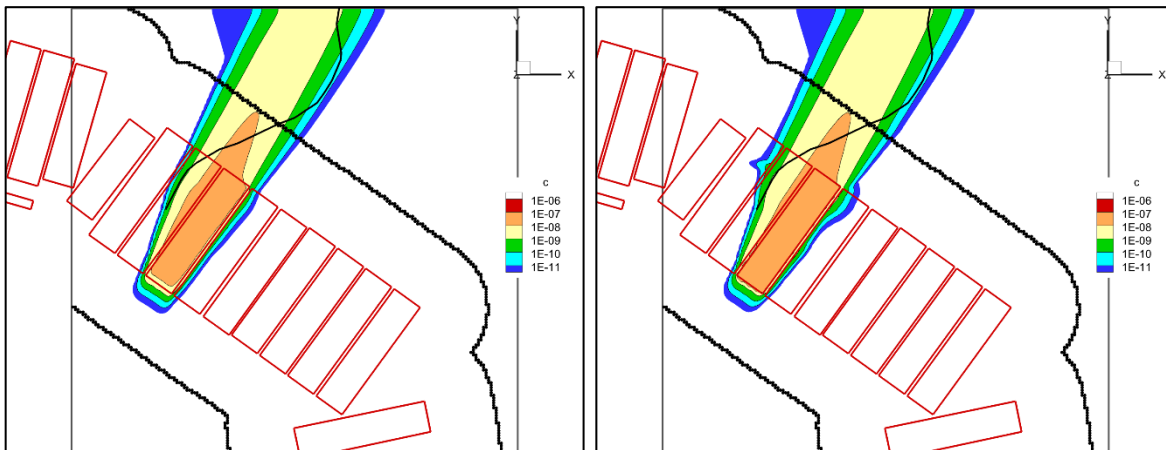
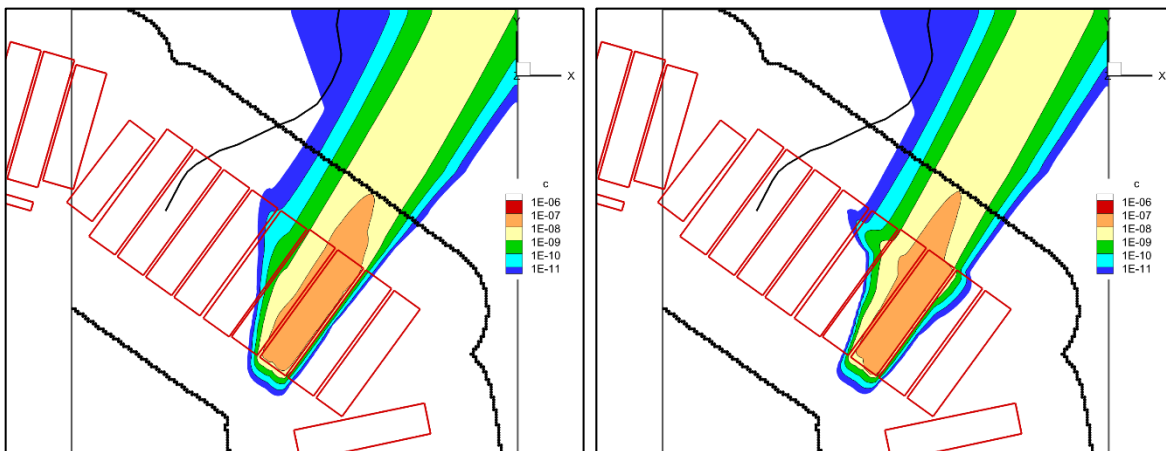**Figure C-23. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST03)**

Figure C-24. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST04)
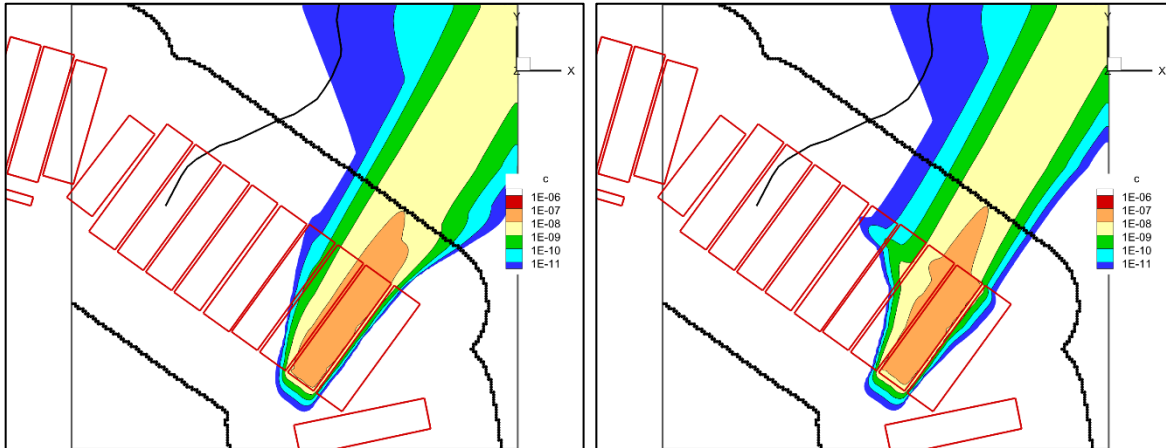
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Figure C-25. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST23)

Figure C-26. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST24)

Figure C-27. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST05)

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Figure C-28. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST06)
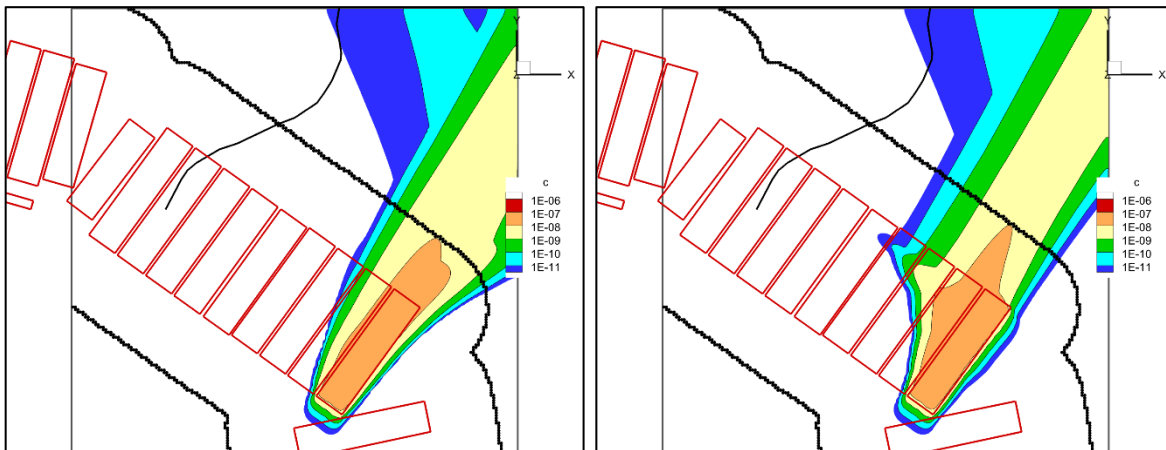
Figure C-29. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: Center PIF Aquifer Cutout (ST07)

C.1.2.3. East1 Footprint

The East1 PIF aquifer cutout footprint contains the following DUs:

**ET02, ET01, ST14, ET05, LAWV, ET06, ST17, ST18, ST19, ST20, ST21, ST22**

As seen by comparing the left-hand (TP0) and right-hand (TP1) concentration profiles in Figure C-30 through Figure C-41, the impact of the final closure cap is primarily a counter-clockwise rotation of the flow field. For all cases shown, the East1 PIF aquifer cutout footprint meets the criteria chosen (Section 3.5.3.2.2) in establishing this footprint.

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Figure C-30. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ET02)
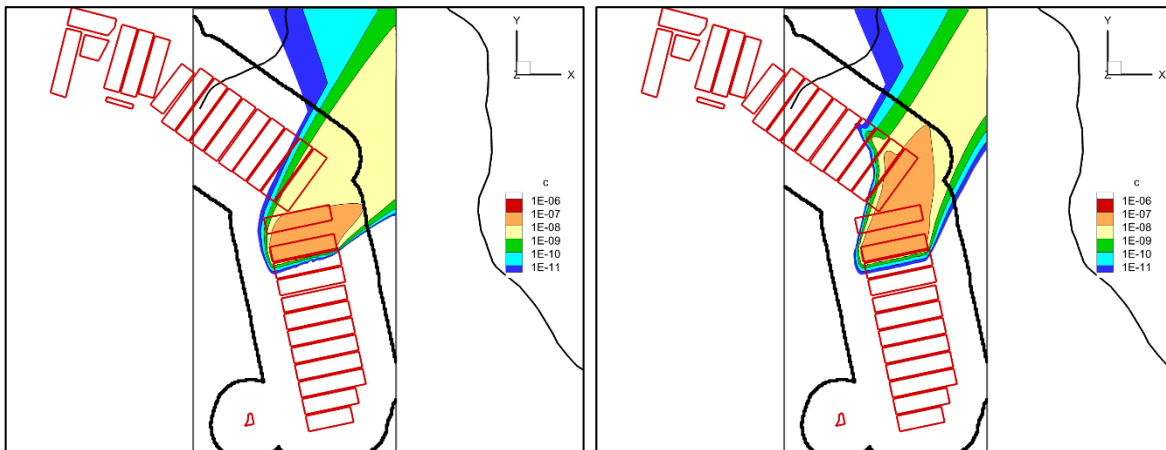
Figure C-31. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ET01)
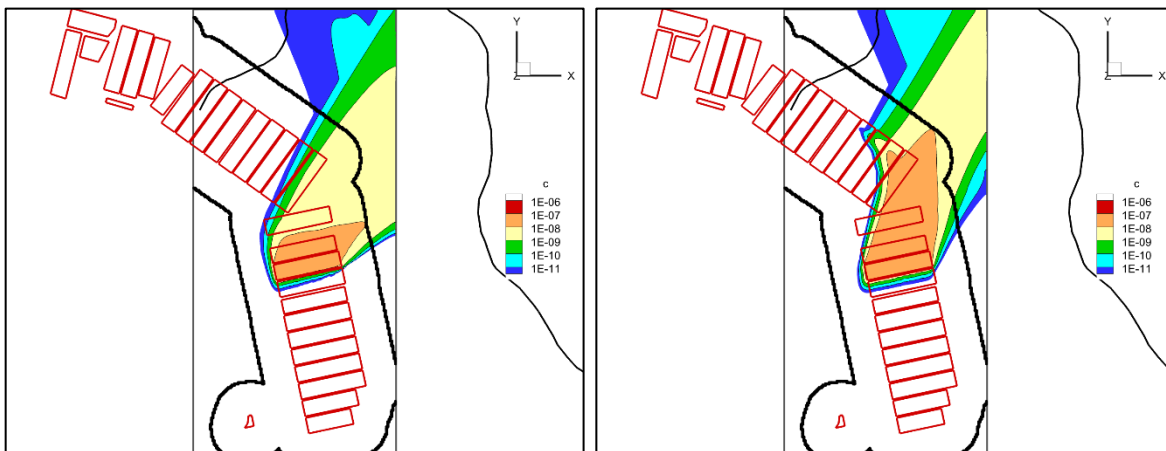
Figure C-32. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST14)

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Figure C-33. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ET05)

Figure C-34. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (LAWV)
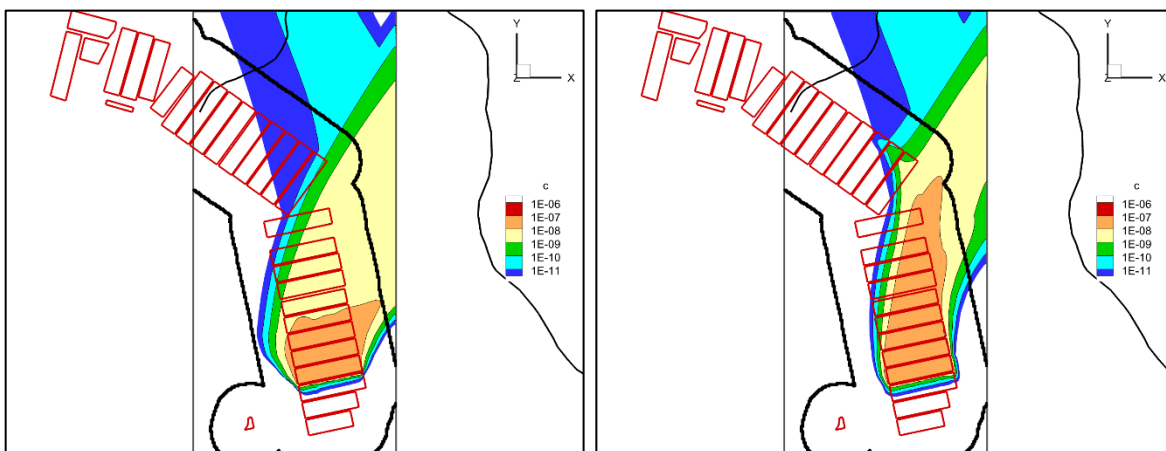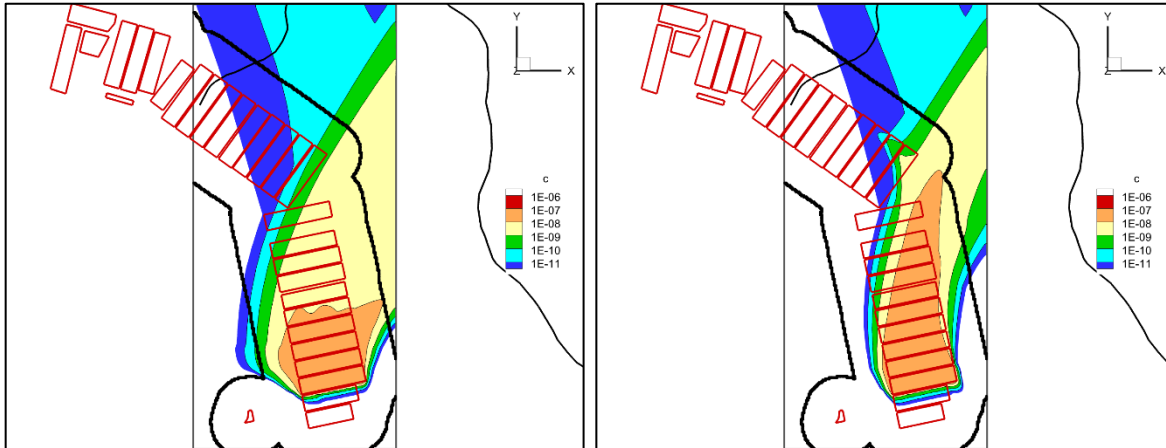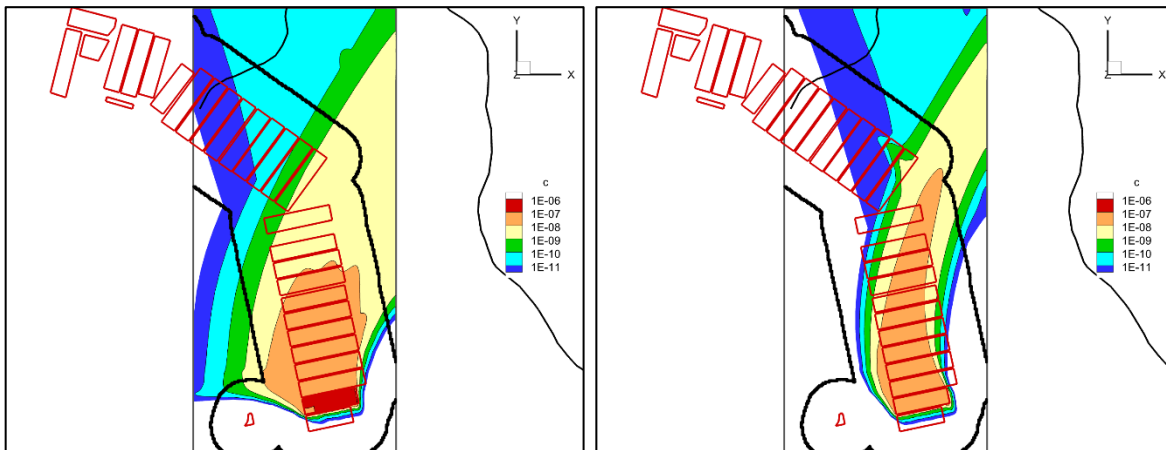

Figure C-35. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ET06)

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Figure C-36. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST17)

Figure C-37. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST18)
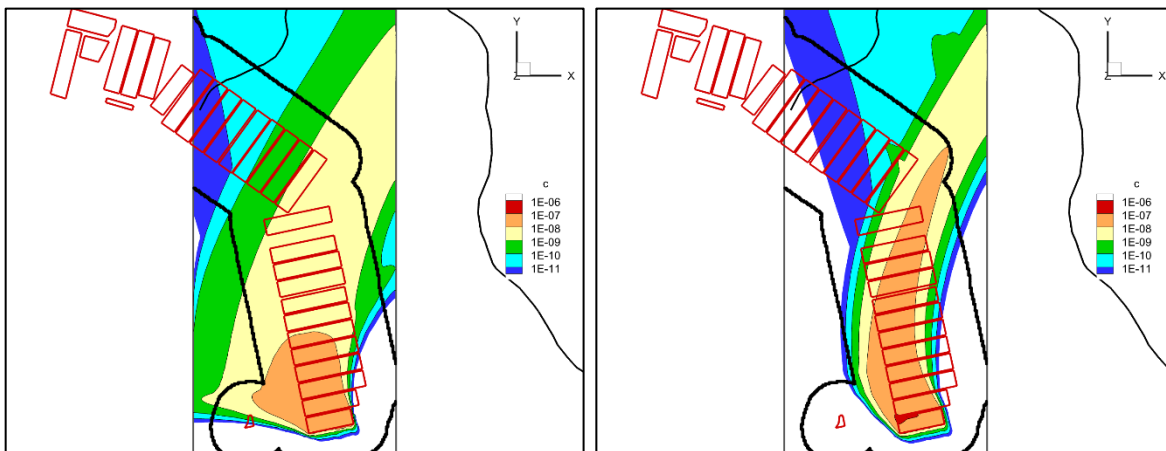

Figure C-38. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST19)

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Figure C-39. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST20)

Figure C-40. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST21)

Figure C-41. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 and TP1: East1 PIF Aquifer Cutout (ST22)

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C.1.2.4. East2 Footprint

The East2 PIF aquifer cutout footprint contains the following DU:

NR07E

As seen by comparing the left-hand (TP0) and right-hand (TP1) concentration profiles in Figure C-42, the impact of the final closure cap is primarily a counter-clockwise rotation of the flow field. For the case shown, the East2 footprint meets the criteria chosen (Section 3.5.3.2.2) in establishing this footprint.
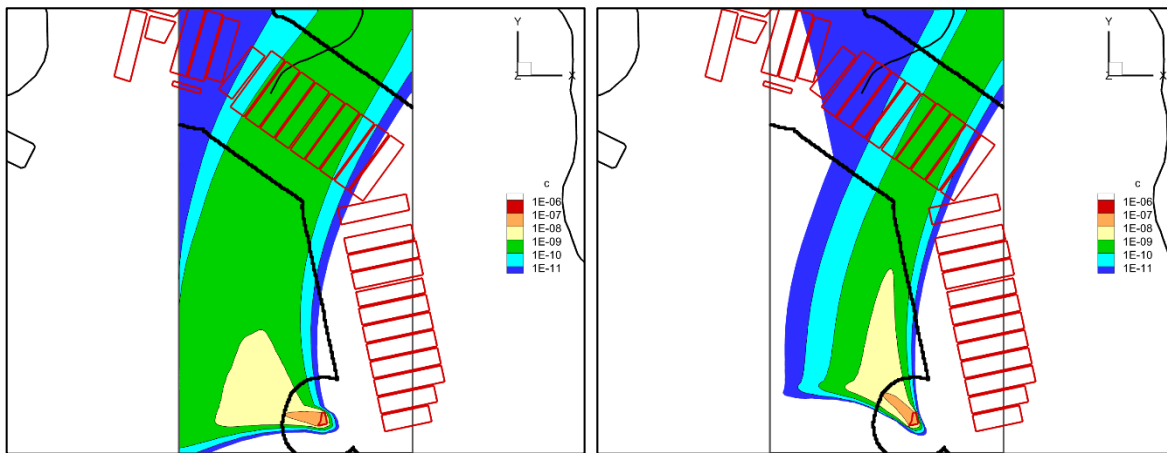
Figure C-42. Steady-State Tracer Concentration Profiles (gmol L⁻¹) for TP0 and TP1: East2 PIF Aquifer Cutout (NR07E)

C.1.3 Cutouts for Inventory Limits Analyses

The cutouts for limits analyses are initially set to the four PIF cutouts presented in Section C.1.2. To meet the "at and beyond" requirements, these initial footprints are altered and, in most cases, multiple cutouts are created. For example, the West PIF cutout is split into two separate A and B cutouts.

C.1.3.1. West Footprint

The DUs residing within the West aquifer cutout footprint are broken into two subgroups for the inventory limits analyses:
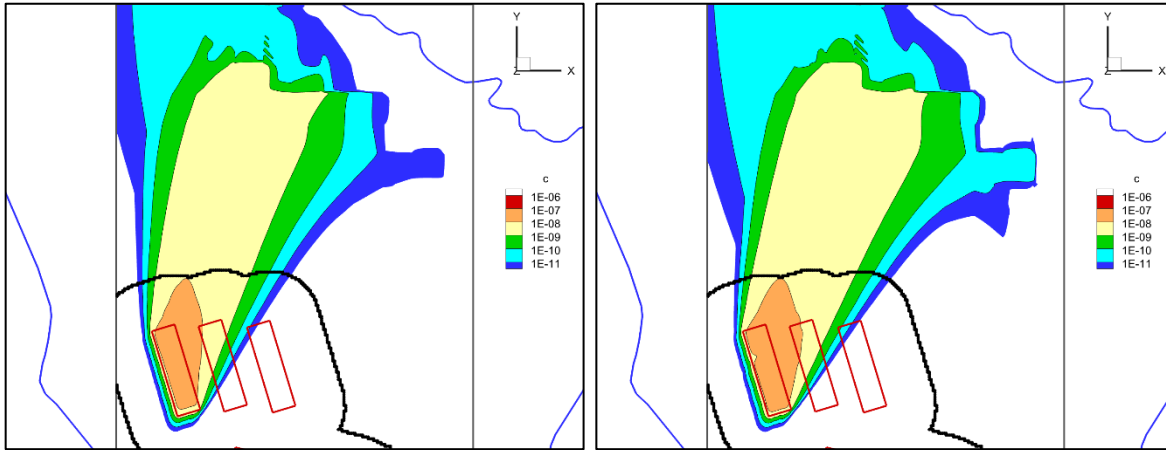
- **West_A:** ET07, ET08, ET09
- **West_B:** ET03, ET04, NR26E, ST08, ST09, ST10, ILV, ST11

PORFLOW steady-state tracer runs are made to assess the adequacy of the chosen footprint domains.

C.1.3.1.1. West_A Footprint

For all cases shown, the West_A limits aquifer cutout footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.

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Figure C-43. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_A Limits Aquifer Cutout (ET07)
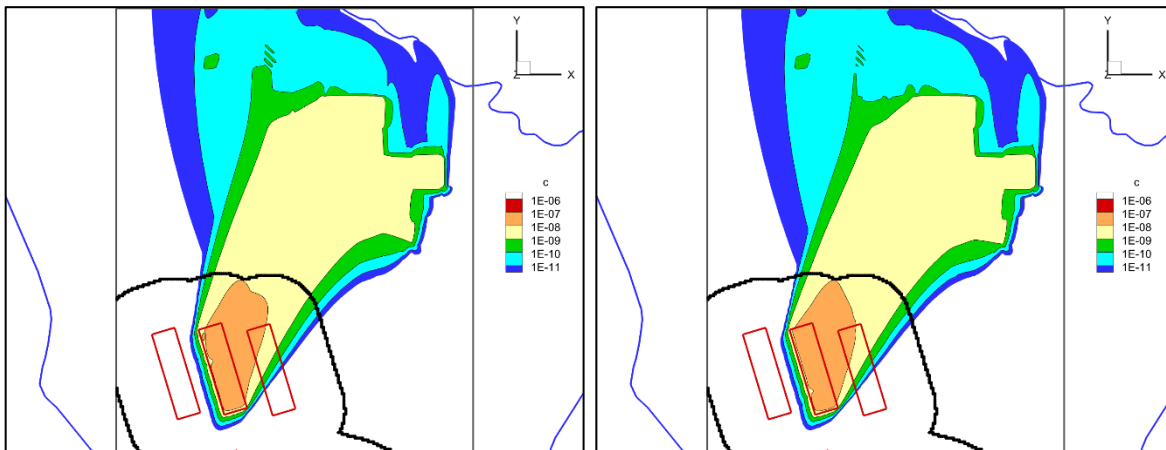
Figure C-44. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_A Limits Aquifer Cutout (ET08)
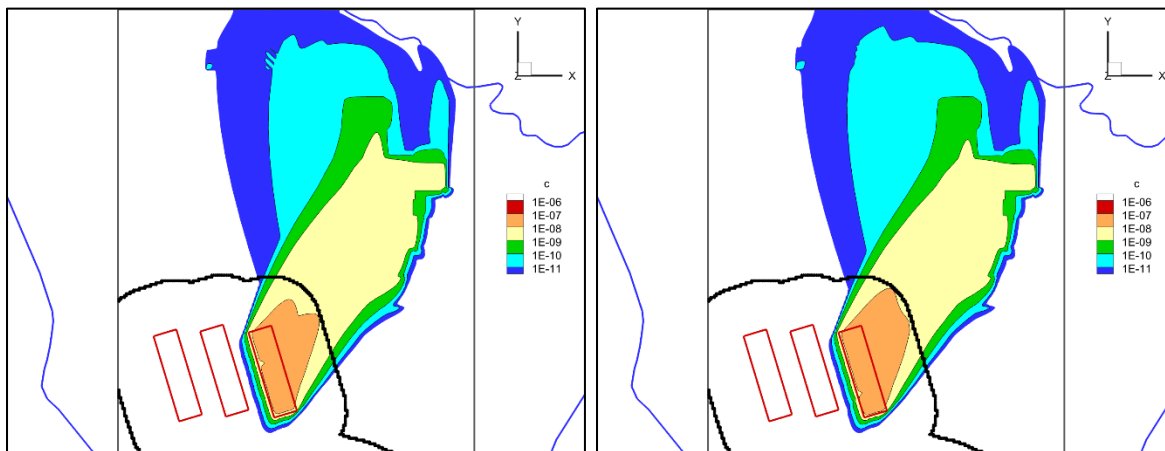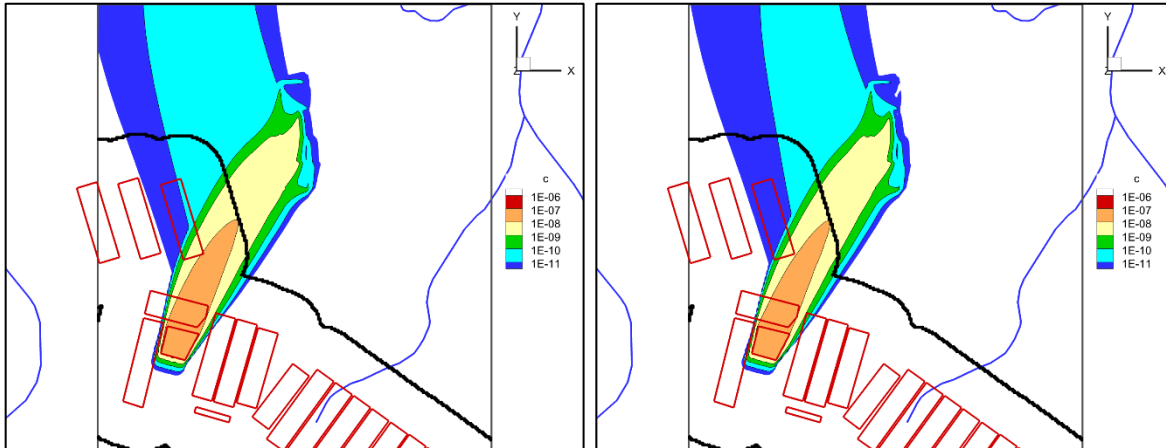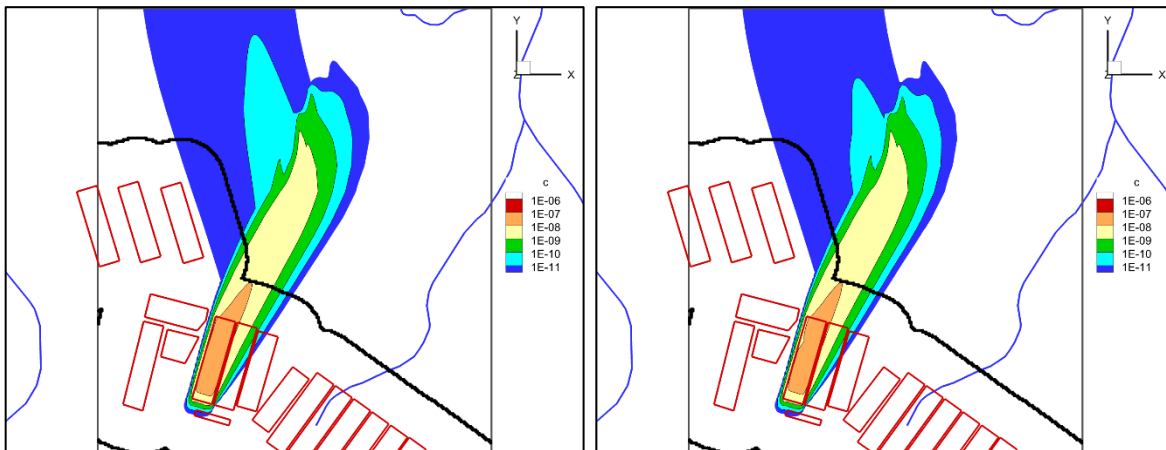

Figure C-45. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_A Limits Aquifer Cutout (ET09)

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C.1.3.1.2. West_B Footprint

For all cases shown, the West_B limits aquifer cutout footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.
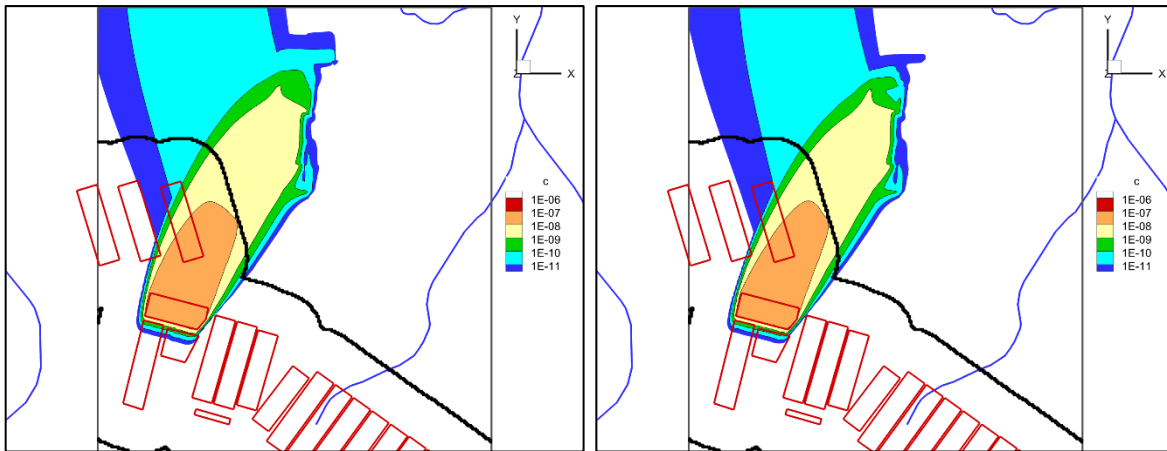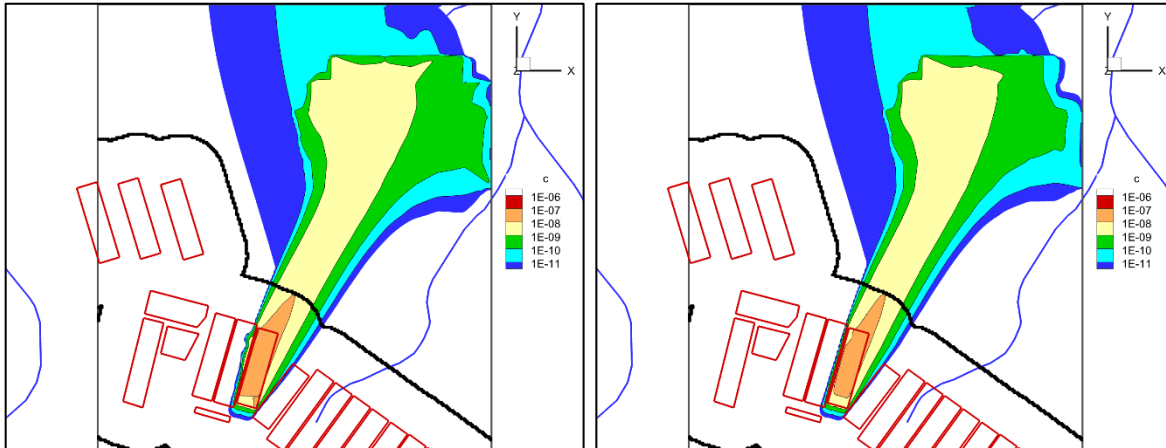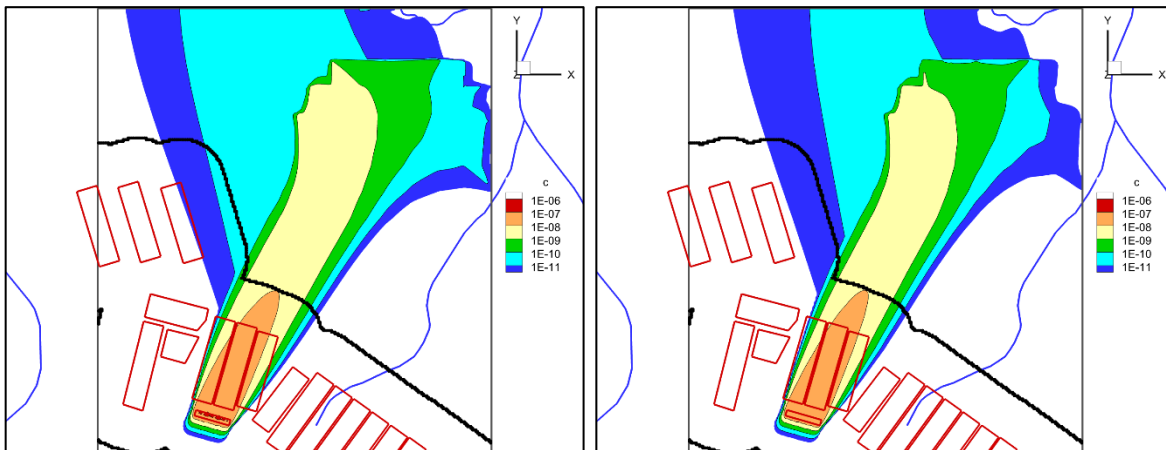

Figure C-46. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ET03)
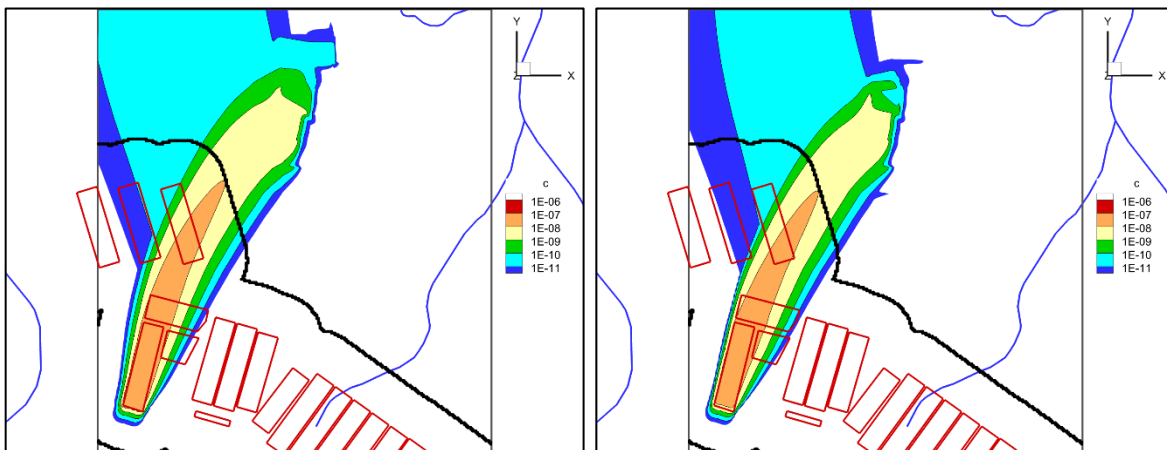
Figure C-47. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ET04)

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Figure C-48. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (NR26E)

Figure C-49. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ST08)
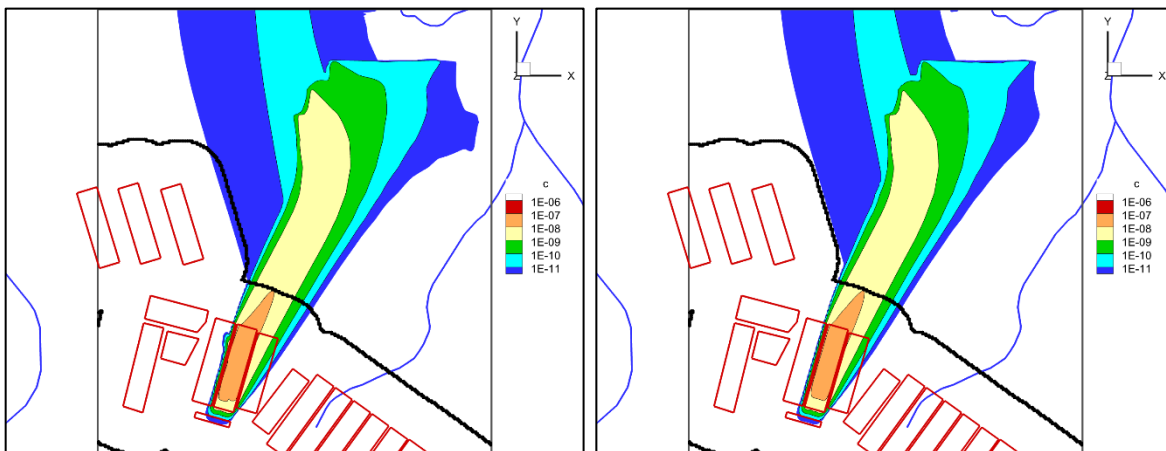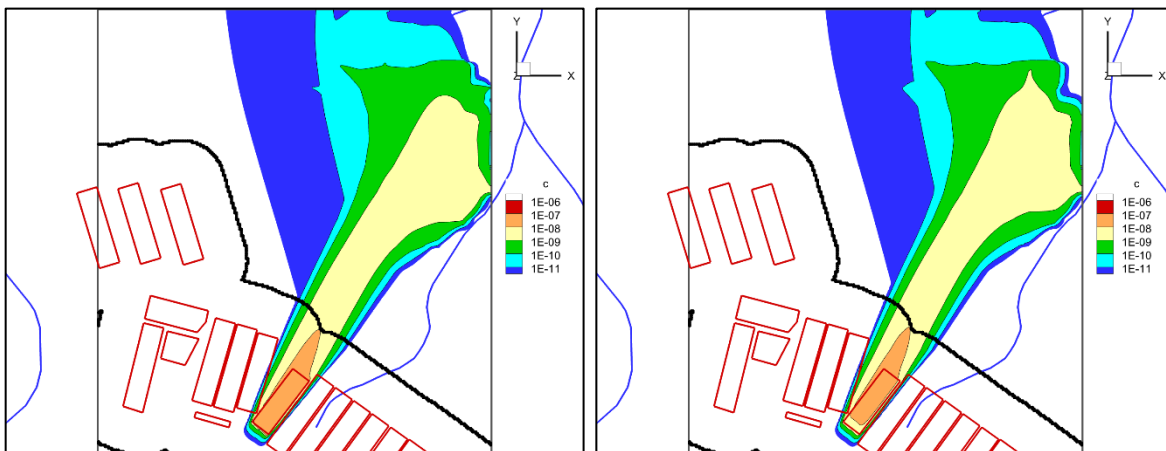

Figure C-50. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ST09)

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Figure C-51. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ST10)

Figure C-52. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ILV)

Figure C-53. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: West_B Limits Aquifer Cutout (ST11)

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C.1.3.2. Center Footprint

The DUs residing within the Center aquifer cutout footprint are separated into two subgroups for the inventory limits analyses:

- **Center_A:** ST01, ST02, ST03, ST04, ST23
- **Center_B:** ST24, ST05, ST06, ST07

PORFLOW steady-state tracer runs are made to assess the adequacy of the chosen footprint domains.

C.1.3.2.1. Center_A Footprint

For all cases shown, the Center_A limits aquifer cutout footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.
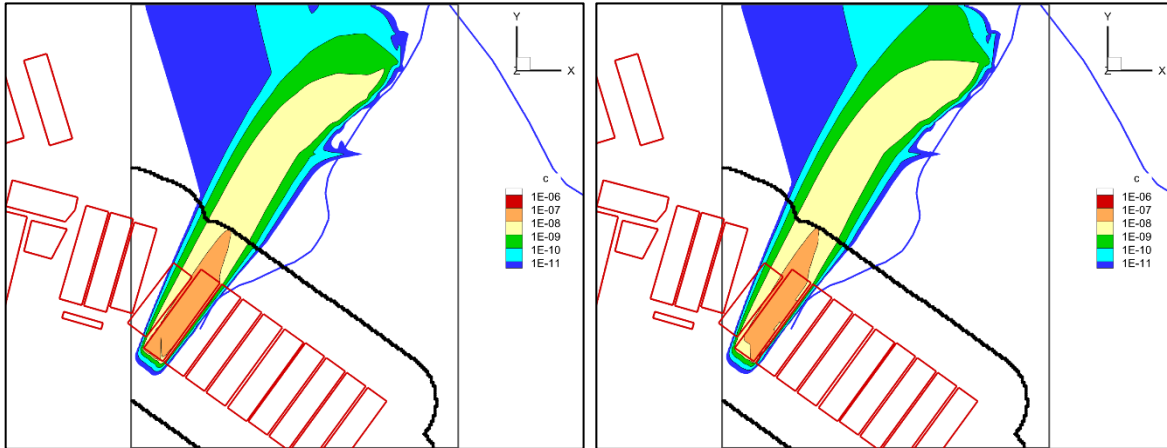

Figure C-54. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_A Limits Aquifer Cutout (ST01)
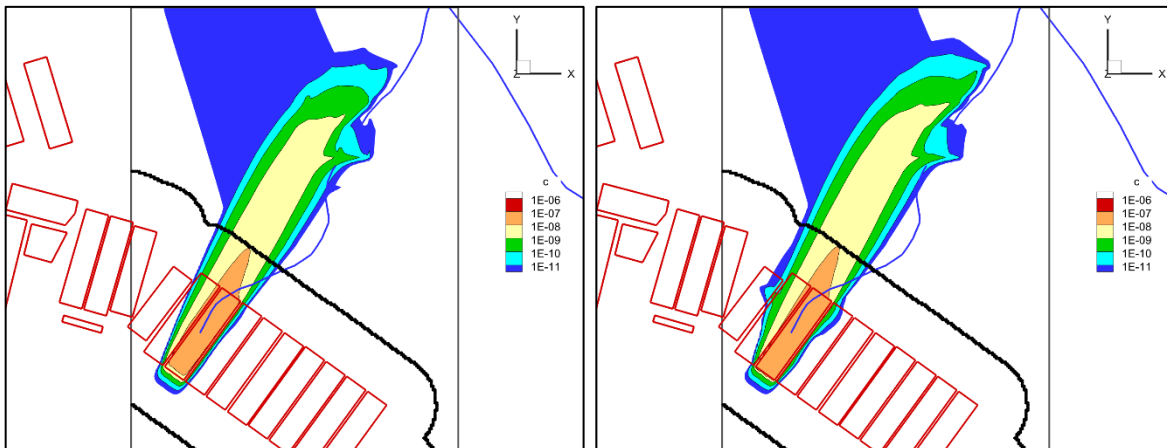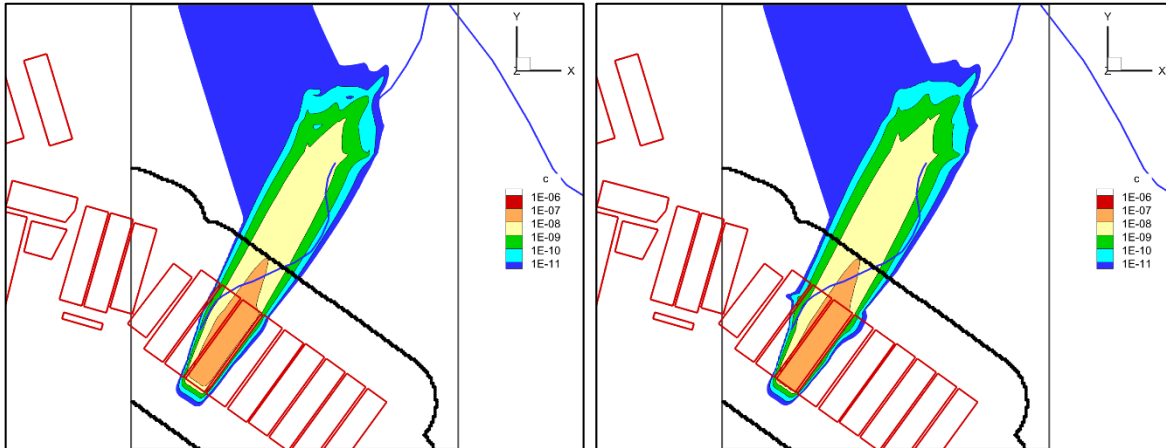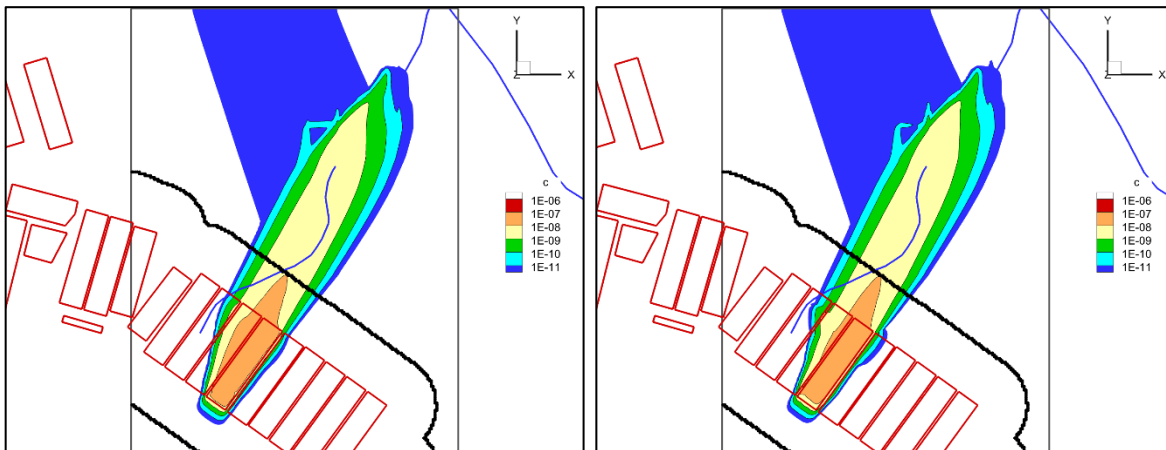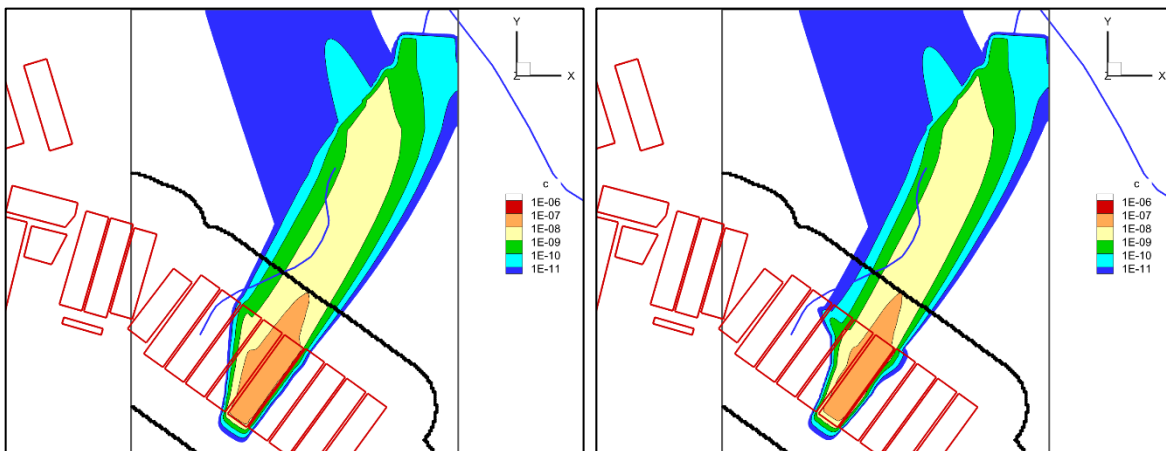

Figure C-55. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_A Limits Aquifer Cutout (ST02)

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Figure C-56. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_A Limits Aquifer Cutout (ST03)

Figure C-57. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_A Limits Aquifer Cutout (ST04)

Figure C-58. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_A Limits Aquifer Cutout (ST23)

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C.1.3.2.2. Center_B Footprint

For all cases shown, the Center_B limits aquifer cutout footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.
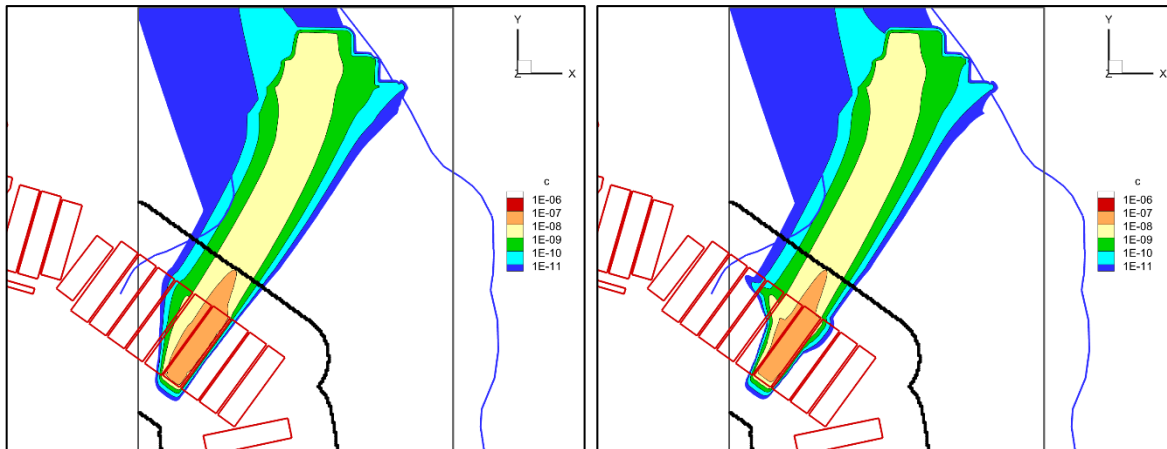

Figure C-59. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_B Limits Aquifer Cutout (ST24)

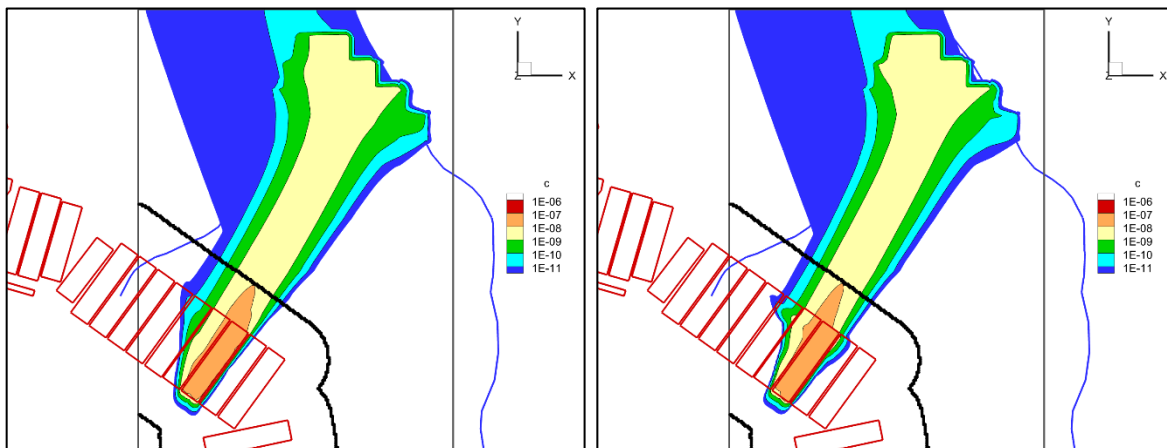
Figure C-60. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_B Limits Aquifer Cutout (ST05)
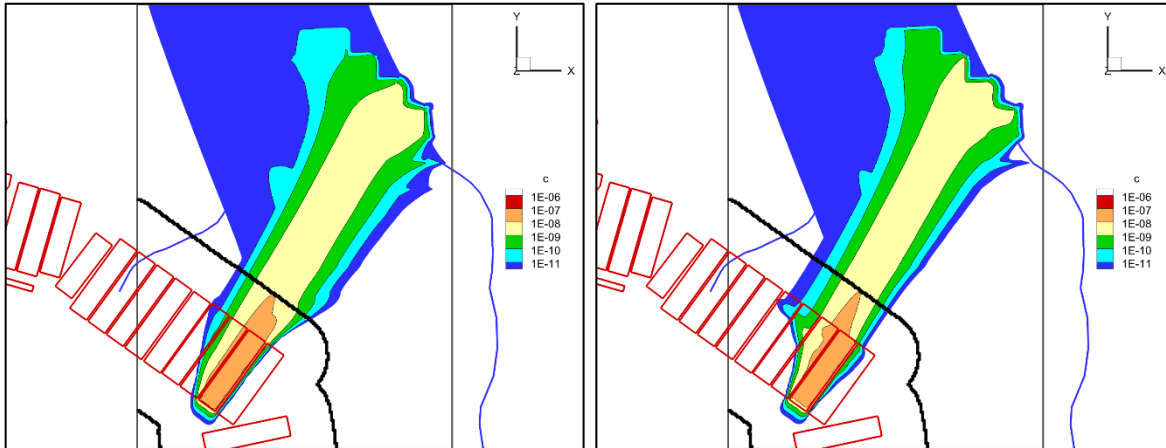
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Figure C-61. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_B Limits Aquifer Cutout (ST06)
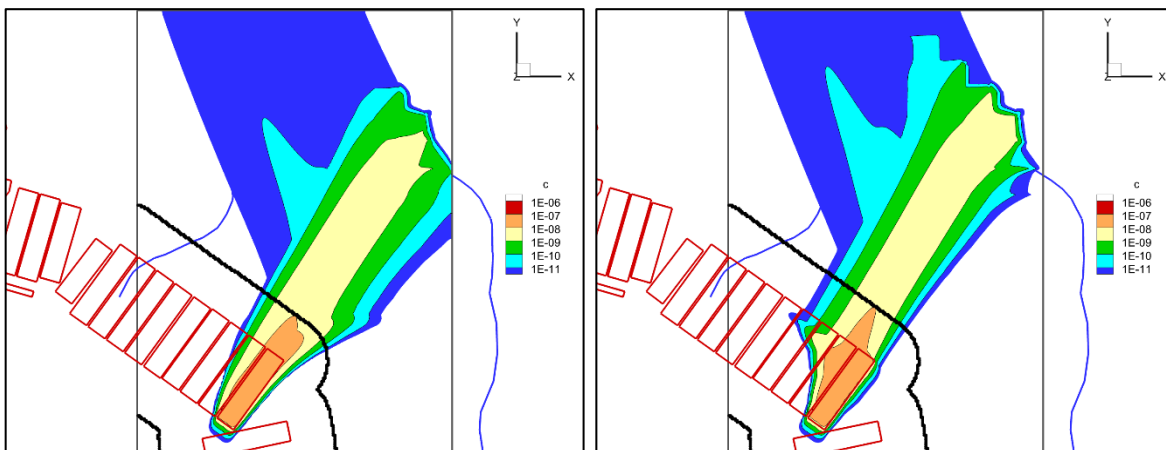

Figure C-62. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: Center_B Limits Aquifer Cutout (ST07)
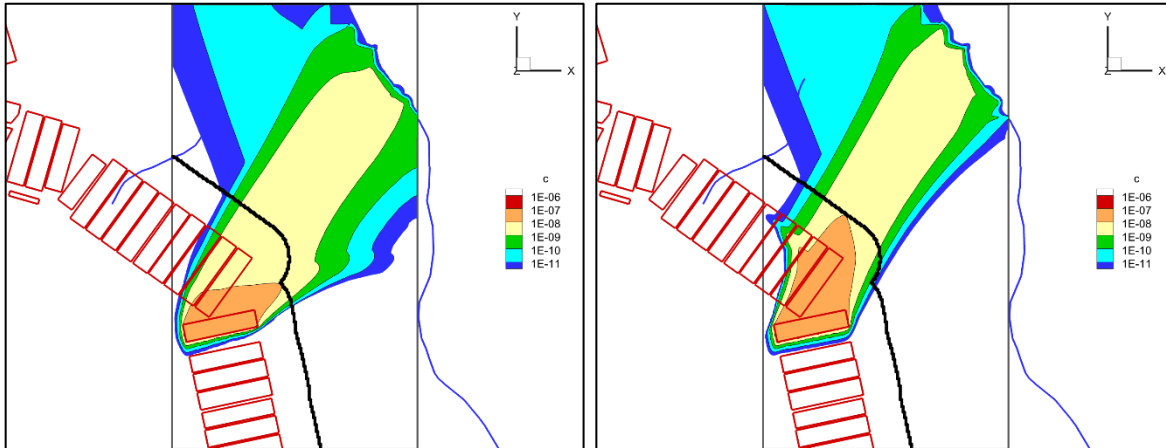
C.1.3.3. East1 Footprint

The DUs residing within the East1 aquifer cutout footprint are separated into three subgroups for the inventory limits analyses:

- **East1_A:** ET02, ET01, ST14, ET05, LAWV
- **East1_B:** ET06, ST17, ST18, ST19, ST20
- **East1_C:** ST21, ST22

PORFLOW steady-state tracer runs are made to assess the adequacy of the chosen footprint domains.
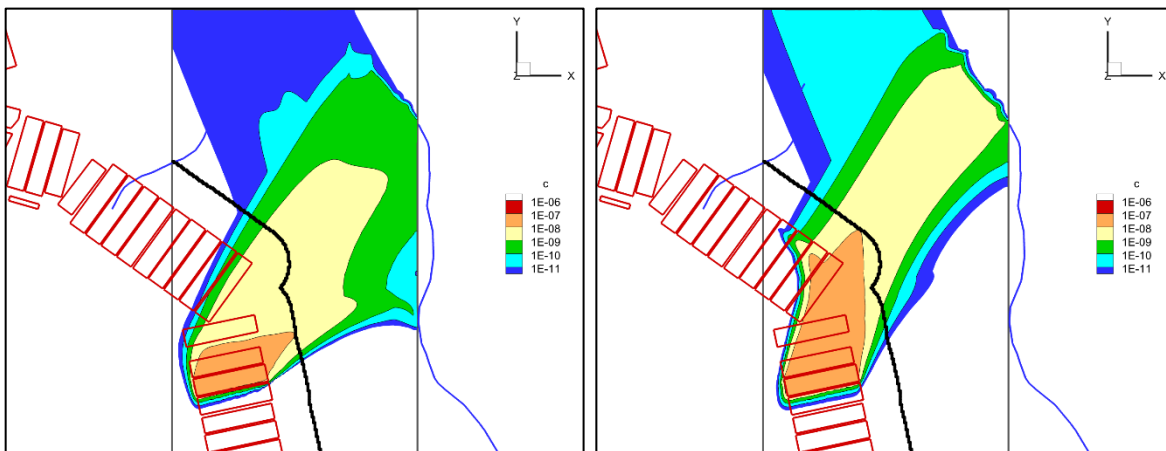
C.1.3.3.1. East1_A Footprint

For all cases shown, the East1_A footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.

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Figure C-63. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_A Limits Aquifer Cutout (ET02)
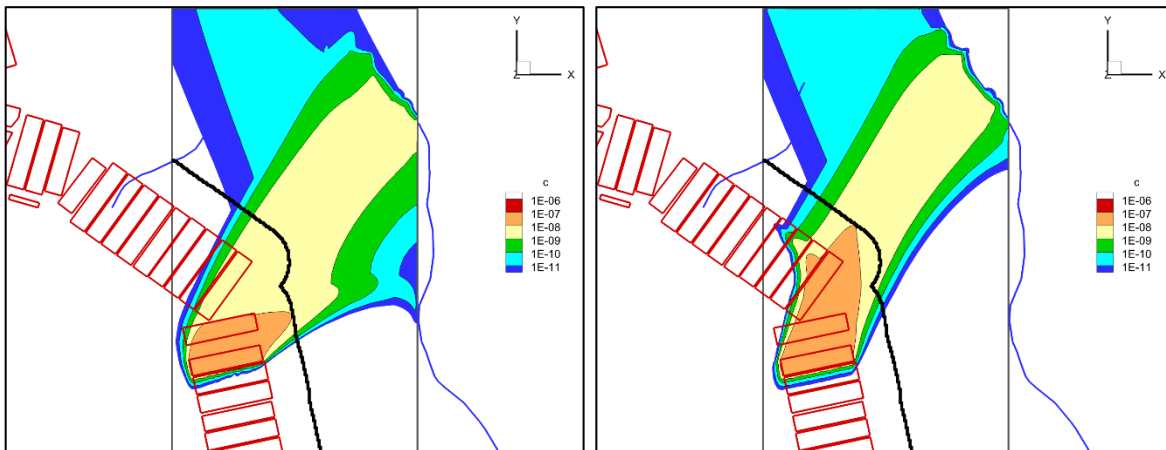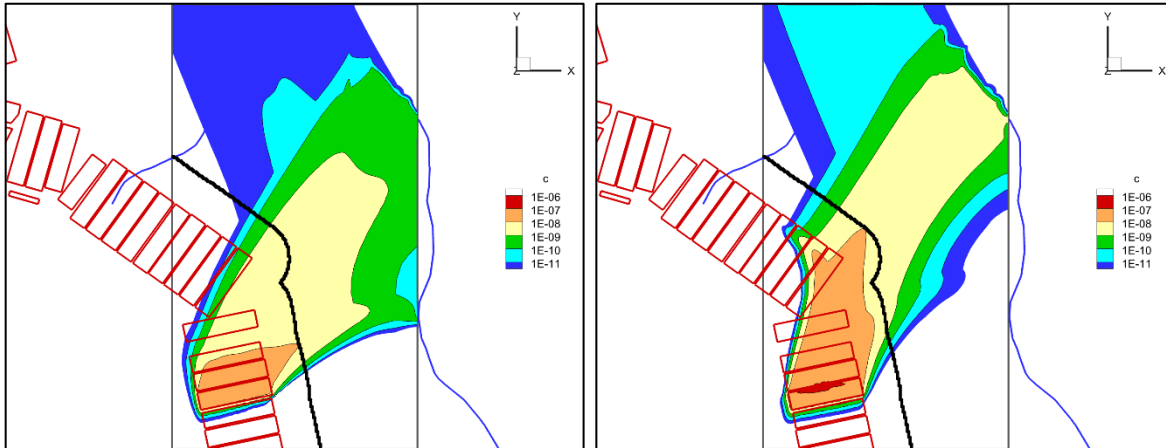

Figure C-64. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_A Limits Aquifer Cutout (ET01)
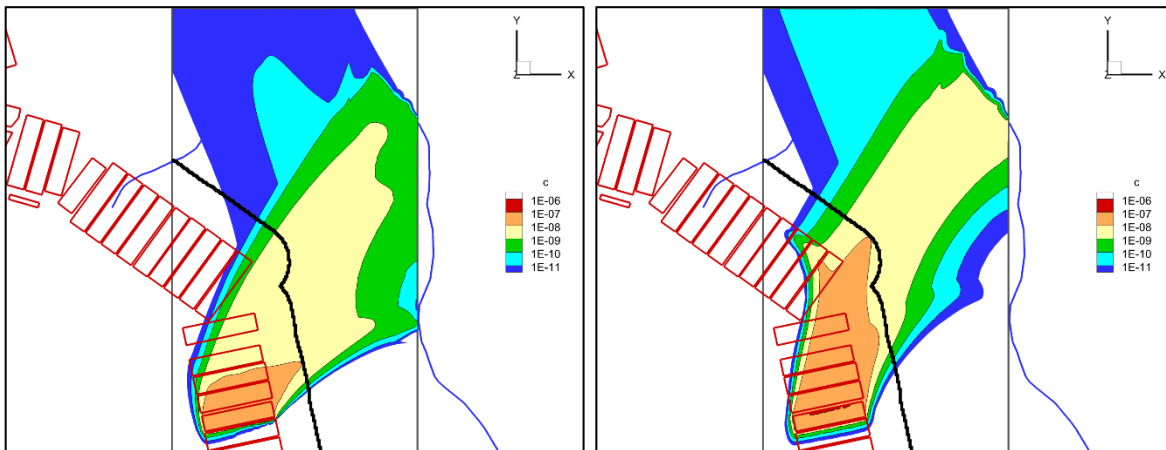

Figure C-65. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_A Limits Aquifer Cutout (ST14)

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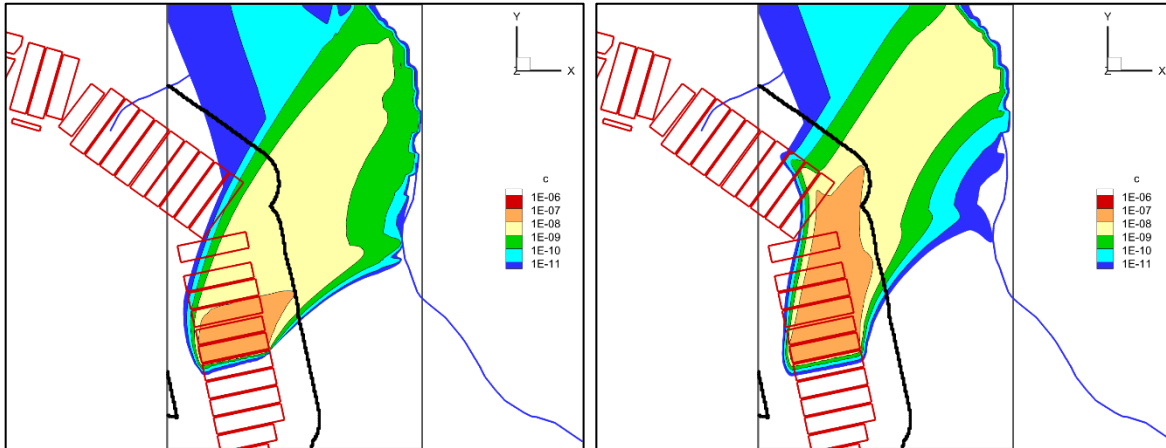at the Savannah River Site

Figure C-66. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_A Limits Aquifer Cutout (ET05)
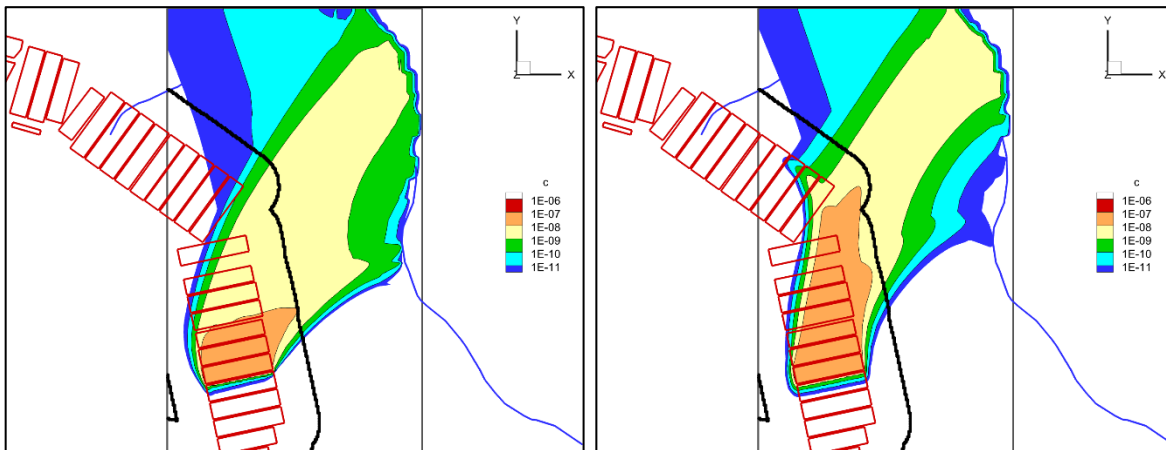

Figure C-67. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_A Limits Aquifer Cutout (LAWV)
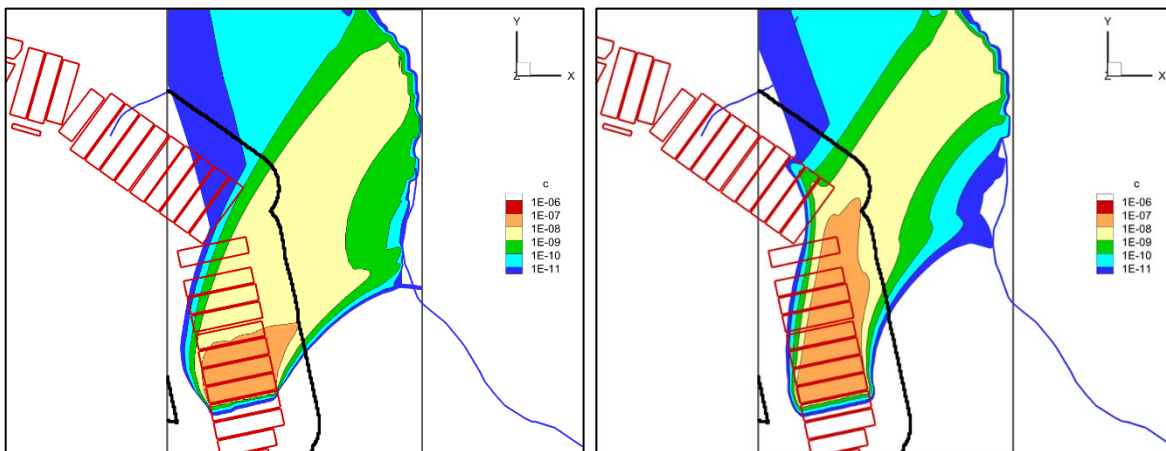
C.1.3.3.2. East1_B Footprint

For all cases shown, the East1_B limits aquifer cutout footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.
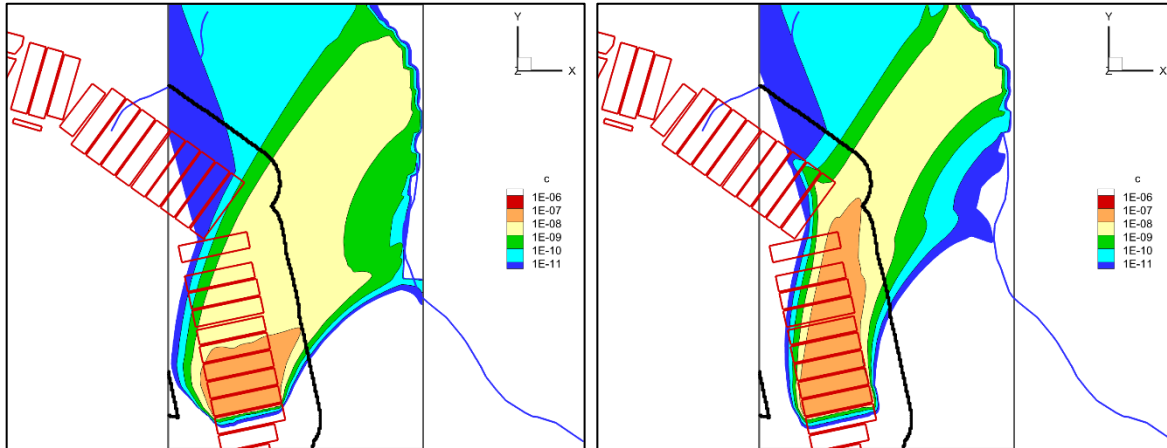
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Figure C-68. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_B Limits Aquifer Cutout (ET06)

Figure C-69. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_B Limits Aquifer Cutout (ST17)

Figure C-70. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_B Limits Aquifer Cutout (ST18)

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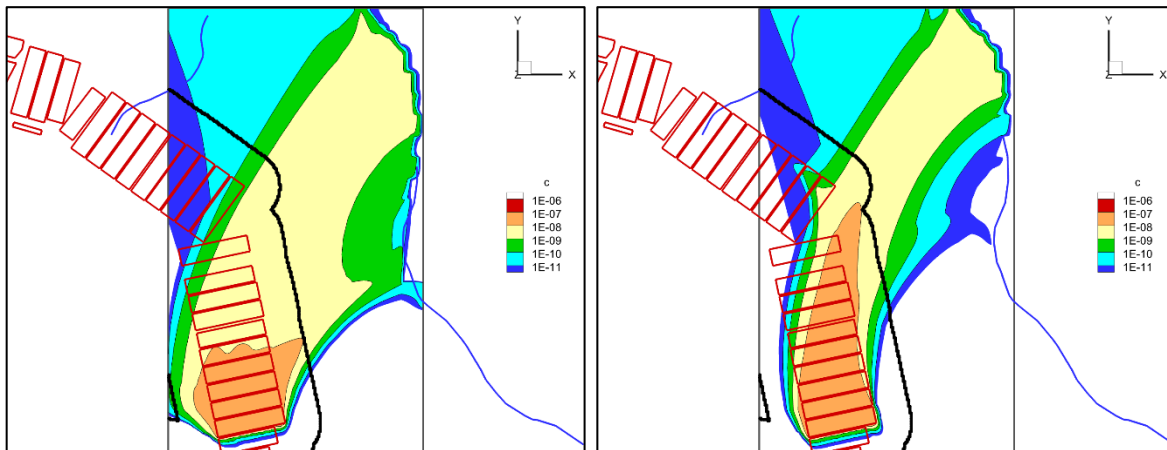at the Savannah River Site

Figure C-71. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_B Limits Aquifer Cutout (ST19)

Figure C-72. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_B Limits Aquifer Cutout (ST20)

C.1.3.3.3. East1_C Footprint

For all cases shown, the East1_C limits aquifer cutout footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.
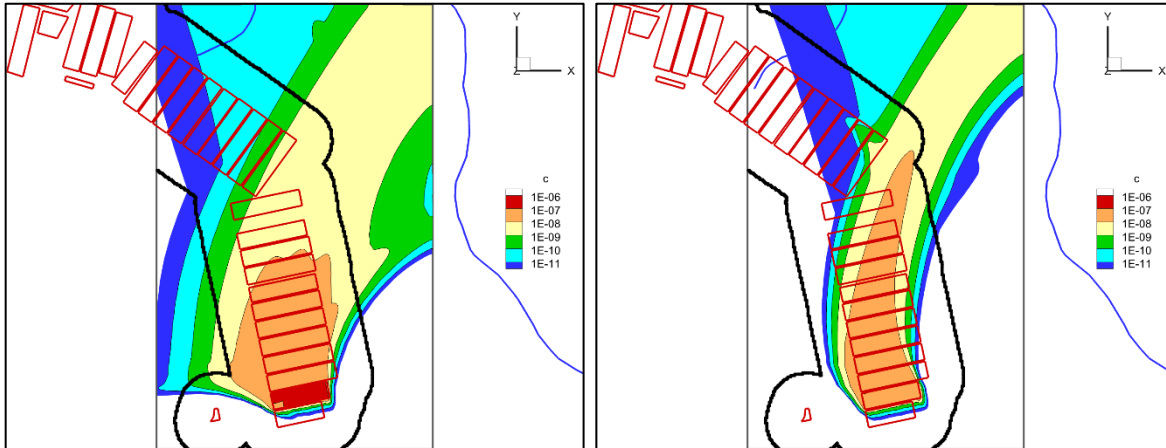
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Figure C-73. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_C Limits Aquifer Cutout (ST21)
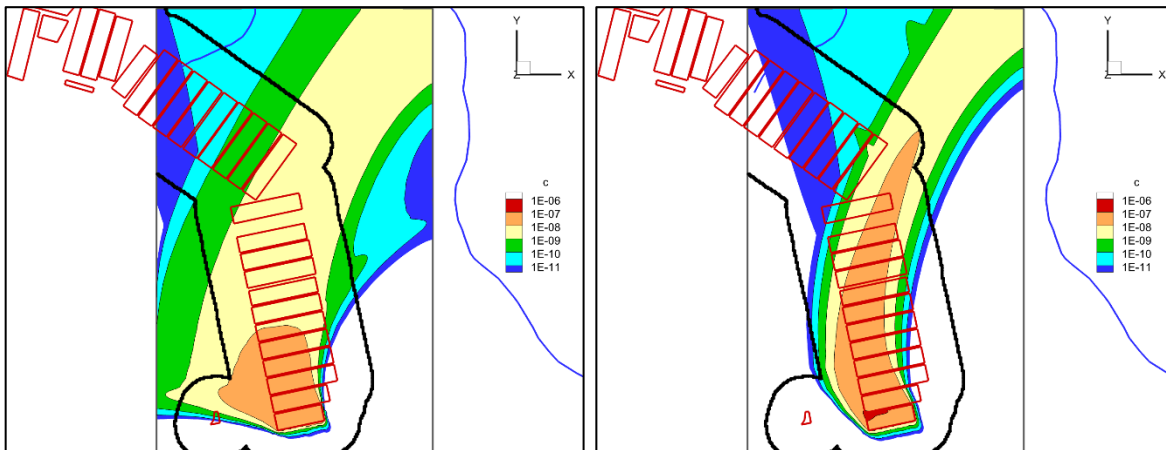

Figure C-74. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East1_C Limits Aquifer Limits Aquifer Cutout (ST22)
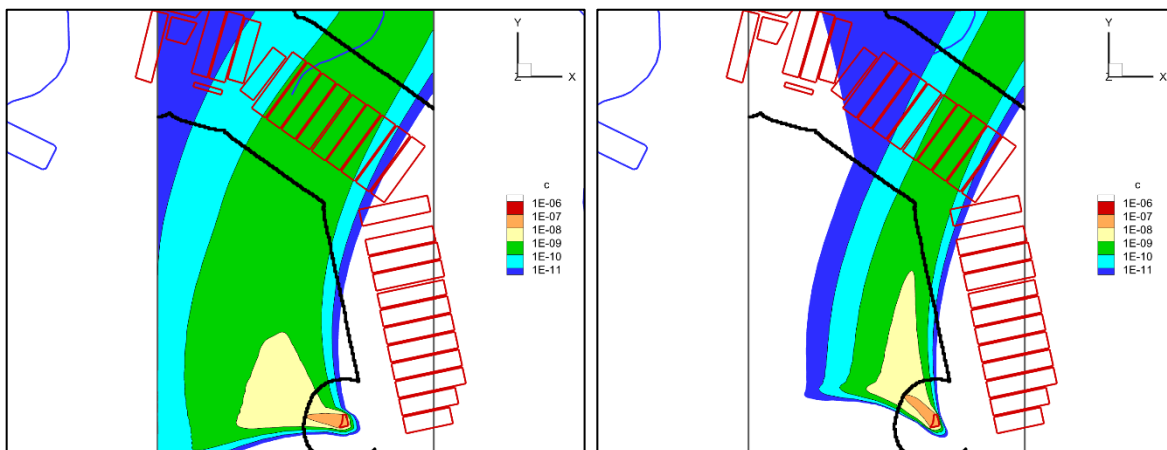
C.1.3.4. East2 Footprint

For the inventory limits analyses, the only DU residing within the East2 aquifer cutout footprint is addressed as:

- **East2_A:** NR07E

PORFLOW steady-state tracer runs are made to assess the adequacy of the chosen footprint domain.

C.1.3.4.1. East2_A Footprint

For the case shown, the East2_A footprint meets the criteria chosen (Sections 3.5.3.2.2 and 3.5.3.2.3) in establishing this footprint.

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Figure C-75. Steady-State Tracer Concentration Profiles (gmol L^{-1}) for TP0 & TP1: East2_A Limits Aquifer Cutout (NR07E)

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C.2 REFERENCES

ACRi (2018). "PORFLOW User's Manual, Keyword Commands Version 6.42.9, Revision 0." Analytical & Computational Research, Inc., Los Angeles, CA. April 23, 2018.