Appendix D. Scenario D—Simulation of 2020 Dry Conditions

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Appendix D. Scenario D—Simulation of 2020 Dry Conditions

Purpose of Scenario

The purpose of Scenario D was to evaluate the effects of adjustments to specified heads in the source-sink layer and along lateral boundaries similar to the 2002 simulation. Projected year 2020 pumping is similar to Scenario C, except that pumping is increased for irrigation wells to simulate dry conditions. Irrigation pumpage, however, is less than the 2002 simulation and projected increases are concentrated in population centers, where additional demands may be placed on public-supply wells.

Water Budget Changes

Total projected ground-water pumpage in Scenario D during this period was 56.9 million gallons per day (Mgal/d), of which 34 percent was from the lower Midville aquifer (layer A7), 21 percent was from the lower Dublin aquifer (layer A5), and 15 percent was from the Gordon aquifer (layer A2). The remaining 30 percent of ground-water pumpage in Scenario D was apportioned to the upper Midville aquifer (layer A6), Millers Pond aquifer (layer A3), and the upper Dublin aquifer (layer A4; table 11). Boundary conditions for Scenario D reflect dry hydrologic conditions similar to the 2002 simulation. The simulated water budget for Scenario D indicates that major components of flow were similar to the 2002 simulation, with the exception that the overall decrease in pumpage of 10.3 Mgal/d (table 8) reduced the recharge from the source-sink layer A1 (Upper Three Runs aquifer) into layer A2 (Gordon aquifer) by 3.5 Mgal/d (fig. D1). The decrease was also evident for inflows through each of the confining units, which ranged from 0.8 to 3.0 Mgal/d. The exception was inflows into A7 (lower Midville aquifer) from A6 (upper Midville aquifer), which showed a slight increase of 0.4 Mgal/d.

Water-Level Changes

Changes in pumping distribution for Scenario D resulted in simulated water-level changes that ranged from declines of as much as 3 feet (ft) in the Gordon aquifer (layer A2), and rises of as much as 5 ft in the Millers Pond aquifer (layer A3; figs. D2 and D3). The most notable change in water levels occurs in the Millers Pond aquifer (layer A3) because the pumping rates for irrigation wells located in Burke County, Ga., are lower than the 2002 dry simulation (fig. D3). Conversely, pumping rates for public-supply wells located in Aiken County, S.C., are higher for the 2020 dry simulation (Scenario D) in the Dublin and Midville aquifer systems because of projected population growth (figs. D4–D7). The area of influence of these wells extends into the northern part of the Savannah River Site (SRS), evident by the position of the 0 ft contour, which moves farther south toward Upper Three Runs Creek from the Gordon aquifer (layer A2) to the Midville aquifer system (layers A6–A7; figs. D2, D4–D7).

Ground-Water Flowpaths

Simulated ground-water flowpaths for Scenario C generally were limited to areas within the SRS boundary (figs. D8–D12). Flowpaths were evaluated using MODPATH in forward-tracking mode from five zones in which particles placed at the base of the Upper Three Runs aquifer (source-sink layer A1) were allowed to migrate to discharge areas. Downward vertical gradients exist that allow depth of penetration into the Dublin aquifer system, but flowpaths inside the boundaries of the SRS eventually are upward toward discharge areas within the Gordon aquifer (layer A2). General ground-water discharge areas or sinks include Upper Three Runs Creek (layer A2) and the alluvial valley of the Savannah River (source-sink layer A1 and layer A2). General ground-water movement from zone 1 is south toward discharge areas along Upper Three Runs Creek, with a southwesterly component moving away from the A/M Area (fig. D8). General ground-water flow directions from zones 2 and 3 are west toward Upper Three Runs Creek, with another flow component moving south toward discharge areas along Pen Branch (figs. D9–D10). Ground-water movement from zones 4 and 5 generally is south toward discharge areas located on the South Carolina side of the Savannah River near Steel Creek (figs. D11–D12). Most of the ground-water flowpaths indicate movement is limited to areas within the boundaries of the SRS. Exceptions to the preceding statement include: (1) ground-water discharge to areas east of Eagle Point (layer A2, fig. D8), located west of the SRS boundary in Aiken County, S.C., from zone 1; (2) trans-river flow zones near Flowery Gap Landing (layer A2), located in Burke County, Ga., originating from zones 2 and 3; and (3) discharge areas located in Allendale County, S.C., migrating from zones 4 and 5.

Time-of-Travel

Simulated time-of-travel for Scenario D from the five zones of recharge on the SRS to discharge areas ranged from 22 year (yr) to about 19,300 yr (figs. D8–D12, table D1). Fastest travel times occurred from zone 1; slowest travel times occurred from zone 5 (table D1). All simulated travel times are for particle movement from the top of the Gordon confining unit (C1) forward toward discharge areas and does not include time-of-travel within the source-sink layer A1 (Upper Three Runs aquifer). According to Flach and others (1999b), model simulations indicate time-of-travel downward through the Upper Three Runs aquifer approximating several decades. The time-of-travel data shown in table D1 indicate travel times from initial placement at the top of the Gordon confining unit (C1) to points of discharge along local streams or the Savannah River floodplain. For example, the statistics indicate that at 94 yr about 10 percent of the particles (98 particles) placed in zone 1 have reached discharge areas along Upper Three Runs Creek. Mean time-of-travel from zone 1 to discharge areas was 293 yr, with values ranging from 22 yr to about 1,280 yr. Mean time-of-travel from zone 2 to discharge areas was 928 yr, with values ranging from 30 yr to about 11,400 yr. Mean time-of-travel from zone 3 to discharge areas was 1,120 yr, with values ranging from 79 yr to about 9,920 yr (table D1). Mean time-of-travel from zone 4 to discharge areas was 502 yr, with values ranging from 123 yr to about 1,650 yr. Mean time-of-travel from zone 5 to discharge areas was about 1,550 yr, with values ranging from 34 yr to about 19,300 yr (table D1).

At the 100-yr time-of-travel interval (figs. D8–D9), about 10 percent (table D1) of the particles have discharged along Upper Three Runs Creek from zone 1 and several groups of particles have moved short distances from zone 2 to discharge areas along Fourmile Branch, Pen Branch, and Upper Three Runs Creek near the Separations and Waste Management Area. Also, several particles have migrated beyond the western boundary of the SRS from zone 1 to areas south of the town of Jackson, S.C. In zone 1, the 200-yr time-of-travel interval (fig. D8) indicates additional particles have discharged to areas along Upper Three Runs Creek and the alluvial valley of the Savannah River. All particles released from zone 1 terminate within South Carolina and have a maximum travel time of 1,284 yr. In zone 2, the 200-yr time-of-travel interval (fig. D9) indicates about 10 percent (table D1) of the particles applied have migrated to discharge areas along Upper Three Runs Creek and Pen Branch with several particles moving toward trans-river areas on the Georgia side of the Savannah River. All particles released from zone 2 terminate within South Carolina and have a maximum travel time of 11,426 yr. In zones 4 and 5, the 500-yr-time-of-travel interval (figs. D11–D12) shows general ground-water movement to the south with particle discharge areas located north of the Savannah River on the South Carolina side. The final endpoints from particles placed in zones 1–3 indicate that most of the particles discharge to areas along Upper Three Runs Creek, and in zones 4 and 5 most of the particles discharge to alluvial areas on the South Carolina side of the Savannah River.

Trans-River Flow

Simulated trans-river flow for Scenario D was limited to ground water moving to discharge areas located near Flowery Gap Landing along the Savannah River (fig. D13). For these trans-river flow areas, recharge occurred between D Area and K Area on the SRS. Of the 300 particles released near Flowery Gap Landing, 92 particles (31 percent) backtracked to recharge areas on the SRS. The remaining 208 particles backtracked to areas along the western model boundary on the Georgia side of the Savannah River. For the particles that backtracked toward the SRS, the mean travel time was 535 yr, with a median value of 507 yr. The cross-sectional view indicates shorter travel times ranged from 110 to 180 yr within layer A2 (Gordon aquifer), and longer travel times ranged from 540 to 850 yr within layers A4 and A5 (upper and lower Dublin aquifers). Also, the cross section shows layer A3 (Millers Pond aquifer) has minimal thickness in this area and has minor effects on particle movement. The 100 yr-time-of-travel interval indicates slow movement through layers A4 and A5 (upper and lower Dublin aquifers). In map view, two particles have backtracked to recharge cells located southwest of R Area, with a simulated travel times of 1,390 and 2,190 yr, respectively (fig. D13). The Gordon confining unit (C1) generally is from 20 to 30 ft thick between D Area and K Area and time-of-travel from the base of the Upper Three Runs aquifer (source-sink layer A1) into the Gordon aquifer (layer A2) is about 10 yr.

Table D1. Time-of-travel for particles seeded in recharge areas (five zones) on Savannah River Site, South Carolina, and forward tracked through time to discharge areas.

Zone number	Number of particles applied		[1]1987–92	2002	Scenario A	Scenario B	Scenario C	Scenario D
			Boundary conditions					
			Wet	Dry	Average	Average	Average	Dry
			Time-of-travel, in years					
Zone 1	984	Mean	301	294	294	249	293	293
		90th percentile	545	561	552	440	550	560
		75th percentile	404	412	407	335	408	417
		Median	264	231	228	217	228	234
		25th percentile	166	164	163	150	163	149
		10th percentile	92	94	91	64	91	94
		Maximum	2,121	1,113	2,481	1,294	1,393	1,284
		Minimum	19	22	21	20	21	22
Zone 2	1,148	Mean	823	917	848	866	861	928
		90th percentile	1,289	1,554	1,364	1,524	1,384	1,587
		75th percentile	828	874	813	819	827	875
		Median	543	591	561	524	564	593
		25th percentile	367	408	388	323	388	407
		10th percentile	212	218	222	144	220	213
		Maximum	6,715	9,425	6,703	27,276	6,699	11,426
		Minimum	28	30	29	29	29	30
Zone 3	1,161	Mean	1,051	1,100	1,095	947	1,085	1,120
		90th percentile	1,553	1,740	1,804	1,764	1,773	1,856
		75th percentile	1,275	1,419	1,375	1,339	1,373	1,429
		Median	1,020	1,146	1,105	834	1,084	1,142
		25th percentile	442	523	470	411	469	518
		10th percentile	178	207	183	181	183	207
		Maximum	58,102	9,724	11,778	5,916	14,658	9,916
		Minimum	61	80	63	63	63	79
Zone 4	882	Mean	522	505	508	494	495	502
		90th percentile	961	969	949	926	940	967
		75th percentile	624	595	600	592	595	594
		Median	402	404	398	395	397	402
		25th percentile	324	335	329	327	327	335
		10th percentile	225	238	233	232	229	236
		Maximum	2,870	1,589	5,741	3,015	1,560	1,647
		Minimum	123	125	124	143	122	123
Zone 5	668	Mean	1,570	1,553	1,532	1,491	1,532	1,552
		90th percentile	2,296	2,218	2,391	2,303	2,453	2,207
		75th percentile	1,575	1,609	1,628	1,596	1,612	1,626
		Median	1,340	1,337	1,349	1,307	1,348	1,354
		25th percentile	1,132	966	1,052	998	1,138	1,108
		10th percentile	672	444	510	460	463	434
		Maximum	13,217	16,045	12,874	11,443	12,071	19,304
		Minimum	38	34	36	36	36	34

[1]Clarke and West (1998)

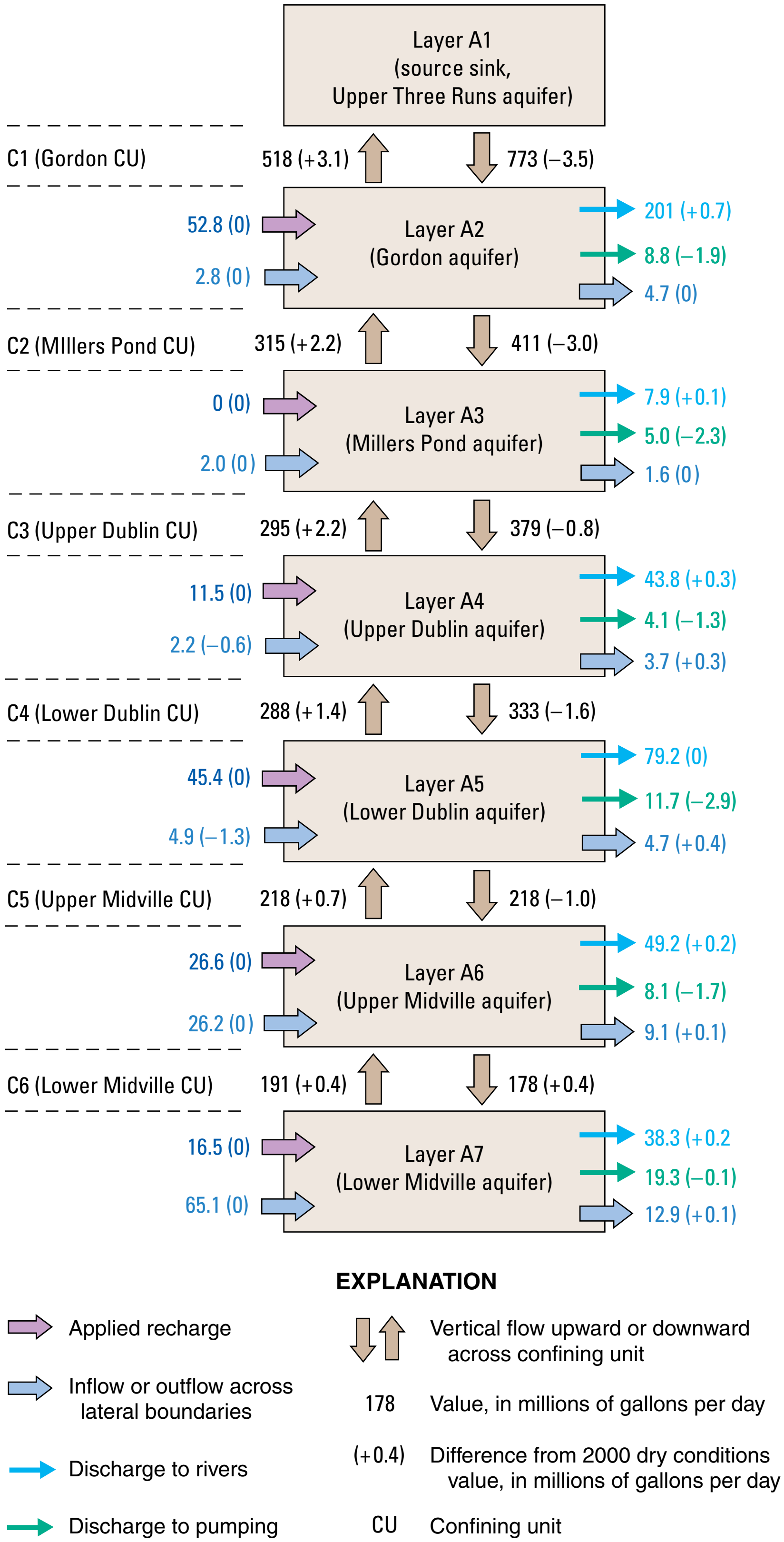


Figure D1. Simulated 2020 dry conditions (Scenario D) water budget by layer and comparison of budget terms with simulated 2002 dry conditions.

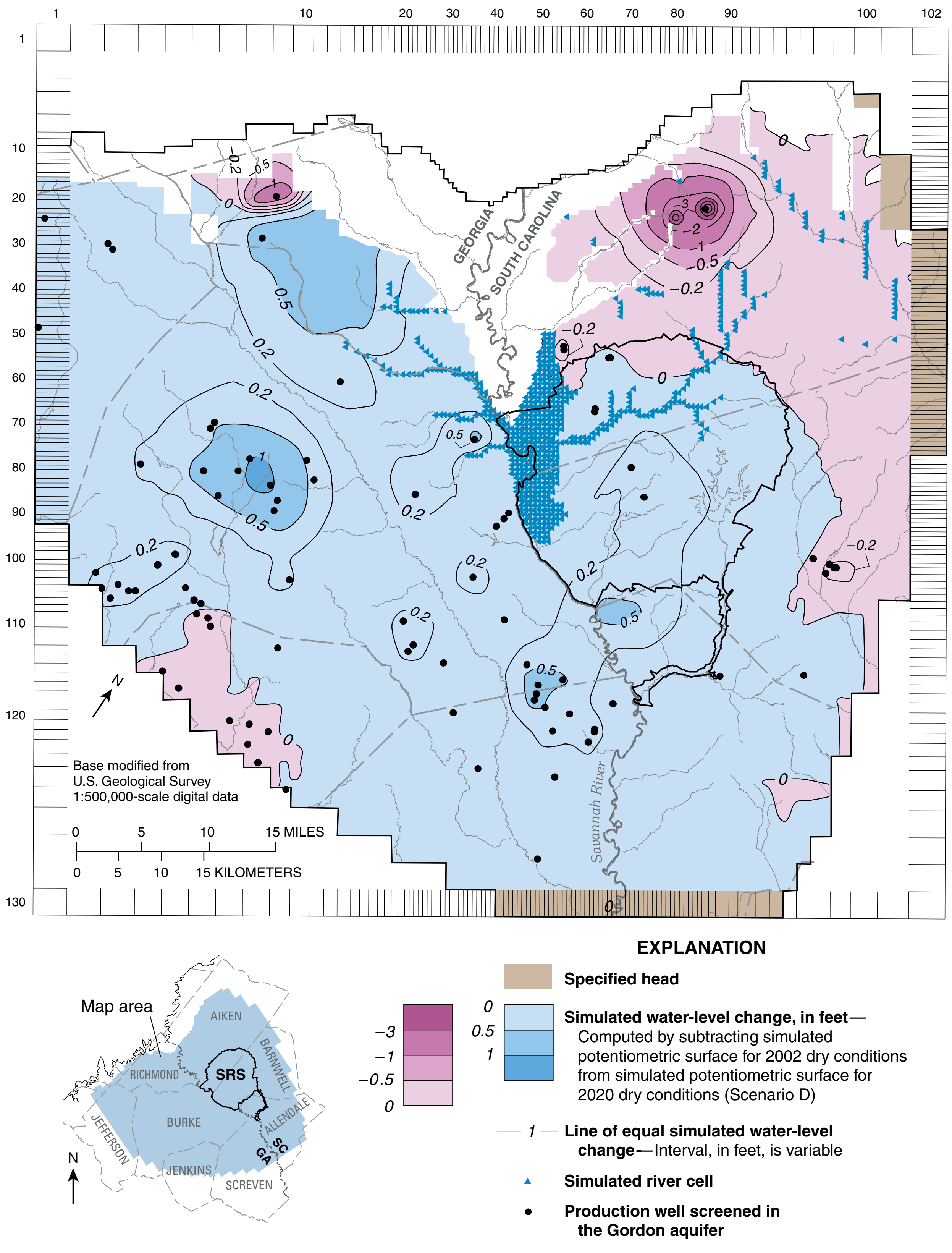


Figure D2. Simulated water-level change between 2002 dry conditions and 2020 dry conditions (Scenario D), and locations of simulated pumpage in the Gordon aquifer (layer A2) in the Savannah River Site (SRS) area, South Carolina.

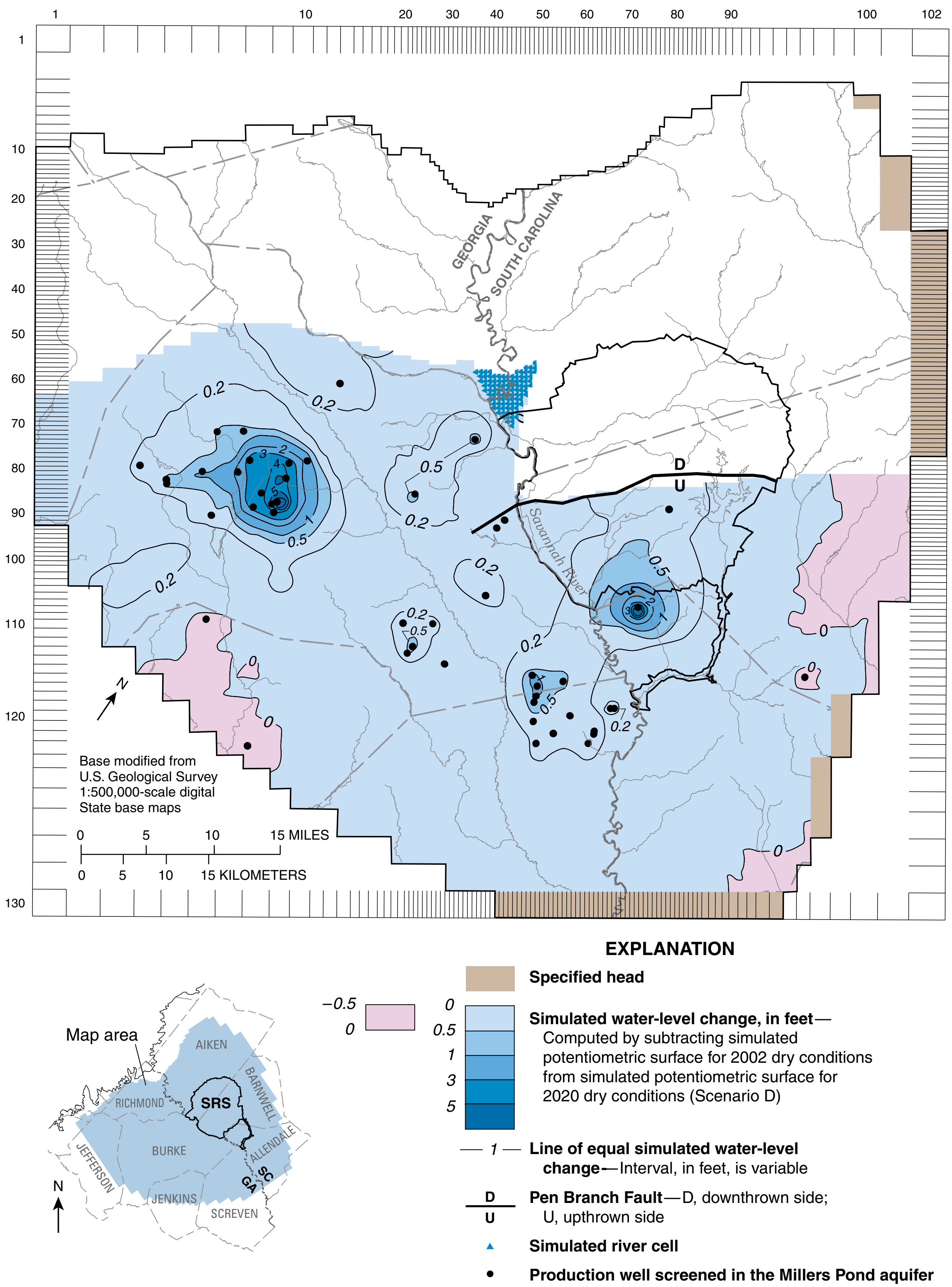


Figure D3. Simulated water-level change between 2002 dry conditions and 2020 dry conditions (Scenario D), and locations of simulated pumpage in the Millers Pond aquifer (layer A3) in the Savannah River Site (SRS) area, South Carolina.

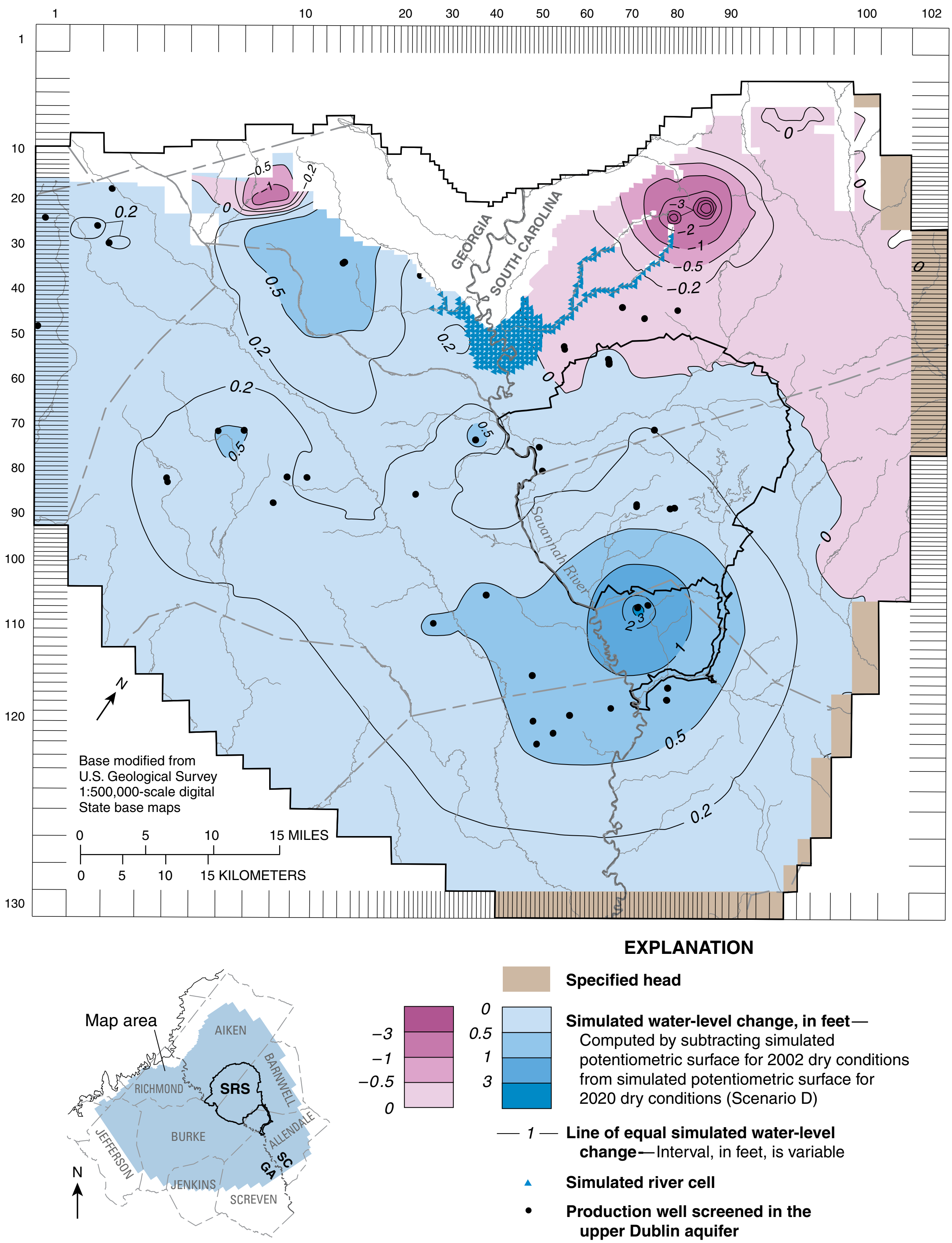


Figure D4. Simulated water-level change between 2002 dry conditions and 2020 dry conditions (Scenario D), and locations of simulated pumpage in the upper Dublin aquifer (layer A4) in the Savannah River Site (SRS) area, South Carolina.

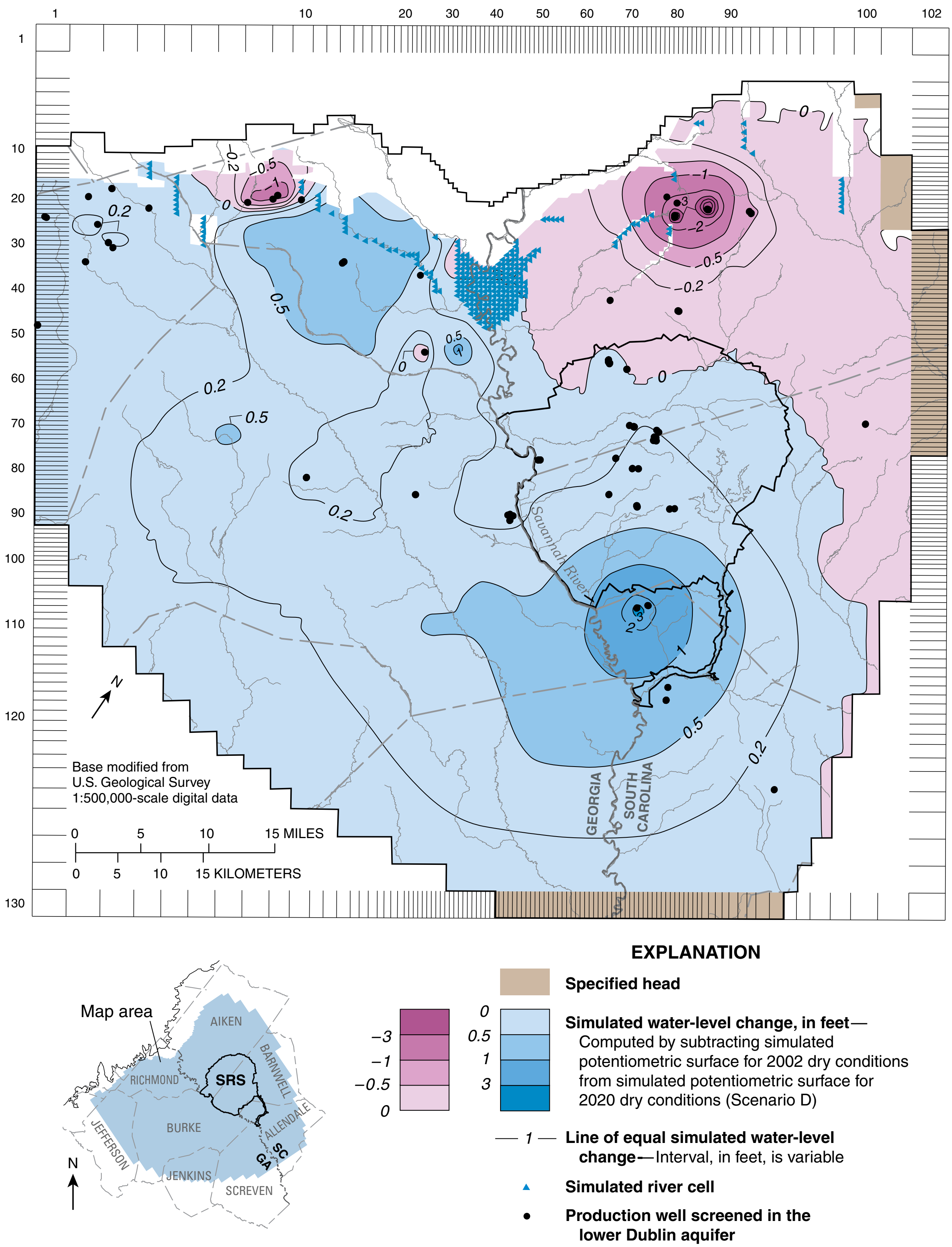


Figure D5. Simulated water-level change between 2002 dry conditions and 2020 dry conditions (Scenario D), and locations of simulated pumpage in the upper Midville aquifer (layer A5) in the Savannah River Site (SRS) area, South Carolina.

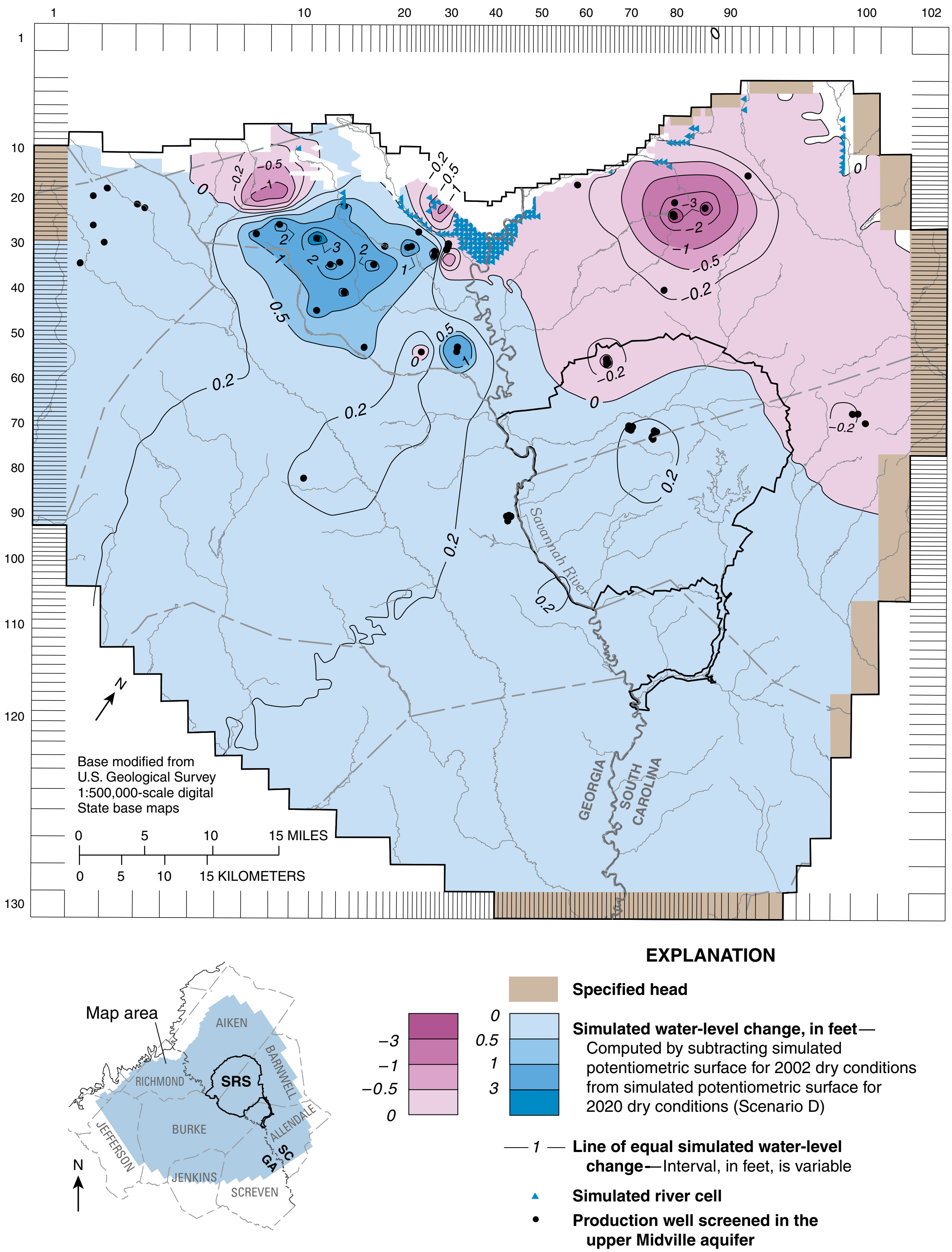


Figure D6. Simulated water-level change between 2002 dry conditions and 2020 dry conditions (Scenario D), and locations of simulated pumpage in the upper Midville aquifer (layer A6) in the Savannah River Site (SRS) area, South Carolina.

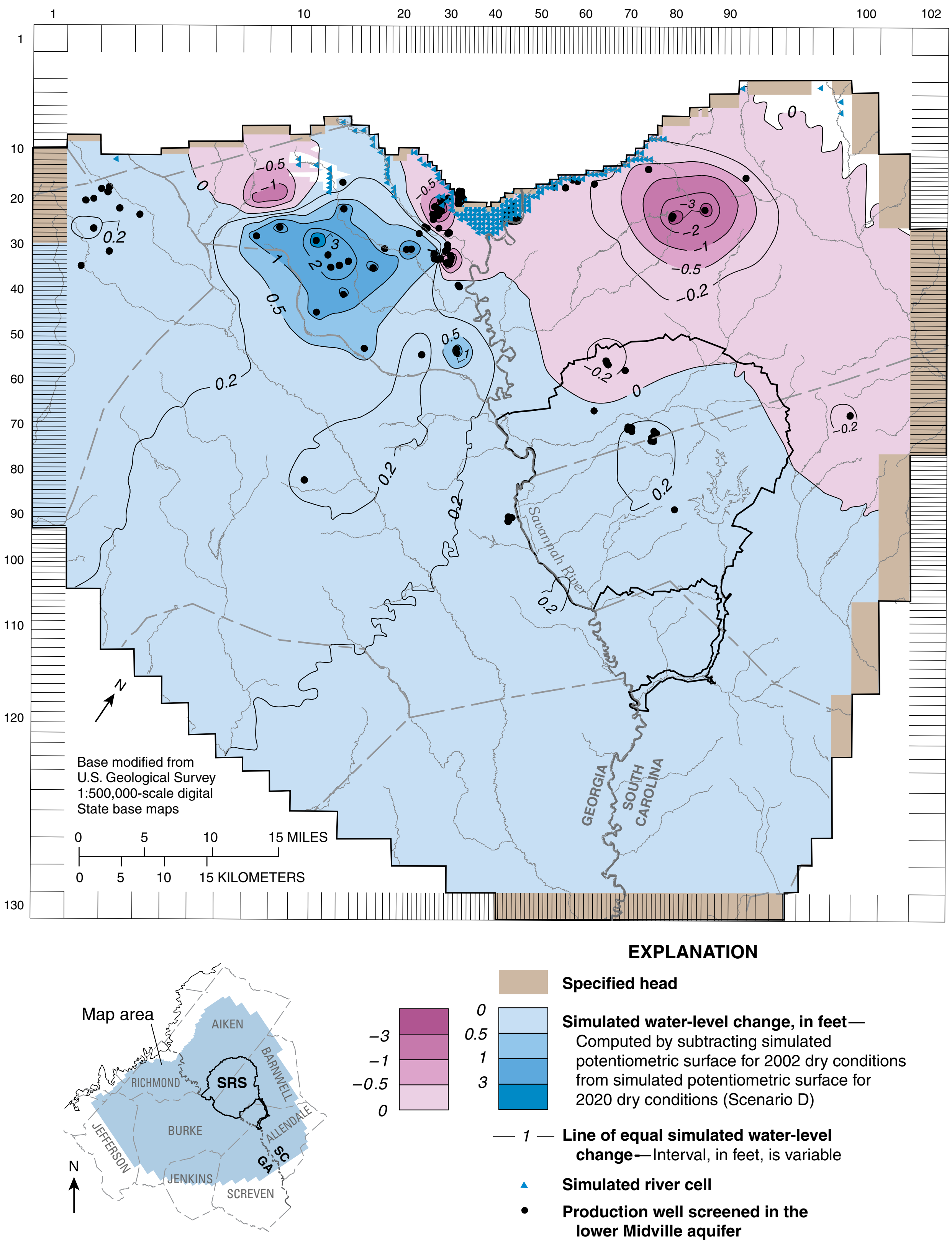


Figure D7. Simulated water-level change between 2002 dry conditions and 2020 dry conditions (Scenario D), and locations of simulated pumpage in the lower Midville aquifer (layer A7) in the Savannah River Site (SRS) area, South Carolina.

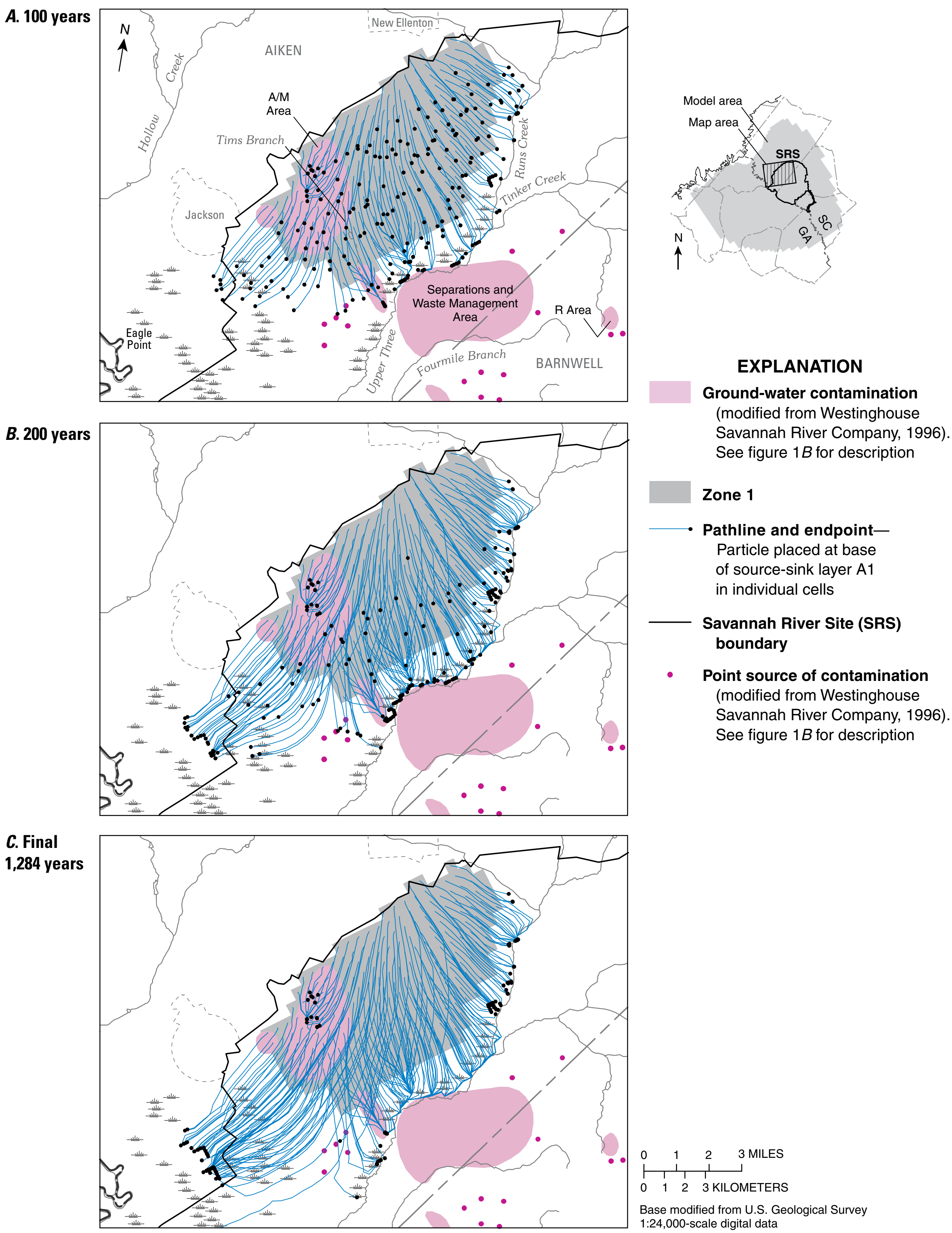


Figure D8. Particle-tracking results from the simulation of 2020 dry conditions (Scenario D) at selected time intervals in zone 1 located in the northwestern part of the Savannah River Site, South Carolina.

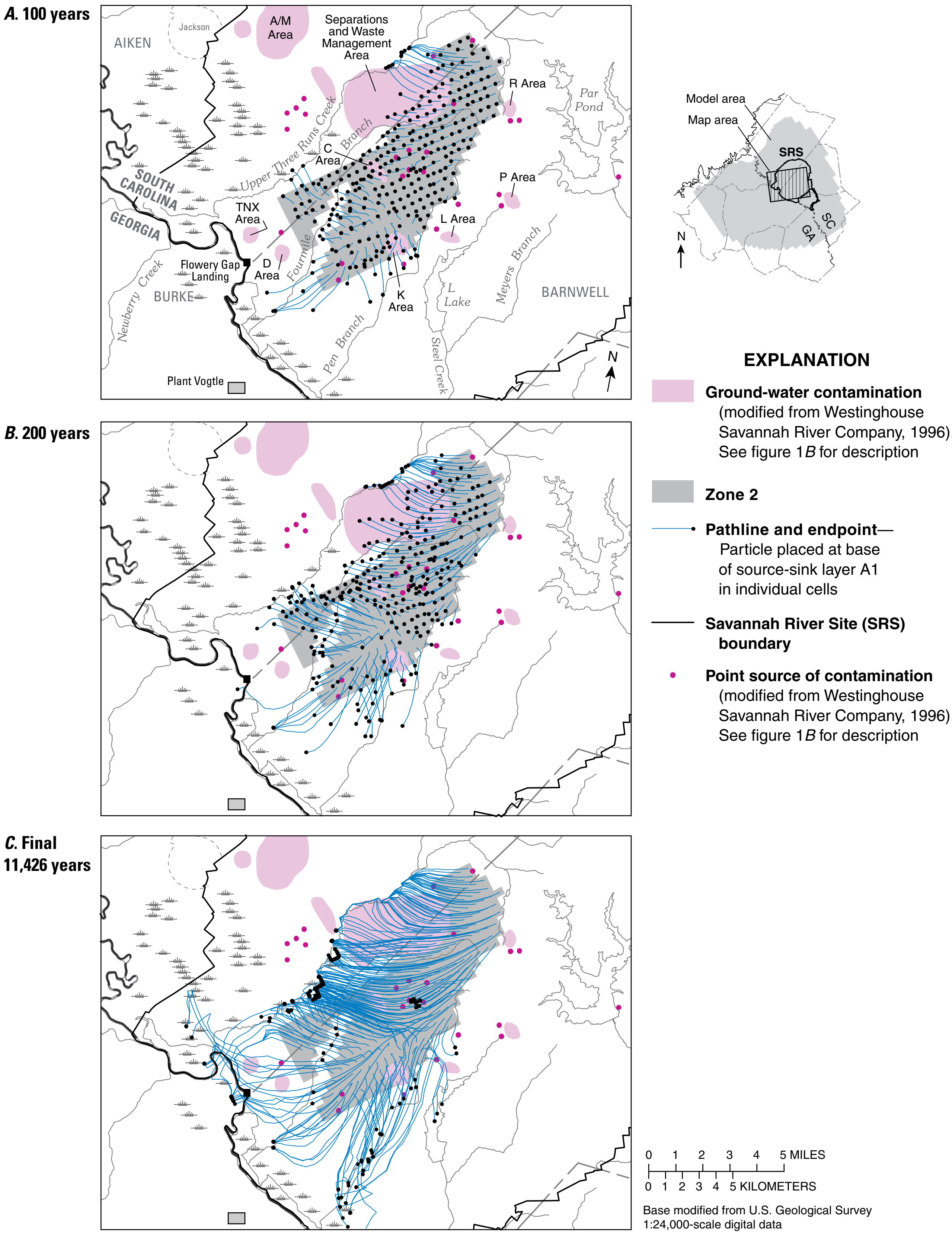


Figure D9. Particle-tracking results from the simulation of 2020 dry conditions (Scenario D) at selected time intervals in zone 2 located in the central part of the Savannah River Site, South Carolina.

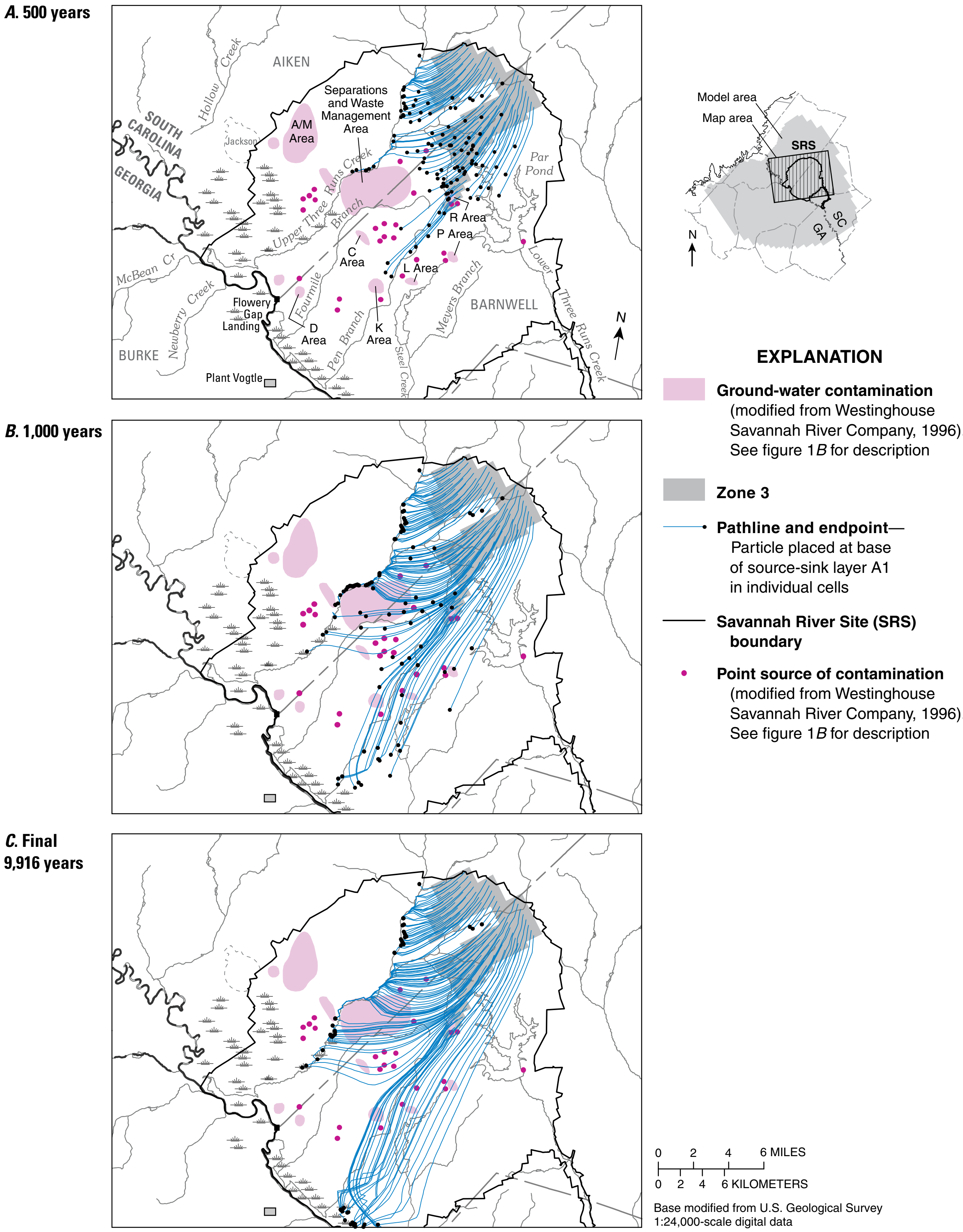


Figure D10. Particle-tracking results from the simulation of 2020 dry conditions (Scenario D) at selected time intervals in zone 3 located in the northeastern part of the Savannah River Site, South Carolina.

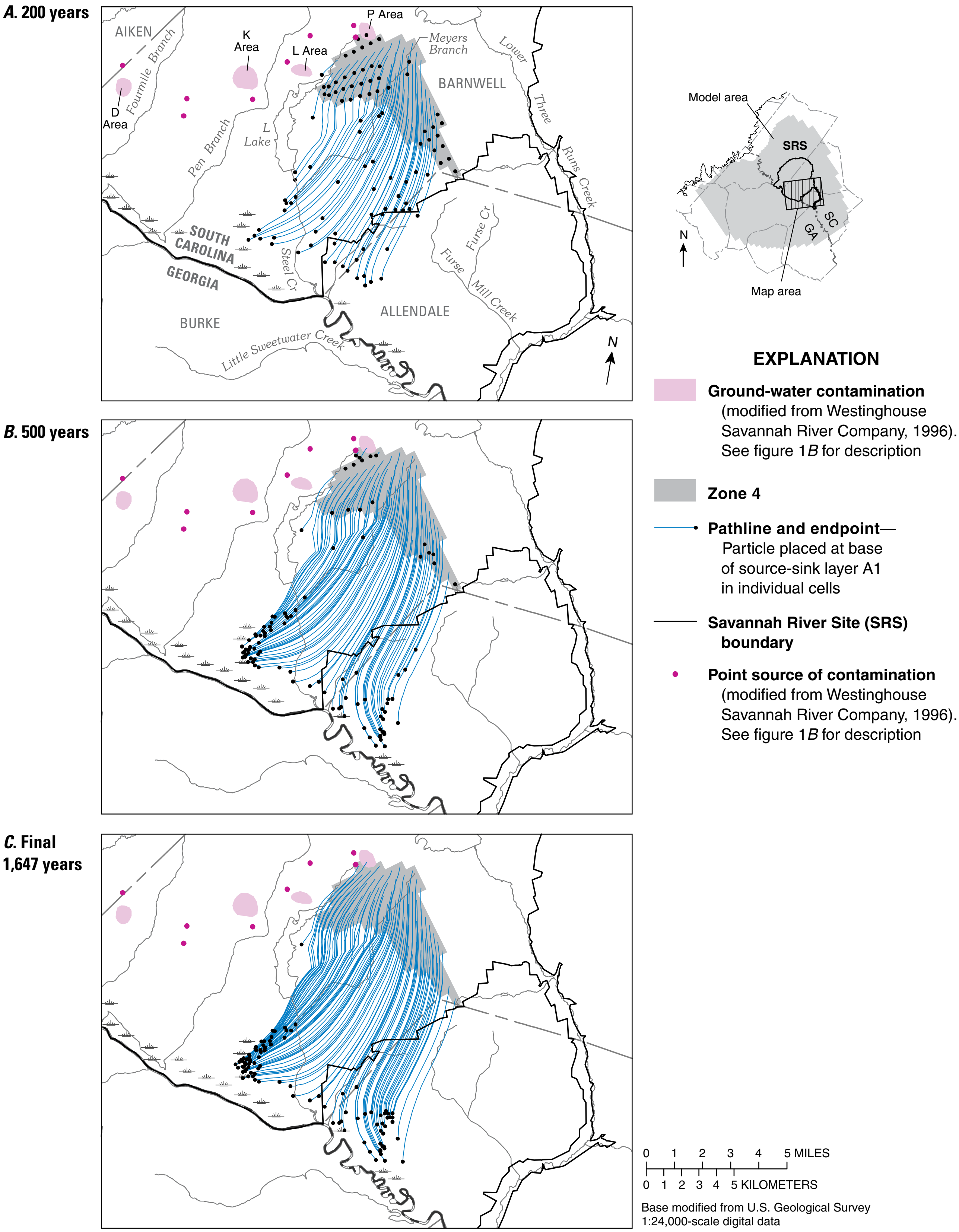


Figure D11. Particle-tracking results from the simulation of 2020 dry conditions (Scenario D) at selected time intervals in zone 4 located in the south-central part of the Savannah River Site, South Carolina.

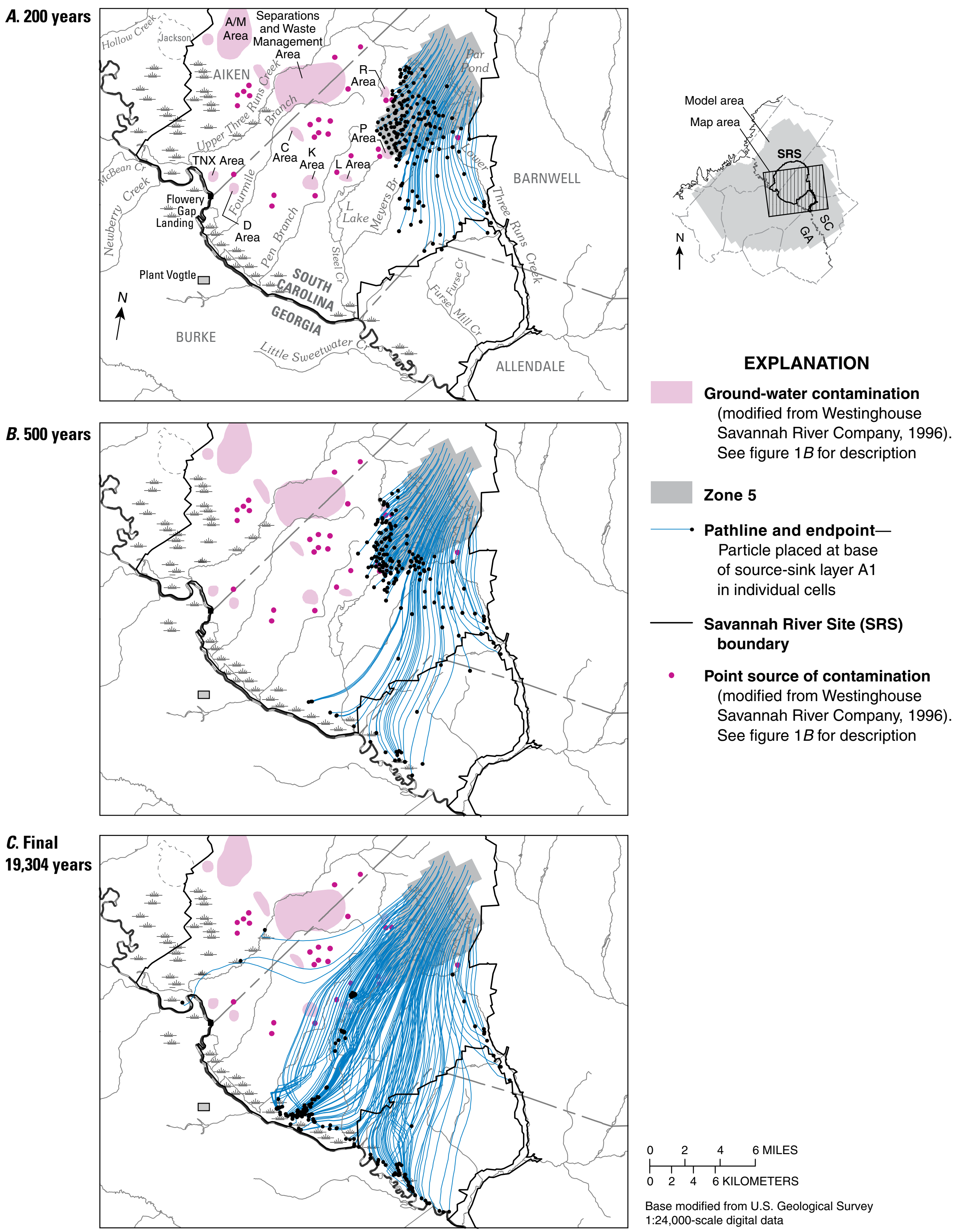
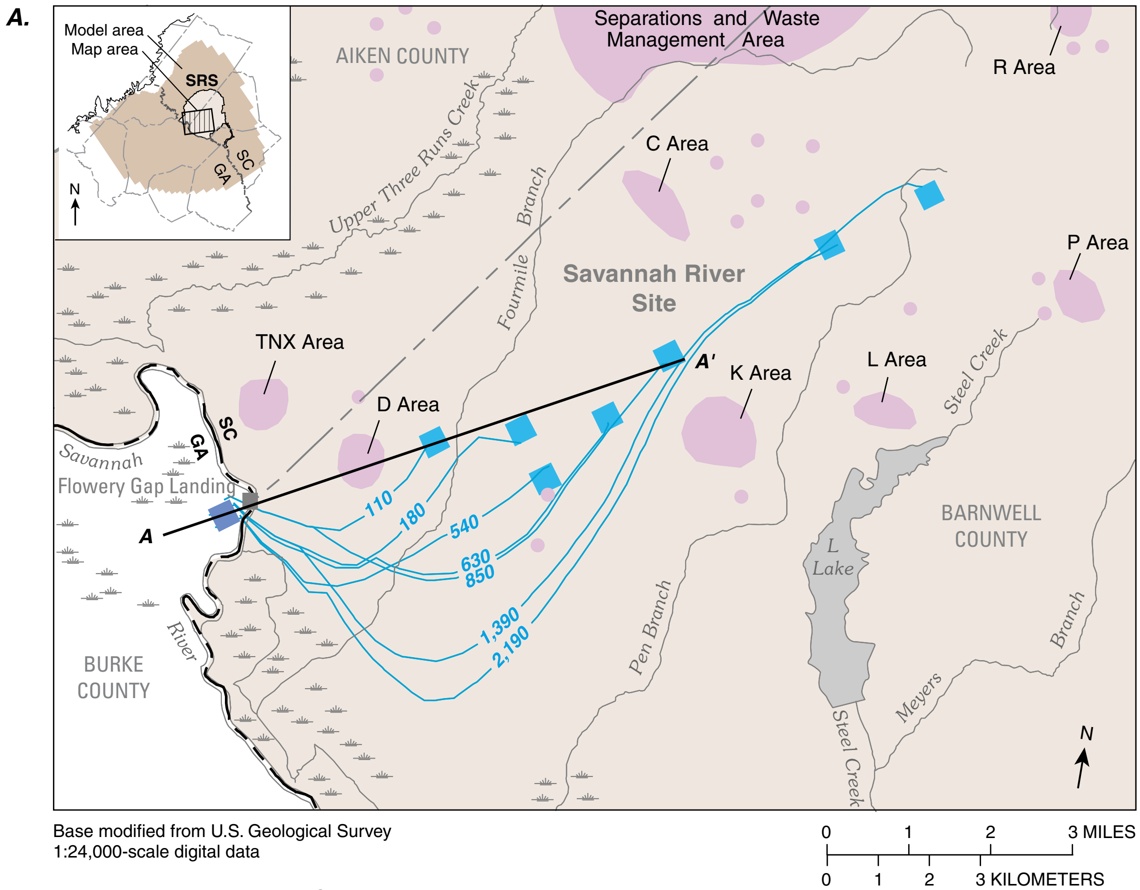
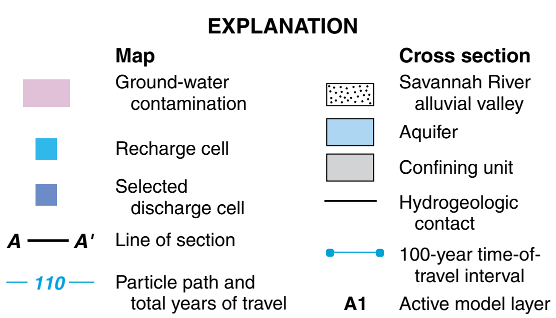


Figure D12. Particle-tracking results from the simulation of 2020 dry conditions (Scenario D) at selected time intervals in zone 5 located in the eastern part of the Savannah River Site, South Carolina.





	Simulation		
	[1]1987–92	2002 Scenario A	2020 Scenario D (projected pumping rates)
Boundary conditions	Long-term average	Average	Average
Particles released	300	300	300
Recharge on SRS	93	89	92
Time-of-travel, in years			
Mean	534	516	535
90th percentile	978	934	1,011
75th percentile	753	736	757
Median	486	462	507
25th percentile	140	145	151
10th percentile	102	103	103
Maximum	2,356	2,299	1,845
Minimum	80	81	79

[1]Clarke and West, 1998

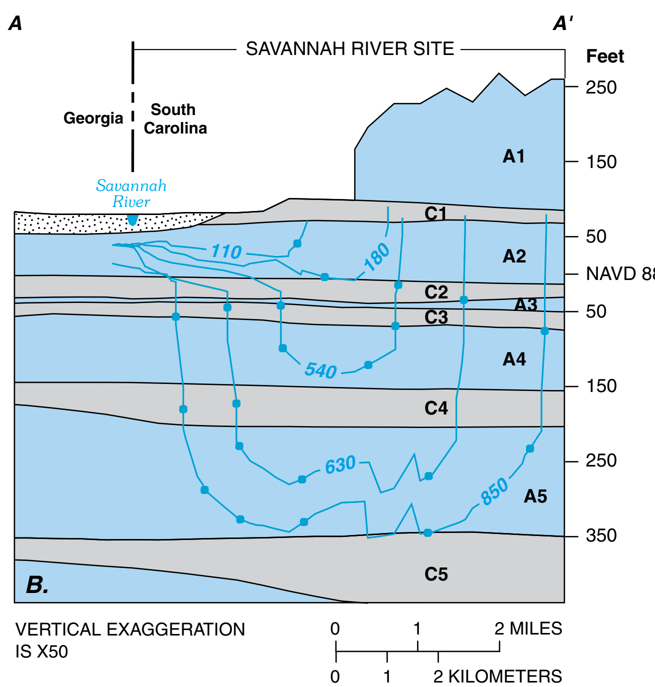


Figure D13. (***A***) Simulated trans-river flow for 2020 dry conditions (Scenario D) and selected ground-water pathlines in map view, and (***B***) selected ground-water pathlines in cross-sectional view along row 82 (see figure 8) at the Savannah River Site (SRS), South Carolina.