PRECIPITATION, GROUND-WATER USE, AND GROUND-WATER LEVELS IN THE VICINITY OF THE SAVANNAH RIVER SITE, GEORGIA AND SOUTH CAROLINA, 1992–2002

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Abstract. Contamination of ground water at the U.S. Department of Energy Savannah River Site has raised concern over the possible migration of water-borne contaminants beneath the Savannah River and into Georgia (trans-river flow). As part of a 1991–97 study, the U.S. Geological Survey completed a steady-state ground-water flow model simulating predevelopment and 1987–92 flow conditions for the Savannah River Site and vicinity.

Overall, ground-water withdrawals have increased from 80 million gallons per day for the model simulation period from 1987 through 1992 to 117 million gallons per day in 2000. Ground-water use for irrigation increased from 24.8 million gallons per day in 1995 to 63.3 million gallons per day in 2000. Most of this use was from the Upper Three Runs aquifer in the southern part of the study area and the Gordon aquifer and Dublin aquifer system in updip areas to the north. Potentiometric surface maps show average head declines of 10.6 feet in wells tapping the Upper Three Runs aquifer, 12.5 feet in wells tapping the Gordon aquifer, 8.6 feet in wells tapping the Dublin aquifer system, and 5.5 feet in wells tapping the Midville aquifer system. The water level in wells at the Brighams Landing well-cluster site shows a downward trend in each of the aquifers along with the seasonal decline from ground-water withdrawals for irrigation in the Gordon aquifer. Potentiometric-surface maps constructed from 2002 water levels that show overall declines in aquifer heads have shifted the contours to the west-northwest on the Georgia side and to the north on the South Carolina side of the study area. The ground-water divide beneath the Savannah River has shifted in the upstream direction for the Gordon aquifer and has extended farther downstream for the Dublin and Midville aquifer systems.

INTRODUCTION

The U.S. Department of Energy (DOE), Savannah River Site (SRS) located near Aiken, S.C. (Fig. 1), has manufactured nuclear materials for the National defense since the early 1950s. A variety of hazardous materials—including radionuclides, volatile organic compounds, and trace metals—are either disposed of or stored at several locations on the SRS. State of Georgia officials have raised concern over the possible migration of contaminants from the SRS into the underlying aquifers and beneath the Savannah River (trans-river flow) into Georgia. As part of a 1991–97 study, the U.S. Geological Survey (USGS) completed a steady-state ground-water flow model simulating predevelopment and 1987–92

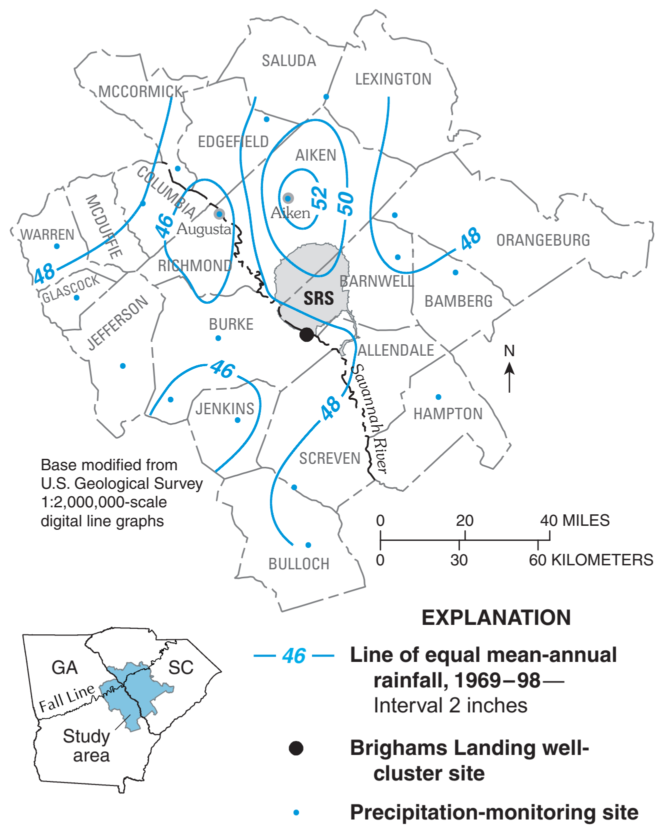

Figure 1. Study area, Savannah River Site (SRS), Brighams Landing well-cluster site, mean-annual rainfall for 1969–98, and precipitation monitoring sites.

flow conditions for the SRS and vicinity (Clarke and West, 1998). The model simulations included particle-tracking analysis of ground-water movement from the present-day Savannah River floodplain to areas of recharge.

The USGS, in cooperation with the DOE, is conducting additional work to determine the occurrence of trans-river flow under current and future hydrologic conditions. The major objectives of this study are (1) to update the previously developed ground-water flow model to better define present-day ground-water flowpaths near SRS and (2) to use the updated model to describe ground-water flowpaths and quantify ground-water flow near SRS under a variety of hypothetical pumping scenarios.

Purpose and Scope

This paper describes changes in climatic, hydrologic, and pumping conditions that occurred since calibration of the earlier (1987–92) ground-water model. Ground-water level measurements were made in 189 wells in early September 2002, and maps were constructed showing the potentiometric surface of the Upper Three Runs and Gordon aquifers, and the Dublin and Midville aquifer system. Continuous and periodic ground-water level measurements were evaluated to determine trends during 1992–2002. Precipitation data were compiled for Augusta, Ga., and the departure was computed from normal conditions (based on the period 1969–98). Water-use data were compiled for irrigation, industrial, and public supply ground-water use categories from 1992 to 2000 using reports and data files.

Previous Investigations

Clarke and West (1997) provided the foundation for the earlier ground-water-modeling study by reporting on ground-water level fluctuations and trends, water use, precipitation, and estimated ground-water contribution to streamflow. Clarke and West (1998) described development and calibration of the ground-water model for predevelopment and 1987–92 conditions. Falls and others (1997) provided the hydrogeologic framework for the ground-water model by subdividing the three aquifer systems into seven aquifers and six confining units.

Description of Study Area

The 5,147 square-mile (mi^2) study area is in the Coastal Plain physiographic province and covers the same area investigated during the earlier 1991–97 study, including the SRS and adjacent parts of Georgia and South Carolina (Fig. 1). Coastal Plain sediments consist of layers of silt, clay, sand, and minor amounts of limestone ranging in age from Cretaceous to Tertiary. Sediments dip to the southeast away from the Fall Line and reach a maximum thickness of about 2,700 feet near the southern boundary of the study area (Wait and Davis, 1986). These younger unconsolidated formations are divided into three aquifer systems consisting of seven aquifers that are hydraulically separated by confining units of clay and sand. In updip areas to the northwest, the confining units thin and become progressively sandier, and aquifers and aquifer systems coalesce or are incised by the Savannah River and other major streams. The aquifer systems are, in descending order, the Floridan, Dublin, and Midville (Falls and others, 1997). The Floridan aquifer system consists of the Upper Three Runs and Gordon aquifers; the Dublin aquifer system consists of the Millers Pond, and the upper and lower Dublin aquifers; and the Midville aquifer system consists of the upper and lower Midville aquifers (Fig. 2).

HYDROGEOLOGIC UNITS				GEOLOGIC UNITS	SERIES	SYSTEM
This study	South Carolina		Georgia	This study		
Upper Three Runs aquifer	Upper Three Runs aquifer	Floridan aquifer system	Upper Floridan aquifer/ Jacksonian aquifer	Post-Eocene	Post-Eocene	Tertiary
				Barnwell Group	Eocene	
Gordon confining unit	Gordon confining unit		Gordon confining unit	Santee Formation		
Gordon aquifer	Gordon aquifer		Gordon aquifer system	Congaree Formation		
Millers Pond confining unit	Crouch Branch confining unit	Meyers Branch confining system	Dublin confining unit	Snapp Formation	Paleocene	
Millers Pond aquifer			Dublin aquifer system			
Upper Dublin confining unit				Ellenton Formation		
Upper Dublin aquifer	Crouch Branch aquifer	Dublin aquifer system		Steel Creek Formation	Upper Cretaceous	Cretaceous
Lower Dublin confining unit				Black Creek Group (undivided)		
Lower Dublin aquifer						
Upper Midville confining unit	McQueen Branch confining unit	Allendale confining system	Midville confining unit			
Upper Midville aquifer	McQueen Branch aquifer	Midville aquifer system	Midville aquifer system			
Lower Midville confining unit				Middendorf Formation		
Lower Midville aquifer						
Basal confining unit	Appleton confining system		Confining unit	Cape Fear Formation		

Figure 2. Hydrogeologic units and geologic units at the Savannah River Site, South Carolina (modified from Falls and others, 1997).

PRECIPITATION

Average annual precipitation for the period 1969–98 ranged from just under 45 inches near Augusta, Ga., to greater than 52 inches near Aiken, S.C. (Fig. 1). Normal precipitation was defined as the average yearly rainfall during the 30-year period (1969–98) and cumulative departure from normal is shown through 2001 for Augusta (Fig. 3). During 1992–98 precipitation at Augusta was mostly above normal, as indicated by a general upward slope on the cumulative-departure graph. A prolonged drought during 1998–2001 resulted in below normal precipitation, as indicated by a steep downward slope on the cumulative-departure graph. By the end of 2001, the cumulative departure from normal precipitation was –26.6 inches.

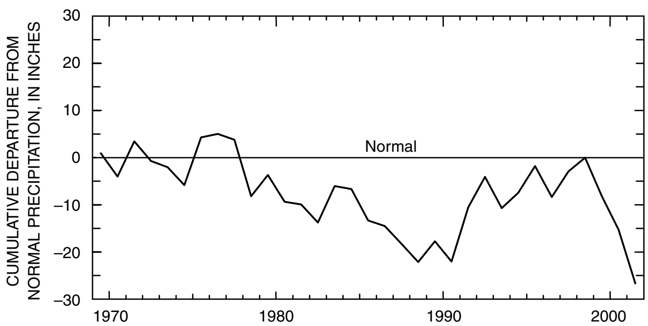

Figure 3. Cumulative departure from normal precipitation at Augusta, Georgia.

GROUND-WATER USE

Data on ground-water use in the eight county study show a substantial increase since the earlier USGS study (Fig. 4). During 1987–92, Clarke and West (1997) reported total ground-water use was about 80 million gallons a day (Mgal/d). By 1995, the total ground-water use was about 85.4 Mgal/d (Fanning, 1997). Available data for 2000 (J.L. Fanning, 2003; W.J. Stringfield, U.S. Geological Survey, written commun., 2002) show total ground-water use was about 117 Mgal/d.

The major increase in ground-water use between 1995 and 2000 is evident, in the water-use data, for Burke, Jefferson, and Screven Counties, Ga., and Allendale and Barnwell Counties, S.C. (Fig. 4). In these counties, ground-water use for irrigation increased from 16.7 Mgal/d in 1995, to 53.1 Mgal/d in 2000 and irrigated acreage increased from 61,690 acres in 1995 to 97,690 acres in 2000. In Georgia, the majority of ground-water use for irrigation is from the Upper Three Runs aquifer in Jenkins and southern Screven Counties and from the Upper Three Runs and Gordon aquifers in Jefferson, Burke, and northern Screven Counties. In South Carolina, irrigation wells in Barnwell and Allendale Counties pump ground water from the Upper Three Runs and Gordon aquifers.

Ground-water use for public supply increased from 24.4 Mgal/d in 1990 to 31 Mgal/d in 2000. Burke and Richmond Counties in Georgia and Aiken County in South Carolina accounted for most of the 7 Mgal/d increase during the 10-year period. The Richmond County Water System alone accounted for ground-water withdrawals of 14.9 Mgal/d (2000) from the Midville aquifer system near the outcrop areas, an increase of 1.7 Mgal/d since 1990.

Ground-water use for industrial and mining purposes showed a slight decrease from 22.1 Mgal/d in 1990 to 17.6 Mgal/d in 2000, as a result of the decrease in ground-water use at the SRS from 9.0 Mgal/d in 1990 to 5.5 Mgal/d in 2000 (R.A. Hiergesell, Westinghouse Savannah River Company, written commun., 2002). The other ground-water use categories of domestic/commercial, livestock, and thermoelectric remained relatively constant during 1990–2000.

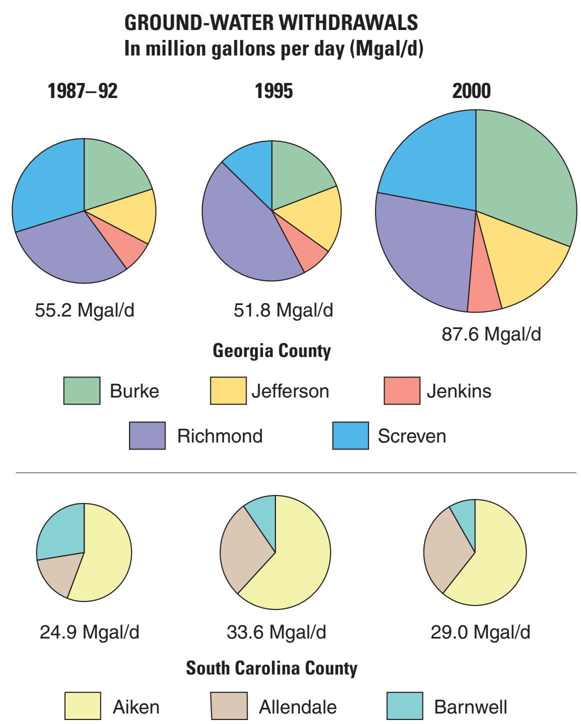

Figure 4. Ground-water use by county, Georgia and South Carolina, 1987–2000.

GROUND-WATER LEVELS

During 1992–2002, water levels in each of the major aquifers generally declined due to below-normal precipitation and increased ground-water use. Declines, based on periodic water-level measurements, in the Upper Three Runs aquifer ranged from 2 to 5 feet (ft) in northeastern Burke County and were greater than 20 ft in southern Burke and Screven Counties. In the Gordon aquifer the average decline was 12.5 ft during this period. The average decline in the Dublin aquifer system was 6.5 ft and in the Midville aquifer system was 5.5 ft. Water-level trends in the Gordon aquifer and in the Dublin and Midville aquifer systems are shown on the hydrographs for wells located at Brighams Landing, in the Savannah River valley in Burke County (Fig. 5). Water-level declines at Brighams Landing were most pronounced in the Gordon aquifer and were progressively less in the deeper Dublin and Midville aquifer systems. In well 32Y033 completed in the Gordon aquifer, the water level declined about 16 ft, from a daily-mean water-level elevation of 120.4 ft in September 1995 to 104.4 ft in September 2002. Steep seasonal declines in ground-water levels from 1998 to 2002 coincide with the growing season and heavy ground-water use for irrigation. In well 32Y031 completed in the Dublin aquifer system, the water level declined about 7 ft during the same period. The water level in well 32Y030 completed in the Midville aquifer system declined about 5 ft from September 1995 to September 2002.

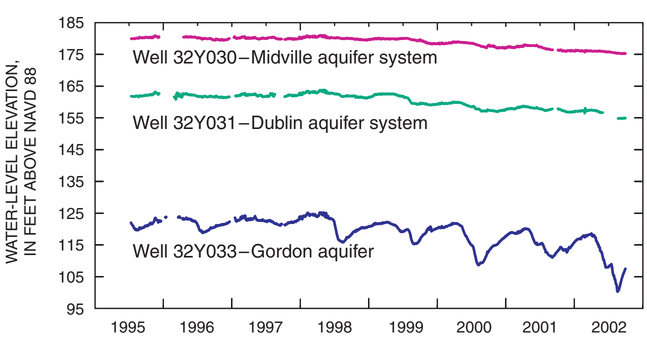

Figure 5. Water-level elevation at the Brighams Landing well-cluster site in feet above North American Vertical Datum of 1988 (NAVD 88) for wells 32Y030, 32Y031, and 32Y033 (see Figure 1 for well locations).

The potentiometric-surface map for the Upper Three Runs aquifer was constructed using water-level data from 78 wells (Fig. 6*A*). The map reflects the water-level decline that occurred during 1992-2002, especially in topographically higher areas in Burke County, Ga., and Barnwell and Allendale Counties, S.C. Decreased aquifer heads are illustrated by the northern shift of the 140- and 180-ft contours in Allendale and Barnwell Counties, S.C. Despite these declines, the general contours of the map are similar to the previous map for 1987–92.

The potentiometric-surface map for the Gordon aquifer was constructed using water-level data from 49 wells (Fig. 6*B*). The map shows the impact of drought and ground-water withdrawal on the potentiometric surface. Water-level declines are indicated by a northwestern shift of the 120- and 140-ft contours in Georgia, and by a northern shift of the 120-, 140-, 160-, and 180-ft contours in South Carolina. Perhaps the most pronounced effect on the configuration of the potentiometric surface is in the vicinity of a ground-water divide beneath the Savannah River. Here a portion of ground water flows updip toward the area where the ancient Savannah River breached the confining unit overlying the Gordon aquifer, and another segment flows southward toward the coast. The overall decline in aquifer heads for the Gordon aquifer is best illustrated by the 120-ft contour, which crossed the Savannah River in 1992, but is replaced in 2002 by the 100-ft contour. The ground-water divide beneath the river has thus moved farther upstream than in 1987–92.

The potentiometric-surface map for the Dublin aquifer system was constructed using water-level data from 32 wells (Fig. 6*C*). Water-level declines are indicated on the map by the westward shift of the 160-ft contour in Georgia and by the northern shift of the 160-, 180-, 200-, and 220-ft contours in South Carolina. The southeastern shift of the 140-ft contour beneath the Savannah River reflects water-level decline and shows an apparent movement of the position of the ground-water divide in the downstream direction.

The potentiometric-surface map for the Midville aquifer system was constructed using water-level data from 30 wells (Fig. 6*D*). Water-level decline is indicated by the westward shift of the 180-, 200-, and 220-ft contours in Georgia and by the northern shift of the 180-, 200-, and 220-ft contours in South Carolina. Further evidence of water-level decline is indicated by the downstream and eastward shift of the 160-ft contour beneath the Savannah River. In addition, it appears that the 180-ft contour, which crossed the river near Brighams Landing in 1992, now does not cross the river.

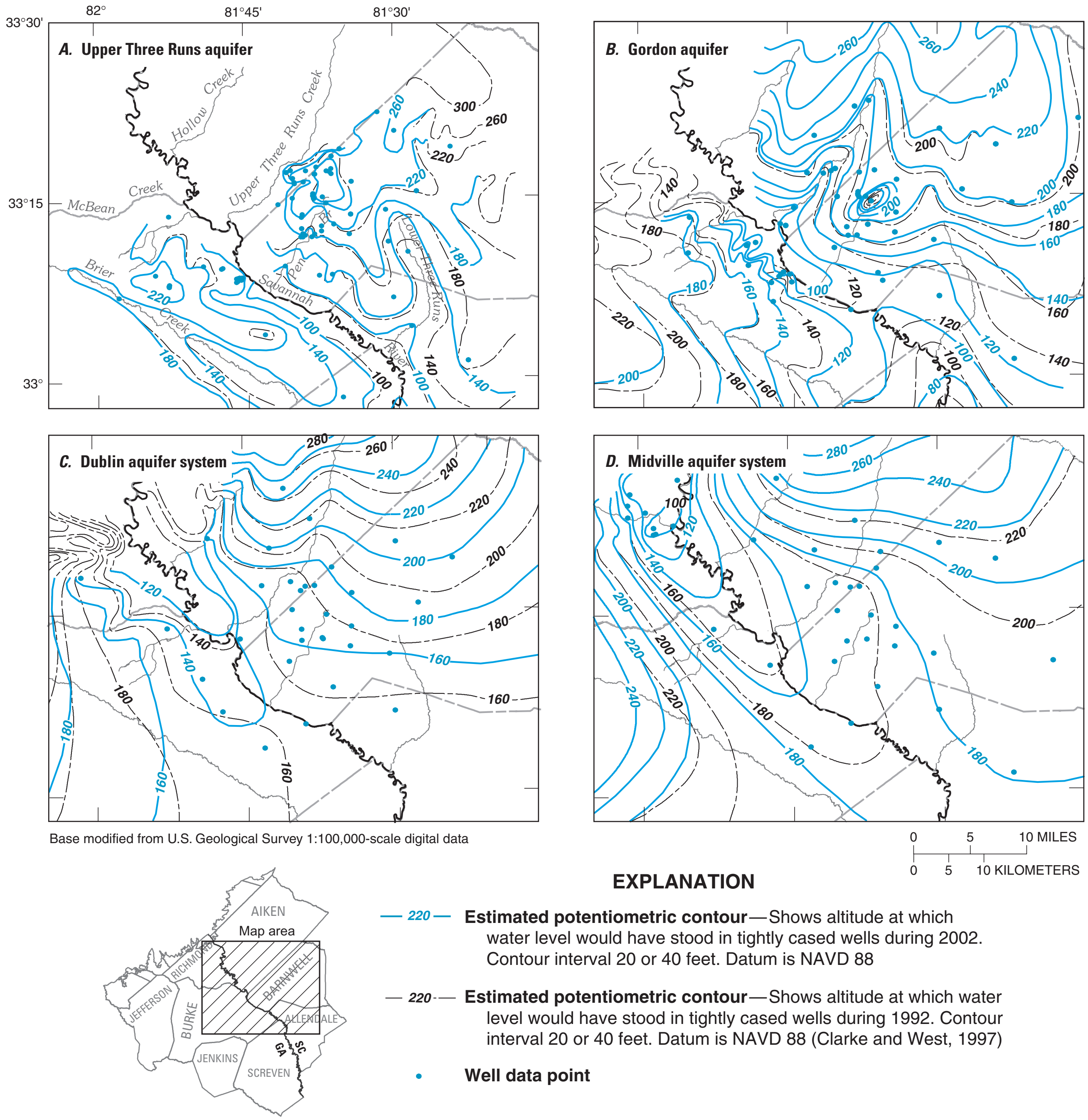

Figure 6. Potentiometric-surface maps for the *(A)* Upper Three Runs aquifer, *(B)* Gordon aquifer, *(C)* Dublin aquifer system, and *(D)* Midville aquifer system for 1992 and 2002, in the vicinity of the Savannah River Site, Georgia and South Carolina.

SUMMARY

Potentiometric-surface maps for the Upper Three Runs and Gordon aquifers and for the Dublin and Midville aquifer systems show overall declines from 1992 to 2002 because of rainfall deficits from 1999 to 2001 and increasing ground-water use for irrigation and public supply. The greatest observed water-level declines of nearly 20 feet occurred within the Upper Three Runs and Gordon aquifers in Burke and Screven Counties, Ga., because of substantial increases in ground-water use for irrigation. The water-use data for Burke, Jefferson, and Screven Counties in Georgia and Allendale and Barnwell Counties in South Carolina show ground-water withdrawal for irrigation in these counties has increased from 16.7 Mgal/d in 1995 to 53.1 Mgal/d in 2000. During 1992–98, precipitation at Augusta was mostly above normal, as indicated by a general upward slope on the cumulative-departure graph, which reduced rainfall deficits from an earlier drought in the 1980s. Water levels from the Brighams Landing well cluster site show an overall downward water-level trend in each of the confined aquifers since 1998, but the hydrograph of well 32Y033 completed in the Gordon aquifer shows an increased rate of water-level decline has occurred during the past 5 years during the growing season because of increased ground-water use for irrigation. Water-level declines within the Gordon aquifer since the previous study in 1987–92 were reflected in the potentiometric surface map where the 120-ft contour was replaced in 2002 by the 100-ft contour. The Dublin and Midville aquifer systems show overall water-level declines illustrated by the apparent movement of the contours to the west on the Georgia side of the study area and apparent movement of the contours to the north on the South Carolina side of the study area. The ground-water divide shown on the 1987–92 map has moved upstream in the Gordon aquifer and downstream along the Savannah River for the Dublin and Midville aquifer systems.

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