HYDROLOGIC ATLAS 22

POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER IN GEORGIA AND ADJACENT PARTS OF ALABAMA, FLORIDA, AND SOUTH CAROLINA, MAY 1998, AND WATER-LEVEL TRENDS IN GEORGIA, 1990–98

by

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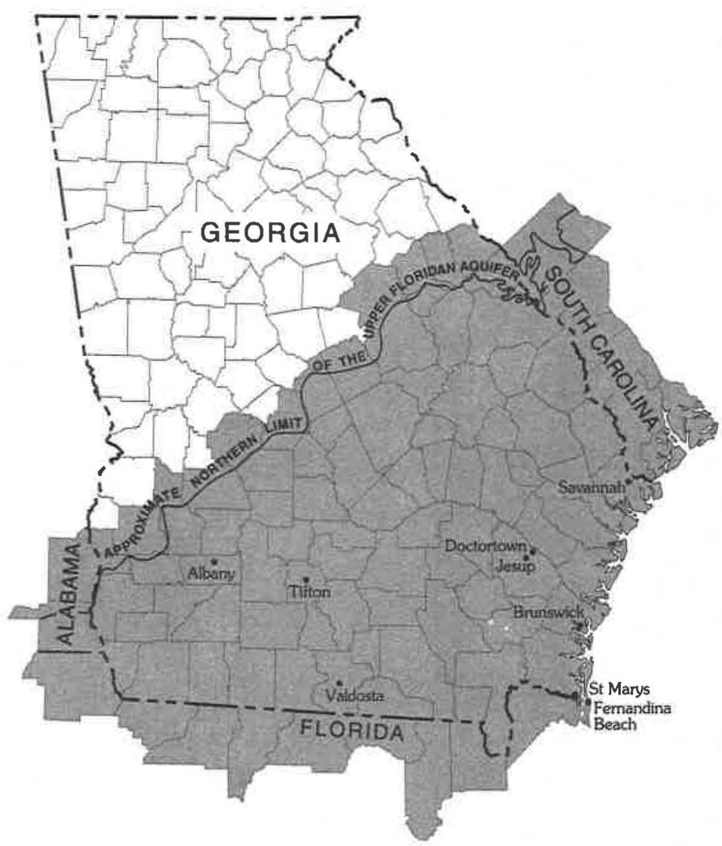

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INTRODUCTION

The Upper Floridan aquifer is part of the Floridan aquifer system that underlies most of the Coastal Plain of Georgia, southern South Carolina, extreme southeastern Alabama, and all of Florida (Miller, 1986). The aquifer system is one of the most productive in the United States and a major source of water in the region. Approximately 700 million gallons per day (Mgal/d) of water was withdrawn from the Floridan aquifer system during 1995 in Georgia. Most of this water was withdrawn from the Upper Floridan aquifer mainly for industrial and irrigation purposes (Fanning, 1997). To monitor seasonal and long-term water-level fluctuations and trends in the Upper Floridan and other aquifers in Georgia, the U.S. Geological Survey (USGS), in cooperation with the Georgia Department of Natural Resources Environmental Protection Division, Georgia Geologic Survey, and other State and local agencies, maintains a network of approximately 1,050 water-level monitoring wells, including 153 wells equipped with continuous water-level recorders.

This report illustrates and describes the potentiometric surface of the Upper Floridan aquifer in Georgia and adjacent parts of Alabama, Florida, and South Carolina for May 1998, and water-level trends in Georgia for the period May 1990 to May 1998. The potentiometric surface, which represents the altitude at which water would have stood in tightly cased wells open to the Upper Floridan aquifer, was constructed by using water-level and pressure measurements collected from more than 2,000 wells during May 1–26, 1998. The potentiometric-surface map is used to better understand ground-water flow in the Upper Floridan aquifer. In addition, the potentiometric-surface map and related water-level data will be used in the development of ground-water-flow models of the aquifer system for the coastal area of Georgia.

This report follows a similar format used by Krause and Hayes (1981) and Clarke (1987). The 1998 potentiometric-surface map is more detailed than previous maps because of recent hydrogeologic studies of the Upper Floridan aquifer and covers a larger geographic area by including adjacent parts of Alabama, Florida, and South Carolina. Recent hydrologic studies have increased the number of wells in the water-level monitoring network, providing greater detail of the potentiometric surface. Three areas of the map show the greatest increase in detail—the north-central area and northern part of the coastal area (Clarke and West, 1997, 1998), the southwestern area near Albany-Dougherty County (Hicks and others, 1987; McSwain, 1999), and the south-central area near Valdosta-Lowndes County (McConnell and Hacke, 1993; McConnell and others, 1994).

The ground-water data compiled for this report were obtained through the cooperation of numerous private well owners, industries, and local municipalities who permitted access to their wells for water-level measurements. Water-level measurements were made in cooperation with State and local agencies. In particular the authors would like to thank Tom Pratt and Michael Maloney of the Northwest Florida Water Management District; Ron Ceryak of the Suwannee River Water Management District; Larry Fayard of the St. Johns Water Management District; and Denny Moore and Blakeney Gillett of the Alabama Geological Survey for their assistance in the collection and tabulation of ground-water data used in this report.

POTENTIOMETRIC SURFACE AND WATER-LEVEL TRENDS

The configuration of a potentiometric surface indicates general directions of ground-water flow and areas of recharge (highest water levels) and discharge (lowest water levels). Water infiltrating an aquifer flows from recharge areas to discharge areas. The Coastal Plain of Georgia has been informally divided into four subareas for discussion of the configuration of the potentiometric surface and water-level trends; these are the southwestern, south-central, north-central, and coastal areas. These hydrologic areas are similar to those used by Clarke (1987), except for the coastal area which now includes Ware and Toombs Counties. The coastal area has been further subdivided by major pumping centers, into the Savannah, Jesup-Doctortown, Brunswick, and St Marys, Ga.-Fernandina Beach, Fla., areas.

Recharge to the Upper Floridan aquifer predominately is derived from precipitation that infiltrates the aquifer in areas where the aquifer crops out or is near land surface and the confining unit is thin or missing. In the south-central area near Valdosta, the aquifer also receives recharge directly from the Withlacoochee River which flows into sinkholes that have been exposed by erosion of the overlying confining unit (Krause, 1979; McConnell and Hacke, 1993).

One of the more prominent features of the potentiometric surface is the Gulf Trough, an area where the hydraulic gradient abruptly steepens. The Gulf Trough consists of fine grained, dense, low permeability limestone overlain by a thick sequence of Miocene and younger sediments, that extends from Colquitt County in the southwestern area to Bulloch County in the northern coastal area (Kellam and Gorday, 1990). This feature is indicated by tightly spaced potentiometric contours, particularly the 70- to 200-ft contours in the southwestern area and the 60- to 120-ft contours in the northern coastal area. Downgradient of the trough, the permeability of the Upper Floridan aquifer is high, as indicated by the widely spaced potentiometric-surface contours. In areas upgradient of the trough the Upper Floridan aquifer is thin, near land surface, poorly confined, and the permeability is lower. Here the potentiometric surface reflects surface topography and a greater interconnection with streams, as indicated by contours that bend upstream, an indication that water from the aquifer discharges to the streams.

Water levels throughout the Coastal Plain generally were higher in May 1998 than in May 1990. Water-level changes during this period are shown on selected hydrographs and the water-level-change map, and summarized by subarea in boxplots. These trends are described in the following sections.

Southwestern area

The Upper Floridan aquifer in the southwestern area is exposed or overlain by sandy clay regolith that is hydraulically connected to streams. This connection is evident on the potentiometric surface where the contours cross the Flint River and bend upstream, an indication that ground water discharges to the river. To the southeast in the area of Worth and Mitchell Counties, the potentiometric contours are more closely spaced, and the hydraulic gradient is steep because of the lower permeability sediments of the Gulf Trough. Water levels in the southwestern area generally were higher in May 1998 than in May 1990; however, water levels in south-central Worth County declined about 2 to 5 ft, and in Early, Miller, and Baker Counties declined about 1 to 19 ft.

Water-level fluctuations in the southwestern area are shown on hydrographs for well 13L003 in eastern Dougherty County and well 09F520 in central Decatur County. Water levels in these wells generally are highest in the winter and early spring and decline from late summer to early winter because of decreased precipitation and increased seasonal irrigation pumping. The seasonal pattern of irrigation pumping is evident on the hydrograph for well 09F520 in Decatur County—sharp water-level declines starting in the early spring and extending into early fall reflect irrigation pumping. Both hydrographs show pronounced water-level rises in 1994 and 1998 that correspond to periods of flooding along the Flint River. Heavy rainfall caused the Flint River to flood in July 1994, resulting in record high water levels in the Upper Floridan aquifer (Hicks, 1995). In March 1998, a flood occurred along the Flint River that resulted in even higher ground-water levels than those recorded during the 1994 flood. Water levels were higher in March 1998 than in July 1994 because the 1998 flood occurred when water levels were already at or near the annual seasonal high due to normal winter recharge. Conversely, during the July 1994 flood, the water level in the aquifer was nearing its annual seasonal low and the water-level rise was less pronounced (David W. Hicks, U.S. Geological Survey, oral comm., 1998).

South-Central area

Lowndes County, located in the south-central area, is a karst region having abundant sinkholes and sinkhole lakes that have formed where the aquifer crops out and the overlying confining unit has been removed by erosion (Krause, 1979). The Withlacoochee River flows into these sinkholes and recharges the Upper Floridan aquifer at a rate of about 70 Mgal/d (Krause, 1979). This recharge produces a potentiometric high centered around Brooks and Lowndes Counties. Water levels in the south-central area were generally higher in May 1998 than in May 1990. Water-level fluctuations in the south-central area during 1990–98 are illustrated by the hydrographs for well 19E009, located at Valdosta in Lowndes County; and 18K049, located at Tifton in Tift County. On both hydrographs, seasonal water-level fluctuations are indicated by high water levels during late winter and early spring and low water levels during late summer and fall.

North-Central area

In the north-central area, the configuration of the potentiometric surface is influenced by surface topography and streams because of the shallow depth of the Upper Floridan aquifer and the thin or absent confining unit. Stream interaction is indicated by potentiometric contours that cross the Ocmulgee, Oconee, and Ogeechee Rivers and bend upstream. Steep topographic relief, particularly near the Savannah River valley, causes a steep hydraulic gradient between topographic highs (recharge areas) and stream valleys (discharge areas) (Clarke and West, 1997). In the southeastern part of the north-central area, the lower permeability sediments of the Gulf Trough result in a steep potentiometric gradient between the 70- and 120-ft contours. Water levels in the north-central area generally were higher in May 1998 than in May 1990. Water-level fluctuations for the period 1990–98 are illustrated by the hydrographs for well 25Q001 in southern Montgomery County and well 21T001 in western Laurens County. Typical seasonal water-level variations are indicated by high water levels during late winter-early spring and low water levels during the summer and fall. Although water levels in well 21T001 show little trend, the water level in well 25Q001 declined during 1990–98, a continuation of a trend that has been recorded since 1966.

Coastal area

The configuration of the potentiometric surface of the Upper Floridan aquifer in the coastal area is characterized by four large cones of depression resulting from pumping from the Upper Floridan aquifer. Major pumping centers at Savannah, Jesup-Doctortown, Brunswick, and St Marys, Ga.-Fernandina Beach, Fla., have a pronounced effect on the configuration of the potentiometric surface of the Upper Floridan aquifer. During 1997, about 347 Mgal/d of water was withdrawn from the Upper Floridan aquifer in the coastal area (Fanning, 1999). Water levels in the coastal area generally were higher in May 1998 than in May 1990 corresponding to a decrease in pumpage from about 369 Mgal/d in 1990 (Fanning, 1992), to 347 Mgal/d in 1997 (Fanning, 1999).

Savannah area

Since development of the Upper Floridan aquifer in the Savannah area in the 1880's, pumping from the aquifer has resulted in a water-level decline of more than 100 ft and development of a widespread cone of depression centered around Savannah. In 1998, the water level near the center of the cone was 97 ft. The cone of depression in the Savannah area encompasses a larger area and is deeper than in other coastal areas, despite similar rates of pumpage, because the permeability of the Upper Floridan aquifer in this area is lower (Krause and Hayes, 1981). In addition to the Savannah area, a smaller cone of depression has developed southwest of Savannah in Liberty County because of industrial pumpage of about 17.7 Mgal/d (Fanning, 1999). Water levels in the Savannah area generally rose during the period May 1990 to May 1998, corresponding to decreased pumpage from the Upper Floridan aquifer. Pumpage decreased from about 88 Mgal/d in 1990 (Fanning, 1992), to 76 Mgal/d in 1997 (Fanning, 1999). The overall water-level rise due to reduction in industrial pumpage during 1990–98 is illustrated by the hydrograph for well 36Q008; this well is located near the center of pumping in the Savannah area.

Jesup-Doctortown area

In the Jesup-Doctortown area, a cone of depression has developed mainly as a result of industrial pumping. In 1998, the water level near the center of the cone was about 45 ft. Water levels in the Jesup-Doctortown area generally rose during the period 1990–98, corresponding to decreased pumpage from the Upper Floridan aquifer. Pumpage decreased from about 70 Mgal/d in 1990 (Fanning, 1992), to 64 Mgal/d in 1997 (Fanning, 1999). Water levels in the Jesup-Doctortown area are illustrated by the hydrograph for well 30L003. The sharp peaks on the hydrograph represent rapid water-level rises due to reductions in nearby industrial pumping.

Brunswick area

In the Brunswick area, a cone of depression has developed as a result of industrial and municipal pumping. The cone extends throughout most of eastern and southeastern Glynn County, and the water level near the center of the cone was less than –10 ft in May 1998. Although pumping rates are similar, the depth of the cone of depression at Brunswick is smaller than at Savannah and Jesup-Doctortown. This shallower depth results from leakage from underlying units and the relatively greater thickness and permeability of the Upper Floridan aquifer at Brunswick (Krause and Randolph, 1989). Water levels in the Brunswick area generally rose during May 1990 to May 1998, corresponding to decreased pumpage from the Upper Floridan aquifer. Pumpage decreased from about 85 Mgal/d in 1990 (Fanning, 1992), to 65 Mgal/d in 1997 (Fanning, 1999). The water-level rise during 1990–98 is illustrated by the hydrograph for well 33H133. The sharp peaks on the graph represent rapid rises in water level due to reductions in nearby industrial pumping.

St Marys, Georgia-Fernandina Beach, Florida

A cone of depression has developed in the St Marys, Ga.-Fernadina Beach, Fla., area as a result of industrial and municipal pumping. The cone of depression extends from southeastern Camden County, Ga., to northeastern Nassau County, Fla. Water levels in the St Marys, Ga.-Fernandina Beach, Fla., area had little trend during the period May 1990 to May 1998, even though pumpage reportedly increased from about 38 Mgal/d in 1990 (Fanning, 1992) to 40 Mgal/d in 1998 (Fanning, 1999). The water-level rise during 1990–98 is illustrated by the hydrograph for well 33E027.

SELECTED REFERENCES

Clarke, J.S., 1987, Potentiometric surface of the Upper Floridan aquifer in Georgia, May 1985, and water-level trends, 1980-85: Georgia Geologic Survey Hydrologic Atlas 16, scale 1:1,000,000, 1 sheet.

Clarke, J.S., and West, C.T., 1997, Ground-water levels, predevelopment ground-water flow, and stream-aquifer relations in the vicinity of the Savannah River Site, Georgia and South Carolina: U.S. Geological Survey Water-Resources Investigations Report 97-4197, 120 p.

_____ 1998, Simulation of ground-water flow and stream-aquifer relations in Georgia and South Carolina, predevelopment through 1992: U.S. Geological Survey Water-Resources Investigations Report 98-4062, 134 p.

Fanning, J.L., 1992, Water use in Georgia by county: Georgia Geologic Survey Information Circular 90, 98 p.

Fanning, J.L., 1997, Water use in Georgia by county for 1995: Georgia Geologic Survey Information Circular 101, 95 p.

Fanning, J.L., 1999, Water use in Coastal Georgia by county and source, 1997; and water use trends, 1980–97: Georgia Geologic Survey Information Circular 104, 37 p.

Hicks, D.W., Gill, H.E., and Longsworth, S.A., 1987, Hydrogeology, chemical quality, and availability of ground water in the Upper Floridan aquifer, Albany area, Georgia: U.S. Geological Survey Water-Resources Investigations Report 87-4145, 52 p.

Hicks, D.W., 1995, The Independence Day flood of 1994 and effects on water levels in the Upper Floridan aquifer, Albany area, Georgia: Proceedings of the 1995 Georgia Water Resources Conference, held April 11-12, 1995 at the University of Georgia, K.J. Hatcher ed. Institute of Natural Resources, University of Georgia, Athens Ga., p. 317-322.

Kellam, M.F., and Gorday, L.L., 1990, Hydrogeology of the Gulf Trough-Apalachicola Embayment area, Georgia: Georgia Geologic Survey Bulletin 94, 74 p.

Krause, R.E. 1979, Geohydrology of Brooks, Lowndes, and western Echols Counties, Georgia: U.S. Geological Survey Water-Resources Investigations Report 78-117, 48 p.

Krause, R.E., and Hayes, L.R., 1981, Potentiometric surface of the principal artesian aquifer in Georgia, May 1980: Georgia Geologic Survey Hydrologic Atlas 6, scale 1:1,000,000, 1 sheet.

Krause, R.E., and Randolph, R.B., 1989, Hydrogeology of the Floridan aquifer system in southeast Georgia and adjacent parts of Florida and South Carolina: U.S. Geological Survey Professional Paper 1403-D, 65 p.

McConnell, J.B., and Hacke, C.M., 1993, Hydrogeology, water quality, and water resources development potential of the Upper Floridan aquifer in the Valdosta area, south-central Georgia: U.S. Geological Survey Water-Resources Investigations Report 93-4044, 44 p.

McConnell J.B., Busenberg, Eurybiades, and Plummer, L.N., 1994, Water-resources data for the Valdosta area, south-central Georgia, 1961–93: U.S. Geological Survey Open-File Report 94-350, 58 p.

McSwain, K.B., 1999, Hydrogeology of the Upper Floridan aquifer in the vicinity of the Marine Corps Logistics Base near Albany, Georgia: U.S. Geological Survey Water-Resources Investigations Report 98-4202, 49 p.

Miller, J.A., 1986, Hydrogeologic framework of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina: U.S. Geological Survey Professional Paper 1403-B, 91 p.

Peck, M.F., 1991, Potentiometric surface of the Upper Floridan aquifer in Georgia and adjacent parts of Alabama, Florida, and South Carolina, May-June 1990: U.S. Geological Survey Open-File Report 91-206, 3 p.

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