PREFACE

This report is the culmination of a concerted effort by personnel of the U.S. Geological Survey who collected, compiled, organized, analyzed, verified the data, and edited and assembled the report. In addition to the authors, who had primary responsibility for ensuring that the information contained herein is accurate and complete, the following individuals contributed substantially to the collection, processing, tabulation, and review of the data:

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Cover photograph: Irrigation pivot near Brighams Landing, Burke County, Georgia
Photograph by Donald R. Dowling, U.S. Geological Survey, January 2003

Data used in this report may be obtained upon request from

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Ground-Water Conditions and Studies in Georgia, 2001

by David C. Leeth, John S. Clarke, Steven D. Craigg, and Caryl J. Wipperfurth

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VERTICAL AND HORIZONTAL DATUMS

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88). Historical data collected and stored as National Geodetic Vertical Datum of 1929 have been converted to NAVD 88 for use in this publication.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83). Historical data collected and stored as North American Datum of 1927 (NAD 27) have been converted to NAD 83 for use in this publication.

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ABSTRACT

The U.S. Geological Survey (USGS) collects ground-water data and conducts studies to monitor hydrologic conditions, to better define ground-water resources, and address problems related to water supply and water quality. Data collected as part of ground-water studies include geologic, geophysical, hydraulic property, water level, and water quality. A ground-water-level network has been established throughout most of the State of Georgia, and ground-water-quality networks have been established in the cities of Albany, Savannah, and Brunswick and in Camden County, Georgia.

Ground-water levels are monitored continuously in a network of wells completed in major aquifers of the State. This network includes 17 wells in the surficial aquifer, 12 wells in the upper and lower Brunswick aquifers, 73 wells in the Upper Floridan aquifer, 10 wells in the Lower Floridan aquifer and underlying units, 12 wells in the Claiborne aquifer, 1 well in the Gordon aquifer, 11 wells in the Clayton aquifer, 11 wells in the Cretaceous aquifer system, 2 wells in Paleozoic-rock aquifers, and 7 wells in crystalline-rock aquifers. In this report, data from these 156 wells were evaluated to determine whether mean-annual ground-water levels were within, below, or above the normal range during 2001, based on summary statistics for the period of record. Information from these summaries indicates that water levels during 2001 were below normal in almost all aquifers monitored, largely reflecting climatic effects from drought and pumping. In addition, water-level hydrographs for selected wells indicate that water levels have declined during the past 5 years (since 1997) in almost all aquifers monitored, with water levels in some wells falling below historical lows. In addition to continuous water-level data, periodic measurements taken in 52 wells in the Camden County–Charlton County area, and 65 wells in the city of Albany–Dougherty County area were used to construct potentiometric-surface maps for the Upper Floridan aquifer.

Ground-water quality in the Upper Floridan aquifer is monitored in the cities of Albany, Savannah, and Brunswick and in Camden County; and monitored in the Lower Floridan aquifer in the Savannah and Brunswick areas. In the Albany area since 1998, nitrate concentrations in the Upper Floridan aquifer have increased in 4 of the 11 wells monitored, and in 1 well, concentrations were above the U.S. Environmental Protection Agency's (USEPA) 10 milligrams per liter (mg/L) drinking-water standard. In the Savannah area, chloride concentration in water from four wells in the Upper Floridan aquifer showed no appreciable change during 2001, remaining within the USEPA 250 mg/L drinking-water standard; in seven wells completed in the Lower Floridan aquifer and in underlying zones, the chloride concentration remained above the drinking-water standard, with one well showing an increase over previous years.

In the Brunswick area, water samples from 66 wells completed in the Upper or Lower Floridan aquifers were collected during June 2001 and analyzed for chloride. A map showing chloride concentrations in the Upper Floridan aquifer during June 2001 indicates that concentrations remained above USEPA drinking-water standards across a 2-square-mile area. In the north Brunswick area, chloride concentrations in the Upper Floridan aquifer continued to increase, whereas in the south Brunswick area, concentrations continued to decrease.

In the Camden County area, chloride concentrations in six wells completed in the Upper Floridan aquifer remained within drinking-water standards. With the exception of one well, concentrations remained the same and were below 40 mg/L. In one well, concentrations showed a sharp decline during 2001, but remained above 130 mg/L.

Ongoing studies during 2001 include evaluation of agricultural chemicals in shallow ground water in southwestern Georgia; evaluation of saltwater intrusion and water-level and water-quality monitoring in the city of Brunswick–Glynn County area; evaluation of ground-water flow, and water-quality and water-level monitoring in the city of Albany–Dougherty County area; evaluation of saltwater intrusion and alternative water sources as part of the Coastal Sound Science Initiative; assessment of the effects of impoundment of Lake Seminole on water resources in southwestern Georgia; assessment of stream-aquifer relations in the lower Apalachicola–Chattahoochee–Flint River Basin; assessment of ground-water availability and supply at Fort Gordon near Augusta; and evaluation of the hydrogeology of fractured crystalline-rock aquifers in the city of Lawrenceville area and Rockdale County.

Technical highlights from selected USGS ground-water studies during 2001 include the characterization of fractured crystalline-rock aquifers at selected sites in the Lawrenceville area, the hydrogeology and aquifer tests in the Floridan aquifer system at selected sites in coastal Georgia, and the hydrogeology and ground-water quality of coastal plain sediments at Fort Gordon. Also a listing is presented of selected publications, technical presentations, and outreach activities during 2001.

INTRODUCTION

Reliable and impartial scientific information on the occurrence, quantity, quality, distribution, and movement of water is essential to resource managers, planners, and others throughout the Nation. The U.S. Geological Survey (USGS) in cooperation with numerous local, State, and Federal agencies collects hydrologic data and conducts studies to monitor hydrologic conditions and better define the water resources of Georgia and the other States.

Ground-water-level and ground-water-quality data are essential for water-resource assessment and management. Water-level measurements from observation wells are the principal source of information about the hydrologic stresses on aquifers and how these stresses affect ground-water recharge, storage, and discharge. Long-term, systematic measurements of water levels provide essential data needed to evaluate changes in the resource over time, develop ground-water models and forecast trends, and design, implement, and monitor the effectiveness of ground-water management and protection programs (Taylor and Alley, 2001).

Purpose and Scope

This report presents an overview of ground-water conditions and hydrologic studies conducted during 2001 by the USGS Water Resources Discipline office in Georgia. Summaries of selected ground-water studies with objectives and progress are presented, together with selected technical highlights. These summaries and highlights include:

- Ground-water-level and ground-water-quality conditions in Georgia during 2001, based on information collected from State and local monitoring networks;
- Characterization of fractured crystalline-rock aquifers at selected sites in the vicinity of Lawrenceville, Georgia, 2001;
- Hydrogeology and aquifer tests in the Floridan aquifer system at selected sites in coastal Georgia, 2001;
- Hydrogeology and ground-water quality of Coastal Plain sediments in the central Fort Gordon area, near Augusta, Georgia, 2001;
- Publications released and scientific conferences attended during 2001 also are summarized; and
- Previously published reports on Georgia ground-water conditions are listed in the table on the facing page.

Periodic water-level measurements were taken in 257 wells, and continuous water-level measurements were obtained from 156 wells. Of the 156 wells equipped with continuous water-level recorders, 146 wells had electronic data recorders, which recorded the water level at 60-minute intervals and these data were retrieved monthly. Thirteen wells had real-time satellite telemetry, which recorded the water level at 60-minute intervals and transmitted water-levels every 4 hours for display on the USGS Georgia District Web site at URL: *http://water.usgs.gov/ga/nwis/current?type=gw*.

Median-annual water levels for 2001 were compared to the normal range of ground-water levels for the period of record; the results of this comparison are shown on maps for selected aquifers and areas of the State. In addition, hydrographs showing monthly mean ground-water levels for the period 1997–2001 are shown with period-of-record water-level statistics.

In addition to continuous water-level records, periodic measurements in the Upper Floridan aquifer were collected during November 2001 in 65 wells in south-central Dougherty County near Albany, and a map showing the potentiometric surface of the aquifer was constructed. A similar map of the Upper Floridan aquifer was constructed for Camden and Charlton Counties and adjacent counties in Florida using water-level measurements collected during September 2001 from 52 wells (Knowles and Kinnaman, 2002).

Chloride concentrations in water collected from the Upper and Lower Floridan aquifers are shown in graphs for five wells in the city of Brunswick area, six wells in the city of Savannah area, and four wells in the Camden County area. A map showing the chloride concentration in water from the upper water-bearing zone of the Upper Floridan aquifer at Brunswick during June 12–13, 2001, was constructed using data from 65 wells. Nitrate concentrations in water from the Upper Floridan aquifer during November 13–16, 2001, were analyzed in 11 wells and plotted on a map for south-central Dougherty County near Albany.

Previous reports on ground-water conditions in Georgia

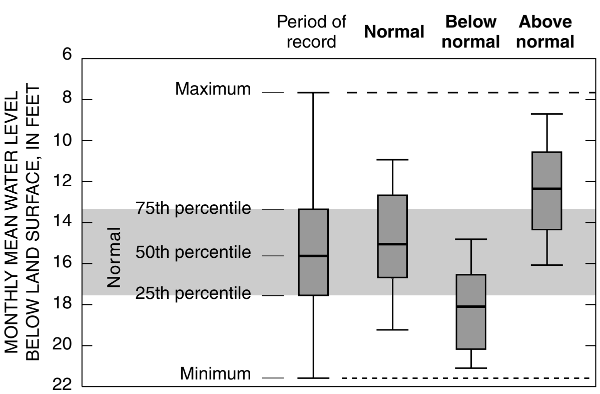
Year of data collection	USGS Open-File Report number	Author(s)	Year of publication
1977	79-213	U.S. Geological Survey	1978
1978	79-1290	Clarke, J.S., Hester, W.G., and O'Byrne, M.P.	1979
1979	80-501	Mathews, S.E., Hester, W.G., and O'Byrne, M.P.	1980
1980	81-1068	Mathews, S.E., Hester, W.G., and O'Byrne, M.P.	1981
1981	82-904	Mathews, S.E., Hester, W.G., and McFadden, K.W.	1982
1982	83-678	Stiles, H.R., and Mathews, S.E.	1983
1983	84-605	Clarke, J.S., Peck, M.F., Longsworth, S.A., and McFadden, K.W.	1984
1984	85-331	Clarke, J.S., Longsworth, S.A., McFadden, K.W., and Peck, M.F.	1985
1985	86-304	Clarke, J.S., Joiner, C.N., Longsworth, S.A., McFadden, K.W.,and Peck, M.F.	1986
1986	87-376	Clarke, J.S., Longsworth, S.A., Joiner, C.N., Peck, M.F., McFadden, K.W., and Milby, B.J.	1987
1987	88-323	Joiner, C.N., Reynolds, M.S., Stayton, W.L., and Boucher, F.G.	1988
1988	89-408	Joiner, C.N., Peck, M.F., Reynolds, M.S., and Stayton, W.L.	1989
1989	90-706	Peck, M.F., Joiner, C.N., Clarke, J.S., and Cressler, A.M.	1990
1990	91-486	Milby, B.J., Joiner, C.N., Cressler, A.M., and West, C.T.	1991
1991	92-470	Peck, M.F., Joiner, C.N., and Cressler, A.M.	1992
1992	93-358	Peck, M.F., and Cressler, A.M.	1993
1993	94-118	Joiner, C.N., and Cressler, A.M.	1994
1994	95-302	Cressler, A.M., Jones, L.E., and Joiner, C.N.	1995
1995	96-200	Cressler, A.M.	1996
1996	97-192	Cressler, A.M.	1997
1997	98-172	Cressler, A.M.	1998
1998	99-204	Cressler, A.M.	1999
1999	00-151	Cressler, A.M.	2000
2000	01-220	Cressler, A.M., Blackburn, D.K., and McSwain, K.B	2001

Methods of Analysis, Sources of Data, and Data Accuracy

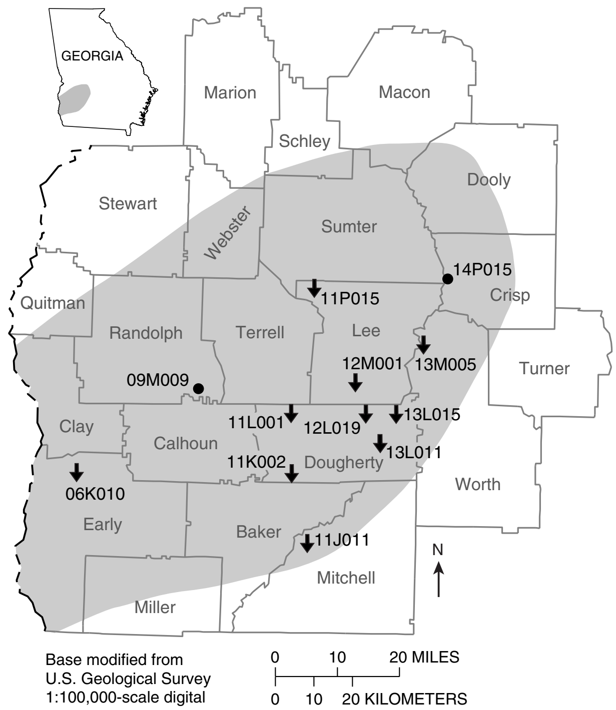
During 2001, ground-water levels were continuously monitored in 156 wells as part of Statewide and local networks and as part of studies of water resources in different parts of the State. Hydrographs from selected wells are presented in this report to compare 5-year trends and seasonal fluctuations to period-of-record statistics in major aquifers throughout the State. A more complete listing of water-level data from USGS continuously monitored wells is provided in the CD–ROM report, "Continuous ground-water-level data, and periodic surface-water- and ground-water-quality data, calender year 2001" (Coffin and others, 2002). That report includes annual and period-of-record ground-water-level hydrographs, summary statistics (maximum, minimum, and mean), and well information (construction and location). Additional well information can be obtained from the USGS National Water Information System (NWIS) at URL: *http://waterdata.usgs.gov/ga/nwis/gw.*

Median water levels for 2001 were compared to period-of-record normal water levels to determine if water levels were above normal, below normal, or normal. In this report, the normal range is defined as those water-level observations during the calendar year that lie between the 25th and 75th percentiles (first and third quartiles), also known as the inter-quartile range, for the period of record. The 75th percentile (third quartile) means that three-quarters of the observations lie below it; the 25th percentile (first quartile) means that one-quarter of the observations lies below it, and the median or 50th percentile (second quartile) means that two-quarters (one-half) of the observations lie below it and two-quarters (one-half) of the observations lie above it (Hamburg, 1985). This can be shown by examining a graphical representation of these values known as a boxplot (Tukey, 1977) (see below).

The results of this comparison are graphically represented on maps in the ground-water-level section of this report (see map to the right, for example) either by an up arrow—2001 monthly mean water levels above period-of-record normal values; a down arrow—2001 monthly mean water levels below the normal range for the period of record; or a circle—2001 monthly mean water levels within the normal range for the period of record.



*Boxplot depicting the method used to decide if 2001 water levels in a well were within, below, or above the normal range. If the median (50th percentile) water level for 2001 was between the 25th and 75th percentiles of period-of-record water levels, then water levels in the well were considered **normal**. If the median water level for 2001 was below the 25th percentile, then water levels in the well were considered **below normal**. If the median water level for 2001 was above the 75th percentile, then water levels were considered **above normal**.*



EXPLANATION

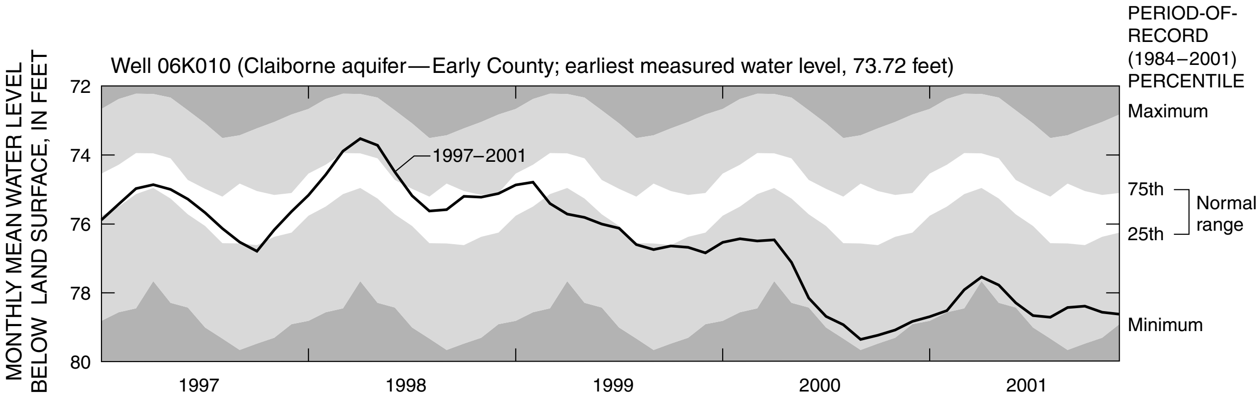
Observation well, site name, and comparison of monthly mean water level during 2001 to period-of-record water level

● 14P015 Normal—Between 25th and 75th percentile water levels for period of record

↓ 11J011 Below normal—Below 25th percentile water level for period of record

*Results of the comparison between period-of-record water levels and 2001 water levels in wells continuously monitored by the USGS. A circle represents water levels in a well that are within the normal range (**normal**). An arrow pointing upward represents water levels in a well that are above the normal range (**above normal**). An arrow pointing downward represents water levels in a well that are below the normal range (**below normal**).*

Hydrographs showing monthly mean ground-water levels during 1997–2001 were plotted together with hydrographs showing period-of-record water-level statistics (monthly mean normal, minimum, and maximum water levels) (see hydrograph, facing page). The period-of-record monthly statistics were calculated through December 2001 and are repeated on the graphs for 1997, 1998, 1999, and 2000. For example, statistics



Hydrograph showing monthly mean water level in well 06K010 for the period 1997–2001 and summary water-level statistics for the period of record 1985–2001.

for the month of June are the same on the plots for each year during 1997–2001. Land-surface altitude for most wells was determined from topographic maps, and is accurate to about one-half the contour interval (usually from 2.5 to 5 feet). Some land-surface altitudes were determined by surveying methods or Global Positioning System (GPS) and are more accurate.

Water samples were analyzed for nitrate at the USGS laboratory in Ocala, Florida. Chloride analyses were conducted at the USGS Ocala laboratory, the USGS Atlanta, Georgia, laboratory, and at the St. Johns River Water Management District in Palatka, Florida (for Camden County). Additional water-quality data for Georgia can be obtained from the USGS National Water Information System (NWIS) at URL: *http://waterdata.usgs.gov/ga/nwis/qw.*

Georgia Well-Naming System

Wells described in this report are given a well name according to a system based on the USGS index of topographic maps of Georgia. Each 7.5-minute topographic quadrangle in the State has been assigned a three- to four-digit number and letter designation (for example, 07H or 11AA) beginning at the south-western corner of the State. Numbers increase sequentially eastward and letters advance alphabetically northward. Quadrangles in the northern part of the State are designated by double letters; AA follows Z, and so forth. The letters “I”, “O”, “II”, and “OO” are not used. Wells inventoried in each quadrangle are numbered consecutively, beginning with 01. Thus, the fourth well inventoried in the 11AA quadrangle is designated 11AA04. In the USGS NWIS database, this information is stored under the field “Well Name.”

Cooperating Organizations

Ground-water monitoring and hydrologic studies in Georgia are conducted in cooperation with numerous local, State, and Federal organizations. Cooperating organizations include:

- Albany Water, Gas, and Light Commission
- City of Brunswick
- City of Lawrenceville
- Georgia Department of Natural Resources
- Georgia Department of Agriculture
- Camden County
- Glynn County
- McIntosh County
- Rockdale County
- U.S. Department of the Army
- U.S. Department of the Air Force
- St. John’s Water Management District (Florida)

With the exception of the Federal agencies, all of these organizations participate in the USGS Cooperative Water Program, an ongoing partnership between the USGS and non-Federal agencies. The program enables joint planning and funding for systematic studies of water quantity, quality, and use. Data obtained from these studies are used to guide water-resources management and planning activities and provide indications of emerging water problems. For a more complete description of the Cooperative Water Program, see Brooks (2001).

Ground-Water Resources

Contrasting geologic features and landforms of the physiographic provinces of Georgia (map, facing page, and table, following two pages) affect the quantity and quality of ground water throughout the State. The surficial aquifer is present in each of the physiographic provinces. In the Coastal Plain Province, the surficial aquifer consists of intermixed layers of sand, clay, and limestone. The surficial aquifer usually is under water-table (unconfined) conditions and is used for domestic and livestock supplies. The surficial aquifer is semiconfined to confined locally in the coastal area. In the Piedmont, Blue Ridge, and Valley and Ridge Provinces, the surficial aquifer consists of soil, saprolite, stream alluvium, colluvium, and other surficial deposits.

The most productive aquifers in Georgia are in the Coastal Plain Province in the southern half of the State. The Coastal Plain is underlain by alternating layers of sand, clay, dolomite, and limestone that dip and thicken to the southeast. Coastal Plain aquifers generally are confined, except near their northern limits where they crop out or are near land surface. Aquifers in the Coastal Plain include the surficial aquifer, upper and lower Brunswick aquifers, Upper and Lower Floridan aquifers, Gordon aquifer system, Claiborne aquifer, Clayton aquifer, and the Cretaceous aquifer system.

In the Valley and Ridge Province, ground water is transmitted through primary and secondary openings in folded and faulted sedimentary and metasedimentary rocks of Paleozoic age, herein referred to as "Paleozoic-rock aquifers."

In the Piedmont and Blue Ridge Provinces, the geology is complex and consists of structurally deformed metamorphic and igneous rocks. Ground water is transmitted through secondary openings along fractures, foliation, joints, contacts, or other features in the crystalline bedrock. In these provinces, aquifers are referred to as "crystalline-rock aquifers." For a more complete discussion of the State's ground-water resources, see Clarke and Pierce (1984).

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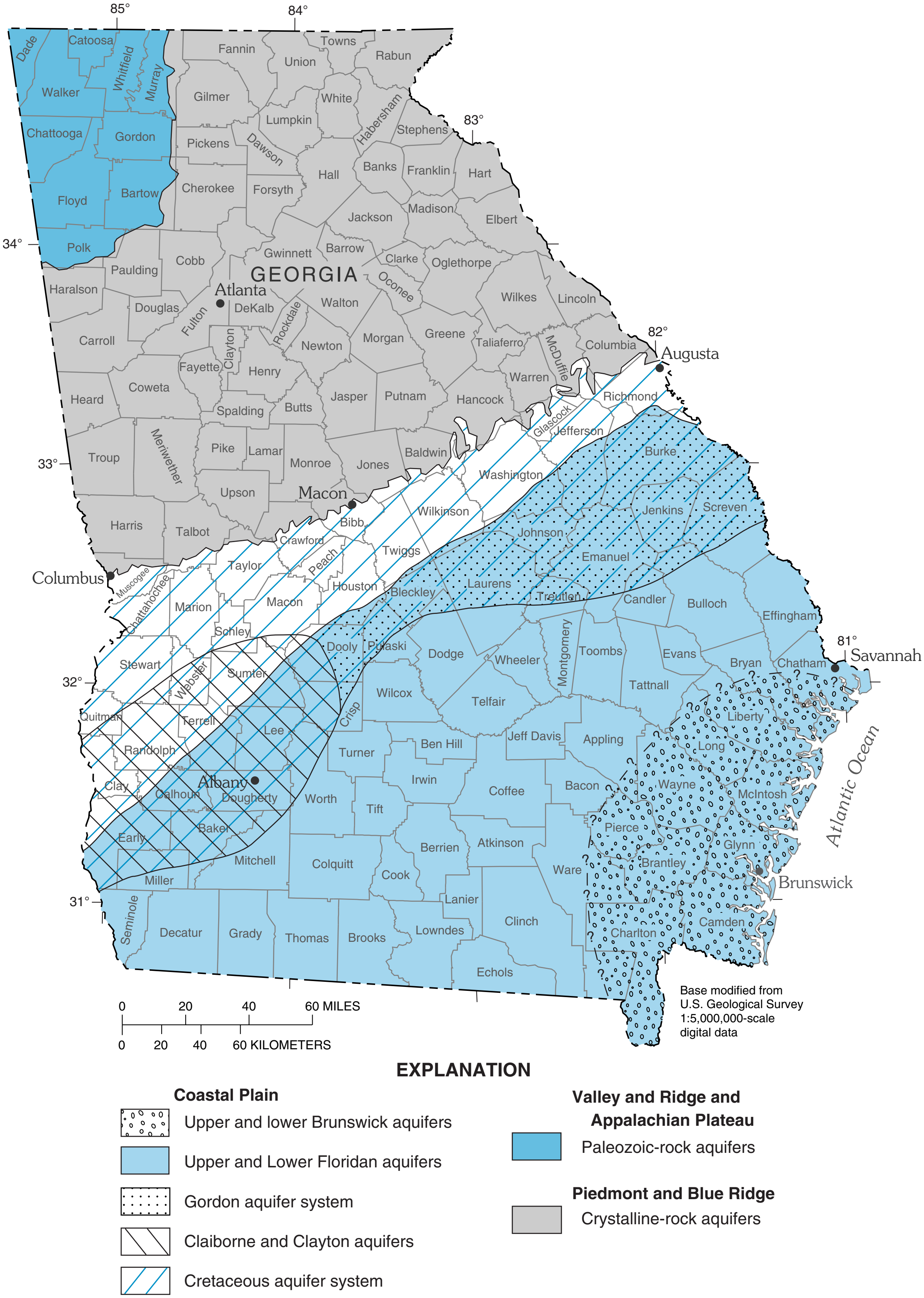

Areas of use of major aquifers in Georgia (modified from Clarke and Pierce, 1984). The surficial aquifer is present throughout the State and is not shown here.

Aquifer and well characteristics in Georgia *[modified from Clarke and Pierce (1984), and Peck and others (1992); ft, feet; gal/min, gallons per minute]*

Aquifer name	Aquifer description	Well characteristics		
		Depth (ft)	Yield (gal/min)	
		Typical range	Typical range	May exceed
Surficial aquifer	Unconsolidated sediments and residuum; generally unconfined	11–72	2–25	25
Upper and lower Brunswick aquifers	Phosphatic and dolomitic quartz sand; generally confined	85–390	10–30	180
Upper and Lower Floridan aquifers	Limestone, dolomite, and calcareous sand; generally confined	40–900	1,000–5,000	11,000
Gordon aquifer system	Sand and sandy limestone; generally confined	270–530	87–1,200	1,800
Claiborne aquifer	Sand and sandy limestone; generally confined	20–450	150–600	1,500
Clayton aquifer	Limestone and sand; generally confined	40–800	250–600	2,150
Cretaceous aquifer system	Sand and gravel; generally confined	30–750	50–1,200	3,300
Paleozoic-rock aquifers	Sandstone, limestone and dolomite; generally confined	15–2,100	1–50	3,500
Crystalline-rock aquifers	Granite, gneiss, schist, and quartzite; generally confined	40–600	1–25	500

Hydrologic response	Remarks
Water-level fluctuations mainly are caused by variations in precipitation, evapotranspiration, and natural drainage. In addition, water levels in the city of Brunswick area are influenced by nearby pumping, precipitation, and tidal fluctuations (Clarke and others, 1990). Water levels generally rise rapidly during wet periods and decline slowly during dry periods. Prolonged droughts may cause water levels to decline below pump intakes in shallow wells, particularly those located on hilltops and steep slopes, resulting in temporary well failures. Usually, well yields are restored by precipitation.	Primary source of water for domestic and livestock supply in rural areas. Supplemental source of water for irrigation supply in coastal Georgia.
In the coastal area, the aquifers may respond to pumping from the Upper Floridan aquifer as a result of the hydraulic connection between the aquifers. Elsewhere the water level mainly responds to seasonal variations in recharge and discharge. In Bulloch County, unnamed aquifers equivalent to the upper and lower Brunswick aquifers are unconfined to semiconfined and are influenced by variations in recharge from precipitation and by pumping from the Upper Floridan aquifer; in the Wayne and Glynn County area, the aquifers are confined and respond to nearby pumping (Clarke and others, 1990).	Not a major source of water in coastal Georgia, but considered a supplemental water supply to the Upper Floridan aquifer.
In and near outcrop areas, the aquifers are semiconfined and water levels in wells tapping the aquifers fluctuate seasonally in response to variations in recharge rate and pumping. Near the coast, where the aquifers are confined, water levels primarily respond to pumping, and fluctuations related to recharge are less pronounced (Clarke and others, 1990).	Supplies about 50 percent of ground water in Georgia. The aquifer system is divided into the Upper and Lower Floridan aquifers. In the Brunswick area, the Upper Floridan aquifer includes two freshwater-bearing zones, the upper water-bearing zone and the lower water-bearing zone. The Lower Floridan aquifer is not considered a major aquifer. In the Brunswick area and in southeastern Georgia, the Lower Floridan aquifer includes the brackish-water zone, the deep freshwater zone, and the Fernandina permeable zone (Krause and Randolph, 1989). The Lower Floridan aquifer extends to more than 2,700 ft deep and yields high-chloride water below 2,300 ft (Jones and Maslia, 1994).
Water levels are influenced by seasonal fluctuations in recharge from precipitation, discharge to streams, and evapotranspiration (Clarke and others, 1985).	Major source of water for irrigation, industrial and public-supply use in east-central Georgia.
Water levels mainly are affected by precipitation and by local and regional pumping (Hicks and others, 1981). The water level is generally highest following the winter and spring rainy seasons, and lowest in the fall following the summer irrigation season.	Major source of water for irrigation, industrial, and public-suppy use in southwestern Georgia.
Water levels are affected by seasonal variations in local and regional pumping (Hicks and others, 1981).	Major source of water for irrigation, industrial, and public-supply use in southwestern Georgia.
Water levels are influenced by variations in precipitation and pumping (Clarke and others, 1983, 1985).	Major source of water in east-central Georgia. Supplies water for kaolin mining and processing. Includes the Providence aquifer in southwestern Georgia, and the Dublin, Midville, and Dublin–Midville aquifer systems in east-central Georgia.
Water levels mainly are affected by precipitation and local pumping (Cressler, 1964).	Not laterally extensive. Limestone and dolomite aquifers are most productive. Storage is in regolith, primary openings, and secondary fractures and solution openings in rock. Springs in limestone and dolomite aquifers discharge at rates of as much as 5,000 gal/min. Sinkholes may form in areas of intensive pumping.
Water levels mainly are affected by precipitation and evapotranspiration, and locally by pumping (Cressler and others, 1983). Precipitation can cause a rapid rise in water levels in wells tapping aquifers overlain by thin regolith.	Storage is in regolith and fractures in rock.