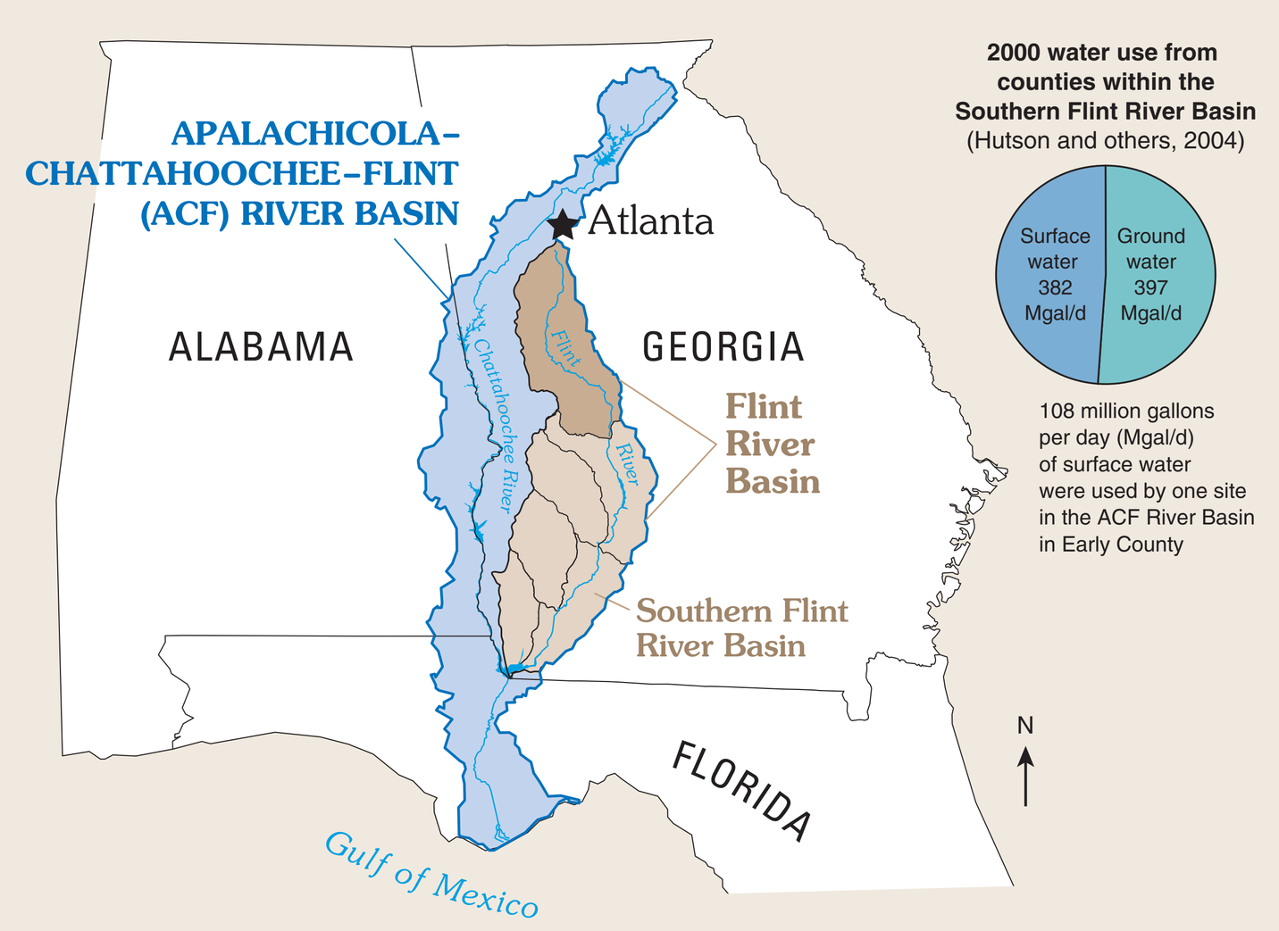
Water—Essential Resource of the Southern Flint River Basin, Georgia

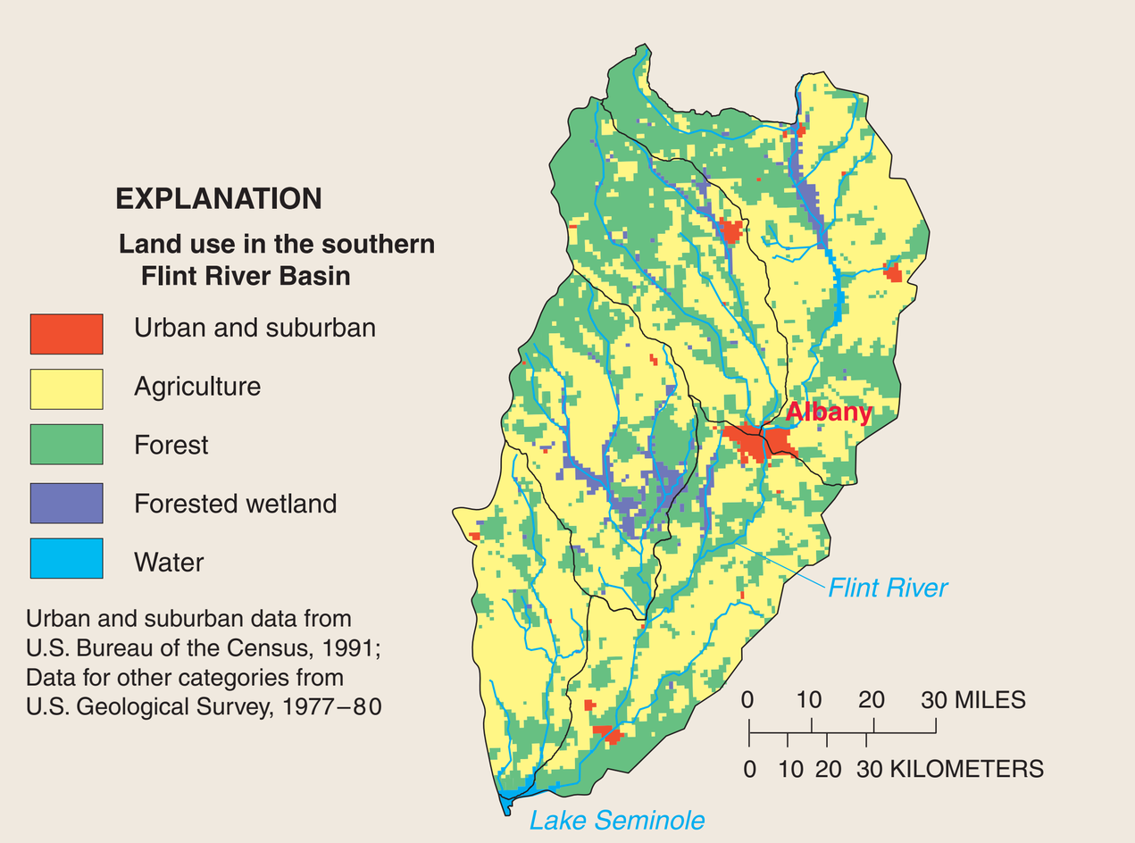
USGS science for a changing world

Flint River Water Planning & Policy Center — Albany State University

Introduction

Abundant water resources of the Flint River Basin have played a major role in the history and development of southwestern Georgia. The Flint River—along with its tributaries, wetlands, and swamps—and the productive aquifers of the river basin are essential components of the area's diverse ecosystems. These resources also are necessary for sustained agricultural, industrial, and municipal activities. Increasing, and in some cases conflicting, demand for water makes careful monitoring and wise planning and management of southwestern Georgia's water resources critical to the ecological and economic future of the area. This poster presents the major issues associated with increasing competition for water resources in the southern Flint River Basin.





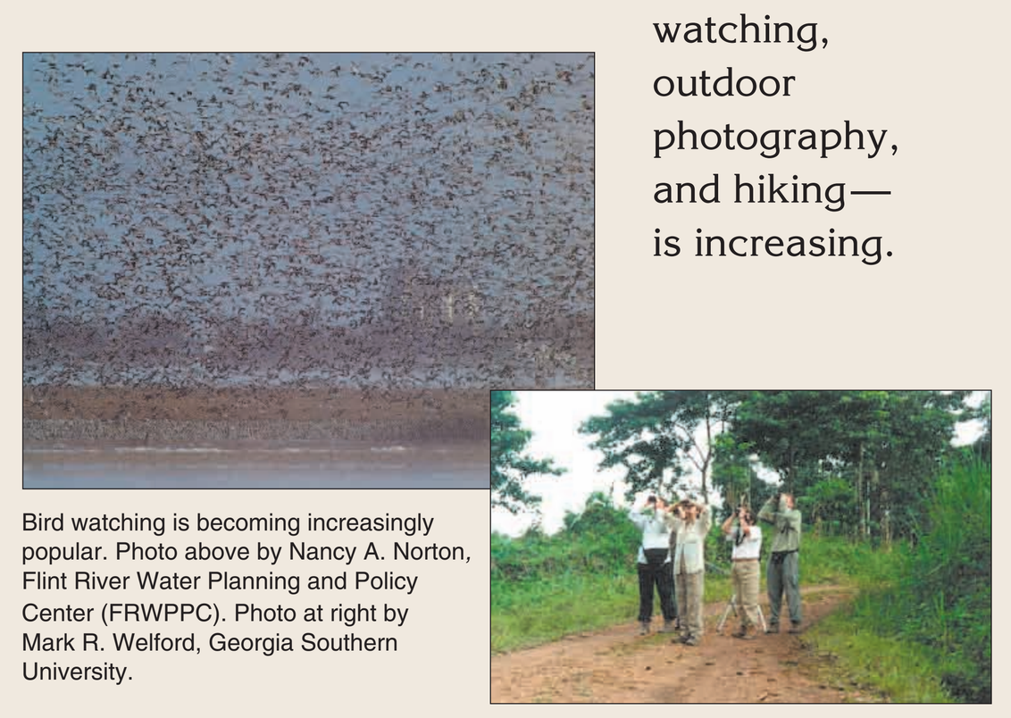
Urban and suburban data from U.S. Bureau of the Census, 1991; Data for other categories from U.S. Geological Survey, 1977–80

Economic Activity

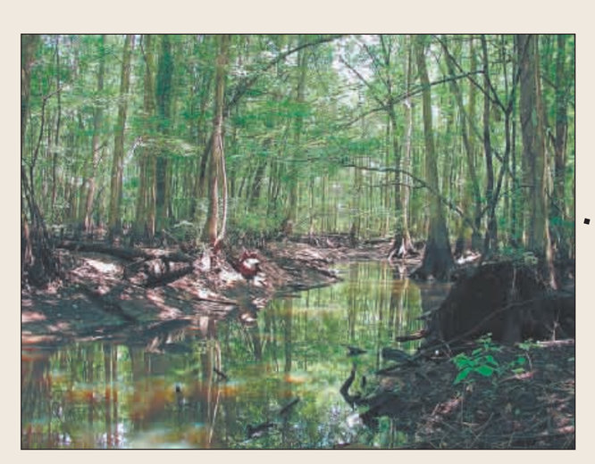
Georgia ranks among the top five states in production of peanuts, pecans, cotton, peaches, rye, and tomatoes (Georgia Department of Agriculture, 2003). Irrigated agriculture provides much of the employment and income of the southern Flint River Basin as well as the tax base that supports education, health care, and other local community services. Abundant water resources in the subbasins have been a factor in industry location decisions.

Cotton field in the Kinchafoonee–Muckalee Creek subbasin. Photo by L. Elliott Jones, USGS

Hunting and fishing are important to the economy of the area. Reservoirs—such as Lakes Blackshear, Chehaw, and Seminole—are widely used by residents and visitors. Participation in nonconsumptive activities—such as canoeing, bird watching, outdoor photography, and hiking—is increasing.



Bird watching is becoming increasingly popular. Photo above by Nancy A. Norton, Flint River Water Planning and Policy Center (FRWPPC). Photo at right by Mark R. Welford, Georgia Southern University.



Swamp of Toa. Photo courtesy of Chip Evans, Lenz Design and Communications, Inc.

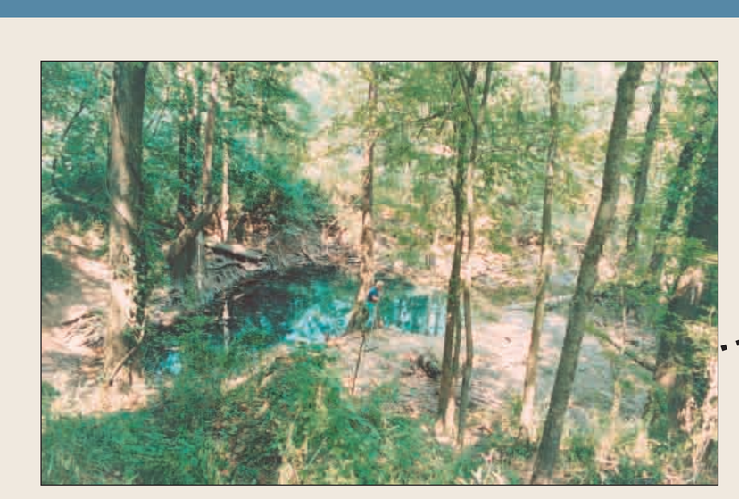
*Real-time data at wells and gaging stations can be accessed on the World Wide Web at **http://waterdata.usgs.gov/ga/nwis/rt***

Hydrogeology of the Southern Flint River Basin

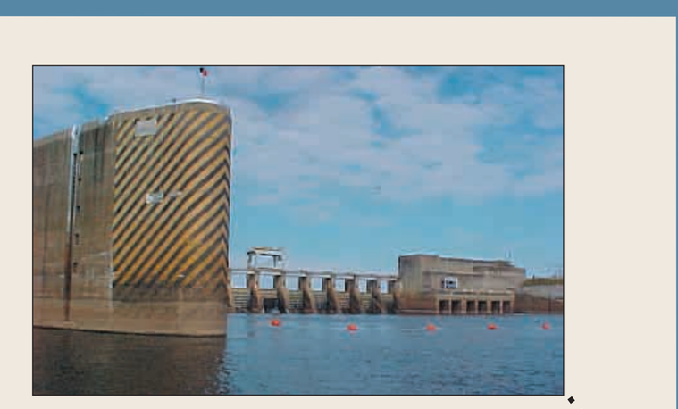
ERATHEM	SYSTEM	SERIES		THICKNESS (feet)	AQUIFER OR CONFINING UNIT	LITHOLOGY	REMARKS
Cenozoic	Quaternary	Holocene		20–80	Surficial aquifer/ upper semiconfining unit	Sand and clay	Not a primary source of water, but has been used for domestic purposes.
		Pleistocene					
	Tertiary	Pliocene				Weathered limestone	
		Miocene					
		Oligocene					
		Eocene	Upper	20–270	Upper Floridan aquifer: Upper water-bearing zone; Middle unit; Lower water-bearing zone	Sandy limestone	Major source of water for irrigation and domestic use.
			Middle	10–100	Lisbon confining unit	Glauconitic limestone	
				0–270	Claiborne aquifer	Sand; Fossiliferous limestone; Sand; Glauconitic limestone	Major source of water for public supply.
			Lower				
		Paleocene		0–260	Wilcox confining unit	Sand; Glauconitic sand; Clay	In some areas, sand and limestone layers in the Hatchetigbee Formation, Tuscahoma Formation, Nanafalia Formation, and upper Clayton Formation provide ample supplies for domestic use.
				0–265	Clayton aquifer	Limestone	Major source of water for irrigation, industrial, and public-supply use. In the carbonate area, the aquifer consists primarily of limestone and provides ample water for municipal, agricultural, and industrial supply.
Mesozoic	Cretaceous	Upper Cretaceous		0–390	Providence aquifer	Sand	
				0–300	Providence–Ripley confining unit	Silty sand	Where absent, the Providence Sand, Ripley Formation, and upper Cusseta Sand form a single aquifer
				0–150	Cusseta aquifer	Sand	Forms a single aquifer with the Providence Sand and Ripley Formation downdip and eastward
				0–700	Blufftown aquifer	Glauconitic sand; Clay and marl	
				200–1,200	Eutaw and Tuscaloosa Formations	Sand and clay	

Modified from Clarke and others, 1984 (lower Eocene and deeper); and Hicks and others, 1987 (middle Eocene and upper)

Ground water is the principal source of water for irrigation, industry, and domestic uses in the southern Flint River Basin. Aquifers consist of layers of sand or limestone that are separated by confining units of low permeability. Discharge of water from the aquifers to wetlands, streams, and springs is vital to maintain wildlife and plant species.



Wilson Blue Spring south of Albany. Water discharges from the Upper Floridan aquifer into the Flint River. Photo by Debbie Warner, USGS



Jim Woodruff Lock and Dam. Photo by Lynn J. Torak, USGS

*The **Jim Woodruff Lock and Dam** impounds the Flint and Chattahoochee Rivers at their confluence, creating Lake Seminole. The USGS is conducting a study on Lake Seminole, in cooperation with the Georgia Environmental Protection Division (GaEPD), to:*

- *develop a water budget for the lake;*
- *compare 2001 and pre-Lake Seminole ground-water and surface-water flows;*
- *evaluate possibility of a substantial amount of water entering the ground-water system from the lake, flowing beneath Jim Woodruff Lock and Dam, and entering Florida; and*
- *assess the likelihood of increased dissolution in the karst limestone of the lake bottom leading to sinkhole collapse and sudden lake drainage.*

Climax Cave in the lower Flint River subbasin. Photo by Alan M. Cressler, USGS

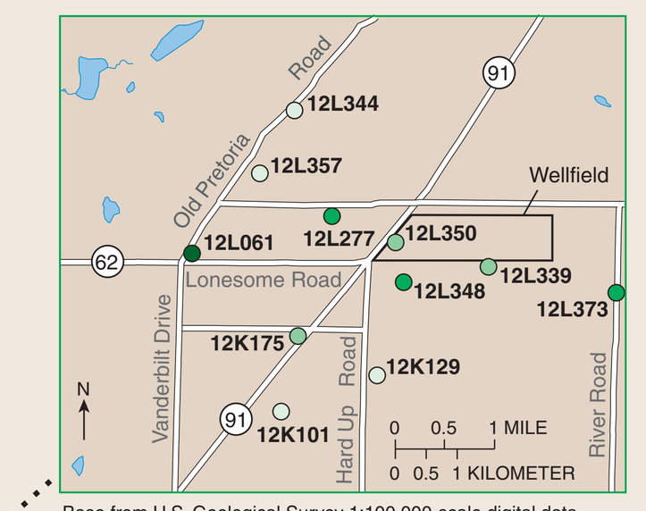
***Water from the Upper Floridan aquifer** forms a pool in Climax Cave, Grady County. The crystal-clear pool is about 10 feet in diameter and 8 feet deep. Water levels fluctuate as much as 5 feet. Caves are common in karst areas, such as the lower Flint River subbasin, causing much of the drainage to go underground.*

Water Quality

Overall, there are few surface- or ground-water quality issues in the area. Pesticide and nutrient concentrations in stream water within the subbasins generally are below current drinking-water standards (Frick and others, 1998).

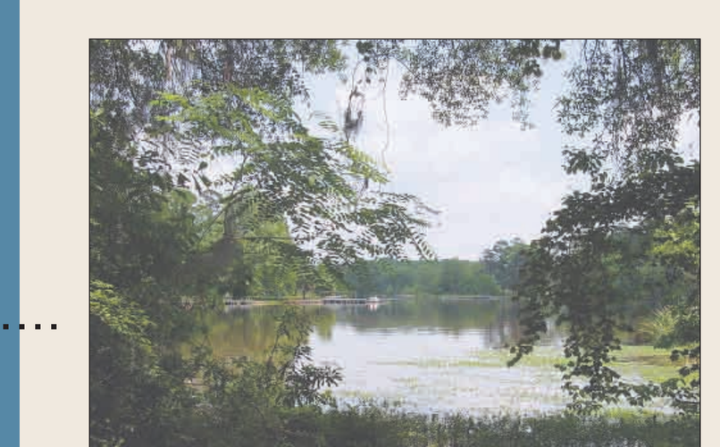
Nitrate concentrations in ground water rarely exceed the drinking-water standard of 10 milligrams per liter (mg/L) (U.S. Environmental Protection Agency, 2000; Frick and others, 1998).

Water-quality sampling. Photo by Debbie Warner, USGS



Base from U.S. Geological Survey 1:100,000-scale digital data

__Concentrations of nitrate__ greater than 10 mg/L have been detected in water from the Upper Floridan aquifer near Albany. These nitrate levels occur in a small area and are not indicative of a regional problem. The USGS is conducting a study—in cooperation with Albany Water, Gas, and Light Commission—to monitor ground-water levels and water quality in the Upper Floridan aquifer near the wellfield.

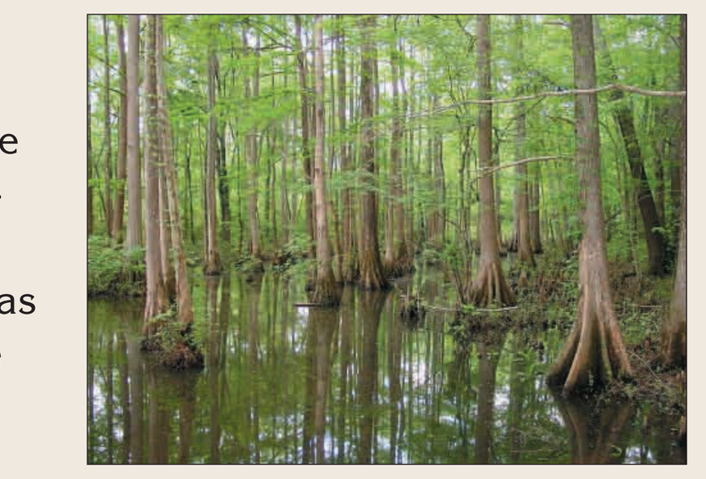


Lake Chehaw, just north of Albany, Georgia. Photo by Nancy A. Norton, FRWPPC

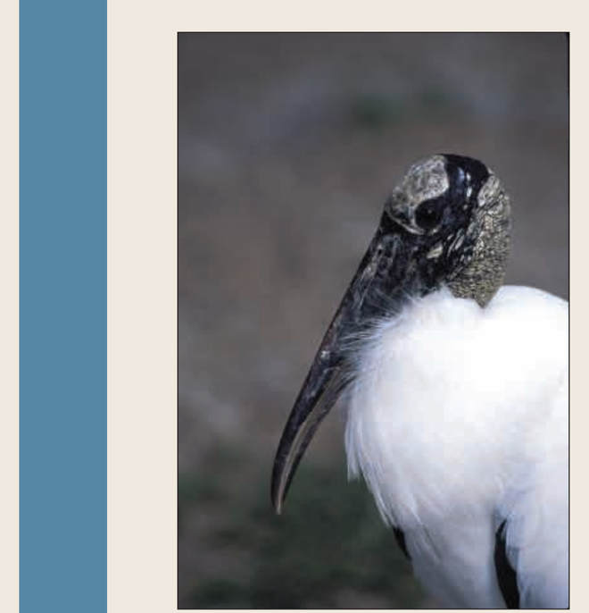
*The Flint River is **free flowing** (no impoundments) for about 21 miles between Lake Blackshear Dam (Crisp County Hydro-electric Dam) and the upper end of Lake Chehaw. Downstream to Lake Seminole are approximately 75 miles of free-flowing river.*

Wildlife and Endangered Species

The swamps and wetlands of southwestern Georgia provide unique plant and animal habitats. The Swamp of Toa—also referred to as the Chickasawhatchee Swamp—is one of the largest remaining, relatively intact, fresh-water swamps in the Southeastern United States. The swamp is a critical site for migratory birds, freshwater fish and mussels, and animal and plant communities. Many of these plant and animal species—such as the bald eagle, wood stork, mussels (shinyrayed pocketbook, oval pigtoe, gulf moccasinshell), swamp buckthorn, and variable-leaved Indian plantain—are listed as federally or State threatened or endangered. "The Chickasawhatchee Swamp purchase is our largest single land purchase in recent history," said David Waller, Director of the Wildlife Resource Division of the Georgia Department of Natural Resources (GaDNR) "… and will allow us to preserve an environmentally significant piece of property for future generations as well as provide many opportunities for outdoor education and recreational activities such as hunting, fishing, bird watching, hiking and canoeing" (accessed April 21, 2003, at *http://nature.org/wherewework/northamerica/states/georgia/press/press438.html*).



Cypress trees in swamp. Photo by Nancy A. Norton, FRWPPC



Wood stork, an endangered species. Photo by George Gentry U.S. Fish and Wildlife Service

A portion of the area was recently designated as the Swamp of Toa Important Bird Area (IBA). The aim of the National IBA program is to identify and conserve key breeding and feeding sites for birds. IBAs are considered by the North American Bird Conservation Initiative to be exceptionally important for bird conservation (accessed April 21, 2003, at *http://www.audubon.org/bird/iba*).

Shinyrayed pocketbook, an endangered mussel. Photo by Sean Kelly and Stephen W. Golladay, J.W. Jones Ecological Research Center, Newton, Georgia

What Is Being Done to Protect Water Resources?

Scientific Studies and Monitoring

To ensure that adequate water supplies are available in southwestern Georgia, the GaEPD—in cooperation with the USGS—has implemented scientific studies to better understand the hydrologic system in the southern Flint River Basin. In these studies, researchers are:

- Collecting new hydraulic-property data for the Upper Floridan and surficial aquifers;
- Obtaining accurate locations of pumping wells;
- Collecting and compiling ground-water-level, stream seepage, and offstream spring-discharge data; and
- Developing a transient finite-element model of ground-water flow to simulate seasonal ground-water levels, stream-aquifer interaction, and pumping-induced streamflow reduction. Computer simulations are used to help scientifically predict future water availability.

In addition to these scientific studies, the USGS—in cooperation with the GaEPD—operates continuous streamflow and ground-water-level monitoring networks in the southern Flint River Basin. Many of the sites are "real time" and are linked by satellite telemetry *(http://waterdata.usgs.gov/ga/nwis/rt)*. These data provide water planners with information necessary to manage the area's water resources.

Agricultural Water Conservation

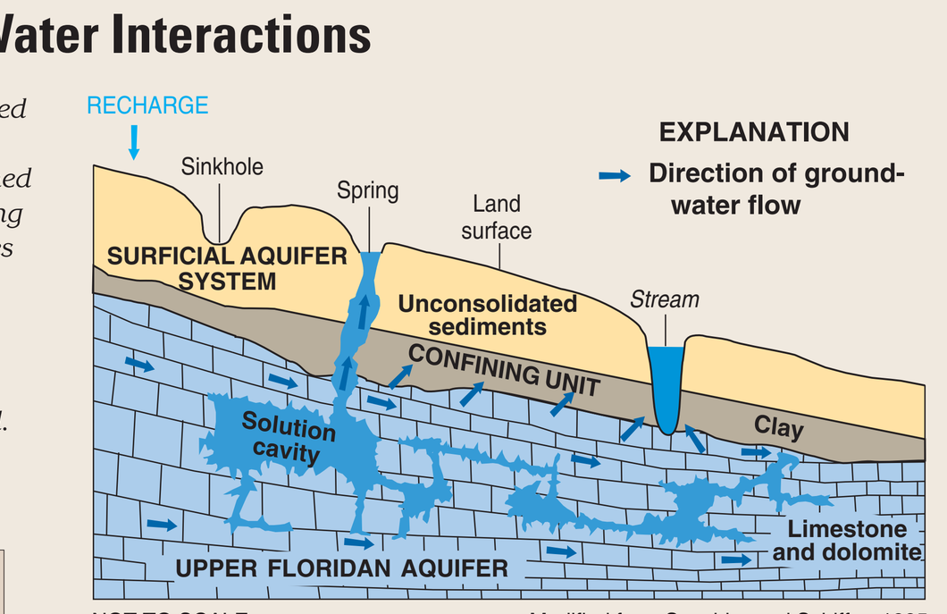
Irrigation is costly, so farmers are enhancing the efficiency of irrigation water use by installing low-pressure nozzles and endgun shutoffs, and improving uniformity and efficiency of their systems (Flint River Regional Water Council, 2001). Several organizations in the area work together to provide irrigation management and technology development research to assist farmers in improving efficiency of agricultural water use and enhance net revenue. These organizations include:

Center-pivot irrigation Photo by Mark Masters, FRWPPC

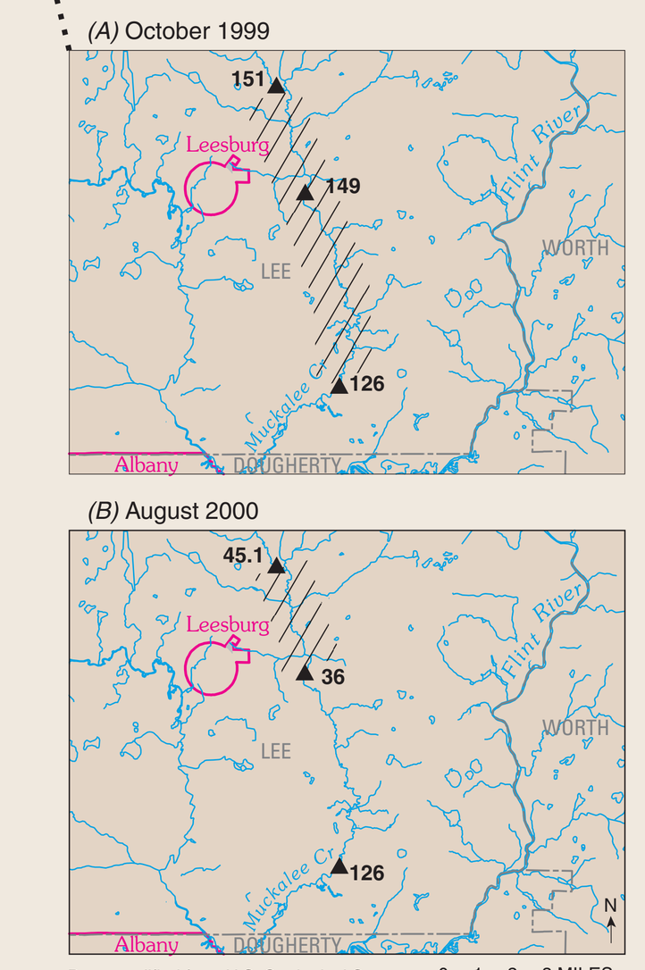
- Albany State University, Flint River Water Planning and Policy Center;
- Georgia Soil and Water Conservation Commission;
- U.S. Department of Agriculture National Peanut Research Laboratory; and
- The University of Georgia, Stripling Irrigation Research Park.

Ground-Water/Surface-Water Interactions

*The lower Flint River subbasin is characterized by **karst topography** in which sinkholes, caves, and underground drainage have formed because of dissolution of limestone comprising the Upper Floridan aquifer. Lack of tributaries and little surface-water drainage between Albany and Lake Seminole indicates underground drainage; most surface water either flows into wetlands and then seeps into the ground, or infiltrates directly into the ground.*



Modified from Spechler and Schiffer, 1995



Base modified from U.S. Geological Survey 1:100,000-scale digital data

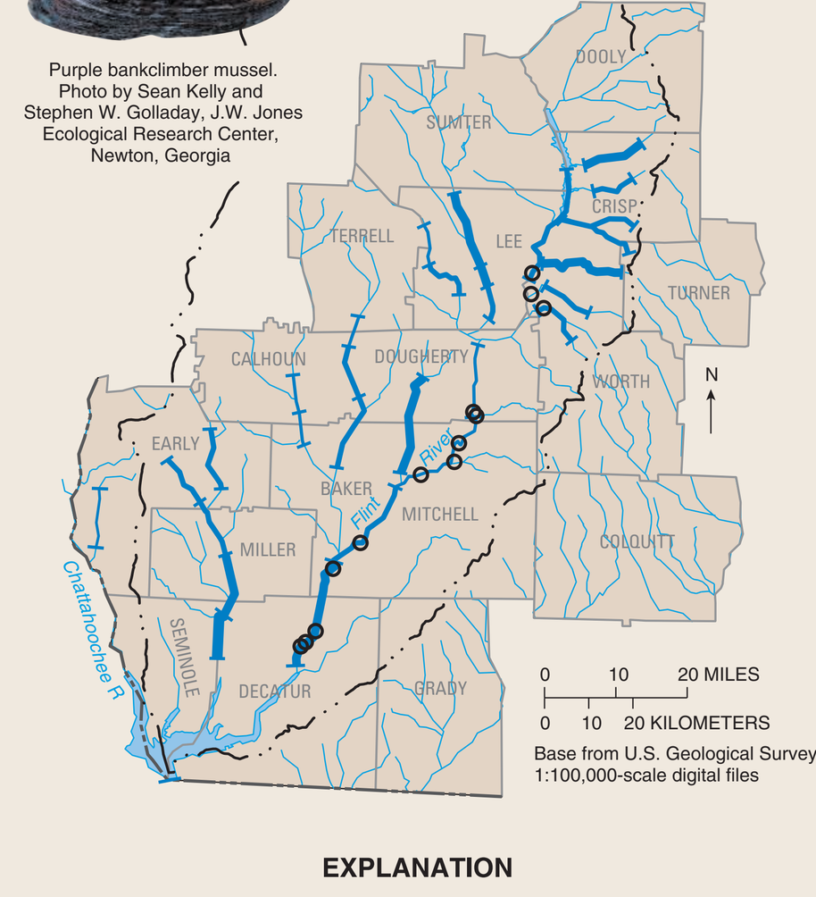
EXPLANATION

Stream seepage—Hachures indicate net loss in stream discharge between stations

▲126 **Surface-water monitoring station and measured stream discharge**—In cubic feet per second

***Stream seepage** along Muckalee Creek near Leesburg, Georgia, (A) October 1999 and (B) August 2000. The Upper Floridan aquifer typically discharges water to stream channels, which constitutes the majority of baseflow. Drought conditions typically decrease both runoff and ground-water discharge to streams. These decreases, from May 1998 through August 2000, resulted in record or near-record low streamflows occurred throughout the subbasins (Mosner, 2002).*

Purple bankclimber mussel. Photo by Sean Kelly and Stephen W. Golladay, J.W. Jones Ecological Research Center, Newton, Georgia



Base from U.S. Geological Survey 1:100,000-scale digital files

EXPLANATION

Simulated stream reach sensitivity to additional pumpage

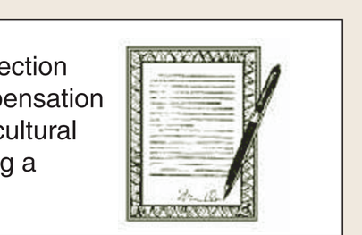
Low — Medium — High

○ **Site containing federally protected mussel species purple bankclimber** *(Elliptoideus sloatianus)*

***A ground-water model** was used to simulate stream reach sensitivity to ground-water pumpage for sites containing federally protected mussel species such as the purple bankclimber (Elliptoideus sloatianus) in the lower Apalachicola–Chattahoochee–Flint River Basin (Albertson and Torak, 2002).*

Drought Protection Act—Influences agricultural water use

The Flint River Drought Protection Act of 2001 authorizes compensation to farmers for removing agricultural acreage from irrigation during a severe drought year.

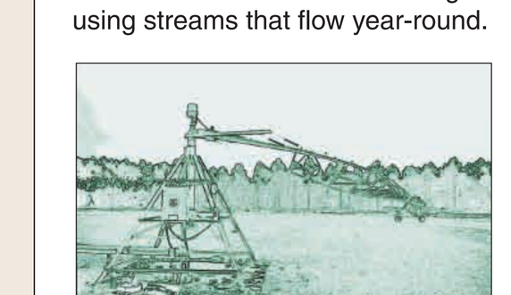


WILL DROUGHT BE DECLARED ON MARCH 1? Each March 1st, as long as this legislation is in effect, the Director of the GaEPD must announce whether or not drought conditions exist.

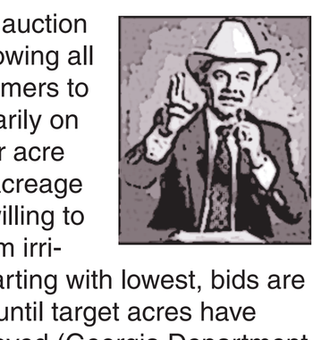
Information used to make drought decision:

- Water levels in nine USGS monitoring wells open to the Upper Floridan aquifer,
- Flow data from five USGS streamgaging stations in the lower Flint River Basin, and
- Precipitation forecast from The University of Georgia environmental monitoring network.

NO—farmers are allowed to irrigate using streams that flow year-round.



YES—an auction is held allowing all eligible farmers to bid voluntarily on a price per acre basis for acreage they are willing to refrain from irrigating. Starting with lowest, bids are accepted until target acres have been removed (Georgia Department of Natural Resources, 2001).

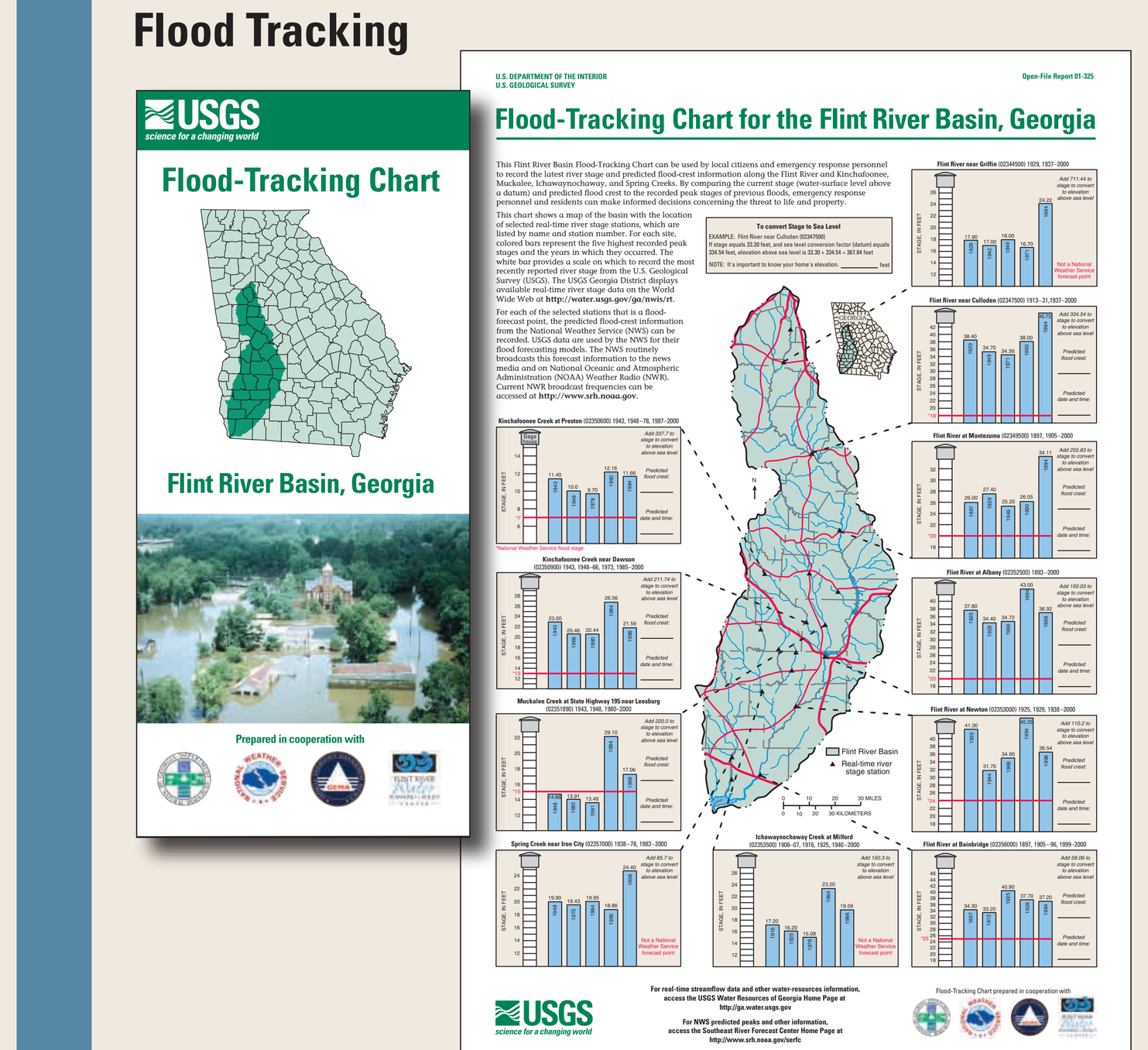


AUCTION ACRES LESS THAN TARGET?

YES—**"non-voluntary irrigation acreage reduction"** begins with the most recent permit issued and continues with the next most "junior in time" permits ("last-in, first-out" or LIFO). These permit owners would be ***required***, in LIFO order, to forgo use of their water permit at a price per acre equal to the ***average*** price paid in the voluntary auction (Georgia Department of Natural Resources, 2001).

The Flint River Drought Protection Act was enacted to better manage the water resources of Georgia during periods of drought. A drought was declared on March 1, 2001, and an irrigated-acreage auction was held. The result was to voluntarily eliminate, for the balance of 2001, surface-water irrigation on 33,101 acres at an average accepted bid of \$135 per acre. A drought also was declared for the 2002 growing season, and 40,894 acres were voluntarily removed from irrigation. The average 2002 bid was \$128 per acre (Flint River Regional Water Council, Inc., 2002; McDowell, 2002). No drought was declared for 2003 or 2004.

Flood Tracking

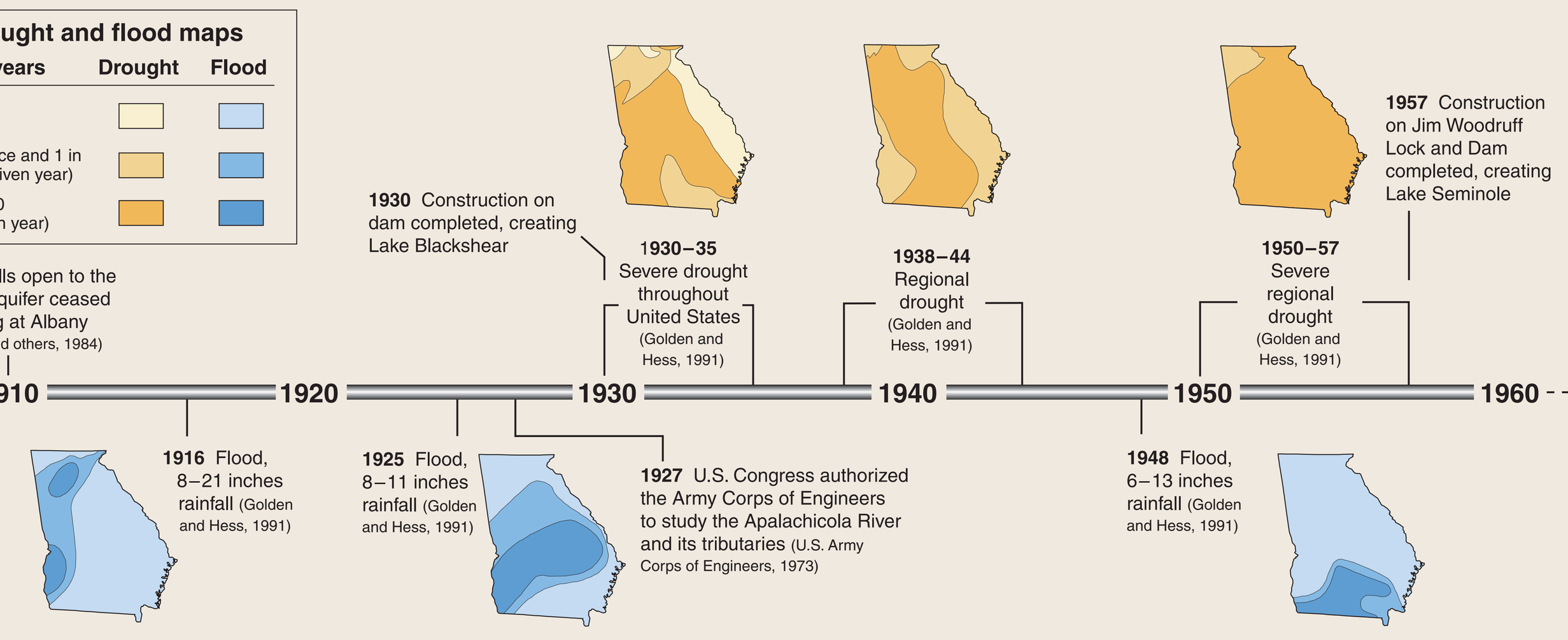


Floods have played an important role in Georgia's history. The USGS—in cooperation with other Federal, State, and local agencies—operates a Flood Monitoring System in the Flint River Basin. To receive a copy of the above *Flood-Tracking Chart—Flint River Basin, Georgia* (Cochran and others, 2001), which includes flood emergency phone numbers and a chart for recording current stage to compare to predicted flood crest, contact the USGS Georgia District Office at 770-903-9100 or at *http://ga2.er.usgs.gov/HydroWatch/FloodTracking.cfm*. Real-time river-stage data can be accessed at *http://waterdata.usgs.gov/ga/nwis/rt*

Timeline of Scientific Studies, Water Management, and Major Events Affecting Water Resources

Explanation for drought and flood maps

Recurrence interval, in years	Drought	Flood
Insignificant		
10 to 25 (Between 1 in 10 chance and 1 in 25 chance of occurring in any given year)		
Greater than 50 (At least 1 in 50 chance of occurring in any given year)		



1881 First flowing-artesian well in Georgia near Albany. Albany designated as Artesian City (accessed April 21, 2003, at *http://www.albanyga.com/cvb/hist1871.html*)

1903–05 Severe drought

1910 Wells open to the Clayton aquifer ceased flowing at Albany (Clarke and others, 1984)

1916 Flood, 8–21 inches rainfall (Golden and Hess, 1991)

1925 Flood, 8–11 inches rainfall (Golden and Hess, 1991)

1927 U.S. Congress authorized the Army Corps of Engineers to study the Apalachicola River and its tributaries (U.S. Army Corps of Engineers, 1973)

1930 Construction on dam completed, creating Lake Blackshear

1930–35 Severe drought throughout United States (Golden and Hess, 1991)

1938–44 Regional drought (Golden and Hess, 1991)

1948 Flood, 6–13 inches rainfall (Golden and Hess, 1991)

1950–57 Severe regional drought (Golden and Hess, 1991)

1957 Construction on Jim Woodruff Lock and Dam completed, creating Lake Seminole

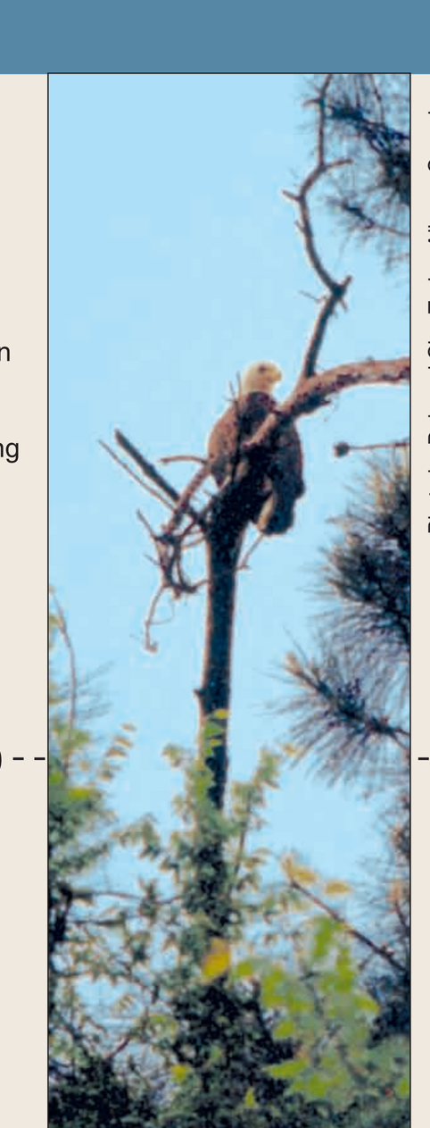


Photo by Dab and Clay Taylor, Albany, Georgia

1968–71 Drought, variable severity

1970s Rapid expansion of irrigation pumpage

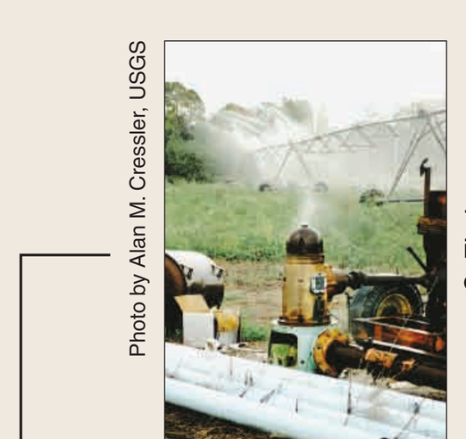


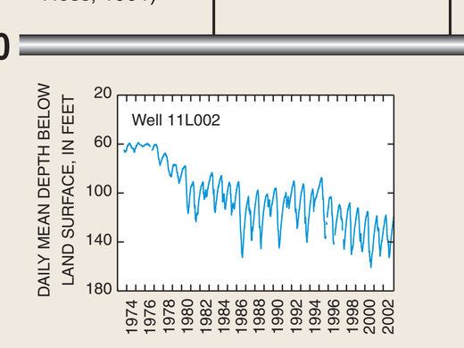
Photo by Alan M. Cressler, USGS

1970–80 Irrigation water use in Georgia increased by a factor of about 12 (Pierce and others, 1984)

1972 Georgia General Assembly passed Ground-Water Use Act requiring permitting of all non-agricultural users withdrawing 100,000 gallons per day or more

1977 USGS began cooperative water-resources program with Albany Water, Gas, and Light Commission

1980–82 Regional drought (Golden and Hess, 1991)



Hydrograph showing steady decline of Clayton aquifer water levels in Albany area

1984 U.S. Army Corps of Engineers completed water assessment for ACF River Basin Water Management Study (U.S. Army Corps of Engineers, 1984)

1985 USGS began cooperative study with U.S. Army Corps of Engineers

1985–89 Regional drought (Golden and Hess, 1991)

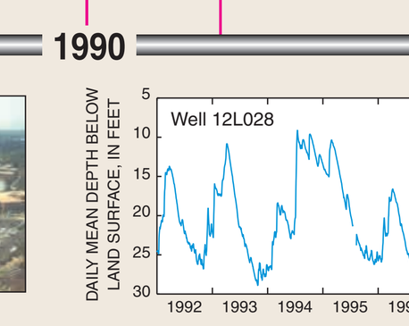
1988 Permit required by GaEPD for agricultural irrigation

Apalachicola–Chattahoochee–Flint River Basin Conflict

1990 Alabama sues U.S. Army Corps of Engineers over plan to increase surface-water allocation to serve Atlanta

1991 Federal lawsuit suspended in lieu of Comprehensive Study

Flooding at Albany State University after Tropical Storm Alberto (July 1994). Photo by Timothy W. Hale, USGS



Hydrograph shows increased water levels in the Upper Floridan aquifer resulting from Tropical Storm Alberto. Water levels remained high through early 1995.

1993 USGS addressed Ground-Water Supply Element of Comprehensive Study

1994 Flood, more than 13 inches rainfall from Tropical Storm Alberto during 24-hour period (Stamey, 1996)

1997 Water supply concerns led Alabama, Florida, and Georgia to sign a preliminary interstate water compact, intended to lay groundwork for the equitable use and availability of water resources in the region while protecting river ecology

1998–2002 Regional drought (Barber and Stamey, 2000)

2000 Flint River Drought Protection Act was enacted by GaEPD to ensure that Flint River flows are adequate to support fish and wildlife during times of severe drought

2001 Georgia General Assembly created Joint Comprehensive Water Plan Study Committee (SR142) (accessed August 10, 2004, at *http://www.cviog.uga.edu/water/sr142.html*)

2002 State of Georgia purchases a portion of Swamp of Toa for wildlife management area

2003 Portion of Swamp of Toa designated as National Important Bird Area; passage of House Bill 579 requiring measurement of all agricultural water use; Compact negotiations lapse

Currently, "the states… are battling over water sharing in federal courts in Washington, DC, Gainesville, Ga., and Birmingham [, Alabama, and] many legal experts have predicted the fight will end in the U.S. Supreme Court" (Shelton, 2004)

2004 House Bill 237 enacted, creating Comprehensive Statewide Water Management Planning Act (accessed August 10, 2004, at *http://www.legis.state.ga.us/legis/2003_04/fulltext/hb237.htm*)

References Cited

Albertson, P.N., and L.J. Torak, 2002, Simulated effects of ground-water pumpage on stream-aquifer flow in the vicinity of federally protected species of freshwater mussels in the lower Apalachicola–Chattahoochee–Flint River basin (Subarea 4), southeastern Alabama, northwestern Florida, and southwestern Georgia: U.S. Geological Survey Water-Resources Investigations Report 02-4016, 23 p.

Barber, N.L., and T.C. Stamey, 2000, Droughts in Georgia: U.S. Geological Survey Open-File Report 00-380, 2 p.

Clarke, J.S., R.E. Faye, and Rebekah Brooks, 1984, Hydrogeology of the Clayton aquifer of southwest Georgia: U.S. Geological Survey Hydrologic Atlas 13, 6 sheets.

Cochran, B.L., B.E. McCallum, T.C. Stamey, and C.J. Wipperfurth, 2001, Flood-tracking chart—Flint River Basin, Georgia:. U.S. Geological Survey Open-File Report 01-325, 1 sheet.

Flint River Regional Water Council, Inc., Winter 2001, Lower Flint Drought Protection Act: Water Stewards, p. 19.

Flint River Regional Water Council, Inc., Spring 2002, State conducts second drought auction: Water Stewards, p. 9.

Frick, E.A., D.J. Hippe, G.R. Buell, C.A. Couch, E.H. Hopkins, D.J. Wangsness, and J.W. Garrett, 1998, Water quality in the Apalachicola–Chattahoochee–Flint River basin, Georgia, Alabama, and Florida, 1992–95: U.S. Geological Survey Circular 1164, 38 p.

Georgia Department of Agriculture, 2003, Georgia agricultural facts: Georgia Agricultural Statistics Service, Edition, 91 p.

Georgia Department of Natural Resources, Environmental Protection Division, 2001, Flint River Drought Protection Environmental Rule, chap. 391-3-28.

Golden, H.G., and G.W. Hess, 1991, Georgia Floods and Droughts *in* Paulson, R.W., E.B. Chase, R.S. Roberts, and D.W. Moody, compilers, National water summary 1988–89—hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 239–246.

Hicks, D.W., H.E. Gill, and S.A. Longsworth, 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.

Hutson, S.S., N.L. Barber, J.F. Kenny, K.S. Linsey, D.S. Lumia, and M.A. Maupin, 2004, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.

McDowell, Robin, 2002, Going once, going twice . . . Georgia's Flint River Drought Protection Irrigation Auction Program: Groundwater Management Districts Association (GMDA) News, v. 2, no. 2, p. 2–3.

Mosner, M.S., 2002, Stream-aquifer relations and the potentiometric surface of the Upper Floridan aquifer in the lower Apalachicola–Chattahoochee–Flint River Basin in parts of Georgia, Florida, and Alabama, 1999–2000: U.S. Geological Survey Water-Resources Investigations Report 02-4244, 30 p.

Pierce, R.R, N.L. Barber, and H.R. Stiles, 1984, Georgia irrigation, 1970–80: A decade of growth: U.S. Geological Survey Water-Resources Investigations Report 83-4177, 29 p.

Shelton, Stacy, Reporter, Atlanta Journal-Constitution, January 19, 2004, accessed on March 15, 2004, at *http://www.ajc.com/metro/content/metro/0104/19waterwars.html*

Spechler, R.M., and D.M. Schiffer, 1995, Springs of Florida: U.S. Geological Survey Fact Sheet FS-151-95.

Stamey, T.C., 1996, Summary of data-collection activities and effects of flooding from Tropical Storm Alberto in parts of Georgia, Alabama, and Florida, July 1994: U.S. Geological Survey Open-File Report 96-228, 23 p.

U.S. Army Corps of Engineers, 1973, Survey report on Apalachicola, Chattahoochee, and Flint Rivers, Alabama, Florida, and Georgia: U.S. Army Corps of Engineers, Atlanta, Georgia, 44 p.

U.S. Army Corps of Engineers, 1984, Ground water section *in* Apalachicola–Chattahoochee–Flint River Basin water management study: U.S. Army Corps of Engineers, and States of Alabama, Florida, and Georgia, variously paged.

U.S. Bureau of the Census, 1991, Census of population and housing, 1990: Public Law 94-171 (Alabama, Florida, and Georgia): Washington, D.C., U.S. Department of Commerce, Bureau of the Census, digital data series, CD–ROM.

U.S. Environmental Protection Agency, 2000, Maximum contaminant levels (Subpart B of part 141, National Primary Drinking-water Regulations). U.S. Code of Federal Regulations, Title 40, parts 100–149, revised as of July 1, 2000, p. 334–560. Accessed January 15, 2003, at *http:/www.epa.gov/safewater/mcl.html*

U.S. Geological Survey, 1977–80, Land use and land cover digital data, 1972–78, Apalachicola, Atlanta, Athens, Dothan, Greenville, Macon, Phenix City, Rome, Tallahassee, and Waycross quadrangles: U.S. Geological Survey, scale 1:250,000.

By Debbie Warner, Hydrologist, U.S. Geological Survey, and Virgil Norton, Director, Flint River Water Planning and Policy Center (FRWPPC), Albany State University (ASU)

Design and layout by Caryl J. Wipperfurth, U.S. Geological Survey

Special thanks to Nancy A. Norton, Associate Professor, FRWPPC, ASU and Charles Irwin, President, Albany Audubon Society

Special funding contributed by The Flint River Regional Water Council, Inc.

For more information, please write to:
District Chief
U.S. Geological Survey
Peachtree Business Center
3039 Amwiler Road, Suite 130
Atlanta, GA 30360-2824

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
Charles G. Groat, Director

To request a copy call 770-903-9100 or access at *http://ga.water.usgs.gov/pubs/galist-gw.html*

U.S. Geological Survey General Interest Publication 4
Reston, Virgina: 2004