U.S. Geological Survey Science Plan for Georgia, 2005

By Edward H. Martin, John S. Clarke, and Brian E. McCallum

Open-File Report 2005-1074

U.S. Department of the Interior
U.S. Geological Survey

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

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

U.S. Geological Survey, Reston, Virginia: 2005
This report is a Web-only publication: *pubs.water.usgs.gov/ofr2005-1074*

For more information about the USGS and its products:
Telephone: 1-888-ASK-USGS
World Wide Web: *http://www.usgs.gov/*

Suggested citation: Martin, E.H., J.S. Clarke, and B.E. McCallum, 2005, U.S. Geological Survey Science Plan for Georgia, 2005, U.S. Geological Survey Open-File Report 2005-1074, 35 p.

Cover photographs:

Left: Hydrologic technician servicing a continuous ground-water-level data recorder at Chckamauga and Chattanooga National Military Park, Walker County, Georgia. Photograph by Alan M. Cressler, U.S. Geological Survey.

Right: Hydrologic technician taking a discharge measurement at Tallulah River near Tallulah Falls, Rabun County, Georgia. Photograph by Bonnie J. Turcott, U.S. Geological Survey.

CONTENTS

U.S. GEOLOGICAL SURVEY SCIENCE PLAN FOR GEORGIA, 2005

A plan for the science focus of the Georgia District for the next 5 to 10 years

INTRODUCTION

This science plan describes how the U.S. Geological Survey (USGS) Georgia District in the next several years will fulfill its mission and focus its efforts to enhance the quality of science provided to local and State governments, other Federal agencies, and the public of Georgia. The plan is based on the goals and mission of the USGS (included in Appendix A), the USGS Eastern Region Science Plan (a summary is included in Appendix B), dated January 2004, and on our evaluation of the particular water-resource issues and problems facing the State of Georgia.

The senior technical staff of the Georgia District—including the Senior District Scientist; Assistant District Chief, Hydrologic Monitoring and Analysis; Chief, National Water-Quality Assessment (NAWQA) Study Unit; Reports Specialist; Technical Specialists; Research Grade Evaluation Guide staff members; and District Chief —developed this science plan. This is the 3rd edition of Georgia District Science Plan, which was originally developed in 1999 and updated in 2002. The plan includes feedback from cooperators and USGS senior staff who attended a strategic review of district programs in June 2004.

The order of presentation for the science plan is:

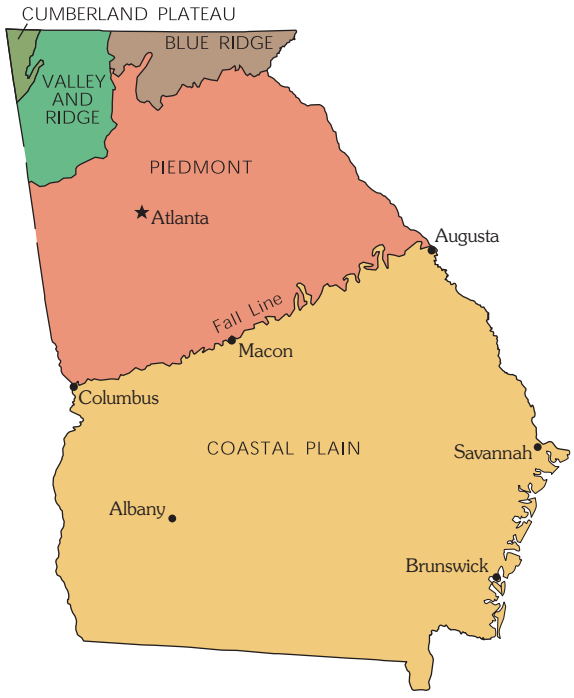
- Physical setting
- Social, political, and economic setting and associated hydrologic stresses
- Resulting priority issues
- A description of the Georgia District's current programs that addresses each issue
- Our vision of what we want the Georgia District to do in helping solve these issues
- Specific future program opportunities and plans to grasp those opportunities

We hope to achieve our vision and program goals by taking specific steps, overcoming challenges, and planning and executing nonprogram (e.g.: organization, training, and facilities) elements. Some of the program opportunities envisioned are several years into the future; we plan on developing the required technologies and techniques to be prepared for these opportunities. Other program opportunities currently exist, and we are proceeding with the work on these opportunities.

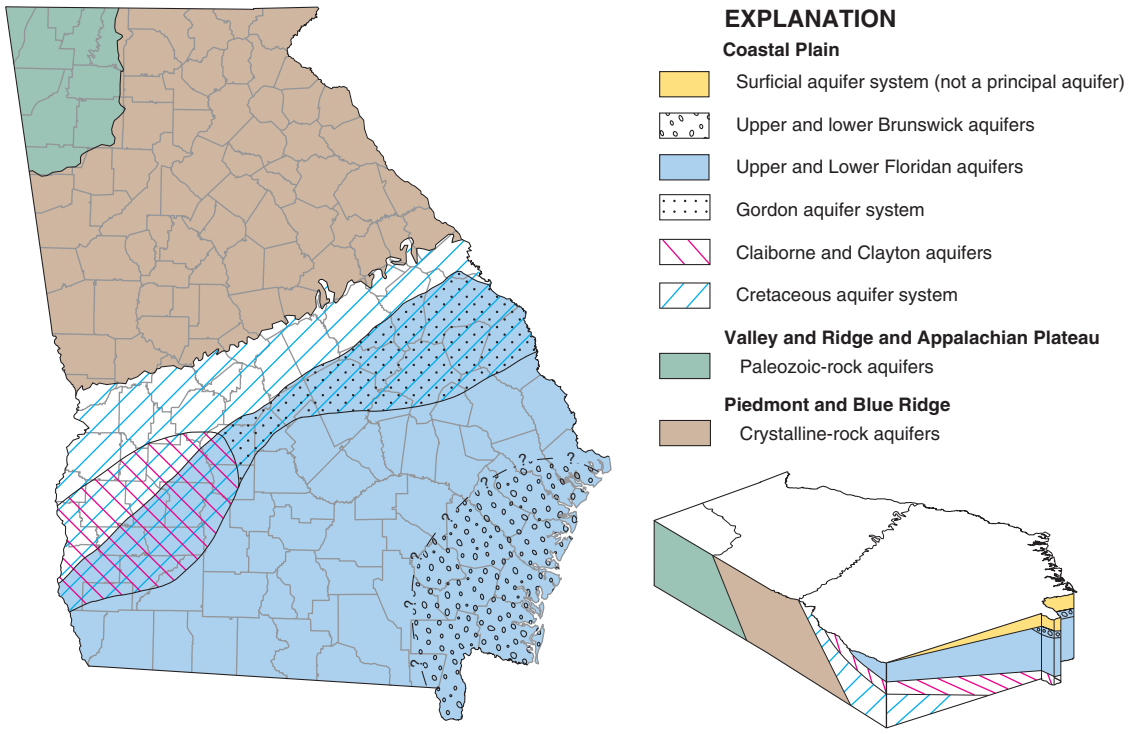
PHYSICAL SETTING

Georgia is the second largest southeastern state, having widely differing physiographic settings—Coastal Plain in the southern part of the State; and Piedmont, Blue Ridge, Valley and Ridge, and Cumberland Plateau in the northern part. The Piedmont, Blue Ridge, and Valley and Ridge have relatively large surface-water sources; whereas, ground-water supplies are limited. The Coastal Plain has large and productive ground- and surface-water systems. Georgia's Atlantic coast in the southeastern part of the State receives discharges from several large rivers. These estuarine areas support a biologically rich and diverse ecosystem, and a few have been developed into ports that can accommodate ocean-going vessels.

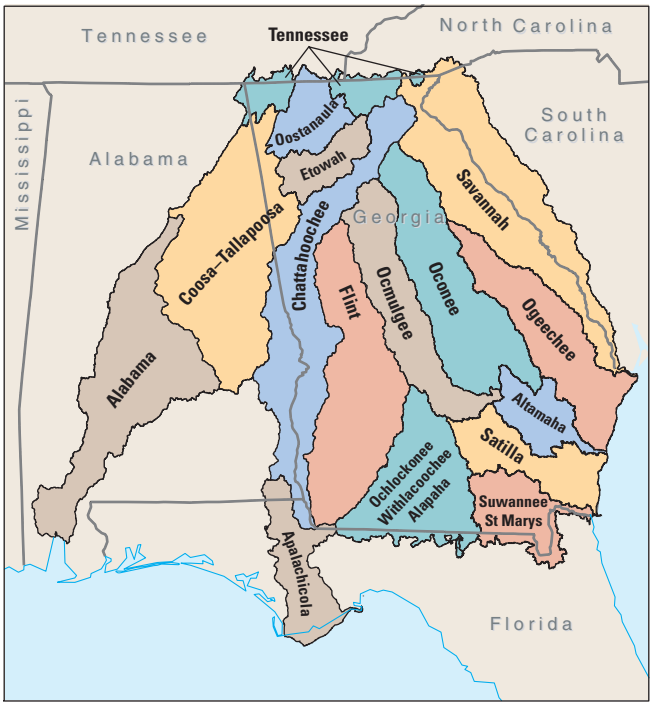
Very little surface water flows into Georgia from adjacent states. However, much of the runoff from Georgia flows into adjacent states or along its State line.



Georgia physiographic provinces



Aquifer systems in Georgia



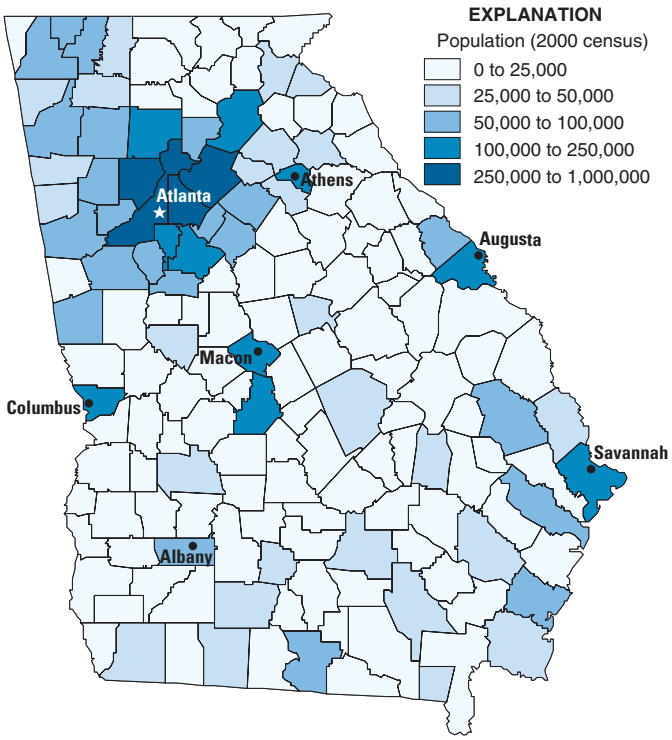
Major river basins in Georgia and part of Alabama

Georgia runoff to other states includes flows into Tennessee and Alabama; along the Alabama–Georgia State line (Chattahoochee River); then into Florida (Apalachicola River); and along the South Carolina–Georgia State line (Savannah River). Only the streamflows from the Altamaha and Satilla watersheds, which flow directly into the Atlantic, are not shared with another state.

The State can receive tropical storms and hurricanes, which can produce tremendous amounts of rainfall, from either the Atlantic Ocean or the Gulf of Mexico. Flooding, resulting from tropical storms or from continental frontal systems, can occur along major rivers and tributaries. However, rainfall can be highly variable—resulting in floods or droughts.

Social, Political, and Economic Setting and Associated Hydrologic Stresses

Metropolitan Atlanta in north-central Georgia has a population of almost 4 million and is the dominant social, political, and economic force in the State. Water supply in the metropolitan area is almost entirely supported by surface-water sources—the river basins from which Metropolitan Atlanta primarily withdraws water are the Apalachicola–Chattahoochee–Flint (ACF) and the Alabama–Coosa–Tallapoosa (ACT) River Basins. Water supply in the lower part of the ACF River Basin is primarily withdrawn from ground-water sources and used extensively for irrigation. Increased ground-water withdrawal reduces discharge to streams flowing into Florida.



Population by county in Georgia, U.S. Census Bureau, 2000

During 1997, the U.S. Congress and the States of Alabama, Florida, and Georgia developed two compacts—the ACF involving Alabama, Florida, and Georgia; and the ACT involving Alabama and Georgia. The three states allowed the ACF Compact to expire in September 2003. Many people expect that water allocation in the ACF River Basin ultimately will be decided by the U.S. Supreme Court. Currently (June 2004), Georgia and Alabama are still negotiating a water allocation for the ACT River Basin.

Regardless of how this matter is ultimately settled, it is clear that continued increases in withdrawal for public supply, industry, and agriculture from the ACF and ACT River Basins in Georgia cannot be sustained. Negotiating positions for both the ACF and ACT River Basins range from forecasted 2010 withdrawal rates to 2030 estimated rates. Quantifying all components of the hydrologic cycle including surface-water/groundwater interactions and nonpoint-source effects on water quality will become critically important to Georgia in the coming years. Nonpoint sources of pollution account for the majority of violations of the Clean Water Act as reported on the 303d List of Impaired Waters in Georgia. The majority of the violations are for bacterial indicators; but dissolved oxygen, pH, metals, nutrients, sediment, and various organic compounds are also commonly involved. The sources for many of these contaminants include nonpoint-source runoff from urban areas, construction sites, agricultural fields, golf courses, and other developed areas. State, county, and municipal governments—as well as environmental groups—are all interested in obtaining information on the sources, transport, and fate of these contaminants. There is also a need for understanding the processes that control the concentrations and loadings of these contaminants in streams, their effect on aquatic ecosystems, and potential for human health consequences.

Burgeoning population growth in the coastal area of Georgia and sustained industrial activity have adversely affected the area's water resources and limited the water supply—which is mainly from the Upper Floridan aquifer. Pumping from the aquifer has resulted in substantial water-level declines and subsequent encroachment of saltwater into the aquifer in the Savannah and Brunswick areas.

Extensive development has occurred in floodplains throughout Georgia, especially in the Coastal Plain where floodplains are very wide and extensive. Flooding from Tropical Storm Alberto during July 1994 was estimated to have caused property damage of one billion dollars in Georgia and resulted in at least 33 deaths. Georgia has an extensive agricultural industry, and droughts can adversely affect both the agricultural interests in Georgia and public and municipal water supplies.

Georgia hosts a large number of Federal lands and facilities. A few of the major Department of the Interior (DOI) lands in Georgia include

National Park Service:

- Chattahoochee River National Recreation Area, Atlanta
- Chickamauga and Chattanooga National Military Park, Fort Oglethorpe
- Cumberland Island National Seashore, St Marys
- Kennesaw Mountain National Battlefield Park, Kennesaw

U.S. Fish and Wildlife Service:

- Bank Lake National Wildlife Refuge
- Blackbeard Island National Wildlife Refuge
- Bonds Swamp National Wildlife Refuge
- Harris Neck National Wildlife Refuge
- Okefenokee National Wildlife Refuge
- Piedmont National Wildlife Refuge
- Pinckney Island National Wildlife Refuge
- Savannah National Wildlife Refuge
- Tybee National Wildlife Refuge
- Wassaw National Wildlife Refuge
- Wolf Island National Wildlife Refuge

Every branch of the armed services has a major presence in the State. A few of the larger facilities include:

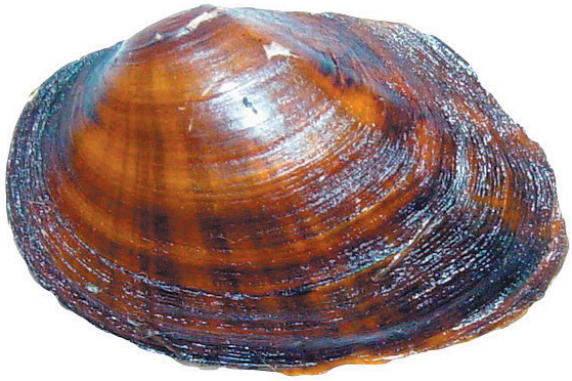
- Fort Benning U.S. Army Infantry Training Center, near Columbus
- Fort Gillem Army Supply Center, near Atlanta

- Fort Gordon U.S. Army Signal Center, near Augusta
- Fort McPherson 3rd Army Headquarters, near Atlanta
- Fort Stewart U.S. Army Signal Center, near Savannah
- Moody Air Force Base, near Valdosta
- Naval Submarine Base Kings Bay
- Robins Air Force Base, Warner Robins
- U.S. Air Force Plant 6, Marietta
- U.S. Marine Corps Logistics Base, Albany

Chattahoochee River National Recreation Area
Photo courtesy of National Park Service

The U.S. Department of Energy (DOE) operates the Savannah River Site near Aiken, South Carolina, near the border with Georgia. During its history, the Savannah River Site manufactured nuclear materials for National defense. These materials were disposed of or stored at numerous hazardous waste facilities throughout the site.

In addition to Federal land management duties, the U.S. Fish and Wildlife Service (USFWS) is responsible for official listing and conservation of threatened and endangered species. Listing by the USFWS confers a special legal status to the species and mandates that specific protection strategies are to be developed by the USFWS. Currently, the USFWS has listed for Georgia, 3 mussel and 4 fish species as threatened and 12 mussel and 3 fish species as endangered. Some of the more well-known threatened and endangered species include the shortnose sturgeon/*Acipenser brevirostrum* (endangered) found in Georgia's large coastal rivers and the snail darter/*Percina tanasi* (threatened) found in the Tennessee River. Other, less well known, species that often inhabit river bottoms and shoals include species such as the Coosa moccasinshell/*Medionidus parvulus* mussel (endangered) and the oval pigtoe/*Pleurobema pyriforme* mussel (endangered).



Oval pigtoe/*Pleurobema pyriforme* mussel (endangered)
Photo courtesy of Sean Kelly and Stephen W. Golladay, J.W. Jones Ecological Research Center, Newton, Georgia

Resulting Water Resources Issues and Georgia District Science Plan Focus Areas

Based on the foregoing discussion and a review of the current Eastern Region Science Plan, the following issues have been identified as priority water-resource issues that the Georgia District will plan for and emphasize during the next several years.

- Water availability and competing demands
- Water-resource development in coastal Georgia
- Hydrologic hazards (flood and droughts)
- Water-quality impacts from nonpoint sources, primarily Metropolitan Atlanta
- Water-resource effects associated with Federal lands and interests in Georgia

During October 2003, the Georgia District convened a program planning retreat to develop program ideas serving the needs of the USGS and cooperators in Georgia and adjacent states. Twenty-seven employees from a variety of backgrounds, including hydrology, geology, geography, and biology participated in the 1-day workshop. Working groups developed ideas for program development, including formulation of the problem, potential technical approaches, discipline involvement, and potential cooperators. At this retreat, the five issues listed above were confirmed and several new program possibilities and initiatives were identified. These new program possibilities have been incorporated into this plan.

The science activities of the Georgia District are not limited to the physical boundaries of the State of Georgia. These activities range from the hydrologic impacts of acid rain in the forests of Scandinavia to evaluating mine impacts of streams and rivers in Idaho. It is the intent of the Georgia District to leverage these activities to improve the overall science competency of the Georgia District and specifically the science activities in the State of Georgia. Consequently, these activities are included as a focus area of this Science Plan.

An important new suggestion from the retreat participants was that the Georgia District should add a seventh focus area, Science Communication, to its Science Plan. The consensus of the retreat participants was that good science, to be an effective and worthwhile, must be effectively communicated. How this will be implemented is more fully described in the Science Communication section of this plan.

The seven focus areas for the Georgia District Science Plan and the corresponding Eastern Region Science Plan elements are shown in the table.

Priority Science Plan Water Resources Issues in Georgia and Corresponding Eastern Region Science Plan Elements.

Georgia District Science Plan Georgia Priority Water Resources Issues and Focus Areas	Eastern Region Science Plan Elements Societal Issues and Integrated Science within the Eastern Region and Management Practices (see Appendix B)
• Water availability and competing demands	I. Urban Dynamics Water quality and availability for humans and ecosystems
• Water resources development in coastal Georgia	I. Urban Dynamics Water quality and availability for humans and ecosystems River and coastal processes
• Hydrologic hazards	IV. Natural Hazards Flooding, storms, and droughts
• Water-quality impacts from nonpoint sources	I. Urban Dynamics Flooding, storms, and droughts Urban expansion and land-use change
• Water resource effects associated with Federal lands and interests in Georgia	I. Urban Dynamics Water quality and availability for humans and ecosystems Also meets USGS role of science agency for the Department of the Interior
• International, National, and Regional science activities of the Georgia District	Supports many different elements in the Eastern Region Science Plan
• Science communication	Management Practice No. 3: Easy to use science information delivery systems that synthesize and convey complex science information to decision makers and the public

WATER AVAILABILITY AND COMPETING DEMANDS

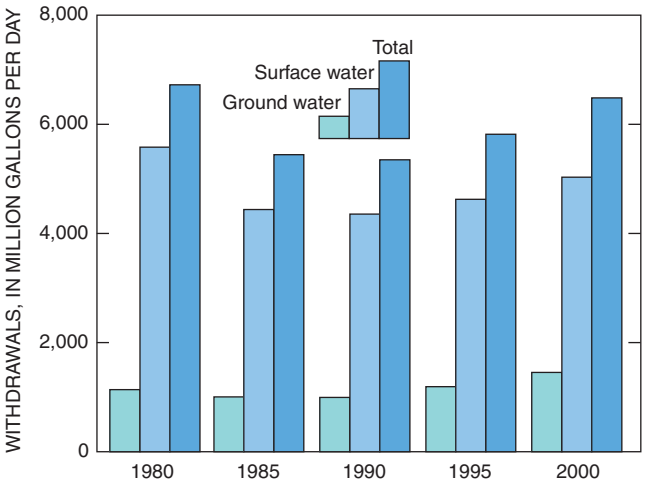
Background

The availability of freshwater sources in Georgia has come under increasing demand as the population and agriculture have grown. Population growth in northern Georgia—particularly the Metropolitan Atlanta region, along the Interstate Highway 85 corridor, and in the northwestern Georgia–Chattanooga, Tennessee area—is beyond previously projected rates, resulting in a significant increase in water demand. During 1980–2000, total water use in northern Georgia increased from 3,970 to 4,230 million gallons per day. During the same period, agricultural withdrawal, mostly in southern Georgia, increased from 580 to 1,090 million gallons per day. This unprecedented growth has put Georgia at the center of a major interstate conflict over water availability and rights. The States of Alabama and Florida are contesting the quantities of water withdrawn by Georgia in the ACF and ACT River Basins. Ongoing water-allocation negotiations with the State of Alabama, and past attempts with the State of Florida, indicate that Georgia may face limitations on agricultural, municipal, and industrial water use as stakeholders in the region compete for this limited resource.

Early projections by water managers that the ACF River Basin in the Metropolitan Atlanta area would be able to sustain projected growth to 2030 are proving to be optimistic; recent projections indicate that the ACF River Basin's water resources may be fully utilized before 2020. Surface water is nearly the sole source in the Piedmont area of the State; obtaining ground water from the underlying fractured crystalline rock in this area is difficult because of the complex geology of the province.

In southwestern Georgia, increased irrigation pumpage from the Upper Floridan aquifer, due to agricultural activity, threatens to reduce the flow of the Flint River significantly—adversely affecting downstream users and the ecosystem in the lower part of the 19,500-square-mile ACF River Basin. In south-central Georgia and north-central Florida, water resources of the Aucilla–Ochlockonee–Suwannee (AOS) River Basins are being stressed in a similar manner as the ACF River Basin—increased demand for irrigation and public supply has caused unprecedented ground-water-level declines and concern by water managers about pumpage-induced streamflow and springflow reduction. Severe drought from the late 1990s to 2002 caused significant reductions in streamflow, with some streams going dry for the first time. Despite recent hydrologic investigations and data collection by a number of Federal and State agencies, stream-aquifer interaction in the ACF and AOS River Basins is poorly defined. Cause-and-effect relations between pumpage and streamflow reduction have yet to be fully understood in this complex karst environment for science to support technically sound water-management decisions by Federal and State officials. In addition, seasonal irrigation pumpage, a critical component of the water budget in both basins is poorly defined.

Buford Dam at Lake Lanier



Surface- and ground-water use during 1980–2000 in Georgia

Competition for the available water supply is also becoming an issue along the South Carolina and Tennessee borders where neighboring states are taking steps to ensure adequate flows from Georgia, setting the stage for new water allocation conflicts over the water from the Savannah and Tennessee River Basins in years to come. Even within Georgia, the rural southern regions are constantly concerned with the increased consumption of water by Atlanta.

Center-pivot spray irrigation system
Photo by Mark Master, U.S. Department of Agriculture National Peanut Research Lab

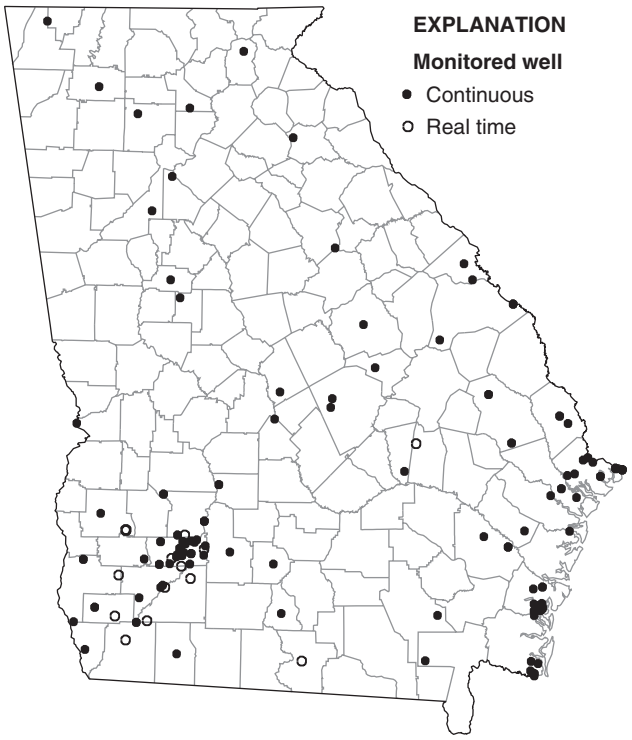
Current Programs

The Georgia District currently is addressing water allocation and availability in several program and project areas. Some of the more important hydrologic investigations being conducted are listed below:

- **Surface-Water, Ground-Water, and Water-Quality Basic Data Networks for Georgia** (*in cooperation with Georgia Environmental Protection Division, county and city governments and water-resources agencies, U.S. Army Corps of Engineers*)—Provide long-term record of hydrologic and water-quality conditions in support of hydrologic investigations and water-management decisions. Data serve as basis to evaluate changes in the hydrologic regime due to climate, extreme meteorological events, and anthropogenic factors and provide information on hydrologic and water-quality conditions.
- **Southwest Georgia Sound Science Initiative** (*in cooperation with Georgia Environmental Protection Division*)—Evaluate stream-lake-aquifer flow and the impact of agricultural withdrawal on the lower ACF River Basin. The program is composed primarily of the Lake Seminole hydrologic assessment project and the lower ACF transient ground-water flow model project. The Lake Seminole project is quantifying lake water-budget components and ground- and surface-water interactions, defining interstate ground-water flow between Georgia and Florida, identifying changes to the ground-water flow system due to lake impoundment, and assessing the potential for sinkhole collapse and catastrophic lake drainage. The lower ACF transient ground-water flow model is developing a better scientific understanding of the impact on the stream-aquifer system of seasonal agricultural withdrawal from the ground-water system and determining the sensitivity of selected stream basins to ground-water pumping. Information from the two studies is being used to support interstate water negotiations between Georgia and Florida, and withdrawal permit decisions by the State of Georgia.
- **Hydrogeology and Water-Resource Potential of Fractured Crystalline Rock in the City of Lawrenceville and Rockdale County Areas** (*in cooperation with city of Lawrenceville and Rockdale County Water Authority*)—Determine the occurrence, availability, and quality of ground water in a fractured-crystalline-rock geologic setting. Information is being used to develop and manage the ground-water resources and is providing techniques to further assess the occurrence of ground water in the Piedmont area and to assess the impact of ground-water development on the stream-aquifer system.

Vision

The vision of the Georgia District is to be the primary source of hydrologic information and understanding in Georgia. We want to use our program to test and prove new techniques in surface-water monitoring and develop innovating new means to communicate effectively the real-time data and results of these scientific studies. It is our to goal lead the science in surface- and ground-water interactions in these basins.



Ground-water-level monitoring wells used to collect data

We hope to play an important role in evaluating alternatives to surface-water supplies, such as ground water in fractured crystalline rock of the Piedmont–Blue Ridge of northern Georgia, and assessing the impact of ground-water development on streamflow in the Piedmont–Blue Ridge region. As part of our efforts, we intend to expand integrated investigations of water and biological resources in the State.

Future Program Opportunities and Goals

The Georgia District plays an active role in developing new program areas to assess water resources availability in Georgia. In addition, the Georgia District will assist with statewide water planning and determining minimum instream-flow needs for aquatic life and water supplies. At the Georgia District Program Development Retreat, several key areas were identified:

- Surface-water flow
  - Recomputation of surface-water flow statistics
  - Flood frequency
  - Determination of basin and reservoir water budgets
- Water use
  - Assist in development of a real-time monitoring network
    - Agricultural use
    - Major river basins
  - Web-based database reporting and management
- Ground water
  - Expand real-time monitoring network
    - Expand monitoring network to fill data gaps throughout state
    - Stream-aquifer relations in the lower ACF River Basin
  - Assess streamflow sensitivity to pumpage
  - Develop real-time decision support model for ACF River Basin
  - Assess current springflows in ACF River Basin; establish springflow monitoring network
- North Georgia (Piedmont) ground water
  - Supply
    - Relation of geology to well yield
    - Sustainability of water supply
    - Stream-aquifer relations (impact of development on streamflow)
  - Water quality
    - Radionuclides
    - Contamination
    - Impact of poultry industry
    - Vulnerability to contamination
- Integrated water and biological resources
  - Quantification of minimum streamflow requirements for biological resources, including threatened and endangered species
  - Assess impact of extreme high and low flow on aquatic ecosystems
  - Assess ecological integrity of urban streams
  - Determine loadings to estuarine systems through modeling
  - Assess impact of aquatic weed problems in lakes and reservoirs
  - Develop statewide network of biological monitoring sites

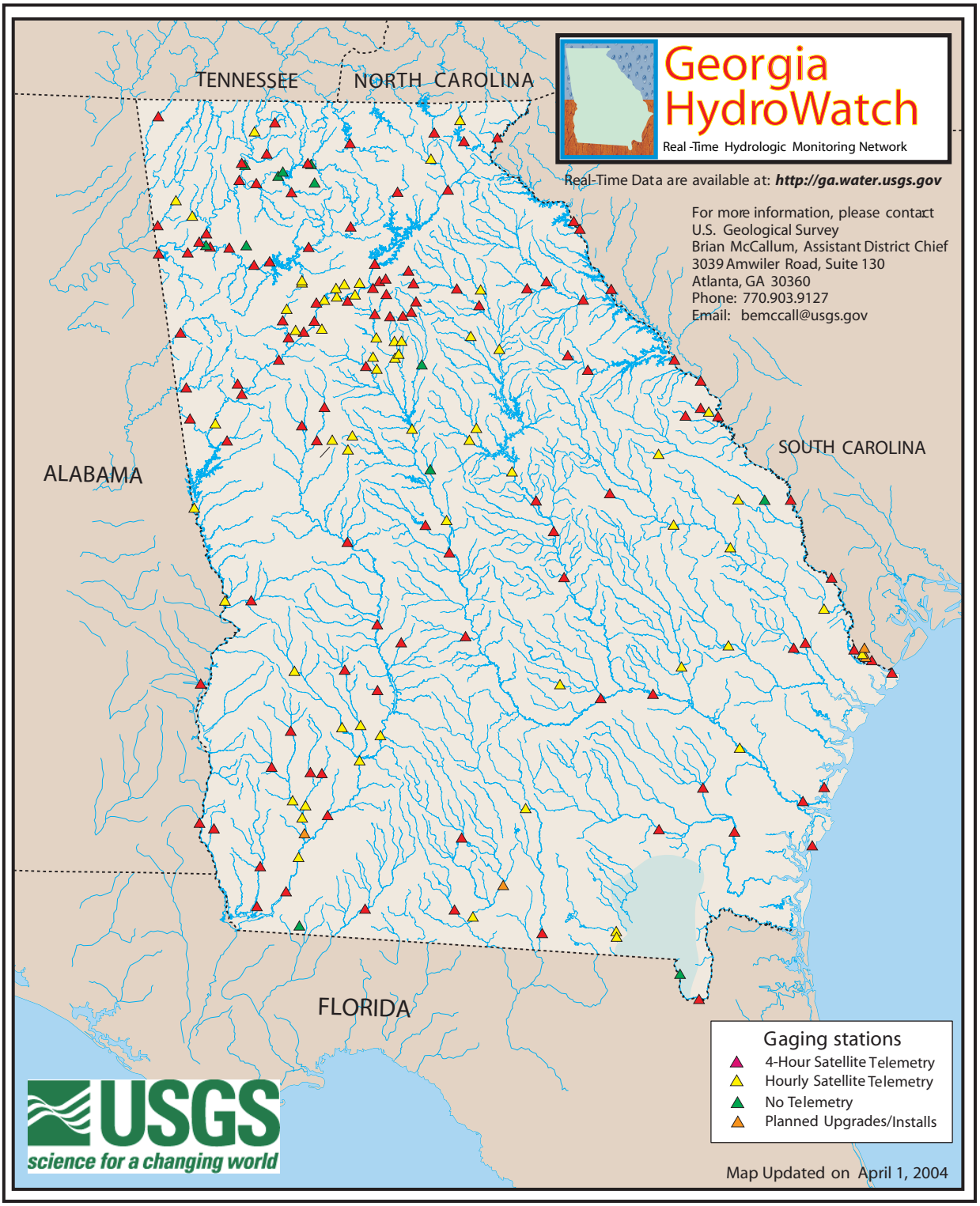
Together with water managers in the government agencies responsible for making decisions on water utilization and allocation, the Georgia District has identified several areas of immediate concern that serve as future program opportunities and goals.

Advanced Statewide Hydrologic Monitoring System (Georgia HydroWatch)

Science Objectives: Determine the occurrence and nature of Georgia's surface and ground waters on a near real-time basis at regional, basin, and subbasin scale

Approach: Continue to expand and upgrade the existing monitoring networks to the latest state-of-the-art real-time satellite telemetry, with the addition of tipping-bucket raingages at streamflow stations and wells wherever possible

- Expand the deployment of continuous water-quality monitors across the State to increase our understanding of the spatial and temporal variability of Georgia's surface waters
- Develop capabilities to monitor water withdrawal and effectively manage water-withdrawal data
  - Near real-time public supply and industrial withdrawal in key river basins
  - Develop database capable of online interactive updating and reporting of water withdrawal
- Estimate missing record and confidence intervals of parameters at ungaged sites
- Combine previous analysis of streamflow trends in southwestern Georgia with results of regional analyses to evaluate effects of climate-related streamflow decline
- Continue to develop new means to communicate the data and scientific results to all users (see Science Communication section)
- Synthesize monitoring data into basinwide water budgets



Surface-Water Continuous Monitoring Stations Network

Real-time streamgage site

Potential Cooperators: Georgia Environmental Protection Division, U.S. Army Corps of Engineers

Expected Science Impacts: Provide hydrologic, water-quality, water use, and ecological information and technical assistance to Federal and State water managers to enable timely decisions regarding the protection and allocation of surface- and ground-water resources

Specific Steps

- Continue to explore any possible means of expanding existing monitoring networks and upgrading to real time
- Develop expertise in estimating missing streamflow record using standard statistical methods or neural network analysis
- Develop team to conduct statistical study of streamflow trends
- Develop technologies to effectively monitor real-time industrial and municipal withdrawal and extrapolate data regionally
- Develop means to effectively communicate monitoring results

Alabama–Coosa–Tallapoosa River Basins Hydrologic and Biologic Monitoring Initiative

Science Objectives: Develop an understanding of the relation among rainfall, reservoir operation, water use, streamflow, water quality, stream and lake habitat, and populations of biological communities in the ACT River Basin

Approach: Develop integrated monitoring networks that include real-time streamflow, and water-quality and biological monitoring

Potential Cooperators: USGS Federal funding

Expected Science Impacts: The data and understanding produced by this program will provide near real-time data to water resource managers in the basin. The comprehensive nature of this program will allow managers to make holistic and environmentally sound decisions.

Specific Steps

- Provide annual analyses in watershed hydrology, trends, and impacts of management decisions on the water resources of the ACT River Basin
- Present hydrologic and biologic monitoring initiative (HBMP) to State technical representatives for approval
- Develop consensus approval of the HBMP within the Federal agency community
- Explore long-term funding possibilities
- Implement the HBMP when funded, through coordination with the USGS Alabama District
- Approach interagency group and States about preparing a science plan for the ACF River Basin

Southwest Georgia Sound Science Initiative Phase II

Science Objectives: Develop a better understanding of the hydrologic impact of agricultural withdrawal in the karst area on stream-aquifer relations in the lower ACF River Basin

Approach

- Refine ground-water flow model by incorporating additional hydrogeologic, streamflow, and agricultural withdrawal data
- Using the calibrated model, generate maps showing the relative sensitivity of streamflow to ground-water withdrawal at varying distances from the stream in selected ground-water basins

- Link ground-water model and real-time hydrologic data to a decision-support system to assess surface-water and ground-water flow throughout ACF River Basin
- Provide database and interpretive support to Georgia Environmental Protection Division (GaEPD) and Georgia Soil and Conservation Commission on real-time monitoring of agricultural withdrawal
- Expand stream and ground-water monitoring networks; develop springflow monitoring network

Potential Cooperators: Georgia Environmental Protection Division, U.S. Army Corps of Engineers

Expected Science Impacts: Improved understanding of stream-aquifer relations in the complex karst environment of the lower ACF River Basin will enable better management of the area's water resources and provide insight for similar hydrologic settings

Specific Steps

- Develop linkage between USGS ground-water model, real-time hydrologic data, and decision support system developed by the Georgia Water Resources Research Institute at the Georgia Institute of Technology
- Develop relationships with potential cooperators
- Develop geostatistical procedures for estimating the temporal and areal distribution of agricultural withdrawal
- Provide support to GaEPD and Georgia Soil and Conservation Commission on real-time monitoring of agricultural withdrawal

Assessment of Stream-Aquifer Relations in the Aucilla–Ochlockonee–Suwannee River Basin

Science Objectives: Improve understanding of the impact of agricultural withdrawal on stream-aquifer relations in the AOS River Basin—develop program similar in scope to Southwest Georgia Sound Science Initiative

Approach

- Develop ground-water flow model capable of simulating stream-aquifer flow and the impact of agricultural withdrawal. Using the calibrated model, generate maps showing the relative sensitivity of streamflow to ground-water withdrawal at varying distances from the stream in selected ground-water basins
- Link ground-water model and real-time hydrologic data to a decision-support system to assess surface- and ground-water flow throughout basin
- Expand stream and ground-water monitoring networks; develop springflow monitoring network

Potential Cooperators: Georgia Environmental Protection Division, U.S. Army Corps of Engineers, Suwannee River Water Management District (Florida)

Expected Science Impact: Improved understanding of stream-aquifer relations in the complex karst environment of the AOS River Basin will enable better management of the area's water resources and provide insight for similar hydrologic settings

Specific Steps

- Use proposal originally submitted for consideration for "RASA II" (an Office of Ground Water initiative) as basis for planning
- Develop relationships with potential cooperators
- Develop procedures for linkage of ground- and surface-water models and decision support systems
- Compile available hydrogeologic information into a geographic information system (GIS) database

North Georgia Ground-Water Initiative

Science Objectives: Develop a Piedmont regionwide hydrologic understanding of the occurrence of ground water in this fractured-rock geologic setting. This understanding will include the relation between ground-water withdrawals and streamflow.

Approach

- Assess development potential of crystalline-rock aquifer as an alternative water supply to the existing surface-water sources in northern Georgia
- Evaluate hydraulic connection of fractured crystalline rock with surface water and the impact of ground-water development on surface-water flow
- Identify potential for water-quality degradation and subsurface migration of surface- and near-surface-applied contaminants
- Assess impaired ground-water quality resulting from radioactivity of native bedrock
- Team with USGS Geologic Discipline to identify major lithologic and geologic units at land surface and determine source rock for radioactive waters
- Characterize surface and subsurface hydrogeologic setting through mapping and borehole geophysical logging
- Establish stream- and ground-water monitoring network; document stream-aquifer system response to pumping

USGS hydrologist at a quartzite-schist outcrop entering structural data into a handheld computer. The USGS, working with the State University of West Georgia, has developed a system for digital collection of structural data into a handheld computer and a global positioning system receiver.
Photo by Ethan W. Williams

- Conduct hydrograph separation analysis of streamflow records to determine ground-water contribution to stream-flow; conduct seepage evaluations during periods of low streamflow to determine ground-water contribution
- Collect and analyze samples to assess quality of water and to determine linkage between ground and surface water

Potential Cooperators: Georgia Environmental Protection Division; city and county governments or water authorities

Expected Science Impact: An improved understanding of ground-water hydrology in the Piedmont will allow resource managers to appropriately and wisely develop ground-water supplies in this Region.

Specific Steps

- Continue development of innovative geophysical methods to evaluate the occurrence of ground water in fractured crystalline rock
- Continue work with USGS Geologic Discipline to develop detailed geologic maps to facilitate assessment of the linkage between geology and ground-water availability

Discharge from air-lifting ground water from a well after penetrating water-bearing fracture zones

- Develop methods to assess and monitor the sustainability of ground-water resources using ground-water level, climatic, and streamflow monitoring techniques
- Assess linkage between rock type and natural radioactivity of ground water; partner effort with interested cooperators from the public health sector

Instream Ecological Systems Flow Needs for Georgia Streams and Estuaries

Science Objectives: Develop an understanding of the relation of aquatic biological habitats and populations and changes in associated streamflow caused by development, primarily withdrawals and reservoir operations

Approach

- Produce a statewide plan of ecoregion specific studies for determining instream flows and flow patterns needed to preserve diverse and healthy aquatic ecosystems
- Determine hydromorphologic and target community regions within Georgia where specific techniques can be applied in a consistent and uniform manner

- Define and describe a series of scientific studies that, when completed, will lead to the development of an instream flow policy that addresses the complicated and diverse ecosystems in Georgia
- Organize and facilitate a series of meetings with interested parties including Federal and State regulators, local governments, economic interests, environmental groups, and other stakeholders

Collecting an invertebrate sample from riffle habitat in a stream in Metropolitan Atlanta

Potential Cooperators: Georgia Department of Natural Resources, U.S. Environmental Protection Agency

Expected Science Impact: This project should result in the information that the State will need to implement an instream flow policy that is protective of all uses, including aquatic wildlife, recreational, economic, and social. If the policy is successful it could provide a guide for other states in the southeast to implement an instream flow policy, thereby enhancing aquatic communities throughout the region.

Specific Steps

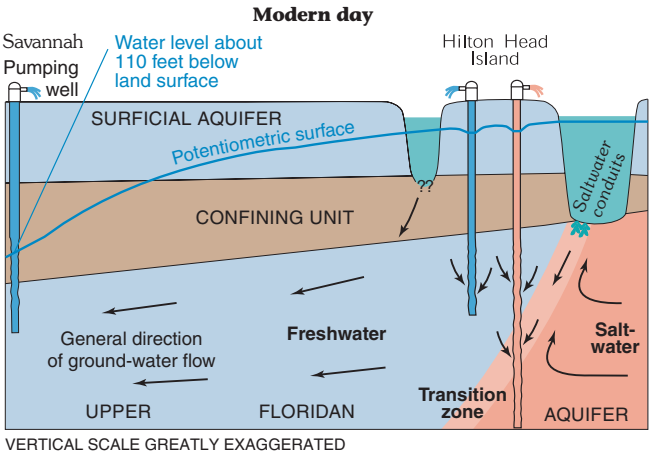
- Develop a cooperative program with Georgia Department of Natural Resources/U.S. Environmental Protection Agency (proposal submitted February 2004)
- Leverage Eastern Region funding for a workshop on the cumulative effects of upstream reservoirs on aquatic resources to “kick off” the instream flow effort
- Identify methods and techniques for quantifying instream flow that are applicable to the region and the ecosystems present
- Use existing environmental data to identify ecoregions where a consistent methodology can be applied
- Define studies needed to obtain results that can be used to design an instream flow policy

WATER-RESOURCES DEVELOPMENT IN COASTAL GEORGIA

Background

Burgeoning population growth in the coastal area of Georgia (purportedly the second fastest growing region in the nation), greatly increased tourism, and sustained industrial activity have adversely affected the area's water resources and limited the water supply. The main source of water supply in the coastal area is the extremely permeable, high-yielding Upper Floridan aquifer, which was first developed in the late 1800s and has been used extensively in the area ever since. Pumpage from the aquifer has resulted in substantial water-level declines and subsequent encroachment of seawater into the aquifer at the northern end of Hilton Head Island, South Carolina, and in saltwater intrusion of the aquifer from underlying brine-filled strata at Brunswick, Georgia, and near Jacksonville, Florida. In the Brunswick area, saltwater has been contaminating the Upper Floridan aquifer for almost 50 years; so that now within an area of a few square miles in downtown Brunswick, the aquifer yields water that has a chloride concentration above National and State drinking-water standards.

Saltwater contamination has constrained further development of the Upper Floridan aquifer in the coastal area and created fierce competing demands for the limited supply of water available for development. During the fall of 2001, GaEPD emplaced a moratorium on permitted withdrawal from the Upper Floridan aquifer throughout the 24-county coastal region through the year 2005, prompting interest in the development of alternative sources of new water supply, primarily the shallower Brunswick and surficial aquifer systems, and the deeper Lower Floridan aquifer.

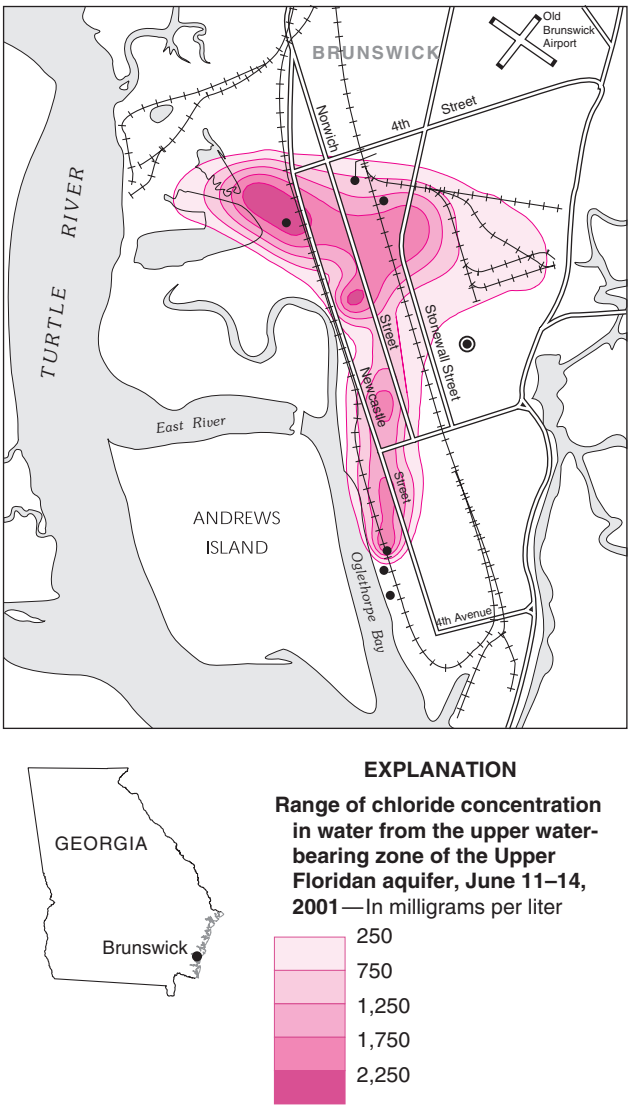


Saltwater encroachment in the Upper Floridan aquifer

U.S. Army Corps of Engineers jack-up barge used as a platform for drilling offshore test borings near Hilton Head Island

Studies suggest that the lowering of ground-water levels caused by pumping in coastal Georgia has decreased and locally eliminated diffuse upward leakage of ground- to surface-water features, which could affect surface-water flow, change the salinity of marshes and estuaries, and affect biological habitats. As shallower ground-water sources are developed for alternative supply, the impact of pumping likely will have a more pronounced effect on ground-water discharge to streams and wetlands. Pumping from the clastic Brunswick and surficial aquifer systems could also lead to land subsidence in areas where heavily utilized. The impact of planned expansion and deepening of Savannah Harbor on surface, ground, and biological resources is currently under assessment by the U.S. Army Corps of Engineers and Georgia Port Authority. The USGS is providing support to this effort through technical advice and oversight, development of GIS data coverages, and expanded surface-water monitoring.

The impact of continued population growth, especially during times of drought, on the quantity and quality of surface waters in the coastal region of Georgia is becoming more critical as water managers seek additional water supplies. With pumping limits applied to ground-water supplies, more expensive alternatives like surface-water withdrawals and desalinization are being explored. Monitoring and analyzing the impact of these water-supply alternatives on fisheries habitats, saltwater marshes, and other surface-water uses will be critical. Other concerns in the coastal region are habitat loss, impact of titanium strip mining, endangering of biota, and coastal erosion in areas of less-than-prudent development.



Chloride concentration in water from the upper water-bearing zone of the Upper Floridan aquifer

Current Programs

The Georgia District has multiyear history of increasing the scientific understanding of the occurrence and nature of ground water in the coastal region of Georgia. The Georgia District presently is engaged in long-term cooperative investigations with GaEPD, the city of Brunswick, and Glynn County to assist water managers in meeting the previously mentioned objectives while maintaining adherence to the USGS mission.

- **Coastal Georgia Sound Science Initiative** (*in cooperation with Georgia Environmental Protection Division*)—Scientific and feasibility studies to support development of the GaEPD final strategy to protect the Upper Floridan aquifer from saltwater contamination. Program includes investigation of paths and rates of ground-water flow and intrusion of saltwater into the Upper Floridan aquifer by developing detailed solute-transport models for the Brunswick and Savannah–Hilton Head Island areas; delineation of areas where saltwater is entering the Floridan aquifer system by constructing offshore test wells near Savannah–Hilton Head Island and deep test wells onshore near Savannah and St Marys; assessment of alternative sources of water supply including seepage ponds connected to the surficial aquifer, the Lower Floridan aquifer at selected deep test-well sites, and the surficial and Brunswick systems; developing and maintaining an expanded monitoring network to assess ground-water levels and quality. The program is providing information needed by the cooperator to manage effectively water resources in coastal Georgia, while providing insight into mechanisms of saltwater contamination in the Atlantic Coastal Zone and on alternative sources of water supply.
- **Brunswick and Surficial Aquifers Study** (*in cooperation with Glynn, Liberty, McIntosh, and Camden Counties and the city of Ludowici*)—Assess development potential of aquifers as supplement to main water source (Upper Floridan aquifer) by constructing test wells, assessing subsurface geology, determining water chemistry, and conducting aquifer tests. The project is providing the cooperator with information needed to guide development of potential supplemental sources of water supply, including better understanding of the geology, water quality, and hydrology of aquifers of Miocene to recent age and monitoring impact of development on hydrologic conditions.
- **City of Brunswick Cooperative Water Program** (*in cooperation with the city of Brunswick*)—Program to monitor and assess impact of ground-water development on saltwater contamination of the Floridan aquifer system at Brunswick, Georgia. Information is being used by cooperator to manage and develop ground-water resources in the area, while providing insight into mechanisms of saltwater intrusion from deep sources of connate water.

Vision

It is the vision of the Georgia District to leverage its long history of scientific investigation in coastal Georgia to maintain its position as a key participant with the State and other stakeholders in providing understanding needed to manage ground-water resources. The Georgia District will continue the role of providing ground-water monitoring data and analyzing the complexities of the ground- and surface-water flow systems, including simulation of ground-water flow, solute transport, and stream-aquifer relations. The Georgia District will continue to work to expand its role in surface-water monitoring and analyses in the coastal region, especially with the use of acoustic streamflow stations.

Future Program Opportunities and Goals

The Georgia District will continue to monitor ground-water levels and quality in coastal Georgia through its ongoing cooperative programs with GaEPD, the city of Brunswick, and Glynn County. Additional partnerships with local governments would enable a more complete regional assessment of the Brunswick and surficial aquifer systems in the coastal area. At the Georgia District Program Development Retreat, several key areas were identified:

- Surface water and biological resources
  - Assess impact of increased surface-water withdrawal on wetlands and biological resources
  - Marsh dieback
  - Impact of land use changes on stream quality; sediment; ecosystems
  - Cumulative impact of reservoirs on aquatic ecosystems
  - Impact of invasive vegetative species
  - Assess effects of municipal and paper mill waste-water discharges on black-water streams
  - Coastal flooding and hurricane monitoring
  - Beach monitoring—bacteria
  - Estuarine modeling—loading to estuarine systems
  - Pesticide and nutrient transport into estuaries
  - Assessment of impact of ground-water development on sturgeon habitat in lower Altamaha River
- Ground water
  - Saltwater contamination (Savannah and Brunswick)
  - Alternative water sources
    - Lower Floridan aquifer
    - Brunswick and surficial aquifer systems
  - Impact of ground-water development on wetlands/ surface water
  - Impact of proposed surface mining on water and biological resources
- Impact of global warming
  - Saltwater intrusion
  - Flooding
  - Coastal morphology

Together with GaEPD, the Georgia District has identified several areas of immediate concern in coastal Georgia that serve as future program opportunities and goals:

Coastal Georgia Sound Science Initiative Phase II

Science Objectives: Provide further understanding and assessment of saltwater intrusion in coastal Georgia; assess the impact of increased development on saltwater intrusion and stream-aquifer relations

Approach

- Refine ground-water models with additional hydrogeologic information
- Use calibrated flow and solute-transport models to run and evaluate additional scenarios for GaEPD (beyond 2005)
- Conduct additional field investigations of the Lower Floridan aquifer and other alternative ground-water sources and incorporate into revised ground-water models
- Assess impact of ground-water development on surface water and wetlands through modeling and field assessments

Potential Cooperators: Georgia Environmental Protection Division

Science Impacts: Improved characterization and understanding of mechanisms of saltwater intrusion and assessment of the impact of ground-water development on streams and wetlands will allow managers to make socially and environmentally sound decisions.

Specific Steps and Challenges

- Accomplish project objective by working with scientists from adjacent USGS Districts, the National Research Program, other USGS Disciplines, academia, and other State agencies
- Expand the streamflow and surface-water-quality monitoring network in the coastal region, using state-of-the-art acoustic technologies
- Provide support to the U.S. Army Corps of Engineers and Georgia Port Authority for Savannah Harbor studies
  - Provide technical advise and oversight
  - Develop GIS data layers
  - Expand surface-water monitoring
- Initiate new interpretive studies concerning the impact of population growth and climatic events—such as drought— on the surface-water quality and aquatic health of estuarine streams and coastal habitat
- Expand expertise in coastal zone hydrology and ecology

Whitley Lake, Cumberland Island National Seashore

HYDROLOGIC HAZARDS

Background

The information provided by the USGS usually relates to the quantity, quality, and distribution of earth resources as a public and ecological resource. However, water resources also represent a significant hazard to human health and property. Flood damage is a major emergency management issue, and timely, accurate flood warning, and flood prediction are critical to public safety. USGS hydrologic-hazard activities in Georgia deal with describing, documenting, and understanding natural hazards and associated risks. These activities include long-term prediction, real-time monitoring, and communication with civil authorities and others during a hazard crisis.

The 1994 flood was the most devastating flood in recent history, having from 100-year to greater than 200-year recurrence interval discharges in most of the Flint and Ocmulgee River Basins. The flood in May 2003 along the middle Chattahoochee River impacted many people in the West Point, Georgia, area and raised concerns about possible bridge scour at the Interstate 85 crossing, closing this major transportation route for several hours.

Droughts represent a kind of hydrologic hazard that is very different from flood hazards; but its economic effects can be equally devastating. Droughts are sustained for several months and cause economic stress across very large areas by affecting agriculture, recreation, municipal, navigation, and power-production activities. The 1998–2002 drought produced the lowest flows of record in many streams in southwest Georgia and led to shortages of surface-water supplies and water restrictions in many parts of the State. Prolonged dry conditions in the spring of 2004 are once again raising concerns of drought in Georgia.

Flooding from Tropical Storm Alberto along the Flint River near Oakfield, Georgia, on July 9, 1994

USGS streamflow gaging station on Ogeechee River near Eden during drought, July 2000

Current Programs

- **Georgia HydroWatch Real-Time Monitoring Network** (*in cooperation with GaEPD, U.S. Army Corps of Engineers, and many Georgia cities and counties*)—Supply the latest real-time hydrologic information collected throughout Georgia to cooperators, water resources managers, and emergency management officials in a timely manner to enable informed decisions regarding Georgia's water resources and public safety.
- **Bridge Scour Monitoring and Analyses** (*in cooperation with Georgia Department of Transportation and Georgia Institute of Technology*)—Develop regional bridge scour design equations and implement real-time bridge scour monitoring; use field data to calibrate physical and numerical models that are being conducted at the Georgia Institute of Technology. The study will enable the Georgia Department of Transportation (GDOT) to design safer and more efficient bridge foundations.
- **Flood Inundation and Visualization of the Flint River near Albany, Georgia** (*in cooperation with Dougherty County, Georgia*)—Accurately model flood inundation using 2-dimensional hydrodynamic model and GIS tools in order to visualize the extent of flooding for a broad range of flood stages from the 10- to the 500-year recurrence interval events. The study will enable emergency management officials, planners, and developers to determine areas prone to flooding and that may need to be evacuated during rising floodwaters.

Extent of flooding in Albany, 1994

Part of Albany West digital orthophoto quadrangle

Vision

It is the vision of the Georgia District to provide relevant, accurate, and timely surface- and ground-water data to State and local emergency officials and the general public for all types of hydrologic hazards information. The use of the latest technology is critical to "broadcast" USGS information to the widest possible audience. We want to develop the capacity to produce flooding area and depth maps on a near real-time basis.

Future Program Opportunities and Goals

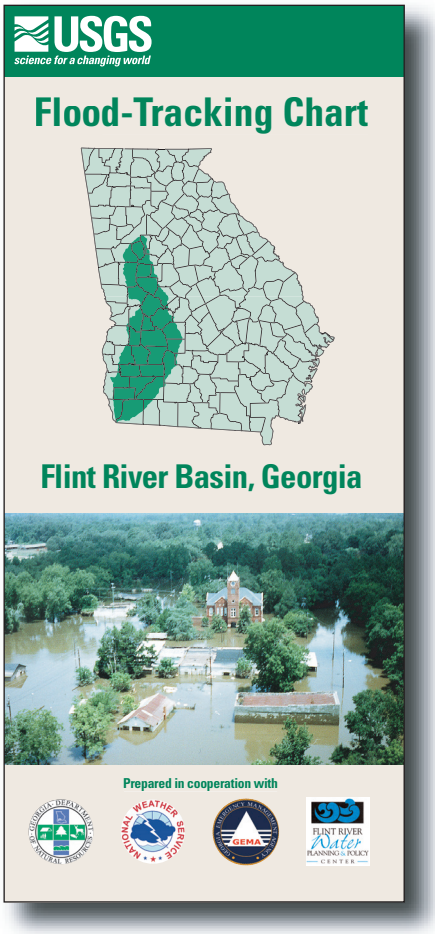
The Georgia District will continue to monitor hydrologic conditions throughout the State through its ongoing cooperative programs that support the Georgia HydroWatch Network. Additional partnerships with State and local governments would enable a more complete coverage to monitor hydrologic hazards throughout the State. At the Georgia District Program Development Retreat, several key areas were identified:

- Provide streamflow information needed to protect people and property from floods, and to protect water quality. Streamflow statistics—such as the 100-year flood, the annual mean flow, and the 7-day 10-year low flow (7Q10)—frequently are used by engineers, land managers, biologists, and many others to help guide decisions
- Complete upgrading of all long-term monitoring streamflow stations and ground-water wells statewide
- Continue to expand installation of raingages at all real-time stations and wells for flood warning and drought monitoring
- Expand monitoring presence in the coastal region for hurricane monitoring, evacuation route traffic counters/inundation monitoring, and long-term acoustic streamflow stations
- Develop program with GDOT to provide long-term, real-time bridge scour monitoring
- Implement fog and ice monitoring equipment at bridge crossings to assist GDOT with public safety
- Investigate the addition of air-quality sensors at existing USGS stations throughout the Metropolitan Atlanta area to assist with air-quality monitoring
- Expand monitoring and analysis presence associated with the Savannah Harbor deepening program to better aid navigation
- Construct a Georgia HydroWatch Real-Time Hazards center in the District Office in Atlanta to coordinate the dissemination of all USGS real-time hazards data
- Develop flood-tracking charts for other major river basins similar to the Flint River Tracking Chart
- Provide expertise and methods to assist in drought planning
- Implement real-time hazards initiative communications action plan
- Continue to perform long-term monitoring of natural hazards and evaluate conditions in the aftermath of disasters
- Complete Flood Inundation Project for Albany and apply knowledge learned statewide
- Encourage and support efforts to collect additional data to improve resolution of Georgia's DEM data and enable more accurate delineation of floodplains
  - Statewide to at least a level 2, 10-meter resolution, constrained by hydrography
  - In urban, suburban, and coastal areas more detailed data approaching 1-foot resolution are needed to improve disaster management and emergency transportation and planning

Specific Steps and Challenges

- Seek the assistance of current and new cooperators and Federal programs to add telemetry to the entire Georgia District hydrologic monitoring network
- Involve new partners (such as the local news/weather media) to relay hazard information quickly and efficiently to the necessary emergency agencies and public

- Continue to invest in the latest acoustic technology to allow for faster, more inexpensive, and safer ways to collect streamflow information
- Continue to ensure that collected real-time data are presented in an accurate, timely, and useful manner so that emergency management officials can make informed decisions regarding public safety (see Science Communication)
- Complete the Flint River flood inundation study and provide the results in a form that may be used by emergency management personnel during flood conditions
- Transfer methods developed in the Flint River flood inundation study to other areas of Georgia



Flood-Tracking Chart for the Flint River Basin, Georgia

WATER-QUALITY IMPACTS FROM URBAN AND AGRICULTURAL NONPOINT SOURCES

Background

Rapid growth of Metropolitan Atlanta and other urban areas in Georgia is transforming the headwaters of many watersheds from forests and pastures to suburban and urban land. Streams provide much of the area's drinking water supplies and many outdoor recreational opportunities. Continued expansion of Metropolitan Atlanta and other urban areas has posed numerous challenges for water-resources management at local, State, and Federal levels. These challenges include:

- Providing additional drinking-water and wastewater treatment capacity to meet demands of water use
- Controlling erosion and sedimentation created by widespread land-disturbing activities
- Controlling urban runoff to mitigate flooding hazards, stream erosion, and destruction of stream habitat and aquatic communities
- Limiting nutrient loads to avoid eutrophication of sensitive water bodies such as reservoirs and coastal estuaries
- Controlling runoff of toxic organic substances, trace elements, and microbial contaminants that may harm humans and aquatic life

Several USGS programs in Georgia are being implemented or planned to:

- Assess the stream quality, habitat, and aquatic ecology of urban streams
- Support the Total Maximum Daily Load (TMDL) process
- Provide scientific information necessary for sound management of water resources in urban, suburban, and urbanizing areas

Improperly disposed of debris in stream

Sediment-laden runoff entering the Chattahoochee River from Suwanee Creek

- Provide information to educate the public regarding their role in protecting and improving urban streams. Many of these programs are based on questions arising from the 1991 NAWQA studies in Georgia. The ACF River Basin NAWQA and District Water-Quality Section staffs are conducting most of these studies.

Current Programs

Many District programs are involved in collecting data, assessing water-quality conditions, and providing information related to nonpoint-source impacts on water quality in Georgia. These programs include the following:

- **National Water-Quality Assessment—Apalachicola–Chattahoochee–Flint River Basin** (*USGS federally funded program*)—Determine long-term trends in water quality and relation to land use; determine occurrence of anthropogenic chemicals and levels of bacterial indicators in Chattahoochee River (drinking-water source for city of Atlanta); examine effects of urban land use on aquatic ecosystems; determine trends in nutrient and pesticide concentrations in shallow ground water in agricultural areas; determine relation between pesticide occurrence in surface water and shallow ground water in relation to pesticide use and hydrogeologic setting; determine the transport and environmental fate of agricultural chemicals in a shallow ground-water system; measure nutrient stream enrichment and determine its relation to aquatic ecosystem health. Study results can be used by planners and resource managers to determine levels of development that will severely impact the quality of water and aquatic biota in urban and agricultural areas.
- **City of Albany Cooperative Program** (*in cooperation with the Albany Water, Gas, and Light Commission*)—Program to monitor and assess nitrate contamination in ground water in the vicinity of a new municipal

wellfield. Information is being used by cooperator to manage and develop ground-water resources in the area, while providing insight into mechanisms of nitrate contamination in a karst hydrogeologic setting.

- **Water, Energy, and Biogeochemical Budgets of the Panola Mountain Research Watershed (PMRW)** (*USGS federally funded program*)—Investigate processes that control the movement and solute composition of water along hydrologic pathways in a small Piedmont watershed; determine relative contributions from a variety of sources of solutes observed in streamwater; investigate biogeochemical processes controlling the regulation of soil-solution chemistry and element cycling; compare the hydrologic and hydrochemical responses at PMRW to those of other watersheds. Research conducted at PMRW should provide a good first step in determining the dominant processes and possible model structures for understanding the functioning of an urban or a suburban watershed, and have transfer value with respect to the back ground characteristics of Piedmont streams.
- **Metropolitan Atlanta Urban Hydrology Program** (*in cooperation with the cities of Atlanta and Roswell, Georgia Department of Natural Resources, and Gwinnett and Rockdale Counties*)—Evaluate water quality and its relation to land use, point- and nonpoint-source discharges, and watershed characteristics; determine relations between water quality, watershed characteristics, and aquatic ecology; contrast the stream water-quality conditions, trends, and loads measured before and after upgrades to wastewater infrastructure and implementation of best management practices; identify the correspondence between fecal coliform bacteria (current indicator bacteria), *Escherichia coli* bacteria (proposed indicator bacteria), and organic compounds identified as wastewater compounds. Provides data that are used in stormwater management plans, in National Pollutant Discharge Elimination System (NPDES) monitoring requirements, and in meeting monitoring requirements of the Federal Clean Water Act as administered by GaEPD.
- **Statewide Stream Water-Quality Sampling Network (**in cooperation with GaEPD)—Ongoing collection of basic long-term data for use in assessing current conditions and trends in streamflow and water quality for the establishment of TMDLs. Includes analysis of nutrients, major ions, and metals at more than 130 sites Statewide. Fifty sites are sampled each year, with the remaining 80 sites sampled on a rotational basis in each of Georgia's five major river basins.

Vision

It is the vision of the Georgia District to maintain its position as one of the few organizations in the State capable of performing broad, regional scale, and scientifically integrated water-quality studies. We want to maintain our reputation for scientific data collection and technically sophisticated and unbiased analysis.

Future Program Opportunities and Goals

The Georgia District will continue to monitor stream and aquifer water quality throughout the State through its ongoing cooperative programs. Additional partnerships with State and local governments would enable a more complete coverage to monitor and assess nonpoint pollution throughout the State. At the Georgia District Program Development Retreat, several key areas were identified:

- Determine impact of urban growth on streamflow and water quality
  - Urban Land-Use Gradient
  - Pharmaceuticals in drinking water
  - Sediment total maximum daily loads
  - Develop networks to better assess urban stream quality
- Determine impact of agriculture and industry on stream quality
- Assess lake water and sediment quality: relate to land use changes
- Develop lake water-quality monitoring networks
- Develop networks to assess bacteria content in rivers, beaches, and recreational areas
- Assess effects of atmospheric deposition on water quality
  - Urban areas
  - Mercury deposition from power-plant emissions
  - Add air-quality monitors to existing real-time monitoring sites

Specific Steps and Challenges

- Develop more interpretive programs to complement urban programs with the Georgia District
- Expand the scope of the Metropolitan Atlanta urban hydrology projects to include additional municipalities and additional streams

- Expand cooperative projects to include assessing the impacts of urban best management practices in mitigating the movement or sources of contaminants to urban streams
- Provide additional real-time estimates of water-quality constituents by monitoring of surrogate compounds
- Work with Federal, State, and local agencies and organizations to conduct studies in and downstream of Metropolitan Atlanta
- Participate in the activities of local watershed groups by providing data and understanding
- Seek funding from cooperators to evaluate data collected as part of the water-quality network
- In cooperation with GaEPD and the city of Albany, develop a solute-transport model to estimate the transport and fate of nitrate as nitrogen concentrations in relation to the city of Albany's municipal wellfield and impacts to domestic wells
- Work more closely with Federal, State, and local agencies in hydrogeologic and ground-water-quality studies in south Georgia
- Produce, in cooperation with State and local agencies, a lay-reader product similar to the "Everyone Lives Downstream" poster that describes water-resources issues in southwest Georgia
- Develop new abilities and skills in watershed modeling
- Assess the effectiveness of artificial wetlands on concentrations and trends in trace metals transported from a rapidly urbanizing basin in Gwinnett County
- Investigate the USGS SPARROW model as a potential tool to determine urban TMDLs in the Atlanta metropolitan area
- Use the OTIS streamwater-quality model to determine stream- and ground-water interaction and the contribution of ground water as a nonpoint source of contaminants to the urban streams of the Atlanta metropolitan area
- Assess the efficiency of artificial wetlands for removal of organic wastewater compounds such as pharmaceuticals, fire retardants, human steroids, and endocrine-disrupting compounds in Clayton County
- Continue to assist Atlanta metropolitan counties with watershed assessment monitoring
- Collect data throughout the State to assist with the conversion from fecal bacterial standards to *E. coli* bacteria standards
- Collect and analyze data to develop a better understanding of factors affecting sediment loads to assist the State in development of TMDLs
- Identify environmental factors affecting survival and transport of indicator bacteria in the Chattahoochee River and selected tributaries
- Determine occurrence of endocrine disrupting compounds, pharmaceuticals, and other wastewater associated compounds in the environment, their potential for affecting aquatic wildlife, and potential as a contaminant in drinking-water supplies
- Improve our understanding of the hydrogeology of surficial aquifers in Coastal Plain sediments of southwest Georgia and the dominant processes that control the subsurface transport of ground-water contaminants

WATER RESOURCES EFFECTS ASSOCIATED WITH FEDERAL LANDS AND INTERESTS IN GEORGIA

Background

In recent years the Georgia District has had the opportunity to support the water resources goals of several sister agencies within the U.S. Department of the Interior. Most notable of these is the collaboration with the National Park Service (NSP) and the U.S. Fish and Wildlife Service. Recent interaction with the NPS includes interpretive studies at the Cumberland Island National Seashore (water quality and ecological appraisal) and the Chattahoochee River National Recreation Area (occurrence of several indicator bacteria pathogens in the river and microbial source-tracking studies using ribotyping). Recent scientific activities conducted with USFWS include assessing the impacts of ground-water withdrawals on the stream habitats of several threatened and endangered mussel species in the Flint River Basin.

The Georgia District began working with the Department of Defense (DOD) during the early 1990s. The first customers were the U.S. Army Reserve at the Reserve Center Motor Pool and the U.S. Navy Southern Division Facilities Engineering Command (SouthDiv) at the U.S. Marine Corps Logistics Base (MCLB) and Naval Submarine Base Kings Bay. At the Army Reserve Motor Pool, the USGS assisted by estimating stormwater-runoff loadings from the Motor Pool to a nearby stream. At the MCLB, the USGS provided review of contractor-prepared resource evaluations and work plans; drafted a stormwater monitoring plan that was required as a part of the MCLB National Pollutant Discharge Elimination System permit; and supplied stormwater runoff instrumentation and sample collection. USGS personnel provided the submarine base with oversight of the U.S. Navy's environmental contractors; reviewed reports supplied by the contractors; and provided a hydrogeologic framework report to the U.S. Navy.

The USGS, Georgia and South Carolina Districts, conducted a comprehensive study with the Department of Energy during 1991–97 to better define ground-water flow and stream aquifer relations in the vicinity of the Savannah River Site near Aiken, South Carolina. A second phase of the Savannah River Site study to conduct further ground-water modeling investigations was begun in 2002 and will be completed by the end of fiscal year 2004.

The largest DOD program in Georgia is at the U.S. Air Force Aeronautical Systems Center (U.S. Air Force Plant 6—AFP6) near Marietta. During the past few years the Georgia District's role at other DOD facilities has decreased somewhat, with most activity limited to streamflow monitoring at Fort Gordon near Augusta and the U.S. Marine Corps Logistics Base in Albany.

Current Programs

- **BacteriALERT Network** (*in cooperation with National Park Service Chattahoochee River National Recreation Area, Upper Chattahoochee Riverkeeper, Georgia Conservancy, Georgia Department of Natural Resources Environmental Protection Division, and Fulton County*)—Collect daily bacteria samples and provide date in near real-time to the public; identify the effects of turbidity, streamflow, water temperature, season, hypolimnion reservoir releases on *E. coli* bacteria density in the Chattahoochee River National Recreation Area; and develop statistical equations that estimate *E. coli* density in real-time use real-time measurements of turbidity, streamflow, water temperature, season, and hypolimnion reservoir releases
- **Habitat modifications resulting from flow alterations in the Chattahoochee River National Recreation Area** (*in cooperation with National Park Service Chattahoochee River National Recreation Area*)—Measure physical characteristics of Chattahoochee River under different flow conditions; determine through modeling, conditions that would result from possible flow alterations designated in any ACF or ACT Compact agreement; determine fish habitat loss resulting from altered flow conditions
- **Savannah River Site Trans-River Flow Phase II** (*in cooperation with U.S. Department of Energy*)—Program to evaluate interstate ground-water flow beneath the Savannah River using digital ground-water flow modeling. Update and refine the earlier calibrated ground-water model to 2002 conditions and define ground-water flowpaths under a variety of hypothetical pumping scenarios.

Chattahoochee Riverway Partnership at the Chattahoochee River near Norcross, Georgia

The C-130 is manufactured at U.S. Air Force Plant 6, Marietta

- **U.S. Air Force Plant 6, Marietta—Aeronautical Systems Center** (*in cooperation with U.S. Air Force*)—Provide technical support for AFP6 environmental assessments, with particular focus on dense nonaqueous phase liquid contaminated ground water in the weathered and fractured crystalline bedrock. USGS provides guidance regarding program priorities and evaluates ongoing investigations, and employs advanced geophysical and ground-water sampling methods to advance understanding of the hydrogeology, with emphasis on the transport and degradation of chlorinated hydrocarbons.

Vision

It is the vision of the Georgia District to play a significant role in providing scientifically sound water-resource data and interpretations for and in collaboration with the Department of the Interior and other Federal agencies as they meet the challenges of water-resource management in the coming years. The Georgia District will conduct studies to provide DOD/DOE with the level of knowledge required to make appropriate science-based decisions to remediate current contamination, ensure the health and well being of the general population who live and work near the DOD facilities, and protect the environment from future releases of contaminated materials. The Georgia District intends to continue research into the movement of contaminants in the fractured-rock aquifer at AFP6.

Future Program Opportunities and Goals

- Utilize microbial source-tracking techniques to identify sources of microbial contaminants in the Chattahoochee River in cooperation with the National Park Service Chattahoochee River National Recreation Area and in collaboration with the Biological Resources Discipline
- Identify environmental factors that limit or facilitate the presence of indicator bacteria, their growth, survival, and suitability as indicators of pathogens in surface waters in Georgia, particularly in the Chattahoochee River National Recreation Area
- Complete investigations at Savannah River Site and publish final report
- U.S. Air Force Plant 6, Marietta—Aeronautical Systems Center (ASC)
  - Continue to provide technical support to ASC
  - Continue characterization of the contaminated fractured-bedrock aquifer; with emphasis on pollutant fate and attenuation, and relation to nearby Rottenwood Creek
  - Develop a water budget for the aquifer and a local stream that drains the study area
  - Publish and distribute a Scientific Investigations Report describing the geology and hydrogeology
  - Develop a project database that includes water-quality data collected by all major site investigators
  - Begin visualization modeling of the contaminant plumes
  - Continue development of advanced water-quality collection methods, including development of straddle-packer capabilities; and begin development of digital modeling

Specific Steps and Challenges

The Georgia District will maintain a DOD program that represents from approximately 10 to 15 percent of its total program. This will be accomplished by proposing new projects with current and potential customers as existing DOD projects are completed.

REGIONAL/NATIONAL/INTERNATIONAL SCIENCE ACTIVITIES OF THE GEORGIA DISTRICT

Background

In addition to studies within the State, Georgia District scientists engage in research of regional, national, and international scope. These external activities cover a wide range including, but not limited to (1) specific projects; (2) scientific consultations; (3) journal editorial responsibilities; and (4) service with international organizations or societies. This element to the Georgia District Science Plan displays our involvement in scientific programs outside the State and demonstrates our commitment to the overall scientific mission of the USGS.

Current Programs

- Sediment-Chemical Partitioning Project
  - **San Francisco Bay—**Provide analytical support for the determination of selinum and mercury in a variety of solid-phase materials in support of other program elements.
  - **Empire Lake, Kansas** (*Federal Program*)—This is a new program involving collaboration with the Kansas District Office and is funded through the Department of Interior's NRDA program. It entails an evaluation of the sediment geochemistry of an area impacted by past mining and ore-processing activities associated with the Missouri lead-zinc mining district.
  - **Seine River Basin, France—**Ongoing collaborative study with Dr. Michel Meybeck of the University of Paris VI that has been investigating the impact of population and urbanization on the Seine River Basin. The project has demonstrated the utility of using recent floodplain deposits to evaluate water-quality conditions and has demonstrated that water quality in the basin has improved during the past 5+ years in response to remediation efforts. The results from these studies have applicability to the local city of Atlanta project as well as to other current USGS urban hydrology studies.
  - **Meuse and Scheldt River Basins, Belgium**—Ongoing collaborative effort with Flanders Hydraulics (a division of the Flemish Community) that entails training and advice on planning and implementing a national suspended sediment and water-quality monitoring network.
- **National Stream Quality Accounting Network (NASQAN) - Monitoring the Water Quality of the Nation's Large Rivers** (*Federal Program*)—
  - **Sediment research**—Analytical support for the determination of inorganic constituents associated with suspended sediment in large U.S. river basins. Develop estimates of the annual fluxes of suspended sediment and associated constituents and evaluate the efficacy of various sampling/monitoring approaches that can be successfully employed in other programs. This also has led to participation in planning additional studies for Louisiana Governor's Office of Coastal Activities.
  - **Estimation of streamwater solute loads** for all NASQAN stations. Provide timely estimates of nutrient loads for the Lower Mississippi River Basin to coordinate with estimates of the extent of Hypoxia in the Gulf of Mexico. Load estimates provide information on water-quality conditions and long-term trends that can be the result of climate change and anthropogenic factors; and are used in support of hydrologic investigations and national water-management decisions.
  - **Water-Quality Networks**—Develop appropriate techniques for estimating streamwater solute loads. Includes evaluation of the effect of methodology, sampling design, concentration-model form, and calibration-period length on load estimates. Techniques developed contribute to the improved ability of the USGS and the hydrologic community to accurately estimate solute loads.
- **National Water Information System (NWIS)—**The Georgia District has been very proactive in supporting the development of NWIS. NWIS is both a work-flow application and a long-term database for national records of ground-water quality and levels; surface-water quality, flow, stage and discharge; and, therefore, must be managed and maintained as a national archive of data. Data are quickly and easily available from NWIS and are essential to the implementation and successful completion of a broad range of interpretive studies addressing ground-water, surface-water, water-quality, and water-use issues that are critical to USGS partners in local, State, tribal, and Federal government. Currently, there are three Georgia USGS employees who are key members of the NWIS supported user groups: Tim Stamey – Surface Water User Group (SWUG) and Automated Data Processing System (ADAPS); Keith McFadden – Ground Water User Group (GWUG); and Nancy Barber – GWUG and Water Use User Group. All three are experts in their fields and have made significant contributions to the water resources programs over several years.
- **International Hydrology Program**—The hydrologic expertise of the Georgia District is an important resource

for International programs. The Overview of Middle East Water Resources, compiled by Georgia District personnel, is the headline product of the water-data effort within the Mideast Peace plan, and one of three projects conducted by USGS personnel in Georgia. Personnel have also supported GIS training in Cyprus and flood warning in the Himalayan Mountain range. These efforts also improve our perspectives and abilities to address problems in Georgia.

- **Collaboration with National and International Scientific Organizations**
  - **International Union of Geodesy and Geophysics (IUGG) & Scientific Committee on Problems of the Environment (SCOPE)**—Jake Peters is the current IUGG/SCOPE liaison until the 2007 IUGG General Assembly, and he is tasked with developing and directing SCOPE projects within the framework of the IUGG. He recently received approval by the SCOPE Executive Committee to initiate a project on *Biological Measures of Water Quality: Their Relevance to Present and Future Contaminants.*
  - **International Association of Hydrological Sciences (IAHS)**—This is the leading formal international association within IUGG for providing oversight of hydrological sciences internationally. Jake Peters is the past President of the International Commission on Water Quality of IAHS and in this capacity, designs and convenes symposia and workshops on major water-quality issues jointly with other IAHS Commissions. He currently is convening a workshop, entitled *Land-use and Water Quality Relationships in Ungauged Basins*, during the IAHS' VII Scientific Assembly convened in Foz do Iguaçu (Brazil) April 3–9, 2005. This workshop is one of several addressing issues of information transfer and uncertainties associated with misrepresentation of hydrological processes and prediction uncertainty.
  - **International Commission on Continental Erosion (ICCE) of the International Association of Hydrological Sciences**—Art Horowitz serves as a vice president of the ICCE/IAHS.
  - **Scientific Journals and Publications—** Jake Peters is an editor of the international journal, *Hydrological Processes*, and is on the editorial board of *Lowland Technology.* Jake also is the associate editor of several chapters on water quality for an *Encyclopedia of Hydrological Sciences*. Art Horowitz serves on the editorial board of the journal *Science of the Total Environment*.

Vision

It is the vision of the Georgia District to continue research and collaborative work on Regional, National, and International scales, and to incorporate results of this research into our in-state programs. District staff will work to explore and develop new and innovative approaches to assessing water quality and processes impacting that quality, to develop databases and procedures that facilitate analysis of earth-science data, and to provide training in the use of these methods and techniques to the USGS and the international scientific community.

Future Program Opportunities and Goals

- **NASQAN—**The Georgia District will continue to provide support to the NASQAN program in estimating streamwater solute loads and method development. Expertise that could be provided in support of other studies includes streamwater solute-load estimation and sample-design optimization for water-quality characterization, trend detection, and solute load estimation.
- **National Flux Program—**This work entails building on the 20 years of NASQAN data on discharge and suspended sediment concentrations used in conjunction with limited active streambed and/or floodplain sampling to estimate current fluvial chemical concentrations for the subsequent development of off-continent flux estimates for the conterminous United States and Alaska. This work is similar to that associated with the global geochemical mapping program, as well as an existing program currently under consideration by the UNEP (United Nations Environmental Program)/GEMS (Global Environmental Monitoring System Water program.
- **Global Geochemical Mapping**—Participation through the ICCE/IAHS and in collaboration with the Norwegian Geological Survey and the Norwegian Water Resources and Energy Directorate to develop a program for a broad-scale geochemical mapping that will include the estimation of large river fluxes of suspended sediment and associated chemical constituents.
- **Lake Coeur d'Alene, Idaho—**The project chief has been asked to act as a consultant to an NAS committee currently reviewing the Environmental Protection Agency's Record of Decision and remediation plans for the Bunker Hill Superfund site. That consultation includes soliciting recommendations for additional work on the Lake and the Coeur d'Alene River Basin. One such recommendation is a resampling of the lake 15 years after the first evaluation to determine the effect(s) of 10 years of remediation in the upper part of the basin.

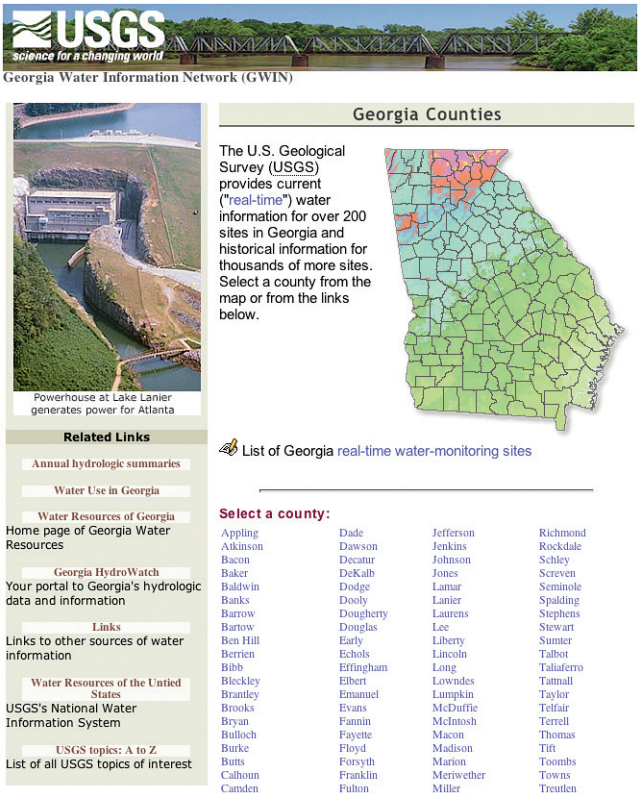
SCIENCE COMMUNICATION

Background

To remain a relevant partner in the hydrologic sciences in Georgia, the USGS must continue to strive to find new and innovative means to present the collected data and interpretive scientific results in an accurate, timely, and useful manner to all users of our information. This element to the Georgia District Science Plan displays our commitment to the role that the timely and useful dissemination of scientific data and results is critical to our overall scientific mission.

Current Programs

- **Digital Annual Data Report** (*in cooperation with GaEPD and numerous local cooperators*)—This CD-ROM-based, GIS-type software interface allows users to view hydrologic data in Georgia in ways never presented before and is changing the way the USGS presents its hydrologic data throughout the Nation. This software interface allows the users to spatially analyze hydrologic information using GIS coverages and accompanying data; view hydrologic information in a new graphical format, as well as the traditional tabular presentation; put the hydrologic information into context with streamflow station photos and maps; search for hydrologic information by station name, county, river basin, or aquifer; extract all historical information from all continuous monitoring locations in other computer applications; perform network analyses to find where data have been collected throughout the State.
- **Water Resources Atlas of Georgia** (*in cooperation with GaEPD*)—A multivolume DVD product with a GIS graphical user interface providing topographic, orthophoto, and watershed data. This includes 8-, 10-, and 12-digit watersheds, land use and land cover, roads, current and historical stream monitoring sites, and selected streamflow and basin statistics. The atlas would promote better understanding and communication of environmental factors affecting streamflow and water-quality characteristics, and provide information needed to conduct river basin and watershed management programs, perform TMDL assessments, and support source water protection.
- **User-targeted Web-page Design** (*in cooperation with GaEPD and numerous local cooperators*)—The Web designers in the Georgia District have created numerous Web pages that augment National Web efforts and target specific users of a particular type of hydrologic information. These Web pages put the hydrologic data and results in an easy to use, easy to find format so that the work of the Georgia District is promoted and understood. Many complement and go beyond the existing capabilities of the existing USGS National Water Information System Web-Page (NWISWeb) System. Some examples of these include:
- The **Georgia Water Information Network (GWIN)** Web page that compiles all available hydrologic information, by county, for the user. This first-of-its-kind Web page will allow local county managers the opportunity to find USGS data that are important to their efforts.



USGS Georgia Water Information Network Web page

- The **Georgia HydroWatch** Web page is a one-stop page for all real-time hydrologic and weather information in Georgia.
- **Online availability of selected interpretive reports**, all USGS reports by Georgia District since about 1999 are being prepared for online access. Older popular reports are being scanned and will be available online.
- **Interactive Flint River Flood Tracking Chart**—presents the latest flood information to citizens living along the Flint River in an easy to use format. The user can relate the latest flood levels to the five largest flood peaks recorded at a site, and put that into a context from their memory of how the previous floods affected their lives.
- **Project-related Web pages** for interpretive studies and urban hydrologic monitoring programs, to allow cooperators and local users the ability to quickly find information relevant to their needs. Examples include: Urban Hydrology Monitoring, City of Atlanta Water-Quantity and Water-Quality Monitoring Program,

Coastal Sound Science Initiative, low-flow and flood-frequency Web pages, and Web pages for the Brunswick, Albany, and Lawrenceville cooperative water programs.

- **Specific Web pages with cooperator-only access** to assist other Federal, State, and local agencies with the use of USGS hydrologic information. Examples include: Automated rating table Web page for the National Weather Service (NWS) and local cooperators to have the latest shifted rating tables to use for flood forecast and drought monitoring and DECODES configuration Web page to allow the NWS and the U.S. Army Corps of Engineers to descramble the transmissions from the real-time streamflow stations for flood forecasting and reservoir operations purposes.

- **Proactive Data Delivery Products** (*in cooperation with GaEPD and numerous local cooperators*)—The Georgia District has developed a number of ways to proactively "push" hydrologic data to users. This method is different from a passive approach in which the user has to search for desired information. In many cases, the user is notified of automatically delivered products via the District Web page, conference presentations, and handouts where they enroll on the subscribers list. Several examples of such proactive products include:
  - Chattahoochee BacteriALERT e–mails that notify the user of the latest *E. coli* bacteria counts on the Chattahoochee River
  - Daily streamflow e–mails, by major river basin, that allow the user to see the latest streamflow conditions of any basin
  - Cell phone real-time streamflow data that lets the cooperator get the latest streamflow data at any station via a Web-enabled cell phone
  - A map-based user interface that allows the user to have an easy to use, means of analyzing real-time hydrologic data. This commercially available software, called DIADvisor, can also show rainfall intensity maps, page users on pre-set thresholds, and graphically display all real-time hydrologic information. It is provided strictly to cooperators and uses FTP connections to push data to their client software packages.

Vision

The Georgia District will continue to strive to find new and innovative means to present data and interpretive scientific results in an accurate, timely, and useful manner to all users of USGS information. To meet this goal, the Georgia District will:

- Improve the timeliness of reporting
- Leverage Georgia District expertise in Web and GIS programming to develop new ways of displaying hydrologic information
- Communicate with users to ensure that data are presented in usable formats

Future Program Opportunities and Goals

- Develop an ArcIMS version of the Digital Annual Data Report
- Promote the development of the Digital Annual Data Report product as a tool for presenting integrated science by all other USGS districts and cost centers
- Continue to add relevant features to the Digital Annual Data Report, including more graphical summaries of continuous data, inclusion of more ecological, geological, and other spatial data sets, and the ability to spatially analyze land use data with USGS hydrologic information
- Implement live webcam capabilities at selected hydrologic monitoring stations that have high visibility to a large audience to complement USGS real-time data
- Expand proactive data delivery to include e–mails that are sent when user-specified thresholds on any particular data parameter are exceeded
- Evolve GWIN capabilities into watershed-based Web pages
- Set up a Georgia HydroWatch Real-Time Hazards center at the Georgia District where all USGS real-time hydrologic data are collected, analyzed, and disseminated in a coordinated manner
- Install an automated fax and voice message system to deliver faxes on demand, batch command group faxes, and computer-generated voice messages that relay the latest hydrologic information
- Continue development of Digital Water Resources Atlas for Georgia—
  - Volume 1: State Topoviewer
  - Volume 2: Watersheds
  - Volume 3: Watersheds and Ground Water

Specific Steps and Challenges

- Maximize limited time of Web programmers to effectively meet the Georgia District's needs
- Develop partnerships with cooperators interested in more effective presentation of hydrologic information
- Continue to stay current in the latest available software and information delivery technologies
- Maintain a user-oriented perspective that drives enhancements to existing products and creativity for new ones

SUMMARY

The following are the several focus areas of the Georgia District Science Plan and some of the major future program opportunities and goals:

- Water availability and competing demands
  - Advanced Statewide hydrologic monitoring system
  - Alabama–Coosa–Tallapoosa River Basin monitoring
  - Southwest Georgia Sound Science Initiative Phase II
  - Aucilla–Ochlockonee–Suwannee River Basin Stream-Aquifer Relations study
  - North Georgia Piedmont Ground-Water Initiative
  - Instream Ecological Systems Flow-Needs Initiative
- Water resources development in coastal Georgia
  - Coastal Georgia Sound Science Initiative Phase II, including Lower Floridan aquifer and wetlands impacts
- Hydrologic hazards
  - Complete upgrading of all surface-water stations to real time
  - Develop flood-tracking charts for Georgia cities
- Water-quality impacts
  - Develop interpretive programs to complement the existing urban monitoring programs
- Water-resource effects associated with Federal land and interests in Georgia
  - Continue to assist DOI agencies, as needed
  - Maintain ongoing program with U.S. Air Force Plant 6 in Marietta, Georgia
- International, National, and Regional Science activities in Georgia District
  - Continue to leverage this wide-ranging group of activities to improve the science of the Georgia District as a whole and specifically the hydrologic scientific work done in Georgia
- Science communication
  - Continue refining Georgia District products:
    - Digital Annual Data Report
    - Water Resources Atlas for Georgia
    - Georgia Water Information Network

APPENDIX A
Vision, Mission, and Strategic Direction of the U.S. Geological Survey

USGS VISION

USGS is a world leader in the natural sciences through our scientific excellence and responsiveness of society's needs.

USGS MISSION

The USGS serves the Nation by providing reliable scientific information to

- Describe and understand the Earth
- Minimize loss of life and property from natural disasters
- Manage water, biological, energy, and mineral resources
- Enhance and protect our quality of life

STRATEGIC DIRECTION

Combine and enhance USGS diverse programs, capabilities, and talents and increase customer involvement to strengthen our scientific leadership and contribution to the resolution of complex issues.

Source: U.S. Geological Survey Strategic Plan 2000–2005, *http://www.usgs.gov/stratplan/stratplan_rev/section2.html*

APPENDIX B
Eastern Region Science Plan, January 2004

MANAGEMENT PRINCIPLES

- Sound, unbiased integrated science
- Long-term monitoring for evaluation of science and decision-making performance measures
- Easy-to-use science information delivery systems that synthesize and convey complex scientific information for decision makers and the public
- First-order priority issues
  - Urban dynamics
    - Water quality and availability for humans and ecosystems
    - River and coastal processes
    - Urban expansion and landscape change
  - Ecosystem and Natural Resources
    - Climate change
    - Fish and wildlife health
    - Eutrophication and hypoxia
    - Biodiversity, habitat integrity and restoration
    - Invasive and nuisance species
    - Energy and mineral resource extraction
  - Human health and safety
    - Arsenic contamination
    - Mercury bioaccumulation
    - Trace elements and radionuclides
    - Synthetic and natural organic contaminants (emerging contaminants)
    - Pathogens and disease
    - Air quality
  - Natural hazards
    - Flooding, storms, and drought
    - Earthquakes
    - Slope failure and subsidence

Source: Eastern Region Science Plan, January 2004, *http://internal.er.usgs.gov/docs/er_science_plan-ver8-01-20-04.doc*