Project Proposal

Evaluation of Ground-Water Flow, Saltwater Contamination, and Alternative Water Sources in the Coastal Area of Georgia

Georgia Coastal Sound Science Initiative

Submitted to

Georgia Department of Natural Resources

Environmental Protection Division

Georgia Geologic Survey

U.S. Geological Survey

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INTRODUCTION

This document describes a comprehensive program to evaluate ground-water resources in the coastal area of Georgia. The program consists of six major elements; workplans for each of the elements are included with this document. The approach presented herein reflects planned activities based on the stated problems and objectives, and on presently available data regarding hydrologic and geologic conditions and may occasionally require revision as additional data are collected that may alter the present understanding of the hydrologic system and the methods of analysis. These changes will be documented in quarterly status reports prepared by project staff and in the minutes of Technical Advisory Committee meetings.

PROBLEM

Burgeoning population growth in the coastal area of Georgia (purportedly the second fastest growing region in the country), greatly increased tourism, and sustained industrial activity have adversely affected the area's water resources and limited the water supply. The principal source of water in the coastal area is the Upper Floridan aquifer, an extremely permeable, high-yielding aquifer which was first developed in the late 1800's, and has been used extensively in the area ever since. Pumpage from the aquifer has resulted in substantial water-level decline 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 nearly 50 years, so that presently within an area of several square miles in downtown Brunswick, the aquifer yields water that has a chloride concentration as high as 2,000 milligrams per liter, and is above State and Federal secondary drinking-water standards.

Studies also suggest that ground-water-level declines caused by pumping has decreased and locally eliminated diffuse upward leakage from the aquifer to surface-water features. This in turn has likely adversely affected springflow and freshwater ponds, marshes and wetlands, streamflow, and the balance of freshwater and saltwater in tidal rivers and estuaries in the coastal zone.

Saltwater contamination has constrained further development of the Upper Floridan aquifer in the coastal area and created competing demands for the limited supply of water. The Georgia Environmental Protection Division (EPD) has capped permitted withdrawal from the Upper Floridan aquifer at 1997 rates in parts of the coastal area (including the Savannah and Brunswick areas), prompting interest in the development of alternative sources of water supply, primarily from the shallower Miocene and surficial aquifers.

Georgia Coastal Sound Science Initiative

The Georgia Coastal Sound Science Initiative is a series of scientific and feasibility studies proposed to support development of the Georgia EPD's final strategy to protect the Upper Floridan aquifer from saltwater contamination. Prior to implementation of the final strategy in January 2006, an interim strategy was released in April 1997, and is described in the document: "Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia" (Georgia Environmental Protection Division, 1997). EPD's intent in this Interim Strategy is to continue to protect the Upper Floridan aquifer from saltwater intrusion.

During the time that the Interim Strategy is in place, EPD plans to work with a broad-based stakeholder advisory committee on information exchange and will encourage and accept input from the committee on matters related to both implementation of the Interim Strategy and development of a final strategy. Additional goals of the Interim Strategy are to "Develop the information needed to assist Georgia's stakeholders with the development and implementation of a final strategy that will acceptably address saltwater intrusion and encroachment problems along Georgia's coast..." and to "Utilize input from stakeholder advisory committees to develop planning, science, and feasibility scopes of work." During formulation of the Interim Strategy and as a result of public and stakeholder feedback to EPD, an expansion of scientific studies to better understand saltwater intrusion and seawater encroachment, as well as the overall hydrologic system, was requested.

In May 1997, a committee was appointed by then Lt. Governor Pierre Howard and Georgia House Speaker Tom Murphy, and together with an appointed Technical Advisory Committee, made recommendations to the General Assembly to conduct the science called for by the stakeholders. Their report, "Recommendations of the Upper Floridan Technical Advisory Committee to the Joint Senate-House Ground-Water Study committee regarding Scientific Studies and Costs to Protect Coastal Georgia from Salt Water Intrusion", was released August 1997. Those recommendations resulted in what Georgia EPD has called the "Sound Science Initiative".

In support of the Sound Science Initiative, the USGS proposes to collect data necessary to characterize and monitor ground-water flow and saltwater contamination; evaluate possible alternative sources of water to the Upper Floridan aquifer; simulate ground-water flow and the movement of saltwater in response to a variety of water-management scenarios; and monitor changes in the hydrologic system.

Study Participants

The coastal sound science initiative is being administered by the Georgia EPD. Several work elements are being conducted by the USGS, the Georgia Water Resources Research Institute, Georgia State University, Georgia Southern University, the South Carolina Department of Health and Environmental Control (DHEC), and private consulting firms. The USGS part of the program is being administered by the Georgia District in cooperation with, and assistance from the South Carolina District and Geologic Division.

The EPD Technical Advisory Committee oversees technical aspects of the program. The committee consists of representatives from EPD, DHEC, academia, industry, environmental groups, and other stakeholders in the coastal area. The committee meets periodically to review project progress and plans.

Project Relevance and Benefits

As stated in USGS Water Resources Division Strategic Plan, studies investigating saltwater intrusion are of National concern. Demographic studies estimate that 75 percent of the U.S. population will live within 50 miles of the Atlantic, Gulf, or Pacific coasts or one of the Great Lakes by the year 2010 (U.S. Geological Survey, 1999). Program goals are directly related to USGS Strategic Plan issue #2, "Effects of land use and population increases on water resources in the coastal zone." Knowledge gained from this study in coastal Georgia and adjacent parts of South Carolina and Florida can be used to understand the processes of saltwater intrusion and the effects of water withdrawal on coastal water resources in other parts of the Nation. Information collected in this study will support the scientific efforts of the USGS and Georgia EPD to simulate the movement of saltwater in the Floridan aquifer system and assess the potential for saltwater contamination. Additionally, the State of Georgia can use this information to manage water resources while considering the effects of saltwater contamination on coastal ground-water resources, thereby helping the State evaluate the consequences of various water-use alternatives.

OBJECTIVES

Project objectives are to:

- Better define mechanisms of ground-water flow and movement of saltwater in the Upper and Lower Floridan aquifers, surficial aquifer, two Miocene aquifers, and the Fernandina permeable zone;
- Delineate paths and rates of ground-water flow and intrusion of saltwater into the Upper Floridan aquifer and simulate a variety of water-management scenarios to alleviate rates of saltwater contamination;
- Delineate areas where saltwater is entering the Floridan aquifer system offshore of the Savannah-Hilton Head Island area;
- Assess alternative sources of water supply from:
  - --seepage ponds connected to the surficial aquifer at two test sites
  - --the Lower Floridan aquifer at three test sites
  - --the Miocene upper and lower Brunswick aquifers
- Assess long-term ground-water levels and quality, and develop and maintain a comprehensive ground-water data base

SCOPE

Georgia EPD defines the coastal area of Georgia to include the 6 coastal Georgia counties and the 18 adjacent counties, an area of 12,240 square miles (fig.1). The study will rely on existing data and monitoring networks, supplemented by new data, including:

- constructing three test wells offshore of Tybee Island, Ga.;
- constructing three deep test wells completed in the Lower Floridan aquifer at Brunswick, St Marys, and Richmond Hill, Ga.;
- constructing several test wells completed in the Miocene and surficial aquifers;
- constructing coreholes penetrating Miocene-age sediments;
- collecting borehole geophysical logs in newly constructed wells and coreholes;
- collecting and analyzing water-chemistry and isotope data from new and existing wells;
- conducting and analyzing aquifer-tests; and
- constructing test wells, climatologic stations, and stage recorders at two seepage-pond test sites.

DESCRIPTION OF THE STUDY AREA

The coastal Georgia study area has been divided into three areas by EPD to facilitate implementation of the State's water-management practices--the northern, central, and southern subareas. The northern subarea generally corresponds to that part of the coastal area that is northwest (updip) of the Gulf Trough, a prominent geologic feature that represents a zone of low permeability in the Floridan aquifer system. The southern subarea is that part of the coastal area that lies south of what EPD has called the "Satilla Line", a hypothetical hydrologic boundary identified by EPD based on a somewhat abrupt change in the potentiometric surface of the Upper Floridan aquifer. The central subarea lies between the northern and southern subareas, and includes the largest concentration of pumping in the coastal area--the Savannah, Brunswick, and Jesup pumping centers (fig. 1).

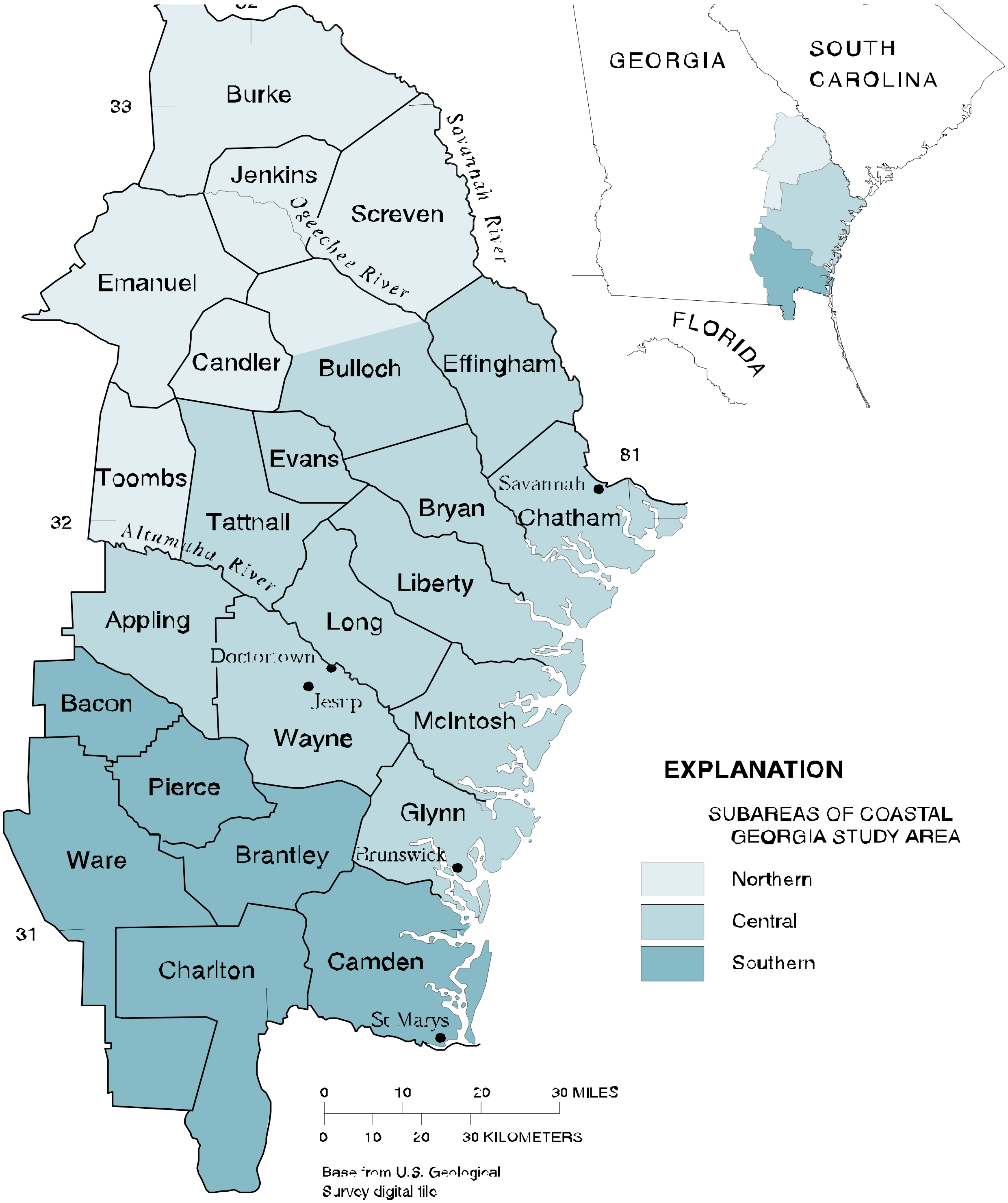

Figure 1. Location of 24-county coastal Georgia study area and subarea divisions.

Average annual precipitation based on the period 1941-70 ranges from less than 44 inches/year in northern Burke County, to 54 inches/year in southern Glynn and Charlton Counties, and in Camden County (Krause and Randolph, 1989). Rainfall is unevenly distributed throughout the year--maximum rainfall occurs during the summer months of July, August, and September. Estimated evapotranspiration ranges from 31 inches/year in the northern part of the area to more than 40 inches/year in Charlton and Ware Counties near the Okefenokee Swamp (Krause and Randolph, 1989). Rainfall as a source of recharge to aquifers is most important during the nongrowing season, generally October through March, when evapotranspiration is lowest. Average annual runoff based on the period 1941-70, ranges from 10 to 12 inches/year in the study area (Krause and Randolph, 1989).

The study area is in the Coastal Plain physiographic province and includes the Coastal Lowlands, Coastal Terraces, Tifton Upland, and Louisville Plateau subdivisions (Krause and Randolph, 1989). Topographic relief ranges from flat in the coastal lowlands, where altitudes are as high as 100 ft, to steep in the Louisville Plateau, where altitudes are as high as 300 ft.

Coastal Plain strata consist of consolidated to unconsolidated layers of sand and clay, and semiconsolidated to very dense layers of limestone and dolomite. These sediments range in age from Late Cretaceous to Holocene, and unconformably overlie igneous, metamophic, and sedimentary rocks of Paleozoic to Mesozoic age. These sedimentary units generally strike southwest-northeast, and dip and thicken to the southeast, where they reach a maximum thickness of 5,500 ft in Camden County (Wait and Davis, 1986).

The principal source of water for all uses in the coastal area is the Floridan aquifer system, consisting of the Upper and Lower Floridan aquifers (Miller, 1986; Krause and Randolph, 1989). Secondary sources of water include the surficial aquifer, and the upper and lower Brunswick aquifers (Clarke and others, 1990), consisting of sand of Miocene to recent age. A generalized correlation of geologic and hydrologic units, and corresponding model layers is shown in figure 2.

The surficial aquifer consists of sand of Miocene to recent age. The aquifer generally is under water-table conditions; however, locally it may be confined to semi-confined.

Geology			Hydrogeology		
Series	Stage	Formation	Savannah Area	Brunswick Area	Model Layer
Post-Miocene		Undifferentiated	Surficial Aquifer		A1
Miocene		Hawthorn Formation	Upper Confining Unit		C1
Oligocene		Suwanee Limestone	Upper Floridan Aquifer		A2
Eocene	Upper	Ocala Limestone	Middle Semiconfining Unit		
	Middle	Avon Park Formation			C2
				Lower Floridan Aquifer	A3
	Lower	Oldsmar Formation	Lower Confining Unit	Lower Semiconfining Unit	C3
Paleocene		Cedar Keys Formation		Fernandina Permeable Zone	A4
Upper Cretaceous		Undifferentiated			Not Simulated

Figure 2.--Geologic units, hydrogeologic units, and model layers, coastal Georgia. Modified from Randoph and others, 1991.

The upper confining unit underlies the surficial aquifer and consists of clay, silt, and sand of Miocene age. Sand within this unit has been identified as sources of water in parts of the coastal area, and were designated by Clarke and others (1990) as the upper and lower Brunswick aquifers. For the purposes of simulation of the Floridan aquifer system, these aquifers were grouped into the upper confining unit.

The Upper Floridan aquifer is highly productive and consists of limestone and dolomite of Eocene to Oligocene age. The aquifer crops out or is near land surface in the northwestern part of the 24-county coastal area, where it is under unconfined to semiconfined conditions. To the southeast, the aquifer becomes progressively more deeply buried and confined.

The middle semiconfining unit underlies the Upper Floridan aquifer and separates it from the underlying Lower Floridan aquifer. The unit consists of dense, low permeability, recrystallized limestone and dolomite of Eocene age. Locally in the Brunswick area, the unit is breached by fractures, which enhances the vertical exchange of water between the aquifers (Krause and Randolph, 1989).

The Lower Floridan aquifer consists of dolomitic limestone of mostly Eocene age, but may locally include dolomitized limestone of Paleocene to Late Cretaceous age. The aquifer is confined throughout the coastal area, and is subdivided into at least three permeable units in the Brunswick area. One of these units, the Fernandina permeable zone (Krause and Randolph, 1989), is highly permeable and cavernous, and contains water of high salinity that may be the source of saltwater contamination problems in the Brunswick area. The Fernandina permeable zone consists of pelletal, recrystallized limestone and finely crystallized dolomite of Paleocene to Eocene age.

The lower semiconfining unit separates the Fernandina permeable zone from the overlying Lower Floridan aquifer. The unit consists of microcrystalline, locally gypsiferous dolomite and finely pelletal micritic limestone of Eocene age.

For a more complete description of the physiographic, geologic, and hydrogeologic features of the study area, the reader is referred to Krause and Randolph (1989) and Clarke and others (1990).

APPROACH

The proposed study will utilize several work elements that are designed to better characterize the fresh and saline ground-water-flow system; evaluate the availability, quantity, and quality of untapped fresh water sources in the study area; and develop ground-water-flow and solute-transport models that accurately describe the movement of ground water and can be adapted for use as management tools for coastal Georgia. These models will be used to characterize ground-water-flow and solute transport; to help evaluate and plan for future water-supply demands in the area; and to better understand saltwater intrusion and seawater encroachment and the limitations they place on additional ground-water development. Following are descriptions of the six work elements:

Work element 1 (Sound Science Initiative project 1, task 3): *Delineation of areas where saltwater is entering the Floridan aquifer system by constructing offshore test wells near Savannah-Hilton Head Island* ***(Approved by Southeastern Region, February 1999).***

Data defining the position of the freshwater-saltwater interface in regional aquifers is important for developing scientific means to monitor and mitigate saltwater encroachment that could irreparably contaminate these essential water resources. The location of the interface has been estimated in previous investigations (Krause and Randolph, 1989; Smith, 1988; Garza and Krause, 1996), but the actual offshore location and characteristics have not been determined. The USGS is working cooperatively with EPD and DHEC to collect and interpret stratigraphic, hydrogeologic, and water-chemistry data from three offshore test holes.

This work element is being conducted in collaboration with the USGS South Carolina District; a proposal (SC99g) was submitted and approved by the Southeastern Region, February 1999. See Appendix A for a detailed workplan for work element 1.

NOTE: The schedule for completion of work element 1 has been moved forward one year from the original proposal due to drilling schedule delays caused by inclement weather.

Work element 2 (Sound Science Initiative project 5, task 2): *Assessment of the Lower Floridan aquifer as a potential source of water supply* ***(Approved by Southeastern Region, May 1999).***

Although the Upper Floridan aquifer is highly productive and utilized in coastal Georgia, the Lower Floridan aquifer is not widely used for water supply because it is deeply buried and contains saline water in much of its area of occurrence (Krause and Randolph, 1989; Clarke and others, 1990). The Lower Floridan aquifer includes the Fernandina permeable zone, a highly productive water-bearing interval that is characterized by water of high salinity. This saline water has been identified as the probable source of saltwater contamination in the Brunswick, Ga., area (Krause and Randolph, 1989).

The proposed study will better define the geologic, hydrologic, and water-quality characteristics of the Floridan aquifer system, focusing on the Lower Floridan aquifer, by collecting data through a test-drilling, water-sampling, and aquifer-testing program. These data will be used to aid evaluation of the paths and rates of saltwater movement into the Upper Floridan aquifer, identify areas where saltwater contamination of the Upper Floridan aquifer could potentially occur, assess the Lower Floridan aquifer as a possible alternative source of freshwater supply, and provide wells for a monitoring network to measure long-term ground-water levels and quality.

This work element is being conducted in collaboration with the USGS South Carolina District; a proposal (SC99o) was submitted and approved by the Southeastern Region, May 1999. See Appendix B for a detailed workplan for work element 2.

Work element 3 (Sound Science Initiative project 5, task 4): *Assessment of seepage ponds connected to the surficial aquifer as potential sources of water supply.*

In the coastal area, seepage ponds are sometimes excavated at golf courses, farms, or communities by digging through sandy surface soils until the water table is reached. These man-made ponds often are used to supply water for irrigation, and are thus a potential supplemental source of water. The potential availability of water from seepage ponds is poorly understood in coastal regions.

To assess the water-supply potential of seepage ponds, two sites will be selected for long-term aquifer tests to assess ground-water and surface-water relations in the vicinity of the ponds; to develop a hydrologic budget for the pond-aquifer system; and determine the potential yield of the seepage ponds.

The proposed study will be conducted in cooperation with the Georgia Water Resources Research Institute at the Georgia Institute of Technology. See Appendix C for a detailed workplan for work element 3.

Work element 4 (Sound Science Initiative project 5, task 3): *Assessment of the Miocene upper and lower Brunswick aquifers as potential sources of water supply.*

In recent studies of coastal Georgia (Clarke and others, 1990; Steele and McDowell, 1998), three aquifers that overlie the Upper Floridan aquifer were considered to be viable, supplemental, albeit comparatively small, sources of water. The three aquifers, in descending order, are the surficial aquifer in sediments of Miocene to recent age, and the upper and lower Brunswick aquifers in sediments of Miocene age.

Ground-water-level, ground-water-chemistry, and aquifer-hydraulics data of water-bearing zones in the surficial and upper and lower Brunswick aquifers are limited, and the areal extent of the aquifers is poorly defined. The proposed study would better define the hydrogeologic and water-chemistry characteristics of the three aquifers by collecting additional data through a test-drilling, well-inventory, water-sampling, and aquifer-testing program. See Appendix D for a detailed workplan for work element 4.

Work element 5 (Sound Science Initiative project 6): *Developing and maintaining an expanded monitoring network to assess ground-water levels and quality, and developing and maintaining a ground-water data base.*

Monitoring ground-water levels and water quality is important for effective management of the water resources of coastal Georgia. To monitor water-level fluctuations in the Floridan aquifer system and overlying aquifers, the USGS proposes to expand existing monitoring networks. Wells in the existing networks are part of local and statewide networks to monitor changes as part of the State-Federal Cooperative Water Resources Program. These include cooperative programs with the EPD, and the city of Brunswick - Glynn County. The expanded networks will focus on additional wells in the Fernandina permeable zone (the probable source of saltwater at Brunswick), the surficial aquifer, and the upper and lower Brunswick (Miocene) aquifers.

To monitor changes in chloride concentration that could indicate saltwater contamination, wells at Tybee Island, Chatham County, and St Marys, Camden County, will be incorporated into EPD's "early warning" network, developed as part of the Sound Science Initiative to give first indication of saltwater encroachment in those areas. Water samples from wells completed in the Upper and Lower Floridan aquifers at these sites will be collected and analyzed periodically for determination of chloride concentration and specific conductance. Deep test wells at Brunswick and Richmond Hill completed in the Lower Floridan aquifer or Fernandina permeable zone will be incorporated into the expanded chloride monitoring network.

All water-level and water-quality data will be stored in the USGS National Water Information System (NWIS) ground-water data base and selected Geographic Information System (GIS) coverages. Data to be stored include ground-water levels and water quality, well construction, water use, geologic, geophysical, and hydraulic properties of aquifers and confining units. All data will be made available to the EPD. See Appendix E for a detailed workplan for work element 5.

Work element 6 (Sound Science Initiative projects 2 and 3): *Investigation of the paths and rates of ground-water flow and intrusion of saltwater into the Upper Floridan aquifer by developing detailed ground-water-flow and solute-transport models. Use the calibrated models to simulate selected water-management scenarios to decrease rates of saltwater contamination.*

Ground-water-flow and solute transport models will be used to help provide better understanding of the processes controlling the movement of saltwater into freshwater aquifers, and serve as a tool to help evaluate various water-management scenarios, such as pumping changes.

Although several ground-water-flow models have been developed to simulate ground-water flow in the coastal area, the models incorporate the Upper and Lower Floridan aquifers, but do not actively simulate the surficial aquifer, the upper and lower Brunswick aquifers, or the Fernandina permeable zone of the Lower Floridan aquifer. In addition, more recent data (pumpage and hydraulic) are available to update the existing flow models. Simulation of saltwater movement using solute transport models is limited to two-dimensional models of the Savannah/Hilton Head area (Smith, 1988; Bush 1988), but these focus specifically on the Hilton Head area, and are limited in scope.

A regional model for the saltwater-freshwater interface does not exist. To improve understanding of the regional ground-water-flow system, the USGS proposes to develop ground-water-flow and solute-transport models to more completely characterize the regional ground-water-flow system and the movement of saltwater into and mixing with freshwater sources. See Appendix F for a detailed workplan for work element 6.

PRODUCTS

The various work elements will result in reports of findings (table 1). Additional papers likely will be prepared during the course of the project. Technical presentations also will be given at technical conferences and technical advisory committee meetings during the course of the study.

A comprehensive project data base will be developed and maintained during the project. This will include well, ground-water-level and water-quality information stored in the USGS National Water Information System (NWIS), water-use data, and various GIS coverages of hydrologic, geologic, and water-quality data.

Table 1: Reports

Work element		Sound Science Initiative project(s)	Report Title	Outlet	Year planned
1	Offshore drilling	1 (task 3)	Stratigraphy, hydrogeology, and water chemistry of the Upper Floridan aquifer in offshore test holes near Savannah, Georgia, 1999-2000	Cooperator report (GGS Bulletin)	2001
2	Lower Floridan	5 (task 2)	Geology and ground-water availability of the Floridan aquifer system at three test sites in the Coastal Area of Georgia	Cooperator report (GGS Bulletin)	2001
3	Seepage ponds	5 (task 4)	Evaluation of the water-supply potential of seepage ponds in the coastal area of Georgia	Cooperator report (GGS Bulletin)	2003
4	Miocene aquifers	5 (task 3)	Geology and ground-water availability of the surficial and upper and lower Brunswick aquifers in the coastal area of Georgia	Cooperator report (GGS Bulletin)	2004
5	Monitoring network	6	Ground-water data and monitoring networks for coastal Georgia (data report)	Cooperator report (GGS Information Circular)	2002
6	Ground-water flow and solute transport model	2 and 3	Analysis of ground-water flow and saltwater intrusion in the Upper Floridan aquifer in the coastal area of Georgia and adjacent parts of South Carolina and Florida	USGS WRIR	2005

PERSONNEL

The program will be managed from the Georgia District office by John Clarke (GS-13), who will oversee all work elements. Project staff will include personnel from the USGS Georgia and South Carolina Districts and USGS Geologic Division, and student interns from the Georgia Water Resources Research Institute (table 2).

Table 2: Project personnel and percentage of time by fiscal year

Personnel	Duties	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005
Georgia District							
Project manager--Hydrologist GS-13 (Clarke)	Project management, technical oversite	75	100	100	100	75	50
Ground-water modeler--Hydrologist GS-11 (Payne)	Ground-water modeling	100	100	100	100	100	50
Field hydrologist GS-11 (Leeth)	Offshore drilling, Lower Floridan evaluation, Miocene evaluation	--	100	100	100	50	--
Hydrologist, GIS specialist GS-7/9	Seepage pond study, Miocene aquifers, ground-water modeling, ground-water monitoring	75	50	50	50	25	25
Hydrologic Technician, GS-10 (Peck)	Seepage pond studies, Miocene aquifers, ground-water monitoring	100	100	100	100	50	25
Hydrologic Technician, GS-7 (student)	Ground-water monitoring	25	25	25	25	25	25
Hydrologic Technician, GS-10 (Stayton)	Ground-water monitoring	15	15	15	15	15	15
Hydrologist GS-13 technical consultant (Torak)	Technical consultation	5	5	5	5	5	5
Student Intern[a]	Seepage pond study	100	100	--	--	--	--
South Carolina District							
Hydrologist GS-12 (Falls)[b]	Offshore and Lower Floridan studies	50	50	--	--	--	--
Hydrologist GS-11 (Harrelson)	Lower Floridan study	100	--	--	--	--	--
Hydrologist GS-9 (Connlon)	Lower Floridan study	100	--	--	--	--	--

a. Employed and funded through Georgia Water Resources Research Institute
b. Project coordinator for South Carolina project activities.

SCHEDULE

The study will be conducted during fiscal years 2000-2005. Note that two of the projects (2, 4) have been in progress since 1999; this document presents plans for FY-2000 through 2005. Detailed timelines are shown in the workplan for each of the work elements; general timelines are provided in table 3.

Table 3: Schedule by major tasks

Federal fiscal year==>	1999	FY-2000				FY-2001				FY-2002				FY-2003				FY-2004				FY-2005		
State fiscal year====>	FY-2000				FY-2001				FY-2002				FY-2003				FY-2004				FY-2005			
Task	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ
Work element 1 -- Offshore drilling[a]																								
Drilling and sampling	■			■	■																			
Geologic evaluation	■				■	■																		
Water quality	■					■																		
Report							■	■																
Work element 2 -- Lower Floridan																								
Test-well drilling and data collection	■	■	■																					
Install water-level monitoring instruments		■	■	■																				
Data analysis and report preparation			■	■	■	■	■	■																
Work element 3 -- Seepage ponds																								
Site 1 setup	■	■																						
Site 1 test			■																					
Analysis of site data and test results, model calibration			■	■	■																			
Site 2 setup					■	■																		
Site 2 test							■																	
Analysis of site data and test results, model calibration							■	■	■															
Report										■	■	■	■	■										

Federal fiscal year==>	1999	FY-2000				FY-2001				FY-2002				FY-2003				FY-2004				FY-2005		
State fiscal year====>	FY-2000				FY-2001				FY-2002				FY-2003				FY-2004				FY-2005			
Task	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ
Work element 4 -- Miocene aquifers																								
Coring					■	■	■	■																
Geologic and paleontologic evaluation of cores					■	■	■	■	■	■														
Test-well drilling						■	■	■	■	■														
Install water-level recorders						■	■	■	■	■	■													
Aquifer tests						■	■	■	■	■	■	■	■											
Water-chemistry sampling and analysis						■	■	■	■	■	■	■	■											
Report preparation														■	■	■	■	■	■	■				
Work element 5 -- Monitoring network and data base																								
Compilation of existing data	■	■	■	■																				
Well inventory	■	■	■	■	■	■	■	■																
Borehole geophysical logs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
Develop and maintain water-level monitoring networks; Install water-level recorders	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Measure water levels for potentiometric-surface maps				■																				
Develop and maintain chloride monitoring networks	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Develop data base	■	■	■	■	■	■	■	■																
Report									■	■	■	■												

Federal fiscal year==>	1999	FY-2000				FY-2001				FY-2002				FY-2003				FY-2004				FY-2005		
State fiscal year====>	FY-2000				FY-2001				FY-2002				FY-2003				FY-2004				FY-2005			
Task	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ
Work element 6 -- Ground-water flow and solute transport model																								
Data Collection[b]	■	■	■	■	■	■	■	■	■	■	■	■	■											
Review of previous studies and data compilation	■	■																						
Development of conceptual model and hydrogeologic framework	■	■	■	■																				
Development of potentiometric surface maps				■	■																			
Stream baseflow analysis						■	■																	
Testing and selection of simulators		■	■	■	■																			
Develop and calibrate detailed ground-water flow model						■	■	■	■	■	■	■	■											
Develop and calibrate saltwater intrusion models						■	■	■	■	■	■	■	■	■	■	■	■							
Run predictive scenarios																		■	■	■				
Report																					■	■	■	■

a. The original schedule for completion of work element 1 has been delayed by one year from the original proposal because of drilling schedule delays caused by inclement weather.

b. See work elements 1-5 for specific tasks and schedule.

SELECTED REFERENCES

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