Coastal River Basins Water Resource Assessment
An Evaluation of Water Use and Availability in Seven Coastal River Basins

Water Policy Working Paper # 2003-005

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March 2003

The authors gratefully acknowledge financial support for this work provided by the Georgia Soil and Water Conservation Commission (480-02-FR1001-2) and the U.S. Department of Agriculture (2001-38869-10607-1).

Abstract

Georgia has experienced a persistent drought for the last four years. While the drought conditions have subsided, the need for effective river basin planning continues. Effective water planning for our river basins will ensure adequate resource availability for the immediate future as well as over the long run.

Basin planning consists of four primary steps:[1] 1) understanding current and future water demands, 2) understanding existing resources (water supply), 3) anticipating potential shortfalls and other issues that might arise from the discrepancies between supply and demand, and 4) devising policy solutions which adequately resolve items identified in step 3).

This report explores the available data for water demands and supplies across the seven river basins that make up the coastal region served by the Coastal Rivers Water Planning and Policy Center at Georgia Southern University. The permit issuing and water use reporting processes have made it difficult to accurately estimate water demand across the region. Moreover, the river data is sparse, sporadic, and insufficient to determine the unimpaired flows for any of our rivers. Our intent is to highlight the areas for future data collection such that our state policy makers may successfully establish river basin water use plans that ensure sustainable economic growth, with minimal environmental impacts.

[1] Steps 1 and 2 may be done simultaneously or in either order. However, the information from these two steps is necessary for completing step 3.

I. Introduction

Coastal Georgia, as one of the State's fastest growing regions in terms of population and economic growth, is only now beginning to recover from the severe drought suffered in the Southeastern U.S. between 1999 and 2002. Georgia's legislature, during the upcoming 2003 session, is expected to dramatically change the manner in which water planning and management are accomplished in the State. Most important among these expected changes is a mandate for the State's Environmental Protection Division (EPD) to prepare basin water plans for each of the state's river basins, where such plans are to rely heavily on inputs from stakeholders in each basin.

Nowhere in the state is basin water planning needed more than in the state's coastal region. This area is served by five major rivers – the Altamaha, Ogeechee, Savannah, Satilla, and St. Mary's Rivers – with two major tributaries[2] (the Oconee and Ocmulgee Rivers), which then involves seven large river basins (see Figure 1). These seven river basins include 93 Georgia counties (see Appendix 1).[3] The critical need for basin water planning in this region is obviated by water shortages experienced during the recent four-year drought coupled with rapid population growth expected in the region over the next 50 years. It is expected that the region will become the home of an additional million people over this time period, with population increasing by some 50% in the Savannah River Basin alone![4]

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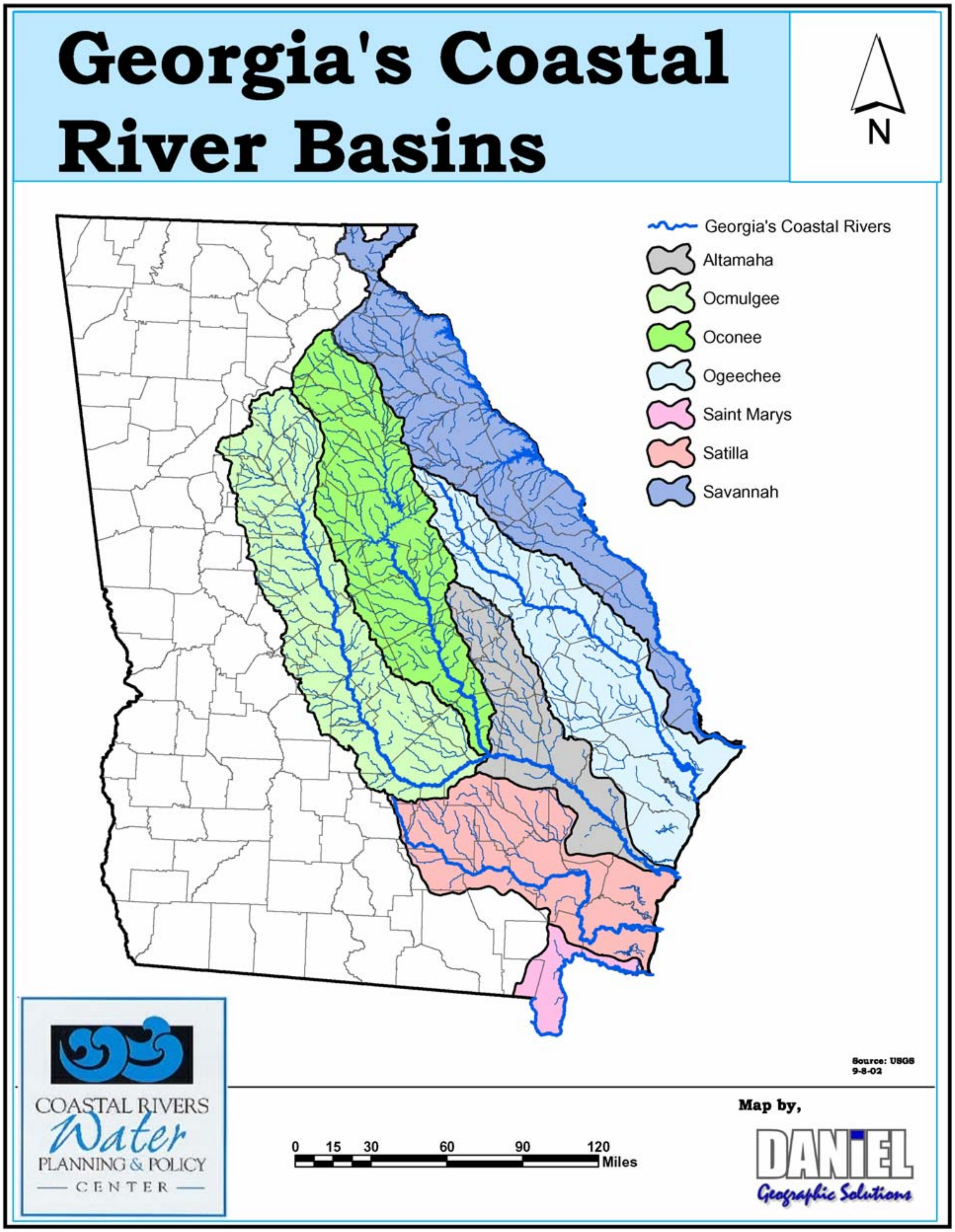
[2] Smaller tributaries serve three of these rivers: the Ohoopee River tributary to the Altamaha River; the Canoochee tributary to the Ogeechee River, and the Broad, Little, Seneca, Tugaloo Rivers tributary to the Savannah River.
[3] A number of counties span multiple river basins, some of which fall outside of the area of consideration.
[4] See Isley, Phyllis, "Population Forecasts for Basin Water Planning in Georgia's Coastal Region: Methodological Issues," Water Policy Working Paper #2003-004, Coastal Rivers Regional Water Planning and Policy Center, Statesboro, February 2003.

Figure 1. Georgia's Coastal River Basins



As a part of its commitment to provide leadership for stakeholders in the coastal region as they contemplate the development of basin water plans for coastal river basins, Georgia Southern University's Coastal Rivers Planning and Policy Center (hereafter, "the Center"), a part of the larger consortium of universities (including Albany State and Georgia State Universities) that form the Georgia Planning and Policy Center, has initiated efforts to assess the quantity and quality of data required for comprehensive basin water planning in the region.

The function of a basin water plan is, of course, to bring together information concerning present and future water needs (demands) and water supplies for the purpose of anticipating future problems that might arise from imbalances in water demands and supplies, and then designing alternative policies that can eliminate, or at least mitigate, such problems. As such, it follows that fundamental data requirements for the basin water planning process are data that allow comprehensive assessment of present and future water needs, and that provide an historical perspective of available water supplies that can be extrapolated into the future for the purpose of assessing conditions under which water stresses or shortfalls occur, and sub-regions that will be affected by such shortfalls.

The purpose of this report is to describe results from the Center's initial explorations focused on the quality of data that are available for these fundamental purposes: assessing present and future water needs and water supplies. To these ends, in section II an assessment related to water needs/demands is provided. The character of data relevant for assessments of water supply is examined in section III. Concluding remarks are offered in section IV.

A brief overview of findings given in this report may motivate the reader's interests in the details provided in the following sections. Two major conclusions derive from our analyses. First, data concerning consumptive water use in the region is, at best, very limited. While extensive data exist concerning permitted water withdrawals, there is little information concerning actual withdrawals and (with the exception of some municipal and public water systems) virtually no information concerning water discharges (which, with water withdrawals, provides the desired measure: consumptive water use). This is particularly the case for municipal and industrial uses (water use permits are not required for withdrawals less than 100,000 gallons per day (GPD), and discharge permits are not required unless discharge contains selected toxic materials) and agricultural uses (agricultural water use permits are not quantified in any meaningful way, thus neither water withdrawals nor return flows are measured).[5]

Second, the most fundamental requisites for basin water planning – data for historical virgin (or unimpaired) flows in the coastal regions rivers – simply do not exist. Periodic measures for flows from stream gauges at specific locations along the rivers are available. These data, however, measure flows that occur after uses and discharges associated with man's activities. Efforts have not been made to adjust these measures to the measure required for water planning: virgin (unimpaired) flows. Moreover, virgin flow from drainage in large parts of all the regions river basins are not accounted for due to limitations on the number of flow gauges on the rivers, especially for long stretches of rivers that ultimately discharge to the ocean. Thus, as argued elsewhere,[6] there is presently an "empty shelf" of water supply data that forms a critical part of any basin water plan.

<u>A Brief Digression: Definition of Terms Used In the Report.</u> Before we proceed with the major topics of this report, a brief digression is warranted for the purpose of defining terms used

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5 See Isley, *Op. Cit.* 2003 for additional details.

6 Fisher, Donna and Ben Thompson, "Basin Water Plans For Georgia's Coastal Region: The 'Empty Shelf' Of Data Critical For The Planning Process," Water Policy Working Paper #2003-002, Coastal Rivers Water Planning and Policy Center, Statesboro, March 2003.

in this report that may enhance the reader's appreciation for and understanding of arguments presented in the following sections.

Agricultural water use permits: issued by the EPD intended for irrigation and livestock water use. Irrigation water use includes water artificially applied to farm, orchard, pasture, and horticultural crops. In addition to normal plant growth, irrigation water may be used for germination, frost and freeze protection, chemical application, crop cooling, harvesting, or dust suppression. Irrigation also includes water used to irrigate public and private golf courses. Irrigation water can be self-supplied or purchased from an irrigation company, irrigation district, or other supplier. Livestock water use includes water used to raise cattle, sheep, goats, hogs, and poultry, but excludes horses, which are considered part of animal specialties water use.

Consumptive use: water withdrawal less water discharges by a water-using entity. The importance of consumptive use measures derives from the fact that these measures define the amount by which the water-using entity depletes available water supplies.

Conveyance: is the intentional movement of water from one point to another, for example, from point of withdrawal to point of delivery; release from public water supplier to user; release from user to wastewater-treatment facility; after release to return flow. Withdrawals, deliveries, releases and return flows are the endpoints of conveyances. *Conveyance **loss*** may occur through evaporation from an open system or seepage. *Conveyance* ***gain*** may occur through infiltration and inflow.

Ground water: water coming from one of the aquifers; under ground water source. Water is accessed using wells, tunnels, drainage galleries, or flows out through springs.

Industrial water use permits: include water withdrawal from ground and surface water; deliveries from public water suppliers; consumptive use through evaporation and product incorporation (as in a bottling plant); water and wastewater treatment, recycling, releases to wastewater collection systems, and return flow to ground and surface water. Large industrial water users are more likely to obtain water directly from wells, rivers, lakes, and estuaries, and may supplement this with water purchased from public water suppliers. Small industries, especially in cities, are more likely to obtain water from public water suppliers.

Municipal water use permits: Water used by local government offices and organizations for human consumption.[7]

Permitted acres: the number of acres that can be irrigated under an agricultural water use permit issued by the EPD.

Public water system permits: Systems which provide water for human consumption (drinking water). In order to be considered a public system, the water system must have at least 15 service connections or regularly serve a minimum of 25 individuals through no less than 60 days each year.

Surface water: consist of rivers, streams, branches, creeks, ponds, tributary streams, drainage basins, natural lakes, artificial reservoirs, and ground water under direct influence of surface water.

Well-pond: Water generally pumped from ground water sources into surface ponds. EPD considers these to be surface water. However, we found it helpful to distinguish them when evaluating water supply and demand within a basin.

[7] The distinction between EPD's Municipal & Industrial (M&I) and Public Water System permits some times appear ambiguous. Not all municipalities in the coastal river basins possess M&I permits. In addition, some companies may have Public water permits used primarily for drinking water.

Attention is now turned to the central concerns of this report: an assessment of data relevant for measuring water demands and water supplies.

II. Water Demand Measures in Coastal Georgia

In principle, measures for current water use in Georgia's coastal region would involve a relatively simple process. Water use, for amounts exceeding 100,000 GPD, requires a water use permit issued by the EPD. One would then take these permits, multiply them by actual use and actual discharges by each permit holder, thereby obtaining the desired measure: total consumptive water use.

Unfortunately, while data concerning permitted water use is readily available from the EPD's permit files, the actual water use and water discharge associated with each permit is not known, with the exception of some permits issued to municipalities and public water systems. Maximum permitted use for industrial water use permits is known, neither actual use nor discharges are known. For agricultural water use permits, the only known limit on water use under a permit is pumping capacity for permits issued, with permitted acreage, for uses prior to 1987 or "reasonable use" for other permits.

Thus, while crude estimates for consumptive use might be derived from permit information – e.g., one might assume some average use by farmers,[8] and arbitrarily discount permitted water use under industrial permits – data simply do not exist that would allow reasonably defensible estimates for consumptive water use in the region.

We then continue by reporting data that are available – data related to permitted water use – leaving to later studies efforts to enhance our ability to translate permit data into estimates for consumptive water use. We begin with an overview of permitted water use in the coastal rivers region as a whole, after which we detail permit information for each river basin.

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[8] Cummings, Ronald G., Nancy A. Norton, Virgil J. Norton, and David A. Eigenberg, "Changing Rules For Agricultural Water Use: Policy Options Related To Metering And Forfeiture For Non-use," Water Policy Working Paper # 2001-03, Georgia State University Andrew Young School of Policy Studies and Albany State University Flint River Planning and Policy Center, October 2001.

The EPD has issued over 26,000 water permits, roughly 9,600 for use in coastal river basins (Table 1). Agriculture accounts for the majority (83%) of permits within the coastal area. For the coastal region, surface water supplies the greater portion of Agricultural permits, as well as Municipal & Industrial permits. As one might expect, Public drinking water system permits mostly utilize ground water. A small portion (less than 0.1%) of permits did not specify a source. Nearly 6% of agricultural permits designate well- ponds as the water source.

Table 1. Georgia Water Permits by Type[9]

Permit Type	GA Total	Coastal Region				
		Total	Surface	Ground	Well - Pond	Unknown
Agriculture	21,480	7,985	5,001	2,491	478	15
Public Water Supply	4,794	1,521	87	1,432	-	2
Municipal & Industrial	277	122	122	-	-	-
Total Permits	26,551	9,628	5,210	3,923	478	17

Table 2 delineates the distribution of the water permits within the Coastal River Basins. Local economic characteristics help define the allocation of the water withdraws among the basins. Surface water supplies the majority of the permits across the basins. Agriculture permits account for the bulk of the permits, most falling within the Ocmulgee and Satilla River Basins.

[9] Table 1 is based on available data as of Fall 2001. Permit data are found in three databases established, maintained and administered by the Georgia Department of Natural Resources, Environmental Protection Division (EPD). These include List of Agricultural Water Withdrawal Permittees; List of Municipal and Industrial Water Withdrawal Permittees; and List of Drinking Water/Public Water System Permittees, Atlanta, September 2001. Electronic databases, http://www.state.ga.us/dnr/environ, accessed, June 2002.
As mentioned previously, not all municipalities are included in the EPD M&I permit database. EPD is in the process of verifying the agricultural permits for the 24-capped counties in Coastal Georgia. This data will be available in Spring 03. Other updates have been made to the three databases and USGS, 2002, "Water Use in Georgia by County for 2000 and Water-Use Trends for 1980 – 2000, Information Circular 106.
For this version of the report, however, the timeliness in highlighting the generic data deficiencies outweighed the benefits of utilizing these data. A future version of the report will reflect these data updates.

Table 2. Coastal River Basin Water Withdrawal Permits by Type[10]

	Agriculture				Public			M & I
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface
Altamaha	872	204	83	1	-	106	-	-
Ocmulgee	1,188	1,018	184	1	30	184	-	35
Oconee	396	157	37	1	29	227	-	33
Ogeechee	904	447	106	1	5	500	2	2
Satilla	1,419	510	55	11	2	184	-	3
Savannah	217	150	9	-	21	219	-	46
St Mary's	5	5	4	-	-	12	-	3
Total	5,001	2,491	478	15	87	1432	2	122
Permit Totals	7,985				1,521			122
Grand Total	9,628							

In the balance of this section, we describe the distribution and nature of permitted water use in each of the seven river basins – Altamaha, Ogeechee, Savannah, Satilla, St. Mary's, Ocmulgee, and Oconee. For convenience, the basins are discussed in alphabetical order.

[10] Table 2 is based on EPD, *Op*. *Cit*., 2001.

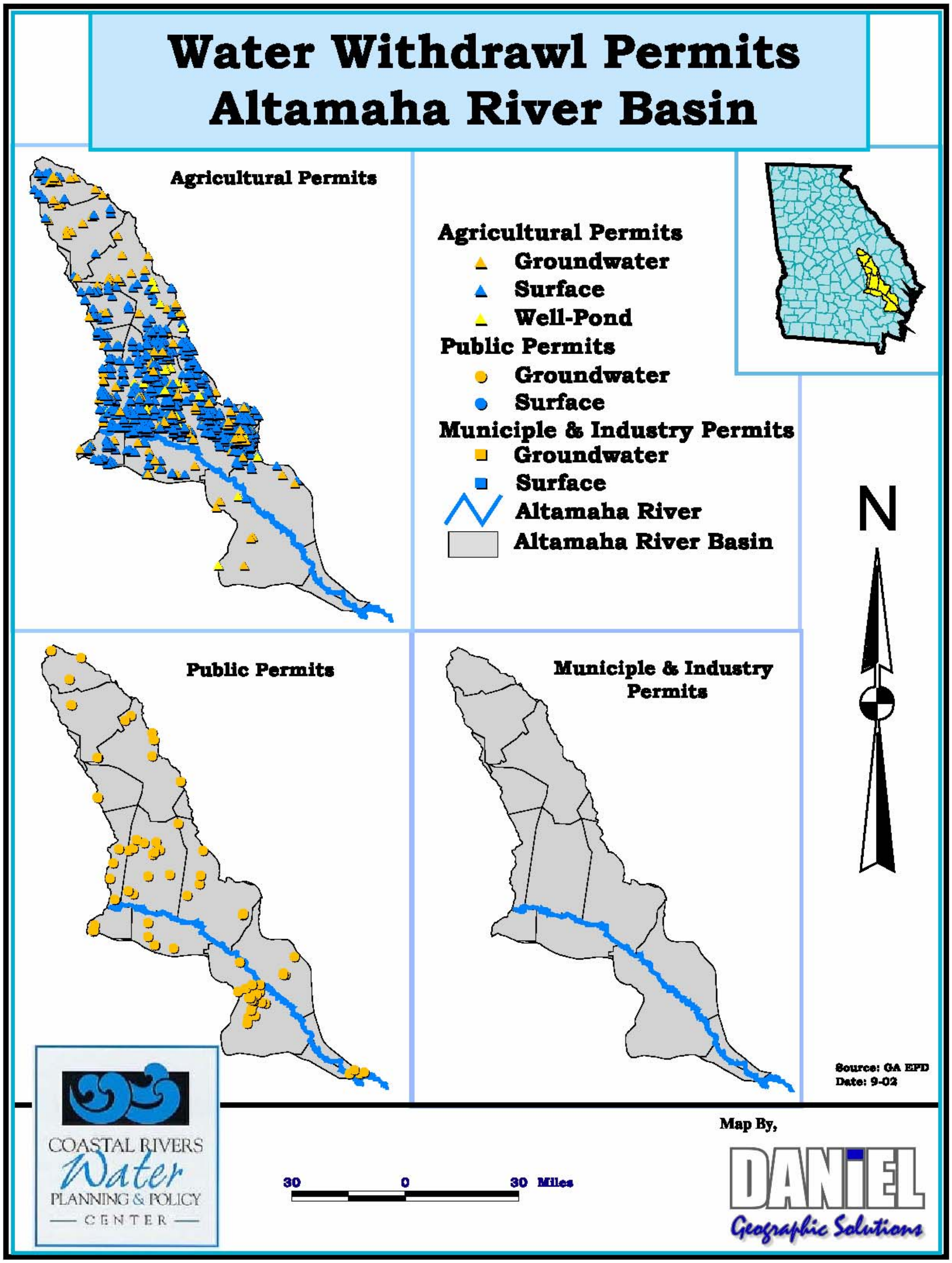
A. Altamaha River Basin

The Altamaha River Basin, the third largest river basin in the United States. The entire Altamaha River Basin consists of waters from the Ocmulgee, Oconee, as well as the Altamaha River. The shrimp and fishing industries make up a large part of the Basin's economy. Vast numbers of pine timber forest are harvested to aid in the production of paper and other wood products within the Altamaha basin. The kaolin industry, located in the northern portion of the basin, supplies inputs for making paper, bathtubs, bricks, fine china, and a myriad of other products. All along the river you will find a multitude of agricultural products under cultivation. The basin also affords wildlife viewing areas and habitats, especially for rare native bird species as well as many migratory birds.

For our purposes of highlighting the water use permits, in this section we focus on the Altamaha River portion of the larger basin, i.e., the portion below the Ocmulgee and Oconee Rivers. The basin falls across 17 counties, in full or in part.[11] Approximately 126,330 people depend on the basin for water.[12] Figure 2 illustrates the distribution of water use permits across the Altamaha River Basin. The basin's 1,160 agricultural water use permits cover roughly 74,377 permitted acres. Surface water supplies 75% (872 permits) of these permits. Tattnall and Toombs counties account for the majority of surface withdrawals, with 386 and 274 permits, respectively. These counties have a high concentration of Vidalia onion production. Glynn, Laurens, and McIntosh counties have no surface water, and few ground water, withdrawal permits for agriculture.

[11] See Appendix 2 for a detailed listing of permits by county for each river basin.
[12] Population estimates for the seven river basins are computed based on U.S. Census Bureau, 2000 "Data for the State of Georgia." Electronic document, http://factfinder.census.gov, accessed September 2002.

Figure 2. **Water Withdrawal Permits for the Altamaha River Basin**



A total of 204 agricultural ground water permits with 17,007 permitted acres fall within the Altamaha River Basin. Again, Tattnall and Toombs Counties contain the most permits, with 61 and 53 permits respectively. In addition, 83 Well Pond permits are in the Altamaha River Basin, covering 9,812 permitted acres. The majority of these permits (29%) are located in Toombs County. One agricultural permit in the river basin had no source identified.

While there are no municipal and industrial water permits issued in the basin, the Altamaha River Basin has 106 Public water permits, all of which utilize groundwater. Withdrawals associated with these permits total 9.10 million gallons per day (MGD).[13] Wayne County, the location of Jesup and the Rayonier, Inc Paper plant, has more public water permits (26) than any other county in the Basin.

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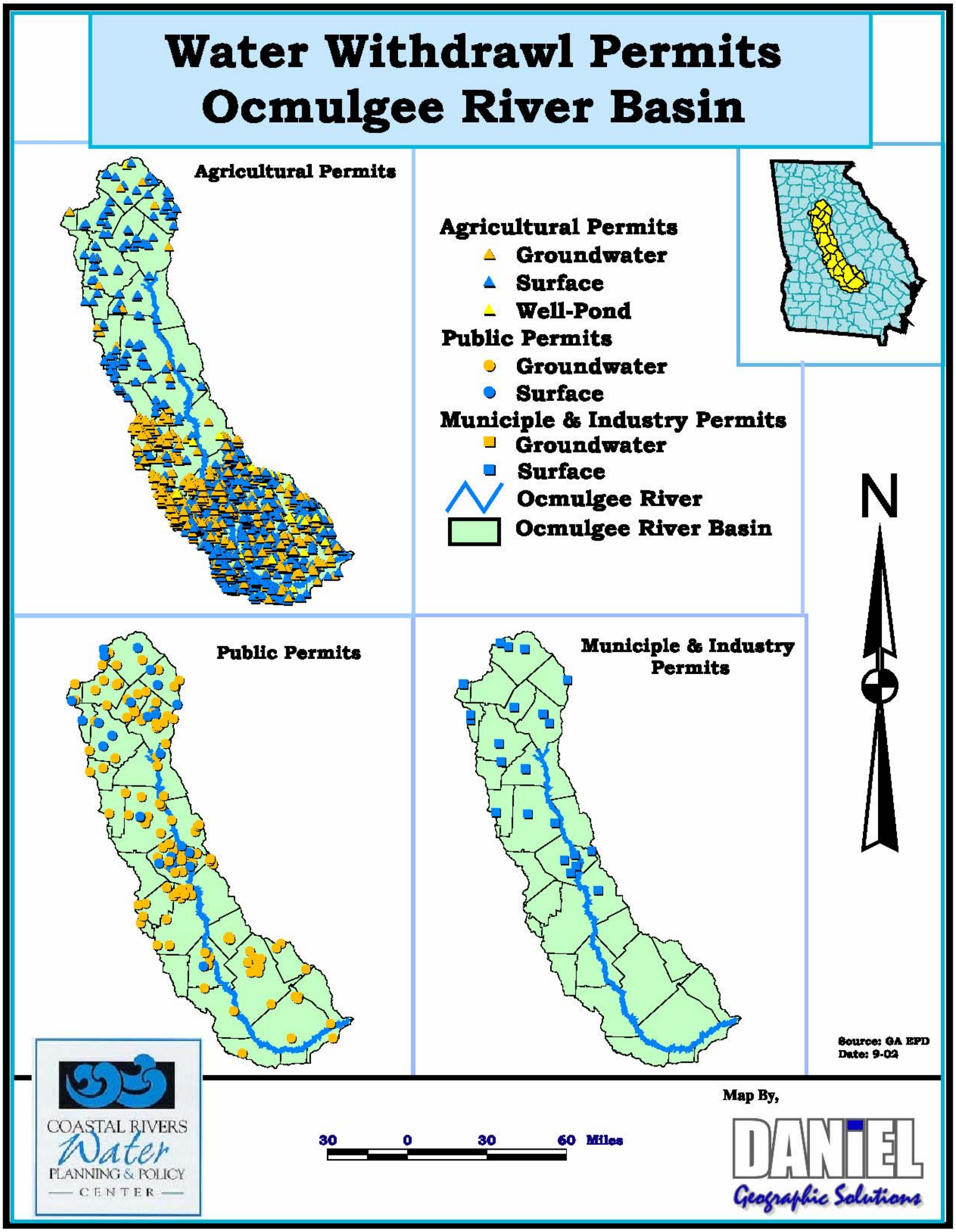
[13] U.S. Geological Survey, Estimated Water Use in the United States in 1995. Electronic document, http://water.usgs.gov/wateuse/spread95.html, accessed September 2002.

B. Ocmulgee River Basin

The Ocmulgee River Basin, located in North Georgia, passes through Atlanta and Macon before joining the Altamaha River. Although the River begins near Metro Atlanta, the remainder of the Basin contains predominately timber and agricultural land. Of the seven river basins the Ocmulgee River Basin has the highest population of 1,714,722 people. The Ocmulgee River Basin is home to a diverse industrial and attraction base: from agriculture to defense. Some of the many attractions include the GA National Fairgrounds, the Agricenter, the GA Music Hall of Fame, the Ocmulgee National Park, and the Andersonville National Cemetery (where many who fought in the Civil War now rest). In addition, you will find such places as Robins Air Force Base and Mercer University.

Of the seven basins, the Ocmulgee has the highest agriculture production and the most agricultural water withdrawal permits. Figure 3 depicts the permits issued to the 34 counties of the basin. The Basin's 2,391 agricultural permits cover 256,276 acres. Surface water accounts for nearly half of the permits (1,188) and a permitted acreage of 112,283 acres. Dodge County contains the most surface water agricultural permits of any counties in the Basin, with 228 permits for 17,959 permitted acres. Ground water supplies 1,018 agricultural permits, accounting for 122,345 acres. Dodge and Pulaski counties, whose primary crop is cotton, hold 306 of the agricultural groundwater permits, with 133 and 173 respectively.

Figure 3. Water Withdrawal Permits for the Ocmulgee River Basin



The 214 public water permits in the Ocmulgee River Basin withdraw approximately 317.12 MGD.[14] Eighty-six percent (184 permits) of the Ocmulgee's Public permits utilize groundwater, however these permits withdraw only 23.71 MGD of the daily Public drinking water. Fulton County has 19% (35) of the Basin's Public groundwater withdrawal permits.

All 35 Municipal & Industrial water permits in the Ocmulgee River Basin utilize surface water. Withdrawals for the basin are 23.39 MGD.[15]

[14] U.S. Geological Survey, *Op*. *Cit*., 1995.
[15] EPD, *Op*. *Cit*., 2001.

C. The Oconee River Basin

The Oconee River Basin enjoys a substantial Kaolin industry, and is home to the University of Georgia. The River begins near Athens, then flows south and meets with the Ocmulgee to form the Altahama River. Figure 4 shows the distribution of the basin's 591 Agricultural, 256 Public, and 33 Municipal & Industrial water permits, which supports a population of 468,746 people.

The Basin's 591 agricultural permits supply 48,671 permitted acres. Surface water accounts for 67% (396 permits) of these permits, and 65% (31,424 acres) of the permitted acreage. Wheeler County has the most agricultural surface water permits (83) in the Oconee River Basin. The Basin has 157 agricultural groundwater permits for 13,919 acres. Laurens and Bleckley counties have the most agricultural ground water permits, with 57 and 30 respectively. The Basin's 256 Public water permits allowed the withdrawal of 44.51 MGD.[16]

Most of these permits (227 permits with permitted withdrawals of 12.28 MGD) are for withdrawals from groundwater. The remaining 29 Public water permits allow for surface water withdrawals of at a rate of 32.23 MGD. Laurens County, location of Dublin, contains most of the Public drinking water permits (37 groundwater and 1 surface water). All of the Basin's 33 Municipal & Industrial permits are for surface water withdrawals.

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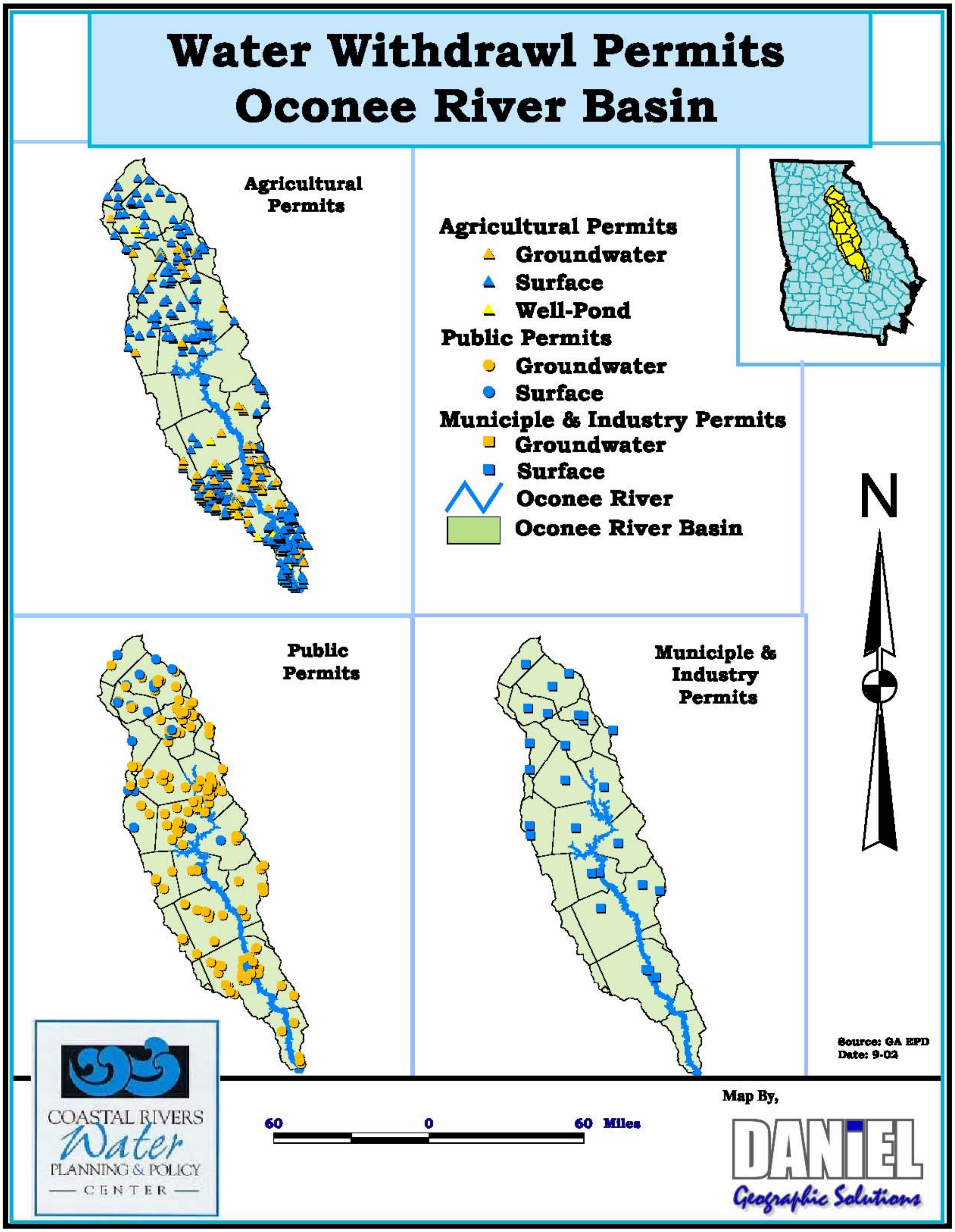
[16] U.S. Geological Survey, *Op*. *Cit*., 1995.

Figure 4. Water Withdrawal Permits for the Oconee River Basin



D. The Ogeechee River Basin

The Ogeechee River originates in Green County and then flows through several of the basin's 22 counties before reaching the coast. The River passes through the eastern boundary of Fort Stewart Army Base. Georgia Southern University, in Statesboro also falls within the Basin. The timber and poultry industries are strong in the area. The Ogeechee River Basin population consists of 275,866 people. It has 1,458 Agriculture, 507 Public, and 2 Municipal and Industrial water withdrawal permits.

The basin enjoys a diverse agricultural production base which includes Vidalia onions, vegetables, cotton and tobacco. The 1,458 agricultural permits in the basin irrigate 154,705 acres. Approximately 62% of the permits (904, with 82,174 permitted acres) utilize surface water. The majority of these permits (64%) are in Bulloch, Evans, and Tattnall counties. McIntosh and Taliaferro have no permits for agricultural surface water.

Similar to other basins in the Coastal region, the Ogeechee River Basin uses less ground water than surface water for agricultural purposes. One third or 447 agricultural groundwater permits supply 58,681 acres in this Basin. Roughly 40% of these permits fall within Bulloch and Screven counties. No agricultural groundwater permits are in Glascock, Greene, McIntosh, Taliaferro, and Warren counties.

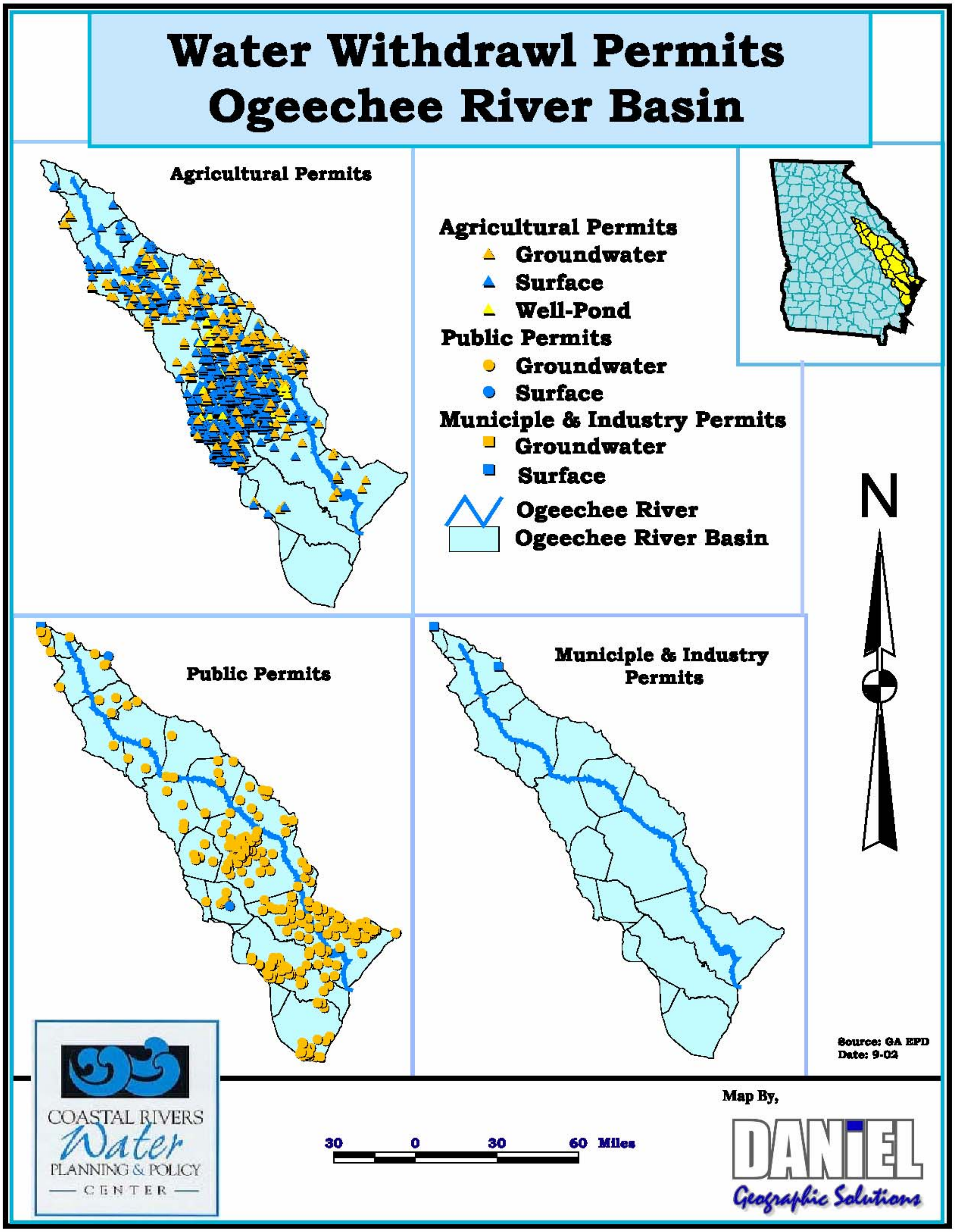
The Basin has 507 Public drinking water permits allowing for the withdrawal of 29.19 MGD. The five public surface water permits account for 0.83 MGD, found in Warren County (2), Greene (1), Evans (1), and Johnson (1) County.

Chatham County's public groundwater permits account for 25% of all withdrawals for the basin. [17]

[17] Note that Chatham County (Savannah) also falls within the Savannah River Basin.

Greene and Warren counties hold the two Municipal & Industrial surface water permits. These permits allow for surface water withdrawals of 28.31 MGD.

Figure 5. Water Withdrawal Permits for the Ogeechee River Basin



E. The Satilla River Basin

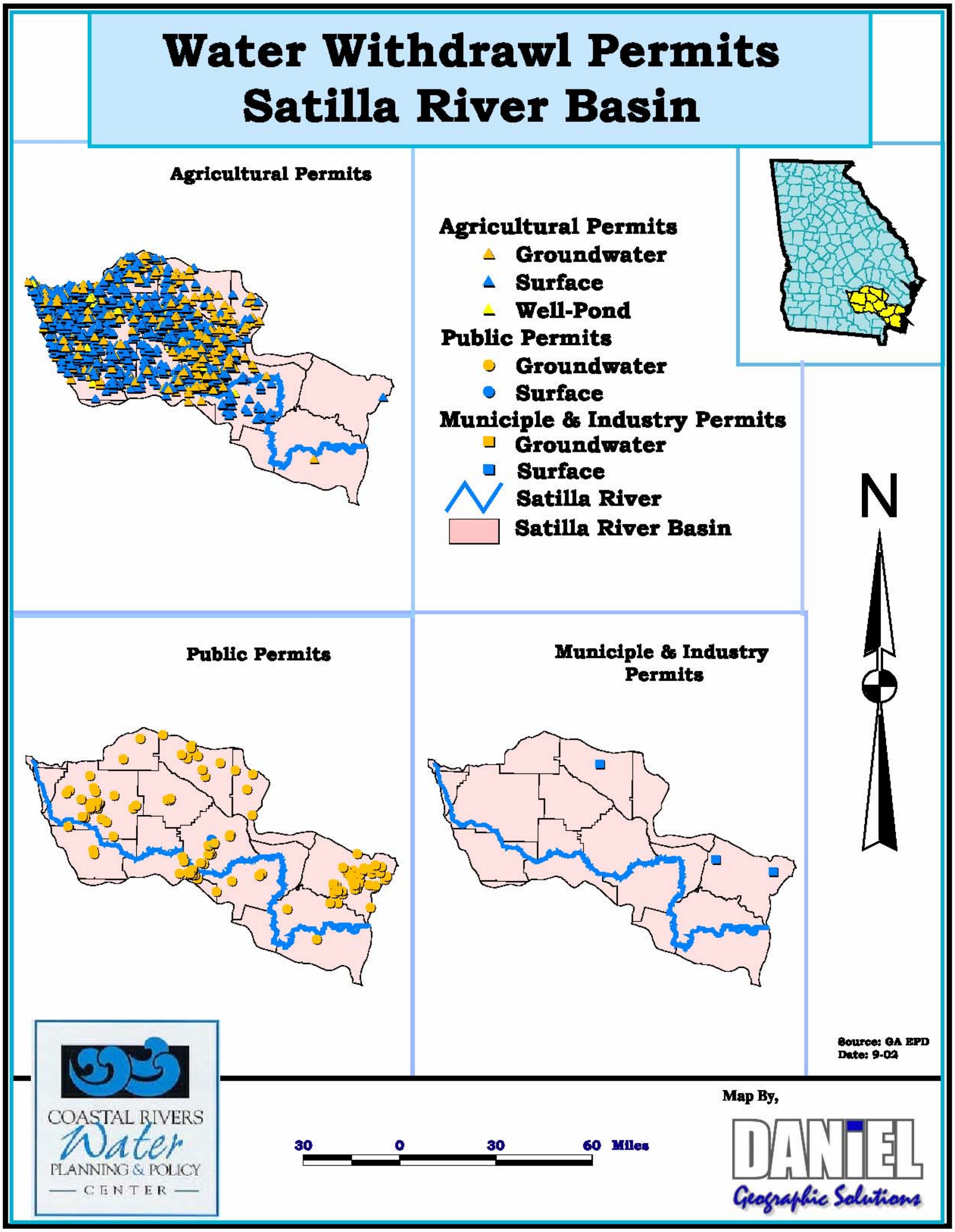
There are 15 counties in the Satilla River Basin with a population of 216,153 people. Figure 6 illustrates the locations of the 1,995 Agricultural, 186 Public, and 3 Municipal & Industrial, and permits in the Satilla River Basin.

The Basin's 1,995 agricultural permits cover 132,932 acres. About 71% of these (1,419 permits over 78,336 acres) utilize surface water. Most of these permits in the region are found in Coffee (468) and Bacon (217) Counties. On the other hand, Charlton and Clinch County have no agriculture- surface, ground, or well-to-pond permits.

The Basin's 510 agricultural water use permits for groundwater supply 50,100 permitted acres. Most (60%) of the permits fall in Pierce, Bacon, and Coffee counties. The Satilla River Basin is predominantly agricultural. However, forestry and timber production is found in the also prevalent in the basin.

The Basin's 186 Public permits allow for withdrawals of 24.28 MGD. Most permits are for groundwater use. Glynn and Coffee counties hold the majority of these permits, with 87 and 35 permits, respectively. The Basin's 3 Municipal & Industrial permits withdraw 73.45 MGD.

Figure 6. Water Withdrawal Permits Satilla River Basin



F. The Savannah River Basin

The Savannah River Basin extends down the entire length of Georgia's eastern border and contains a diverse array of industries and attractions. Beginning in the northern section of the river, reservoirs assist in power generation. In Augusta you find The Medical College of Georgia and Fort Gordan Army Base. Farms populate the landscape between Augusta and Savannah. The Savannah metropolitan area is home to a variety of industry, colleges, tourist attractions such as historic district, and the Port Authority. The Savannah Wildlife Refugee provides habitat for rare animals and plants.

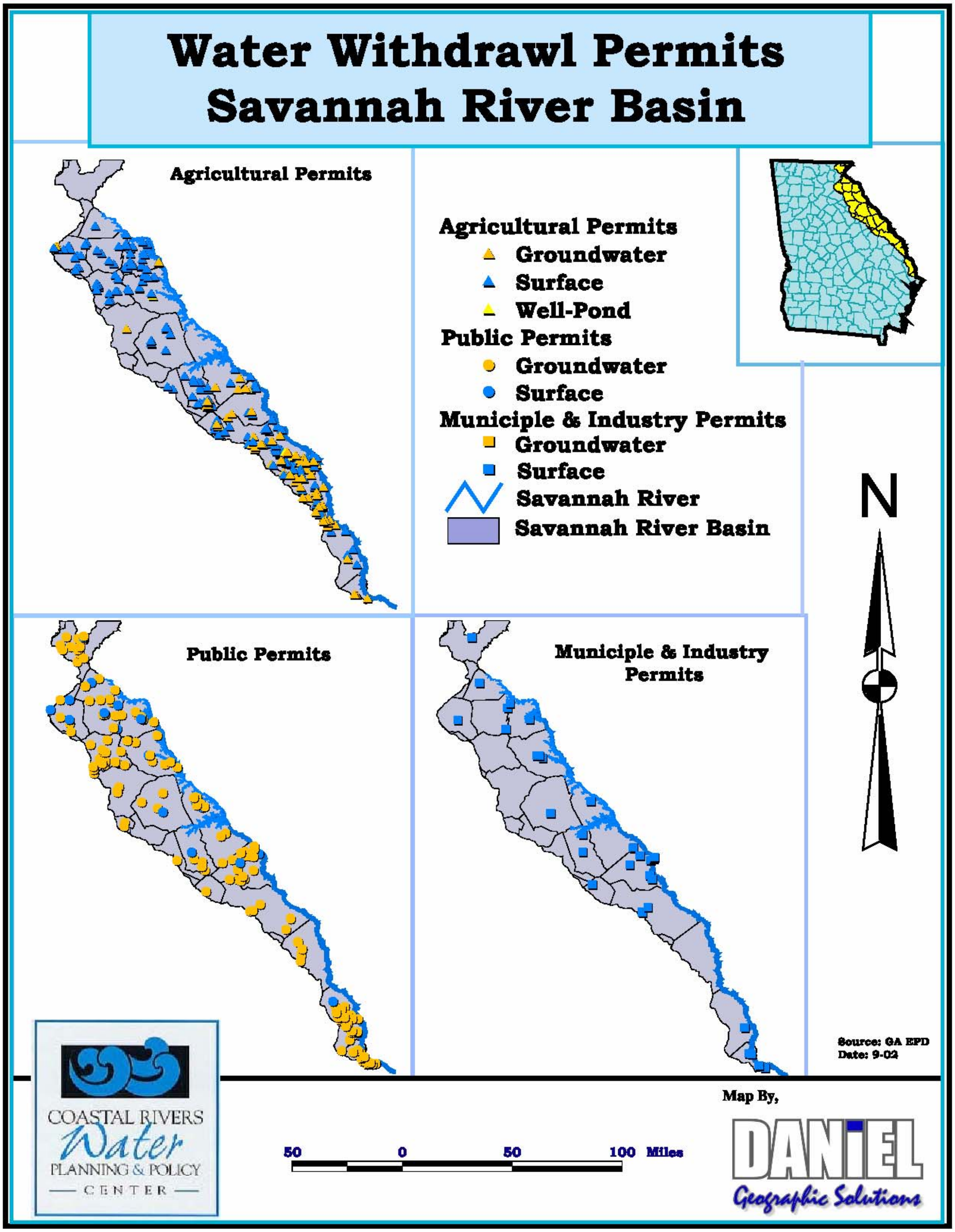
The Savannah River forms the boundary between Georgia and South Carolina, and its tributaries, and the aquifer in the area supports a population of 720,614. Within Georgia the Savannah River Basin encompasses 28 counties (in full or in part of).[18] Figure 7 shows the distribution of the Basin's 376 Agricultural, 240 Public, and 46 Municipal & Industrial water permits.

This Basin's 376 agricultural water use permits include 45,907 permitted acres. Roughly 58% (217 permits) of these permits utilize surface water. The majority of surface water agricultural permits fall in Burke (12%), Hart (7%), and Screven (7%) counties. 11 counties have no agricultural water permits for surface water use.

The Basin's 150 agricultural ground water permits, approximately 40% of all agricultural permits, supply 17,681 permitted acres. The majority (56 permits) is located in Screven County. The Basin has nine well-to-pond agricultural permits for 1,570 permitted acres. Burke County contains six of these agricultural well-to-pond permits.

[18] Water use along the South Carolina side of the Savannah River is not considered in this analysis.

Figure 7. Water Withdrawal Permits for the Savannah River Basin



The Basin's 240 Public water permits provide for withdrawals of 132.13 MGD. The majority (91%) of the permits (219) utilize ground water. The 21 surface water permits account for the bulk of the Public water withdrawals (51.34 MGD). Thirty-eight percent are concentrated in the northern part of the basin. The map on the preceding page displays 13 Public surface water permits. This is due to the fact that permit holders may own multiple permits for the same location. Chatham County Municipal and Industrial (7) account for nearly half of the 132.13 MGD permitted withdrawals.[19] The Basin's withdraws 41.80 MGD for the 46 Municipal and Industrial permits.

[19] Chatham County lies partially in the Ogeechee River Basin as well.

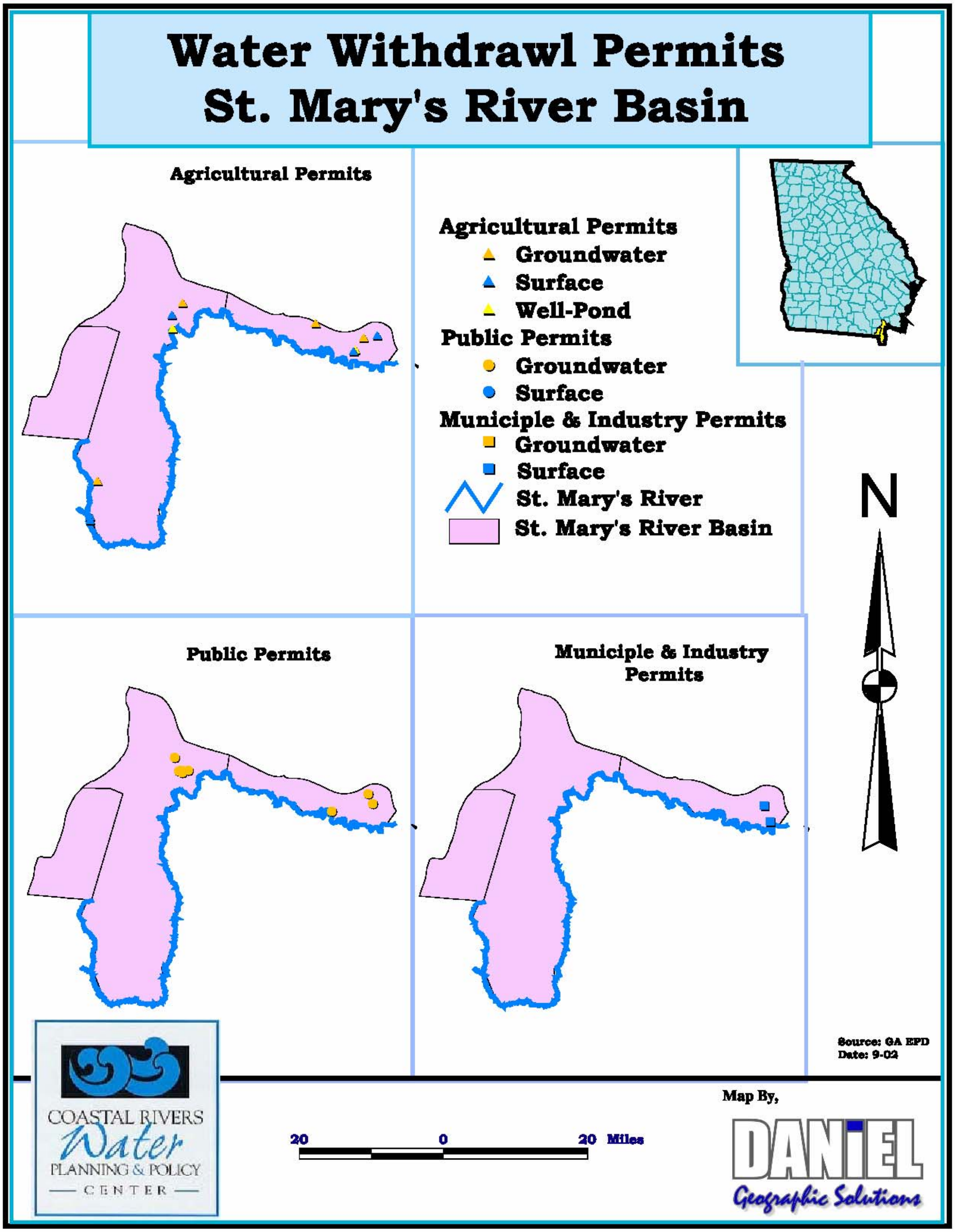
G. The St. Mary's River Basin

The St. Mary's is the smallest river basins in the Coastal region with a population of 43,988. The Okefenokee National Wildlife Refuge, located on the western side of the basin, provides a habitat to many rare wildlife and plant species. Kings Bay Naval Base calls the St. Mary's Basin home. Moreover, timber is a major industry within in the area.

The three counties in the Basin have 14 Agricultural, 12 Public, and 3 Municipal & Industrial water permits. Figure 8 shows the location of these permits.

Agricultural activity is limited – 5 surface water permits, 5 groundwater permits, and 4 well-to-pond permits – covering 855 permitted acres. The Basin's 12 Public water permits allow for withdrawals of 2.13 MGD. The three Municipal and Industrial permits allow for withdrawals of 31.32 MGD.

Figure 8. Water Withdrawal Permits for the St. Mary's River Basin



H. Summary

Next we turn out attention to the determination of water demand for the coastal region. Table 3 provides estimates of the *maximum permitted withdrawals* for the coastal region's seven river basins. We report the water use as it would be if each permit holder withdrew the maximum amount of water indicated by their specific permit(s).

Table 3. Coast Rivers Maximum Daily Water Permitted Withdraw (MGD)[20]

River Basin	Agriculture			Public		Municipal & Industrial
	Surface	Ground	Well-Pond	Surface	Ground	Surface
Altamaha	29.72	10.63	6.13	-	9.10	-
Ocmulgee	70.17	76.46	13.53	293.41	23.71	23.39
Oconee	19.64	8.70	2.08	32.23	12.28	58.96
Ogeechee	51.35	36.67	8.66	0.83	28.36	28.31
Satilla	48.95	31.31	2.81	0.45	23.83	73.45
Savannah	16.66	11.05	0.98	51.34	80.79	41.80
St. Mary's	0.33	0.17	0.02	0.00	2.13	31.32
Total	236.82	174.99	34.21	378.26	180.21	257.22
Category Totals	446.02			558.47		257.22

Agricultural water use is calculated by first determining the number of permitted acres from the permit database.[21] The total permitted acres are then multiplied by the assumed water

[20] U.S. Geological Survey, *Op. Cit.*, 1995, and EPD, *Op. Cit.*, 2001. To obtain the water use for Municipal and Industrial permits we aggregate the USGS withdrawal estimates for commercial, domestic, industrial, and mining uses in the coastal river basin counties. (See U.S. Geological Survey, *Op. Cit.*, 2002). This total is then multiplied by the proportion of the population of the county which lives in the particular river basin. While this estimation procedure is flawed at best, the attempts to calculate directly from the EPD Municipal and Industrial permits proved to be problematic. Again, these estimates, while admittedly inaccurate, are intended to provide a general idea of the water use in each basin.

According to this methodology, 55.58 MGD are withdrawn from the Altamaha River Basin. However, EPD, as of 2001, has no M&I permits for this basin. In order to be consistent with the EPD permit data, no M&I withdrawals for the Altamaha River Basin are included in the report.

[21] Appendix 3 details the permitted acres for agriculture permits in the coastal region river basins.

use per acre.[22] We assume that agriculture uses 0.7 acre-feet per year.[23] In addition, water use is reported in millions of gallons per day (MPG).

[22] One acre-foot equals approximately 325,851 gallons of water. So to obtain the agricultural water use per day, the permitted acres are multiplied by the water use (0.7 * 325,851), then divided by the 365 days to reach the total daily water withdrawals for agriculture.

[23] EPD assumes that agriculture uses 1 acre-foot per year per acre. Appendix 4 compares the permitted water withdrawals for agriculture assuming 1 acre-foot per year with 0.70 acre-feet per year. During drought conditions, water use falls between 1 and 1.5 acre feet. 0.7 represents the water use in an "average" year; 0.4 in a “wet” year.

III. Water Supply in the Coastal Region's River Basins

Attention is now turned from discussions of water "demands" in the coastal region, which turned out to be a discussion simply of permitted water use in the area, to *an attempt* to discuss data available for assessing the supply of water available in the region's seven river basins. Emphasis is given to "attempt" inasmuch as measures for water supply in the region's seven basins simply *do not exist*. The only available data *related* to water supply are readings from river flow gauges operated by the U.S. Geological Survey.

A. Surface Water

It is important that the reader clearly understands the water supply data problem. Consider a representation of a river such as the straight line given below. There are three gauges on the river at points A, B, and C. These gauges continuously (unless they are out of commission for one reason or another, a common occurrence with such gauges) measure the flow of water in the river at the point at which the gauge is located. The river ultimately discharges into the ocean as depicted below.

Ocean ____________________ *C* ____________________ *B* ____________________ *A*

Our interest is with historical data covering a sufficiently long period of record to include the wide range of hydrological conditions that might occur in the Basin: water available in drought years, flood years, and all hydrological circumstances between these two extremes. Assuming that the three gauges were continuously operative during this period of record, what information would data from these three gauges provide? We would know, say, daily average flows observed at each point, A, B, and C, over the period of record. From this, could we then know the amount of water available in the Basin – the "virgin," or "unimpaired" flows in this river? The answer, of course, is NO. If water withdrawals/discharges associated with man's activities occurred between A and B and or between B and C, our gauge readings do not consider these events: they will measure only the flow of water that passes the gauge.

To know virgin flows, it would be necessary for us to know (or estimate) the net withdrawals of water from man's activities between A and B, between B and C, and in the area upstream from the gauge at point A, and add these withdrawals to "observed" flows at each appropriate gauge. This would be an extraordinarily tedious task: taking daily (or hourly) observations at each gauge, and adjusting them for unobserved effects on flows from upstream (from the gauge in question) from man's activities. But even if such adjustments were made, we would still be ignorant as to the total amount of water available in this river basin. This follows from the fact that there is no gauge at a point immediately before the river discharges into the ocean. Thus, we have no idea as to virgin flow that would derive from drainage in the (potentially) large area of the basin lying between point C and the ocean.

Herein lies the water supply data problem facing water planners in the coastal region. There are 125 river gauges in the region's seven river basins (Figure 9).[24] *However*, 72 of these gauges are inactive, 28 of the remaining 53 gauges do not provide consistent flow information for the last five years! Moreover, historical data from many gauges have "holes" in them, reflecting periods (sometimes extending over months) during which the gauge was inoperative. Note (Figure 9) the extensive discharge areas between the last gauge in each river system and the point at which the river discharges into the ocean – thus the potentially large water supplies about which absolutely nothing is known.

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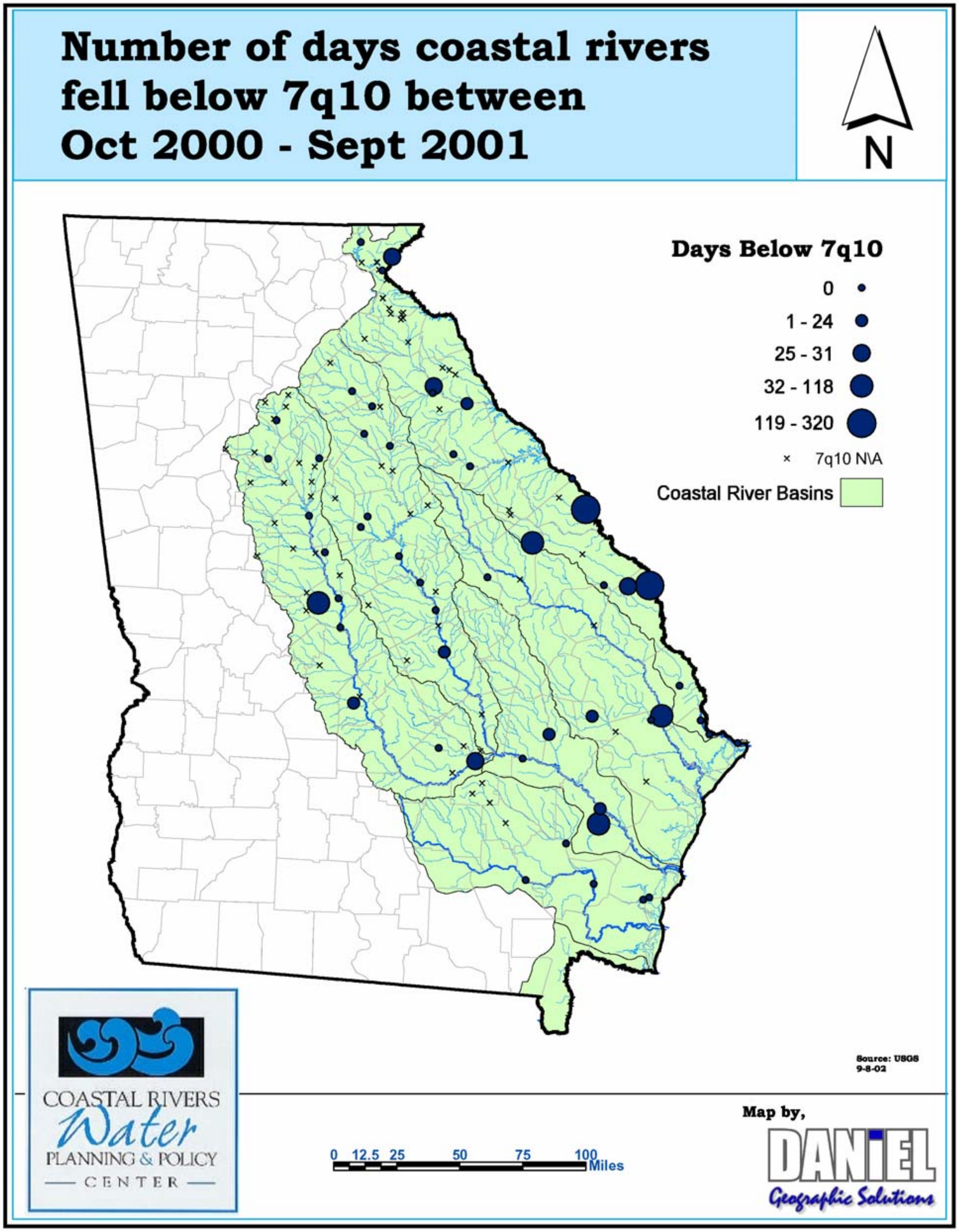
[24] Gauges that are either inactive or do not provide consistent flow data are marked with an "x" in Figures 9 and 10.

Figure 9. Coastal River Low Flow Frequency Statistics for 2001



Thus, as noted by Fisher and Thompson,[25] the supply-data shelf is empty in the coastal region. The region simply does not have data of critical importance for any effort to develop basin water plans for it's seven basins: the volume of water "available" for use during varying hydrological conditions. This critical void will continue until the laborious task of adjusting years of daily gauge data for man's activities is accomplished for *each* gauge in *each* basin, and some method is devised for estimating drainage in each basin from the large areas lying downstream of the last gauge before the river empties into the ocean.

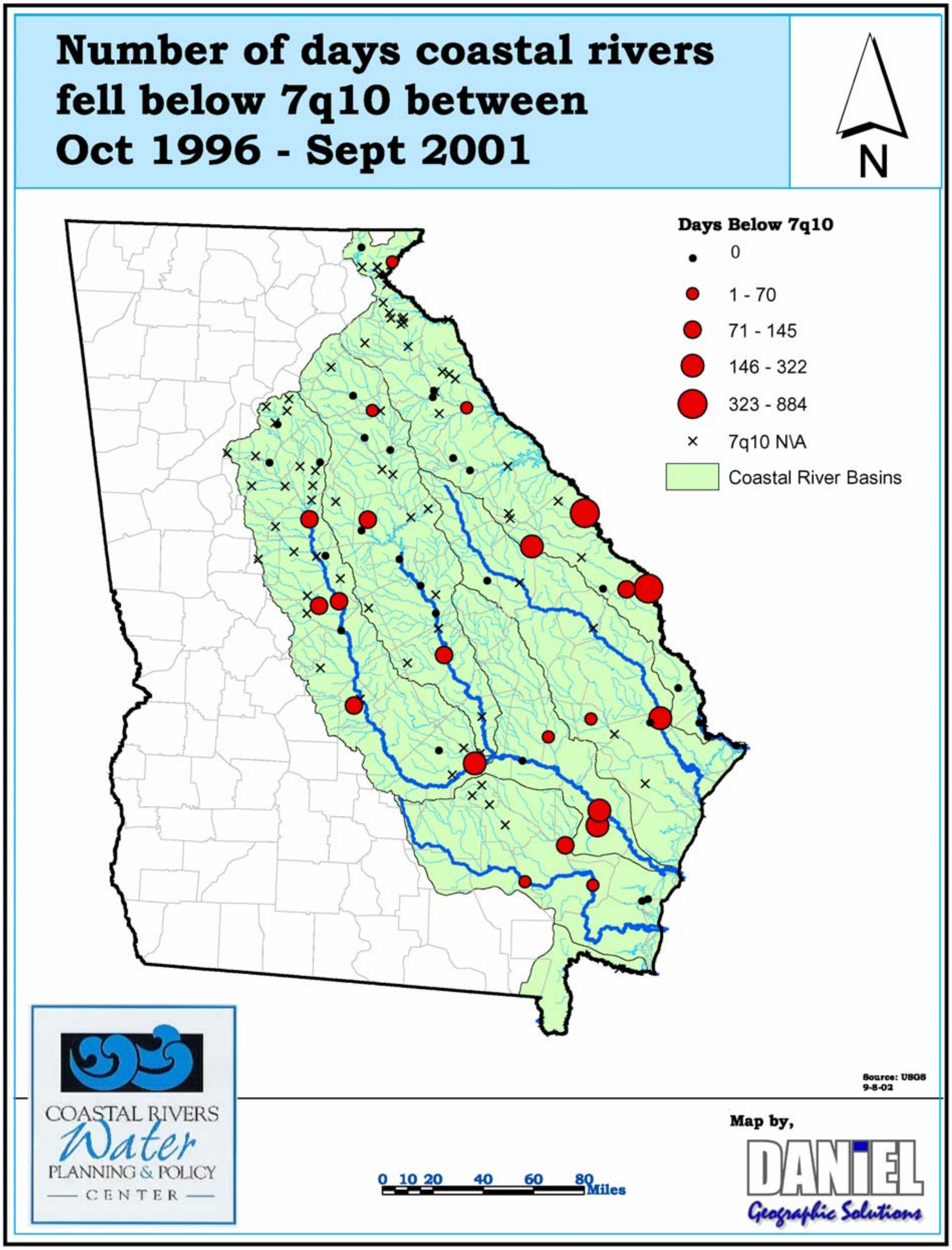
The relatively small amount of data available from roughly 25 operating river gauges can be used, however, to gain insights (however imperfect) as to the general outline of water scarcity in the region as it has evolved over the last few years. The state uses a measure for minimum in-stream flow required to protect the riverine environment referred to as a "7Q10" measure. 7Q10 is a measurement of low flow frequency: it is a stream flow that occurs over 7 consecutive days and has a 10-year recurrence interval period.[26] Observations of daily streamflows *below* the 7Q10 level indicate reaches of a river wherein the ecology of the river is under stress – river flows are inadequate to protect the riverine environment.

The authors have taken data available from the 25 gauging stations operating over the last five years and counted the number of days that flows (at some point during each day) *were less than* the relevant 7Q10 measure during two time periods: a drought period, the one-year period October 1, 2000, through September 30, 2001; and the five-year period October 1, 1996 and September 30, 2001 which includes the first three years of the recent four-year drought. The results are reported in Table 5 and presented graphically in Figures 9 and 10. In Figures 9 and 10

[25] Fisher, D. and B. Thompson, *Op. Cit.* 2003.
[26] Carter R.F., and Putnam S.A., 1978, Low Flow Frequency of Georgia Streams: U.S. Geological Survey Water-Resources Investigations Report 77-127, p.104. Electronic document, http://ga2.er.usgs.gov/lowflow/, accessed January 2003.

the height of red bars indicates the number of days that the 7q10 standard was violated at a given gauge station.

Figure 10. Coastal River Days Below 7q10 for the Years 1996-2001



As seen in Table 5, during the one year period October 2000 through September 2001, the Savannah River Basin was the most affected by the drought in east Georgia. The Augusta gauging station reported *320 days* – almost every day of the year – during which flow was observed at levels below the 7Q10 level. While not as severe compared to the Savannah Basin, flows below 7Q10 were observed in the Ogeechee Basin 70 out of 365 days, and 24 to 28 days in the Altamaha and Ocmulgee Basins, respectively.

Table 5. Low Flow Frequency by River Basin[27]

Gauging Station Name	7q10 Level	Days Below 7q10: Oct. 00 to Sept. 01	Days Below 7q10: Oct. 96 to Sept. 01
Savannah River Basin			
Chattooga River Near Clayton	120	31	38
Broad River Near Bell	200	22	55
Savannah River At Augusta	5400	320	884
Savannah River At Burtons Ferry Bridge	5800	259	726
Ogeechee River Basin			
Ogeechee River Near Eden	240	70	242
Ocmulgee River Basin			
Ocmulgee River Near Jackson	340	0	90
Ocmulgee River At Macon	410	0	145
Tucsawhatchee Creek Near Hawkinsville	6	7	83
Ocmulgee River At Lumber City	1250	28	181
Oconee River Basin			
Middle Oconee River Near Athens	45	0	50
Little River Near Eatonton	13	0	105
Oconee River At Milledgeville	250	0	0
Oconee River At Dublin	570	4	122
Altamaha River Basin			
Ohoopee River Near Reidsville	34	18	70
Altamaha River At Doctortown	2250	24	178
Satilla River Basin			
Satilla River Near Waycross	13	0	48
Satilla River At Atkinson	38	0	16

[27] U. S. Geological Survey, Daily Streamflow for Georgia, Electronic Document, http://waterdata.usgs.gov/ga/nwis/discharge, accessed January 2003.

A more dramatic picture of water scarcity in the coastal region's river basins if obtained by examining the five year period from October 1996 through September 2001, which includes three years of the recent drought. Days in which the 7Q10 standard was violated exceeded 100 in all basins except the Satilla. *884 violation days* were observed at the Savannah River Basin's Augusta gauge, 242 days in the Ogeechee River at the Eden gauge, and 181 days at the Ocumulgee River's Lumber City gauge.

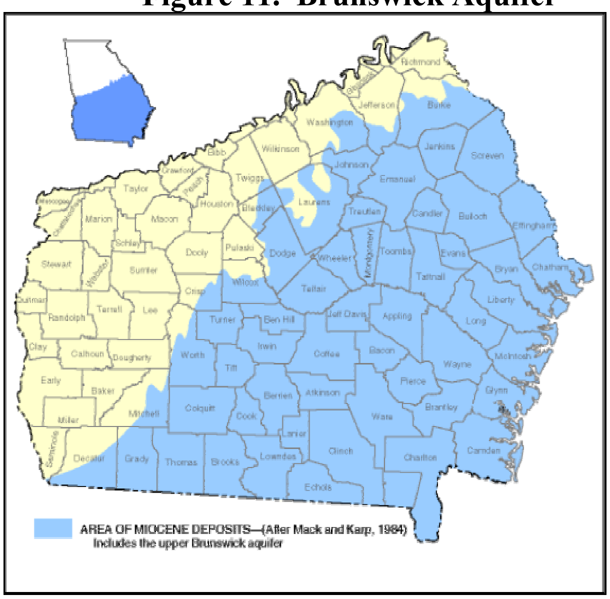
However limited the data given in Table 5, they should unquestionably serve to make perfectly clear the importance, indeed the urgency, of the need to initiate basin water planning the the coastal river region.

B. Groundwater

Georgia's coastal region contains four major aquifer systems including the Brunswick aquifers, the Floridan aquifer system, the Gordon aquifer, and the Cretaceous aquifer system. An aquifer is a rock formation capable of yielding amounts of water that may be used for public consumption, agricultural irrigation, and industrial consumption. There are two types of aquifers known as confined and unconfined.[28]

The upper and lower Brunswick aquifers, as seen in Figure 11, can be located at a depth between 85 and 390 feet below the surface. Wells drawn from this system usually yield 10 to 30 gallons of water per minute. Although not a major source of water in the coastal area, the Brunswick aquifers supplement the Floridan aquifer.

Figure 11. Brunswick Aquifer[29]

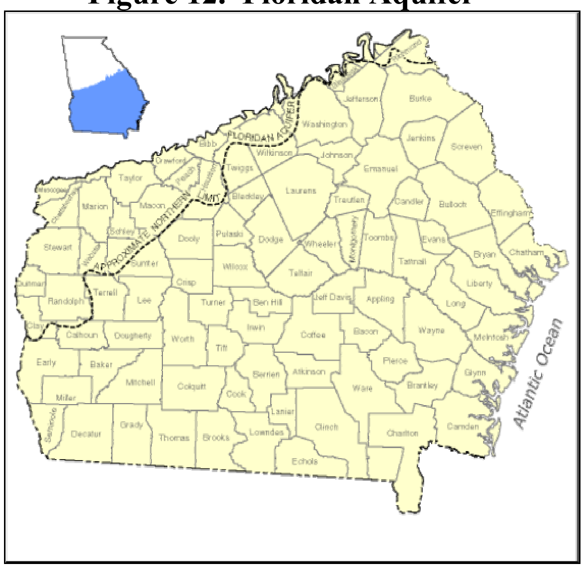


[28] According to Chalmers A.G., Summit to the Sea. Electronic document, http://coastgis.marsci.uga.edu/summit/aquifers.htm, accessed November 2002, a confined aquifer is a water supply contained between impermeable layers of soil and rock. When under pressure, this type of aquifer can also be referred to as an artesian aquifer. The second type of aquifer is known as an unconfined aquifer, which has no impermeable layer above it. From Dorman, Dale, (1996), *Understanding the Water System.* Athens, GA: University of Georgia, Cooperative Extension Service, Electronic Document, http://www.fcs.uga.edu/pubs/current/C819-7.html, accessed March 2003, an unconfined aquifer is also referred to as a water table aquifer.

[29] Cressler, Alan M., 1999, Ground-water Conditions in Georgia, U.S. Geological Survey Open-File Report 00-151, Electronic document, http://ga.water.usgs.gov/publications/ofr00-151/ubrunswick.html, accessed November 2002.

The region's major groundwater source, the Floridan aquifer (Figures 12 and 13), supplies about 50 percent of *Georgia's* (the entire state's) freshwater. This aquifer system, which consists of limestone, dolomite, and calcareous sand, is comprised of the Upper and Lower Floridan aquifers and is generally confined. A well depth for the system generally falls between 40 and 900 feet below the surface, and yields vary between 1,000 and 5,000 gallons/minute. The Lower Floridan aquifer can extend to more than 2,700 feet below the surface. However, the usefulness of the Lower Floridan in the coastal region is limited by the fact that wells in the lower Floridan can yield high chloride water below 2,300 feet.

Figure 12. Floridan Aquifer[30]



The Savannah metropolitan area and Chatham County's primary source of groundwater is the Upper Floridan aquifer. Given that pumping from this aquifer is seemingly resulting in seawater intrusion, extending northeast to South Carolina's Hilton Head Island, a moratorium on new permits to pump from this source has been imposed by the EPD, a moratorium that is likely

[30] See Cressler, Alan M., *Op. Cit*., 1999.

to become a permanent ban.[31] Considerable controversy surrounds the possibility of more extensive use of the Lower Floridan due to the potential connectivity between the Upper and Lower aquifers. Only recently, late January 2003, has the EPD made possible the construction of new wells in the Lower Floridan aquifer, but such construction is subject to extraordinarily stringent requirements to demonstrate that the new well will not affect water levels in the Upper aquifer.

Figure 13. Floridan Aquifer Depths[32]

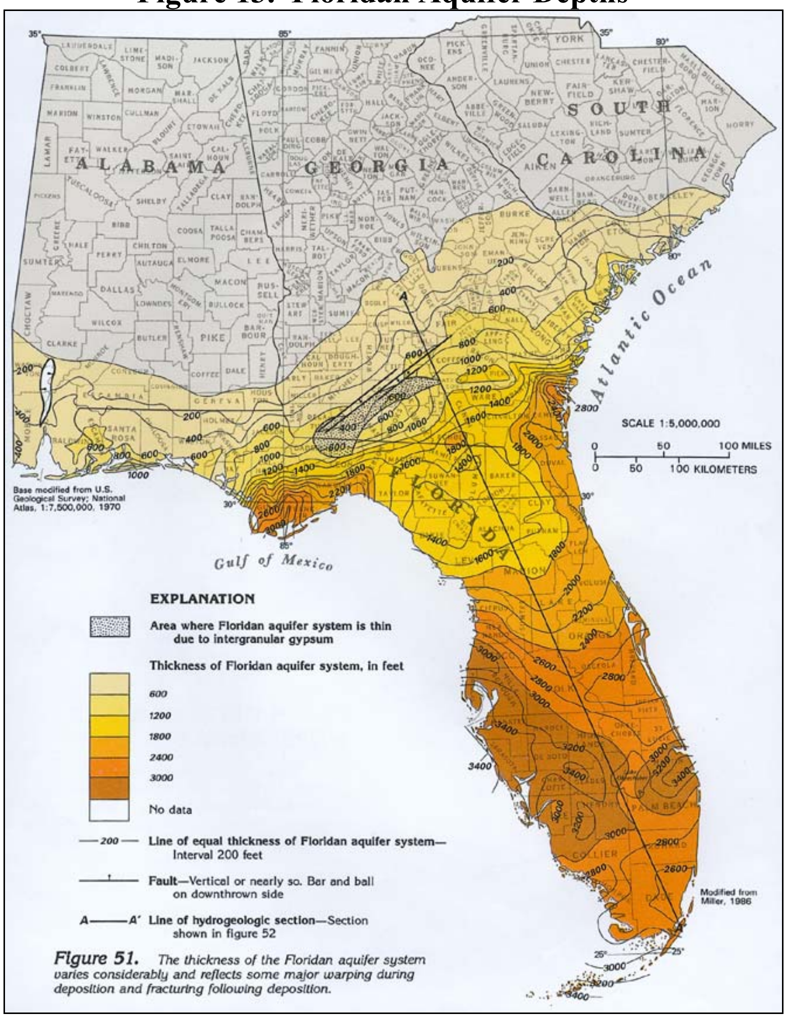
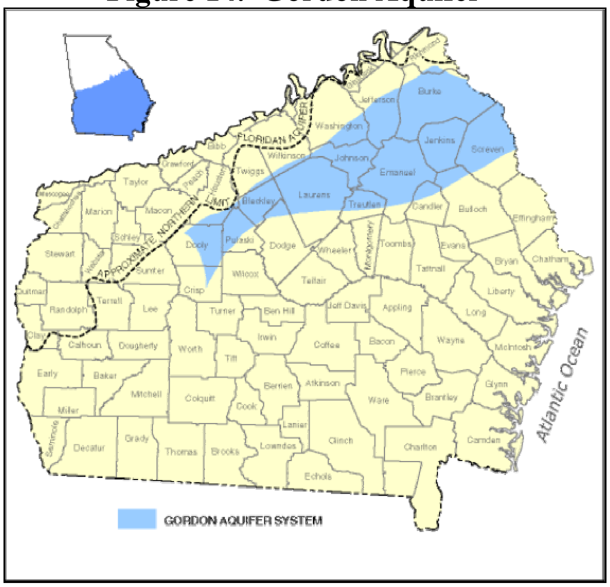


Figure 51. *The thickness of the Floridan aquifer system varies considerably and reflects some major warping during deposition and fracturing following deposition.*

[31] See Georgia Department of Natural Resources, EPD, Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia, Atlanta, April 1997. Also see, sources for here, Georgia Department of Natural Resources, EPD, Supplement to the Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia, Atlanta, September 2001a.
[32] Miller, James, A, 1990, Groundwater Atlas of the United States: Alabama, Florida, Georgia, and South Carolina, HA 730-G. Electronic Document, http://capp.water.usgs.gov/gwa/ch_g/jpeg/G051.jpeg, accessed November 2002.

Figure 14 depicts the Gordon aquifer, a confined aquifer, which consists of sand and sandy limestone. Wells are usually located between 270 and 530 feet in depth, pumping any where from 87 to 1,200 gallons of fresh water per minute. Irrigation, industry, and public-supply are the major users of the Gordon aquifer in east-central Georgia.

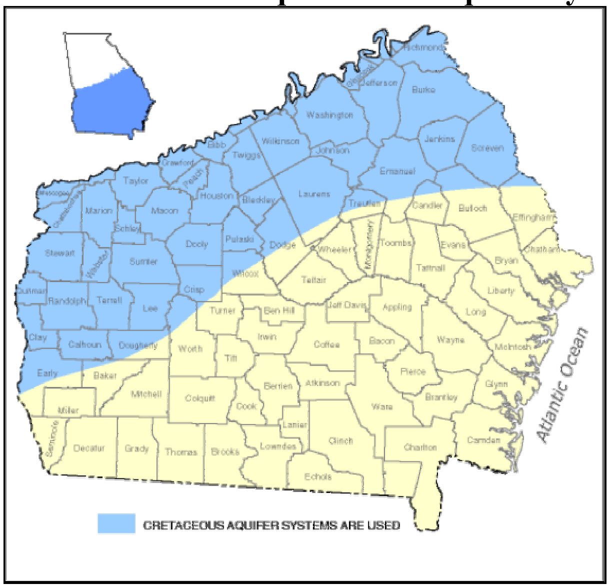
Figure 14. Gordon Aquifer[33]



The Cretaceous aquifers and aquifer systems can generally be found at a depth between 30 and 750 feet and consists of sand and gravel (Figure 15). These wells usually yield between 50 and 1,200 gallons of water per minute. East-central Georgia considers the Cretaceous aquifer system a major source of water for the region. This water is used in the mining and processing of kaolin. Other minor aquifer systems located in the region include the Dublin, Midville, and Dublin-Midville aquifer systems.

[33] See Cressler, Alan M., *Op. Cit.*, 1999.

Figure 15. Cretaceous Aquifers and Aquifer Systems[34]



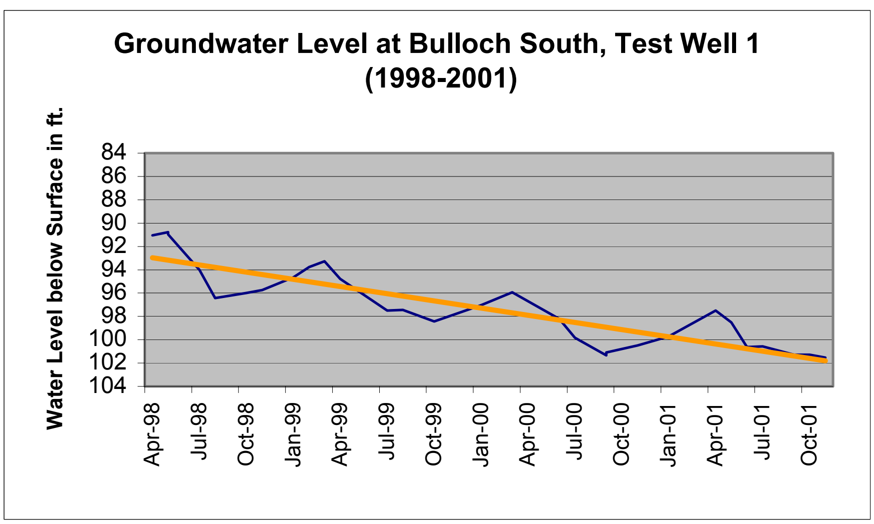
[34] See Cressler, Alan M., *Op. Cit*., 1999.

C. Groundwater Monitoring

Aquifer sustainability is monitored through various groundwater wells. Figure 16 illustrates the multitude of wells through out the coastal rivers region. In order to better understand the situation with aquifers, lets turn our attention to an example of the information available regarding ground water level variations. The selected ground water measurement stations all fall within Bulloch County.

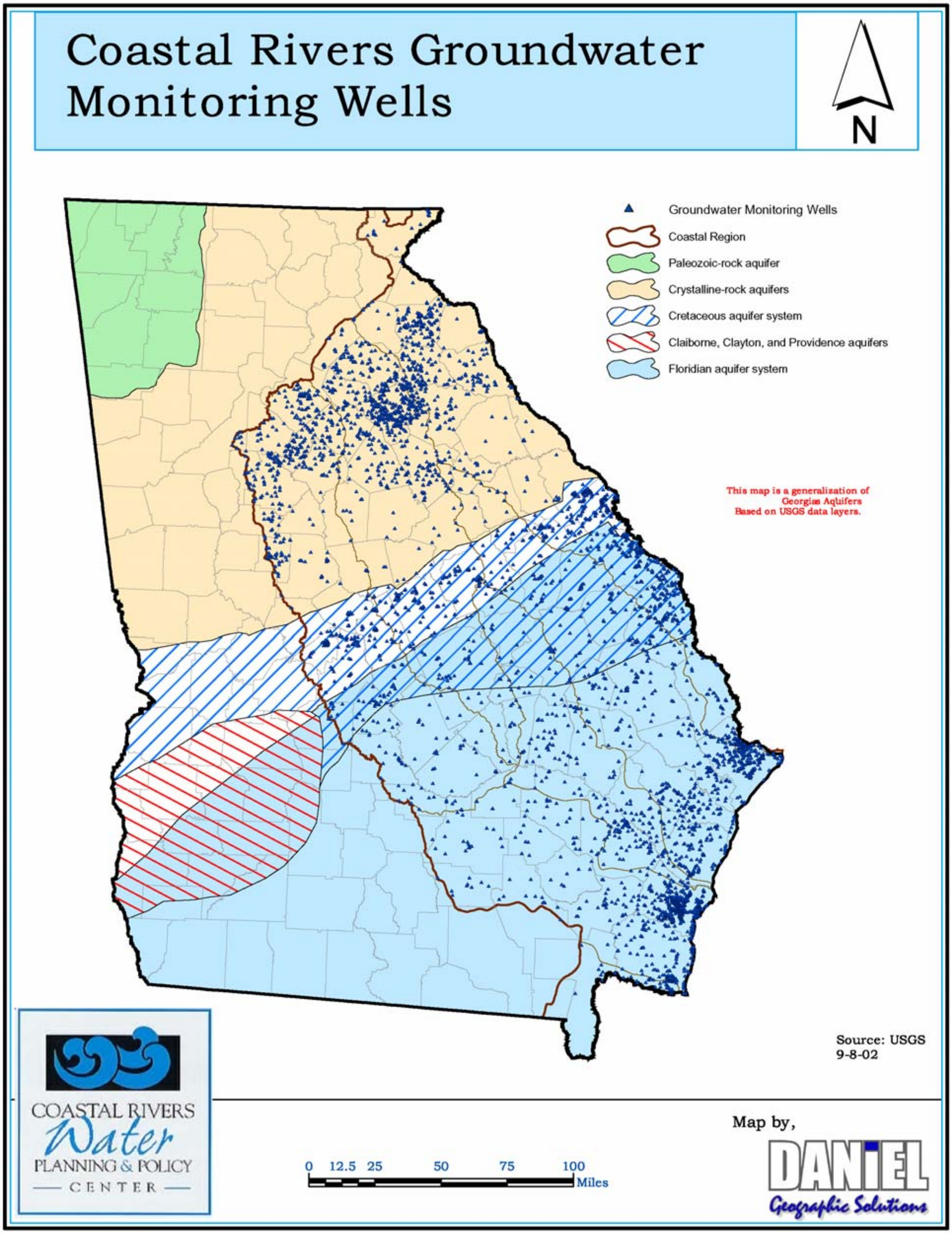
Figures 17 and 18 illustrate the groundwater situation at one of the three sites in Bulloch County. Unfortunately, data were only available for a four-year time-period. Figure 17 shows that the groundwater level has fallen significantly over the 4-year period from 1998 to 2001.[35] The decline is most likely due to the persistent drought conditions that have plagued the area. However, these effects are grossly exaggerated due to the short length of the time interval.

Figure 17. Bulloch County Groundwater Monitoring for Test Well 1 1998-2001



[35] U. S. Geological Survey, Groundwater Levels, Electronic document, http://waterdata.usgs.gov/ga/nwis/gwlevels, accessed July 2002.

Figure 16. Groundwater Monitoring Wells for the Coastal Region

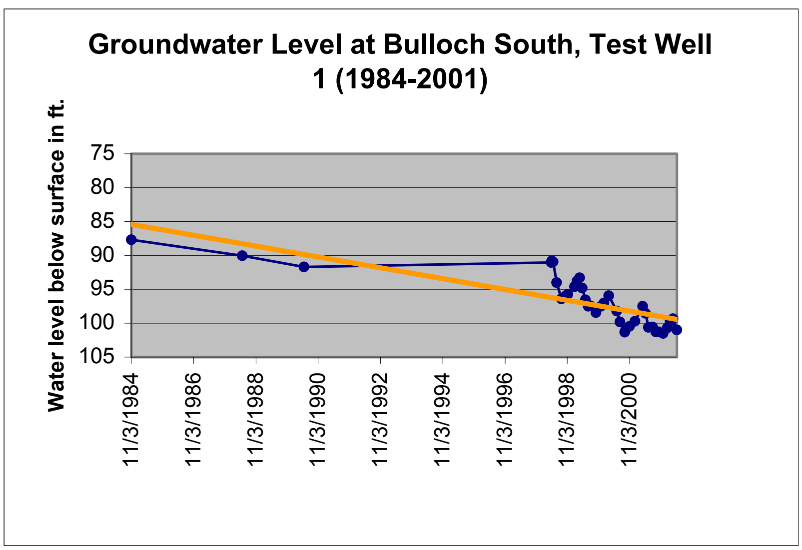


Groundwater levels reach their annual highs early in the year between March and April after groundwater recharge has taken place throughout the winter and early spring. Levels continue to drop due to increased evapo-transpiration, intensive irrigation during growing season, and less frequent precipitation. Lows are reached around the month of October.

The y-axis reflects the water level depth from the surface of the monitoring well. The water level dropped roughly ten feet over the analyzed period. The figure also illustrates the yearly cycles of groundwater recharge and use. The groundwater level at Bulloch South, Test Well 1 experienced a 10.3% decline over the interval.

Figure 18 demonstrates the long-run behavior of the aquifer at this particular monitoring well in Bulloch County. As you can see the data is sporadic at best, making it difficult to draw any decisive conclusions.

Figure 18. Bulloch County Groundwater Monitoring for Test Well 1 1984-2001



In summary, the coastal region, particularly those areas reliant on the Floridan aquifer, cannot look to groundwater as a water supply source to satisfy expected growth in the region. The reliability of supplies from all of the region's aquifers during periods of drought has become increasingly problematic given the persistent declines in water tables observed in many observation wells during the recent four-year drought.[36]

In closing, we simply note that the general role that groundwater might play in the regions water future cannot meaningfully be defined out of a context that includes available surface water supplies – a context that cannot be formed until information concerning surface water supplies is developed.

[36] Hickey, Andrew C., John F. Kerestes, and Brian E. McCallum, Water Resources Data-Georgia, 2001, Volume 1: Continuous water-level, streamflow, water-quality data, and periodic water-quanlity data, Water Year 2001, Water-Data Report GA-01-1. Also Coffin,R., and Alan M. Cresler, Volume 2: Continuous ground-water-level data, and periodic surface-water- and ground-water-quality data, Calender Year 2001, Water-Data Report GA-01-2.

Concluding Remarks

Record-setting low levels for stream flows and groundwater tables during the recent four-year drought, coupled with expectations for growing stress on the region's water supplies from rapid growth in population and economic activity combine to make compelling the coastal region's urgent need to institute a basin water planning process in each of its seven river basins. Such a task is challenging under "normal" conditions. We have shown here that planning conditions in Georgia's coastal region are anything but "normal." Data required for such processes are either very weak, in terms of our understanding of the precise nature and magnitude of water needs, or non-existent, in terms of our knowledge of water supplies available for use under hydrological conditions faced by the region historically.

The primary intended contribution of this study is to make this case – to make clear the magnitude of the data development task that lies ahead if the region is to meet the challenges of basin water planning. In closing this report we reiterate the Center's commitment to provide leadership in this effort, and to play a leading role in filling critical voids in data required for the basin water planning process.[37]

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[37] See Fisher, D., and B. Thompson, Op. Cit. 2003, for a proposal to initiate the task of developing estimates for surface water supplies over an extended historical period of record.

Appendix 1. Coastal Region River Basins by County

Table A1. Counties by River Basin

Coastal Regional County list	Altamaha	Ocmulgee	Oconee	Ogeechee	St Mary's	Satilla	Savannah
Appling*	X					X	
Atkinson #						X	
Bacon						X	
Baldwin			X				
Banks*			X				X
Barrow			X				
Ben Hill* #		X				X	
Bibb		X					
Bleckley*		X	X				
Brantley #						X	
Bryan				X			
Bulloch				X			
Burke*				X			X
Butts		X					
Camden*					X	X	
Candler*	X			X			
Charlton* #					X	X	
Chatham*				X			X
Clarke*			X				X
Clayton #		X					
Clinch #						X	
Coffee* #		X				X	
Columbia							X
Crawford #		X					
De Kalb #		X					
Dodge*		X	X				
Dooly #		X					
Effingham*				X			X
Elbert							X
Emanuel*	X			X			
Evans*	X			X			
Franklin							X
Fulton #		X					

Coastal Regional County list	Altamaha	Ocmulgee	Oconee	Ogeechee	St Mary's	Satilla	Savannah
Glascock*				X			X
Glynn*	X					X	
Greene*			X	X			X
Gwinnett* #		X	X				
Habersham #							X
Hall* #			X				X
Hancock*			X	X			
Hart							X
Henry #		X					
Houston #		X					
Irwin* #		X				X	
Jackson*			X				X
Jasper*		X	X				
Jeff Davis*	X	X				X	
Jefferson*	X			X			X
Jenkins*				X			X
Johnson*	X		X	X			
Jones*		X	X				
Lamar #		X					
Laurens*	X	X	X				
Liberty				X			
Lincoln							X
Long*	X			X			
Macon #		X					
Madison*			X				X
McDuffie							X
McIntosh*	X			X			
Monroe #		X					
Montgomery*	X	X	X				
Morgan			X				
Newton*		X	X				
Oconee			X				
Oglethorpe*			X				X
Peach #		X					
Pierce						X	
Pulaski		X					
Putnam			X				

Coastal Regional County list	Altamaha	Ocmulgee	Oconee	Ogeechee	St Mary's	Satilla	Savannah
Rabun #							X
Richmond							X
Rockdale		X					
Screven*				X			X
Spalding #		X					
Stephens							X
Taliaferro*			X	X			X
Tattnall*	X			X			
Telfair		X					
Toombs	X						
Towns #							X
Treutlen*	X		X				
Twiggs*		X	X				
Upson #		X					
Walton*		X	X				
Ware* #					X	X	
Warren*				X			X
Washington*	X		X	X			
Wayne*	X					X	
Wheeler*		X	X				
Wilcox #		X					
Wilkes							X
Wilkinson #			X				
Total Counties[38]	**17**	**34**	**29**	**22**	**3**	**15**	**28**

*Falls across more than one river basin
Part of the county falls outside the 7 coastal river basins

[38] Totals do not sum to the actual number of counties in the Coastal River Basins as some counties fall across multiple basins.

Appendix 2. Coastal River Basin Water Permits by County[39]

Table A 2.1. Altamaha River Basin Water Permits by County

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Appling	18	13	-	-	-	6	-	-	-
Candler	3	4	4	-	-	-	-	-	-
Emanuel	34	16	8	-	-	16	-	-	-
Evans	-	-	-	-	-	-	-	-	-
Glynn	-	-	-	-	-	1	-	-	-
Jeff Davis	29	4	-	-	-	-	-	-	-
Jefferson	1	-	-	-	-	4	-	-	-
Johnson	6	9	-	-	-	3	-	-	-
Laurens	-	-	-	-	-	-	-	-	-
Long	19	4	2	-	-	13	-	-	-
McIntosh	-	-	-	-	-	3	-	-	-
Montgomery	57	10	4	-	-	4	-	-	-
Tattnall	386	61	29	1	-	12	-	-	-
Toombs	274	53	32	-	-	12	-	-	-
Treutlen	24	9	-	-	-	3	-	-	-
Washington	20	15	-	-	-	3	-	-	-
Wayne	1	6	4	-	-	26	-	-	-
Total	872	204	83	1	0	106	0	0	0
Category Totals	1,160				106			0	
Grand total	1,266								

[39] All tables in Appendix 2 are based on EPD, *Op. Cit.*, 2001.

Table A2.2. Ocmulgee River Basin Water Permits by County

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Ben Hill	90	33	6	-	-	1	-	0	-
Bibb	8	1	6	-	7	13	-	6	-
Bleckley	106	76	11	-	-	5	-	0	-
Butts	7	2	-	-	-	-	-	2	-
Clayton	2	-	-	-	1	-	-	4	-
Coffee	16	7	4	-	-	1	-	0	-
Crawford	8	23	-	-	-	-	-	0	-
De Kalb	9	-	-	-	-	4	-	0	-
Dodge	228	133	42	-	-	9	-	0	-
Dooly	24	80	16	-	-	-	-	0	-
Fulton	2	1	-	-	2	35	-	2	-
Gwinnett	13	2	3	-	4	2	-	3	-
Henry	14	3	-	-	1	1	-	4	-
Houston	14	77	13	-	2	12	-	0	-
Irwin	6	2	-	-	-	5	-	0	-
Jasper	-	-	-	-	-	3	-	0	-
Jeff Davis	6	2	-	-	1	4	-	0	-
Jones	1	-	-	-	-	6	-	0	-
Lamar	10	3	-	-	-	3	-	3	-
Laurens	21	20	12	-	-	5	-	0	-
Macon	1	41	-	-	-	2	-	0	-
Monroe	27	2	-	-	1	11	-	4	-
Montgomery	-	-	-	-	1	1	-	0	-
Newton	11	3	-	-	5	17	-	4	-
Peach	10	95	2	-	-	3	-	0	-
Pulaski	178	173	10	-	1	3	-	0	-
Rockdale	8	-	2	-	1	9	-	1	-
Spalding	6	-	-	-	-	4	-	0	-
Telfair	94	87	23	-	1	10	-	0	-
Twiggs	2	5	2	-	-	9	-	1	-
Upson	13	3	-	-	-	-	-	0	-
Walton	14	2	-	-	2	2	-	1	-
Wheeler	91	31	24	1	-	1	-	0	-
Wilcox	148	111	8	-	-	3	-	0	-
Total	1188	1018	184	1	30	184	0	35	0
Category Totals	2,391				214			35	
Grand Total	2,640								

Table A2.3 Oconee River Basin Water Permits by County

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Baldwin	1	-	-	-	2	5	-	3	-
Banks	1	-	-	-	1	-	-	0	-
Barrow	7	-	4	-	4	4	-	2	-
Bleckley	12	30	-	-	-	-	-	0	-
Clarke	17	5	-	-	1	22	-	3	-
Dodge	3	-	-	-	-	-	-	0	-
Greene	14	1	-	-	1	28	-	2	-
Gwinnett	1	2	-	-	-	-	-	0	-
Hall	5	2	-	-	1	1	-	1	-
Hancock	-	-	-	-	2	5	-	1	-
Jackson	14	-	-	-	4	10	-	3	-
Jasper	8	1	-	-	2	5	-	2	-
Johnson	4	-	3	-	-	-	-	0	-
Jones	-	-	-	-	-	5	-	0	-
Laurens	69	57	15	-	1	37	-	3	-
Madison	-	-	-	-	-	-	-	0	-
Montgomery	31	9	-	-	-	4	-	0	-
Morgan	25	-	-	-	-	3	-	2	-
Newton	-	-	-	-	-	9	-	0	-
Oconee	14	12	-	-	4	16	-	1	-
Oglethorpe	1	-	-	-	1	6	-	1	-
Putnam	24	2	-	-	4	23	-	1	-
Taliaferro	-	-	-	-	-	1	-	0	-
Treutlen	34	2	-	-	-	2	-	0	-
Twiggs	2	4	-	-	-	9	-	0	-
Walton	10	5	-	1	1	7	-	3	-
Washington	9	6	-	-	-	11	-	3	-
Wheeler	83	18	12	-	-	1	-	0	-
Wilkinson	7	1	3	-	-	13	-	2	-
Total	396	157	37	1	29	227	0	33	0
Category Totals	591				256			33	
Grand total	880								

Table A2.4 Ogeechee River Basin Water Permits by County

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Bryan	3	7	-	-	-	29	-	-	-
Bulloch	287	119	32	-	-	120	-	-	-
Burke	14	33	5	-	-	14	-	-	-
Candler	105	19	23	1	-	2	-	-	-
Chatham	2	5	-	-	-	124	-	-	-
Effingham	2	4	-	-	-	29	-	-	-
Emanuel	15	17	1	-	-	9	-	-	-
Evans	153	48	2	-	1	10	-	-	-
Glascock	5	-	-	-	-	3	-	-	-
Greene	2	-	-	-	1	7	-	1	-
Hancock	2	10	-	-	-	1	-	-	-
Jefferson	63	45	11	-	-	1	-	-	-
Jenkins	36	48	29	-	-	7	-	-	-
Johnson	-	-	-	-	1	1	-	-	-
Liberty	1	1	-	-	-	60	1	-	-
Long	3	2	-	-	-	15	-	-	-
McIntosh	-	-	-	-	-	46	1	-	-
Screven	48	57	3	-	-	15	-	-	-
Taliaferro	-	-	-	-	-	1	-	-	-
Tattnall	142	14	-	-	-	2	-	-	-
Warren	2	-	-	-	2	3	-	1	-
Washington	19	18	-	-	-	1	-	-	-
Total	904	447	106	1	5	500	2	2	0
Category Totals	1,458				507			2	
Grand total	1,967								

Table A2.5. Satilla River Basin Water Permits

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Appling	29	48	-	-	-	12	-	1	-
Atkinson	158	25	4	1	-	3	-	-	-
Bacon	217	80	10	3	-	5	-	-	-
Ben Hill	22	13	2	-	-	-	-	-	-
Brantley	34	4	4	-	-	5	-	-	-
Camden	-	3	-	-	-	2	-	-	-
Charlton	-	-	-	-	-	3	-	-	-
Clinch	-	-	-	-	-	-	-	-	-
Coffee	468	86	19	-	-	35	-	-	-
Glynn	1	-	-	-	-	87	-	2	-
Irwin	124	28	6	-	-	-	-	-	-
Jeff Davis	99	39	2	-	-	2	-	-	-
Pierce	174	141	4	7	2	11	-	-	-
Ware	83	21	-	-	-	13	-	-	-
Wayne	10	22	4	-	-	6	-	-	-
Total	1419	510	55	11	2	184	0	3	0
Category Totals	1,995				186			3	
Grand total	2,184								

Table A2.6. Savannah River Basin Water Permits

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Banks	14	1	-	-	1	2	-	1	-
Burke	44	34	6	-	1	5	-	2	-
Chatham	-	9	-	-	1	37	-	7	-
Clarke	-	-	-	-	-	2	-	-	-
Columbia	3	10	-	-	-	10	-	3	-
Effingham	6	4	-	-	1	34	-	3	-
Elbert	11	-	2	-	1	9	-	3	-
Franklin	6	-	-	-	3	8	-	4	-
Glascock	-	-	-	-	-	-	-	-	-
Greene	-	-	-	-	-	2	-	-	-
Habersham	-	-	-	-	1	3	-	-	-
Hall	-	1	-	-	1	1	-	-	-
Hart	27	1	-	-	2	19	-	1	-
Jackson	1	-	-	-	-	1	-	-	-
Jefferson	19	3	-	-	-	1	-	1	-
Jenkins	1	1	-	-	-	-	-	-	-
Lincoln	-	-	-	-	2	11	-	1	-
Madison	14	-	-	-	-	20	-	1	-
McDuffie	23	22	-	-	1	-	-	3	-
Oglethorpe	-	1	-	-	-	4	-	-	-
Rabun	-	-	-	-	2	17	-	1	-
Richmond	5	7	-	-	2	17	-	11	-
Screven	26	56	1	-	-	5	-	-	-
Stephens	1	-	-	-	1	6	-	1	-
Taliaferro	-	-	-	-	-	-	-	-	-
Towns	-	-	-	-	-	1	-	-	-
Warren	2	-	-	-	-	1	-	1	-
Wilkes	14	-	-	-	1	3	-	2	-
Total	217	150	9	0	21	219	0	46	0
Category Totals	376				240			46	
Grand total	662								

Table A2.7. St. Mary's River Basin Water Permits

County	Agriculture				Public			Municipal & Industrial	
	Surface	Ground	Well-Pond	Unknown	Surface	Ground	Unknown	Surface	Ground
Camden	2	2	2	-	-	1	-	3	-
Charlton	3	3	2	-	-	11	-	-	-
Ware	-	-	-	-	-	-	-	-	-
Total	5	5	4	0	0	12	0	3	0
Category Totals	14				12			3	
Grand total	29								

Appendix 3. Permitted Acres for the Coastal Region River Basins

Table A3.1 Irrigated Acres in the Coastal Rivers Area by Withdrawal Type[40]

River Basin	Total Acreage	Surface	Ground	Well-Pond
Altamaha	74,377	47,558	17,007	9,812
Ocmulgee	256,276	112,283	122,345	21,648
Oconee	48,671	31,424	13,919	3,328
Ogeechee	154,705	82,174	58,681	13,850
Satilla	132,932	78,336	50,100	4,496
Savannah	45,907	26,656	17,681	1,570
St. Mary's	855	535	280	40
Total	713,723	378,966	280,013	54,744

Table A3.2. Coastal River Basin Permits with Unreported Irrigated Acres[41]

River Basin	Total	Surface	Ground	Well-Pond	Unknown
Altamaha	41	17	18	5	1
Ocmulgee	83	36	42	4	1
Oconee	36	11	24	-	1
Ogeechee	42	12	28	1	1
Satilla	51	15	23	2	11
Savannah	11	7	4	-	-
St. Mary's	2	-	-	2	-
Total	266	98	139	14	15

[40] Agricultural water use permits reported in EPD, *Op. Cit*., 2001, provide the permitted acreage data.
[41] A number of permits in the database indicated no acreage amounts. These permits are summaries in Table 3A.2. The EPD's ongoing verification process will resolve this issue for many of these permits.

Appendix 4. Scenarios of Agricultural Water Use in the Coastal Region River Basins

Tables A4.1 and A4.2 illustrate the maximum permitted daily water use for agriculture across the seven coastal river basins using annual irrigation water application estimates of 1 acre feet and 0.7 acre feet respectively. During periods of drought, agricultural water needs can increase by more than 30%.

Table A4.1 Coastal Rivers Maximum Daily Water Use for Agriculture (MGD), 1 Acre Foot[42]

River Basin	Total Withdrawal	Surface	Ground	Well-Pond
Altamaha	66.40	42.46	15.18	8.76
Ocmulgee	228.79	100.24	109.22	19.33
Oconee	43.45	28.05	12.43	2.97
Ogeechee	138.11	73.36	52.39	12.36
Satilla	118.67	69.93	44.73	4.01
Savannah	40.98	23.80	15.78	1.40
St. Mary's	0.76	0.48	0.25	0.04
Totals	637.17	338.32	249.98	48.87

Table A4.2. Coastal Rivers Maximum Daily Water Use for Agriculture (MGD), 0.7 Acre Foot[43]

River Basin	Total Withdrawal	Surface	Ground	Well-Pond
Altamaha	46.48	29.72	10.63	6.13
Ocmulgee	160.16	70.17	76.46	13.53
Oconee	30.42	19.64	8.70	2.08
Ogeechee	96.68	51.35	36.67	8.66
Satilla	83.07	48.95	31.31	2.81
Savannah	28.69	16.66	11.05	0.98
St. Mary's	0.52	0.33	0.17	0.02
Totals	446.02	236.82	174.99	34.21

[42] Calculated from the agricultural permits data found in EPD, *Op. Cit.*, 2001.
[43] Calculated from the agricultural permits data found in EPD, *Op. Cit.*, 2001.