DEVELOPMENT OF A WATER-USE DATABASE FOR USE IN COASTAL REGION GROUND-WATER MODELS, GEORGIA, SOUTH CAROLINA, AND FLORIDA, 1980–2000

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Abstract. The U.S. Geological Survey (USGS) compiled and integrated water-use data from 1980 to 2000 for coastal Georgia, South Carolina, and Florida for use in regional ground-water flow models. To represent accurately stresses on the ground-water flow system, ground-water flow models require that pumping rates be distributed temporally and spatially among three aquifer units. Water withdrawal data from different sources are inconsistent: pumping rates are estimated for different years or different schedules; data sets include estimates of single well or well-field specific pumping rates or a countywide aggregate pumping rate; and each of these data sources may not include aquifer designations. Several assumptions were made to construct model input to accommodate these inconsistencies.

INTRODUCTION

The Georgia Coastal Sound Science Initiative (CSSI) is a series of scientific studies commissioned by the Georgia Environmental Protection Division (GaEPD) in an effort to protect the Upper Floridan aquifer from saltwater intrusion. As part of the CSSI, the U.S. Geological Survey is developing ground-water models to simulate the processes controlling ground-water flow and saltwater movement into freshwater aquifers, and to serve as a tool to help evaluate various water-management scenarios, such as pumping changes. The regional ground-water flow models encompass a 37,300-square-mile (96,606.6-square-kilometer) area of coastal Georgia, South Carolina, and Florida (Fig. 1*A*).

The database includes water-level, hydrologic-property, hydrogeologic, and water-use data. The water-use data include information on the locations and amount of ground water withdrawn, for specific years. This paper describes the methods used to spatially and temporally distribute the water-use data, by aquifer, for use in simulating the amount of ground water withdrawn from the system.

Sources of Data and Method of Analysis

Water-use data were obtained from reports by Pierce and others (1982), Turlington and others (1987), Trent and others (1990), Fanning (1997, 1999), and Marella (1995). Data also were obtained from Richard Marella (U.S. Geological Survey, written commun. with Dorothy Payne and Da'Vette Taylor, 2002), and Whitney Stringfield (U.S. Geological Survey, written commun. with Da'Vette Taylor, 2002). Data were tabulated and stored in a database that consists of spreadsheets and Geographic Information System (GIS) coverages. The database was linked to the USGS Ground-Water Site Inventory (GWSI) database, so that water-use data could be distributed spatially by aquifer.

The database is comprised of subsets of site-specific data and nonsite-specific or aggregate data, which are processed differently. Site-specific data generally include permitted industrial and public-supply permitted systems, and consist of withdrawal data, permit information, and well locations. The well-field specific data give the withdrawal rate from a cluster of wells and the location of each well. Nonsite-specific or aggregate data consist of annual withdrawals at the county level and are broken down by water-use category (industrial, public supply, or irrigation).

Site-Specific Data Processing. Site-specific withdrawal data are available for Georgia and Florida, but not for South Carolina. Site-specific data distribution for the Upper Floridan aquifer in Georgia during 1995 is shown in Figure 1*B*. Site-specific withdrawal data for Georgia are available for 1980, 1985, 1990, 1995, 1997, and 2000. To distribute these data withdrawals spatially, the total amount for each permit was distributed evenly among the well sites included in that permit. The withdrawal attributed to a specific well was determined by taking the number of wells for a permit and dividing by the total reported withdrawal for that permit. Each permit included information on the aquifer utilized, allowing assignment of the withdrawal to specific aquifer layers simulated by the models.

In Florida, the site-specific withdrawal data are not consistent with those data available for Georgia. However, locations of major industrial and public-supply wells during 1993–1994 are available, along with aquifer designations (Sepulveda, 2002). These data were used to subdivide equally annual county-aggregate withdrawal data for the industrial and public supply categories for each well in the county.

Nonsite-Specific Data Processing. Nonsite-specific withdrawal data are available for Georgia, Florida, and South Carolina. These data consist of county-aggregate withdrawal rates by water-use category. County-aggregate withdrawal data are available for all Georgia counties for 1980, 1985, 1990, 1995, 1997, and 2000; for Baker, Columbia, and Hamilton Counties in Florida for 1980, 1985, 1990, 1995, and 2000; for Nassau and Duval Counties in Florida for all years from 1980 through 2000; and for all South Carolina counties for 1985, 1990, 1995, and 2000.

To account for site-specific withdrawal in each county, the total nonsite-specific withdrawal was calculated by subtracting the total site-specific withdrawal from the total aggregate withdrawal for the county. To distribute the nonsite-specific pumpage by aquifer unit, the percentage per county withdrawn from a given aquifer was calculated using data from GWSI (the most complete well data available). That value was then multiplied by the total nonsite-specific pumping rate for each county. For example, the pumpage for the Upper Floridan aquifer in Screven County during 1995 would be calculated as:

$$\text{Upper Floridan aquifer pumpage in Screven County, 1995} = \frac{\text{Number of Upper Floridan aquifer wells in Screven County}}{\text{Total number of wells in Screven County}} \times \text{Total nonsite-specific pumping rate for Screven County, 1995}$$

Spatial Analysis

Ground-Water Model Grid-Based Distribution. Data were spatially distributed into 5-square-kilometer (1.93-square-kilometer) model grid cells for incorporation into the ground-water models (Fig. 1*A*). Site-specific withdrawal was assigned to the appropriate model cells; if multiple sites were present within a single model grid cell, then the rates were summed and assigned to that grid cell.

The nonsite-specific pumping rates were distributed equally across a county, and the centroids of each model cell were located. Many grid cells fell within multiple counties, so the county in which the centroid was located was the county to which the grid cell was attributed. The total number of model grid cells attributed to each county was counted. The total nonsite-specific withdrawal was distributed evenly between all of the grid cells attributed to that county. For example, the total Upper Floridan aquifer nonsite-specific pumpage for Screven County during 1995 was computed as follows:

$$\text{Nonsite-specific pumpage for the Upper Floridan aquifer of each grid cell in Screven County} = \frac{\text{Nonsite-specific pumpage for the Upper Floridan aquifer of Screven County for 1995}}{\text{Number of grid cells attributed to Screven County}}$$

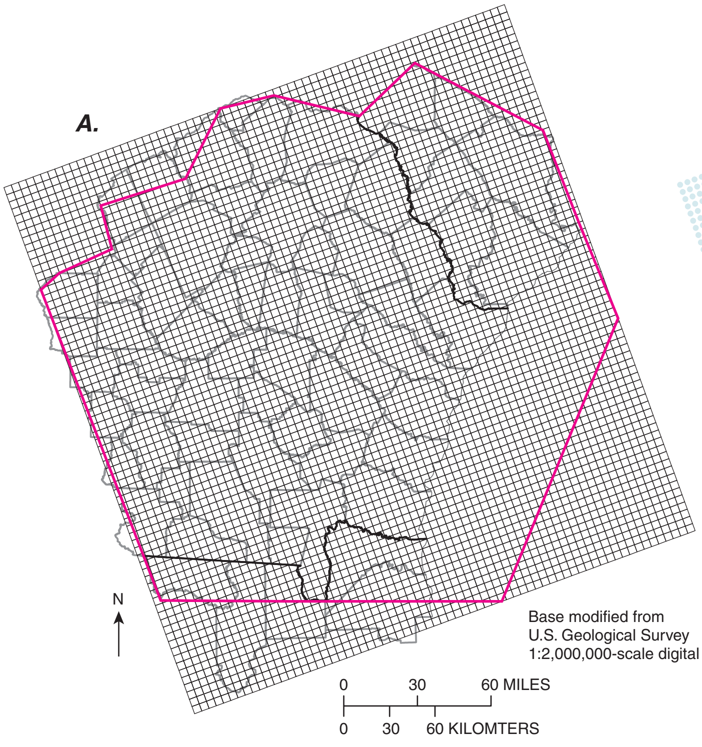
The total site-specific pumpage was added to the nonsite-specific rate to obtain the total withdrawal rate for each grid cell. The withdrawal assigned to the model for the Upper Floridan aquifer for 1995 is shown in Figure 1*C*.

Irrigation Data. In agricultural counties, irrigation was estimated to comprise a large amount of the county-aggregate withdrawal. A test was performed to determine the effect of distributing irrigation pumping in each county using land-use distribution on the overall spatial distribution of nonsite-specific pumping. Bleckley, Bulloch, and Screven Counties in Georgia were tested using pumpage data from 1995, because each has relatively high proportions of ground-water pumpage attributed to irrigation.

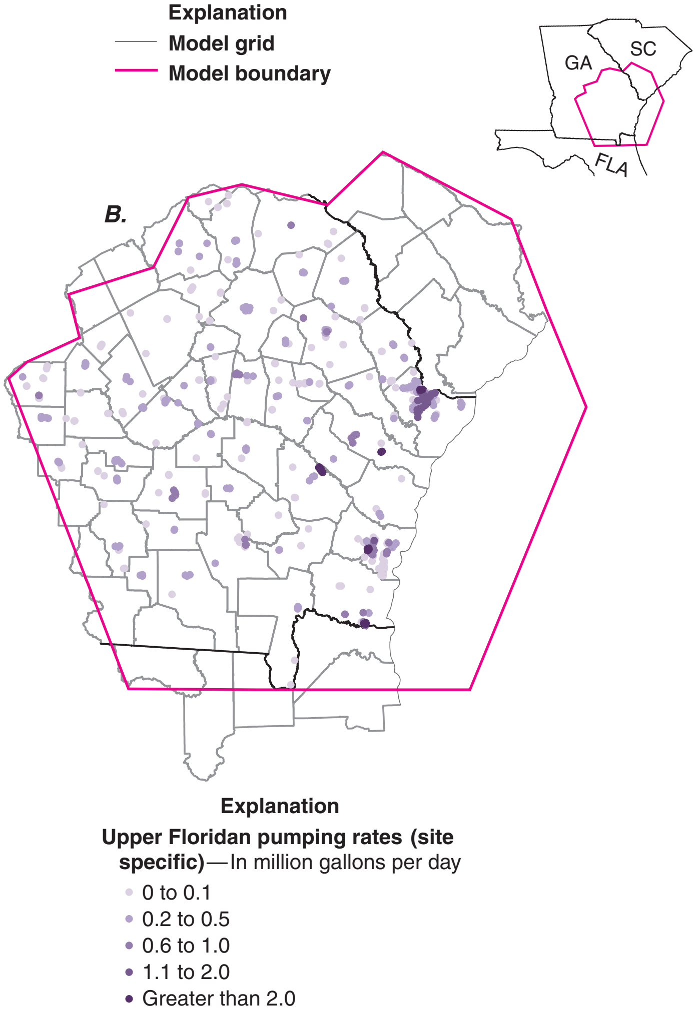
The National Land Cover Data grid (Alhadeff and others, 2001) was used to identify irrigated land. The categories are row crops, pasture, and urban/recreation categories. For each model cell attributed to a given county, the irrigated land area was determined and multiplied by the amount of irrigation water use attributed to that county, as follows:

$$\text{Irrigation pumping rate per model grid cell} = \frac{\text{Area of irrigated land in model grid cell}}{\text{Total area of irrigated land in county}} \times \text{Irrigation pumping rate for the county}$$

For example, in Screven County, the range of nonsite-specific irrigation pumpage per model cell ranged from 0 to 92,227 gallons per day. The maximum irrigation pumpage per model cell represents only 1.4 percent of the total pumpage; thus, it was not considered significant enough to warrant incorporating this more complex approach to distribute the irrigation data among model grid cells. The amount of irrigated land and total number of gallons pumped per day in Screven County are shown in Figure 2.



Base modified from
U.S. Geological Survey
1:2,000,000-scale digital data



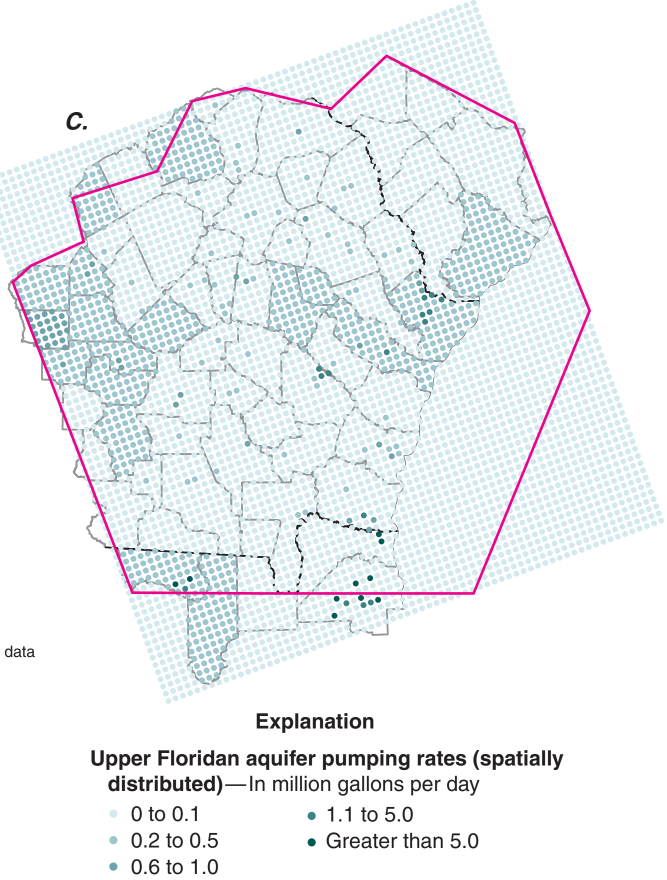


Figure 1. Geographic extent of regional ground-water flow models *(A)* model grid and boundary areas; *(B)* specific-site data; and *(C)* spatially distributed data.

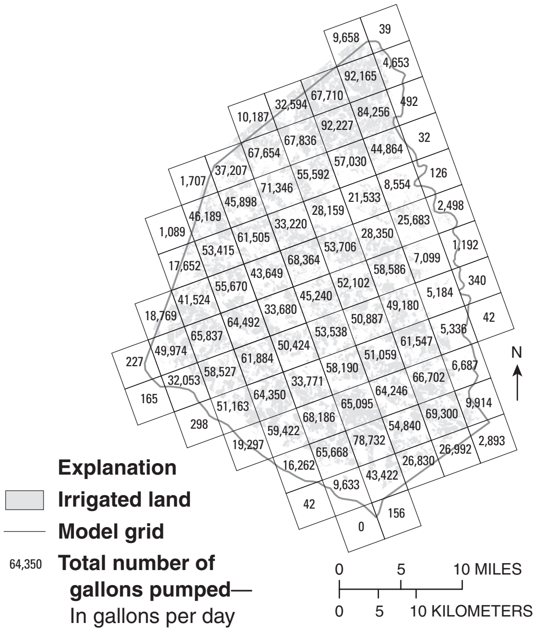


Figure 2. Irrigated land and total number of gallons pumped per day in Screven County during 1995. (Irrigated land from Alhadeff and others, 2001.)

Temporal Distribution

The ground-water models require that withdrawal data be temporally distributed by year during 1980–2000. This was accomplished by linear interpolation between, or extrapolation from, years for which data are available, on a model cell-by-cell basis. For example, to interpolate the pumping rate for the Upper Floridan aquifer in a grid cell for 1993, the following formula was developed:

$$\text{1993 rate} = \text{1990 rate} + \frac{|\text{1995 rate} - \text{1990 rate}|}{(1995 - 1990)} \times (1993 - 1990)$$

In South Carolina, withdrawal data are not available before 1985; therefore, values for earlier years were extrapolated. The extrapolations are continuations of linear interpolations from 1985 through 1990, except when the extrapolated rates were less than zero; in those cases, the values were assumed to be zero.

Summary

A water-use database for 1980–2000 for coastal Georgia, and adjacent parts of South Carolina and Florida was developed for use in regional ground-water flow models. The ground-water flow models require that pumping rates be distributed temporally, spatially, and among three aquifer units to represent stresses acting on the ground-water flow system. Because withdrawal data from different sources are inconsistent, several assumptions were made to construct model input to accommodate these inconsistencies. When not available, aquifer designations were estimated by calculating the percentage of wells in a county by aquifer, using data from GWSI and aggregate use.

Nonsite-specific data were assumed to be distributed evenly across a county. Although irrigation pumpage may comprise a large portion of total pumpage for some counties, rates were evenly distributed across model cells. The variability of rates as a function of land-use distribution was not significant enough to warrant more complex analyses. Site-specific and nonsite-specific data were summed for each model cell and aquifer layer, and temporally distributed at 1-year intervals during 1980–2000.

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