

HYDROGEOLOGY AND WATER QUALITY OF THE LOWER FLORIDAN AQUIFER, COASTAL GEORGIA, 1999-2000

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Abstract. The Lower Floridan aquifer at Richmond Hill, Brunswick, and St Marys, Ga., has permeable intervals of freshwater to slightly brackish water that could provide water users with an alternative water supply to supplement water use from the Upper Floridan aquifer. Strong similarities in water-level fluctuations for the Upper and Lower Floridan aquifers at Richmond Hill, and similar water-level elevations indicate that both aquifers respond as one saturated unit to regional ground-water withdrawals and recharge. Conversely, at Brunswick and St Marys, abrupt changes in water level and chemistry indicate stronger confinement between permeable zones in the Upper and Lower Floridan aquifers, relative to the Richmond Hill area.

At Richmond Hill, water in the Upper Floridan aquifer is fresh with total dissolved solids (TDS) concentration of 172 milligrams per liter (mg/L) and a chloride concentration of 5 mg/L. Water in the Lower Floridan aquifer at Richmond Hill is slightly brackish, with a TDS concentration of 1,630 mg/L and a chloride concentration of 160 mg/L.

As a result of decades of ground-water withdrawal in downtown Brunswick, water in the Upper Floridan aquifer is brackish with TDS concentrations as high as 5,000 mg/L and chloride concentrations varying from 1,500 to 3,000 mg/L. The Lower Floridan aquifer at Brunswick consists of a freshwater zone from 1,230 to 1,664 ft below sea level with concentrations of 289 mg/L for TDS and 26 mg/L for chloride; a brackish-water zone from 1,664 to 2,176 ft below sea level with concentrations of 1,360 to 4,330 mg/L for TDS and 190 to 1,300 mg/L for chloride; a saline-water zone from 2,176 to 2,675 ft below sea level with concentrations of 33,600 mg/L for TDS and 18,000 mg/L for chloride; and a brine zone from 2,675 ft below sea level to the total borehole depth of 2,710 ft below sea level with concentrations of 48,300 mg/L for TDS and 26,000 mg/L for chloride.

At St Marys, water in the Upper Floridan aquifer is fresh, with a TDS concentration of 463 mg/L and a chloride concentration of 32 mg/L. Water in the Lower Floridan aquifer at St Marys is also fresh, with a TDS concentration of 623 mg/L and a chloride concentration of 28 mg/L.

INTRODUCTION

Ground-water withdrawal from the Upper Floridan aquifer has resulted in substantial water-level declines and the occurrence of—and potential for—saltwater intrusion in coastal areas of Georgia and adjacent areas of South Carolina and Florida (Gill and Mitchell, 1979; Smith, 1993; Krause and Randolph, 1989; Clarke and others, 1990; Spechler, 1994; Landmeyer and Belval, 1996). The U.S. Geological Survey, in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, is investigating the Lower Floridan aquifer as an alternative ground-water resource along the Georgia coast.

This paper documents the results of an investigation of potential sources of saltwater contamination and the potential of the Lower Floridan aquifer to serve as an alternative water resource. As part of the Georgia Coastal Sound Science Initiative, wells were drilled at Richmond Hill in Bryan County, Brunswick in Glynn County, and St Marys in Camden County, Ga., in 1999 and 2000, to obtain hydrogeologic and water-quality data for the upper permeable zone of the Lower Floridan aquifer and to document the presence or absence of the Fernandina permeable zone below the Lower Floridan aquifer at Richmond Hill, Ga. (fig. 1). Well cuttings and water-quality samples were collected during reverse-air rotary drilling of the boreholes. These data, geophysical logs, and observations of flow and water levels during drilling were used to interpret the hydrogeology and water chemistry of the permeable zones in the Lower Floridan aquifer (fig. 2).

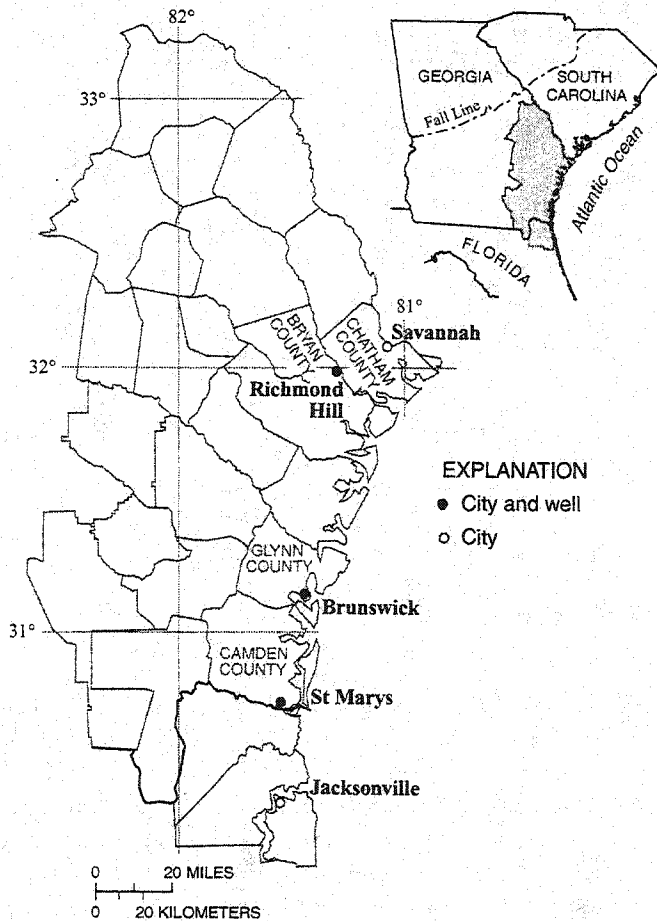


Figure 1. Coastal Georgia study area.

HYDROGEOLOGY AND WATER-QUALITY RESULTS

Richmond Hill—Two wells (35P110 and 35P109) were drilled at the Sterling Creek sewage treatment facility near Richmond Hill in Bryan County, Ga. Test well 35P110 is open to the Upper Floridan aquifer in the interval from 302 to 427 ft below sea level. Test well 35P109 penetrated the base of the Floridan aquifer system at 1,611 ft below sea level; however, the borehole was backfilled with cement to complete the well with an open interval in the Lower Floridan aquifer from 1,002 to 1,262 ft below sea level.

Carbonates of the Floridan aquifer system consist of limestone from 317 to 1,611 ft below sea level. The limestone is dolomitic in several intervals; however, beds of dolomite were not present. The Upper Floridan aquifer consists of a porous, permeable zone of limestone from 317 to 677 ft below sea level. The Lower Floridan aquifer includes a porous, permeable

zone of mostly limestone with some dolomitic limestone from 937 to 1,063 ft below sea level. Strata below the permeable zone of the Lower Floridan aquifer consist of fine-grained limestone from 1,063 to 1,280 ft below sea level, clay from 1,280 to 1,305 ft below sea level, and clayey limestone with chert nodules from 1,305 to 1,611 ft below sea level. A permeable zone was not identified in the fine-grained lithologies below 1,305 ft below sea level.

Hydrographs for wells completed in the Upper and Lower Floridan aquifers at this site for the period from June–October 2000, have nearly identical trends with water levels ranging between 17 and 22 ft below sea level. No abrupt changes in water level were observed during drilling.

At Richmond Hill, water in the Upper Floridan aquifer is fresh with TDS concentration of 172 mg/L and a chloride concentration of 5 mg/L. Water in the Lower Floridan aquifer at Richmond Hill is slightly brackish, with a TDS concentration of 1,630 mg/L and a chloride concentration of 160 mg/L. The change from freshwater to slightly brackish is gradational and occurs from 1,002 to 1,063 ft below sea level in the permeable zone of the Lower Floridan aquifer. Hydrogen sulfide concentrations are less than 1.0 mg/L in both aquifers at this site. Formation water collected below the clay at 1,305 ft below sea level has a TDS concentration of 2,100 mg/L and chloride concentrations of 280 mg/L, which exceeds the secondary drinking water standard for chloride of 250 mg/L (U.S. Environmental Protection Agency, 1988).

Brunswick—Two wells were drilled at the Georgia Ports Authority Mayor Point facility in downtown Brunswick, Glynn County, Ga. Test well 34H500 is open to a permeable zone of the Lower Floridan aquifer in the interval from 1,207 to 1,390 ft below sea level. Test well 34H495 is open to the Fernandina permeable zone of the Lower Floridan aquifer in the interval from 2,079 to 2,710 ft below sea level.

The Floridan aquifer system beneath Brunswick consists of the upper and lower permeable zones of the Upper Floridan aquifer, and the upper and Fernandina permeable zones of the Lower Floridan aquifer. The Upper Floridan aquifer consists of limestone from 520 to 873 ft below sea level and interbedded limestone and dolomite from 873 to 1,183 ft below sea level. The Lower Floridan aquifer consists of interbedded limestone and dolomite from 1,230 ft below sea level to the bottom of the borehole at 2,710 ft below sea level.

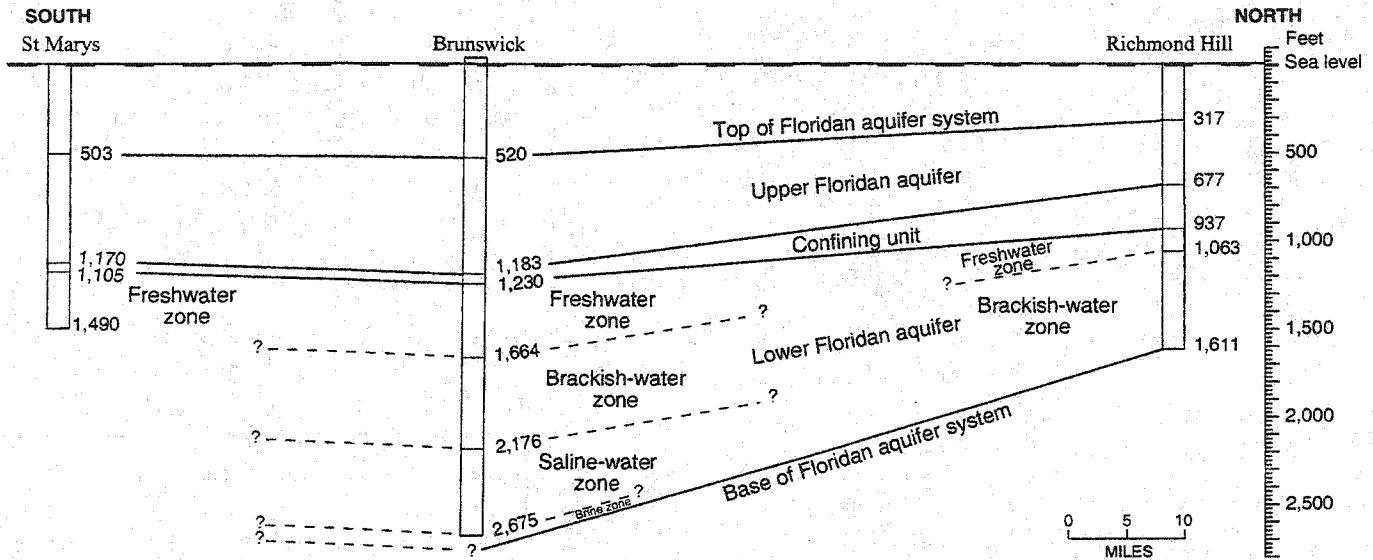


Figure 2. Hydrogeology of Floridan aquifer system and water-quality zones of the Lower Floridan aquifer.

The Upper Floridan aquifer at this site has a water-level altitude at or just above land surface, or 10 to 12 ft above sea level. Water-level altitudes in the permeable zones of the Lower Floridan aquifer range from 10 to 75 ft above sea level. Abrupt changes in water-level altitudes and/or flow were observed during drilling at depths of 1,664, 2,064, 2,176, and 2,675 ft below sea level.

As a result of decades of ground-water withdrawal in downtown Brunswick, water in the Upper Floridan aquifer at this site is brackish with TDS concentrations as high as 5,000 mg/L and chloride concentrations varying from 1,500 to 3,000 mg/L. The Lower Floridan aquifer contains a freshwater zone from 1,230 to 1,664 ft below sea level, a brackish-water zone from 1,664 to 2,176 ft below sea level, a saline-water zone from 2,176 to 2,675 ft below sea level, and a brine zone from 2,675 ft below sea level to the total borehole depth of 2,710 ft below sea level (table 1). Hydrogen sulfide concentrations are less than 2.2 mg/L for all sample intervals. Immediate changes in flow to the well bore and changes in water chemistry observed at depths of 1,664, 2,064, 2,176, and 2,675 ft below sea level during drilling most likely reflected penetration of confining units between permeable intervals in the Lower Floridan aquifer.

St Marys—One well was drilled at the Gallop Road ballpark in St Marys, Camden County, Ga. Test well 33D073 is open to the Lower Floridan aquifer in the interval from 1,355 to 1,490 ft below sea level.

The Upper Floridan aquifer at St Marys consists of limestone from 503 to 1,105 ft below sea level with two intervals of interbedded limestone and dolomite from

804 to 1,105 ft below sea level. The Lower Floridan aquifer at the St Marys site was penetrated at a depth of 1,170 ft below sea level and consists of thick beds of dolomite and interbedded limestone and dolomite. Measurements during drilling indicate the water-level altitude of the Upper Floridan aquifer ranged between 2 and -5 ft, and the water-level altitude in the Lower Floridan aquifer was about 10 ft in December 1999. The difference in water levels may reflect water-level declines in the Upper Floridan in response to ground-water withdrawal. Water from the Upper and Lower Floridan aquifers has TDS concentrations of 463 and 623 mg/L, respectively, chloride concentrations of 32 and 28 mg/L, respectively, and hydrogen sulfide concentrations of 4.3 and 3.4 mg/L, respectively.

Table 1. Water-quality characteristics of water zones of the lower Floridan aquifer in the Brunswick area [mg/L, milligrams per liter]

Water zone	Altitude below sea level (feet)	Total dissolved solids (mg/L)	Chlorides (mg/L)
Freshwater	1,230 to 1,664	289	26
Brackish	1,664 to 2,064	1,360	190
Brackish	2,064 to 2,176	4,330	1,300
Saline	2,176 to 2,675	33,600	18,000
Brine	2,675 to 2,710	48,300	26,000

DISCUSSION

The Lower Floridan aquifer at all three coastal sites consists of permeable intervals of freshwater to slightly brackish water that could provide additional water for municipal and industrial supply. Dense, low permeability layers of dolomite interbedded with dense limestone are more abundant in the Brunswick and St Marys areas than in the Richmond Hill area. As a result, confinement between the Upper and Lower Floridan aquifers is greater at Brunswick and St Marys compared to Richmond Hill.

The Richmond Hill site is within the potentiometric cone of depression that results from decades of ground-water withdrawal from the Upper Floridan aquifer in Chatham County and the surrounding area (Clarke and others, 1990). Strong similarities in water-level trends for the Upper and Lower Floridan aquifers, and similar water-level elevations indicate that both aquifers in this area respond as one saturated unit to regional ground-water withdrawal and recharge. Wells completed in the Upper and Lower Floridan aquifers would distribute the stress of withdrawal over a thicker interval, in comparison with wells completed only in the Upper Floridan aquifer; however, mixing waters from both aquifers in the well bore would likely increase the TDS and chloride concentrations. Completing wells in the carbonates below 1,305 ft below sea level would provide little additional yield to the well, and could increase chloride concentrations above the secondary drinking-water standard. It does not appear that the Fernandina permeable zone is present in the Floridan aquifer system at this site.

Previous investigations in the Brunswick area suggest that saltwater from the Lower Floridan aquifer moves to the Upper Floridan aquifer by way of vertical fractures, and then moves laterally through the permeable zones of the Upper Floridan aquifer in response to ground-water withdrawal (Krause and Randolph, 1989; Maslia and Prowell, 1990). The freshwater and slightly brackish-water zones of the Lower Floridan aquifer have chloride concentrations less than the secondary drinking-water standard. These intervals could be used as potential sources of drinking water; however, ground water withdrawn from these intervals of the Lower Floridan aquifer could reduce the local pressure head and potentially induce saltwater to migrate along the same vertical fractures that serve as pathways for migration to the Upper Floridan aquifer.

Although the water chemistry of the Lower Floridan aquifer at St Marys is similar to that of the Upper Floridan aquifer, water-level differences suggest that the aquifers are separated by an interval of dense, low porosity limestone and dolomite, which serve as a confining unit in the St Marys area. The upper permeable zone of the Lower Floridan aquifer may provide a source of freshwater comparable in water quality to the Upper Floridan aquifer. The Fernandina permeable zone is known to be present to the southeast at Fernandina Beach, Florida (Spechler, 1994) and to the north near Brunswick (Gill and Mitchell, 1979); however, the well drilled at St Marys did not penetrate the Fernandina zone.

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