THE SURFICIAL AND BRUNSWICK AQUIFER SYSTEMS—ALTERNATIVE GROUND-WATER RESOURCES FOR COASTAL GEORGIA

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REFERENCE: *Proceedings of the 2003 Georgia Water Resources Conference*, held April 23–24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. The surficial and Brunswick aquifer systems may provide a supplemental water source in coastal Georgia. The surficial aquifer system consists of two to three water-bearing zones—the water-table zone and the confined upper and lower water-bearing zones. The Brunswick aquifer system is comprised of the upper and lower Brunswick aquifers. Productivity of the aquifer systems is greatest in the vicinity of the southeast Georgia embayment and is highly variable along the outer margins of this structural feature. In the southeast Georgia embayment, transmissivity of the lower Brunswick aquifer ranges from 2,000 to 4,700 feet squared per day (ft^2/d). Outside of the embayment, permeable sediments are thin or absent and the productivity is low—reported transmissivity of the Brunswick aquifer system ranges from 5 to 500 ft^2/d.

Withdrawal from the Brunswick aquifer system increased from about 1.5 million gallons per day (Mgal/d) during 1990 to 3.7 Mgal/d during 2000. At one site in Glynn County, average withdrawal of 0.6 Mgal/d or less since early 1999 resulted in water-level declines of about 12 feet (ft) in the upper Brunswick aquifer and about 5 ft in the lower Brunswick aquifer. This difference may reflect differences in the amount of leakage from adjacent units, the connection of the aquifer to recharge areas, or the aquifer's hydraulic properties.

INTRODUCTION

Coastal Georgia is experiencing increasing demands on limited freshwater resources. To alleviate saltwater intrusion, the Georgia Environmental Protection Division (GaEPD) has restricted further development of the Upper Floridan aquifer (the principal source of water) in parts of the coastal area. In recent studies, three aquifers—the surficial aquifer and the upper and lower Brunswick aquifers—were assessed to determine if they might be viable, supplemental sources of ground water. Information on the geologic, water-quality, and water-bearing characteristics of the aquifers is needed to assess their potential as a source of water supply. Water-level monitoring is needed to assess the effect of development as the aquifers become increasingly utilized for water supply.

Purpose and Scope

This paper provides an overview of current understanding of the geologic and hydraulic characteristics of the surficial aquifer and upper and lower Brunswick aquifers, proposes a revised hydrogeologic nomenclature for coastal Georgia, and describes the effects of development on ground-water levels in coastal Georgia. Data and information were derived from previous studies and from ongoing technical investigations being conducted as part of the Coastal Sound Science Initiative (CSSI), a series of scientific and feasibility studies being conducted to support development of the GaEPD's final strategy to protect the Upper Floridan aquifer from saltwater intrusion.

GaEPD defined the coastal area of Georgia to include the 6 coastal counties and adjacent 18 counties (Fig. 1), an area of about 12,240 square miles (mi^2). Topographic relief ranges from flat in the coastal counties, to steep in northwestern parts of the area. Altitudes range from sea level along the coast to as high as 300 ft in the northwestern part of the area.

Previous Studies

Clarke and others (1990) defined the surficial and upper and lower Brunswick aquifers and described their water-bearing characteristics. Steele and McDowell (1998) mapped the permeable zones of the upper and lower Brunswick aquifers. Leeth (1999) described the hydrogeology of the surficial aquifer at Naval Submarine Base Kings Bay in Camden County. Hodges (1998, 1999) described results of aquifer tests in Toombs and Evans Counties. More recent investigations include Gill (2001) who described the development potential of the upper and lower Brunswick aquifers in Glynn and Bryan Counties; Radtke and others (2001) who described results of an engineering assessment of the "Miocene" aquifer system in coastal Georgia; and Weems and Edwards (2001) who described the geology of Oligocene and younger deposits in coastal Georgia.

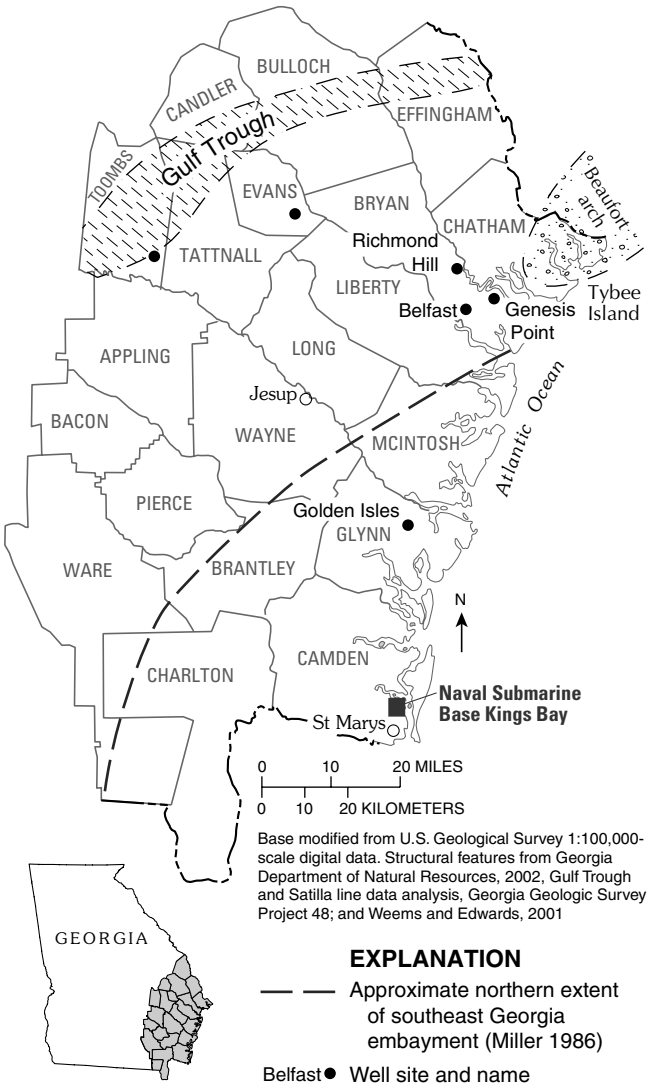

Figure 1. Structural features and selected well sites in coastal Georgia.

Geologic Setting

Coastal Plain strata consist of unconsolidated layers of sand and clay and semiconsolidated to consolidated layers of limestone and dolomite of Late Cretaceous to Holocene age. The Coastal Plain units strike southwest-northeast and dip and thicken to the southeast; maximum thickness is about 5,500 ft in Camden County.

Major structural features that affect the geology and hydrogeology of coastal Georgia include the southeast Georgia embayment, the Beaufort arch, and the Gulf Trough (Fig. 1). The southeast Georgia embayment (Miller, 1986) is an east-northeast-plunging synclinal feature, which extends from northeastern Florida into southeastern Georgia and offshore. Within this embayment, thick deposits of Coastal Plain sediments comprise thicker and more abundant aquifer layers compared to elsewhere in the coastal area. The Beaufort arch is an area of geologic uplift in which Coastal Plain sediments are thin and near land surface; hence, aquifers are thinner and less abundant than in the area of the southeast Georgia embayment. The Gulf Trough (Herrick and Vorhis, 1963), which could be of either structural or depositional origin, is an area of increased clay content and decreased permeability in Coastal Plain sediments.

AQUIFER SYSTEMS

An aquifer system is a body of intercalated permeable and poorly permeable material that acts as a water-yielding hydrologic unit of regional extent. The concept of an aquifer system is useful because it provides a framework for grouping local aquifer and confining units into a regional hydrologic unit. Previous studies (Clarke and others, 1990) have defined several separate aquifers in Miocene and younger deposits in coastal Georgia that are largely of local extent. Two aquifer systems are proposed for coastal Georgia—the surficial aquifer system (comprised of two to three water-bearing zones) and the Brunswick aquifer system (comprised of the upper and lower Brunswick aquifers) (Fig. 2).

The surficial and Brunswick aquifer systems are thickest in the vicinity of the southeast Georgia embayment, which is deepest in the southern part of the coastal area (Fig. 1), and become progressively thinner to the north and west. Along the northern margins of the embayment, and in the vicinity of the Beaufort arch, the aquifer systems thin and are dissected by ancient channels. Weems and Edwards (2001) reported an ancient alluvial channel that breached the confining unit between the upper and lower Brunswick aquifers in a corehole at Evans County, and presented maps showing the discontinuity of Miocene deposits in Evans, Chatham, and Effingham Counties. In these areas, sediments comprising the aquifer system are discontinuous or absent, and the two aquifer systems may be interconnected to varying degrees.

Surficial Aquifer System

The surficial aquifer system consists of interlayered sand, clay, and thin limestone beds of Miocene and younger age (Fig. 2), which were formerly called the surficial aquifer (Clarke and others, 1990). The aquifer system designation proposed herein is based on Leeth (1999), who subdivided the aquifer into three zones—the water-table zone and the confined upper and lower water-bearing zones. Weems and Edwards (2001) assigned the confined zones to the Ebenezer Formation and the water-table zone to the Satilla and Cypresshead

Formations. The areal extent of the confined units of the surficial aquifer system is currently unknown. Leeth (1999) reported two confined water-bearing zones in Camden County; and Clarke and others (1990) reported one confined water-bearing zone at Brunswick, Glynn County, and one at Skidaway Island, Chatham County. Multiple confined water-bearing zones are believed to occur mostly in areas where deposits are thick, such as in the southeast Georgia embayment.

For the water-table zone, Clarke and others (1990) and Leeth (1999) reported well yields ranging from 2 to 140 gallons per minute (gal/min) and transmissivity ranging from 14 to 6,700 ft^2/d in Glynn and Camden Counties. For the confined water-bearing zones, Clarke and others (1990) reported well yields ranging from 40 to 180 gal/min and transmissivity ranging from 150 to 6,000 ft^2/d. Leeth (1999) reported well yields from 15 to 100 gal/min and a transmissivity of 180 ft^2/d at Camden County. Industrial supply wells near Jesup, Wayne County, formerly yielded about 250 gal/min from the confined water-bearing zones, with a total withdrawal of about 0.86 Mgal/d during 1986 (Clarke and others, 1990).

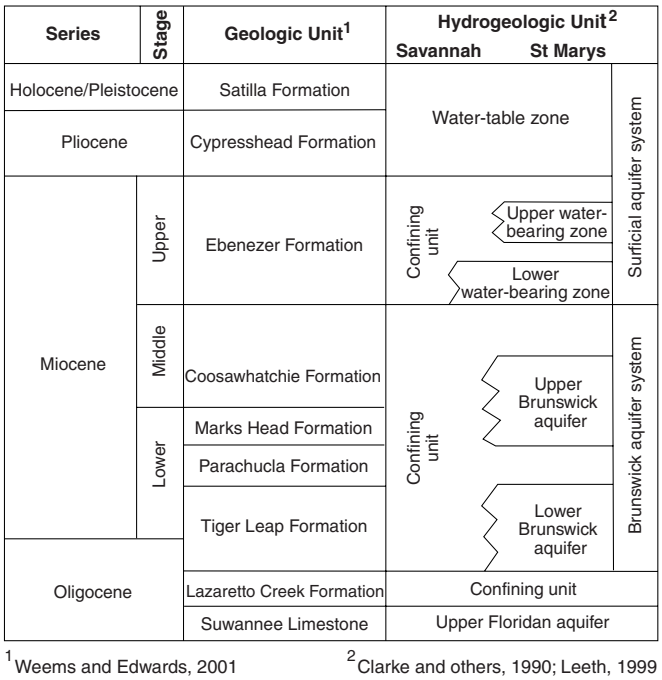

Figure 2. Geologic and hydrogeologic units of Oligocene and younger age, coastal Georgia.

Brunswick Aquifer System

The upper and lower Brunswick aquifers comprise the Brunswick aquifer system, which consists of poorly sorted, fine to coarse, slightly phosphatic and calcareous or dolomitic quartz sand of Miocene age (Fig. 2). The upper Brunswick aquifer includes the Coosawhatchie and Marks Head Formations, and the lower Brunswick aquifer is within the Tiger Leap Formation (Weems and Edwards, 2001). The upper Brunswick aquifer is separated from the overlying surficial aquifer system by a confining unit comprised of clay from the Coosawhatchie Formation. The upper and lower Brunswick aquifers are separated from one another by clay of the Parachucla Formation. Recent investigations have provided better definition of the areal extent and water-bearing properties of the Brunswick aquifer system (Weems and Edwards, 2001; Gill, 2001; Radtke and others, 2001).

Within the southeast Georgia embayment (Fig. 1), transmissivity and yield of the Brunswick aquifer system is the highest observed in coastal Georgia. In Glynn County, reported transmissivities of the lower Brunswick range from 2,000 to 4,700 ft^2/d, and reported well yields range from 340 to 750 gal/min (Clarke and others, 1990; Gill, 2001; Radtke and others, 2001). In general, the upper Brunswick aquifer has lower transmissivity than the lower Brunswick aquifer. Reported transmissivities of the upper Brunswick aquifer range from about 20 to 3,500 ft^2/d, with a maximum reported well yield of 750 gal/min in Glynn County (Gill, 2001; Radtke and others, 2001).

Outside the area of the southeast Georgia embayment, permeable sediments are thin or absent. In Toombs County, in the area of the Gulf Trough, combined transmissivity of the Brunswick aquifer system is about 500 ft^2/d with a test yield of 35 gal/min (Hodges, 1998). South of the Gulf Trough in Evans County, the lower Brunswick aquifer has a transmissivity of about 25 ft^2/d with a test yield of 5 gal/min (Hodges, 1999). In Chatham and Effingham Counties, transmissivity of the upper Brunswick aquifer is generally less than 15 ft^2/d, and reported test yields are 5 gal/min (Gill, 2001; Radtke and others, 2001). At Richmond Hill and on Tybee Island in Chatham County, core and geophysical logs indicate that the aquifer system consists of very fine sand, silt, and clay of low permeability.

Along the outer margins of the southeast Georgia embayment, hydraulic properties of the Brunswick aquifer system are highly variable. For example, in Bryan County, reported transmissivities for wells at Belfast and Genesis Point (Fig. 1), only 8 miles apart, are 90 and 2,300 ft/d, respectively (Gill, 2001; Radtke and others, 2001). Because the Miocene sediments comprising the

Brunswick aquifer system were deposited in a marine-shelf environment (Weems and Edwards, 2001), they should be relatively homogeneous—variations in hydraulic properties are probably related to discontinuous deposition and erosion rather than changes in lithofacies.

EFFECTS OF DEVELOPMENT

Because of restrictions on water withdrawal from the Upper Floridan aquifer, numerous wells are being completed in the Brunswick aquifer system—withdrawal increased from about 1.5 Mgal/d during 1990 to 3.7 Mgal/d during 2000 (Da'Vette Taylor, U.S. Geological Survey, written commun., 2002). At the Golden Isles development in Glynn County, the Brunswick aquifer system is being used as a source for public supply, with an average withdrawal of 0.6 Mgal/d or less since early 1999. The water level in an upper Brunswick aquifer well at the site declined about 12 ft; whereas the water level in a lower Brunswick well declined only 5 ft during the same period (Fig. 3).

This difference may reflect differences in the amount of leakage from adjacent units, the connection of the aquifer to recharge areas, or the aquifer's hydraulic properties. A possible leakage response between the lower Brunswick aquifer and Upper Floridan aquifer is indicated by similar water-level fluctuations (Fig. 3).

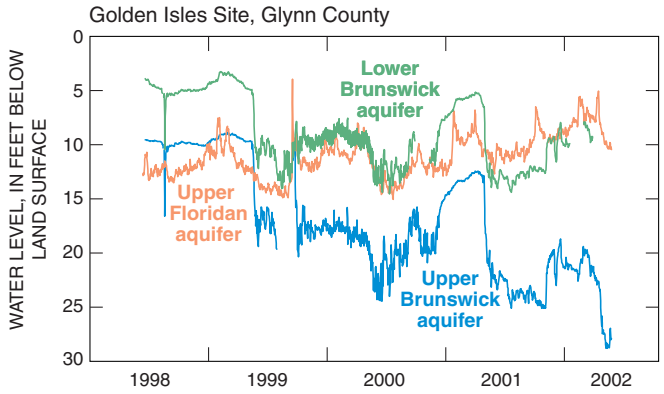

Figure 3. Ground-water levels in the upper and lower Brunswick and Upper Floridan aquifers at the Golden Isles site, Glynn County, Georgia, 1998–2002.

ONGOING RESEARCH

In addition to the CSSI study, the surficial and Brunswick aquifer systems are being evaluated as part of the USGS cooperative water-resources program. These studies, being conducted in Camden, Glynn, Liberty, Long, and McIntosh Counties, include completing test wells, conducting aquifer tests, determining water quality, and assessing interaquifer leakage. Results are being synthesized into a regional hydrogeologic characterization of these aquifer systems.

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