THE RESULTS OF THE AQUIFER INTERCONNECTION AND LEAKAGE ANALYSIS AT EBENEZER BEND AS PART OF THE ENGINEERING ASSESSMENT OF THE BRUNSWICK AQUIFER SYSTEM IN COASTAL GEORGIA

Christopher D. Hemingway[1] and Jonathan S. Radtke[2]

AUTHORS: [1]Senior Project Hydrogeologist and [2]Senior Hydrogeologist, Golder Associates Inc., 3730 Chamblee Tucker Rd, Atlanta, GA 30341.
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Abstract. Golder Associates Inc. (Golder) conducted two aquifer pumping tests and performed numeric modeling to characterize and evaluate the water-bearing properties of the Brunswick aquifer system of the Brunswick aquifer system (also known as the upper and lower Brunswick aquifers) in Glynn County, Georgia. Multi-level observation wells were utilized to evaluate possible hydraulic communication between the Brunswick aquifers and the Altamaha River due to concerns that long term pumping might adversely impact sturgeon habitat in the vicinity of Ebenezer Bend. No leakage between the Brunswick aquifers and overlying aquifers or the river was observed during the test period. A numeric model was created to estimate the long-term effects of pumping. The results of the model simulations indicated that well planned development of the upper and lower Brunswick aquifers should not significantly impact the source of subsurface recharge to the Altamaha River at Ebenezer Bend.

INTRODUCTION

Extensive use of the Upper Floridan Aquifer system has caused cones of depression in the potentiometric surface along the Georgia Coastline (particularly around the communities of Savannah and Brunswick) and salt water intrusion is a significant concern. Consequently, the Georgia Environmental Protection Division (EPD) has developed an *Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Georgia*. Key components of the strategy are to conduct research that will lead to development of measures to stop salt water intrusion and to develop a long term management plan to protect the Upper Floridan Aquifer. Consistent with these components, the Miocene-aged Brunswick Aquifer System is being utilized as an alternative water source to the Upper Floridan aquifer. Properly evaluating withdrawals from these new sources is becoming more important as their utilization increases.

Currently, water supply wells are in use near the Altamaha River (Ebenezer Bend). These wells are used to supply Glynn County residents and industry. As growth continues there is potential for increased groundwater withdrawal from additional well fields in this general vicinity. EPD and others are concerned that withdrawals may affect the sturgeon habitat that exists due to colder spring flow from groundwater into the Altamaha River at this location. There are also concerns about potential impacts to the Upper Floridan aquifer caused by pumping in the Brunswick aquifers.

Therefore, in order to characterize the local aquifers and determine the potential impact of future withdrawals on the Altamaha River, an aquifer investigation and leakance analysis was performed. This investigation included implementation of aquifer tests using multi-level observation wells and development of a numerical model to predict how long term pumping and increased withdrawal from a potential well field in the proximity of the river may impact the Altamaha River. The investigation also provides aquifer parameters for regional groundwater flow and solute transport models currently being developed by the United States Geological Survey (USGS) and others, and provides other valuable information for water supply planning.

AQUIFER ASSESSMENT PROGRAM AT EBENEZER BEND

The Ebenezer Bend Investigation Site (Site) is located off Interstate I-95 in northern Glynn County on property occupied by the Morningstar Youth Facility Boys Camp (Figure 1). It is situated adjacent to marshlands surrounding the Altamaha River, approximately one mile southeast of Ebenezer Bend and approximately 2 miles north of the existing production well on the Golden Isle Gateway Tract.

Figure 1. Ebenezer Bend test site location.

METHODS

The aquifer assessment program at the Ebenezer Bend Site consisted of the following activities:

- Drilling and installation of test wells in the upper and lower Brunswick aquifers, and corresponding observation wells in the surficial, upper, and lower Brunswick aquifers;
- Performance of two 120-hour pumping tests in the test wells to obtain data to adequately characterize the water-bearing properties of the aquifer;
- Analysis of pumping test data using analytical methods, including pressure derivative analyses, to calculate specific aquifer parameters such as transmissivity, storativity, hydraulic conductivity, etc. in the vicinity of the wells;
- Based on parameters derived from aquifer tests, predictive modeling was performed using numerical simulation techniques to determine the water bearing capacity of these aquifers and to assess the potential impact of increased development and usage of these aquifers in the vicinity of Ebenezer Bend on the Altamaha River; and,
- A nearby Upper Floridan well was also monitored to assess leakage from this aquifer during the test period.

The surficial aquifer observation well was screened in the very bottom portion of the aquifer and within the top of the confining unit in an attempt to monitor responses to pumping from the underlying Brunswick aquifers. A packer was employed directly above the screened interval in the Surficial observation well in order to increase the signal resolution and thus, the chance of detecting a response by reducing the masking effect caused by well-bore storage. 120-hour pumping tests were performed on both the upper and lower Brunswick aquifer test wells and pressure responses within the lower Surficial well were monitored. In addition to the lower Surficial well, observation wells within the Brunswick aquifers (upper and lower) and Upper Floridan aquifer were also monitored using pressure transducers during the pumping tests to assess the hydraulic communication between these aquifers. Relative Altamaha River stage data and barometric pressure data were also measured prior to, and during the test period.

PUMPING TESTS RESULTS

The surficial aquifer was encountered from approximately 50 to 140 ft.bgs. and consisted predominately of fine to medium quartz sand with inter-fingered olive-green clay stringers. The upper Brunswick aquifer consisted of limestone and fine to coarse quartz sand with some dark olive green clay, and was encountered from approximately 365 to 435 ft.bgs., The unit is confined above and below by a dark to light olive green and white clay with occasional little phosphatic/quartz sand. Based on the geophysical logs, the thirty-foot zone between 365 and 395 ft.bgs comprises the primary water-bearing portion of the aquifer.

The lower Brunswick aquifer consisted of light gray and white limestone with trace to some quartz sand and shell fragments. This unit was encountered from approximately 480 to 555 ft.bgs., and is confined above by a dark to light olive green and white clay with occasional little phosphatic/quartz sand and below by relatively less permeable limestone. The top of the upper Floridan was encountered at approximately 650 ft.bgs and consisted of limey green and white clays that graded into light green and white, fossiliferous limestone and silty clay. A nearby Upper Floridan well was capped and monitored using pressure transducers during the tests.

A pumping well and observation well were each installed into both the upper and lower Brunswick aquifers. A 120-hour pumping test was completed on the upper Brunswick aquifer using a pumping rate of approximately 65 gpm. A 120-hour pumping test was also completed on the lower Brunswick aquifer using a

Table 1. Summary of Ebenezer Bend Site Aquifer Characteristics

Aquifer Properties	Upper Brunswick Aquifer	Lower Brunswick Aquifer
Formation Model	confined, no apparent leakage	confined, no apparent leakage
Geometry	homogeneous	homogeneous composite (decreasing thickness away from the pumping well)
Inner Boundary	wellbore storage and skin	wellbore storage and skin
Outer Boundary	infinite in lateral extent	infinite in lateral extent
Significant recharge and/or discharge boundaries:	None	None
Transmissivity (T):	582 - 595 $ft.^2$/day	970 – 1700 ** $ft.^2$/day
Aquifer Thickness	30 feet *	75 feet
Hydraulic Conductivity (K):	19.4 – 19.8 ft./day	13 – 23 ft. /day
Storativity (S):	2.9×10^{-4}	3.6×10^{-4}
Specific Storage (Ss):	9.67×10^{-6} $feet^{-1}$	4.8×10^{-6} $feet^{-1}$
Specific Capacity (Q/s):	0.75 gpm/foot	2.97 gpm/foot

Notes: * Based on the assumption that the majority of water is produced in the 365 to 395 ft.bgs portion of the screened interval. Note that large screened intervals were installed in an attempt to produce as much water as possible. However, for parameter estimation, only the portion of the screened interval that indicated production based on geophysical information was used as the aquifer thickness.

** Represents range of Transmissivity (T) with a near well T of approximately 1700 ft^2/day and a decrease in T away from the borehole to as little as approximately 970 ft^2/day).

pumping rate of approximately 330 gpm. No decrease in formation pressure in the other aquifers (Surficial, upper/lower Brunswick, and Upper Floridan) was observed during the two separate pumping tests. In addition, no evidence for vertical communication was recognized in the pressure derivative analyses in either the pumping or observation zone responses. The results of the pumping tests data analyses are presented in Table 1.

AQUIFER INTERCONNECTION

A primary objective of the aquifer investigation was to evaluate the potential for hydraulic communication between the Brunswick aquifers and the Surficial aquifer, and, if communication is observed, to quantify the leakage rate. Evidence of communication can be ascertained through water level (formation pressure) responses in adjacent aquifers and through the drawdown response within the pumped aquifer. Pressure response data from the observation wells were evaluated qualitatively and, where possible, quantitatively. The Altamaha River is likely in direct hydraulic communication with the Surficial Aquifer, and therefore, a significant pressure change in the Surficial aquifer in response to pumping the Brunswick aquifers may indicate the potential for impact to the Altamaha River.

At the Ebenezer Bend test site, the lower Surficial aquifer is separated from the upper Brunswick aquifer by more than 200 feet of low-permeability clayey material. The upper and lower Brunswick aquifers are separated from each other by about 50 feet of low-permeability clayey material.

The pumping test performed on the lower Brunswick aquifer produced approximately 111 feet of drawdown in the pumping well and 30 feet of drawdown in the observation well located about 180 feet away within the same aquifer. No decrease in formation pressure in the other aquifers (Surficial, upper Brunswick, and Upper Floridan) was observed during the pumping test. Pressure response data from observation wells in each aquifer during the lower Brunswick pumping test suggest that significant leakage into the lower Brunswick aquifer did not occur during the test period.

Similarly, no measurable response was observed in the other aquifers (lower Surficial, lower Brunswick, Upper Floridan) during the upper Brunswick pumping test. Since this aquifer is situated closest to the lower Surficial aquifer, this test was expected to have the

best chance of producing a measurable formation pressure response in the lower Surficial aquifer. However, no response was observed.

Further evidence of the absence of measurable leakage between aquifer units is provided in the results of the pressure derivative analyses for each test, which show a close match to the Theis type curve, and therefore does not indicate leakage to the upper or lower Brunswick aquifers during the test periods.

LEAKANCE ANALYSIS

A qualitative evaluation of leakance was peformed using numeric modeling techniques based on aquifer properties derived from the pumping tests. Leakance values were changed during five-day pumping test simulations until drawdown was barely observed in the overlying model layer. Since no leakage was observed during the tests, actual leakance values must be less than the model-derived values. However, the available data do not allow for assessing how much lower the actual leakance is for each confining unit. The model results from the upper Brunswick simulation led to a leakance value of 1×10^{-5} 1/day; therefore, the vertical hydraulic conductivity of the confining unit between the surficial and upper Brunswick aquifers is less than 2.25×10^{-3} ft/day. The leakance value derived from the lower Brunswick simulation is 5×10^{-6} 1/day; therefore, the vertical hydraulic conductivity of the confining unit between the upper Brunswick and lower Brunswick aquifers is less than 2.0×10^{-4} ft/day.

SUMMARY

The results of this investigation indicate no observed interconnection between the surficial aquifer and the upper and lower Brunswick aquifers at the Ebenezer Bend test site during the 120-hour test period. To assess the potential for long-term communication, a numerical model was created to simulate long-term pumping scenarios. Predictive modeling results indicate that well planned development of the upper and lower Brunswick Aquifers, and thus, a small decrease in the potentiometric head surface, should not significantly impact the source of subsurface recharge to the Altamaha River at Ebenezer Bend.

REFERENCE

Golder Associates, 2003. Engineering Assessment of the Brunswick Aquifer System in Coastal Georgia, Georgia Geologic Survey Publication CD-4