IMPACT OF A MAJOR INDUSTRIAL SHUTDOWN ON GROUNDWATER FLOW AND QUALITY IN THE ST. MARYS AREA, SOUTHEASTERN GEORGIA AND NORTHEASTERN FLORIDA, 2001–2003

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Abstract. During October 2002, the Durango Paper Company (formerly Gillman Paper Company) in St. Marys, Georgia, shutdown paper-mill operations. The shutdown reduced groundwater withdrawal in Camden County, Georgia, by 35.6 million gallons per day. Pumping at the mill resulted in the development of a cone of depression at St. Marys that coalesced with a larger cone of depression at Fernandina Beach, Florida. Since the closure of the mill, the cone at St. Marys is no longer present and it is estimated that water levels in the Upper Floridan aquifer at the mill site have risen about 140 feet (ft) and are now at about 30 ft above sea level. The water-level rise in wells in outlying areas in Camden County was less pronounced and ranged from about 5 to 10 ft above sea level. Because of the regional upward water-level trend in the Upper Floridan aquifer that started during 1999–2000 in most of the coastal area, combined with a steeper upward trend beginning during October 2002, it was not possible to determine if the 5–10 ft water level rises in wells away from St. Marys was due to the mill closure. In addition to water-level rises of 22–26 ft in the Floridan aquifer system at St. Marys, water-level rises in the overlying surficial and Brunswick aquifer systems after the shutdown indicates upward leakage of water.

Chloride concentrations in water from the Upper Floridan aquifer in Camden County do not exceed the State and Federal drinking-water standards (250 milligrams per liter). However, water in three wells in the St. Marys area had chloride concentrations above the background range, but still below the drinking water standard. The source for the elevated chloride concentration in these wells has not been determined. Chloride concentrations throughout Camden County, Georgia showed little change after the paper-mill shutdown.

INTRODUCTION

In the coastal area of Georgia and northeastern Florida, the Floridan aquifer system, which consists of the Upper and Lower Floridan aquifers, is heavily used for water supply by the pulp and paper industry and local municipalities. Concern about saltwater intrusion at Hilton Head Island, South Carolina, and Brunswick, Georgia, has resulted in restrictions imposed by the State of Georgia on permitted groundwater withdrawal from the Upper Floridan aquifer. During October 2002, the Durango Paper Company (formerly Gillman Paper Company) in St. Marys, Georgia (Fig. 1), shutdown paper-mill operations; the shutdown resulted in decreased groundwater withdrawal in Camden County by 35.6 million gallons per day (Mgal/d). The decrease in withdrawal resulted in water-level rise in wells completed in the Floridan aquifer system and the overlying surficial and Brunswick aquifer systems; many wells in the St. Marys area flowed for the first time since the mill began operations during 1941.

To assess the impact of the Durango Paper Company shutdown on groundwater levels and chloride concentrations in Camden County, Georgia, and groundwater levels in Nassau County, Florida, the U.S. Geological Survey (USGS)—in cooperation with the Georgia Department of Natural resources, Environmental Protection Division (GaEPD)—conducted an investigation from September 2002 to May 2003. Results of this investigation have provided water managers with information to help manage water resources in coastal Georgia.

This paper is a summary of a more extensive report (Peck and others, 2005), which can be accessed at *http://ga.water.usgs.gov/pubs/galist-gw.html/*. As part of this study, synoptic water-level measurements were made during three time periods in 55 wells open to the Upper Floridan aquifer in Camden County, Georgia, and Nassau County, Florida, prior to the mill shutdown (September 2002) and after the shutdown (January and May 2003). Potentiometric-surface maps were constructed for each time period to show changes in groundwater flowpaths and to help determine the areal extent of water-level rise.

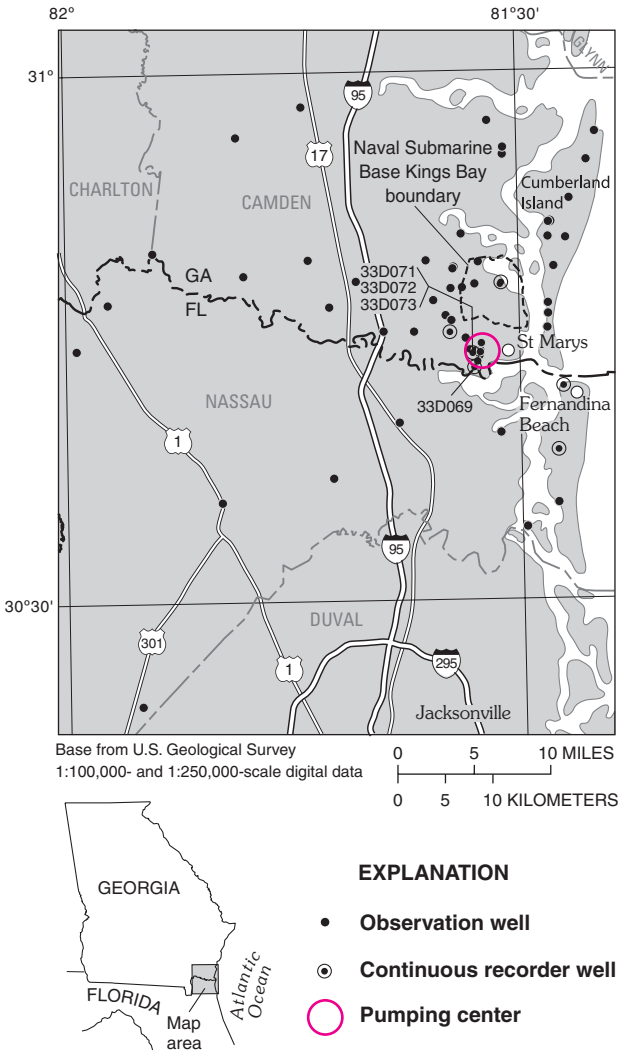

Figure 1. Location of study area and selected groundwater-level and chloride monitoring sites in Camden County, Georgia, and Nassau County, Florida.

Hydrographs from six continuously monitored wells in Camden County, Georgia, and two wells in Nassau County, Florida (Fig. 1), were used to evaluate water-level trends and the effects of decreased groundwater withdrawal on a regional scale and to assess interaquifer leakage response. Water-use data were compiled and compared to water-level data from continuous recorders to evaluate the effects of industrial withdrawal. Water samples were collected from 31 wells in Camden County, Georgia, during the same three time periods, to evaluate possible changes in chloride concentration in the Upper Floridan aquifer.

GROUNDWATER WITHDRAWAL

In Camden County, Georgia, and Nassau County, Florida, groundwater withdrawal increased from about 0.5 Mgal/d during 1938 to about 105 Mgal/d during 1977 (Brown, 1984). Much of the increase occurred during the 1940s when three major paper mills—one at St. Marys, Georgia and two at Fernandina Beach, Florida—began operation. From 1985 to 2000, industrial and municipal groundwater withdrawal in Camden County, Georgia, and Nassau County, Florida, ranged from about 81 to 90 Mgal/d primarily from the Floridan aquifer system (Frick and others, 2002).

GROUNDWATER LEVELS

Following the shutdown, water levels in the Floridan aquifer system and in the overlying surficial and Brunswick aquifer systems recovered (Fig. 2), resulting in flow from many wells in the St. Marys area for the first time since the mill began operations in 1941.

The most prominent changes in the potentiometric surface of the Upper Floridan aquifer after the industrial shutdown are the disappearance of the cone of depression centered at St. Marys, Georgia, the decreased Fernandina Beach cone, and the growth of the 40-foot (ft) mound northwest of St. Marys (Fig. 3). The water level in the Upper Floridan aquifer at St. Marys ranged from about 10 ft below land surface to 10 ft above land surface during September 2001, and by May 2003 had risen to about 30 ft, which is 20 ft lower than 1880 predevelopment water levels (Johnston and others, 1980). The water-level changes resulting from the shutdown are greatest in the St. Marys area and less pronounced and more difficult to distinguish from regional trends farther away from the center of pumping (Fig. 3).

Analysis of continuous water-level data from wells in coastal Georgia and Nassau County, Florida, indicate a regional upward water-level trend in the Upper Floridan aquifer beginning during 1999–2000 in many wells. This trend became more pronounced during early October 2002 and continued through May 2003. Water-level rises resulting from the Durango Paper Company shutdown are easy to discern in wells located at St. Marys; however, for wells located farther away in Glynn County, Georgia, and Nassau County, Florida, the response to the industrial shutdown is not discernable because of the overall regional water-level rise due to the end of drought conditions and the effects of groundwater withdrawal. Since the shutdown, the water levels at the mill have risen about 140 ft and are currently (2004) about 30 ft above sea level.

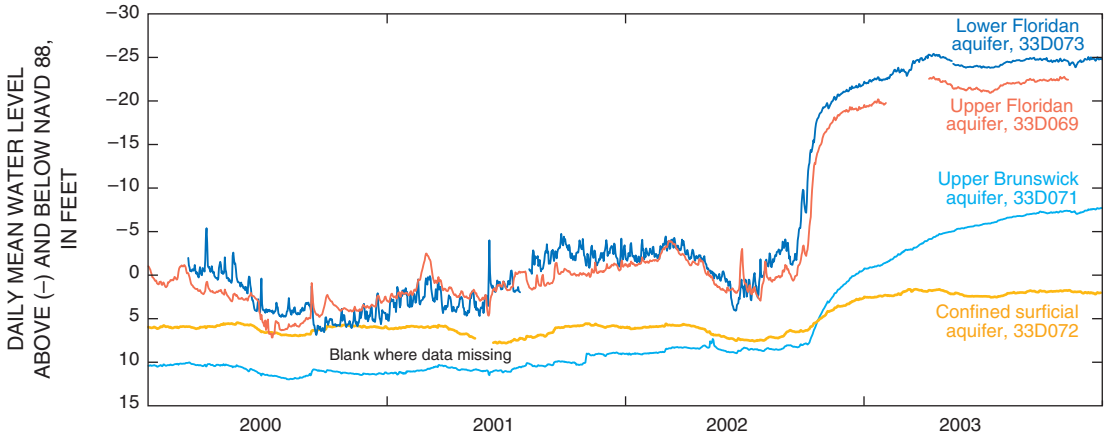

Figure 2. Hydrographs for the St. Marys well cluster (33D071, 33D072, and 33D073) and nearby National Park Service well (33D069), Camden County, Georgia, 2000–2003 (location of wells shown in Figure 1).

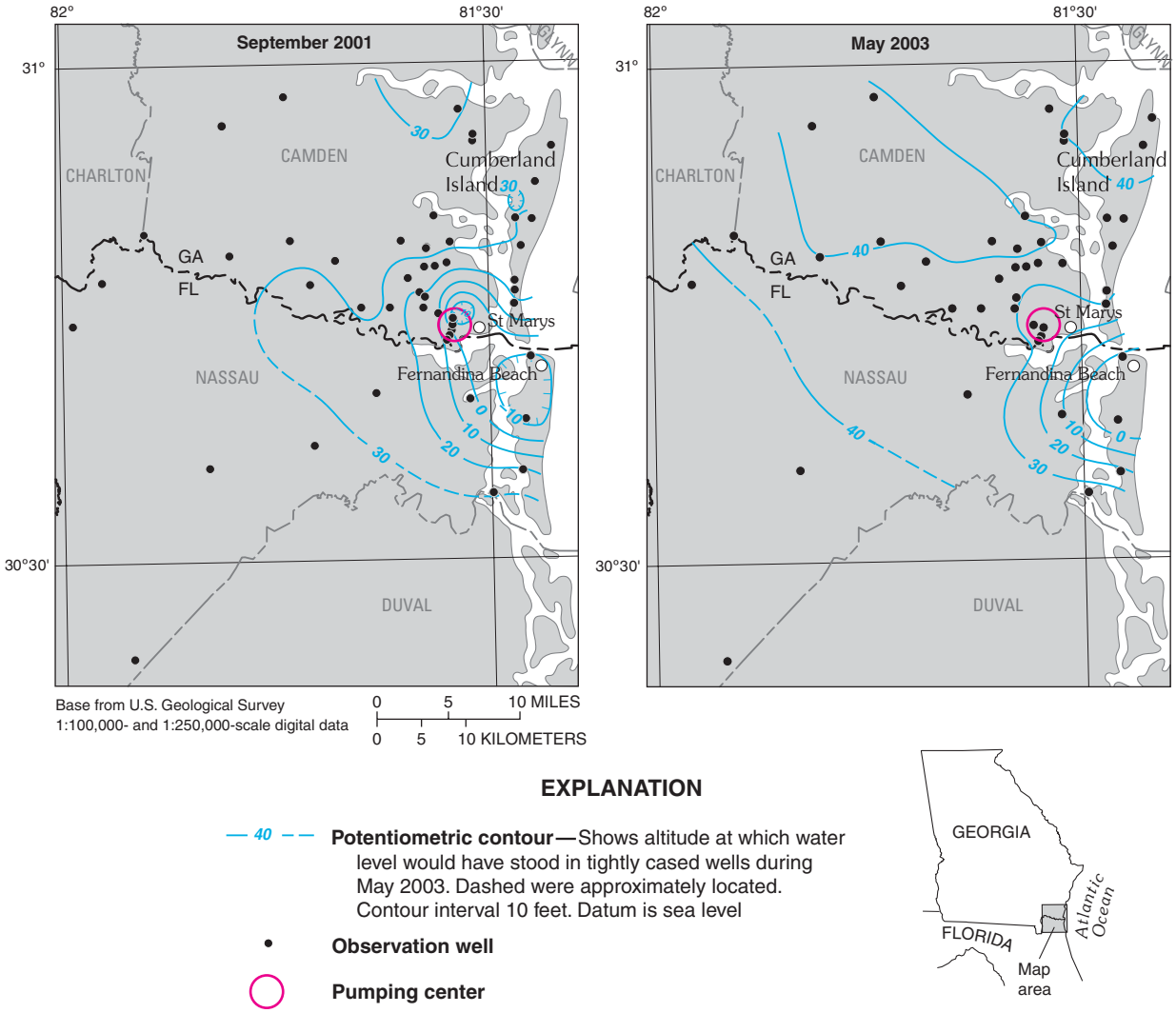

Figure 3. Potentiometric surface of the Upper Floridan aquifer in Camden County, Georgia, and Nassau County, Florida, September 2001 and May 2003.

INTERAQUIFER LEAKAGE

In addition to the recovery observed in the Upper Floridan aquifer, water levels in the underlying Lower Floridan aquifer and the overlying upper Brunswick aquifer and confined zone of the surficial aquifer system began rising during late October 2002 after the Durango shutdown and continued rising through at least May 2003, suggesting interaquifer leakage (Fig. 2). Throughout Camden County, the vertical hydraulic gradient is upward from the Floridan aquifer system to the Brunswick and surficial aquifer systems. However, when the mill was operating, water levels in the Upper Floridan aquifer at the center of pumping ranged from 68 to 235 ft below sea level, and the water levels in the overlying aquifers ranged from about 2 ft below to 3 ft above sea level, reversing the vertical hydraulic gradient within the cone of depression.

This reversal of vertical gradient created the potential for downward leakage from the surficial and Brunswick aquifers to the Upper Floridan aquifer. Typical head relations in the four different zones being monitored at St. Marys prior to the shutdown were as follows: the highest hydraulic head was in the Lower Floridan aquifer, followed by the Upper Floridan aquifer, the confined surficial aquifer, and the upper Brunswick aquifer (Fig. 2). After the mill ceased operations during October 2002, the hydraulic head separation between the aquifers increased and the head in the upper Brunswick rose above the head in the confined surficial, reversing the vertical hydraulic gradient. At present (2004), the rate of leakage between the three aquifer systems in the St. Marys area has not been determined. Digital modeling could be used to estimate confining unit leakance rates and to study local interaquifer connection.

CHLORIDE CONCENTRATIONS

Chloride concentrations in water from the Upper Floridan aquifer in Camden County do not exceed the State and Federal drinking-water standard of 250 mg/L. Concentrations in most of the wells sampled during this study (from September 2002 to May 2003) ranged from 30 to 50 mg/L, which is considered within background levels for the Upper Floridan aquifer. However, water in three wells in the St. Marys area had chloride concentrations above the background range. Well 33D061 (Durango Paper Company well) has had an increase in chloride concentration since sampling began during 1984; however, these concentrations are below the drinking water limit of 250 mg/L. The source for the elevated chloride concentrations in this well has not been determined, and chloride concentrations have decreased slightly since the Durango Paper Company shutdown.

The depth of the Upper Floridan aquifer (about 560 ft) and the presence of freshwater in the aquifer as far as 70 miles offshore (Johnston and others, 1982) make lateral saltwater encroachment in well 33D061 unlikely. In addition, the presence of freshwater in the aquifer to a depth of 2,060 ft makes upward movement of saline water unlikely. A possible mechanism for elevated chloride concentration is vertical movement along the annular space of the well bore; whereby saline marsh water moves downward into the Upper Floridan aquifer. Changes in chloride concentration support the hypothesis of saltwater movement along the annular well space. Overall chloride concentrations in the Upper Floridan aquifer did not change appreciably after the reduction in groundwater withdrawal, and the sulfate concentration remained about the same. Borehole geophysical logging techniques could be used to determine if saltwater is entering the wells from the marsh.

LITERATURE CITED

Brown, D.P. 1984. Impact of development on availability and quality of ground water in eastern Nassau County, Florida, and southeastern Camden County, Georgia. U.S. Geological Survey Water-Resources Investigations Report 83-4190, 113 pp.

Frick, E.A., M.B. Gregory, D.L. Calhoun, and E.H. Hopkins. 2002. Water quality and aquatic communities of upland wetlands, Cumberland Island National Seashore, Georgia, April 1999 to July 2000. U.S. Geological Survey Water-Resources Investigations Report 02-4082, 72 p.

Johnston, R.H., R.E. Krause, F.W. Meyer, P.D. Ryder, C.H. Tibbals, and J.D. Hunn. 1980. Estimated potentiometric surface for the Tertiary limestone aquifer system, southeastern United States, prior to development. U.S. Geological Survey Open-File Report 80-406, 1 sheet.

Johnston, R.H., P.W. Bush, R.E. Krause, J.E. Miller, and C.L. Sprinkle. 1982. Summary of hydrologic testing in the Tertiary limestone aquifer, Tenneco offshore exploratory well—Atlantic) CS, Lease-Block 427 (Jacksonville NH 17-5). U.S. Geological Survey Water-Supply Paper 2180, 15 pp.

Peck, M.F., K.W. McFadden, and D.C. Leeth. 2005. Effects of decreased ground-water withdrawal on ground-water levels and chloride concentrations in Camden County, Georgia, and ground-water levels in Nassau County, Florida, from September 2001 to May 2003. U.S. Geological Survey Scientific Investigations Report 2004-5295, 36 pp.