SIMULATION OF THE FLOW SYSTEM IN THE SHALLOW AQUIFER, DAUPHIN ISLAND, ALABAMA

Robert E. Kidd and Will S. Mooty
U.S. Geological Survey
Tuscaloosa, Alabama

INTRODUCTION

The development of freshwater aquifers on Dauphin Island, Alabama, for industrial and domestic supplies is threatened by saltwater encroachment. At present, chloride, iron, and total dissolved solids concentrations in water at depths from 250 to 300 feet in municipal wells supplying the island exceed maximum contaminant levels recommended in National Secondary Drinking-Water Regulations (U.S. Environmental Protection Agency, 1982). The surficial aquifer is the only source of potable water with a chloride concentration below the maximum contaminant level recommended in the National Drinking-Water Regulations.

Dauphin Island is a barrier island located about 4 miles offshore of mainland Mobile County, Alabama. The island extends from the point of confluence of the waters of Mobile Bay, Mississippi Sound, and Gulf of Mexico westward for about 15 miles. The study area, the eastern 3 miles of the island, is about 1.6 miles wide across the main body of the island.

The elevation of most of the study area is about 5 to 10 feet above mean sea level. A barrier dune ridge ranging from 25 to 50 feet in height has migrated more than 500 feet between 1917 and 1942 from the Gulf shore to the forest edge (Hardin and others, 1976).

Dauphin Island is characterized by a warm humid subtropical climate influenced greatly by the Gulf of Mexico. Precipitation is rather evenly distributed with a slight increase in July and August. Precipitation data from the Dauphin Island Sea laboratory Meteorological Observation Station show the average annual rainfall from 1975 through 1985 was 66.5 inches.

The surficial sand covering the island allows rapid infiltration of precipitation resulting in the absence of perennial streams. During periods of prolonged precipitation, flow occurs in drainage ditches several days after storms and standing water remain in the low areas for several weeks.

HYDROGEOLOGY

Dauphin Island is underlain by more than 23,000 feet of Coastal Plain sediments ranging in age from Jurassic to Holocene (Chandler and Moore, 1983). This investigation was limited to the sediments with potential as freshwater aquifers.

The uppermost water-bearing zone consists of the surficial aquifer, which is a thin veneer of Holocene sand that covers most of the surface, and the underlying Pleistocene Gulfport Formation. The Gulfport Formation consists of well to moderately sorted, medium to very fine-grained quartz sand, lenses of dark-brown humate, silt, limonite and streaks of semi-consolidated sands (Otvos, 1985). The surficial aquifer ranges from about 3 to 7 feet above mean sea level in the interior to less than 1 to 2.5 feet above mean sea level near the Gulf. The surficial aquifer is recharged by rainfall. Water leaves the surficial aquifer by seepage to surface water, evapotranspiration, and pumpage.

DIGITAL COMPUTER MODEL

A two-dimensional finite-difference model of the water-table aquifer was used to evaluate the flow system McDonald and Harbaugh, 1984). A steady-state model was developed based on near-saturated aquifer conditions in April 1986 when approximately steady- state conditions prevailed. An absolutely steady-state condition is never attained because of variations in aquifer recharge and continuous discharge to surface water bodies surrounding the island.

A model grid with a uniform spacing of 120 feet on a side was overlain on a base map of Dauphin Island (fig. 1). The grid dimensions were 70 nodes in a north- south direction (columns) and 170 nodes in an west-east direction (rows). The grid covers the eastern end of the island, the part with the greatest width, and extends approximately 1,000 feet beyond the shoreline of the island to allow for freshwater discharge into the surrounding bodies of water.

MODEL INPUT DATA

The model parameters used in the model are: aquifer hydraulic conductivity, aquifer thickness, recharge to the aquifer, and the vertical hydraulic connection between the aquifer and the surrounding surface water bodies. The hydraulic conductivity of the aquifer was determined from aquifer tests of 2 and 30 days duration. Based on 42 wells drilled in the study area, the aquifer is from 28 to 35 feet thick. To estimate the recharge rate, two rain gages were installed near wells with continuous water level recorders. The vertical hydraulic connection was estimated by varying the value until the computed water levels closely matched the known water levels in the center of the island.

The performance criteria for the steady-state model are that the computed ground-water levels match, with reasonable closeness, the corresponding measured ground-water levels. Fifty-six percent (9 of 16) of the model calculated water levels were within 0.50 foot of the measured water levels. All computed water levels were within 1 foot of measured water levels.

The calibrated steady-state model (fig. 1) was used to develop a transient model to define the specific yield of the aquifer (fig. 2). The parameters established in the steady-state model were used without change in the transient model and used to simulate periods of no rainfall. The water levels calculated in the steady-state model were used as starting heads in the transient model. Two simulation periods, April-May 1985 and May-June 1985, were modeled. The total average head change measured in observation wells was about 3 feet during the simulation periods. Eighty-two percent (14 of 17) of the calculated water levels were within 0.50 foot and 94 percent (16 of 17) were within 1.00 foot of the actual levels for both simulation periods using a specific yield of 0.08.

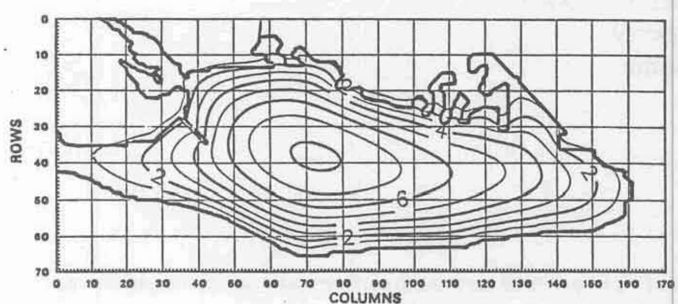

Figure 1. Simulated steady-state water-table elevations April, 1985.

EXPLANATION
grid scale 120 feet per column or row
44 grid units per mile
countour interval 1 foot

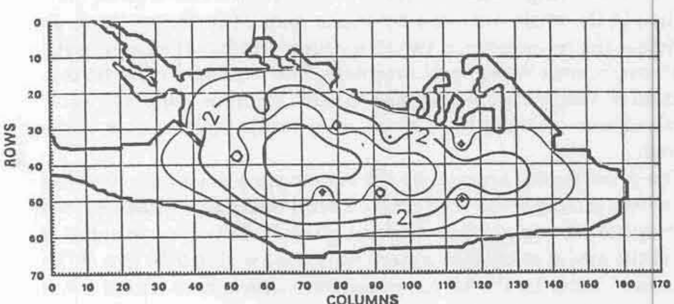

Figure 2. Simulated transient-state water-level elevations with 0.6 million gallons per day pumpage and no recharge.

MODEL SIMULATED PUMPAGE

The average water demand on the island is about 0.2 million gallons per day (Mgal/d). Aquifer tests indicate that 50 gallons per minute (gpm) could be obtained from wells in the water-table aquifer. Pumpage schemes with eight wells pumping a total of 0.3 Mgal/d (200 gpm) and 0.6 Mgal/d (400 gpm) were simulated with both steady-state and transient models. The evaluations were considered successful if a ground- water divide was maintained between the pumping center and the salt-water bodies surrounding the island. Steady-state simulation of pumping at 0.3 Mgal/d produced water levels of about 1 to 2 feet above sea level at each of the eight wells. Increasing pumpage to 0.6 Mgal/d produced water levels of about 2 to 3 feet below sea level at each well.

Transient model simulation of 0.3 Mgal/d pumpage created water levels of 1 to 2 feet above sea level. Pumpage of 0.6 Mgal/d created water levels from about 2 1/2 to near 4 feet below sea level (fig. 2). The simulated pumping schemes indicate the water-table aquifer could yield 0.6 Mgal/d without lateral encroachment with recharge less than the 10-year average minimum. All of the schemes maintained a ground-water divide between the wells and the surrounding salt-water bodies.

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