HYDROGEOLOGY AND WATER-SUPPLY POTENTIAL OF THE WATER-TABLE AQUIFER ON DAUPHIN ISLAND, ALABAMA

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CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per day (ft/d)	0.3048	meter per second (m/s)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
gallon per day (gal/d)	0.00375	cubic meter per day (m^3/d)
million gallons (Mgal)	3,785	cubic meter (m^3)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
		microsiemens per centimeter at 25° Celsius (uS/cm at 25°C)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level of 1929."

DEFINITION OF TERMS

Aquifer - A formation, group of formations, or part of a formation that contains sufficient saturation of permeable material to yield significant quantities of water to wells or springs.

Confined aquifer - Aquifer in which the water level in a well is above the top of the aquifer.

Digital model - A mathematical representation of a system. A computer program used to solve ground-water flow equations.

Discharge - Flow of water expressed as a volume per unit of time.

Evapotranspiration - Volume of water that is lost to the atmosphere by transpiration from vegetative growth and by evaporation from the soil.

Hydraulic conductivity - Volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydraulic gradient - Change in head per unit of distance in a given direction.

Hydraulic head - Height above standard datum of the surface of a column of water that can be supported by the static pressure at a given point.

Infiltration rate - Rate at which water made available at the ground surface enters into the soil zone.

Perennial stream - Stream that flows throughout the year and has a channel that generally is below the water table.

Potentiometric surface - A surface that represents the hydrostatic head. In a confined (artesian) aquifer, the water is under a pressure significantly greater than atmospheric, and the surface is defined by the altitude of water levels in wells that are tightly cased into the aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

Pumpage - Withdrawal of ground water from the aquifer by pumps.

Recharge - Amount of water added to the zone of saturation from precipitation.

Saturated thickness - Amount of water-bearing material filled with water under pressure equal to or greater than atmospheric.

Specific yield - Ratio of the volume of water that the saturated material will yield by gravity to the volume of the material.

Steady state - Equilibrium conditions occur when hydraulic heads and the volume of water in storage do not change with time.

Storage coefficient - Volume of water an aquifer releases from storage for a unit prism of aquifer material per unit change in head.

Transient state - Nonequilibrium conditions occur when hydraulic heads and the volume of water in storage change with time.

Transmissivity - Rate at which water transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity is the product of hydraulic conductivity and saturated thickness.

Unconfined aquifer - Aquifer in which a water level in a well is below the top of the aquifer.

Water table - Surface defined by water levels in an unconfined aquifer at which the pressure is atmospheric.

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ABSTRACT

The water-table aquifer on Dauphin Island, Alabama, consists of a thin veneer of Holocene sand and an underlying Pleistocene unit locally known as the Gulfport Formation. The aquifer is from 28 to 35 feet thick with a thick marine clay at its base. Water in the aquifer generally is low in chloride content except near the coast. Excessively high iron concentrations in ground water, as high as 36 milligrams per liter were found locally.

A two-dimensional finite-difference ground-water flow model of the water-table aquifer on Dauphin Island was used in the steady-state mode to evaluate the flow system under steady-state conditions. Model input data were obtained primarily from 40 test wells, 2 aquifer tests, continuous recording of ground-water levels, and rainfall. The model was calibrated to the low water-table conditions of July 1985 and high water-table conditions of April 1985. Aquifer recharge rates of 15 and 20 inches per year were used in the model calibrations.

The model was also used to simulate pumpage from the aquifer under transient conditions with no rainfall. Patterns of computed head changes compared favorably to the natural recession of water levels for the periods of April to May 1985 and May to June 1985.

Simulation of ground-water withdrawals in the transient model showed the feasibility of producing 0.6 million gallons per day from eight wells that tap the water-table aquifer without inducing lateral seawater encroachment.

INTRODUCTION

The development of public-water supplies from ground water on Dauphin Island for industrial and domestic use is threatened by saltwater encroachment. Three public-supply wells tap Miocene age sand and gravelly sand beds at depths of 200 to 300 feet below land surface. Chandler and Moore (1983) reported that the wells at times have produced dissolved chloride concentrations greater than 250 mg/L (milligrams per liter), which is the limit set by the secondary drinking water standards (U.S. Environmental Protection Agency, 1986a). Chloride concentration of water from one well increased from 96 mg/L in 1955 to 795 mg/L in 1976. Specific conductances greater than 1,000 uS/cm (microsiemens per centimeter) were measured in water from two other wells on November 7, 1984 and indicated elevated dissolved-solids contents.

The present water demand on Dauphin Island (about 0.3 Mgal/d [million gallons per day]) is expected to increase. Consequently, to meet the future water demands, the Dauphin Island Water, Sewer, and Fire Protection Authority decided that a pipeline would be constructed from the mainland to Dauphin Island. However, because the pipeline would take 10 years to complete, the Authority decided to investigate the possibility of obtaining a potable ground-water supply while the pipeline is being constructed.

In 1984, the U.S. Geological Survey, in cooperation with the Dauphin Island Water, Sewer, and Fire Protection Authority, began a 2-year study of the hydrogeology and water supply potential of aquifers on Dauphin Island.

Purpose and Scope

The purposes of this report are to describe the hydrogeology of the water-table aquifer on Dauphin Island, Alabama, and to evaluate its potential as a drinking water supply. The scope of this study included a test drilling program, aquifer tests, water-quality analyses, and the development of a digital ground-water flow model. The model was used to evaluate ground-water withdrawal schemes on Dauphin Island. The investigation focused on the eastern one-fourth of the island because the western three-quarters of the island is lower in elevation and subject to frequent storm surges that limit freshwater reserves.

Previous Studies

Chandler and Moore (1983) described the occurrence, quantity and quality of ground water on Dauphin Island. Riccio and others (1973), Reed and McCain (1972), and Walter (1976) provided general information on the geology and hydrology of the island.

Otvos (1979, 1981, 1985a, 1985b) described the stratigraphy and geologic evolution of the island. Other studies of geology of the area were made by Ryan (1969), Reed (1971), and Boone (1973).

Physical Setting of the Area

Dauphin Island is a barrier island located about 4 miles offshore of mainland Mobile County, Alabama. The island extends from the confluence of the waters of Mobile Bay, Mississippi Sound, and Gulf of Mexico westward for about 15 miles (fig. 1). The study area, the eastern 3 square 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 between 5 to 10 feet above sea level. The area is pine woodland with deciduous trees in seasonally swampy areas that parallel the coast. Alligator Lake is a small lake in the Audubon Bird Sanctuary near the southeastern end of the study area. French Lake is located on the Country Club Golf Course (fig. 2). The island is constantly undergoing change. A barrier dune ridge that ranges from 25 to 50 feet in height migrated more than 500 feet inland between 1917 and 1942 (Hardin and others, 1976). There is a general trend of erosion along the Gulf and deposition and subsequent elongation of the western end of the island (Hardin and others, 1976).

Dauphin Island is characterized by a warm humid subtropical climate influenced by the Gulf of Mexico. Precipitation is evenly distributed with a slight increase in July and August and a slight decrease in the fall (fig. 3).

Precipitation data from the Dauphin Island Sea Laboratory Meteorological Observation Station show that the annual rainfall has averaged 66.5 inches from 1975 through 1985 (fig. 3). The greatest rainfall, 80.4 inches, occurred in 1979 and the least, 48.9 inches, in 1977. Average annual evapotranspiration from watersheds in southern Alabama is about 60 percent of the average yearly rainfall (Riccio and others, 1973). About 40 percent, 26.5 inches per year, of the average precipitation is available for runoff, storage in the soil moisture zone, and recharge to the ground-water system. Rain that enters the soil is available for vegetation. Evapotranspiration is a continuous process on Dauphin Island; the greatest demand for water by vegetation occurring in the summer months.

On the average, the Alabama coast is affected by a hurricane every 52 months (Hardin and others, 1976). The hurricane season extends from August through November. Sixty-five percent of the hurricanes that have affected Dauphin Island occurred during September (Hardin and others, 1976).

Storm surges, which occur frequently on Dauphin Island, are produced by hurricanes and cause rises of sea level above normal tide levels. These swells travel faster than the storm and, as the swell advances and breaks, the water surges to about twice its original height (Walter and Kidd, 1979). The dune ridge along the gulf coast acts as a barrier to storm surges. Storm surges inundate the areas not protected by dune ridges and may allow seawater to enter the water-table aquifer.

The surficial sand covering the island allows rapid infiltration of precipitation that results in the absence of perennial streams. This precludes estimation of ground-water recharge from base flow of streams. However, during periods of prolonged precipitation, flow was observed in drainage ditches several days after the storm.

Ground-water flow is generally from the center of the island southward to the Gulf of Mexico and northward to the Mississippi Sound. Areas of lower elevation that are seasonally swampy may receive some local subsurface drainage.

Acknowledgments

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METHODS OF INVESTIGATION

Well Inventory

Available data for wells on Dauphin Island were collected and analyzed during the investigation. The data included driller's logs and information related to depth, yield, water level and specific conductance. Twenty-five wells were inventoried (fig. 2); most were shallow, 50 feet or less in depth, and used primarily to water lawns.

Test Drilling

Part of the investigation involved the drilling of 40 test wells (fig. 2). The wells ranged in depth from 30 to 100 feet below land surface. Drill cuttings were examined at each drill site to identify changes in lithology. Sieve analyses of selected samples were made in the laboratory. Thirty seven of the test wells were cased with 2-inch I.D. casing and screen to determine water level fluctuations and water quality. Two wells were cased with 6-inch I.D. casing and one with 10-inch I.D. casing and gravel packed. Two of these large diameter, gravel-packed wells were used as production wells for aquifer tests.

Selected geophysical logs were made in each well to aid in correlation of geologic strata, porosity and fluid content. Resistivity, spontaneous potential, gamma-gamma, neutron porosity, and natural gamma logs were made.

Water Samples

Water samples were taken from selected wells during the well inventory and from each test well. Temperature and specific conductance of all samples were measured in the field. Water samples were taken periodically from selected test wells to determine changes in specific conductance. The samples were collected by pumping a volume of water greater than that stored in the well casing from each well. A hand-operated piston pump was used to pump the water from all of the wells except for well 10 (fig. 2), which was the production well during a 26-day aquifer test. Samples were collected during aquifer tests for laboratory analyses to determine water-quality changes caused by possible saltwater intrusion.

Aquifer Tests

Two aquifer tests were conducted to determine hydraulic characteristics of the water-table aquifer and to assess changes in water quality. Methods of analysis included: (1) Thiem method as modified by Jacob for thin unconfined aquifers (Lohman, 1972) and (2) Boulton's unconfined, delayed yield (Lohman, 1972).

A 48-hour aquifer test was conducted from June 20 through June 22, 1985, by pumping well 41. This test was to determine aquifer characteristics. Twelve wells were used to monitor changes in water levels.

A 26-day aquifer test was conducted from April 9 to May 5, 1986, by pumping well 10 with a submersible pump at a rate of 75 gal/min (gallons per minute). Discharged water was piped to the sewer system to prevent recirculation. This test was to determine if water-quality changes would occur. Ten wells were used to monitor changes in water quality and water levels.

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). Chandler and Moore (1983) separated the hydrogeologic units into three intervals based on stratigraphy, hydrology, and water quality. These are in ascending order: the deep Miocene siliciclastic interval, shallow Miocene siliciclastic interval, and Pleistocene-Holocene intervals (fig. 4). Otvos (1979, 1981, 1985a, and 1985b) divided the Pleistocene-Holocene interval of Chandler and Moore into three units. These are in ascending order: Pre-Holocene deposits; Gulfport Formation, first described by Otvos in 1973 (Luttrell and others, 1981); and Holocene deposits. The Gulfport Formation of Otvos on the eastern 3 miles of Dauphin Island was a Pleistocene high ground that became surrounded and veneered by Holocene sediments. Drift transport was instrumental in the westward elongation of the island (Otvos, 1981). For this study, which was limited to sediments with potential as freshwater aquifers, the hydrogeologic units are separated into aquifers which are in ascending order: the deep sand, shallow sand, and water-table aquifers (fig. 4). Only the water-table and shallow sand have potential as freshwater aquifers.

Deep Sand Aquifer

The Miocene sediments 500 feet below sea level were designated deep Miocene siliciclastic interval by Chandler and Moore (1983). The deep sand aquifer consists primarily of very fine- to very coarse-grained subangular to subrounded quartzose sand with shell fragments and traces of dark minerals and some layers of clay and silt. These sediments appear to contain brackish to saline water under artesian conditions. Well 52, reported to be 563 feet in depth, flowed about 2 gal/min and had a specific conductance of 1,990 uS/cm on November 5, 1984 (table 1 and fig. 2). The well had a measured flow of 6 gal/min on March 21, 1980 (Chandler and Moore, 1983). Water flowing from the well infiltrates the ground within about 50 feet of the well.

Shallow Sand Aquifer

The shallow sand aquifer is comprised of the Miocene sediments between 150 and 500 feet below sea level and the Pleistocene sediments between 50 and 150 feet below sea level. The shallow sand aquifer consists of very fine- to very coarse-grained, subangular- to subrounded quartzose sand with some shell fragments, carbonized wood, silt and clay.

Water from this interval is being withdrawn from wells 2 and 8 for public supply (table 1). Dissolved chloride concentration of water from these wells, at times, has exceeded the 250 mg/L limit set for the secondary drinking water standards (U.S. Environmental Protection Agency, 1986a). Two wells (32 and 33) produce from this zone and five test wells (6, 16, 29, 38, and 39) are screened in the shallow sand aquifer.

Test drilling, aquifer tests, water quality and hydraulic head differences show that the shallow sand aquifer is confined by a dense plastic marine clay. The clay contains fossil ostracodes, small gastropods, pelecypods, and benthonic foraminifera and underlies the water-table aquifer (Chandler and Moore, 1983). Thirty-one test wells were drilled to the top of the clay and five test wells penetrated the clay. The test drilling showed that the clay is about 20 feet thick and about 30 to 40 feet below sea level, and is probably continuous throughout the island. During the 48-hour test on the water-table aquifer no drawdown occurred in wells screened below the clay in the shallow sand aquifer. Observation wells 38 and 39 in the shallow sand aquifer were horizontally about 20 feet from the pumped well (41) producing from the water-table aquifer.

Wells screened in the shallow sand aquifer generally have water-level altitudes that are about 2 feet less than those in the water-table aquifer (table 1). Specific conductance greater than 3,000 uS/cm was measured in water from the shallow sand aquifer.

Water-Table Aquifer

The uppermost water-bearing unit is the water-table aquifer (fig. 4) that consists of a thin veneer of Holocene sand and the underlying Pleistocene Gulfport Formation of Otvos (Luttrell and others, 1981). The Holocene sand covers most of the surface of the island, and on the eastern 3 miles of the island it overlies the Gulfport Formation (fig. 5). The surficial sand is fine- to medium-grained quartz and is from 1 to 5 feet thick over most of eastern Dauphin Island except for the gulf shore and the dunes where the sand may be over 50 feet thick. In Mississippi Sound, north of Dauphin Island, the sand grades into a sand, silt and clay unit.

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 semiconsolidated sands. Otvos (1985a) found a 0.4 percent humate-carbon content in the humate bearing sands from a drill hole on eastern Dauphin Island. Test drilling and geophysical logs indicate the Gulfport Formation is about 30 feet thick.

A 48-hour aquifer test was conducted in the east-central part of the study area (well 41) to determine aquifer characteristics. This test indicated the aquifer hydraulic conductivity was about 45 to 55 ft/d (feet per day) and the specific yield was about 0.03. A 26-day aquifer test was conducted in the west-central part of the study area (well 10) to observe changes in water quality with pumpage and to determine aquifer characteristics. Test results showed the hydraulic conductivity was from 56 to 59 ft/d and the specific yield was 0.07 to 0.12. Because of recharge by precipitation during the 26-day test, drawdown values after 4,080 minutes were not used in determining the aquifer characteristics. The larger specific yield values obtained in the 26-day test indicated the delayed yield of the water-table aquifer.

Geologic data and water-level measurements from December 1984 to October 1986 for 42 test wells show that the water-table aquifer is hydraulically separate from the shallow sand aquifer. The water table in the aquifer ranged from about 3 to 7 feet above sea level in the interior of the island to less than 1 to 2.5 feet above sea level near the coast (fig. 6). Water levels fluctuated in response to diurnal tides from about 1 foot near the coast to less than 0.1 foot near the center of the island (fig. 7). The aquifer is recharged by rainfall, and water discharges from the aquifer by seepage to the ocean, evapotranspiration, and pumpage. Ground-water flow is generally from the center of the island to the surrounding surface water bodies (fig. 8).

WATER QUALITY

The chemical composition of ground water in the study area is the principal constraint on development and management of this resource. In terms of a potable water supply for the area, the water-table aquifer is the only source with a chloride concentration less than the limit set by the secondary drinking water standards (U.S. Environmental Protection Agency, 1986a). Water from the aquifer commonly contains concentrations of iron that are greater than drinking water standards. The chemical analyses of selected water samples collected as part of this study are tabulated in table 2.

Water in the water-table aquifer is generally low in dissolved solids except near the coast where it contains brackish water (fig. 9). The chemical composition of water in the aquifer is primarily controlled by the salt content of dry fallout, rain which recharges the aquifer, and the sea spray which probably affects the entire ground-water system of the island. Storm surge and an uncapped flowing well (52) tapping the deep sand are probably the sources of the higher chlorides near the eastern end of the island. Dissolved chloride concentrations of 310 and 550 mg/L were found in the two southeasternmost test wells (wells 54 and 55) (figs. 2 and 9).

Near the coast and near drainage ditches containing brackish water affected by tides, wells are subject to contamination due to natural mixing of water (fig. 9). Water from test wells 1 and 51 (fig. 2) are near the coast and had dissolved chloride concentrations of 1,700 and 5,500 mg/L, respectively. Water from test wells 7 and 24 (fig. 2), located near lowland areas and drainage ditches affected by tides, had chloride concentrations of 430 and 270 mg/L, respectively.

Differences in the quality of water in the water-table aquifer and the shallow sand aquifer indicate that the aquifers are separate units. Test wells 6, 16, and 29 are screened about 100 feet below land surface in the shallow sand aquifer and their corresponding shallow test wells, 5, 17, and 30, are screened at about 30 feet below land surface in the water-table aquifer (table 2). Chloride concentrations in test wells 29 and 30 were 390 and 43 mg/L. Test wells 6 and 5 had chloride concentrations of 610 and 90 mg/L, and 16 and 17 were 83 and 30 mg/L. The chloride concentrations in test well 16 were lower than anticipated and is probably related to runoff entering the top of the casing during periods of heavy rainfall. This is supported by specific conductance values measured in the wells (table 3).

Water in the water-table aquifer has dissolved iron concentrations exceeding the U.S. Environmental Protection Agency recommended limits for drinking water of 300 ug/L (micrograms per liter) (1986b) (table 2 and fig. 10). The objections to iron in excess of the limit specified are not physiological but aesthetic and practical. Iron may cause stains on clothes and plumbing fixtures. Dissolved iron is easily removed by aeration and filtration. Dissolved iron in the water-table aquifer may be related to organic rich sediments in the aquifer and can vary over short distances. Wells 42 and 43 are screened from 27 to 30 feet below land surface and well 41 is screened from 20 to 30 feet below land surface. The wells are about 30 feet apart horizontally. The total iron concentrations in water from test wells 42, 43, and 41 were 21,000 ug/L, 8,000 ug/L, and 2,800 ug/L, respectively. Total iron concentration in water-table aquifer wells ranged from 540 ug/L in water from well 22 on April 15, 1986 to 36,000 ug/L in water from test well 5 on March 12, 1986.

Water levels declined in the water-table aquifer during the March to May 1986 period (fig. 6), and chlorides generally increased as indicated by wells 3, 5, 14, and 22 (table 2). On March 10, 1986, the public water-supply storage tank overflowed. The water in the storage tank was pumped from the shallow sand aquifer. Specific conductances greater than 1,000 uS/cm were measured in the source wells in November 1984. During the long-term aquifer test (April 8 through May 5, 1986) much of this overflow water was removed as over 2.8 Mgal of water was pumped from test well 10. Wells 10, 11, 13, and possibly 21 were affected by the overflow as indicated by decreasing specific conductance values from March to May (table 2). Also, chloride concentrations from March to May decreased in wells 11, 13, and 21.

Prior to the 26-day aquifer test (April 9 through May 5) water samples were collected March 11 through 13, 1986 from 19 wells completed in the water-table aquifer. Nine of these wells were sampled during the test (table 2).

Dissolved chlorides in water from the nine wells sampled on March 11 through 13, April 24, and May 2 through 5 increased in five wells, decreased in three wells, and did not change in one well. The greatest increase occurred in well 10 with an increase from 100 mg/L on March 11 to 150 mg/L on May 5. The greatest decrease in dissolved chloride concentration occurred in well 11 with a decrease from 210 mg/L on March 11 to 64 mg/L on May 2. The relatively small changes in dissolved chloride concentrations during the aquifer test indicate that no upconing of saltwater through the underlying clay occurred.

Total iron concentrations, from eight wells sampled about half-way through the 26-day test (April 24), decreased in six wells and increased in two wells. Well 10 (fig. 2) decreased in total iron from 6,100 ug/L on

March 11 to 2,700 ug/L on May 5, at the end of the test. Changes in total iron concentrations are probably related to mixing of water during the test or movement of water toward the pumped well.

GROUND-WATER FLOW SIMULATION

The finite-difference, two-dimensional, digital model used to simulate the water-table aquifer flow system was developed by the U.S. Geological Survey (McDonald and Harbaugh, 1984). A two-dimensional simulation was used because geological and hydrological data indicated that the water-table aquifer is a two-dimensional system. Test drilling showed that 20 feet of dense plastic marine clay underlies the water-table aquifer and vertical flow through the clay layer was considered negligible. A comparison of water-level altitudes and specific conductances indicated the water-table aquifer is a separate hydrological unit (table 3). Water levels and specific conductance values measured in wells screened in water-table aquifer near the coast showed that discharge is occurring offshore. Water levels in well 23, located about 50 feet from the coast, are generally 0.5 feet higher than surface water levels and specific conductance values ranged from 530 to 760 uS/cm from January 1985 to April 1986 (fig. 7 and table 3). During the 26-day aquifer test, only small increases in dissolved chloride concentrations occurred in the production well and observation wells, indicating hydraulic separation of the water-table and shallow sand aquifers. No drawdown occurred in wells screened in the shallow sand aquifer during the 48-hour aquifer test on the water-table aquifer.

A map of the study area was overlain with a grid of square blocks (fig. 11). In each block, the aquifer properties are assumed to be uniform. The center of each block is called a node. The block dimensions were 120 feet on a side. The grid consists of a two-dimensional system of nodes numbering 70 (north to south) and 170 (west to east). The grid extended offshore to allow for aquifer discharge into the surrounding surface water. The nodes offshore are head-dependent flux nodes used to simulate the discharge offshore (fig. 11). To be conservative, no-flow boundaries were assigned to terminate lateral ground-water flow at the western end of the study area where Dauphin Island narrows to a width of about 1,000 feet and at the northwestern peninsula which is less than 500 feet in width (fig. 11). These boundary conditions were used during steady-state and transient simulations.

Data Input

The digital model simulates ground-water flow from its point of recharge through the water table and the aquifer, to its discharge points through the sea floor into the ocean (fig. 12). The parameters used in the model are: (1) recharge to the aquifer, (2) aquifer saturated thickness, (3) aquifer hydraulic conductivity and (4) vertical leakage. The vertical leakage parameter is the amount of water exchanged between the aquifer and the surrounding surface water bodies through the sea floor. Vertical leakage is leakance (K'/b), where b is thickness of the sea floor and K' is the vertical hydraulic conductivity, plus the difference in head values between the aquifer and the surface water bodies. This is the same parameter as leakage through a reach of river bed described by McDonald and Harbaugh (1984).

Recharge rates were obtained from previous studies in south Alabama (Riccio and others, 1973). A recharge rate of 20 in/yr (inches per year) (about 30 percent of mean annual rainfall) was used as an initial estimate. Rain gages installed near recording wells also gave an indication of recharge by comparing water-table fluctuations to rainfall.

The saturated aquifer thickness was determined from data obtained during test drilling, from geophysical logs, and water level measurements. The aquifer thickness ranged from 28 to 35 feet. To produce an average saturated thickness of 30 feet for the model, the base of the aquifer was set at 25 feet below sea level.

The average hydraulic conductivity of the aquifer was determined from two aquifer tests. A 48-hour test in the east-central part of the island (well 41) and a 26-day test in the west-central part of the island (well 10) indicated that aquifer hydraulic conductivity ranged from about 45 to 60 ft/d. This range of conductivity values was used in the model calibrations. Specific yield values ranging from 0.03 to 0.15 were used in the transient model. In the steady-state simulation, the effects of storage are not considered.

Vertical leakage between the aquifer and surface water bodies could not be physically measured. The leakage value used in the model was determined by varying the value until the simulated ground-water discharge occurred several hundred feet offshore. As will be shown in the sensitivity analysis, the model calibration was relatively insensitive to changes in the vertical leakage.

Steady-State Model Calibration

The model was calibrated to the water-level conditions of July 1985 when minimum heads could be simulated to test "worst-case conditions" to allow conservative estimates to be made for water-level declines. The calibration consisted of independently adjusting model parameters (recharge, hydraulic conductivity, and vertical leakage) through expected ranges of values until an optimum match of computed and observed heads was obtained. The only stresses in the model are those of naturally occurring recharge and discharge. Values of vertical leakage were adjusted most. Aquifer hydraulic conductivities were adjusted through the range of values determined from the aquifer tests.

Dewatering of parts of the aquifer during construction of a sewage system precluded use of head data from some wells for comparison with computed heads. Water levels were measured in 18 wells and 30 percent (6 of 18) were within 0.3 foot of the computed heads. All (18 of 18) of the measured water levels were within 1.0 foot of the computed water levels. The steady-state model, calibrated to heads in wells in July 1985, required specification of a recharge rate of 15 in/yr.

To provide near-saturated conditions in the water-table aquifer, which would be more like the initial conditions that were needed for the transient model, the model was calibrated under steady-state conditions to the April 1985 heads. Recharge in the calibrated model was increased to 20 in/yr and the computed heads were matched to observed heads in 15 wells in April 1985 when water levels were high. The water table was above land surface at some wells in April and heads of those wells were not used. Sixty percent (9 of 15) of measured water levels were within 0.5 foot of the simulated water levels. All (15 of 15) of the measured water levels were within 1.0 foot of the computed water levels. Table 4 shows the comparisons and figure 13 shows the simulated water-table elevation contours.

Within the constraints of modeling, and having only the aquifer transmissivity, vertical leakage and recharge variables to change, a totally unique solution is not assured. However, the results of aquifer tests indicate that the aquifer properties are consistent from one end of the island to the other. On the basis of test drilling and depositional environment, the water-table aquifer is a relatively uniform system.

Transient Model Calibration

The transient model was calibrated to simulate the natural discharge conditions for two stress periods, April 2 through May 22, 1985, and May 22 through June 15, 1985. Water levels were measured in 17 wells at the beginning and end of each stress period. This period was selected for calibration because it represented natural decline of heads in the water-table aquifer from seasonally high water levels. The total average head change in test wells was about 3 feet during the simulation periods and no appreciable recharge occurred.

The steady-state model, calibrated to April 1985 heads, was used to develop the transient model. The heads, boundary conditions, and parameters obtained in the steady-state model were used as initial conditions in the transient model except for recharge which was set to zero to simulate actual conditions of no rain for those periods. The model was calibrated by varying the specific yield and comparing the pattern of head changes between the computed and observed water levels. Specific yield values were varied from 0.03 to 0.15 and a final value of 0.09 was used in the calibrated model. Table 5 shows the comparisons and figures 14 and 15 show the simulated water-table elevation contour for the two stress periods.

Parameter Sensitivity Analysis

Sensitivity to changes in selected hydrologic parameters used in the model was examined by individually changing the input values and observing the resulting changes in hydraulic head. The parameters selected for sensitivity were (1) recharge, (2) aquifer hydraulic conductivity, (3) vertical leakage, and (4) aquifer specific yield. Table 6 shows the range of variation in the input data and the resulting head changes for the steady-state and transient models. The results of this analysis show that the steady-state model calibration is sensitive to changes in aquifer hydraulic conductivity and recharge. The calibrated steady-state model is relatively insensitive to vertical leakage. The calibrated transient model is moderately sensitive to changes in the specific yield of the aquifer.

WATER-SUPPLY POTENTIAL OF THE WATER-TABLE AQUIFER

In the study area, the water-table aquifer is recharged by infiltration of precipitation and discharges to the surface water bodies around the island. Pumping also discharges the aquifer and, as cones of depression are formed around pumping centers, an increasing proportion of water that was formerly discharged to surface water is directed to wells in response to changing hydraulic gradients with time. If the gradient is reversed, flow is induced from the saline surface-water bodies and salty water flows toward the well field. The simulated pumpage schemes were considered feasible if a reduction of discharge to surface water occurred without a reversal of the hydraulic gradient. To insure a sustained potable supply, actual locations of well sites and pumpage rates should require that the gradient reversal not extend beyond the 250 mg/L dissolved chloride contour shown in figure 9.

Saltwater underlying an aquifer, which is in hydraulic contact with the fresh water of the aquifer will rise or upcone in response to lowering of the fresh water heads by pumping in an isotropic aquifer. This upconing, with continued pumping, rises to successively higher levels until eventually it reaches the bottom of the well. Theoretically, saltwater will rise approximately 40 feet for each foot of freshwater drawdown according to Hubbert's relation (Hubbert, 1940). Hydrologic and geologic data indicate that under natural conditions the water-table aquifer on Dauphin Island is hydraulically separated from the underlying sand aquifer and presents a case of an anisotropic aquifer system where no relation between freshwater drawdown and saltwater rise can be determined. However, the thickness and continuity of the clay separating the aquifers are not completely known nor are the hydraulic characteristics of the clay. On the basis of what is known about the clay layer separating the water-table and shallow sand aquifers, the model assumes no upconing will occur and only considers lateral flow.

The model was run for steady-state conditions with pumpage of 50 gal/min (about 0.3 Mgal/d) from each of four wells, with an aquifer recharge rate of 15 in/yr to simulate drier years. A second set of simulations were made with the pumping rate in all four wells increased to 100 gal/min (about 0.6 Mgal/d) which would be more than twice the amount of the present daily average withdrawal. A recharge rate of 15 in/yr was also used with the increased pumpage rates. Figures 16 and 17 show the water-table maps resulting from the simulations. A seaward gradient is maintained in each simulation. Simulated head declines at the pumping nodes suggest the possibility of increases in chloride as a result of water movement from areas containing chloride concentrations greater than 250 mg/L. Dilution of the water containing higher chlorides would probably keep the chloride concentration of the water produced below the 250 mg/L concentration. In the transient model pumpage simulations, eight wells were simulated to decrease the drawdown at each simulated well.

The calibrated transient model was used to evaluate pumpage during periods of no recharge. Two simulations were run, each with eight wells pumping 25 or 50 gal/min for each well which is equivalent to a total of 0.3 Mgal/d and 0.6 Mgal/d, respectively. Two stress periods of 50 and 74 days were simulated in each run to coincide with the dates of water-level measurements in wells that were made for the transient calibration. Figure 18 shows the simulated steady-state configuration of the water table, which is the starting condition for the transient model. Figures 19 and 20 show the simulated configuration of the water table after 50 days of no recharge and 28.8 Mgal of pumpage (0.6 Mgal/d) and 74 days of no recharge and 42.6 Mgal of pumpage (0.6 Mgal/d). Figure 21 shows a superposition of the initial water-table surface and the surface after the second stress period (74 days) with 0.6 Mgal/d pumpage.

All of the transient simulated pumping schemes are feasible on the basis of criteria that a seaward hydraulic gradient is maintained. However, increased chloride concentrations may occur where the radii of influence of pumping wells extend beyond the line of equal 250 mg/L concentration shown in figure 9 or if the confining unit underlying the water-table aquifer and the shallow sand aquifer is breached; this provides hydraulic connection with the underlying shallow sand aquifer.

SUMMARY AND CONCLUSIONS

The principal factor that limits the development of water resources on Dauphin Island is the threat of saltwater contamination. The water-table aquifer is the only source of water with a chloride content below the recommended limit for drinking water.

The water-table aquifer consists of a thin veneer of Holocene sand and the underlying Pleistocene Gulfport Formation. The Holocene sand covers most of the surface of the island, and on the eastern 3 miles of the island it overlies the Gulfport Formation. The surficial sand is fine- to medium-grained quartz and is from 1 to 5 feet thick over most of eastern Dauphin Island.

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 semiconsolidated sands. Test drilling and geophysical logs indicate the Gulfport Formation is about 30 feet thick.

Aquifer tests showed that the hydraulic conductivity was about 45 to 59 ft/d and the specific yield was 0.03 to 0.12. The larger specific yield values obtained in the 26-day test indicated the delayed yield of the water-table aquifer.

Water in the water-table aquifer is generally low in dissolved solids except near the coast where it contains brackish water. The chemical composition of water in the aquifer is primarily controlled by the salt content of dry fallout, rain which recharges the aquifer, the sea spray which probably affects the entire ground-water system in the island. Storm surge and an uncapped flowing well (52) tapping the deep sand are probably the sources of the higher chlorides near the eastern end of the island.

Water in the water-table aquifer has dissolved iron concentrations exceeding the U.S. Environmental Protection Agency recommended limits for drinking water of 300 ug/L. Dissolved iron in the water-table aquifer may be related to organic rich sediments in the aquifer and can vary over short distances.

The water table in the aquifer ranged from about 3 to 7 feet above sea level in the interior of the island to less than 1 to 2.5 feet above sea level near the coast. Water levels fluctuated in response to diurnal tides from about 1 foot near the coast to less than 0.1 foot near the center of the island. The aquifer is recharged by rainfall, and water discharges from the aquifer by seepage to the ocean, evapotranspiration, and pumpage. Ground-water flow is generally from the center of the island to the surrounding surface water bodies.

The results of the model have shown that eight wells, each pumping 50 gal/min, can produce 0.6 Mgal/d without causing lateral encroachment of seawater. The accuracy of the model results is limited by the accuracy of the input data that describe aquifer properties, recharge rates, and boundary conditions. The model may need to be recalibrated to improve accuracy as additional data become available.

The test wells drilled during this project provide a network for a water-level and water-quality data collection program. Continued monitoring of water-level changes and water-quality changes in response to natural and man-caused stresses on the hydrologic system will help improve the model and its usefulness. Also, data that define the geometry and water quality of the water-table aquifer and the underlying clay near the western and eastern ends of the study area are needed.

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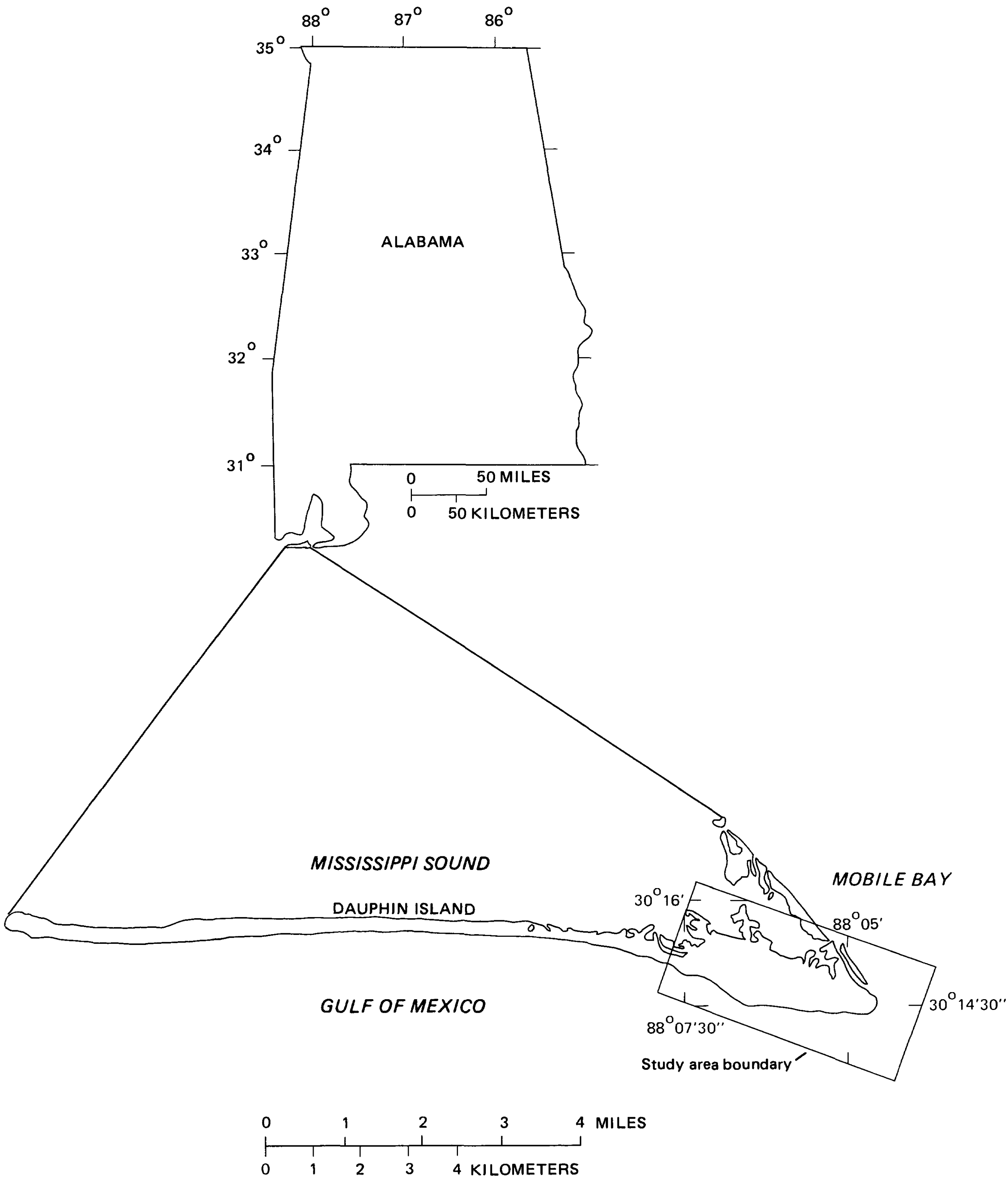
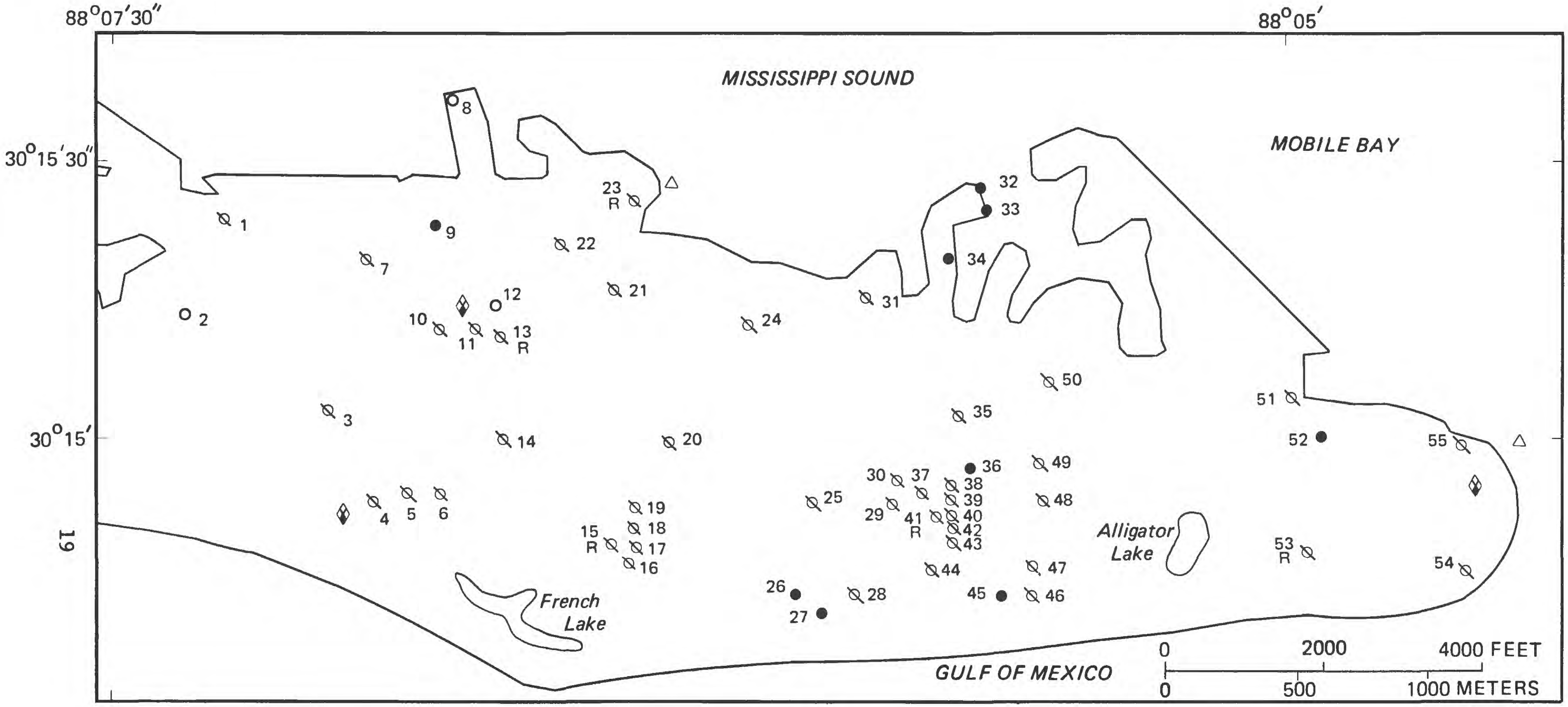


Figure 1.--Location of the study area.



EXPLANATION

- ○2 PUBLIC SUPPLY WELL AND NUMBER
- ●9 DOMESTIC WELL AND NUMBER
- Ø1 STUDY WELL AND NUMBER
- Ø13 R WELL EQUIPPED WITH RECORDER AND NUMBER
- ◈ PRECIPITATION STATION
- △ TIDE GAUGE

Well numbers refer to table 1.

Figure 2.--Location of data sites.

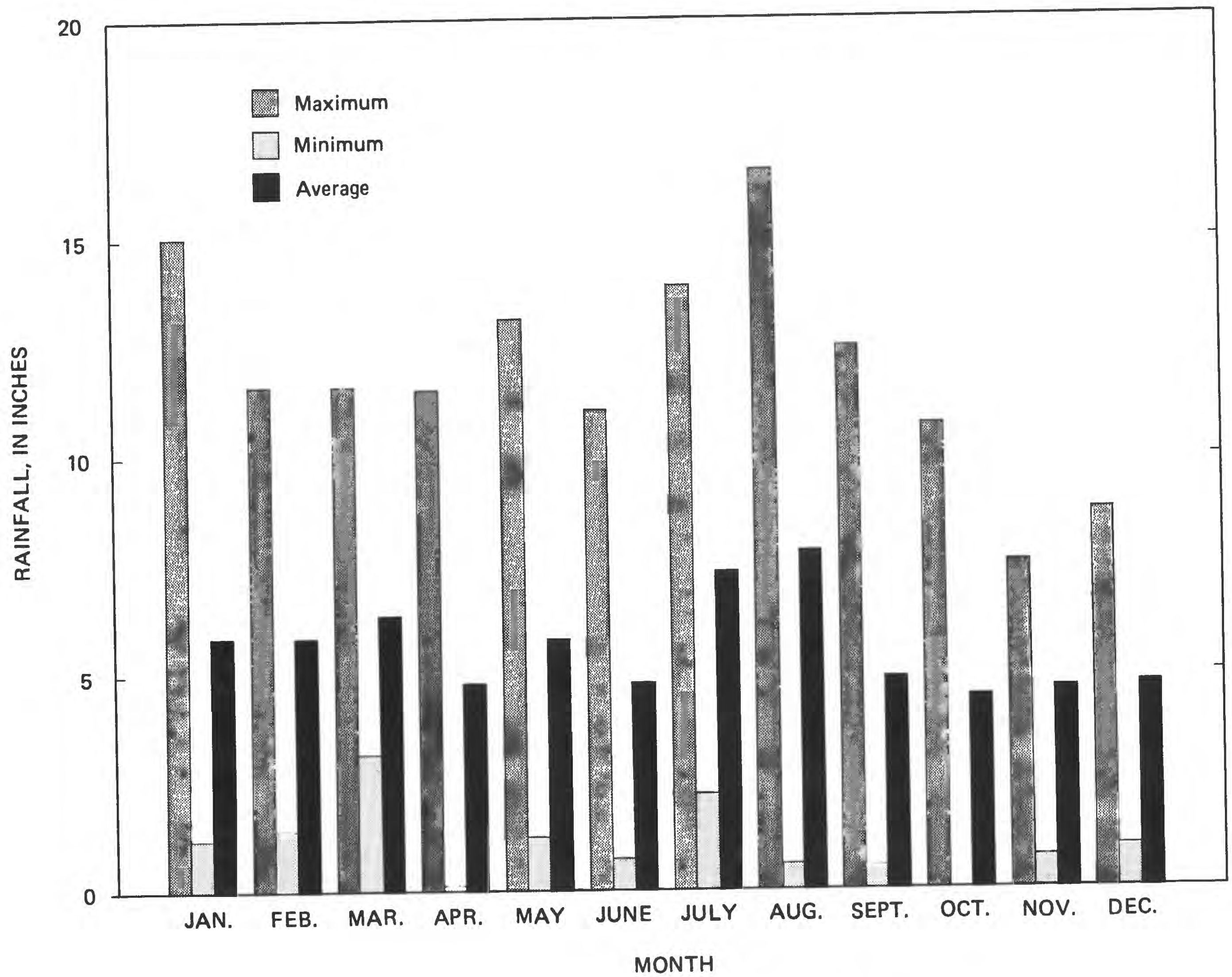


Figure 3.--Maximum, minimum and average monthly rainfall, 1975 - 85.

<table>
<tr><th rowspan="2">EPOCH</th><th colspan="2">Otvos (1979)</th><th colspan="2">Chandler and Moore (1983)</th><th colspan="2">This Report</th></tr>
<tr><th>Formation</th><th>Aquifer</th><th>Formation</th><th>Aquifer</th><th>Formation</th><th>Aquifer</th></tr>
<tr><td>Holocene</td><td>Holocene deposits</td><td rowspan="6"></td><td rowspan="4">Holocene Pleistocene undifferentiated</td><td rowspan="4">Pleistocene - Holocene Interval</td><td>Holocene sand</td><td rowspan="2">Water-table</td></tr>
<tr><td rowspan="3">Pleistocene</td><td>Gulfport Formation</td><td>Gulfport[1] Formation</td></tr>
<tr><td rowspan="2">Pre-Holocene deposits</td><td>Pleistocene clay</td><td>Confining unit</td></tr>
<tr><td>Pleistocene sand</td><td rowspan="2">Shallow sand</td></tr>
<tr><td rowspan="2">Miocene</td><td rowspan="2"></td><td rowspan="2">Miocene undifferentiated</td><td>Shallow Miocene Siliciclastic Interval</td><td rowspan="2">Miocene undifferentiated</td></tr>
<tr><td>Deep Miocene Siliciclastic Interval</td><td>Deep sand</td></tr>
</table>

[1] Local usage, first described by Otvos in 1973 (Luttrell and others, 1981)

Figure 4.--Comparisons of geologic and hydrologic units with those in previous reports.

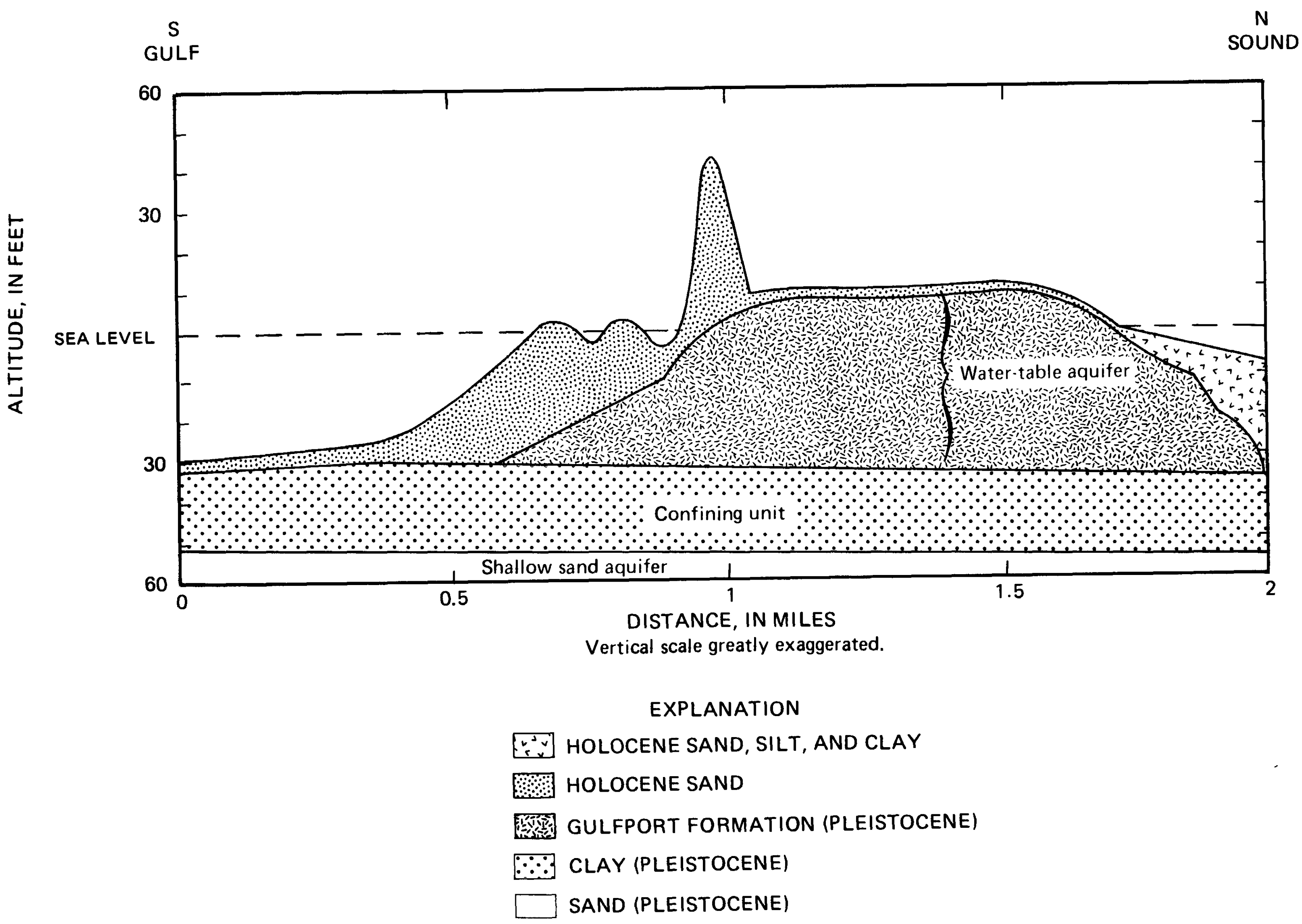


Figure 5.--Generalized south-north hydrogeologic section of Dauphin Island (modified from Otvos, 1985b)

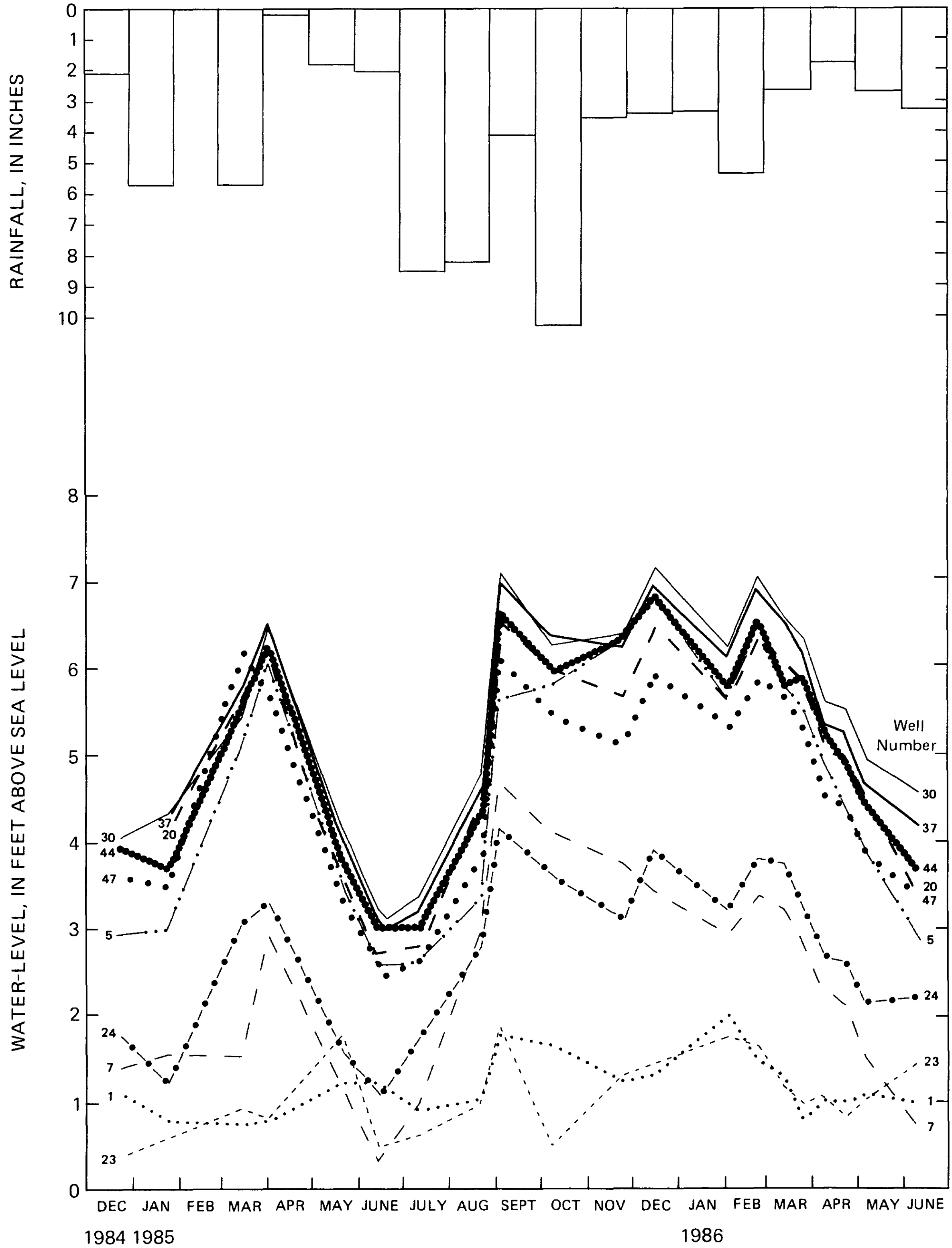


Figure 6.--Monthly rainfall and hydrographs of water levels in selected wells, December 1984–June 1986.

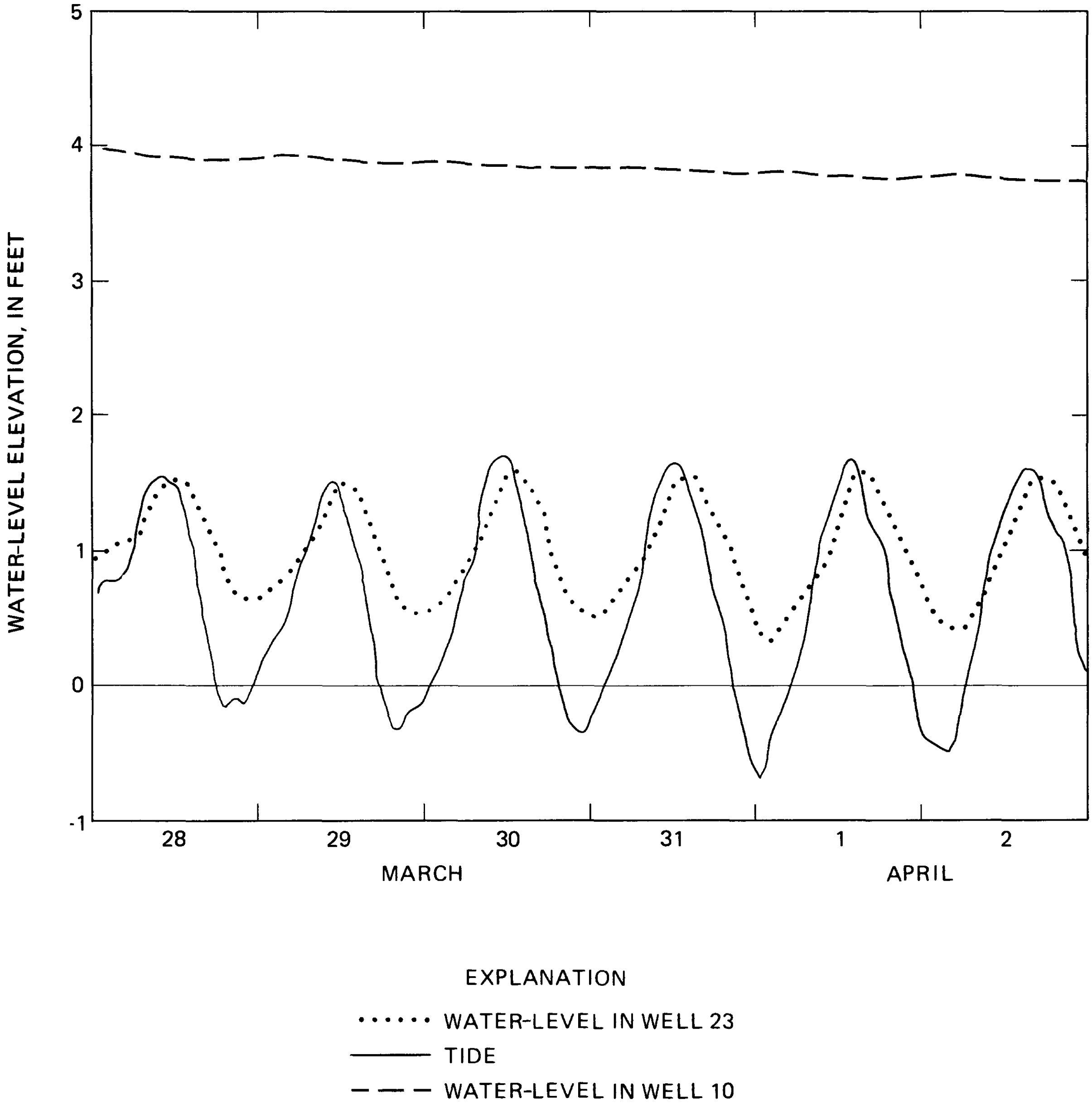
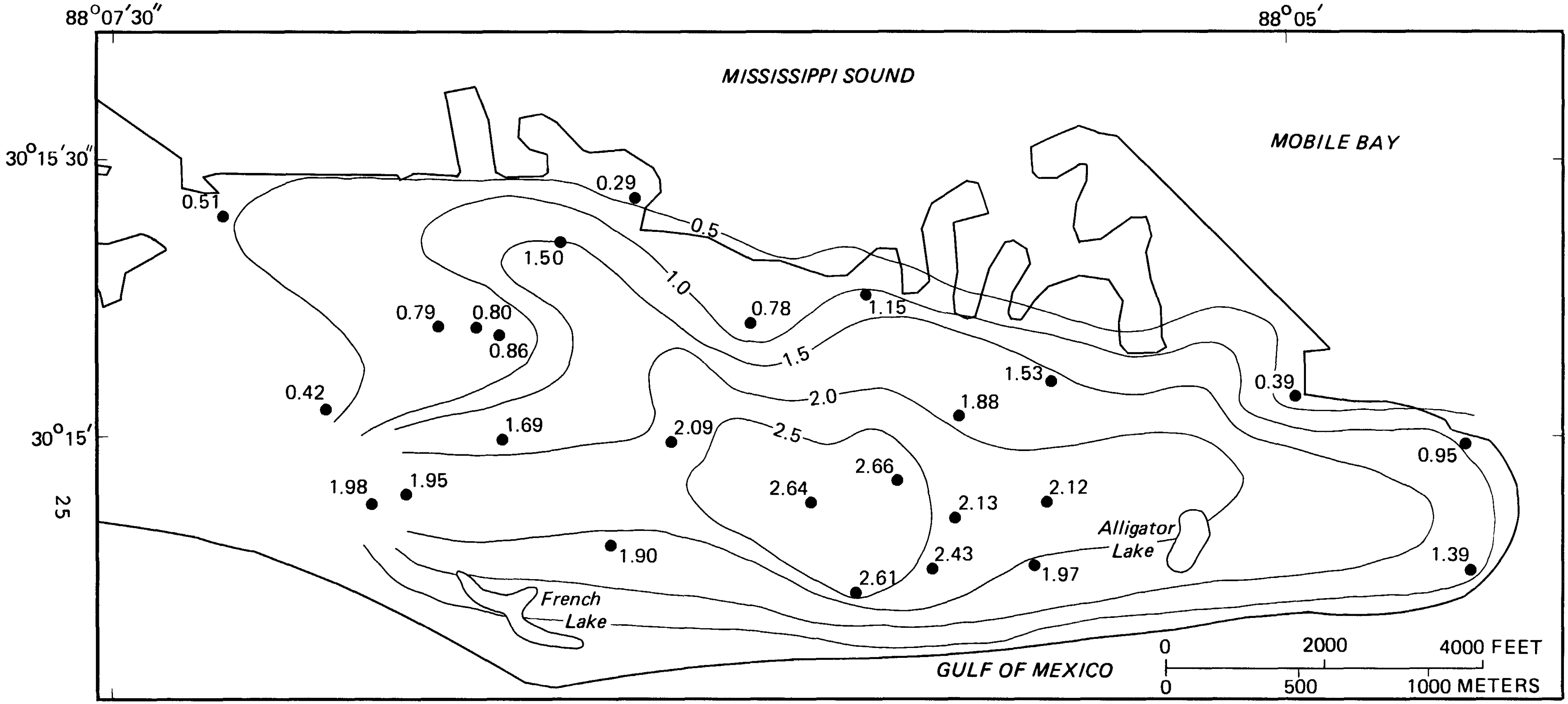


Figure 7.--Hydrographs of water-level elevations in test wells 10 and 23 corresponding to tidal fluctuations, March 28 - April 2, 1986.

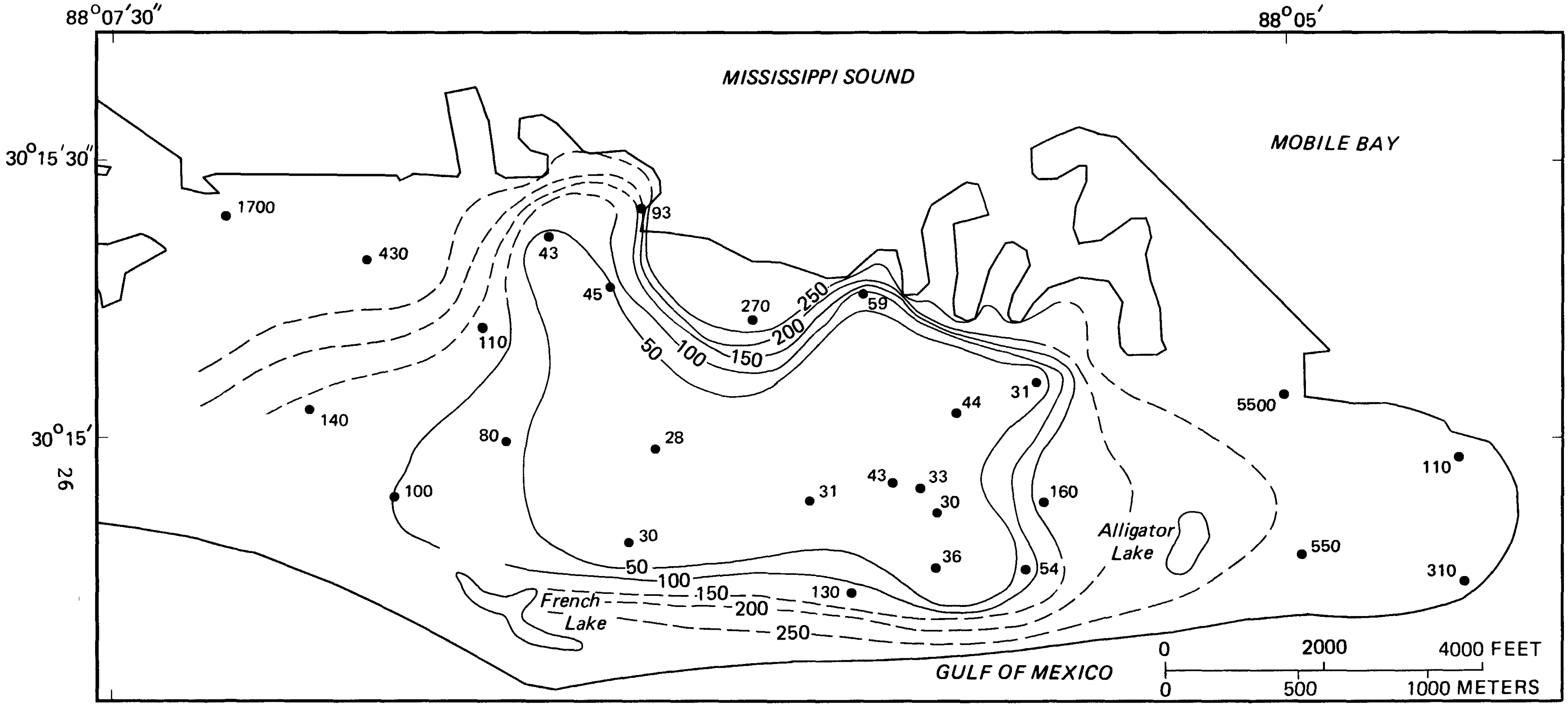


EXPLANATION

—1.0— WATER-TABLE CONTOUR -- Shows altitude of water table. Contour interval 0.50 feet. Datum is sea level

● 0.78 OBSERVATION WELL AND WATER-TABLE ALTITUDE MEASURED ON JULY 29, 1986

Figure 8.--Water-table altitudes, July 29, 1986.

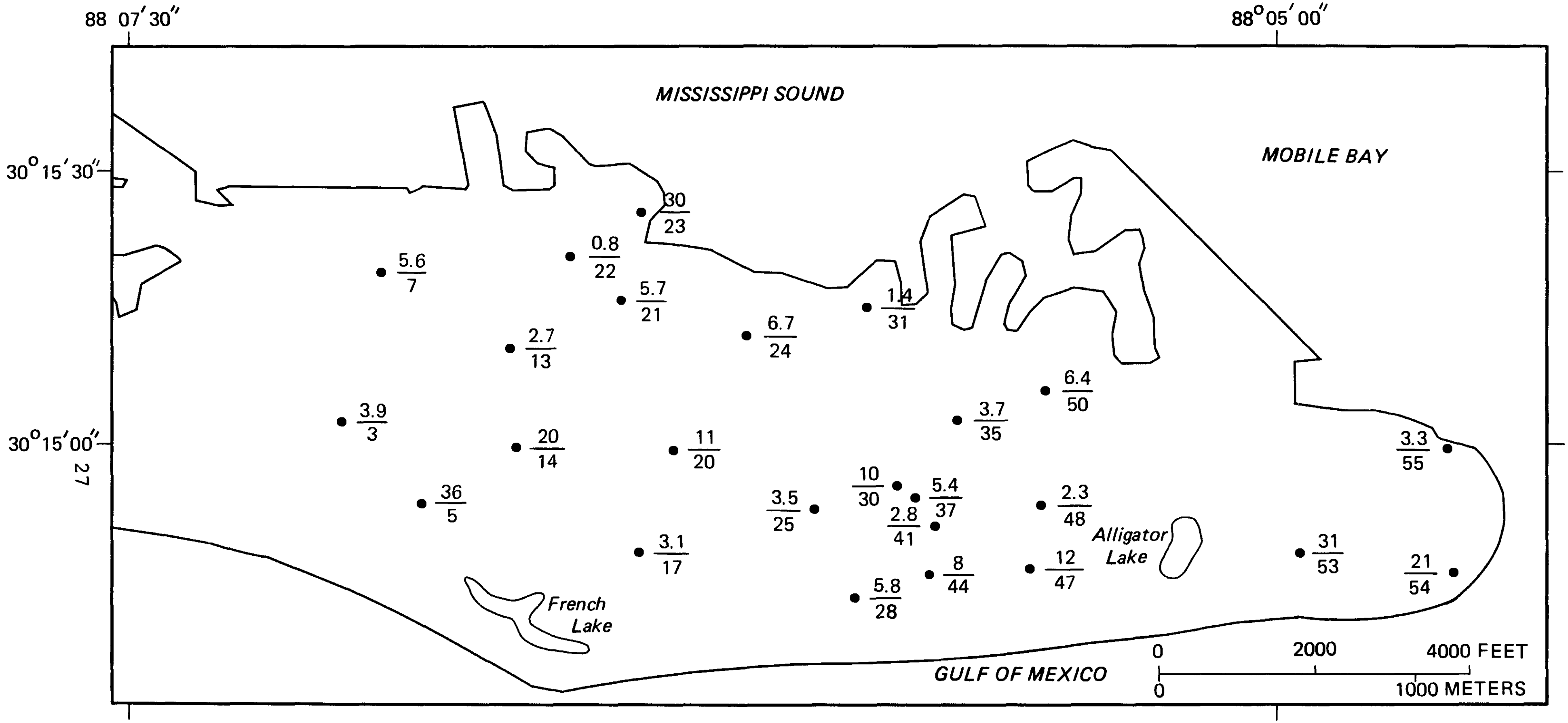


EXPLANATION

—100 - - LINE OF EQUAL CHLORIDE CONCENTRATION -- Dashed where approximately located. Interval 50 milligrams per liter

•30 CHLORIDE CONCENTRATION, IN MILLIGRAMS PER LITER

Figure 9.--Chloride concentrations in the water-table aquifer, March or May 1986.



EXPLANATION

● 5.6 / 7 TOTAL IRON CONCENTRATION IN 1,000 MICROGRAMS PER LITER
WELL SITE AND NUMBER

Figure 10.--Total iron concentrations in selected wells in the water-table aquifer, March or May 1986.

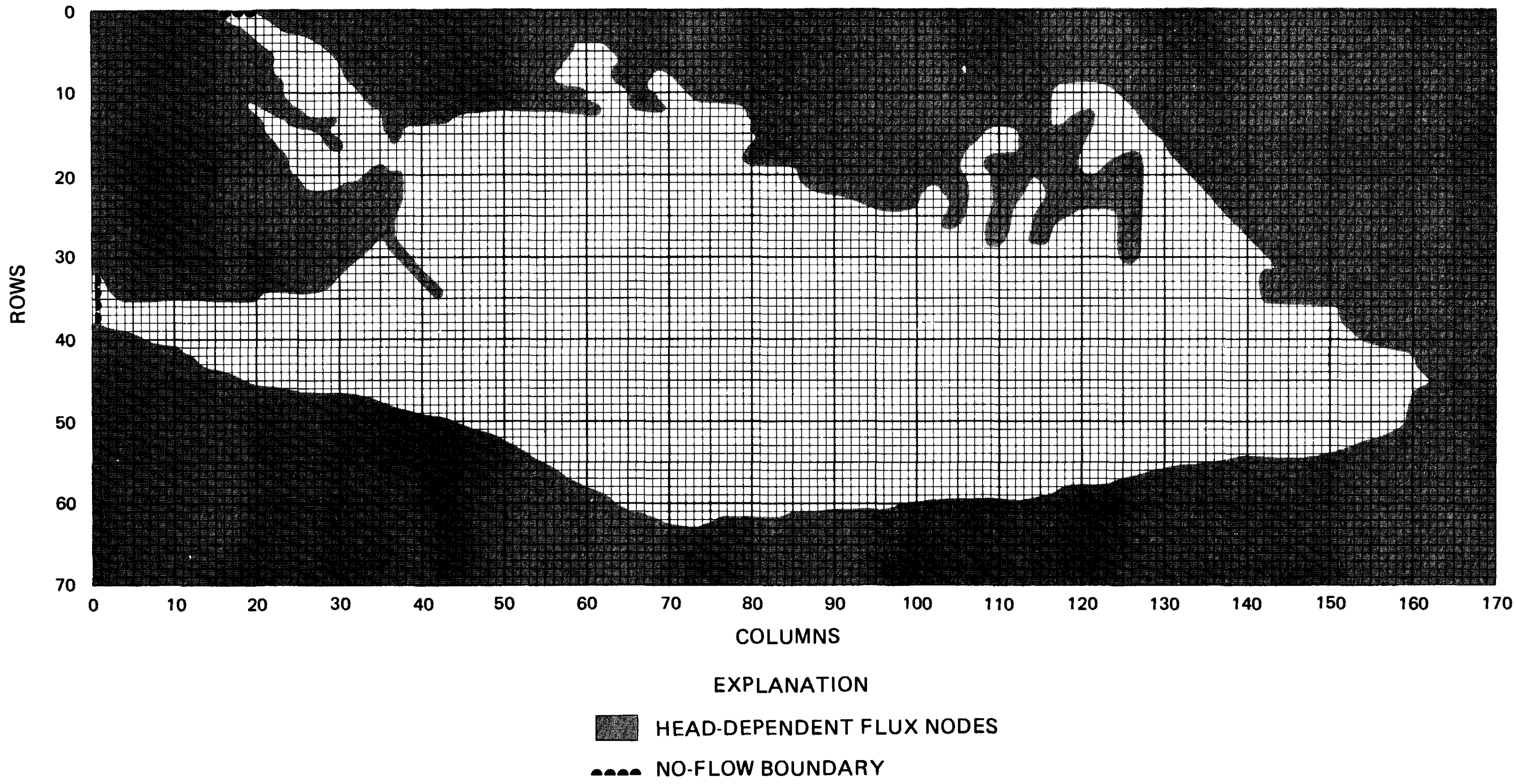


Figure 11.--Digital model grid of the water-table aquifer.

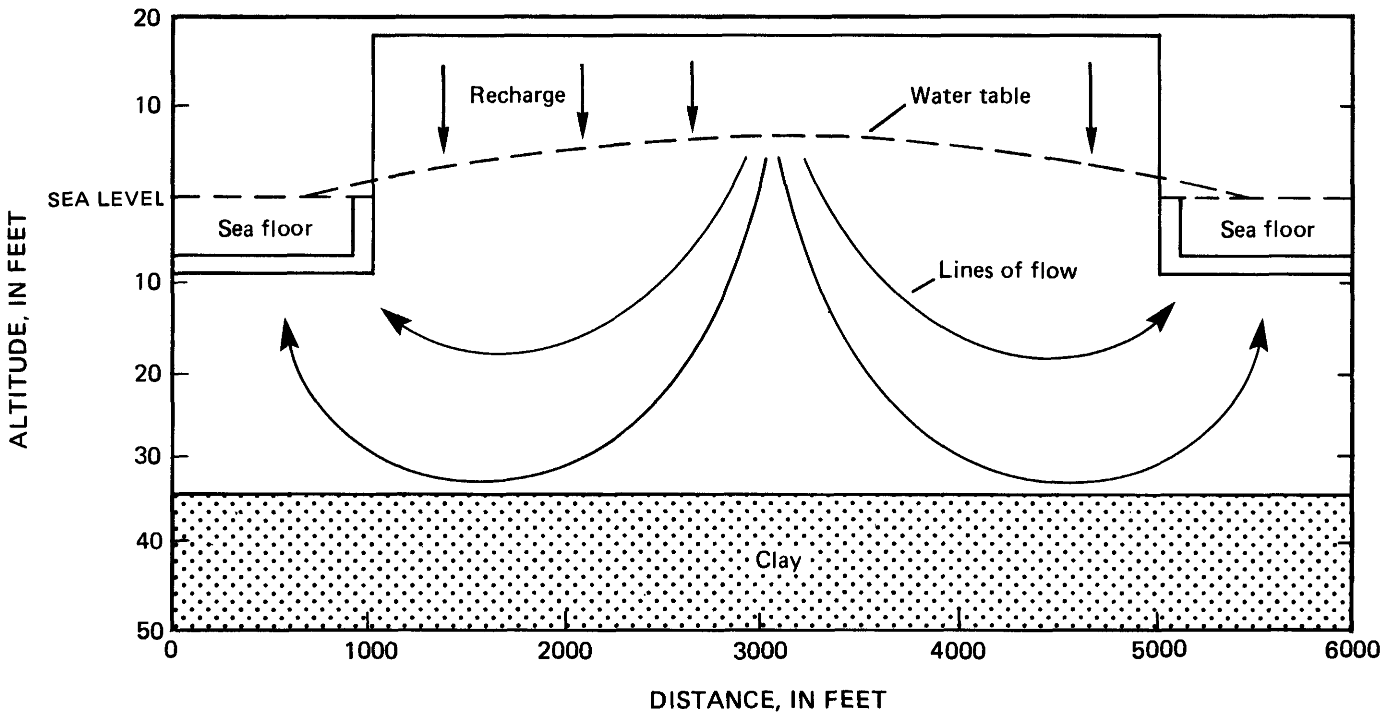
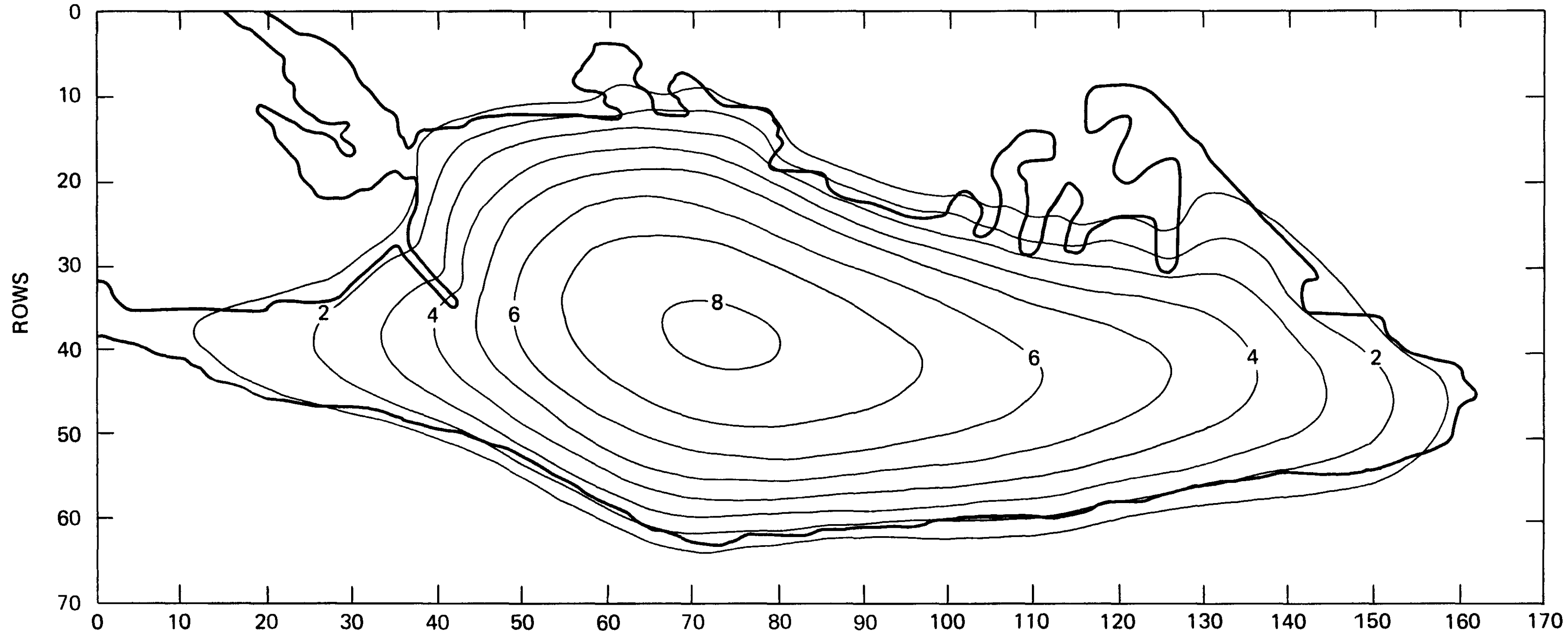


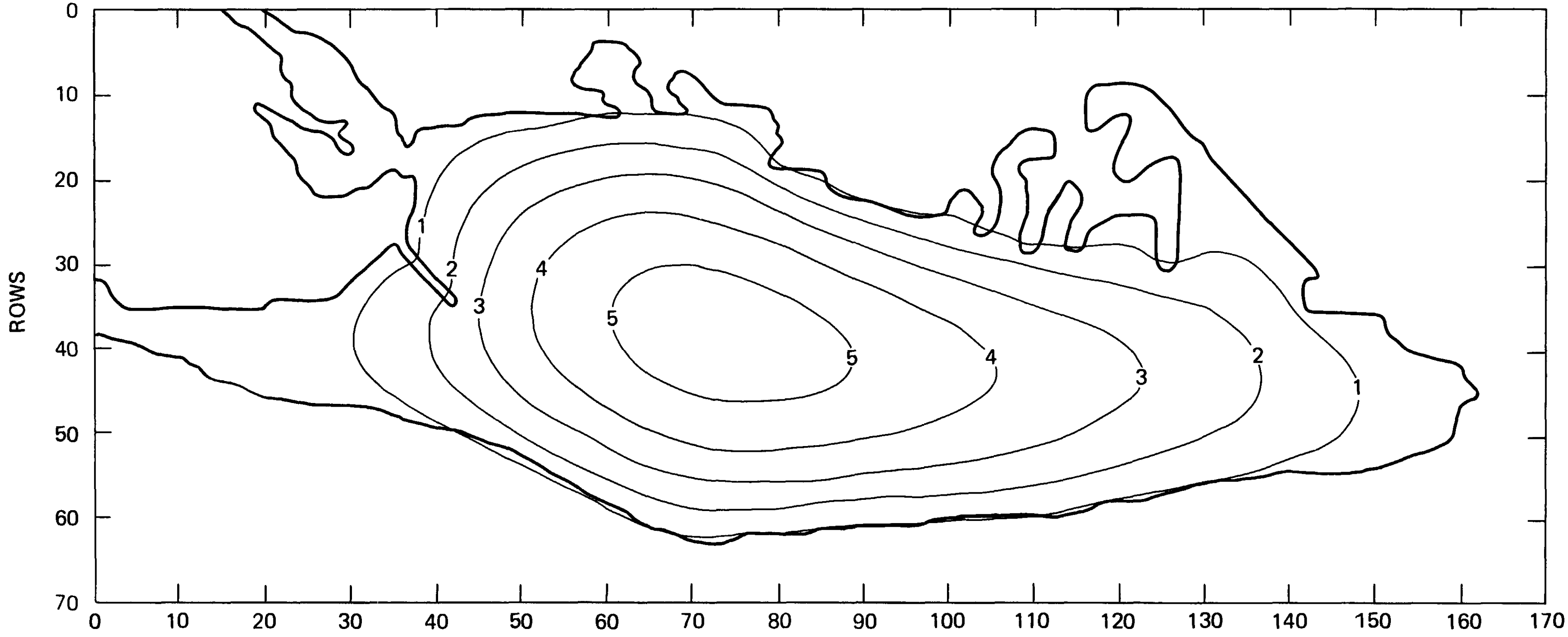
Figure 12.--Generalized north-south section through model showing lines of flow.



EXPLANATION

—8— WATER-LEVEL CONTOUR -- Contour interval 1 foot. Grid scale 120 feet per column or row. Datum is sea level

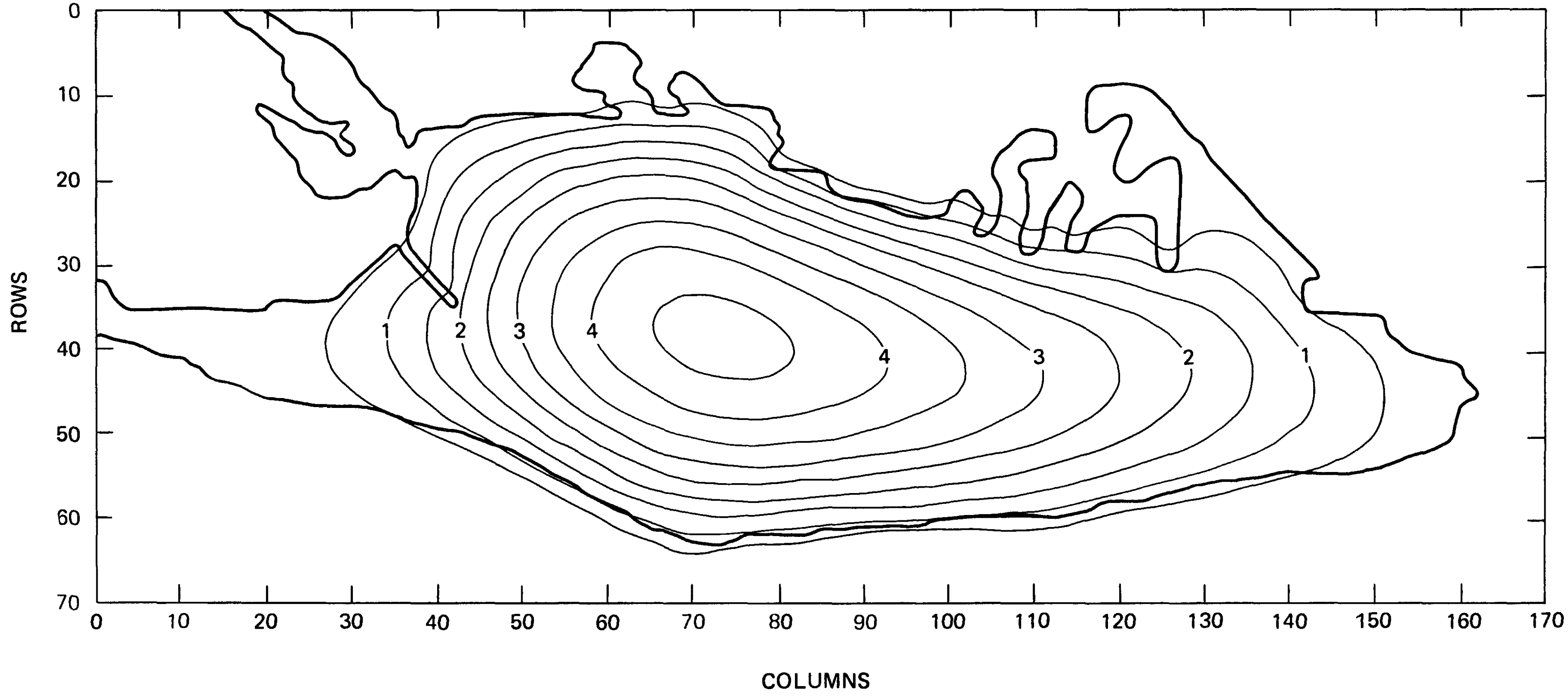
Figure 13.--Simulated steady-state water-table altitude, April 2, 1985.



EXPLANATION

—3— WATER-LEVEL CONTOUR -- Contour interval 1 foot. Grid scale 120 feet per column or row. Datum is sea level

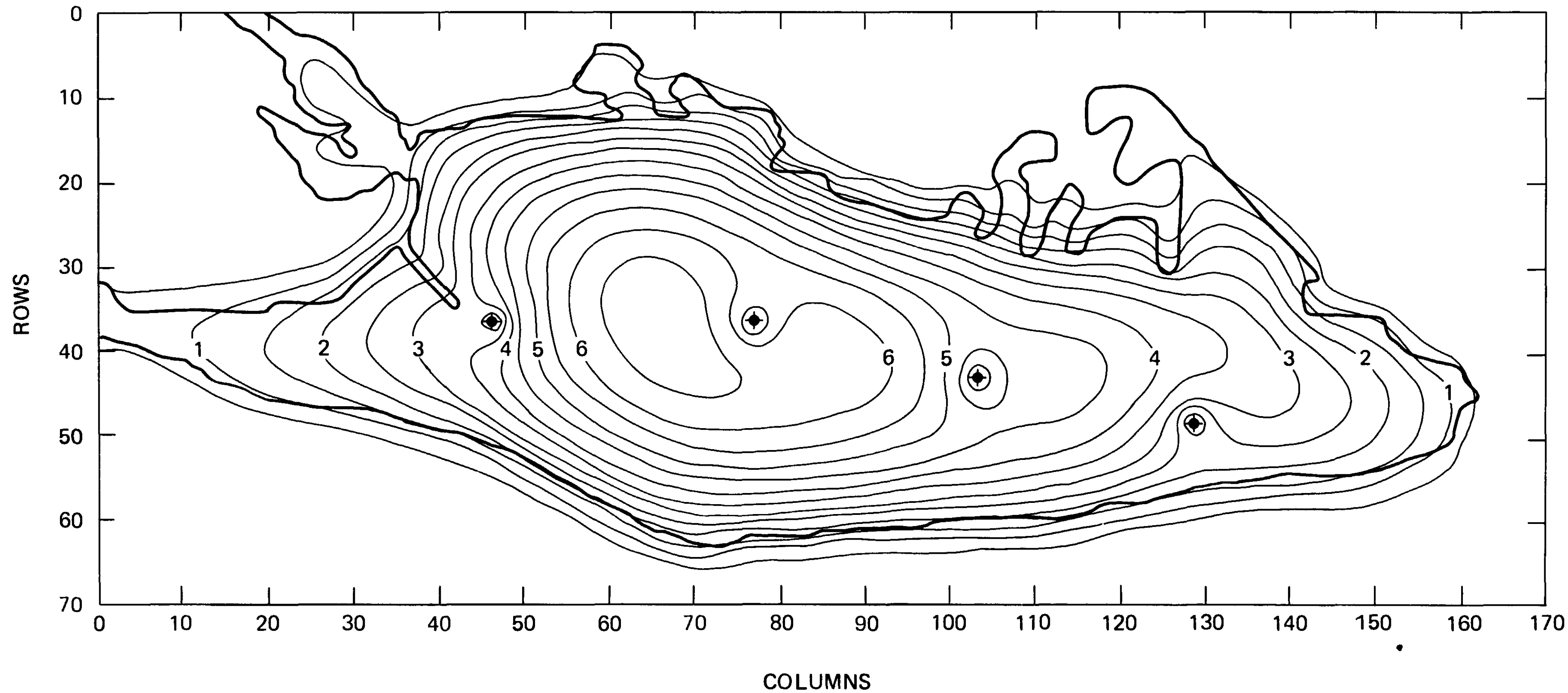
Figure 14.--Simulated water-table after April 2 - May 22, 1985, period of no recharge.



EXPLANATION

—3— WATER-LEVEL CONTOUR -- Contour interval 0.5 foot. Grid scale 120 feet per column or row. Datum is sea level

Figure 15.--Simulated water-table after May 22 - June 15, 1985, period of no recharge.

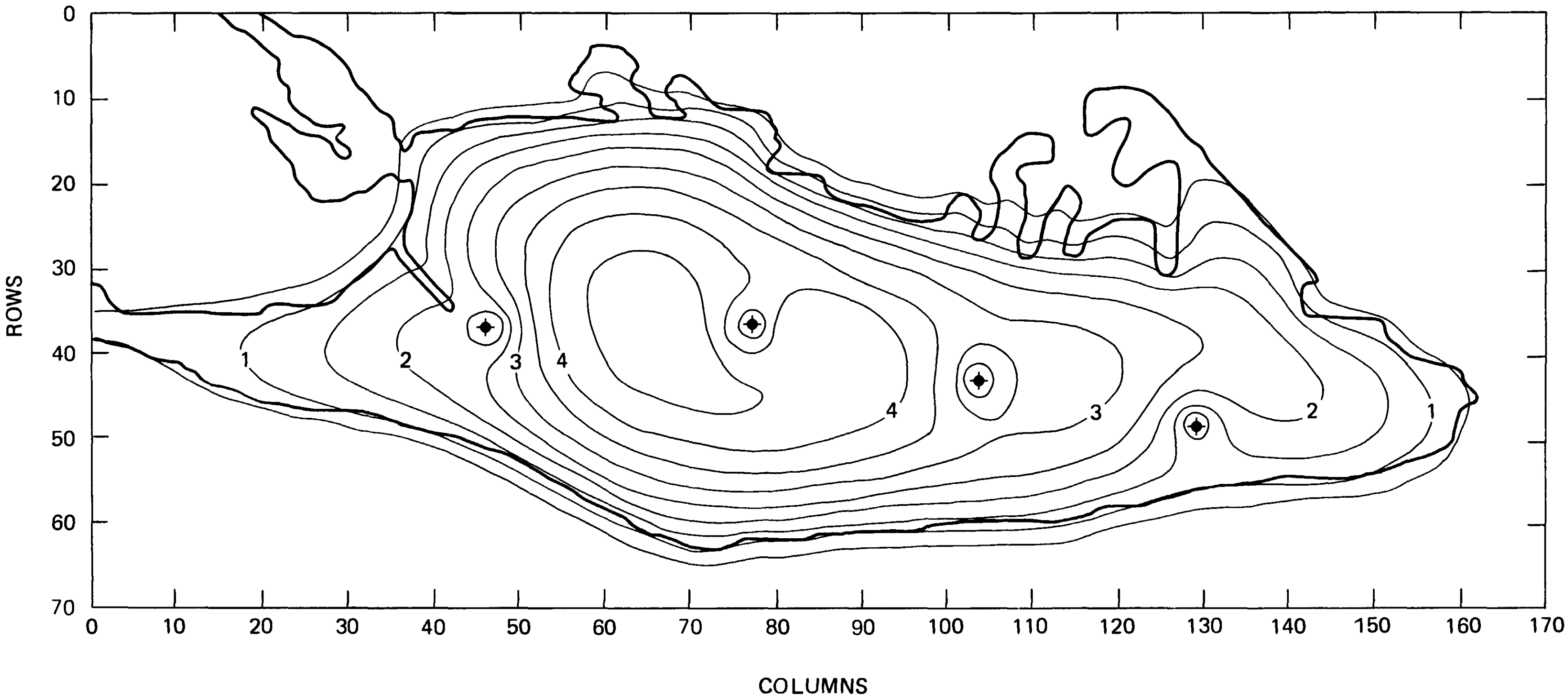


EXPLANATION

—3— WATER-LEVEL CONTOUR -- Contour interval 0.5 foot. Grid scale 120 feet per column or row. Datum is sea level

◆ NODE WITH SIMULATED PUMPING

Figure 16.--Simulated steady-state water-table altitudes with 0.3 million gallons per day pumpage and 15 inches per year recharge.



EXPLANATION

—3— WATER-LEVEL CONTOUR -- Contour interval 0.5 foot. Grid scale 120 feet per column or row. Datum is sea level

NODE WITH SIMULATED PUMPING

Figure 17.--Simulated steady-state water-table altitudes with 0.6 million gallons per day pumpage and 15 inches per year recharge.

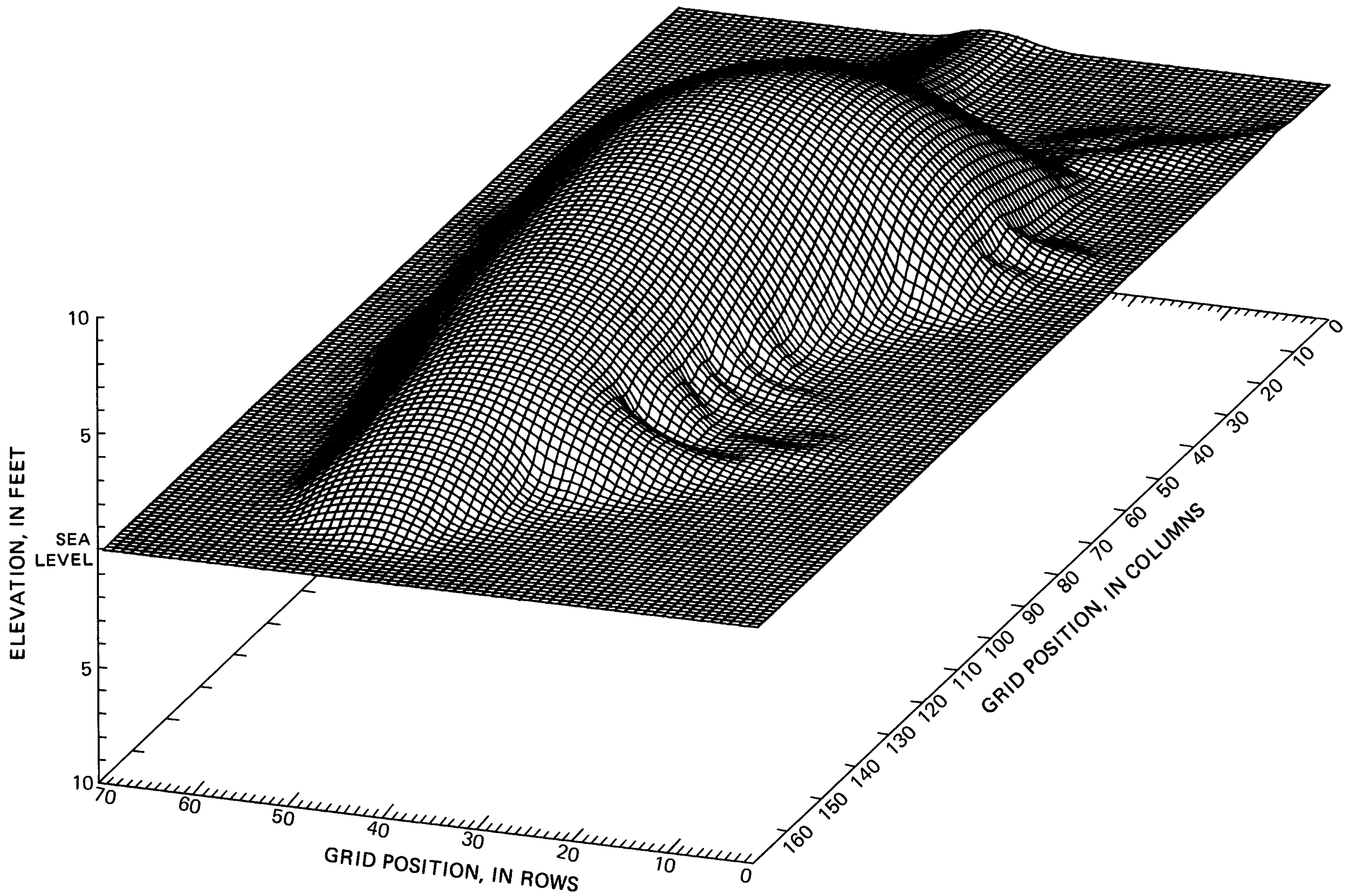


Figure 18.--Simulated steady-state water-table configuration, April 2,1985.

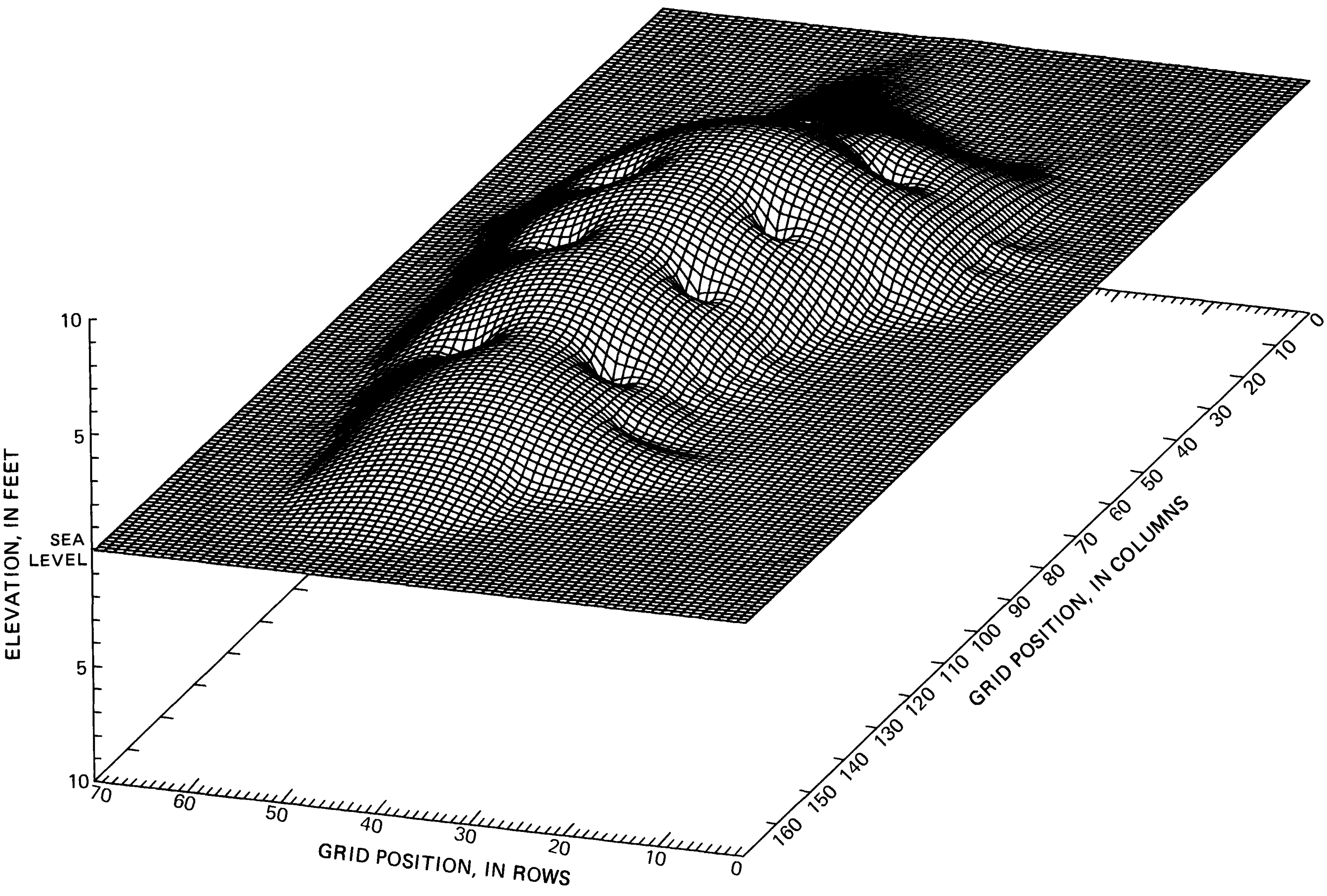


Figure 19.--Simulated water-table configuration after first stress period (April 2 - May 22, 1985) with 0.6 million gallons per day pumpage.

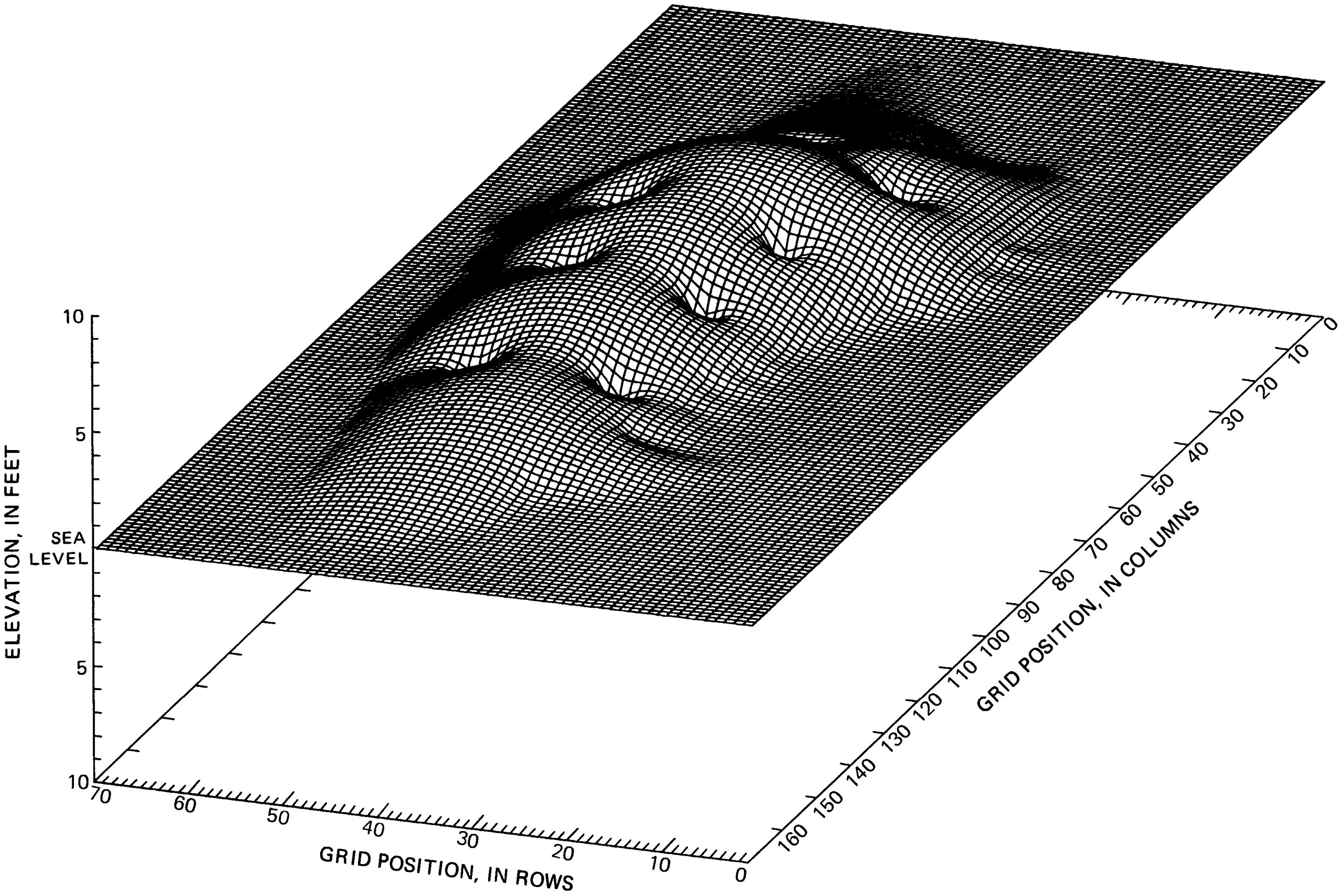


Figure 20.--Simulated water-table configuration after second stress period (May 22 - June 15, 1985) with 0.6 million gallons per day pumpage.

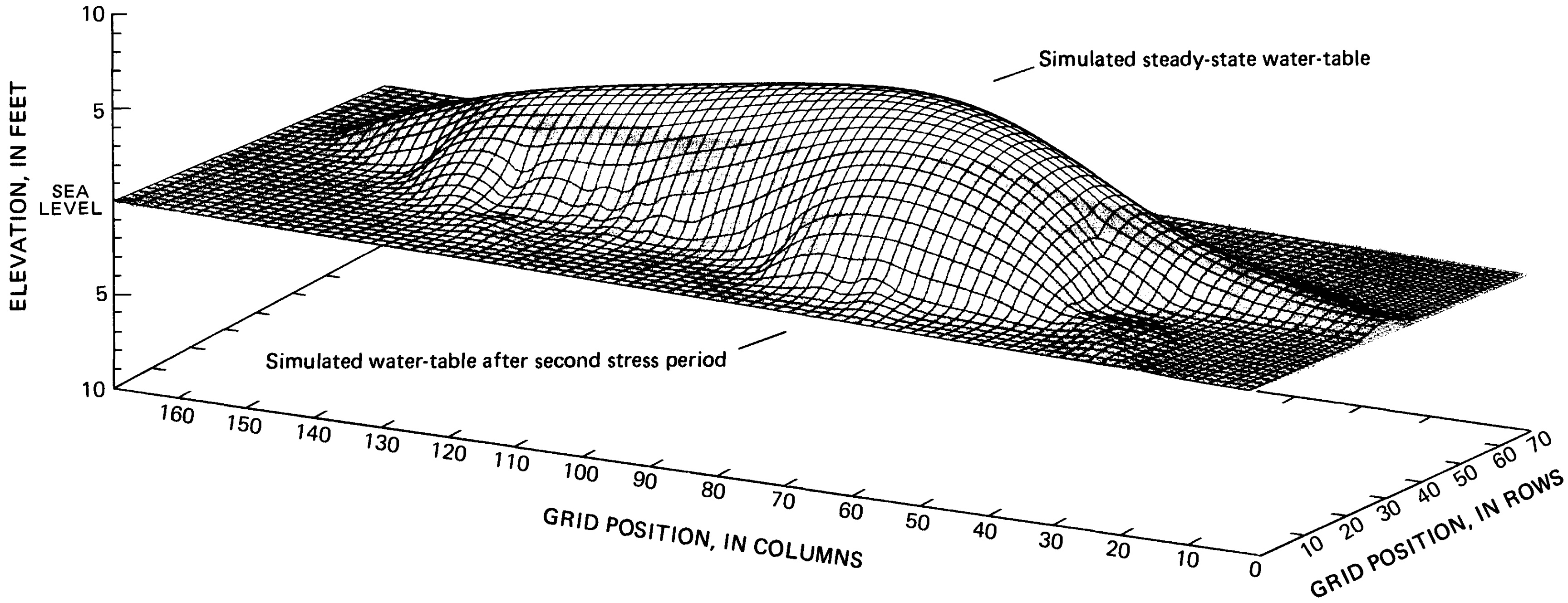


Figure 21.--Superposition of configurations of simulated steady-state water-table and simulated water-table after second stress period (May 22 - June 15, 1986) with 0.6 million gallons per day pumpage.

Table 1.--Records of selected observation wells and test wells

NOTE: Well numbers correspond to those shown in figure 2.

Depth of well and water level: depth of well given in feet; reported water levels are in feet above or below (-) sea level; measured water levels are in feet and tenths.

Well diameter: casing diameter in inches.

Water-bearing unit: wt, water table; ss shallow sand; ds, deep sand.

Altitude of land surface: given in feet above sea level, determined by instrumental leveling.

Use of well: N, none; P, public water supply; D, domestic consumption; G, general utility; O, observation.

Number	Owner	Drilled by and date	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface (feet)	Water Level above or below (-) sea level (feet)	Date of measurement	Use of well	Remarks
1	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	31.50	2	wt	3.24	0.51	7-29-86	O	Screen 28.5-31.5 ft.
2	Dauphin Island Water & Sewer Board	Layne-Central 1962	305	16.8	ss	5.60	-4	11-07-84	P	Owner's well no. 2.
3	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	29.0	2	wt	4.13	.42	7-29-86	O	Screen 27.5-29 ft.
4	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	49.5	2	wt	24.55	1.98	7-29-86	O	Screen 46-49.5 ft.
5	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	33.80	2	wt	6.93	1.95	7-29-86	O	Screen 30.8-33.8 ft.
6	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	103.0	2	ss	6.97	1.23	7-29-86	O	Screen 100-103 ft.
7	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	29.0	2	wt	4.59	-.60	7-09-86	O	Screen 26-29 ft.
8	Dauphin Island Water & Sewer Board	Layne-Central 1967	253	16.8	ss	6.50	-16	11-07-84	P	Owner's well no. 4.
9	Marcell Houston	Owner	16.40	2	wt	4.88	.63	11-06-84	N	
10	Dauphin Island Water, Sewer, and Fire Protection Authority	White Well Co. 1986	30.0	10	wt	4.78	.79	7-29-86	O	Screen 13-30 ft.
11	Dauphin Island Water, Sewer, and Fire Protection Authority	White Well Co. 1986	30.0	2	wt	4.99	.80	7-29-86	O	Screen 20-30 ft.
12	Dauphin Island Water & Sewer Board	Layne-Central 1955	312	16.8	ss	6.55	2	11-07-84	O	Owner's well no. 1. Not used.

Table 1.--Records of selected observation wells and test wells--Continued

Number	Owner	Drilled by and date	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface (feet)	Water Level above or below (-) sea level (feet)	Date of measurement	Use of well	Remarks
13	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	29.0	2	wt	5.13	.86	7-29-86	O	Screen 26-29 ft.
14	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	30.0	2	wt	6.17	1.69	7-29-86	O	Screen 27-30 ft.
15	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	34	6	wt	6.40	1.90	7-29-86	O	
16	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	103.0	2	ss	6.40	1.43	7-29-86	O	Screen 100-103 ft.
17	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30	2	wt	6.46	1.90	7-29-86	O	Screen 27-30 ft.
18	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30	2	wt	6.30	5.60	11-26-85	O	Destroyed 2-24-86.
19	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30	2	wt	6.15	1.91	7-29-86	O	Screen 27-30 ft.
20	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	29.5	2	wt	7.32	2.09	7-29-86	O	Screen 27-29.5 ft.
21	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	30.0	2	wt	5.16	1.30	5-07-86	O	Screen 27-30 ft.
22	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	31	2	wt	6.29	1.50	7-29-86	O	Screen 28-31 ft.
23	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	32	2	wt	4.81	.29	7-29-86	O	Screen 29-32 ft.
24	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30.0	2	wt	4.46	.78	7-29-86	O	Screen 27-30 ft.
25	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	31.50	2	wt	8.39	2.64	7-29-86	O	Screen 28.5-31.5 ft.

Table 1.--Records of selected observation wells and test wells--Continued

Number	Owner	Drilled by and date	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface (feet)	Water Level above or below (-) sea level (feet)	Date of measure-ment	Use of well	Remarks
26	Frank Werether	Owner 1981	10	1.25	wt	---	----	----	G	
27	Dauphin Surf Club	---	36	4	wt	7.07	2.86	11-06-84	G	
28	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	43	2	wt	18.80	2.61	7-29-86	O	Screen 40-43 ft.
29	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	99	2	ss	7.92	1.71	7-29-86	O	Screen 96-99 ft.
30	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	33	2	wt	8.29	2.66	7-29-86	O	Screen 30-33 ft.
31	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	31.5	2	wt	6.86	1.15	7-29-86	O	Screen 29-31.5 ft.
32	John Richardson	White Well Co. 1980	87	4	ss	5.70	3.18	11-07-84	D	
33	Joe Kelly	White Well Co. 1980	82	4	wt	6.73	3.03	11-06-84	D	
34	Pete Russo	----	18.6	4	wt	6.10	3.40	11-07-84	G	
35	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	30.0	2	wt	6.81	1.88	7-29-86	O	Screen 27-30 ft.
36	Lucille Davenn	----	25	2	wt	---	----	----	G	
37	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	32.0	2	wt	7.59	2.42	7-29-86	O	Screen 29-32 ft.
38	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	83	2	ss	6.35	3.85	4-24-85	O	Screen 80-83 ft.
39	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	63	2	ss	6.68	1.84	6-18-85	O	Screen 60-63 ft.
40	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	29	2	wt	6.44	2.30	7-29-86	O	Screen 26-29 ft.
41	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	35	6	wt	7.51	2.30	7-29-86	O	

Table 1.--Records of selected observation wells and test wells--Continued

Number	Owner	Drilled by and date	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface (feet)	Water Level above or below (-) sea level (feet)	Date of measure-ment	Use of well	Remarks
42	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30	2	wt	6.38	2.33	7-29-86	O	Screen 27-30 ft.
43	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30	2	wt	6.37	2.31	7-29-86	O	Screen 27-30 ft.
44	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	33	2	wt	8.92	2.43	7-29-86	O	Screen 30-33 ft.
45	J. C. Bush	White 1984	25	3	wt	---	5	11-05-84	G	
46	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	35.0	2	wt	5.89	1.95	7-29-86	O	Screen 33-35 ft.
47	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	31.0	2	wt	6.64	1.97	7-29-86	O	Screen 28-31 ft.
48	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30.0	2	wt	8.16	2.12	7-29-86	O	Screen 27-30 ft.
49	Joe Scley	----	----	2	wt	---	----	----	D	
50	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1985	32.0	2	wt	5.40	1.53	7-29-86	O	Screen 29-32 ft.
51	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30	2	wt	2.65	.39	7-29-86	O	Screen 27-30 ft.
52	Gaines Park	U.S. Army 1903	563	6	ds	7.93	10	11-05-84	G	Flow about 2 gal/min 11-05-84. Measured flow 6 gal/min 3/21/80.
53	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	30.0	2	wt	8.11	1.20	7-29-86	O	Screen 27-30 ft.
54	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	32	2	wt	5.57	1.39	5-07-86	O	Screen 29-32 ft.
55	Dauphin Island Water, Sewer, and Fire Protection Authority	USGS 1984	100.0	2	wt	5.28	.95	7-29-86	O	Screen 24-27 ft.

Table 2.--Chemical analyses of water from selected test wells for water year October 1985 through September 1986

Note: -- indicates no data reported:

Well	Date	Aquifer	Altitude of land surface datum (feet above sea level)	Depth of well, total (feet)	Chloride, dissolved (mg/L as Cl)	Iron, total recoverable (ug/L as Fe)	Specific conductance, lab (uS/cm)	Specific conductance, field (uS/cm)
	MAR							
1	13...	water table	3.2	31.00	1,700	14,000	5,920	5,300
	MAR							
3	12...	water table	4.1	29.00	120	3,900	442	530
	APR							
	15...		4.1	29.00	130	12,000	449	580
	24...		4.1	29.00	130	7,100	485	650
	MAY							
	02...		4.1	29.00	140	--	498	660
	MAR							
5	12...	water table	6.9	34.00	90	36,000	436	428
	APR							
	15...		6.9	34.00	89	14,000	418	520
	24...		6.9	34.00	94	11,000	469	525
	MAY							
	02...		6.9	34.00	100	--	519	510
	MAR							
6	12...	shallow sand	7.0	103.00	610	12,000	2,210	2,220
	APR							
	15...		7.0	103.00	610	6,700	2,190	2,400
	24...		7.0	103.00	600	12,000	2,140	2,400
	MAY							
	02...		7.0	103.00	600	--	2,170	2,400
	MAR							
7	13...	water table	4.6	29.00	430	5,600	1,640	1,420
	APR							
	15...		4.6	29.00	420	9,000	1,550	1,700
	24...		4.6	29.00	430	7,600	1,550	1,700
	MAY							
	02...		4.6	29.00	430	--	1,570	1,750
	MAR							
10	11...	water table	4.8	30.00	100	6,100	844	960
	APR							
	24...		4.8	30.00	140	--	595	--
	28...				--	--		605
	MAY							
	02...		4.8	30.00	140	--	586	565
	04...		4.8	30.00	--	--	--	565
	05...		4.8	30.00	150	2,700	603	--
	MAR							
11	11...	water table	5.0	30.00	210	7,200	740	795
	APR							
	15...		5.0	30.00	67	15,000	341	360
	24...		5.0	30.00	67	3,000	248	415
	MAY							
	02...		5.0	30.00	64	--	249	470

Table 2.--Chemical analyses of water from selected test wells for water year October 1985 through September 1986--Continued

Well	Date	Aquifer	Altitude of land surface datum (feet above sea level)	Depth of well, total (feet)	Chlo- ride, dis- solved (mg/L as Cl)	Iron, total recov- erable (ug/L as Fe)	Spe- cific con- duct- ance, lab (uS/cm)	Spe- cific con- duct- ance, field (uS/cm)
13	MAR 11...	water table	5.1	29.00	130	2,700	526	490
	APR 24...		5.1	29.00	120	2,100	510	590
	MAY 02...		5.1	29.00	110	--	492	560
14	MAR 12...	water table	6.2	30.00	72	20,000	368	350
	APR 15...		6.2	30.00	73	3,500	388	480
	24...		6.2	30.00	74	4,700	413	495
	MAY 02...		6.2	30.00	80	--	426	500
16	MAR 12...	shallow sand	6.4	103.00	83	1,100	520	400
17	MAR 12...	water table	6.5	30.00	30	3,100	148	136
20	MAR 12...	water table	7.3	29.00	28	11,000	249	135
21	MAR 13...	water table	5.2	30.00	130	5,700	646	680
	APR 15...		5.2	30.00	57	5,700	325	390
	24...		5.2	30.00	55	1,600	307	385
	MAY 02...		5.2	30.00	45	--	305	360
22	MAR 12...	water table	6.3	31.00	23	810	279	252
	APR 15...		6.3	31.00	26	540	282	360
	24...		6.3	31.00	28	640	301	360
	MAY 02...		6.3	31.00	43	--	290	340
23	MAR 13...	water table	4.8	32.00	93	30,000	694	680
24	MAR 13...	water table	4.5	30.00	270	6,700	1,040	950
25	MAY 06...	water table	8.4	31.00	31	3,500	169	165
28	MAY 06...	water table	18.8	43.00	130	5,800	527	250
29	MAY 06...	shallow sand	7.9	99.00	390	1,100	1,540	1,500

Table 2.--Chemical analyses of water from selected test wells for water year October 1985 through September 1986--Continued

Well	Date	Aquifer	Altitude of land surface datum (feet above sea level)	Depth of well, total (feet)	Chloride, dissolved (mg/L as Cl)	Iron, total recoverable (ug/L as Fe)	Specific conductance, lab (uS/cm)	Specific conductance, field (uS/cm)
30	MAY 06...	water table	8.3	33.00	43	10,000	264	250
31	MAY 06...	water table	6.9	31.50	59	1,400	308	280
35	MAY 06...	water table	6.8	30.00	44	3,700	211	170
37	MAY 06...	water table	7.6	32.00	33	5,400	189	160
41	MAY 06...	water table	7.5	35.00	30	2,800	257	160
42	MAY 06...	water table	6.4	30.00	25	21,000	441	155
43	MAY 06...	water table	6.4	30.00	32	8,000	248	155
44	MAY 06...	water table	8.9	33.00	36	8,000	232	230
47	MAY 06...	water table	6.6	31.00	54	12,000	402	220
48	MAY 06...	water table	8.2	29.00	160	2,300	594	--
50	MAY 06...	water table	5.4	32.00	31	6,400	193	180
51	MAR 12...	water table	2.6	30.00	5,500	10,000	16,800	17,000
53	MAR 12...	water table	8.1	30.00	550	31,000	1,870	1,850
54	MAR 12...	water table	5.6	32.00	310	21,000	1,230	1,300
	APR 24...		5.6	32.00	300	8,900	1,070	1,150
55	MAR 12...	water table	5.3	27.00	110	3,300	446	460

Table 3.--Comparison of water level altitudes and specific conductance in selected wells

[Well numbers correspond to those shown in figure 2]

Well	Aquifer	Date of measurement	Altitude of water level (feet, sea level)	Specific conductance (uS/cm)
5	water-table	1-25-85	3.00	350
		9-04-85	5.66	400
		10-09-85	5.81	415
		3-16-86	5.83	428
		4-07-86	5.02	480
6	shallow sand	1-25-85	1.59	2,050
		9-04-85	2.96	220[a]
		10-09-85	3.20	1,950
		3-13-86	2.07	2,220
		4-07-86	1.71	2,400
16	shallow sand	1-25-85	1.60	1,380
		9-04-85	3.20	1,300
		10-09-85	1.73	1,400
		3-12-86	2.23	400[a]
		4-07-86	1.74	1,100
17	water-table	1-25-85	2.29	155
		10-09-85	5.36	170
		3-12-86	5.25	136
		4-07-86	4.56	230
29	shallow sand	1-25-85	1.74	1,480
		7-12-85	1.87	1,500
		9-04-85	2.38	1,500
		10-09-85	2.58	1,500
30	water-table	1-25-85	4.34	185
		9-04-85	7.11	480
		10-09-85	6.28	400

[a] Storm runoff overflowed top of well casing.

Table 4.--Comparison of actual (April 1985) and simulated water levels for the calibrated steady-state model

Well	Row	Column	Water levels, in feet		
			Actual	Simulated	Difference
1	18	38	0.79	1.22	0.43
5	44	55	6.05	6.15	.10
10	25	98	1.09	1.97	.88
23	17	77	1.81	2.30	.49
25	45	93	6.26	7.11	.85
30	43	101	6.47	6.69	.22
28	54	97	4.44	4.79	.35
37	44	104	6.54	6.46	-.08
42	46	107	6.57	6.13	-.44
44	51	105	6.30	5.40	-.90
47	51	114	5.70	4.86	-.84
48	44	116	6.39	5.66	-.73
50	34	115	4.16	4.37	.21
54	52	155	1.15	1.03	-.12
55	41	154	1.88	1.08	-.80

The percentage of water levels within 0.25 ft is 33 for the entire time period (5 of 15 wells).
The percentage of water levels within 0.50 ft is 60 for the entire time period (9 of 15 wells).
The percentage of water levels within 1.00 ft is 100 for the entire time period (15 of 15 wells).

Table 5.--Comparison of actual and simulated water levels for the calibrated transient model

Stress Period One - April 2 to May 22, 1985					
			Water levels, in feet		
Well	Row	Column	Actual	Simulated	Difference
5	44	55	3.61	3.67	0.06
13	28	62	4.71	4.50	-.21
14	39	65	6.25	5.40	-.85
17	47	76	6.04	4.92	-.12
20	40	79	5.39	5.60	.21
24	28	88	3.25	2.93	-.32
25	45	93	4.79	4.80	.01
28	54	97	2.83	2.79	-.04
30	43	101	4.33	4.49	.16
37	44	104	3.93	4.29	.36
42	46	107	3.49	4.00	.51
44	51	105	2.85	3.32	.47
46	53	114	2.01	2.46	.45
47	51	114	2.49	2.90	.41
48	44	116	2.86	3.60	.74
50	34	115	3.31	2.81	-.50
55	41	154	.88	.46	-.42

Percentage of water levels within 0.30 ft is 35 at 6 of 17 wells.
Percentage of water levels within 0.60 ft is 82 at 14 of 17 wells.
Percentage of water levels within 1.00 ft is 94 at 16 of 17 wells.

Stress Period Two - May 22 to June 15, 1985					
			Water levels, in feet		
Well	Row	Column	Actual	Simulated	Difference
5	44	55	2.68	3.03	0.35
13	28	62	3.99	3.74	-.25
14	39	65	5.24	4.58	-.66
17	47	76	5.31	4.15	-1.16
20	40	79	4.43	4.77	.34
24	28	88	2.76	2.42	-.34
25	45	93	4.02	4.05	.03
28	54	97	2.14	2.29	.15
30	43	101	3.46	3.77	.31
37	44	104	3.03	3.59	.56
42	46	107	2.55	3.33	.78
44	51	105	2.10	2.74	.64
46	53	114	1.31	1.97	.66
47	51	114	1.73	2.34	.61
48	44	116	2.00	2.95	.95
50	34	115	2.50	2.32	-.18
55	41	154	0.63	0.29	-.34

Percentage of water levels within 0.30 ft is 23 at 4 of 17 wells.
Percentage of water levels within 0.60 ft is 58 at 10 of 17 wells.
Percentage of water levels within 1.00 ft is 94 at 16 of 17 wells.

Table 6.--Sensitivity analysis for the calibrated models

Aquifer characteristic	Percentage change	Hydrologic value	Change in hydraulic heads, in feet					
			Percentage of heads within plus or minus					
			0.3		0.6		1.0	
Aquifer hydraulic conductivity	0	58 ft/d	31		56		100	
	Increase 50	87 ft/d	12		25		37	
	Decrease 50	29 ft/d	6		12		18	
Aquifer recharge	0	20 in/yr	31		56		100	
	Increase 50	30 in/yr	6		12		12	
	Decrease 50	10 in/yr	9		27		45	
Vertical leakage	0	500 ft^3/d	31		56		100	
	Increase 50	750 ft^3/d	43		62		87	
	Increase 100	1,000 ft^3/d	31		62		68	
	Decrease 50	250 ft^3/d	31		50		81	
			Stress period		Stress period		Stress period	
			1[a]	2[b]	1	2	1	2
Specific yield	0	.092	50	37	87	81	93	100
	Increase 50	.138	6	12	50	31	93	56
	Decrease 50	.046	0	6	6	25	50	50

[a] stress period 1, April 2 to May 22, 1985.
[b] stress period 2, May 22 to June 15, 1985.