GEOHYDROLOGY OF THE DOUGHERTY PLAIN AND ADJACENT AREA, SOUTHWEST GEORGIA

By

Thomas W. Watson

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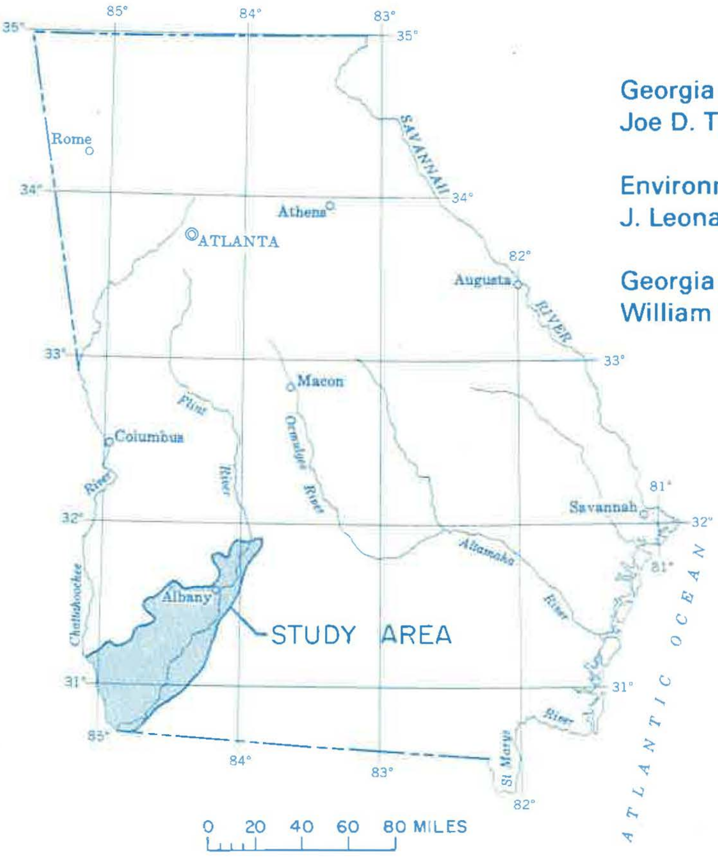

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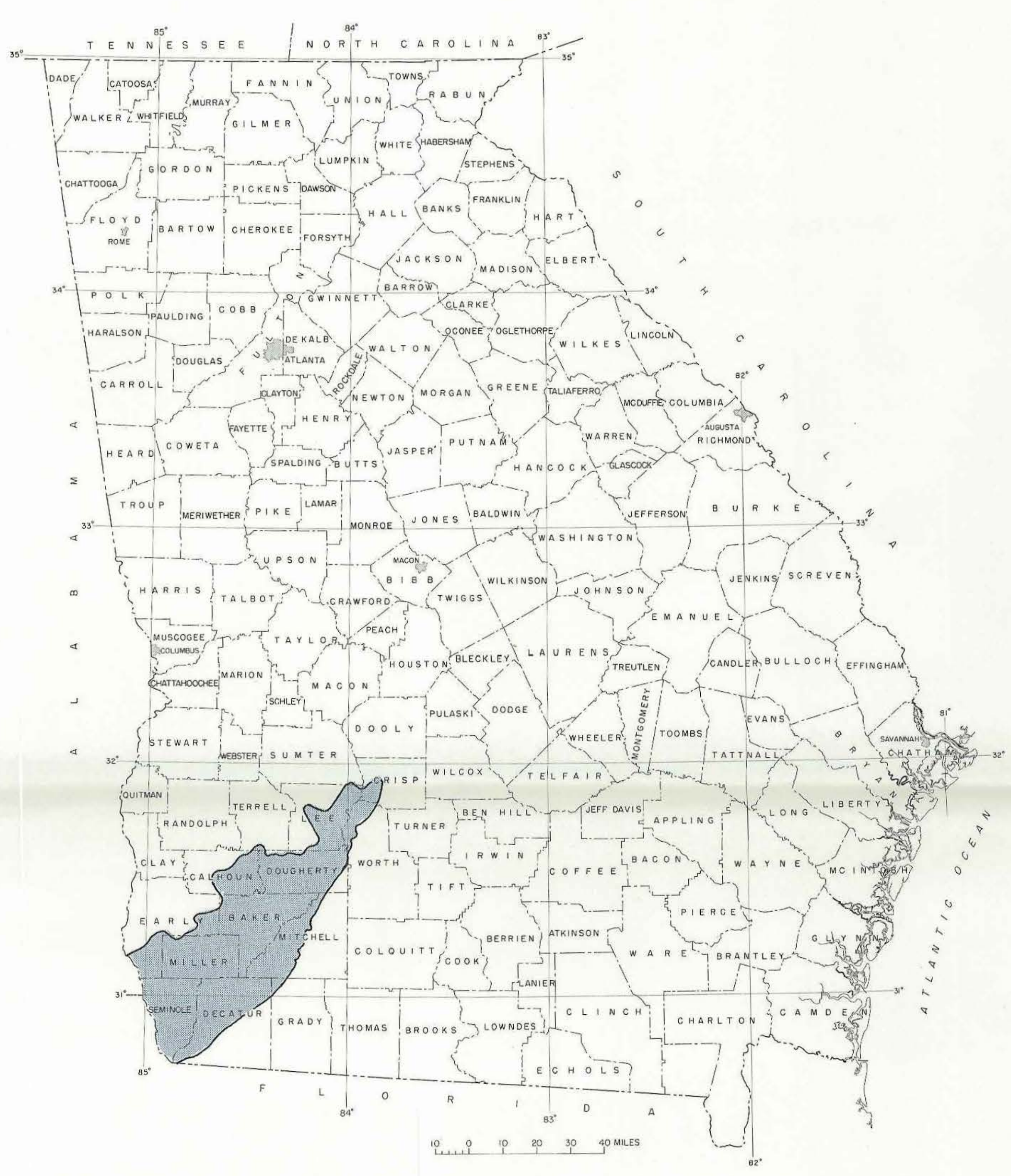

FIGURE 1. LOCATION OF STUDY AREA

Geohydrology Of The Dougherty Plain And Adjacent Area, Southwest Georgia

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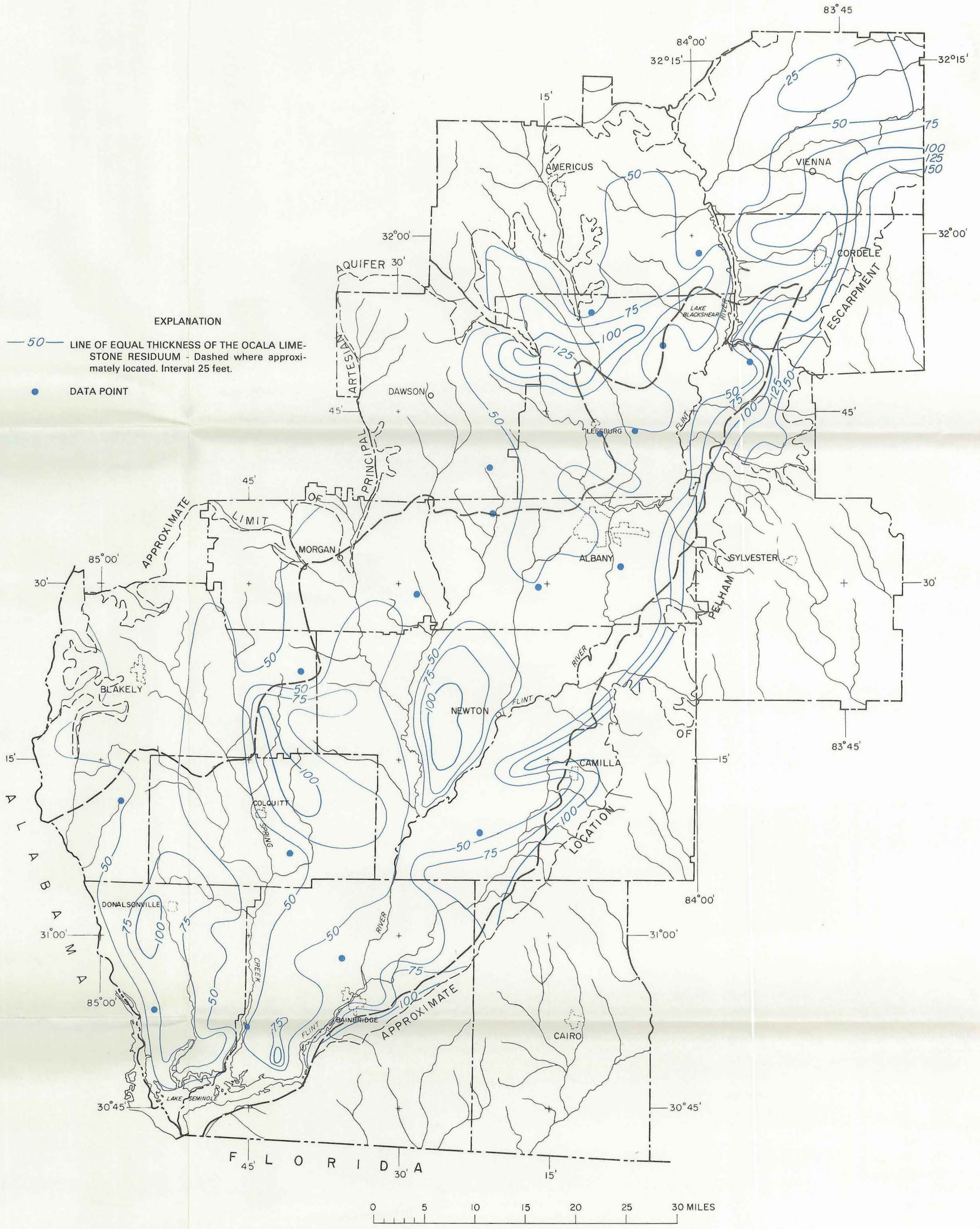

EXPLANATION

—50— LINE OF EQUAL THICKNESS OF THE OCALA LIMESTONE RESIDUUM - Dashed where approximately located. Interval 25 feet.

● DATA POINT

INTRODUCTION

Ground-water use in the Dougherty Plain physiographic district of southwest Georgia (fig. 1) has received considerable attention in recent years. A mild climate, an abundant supply of good-quality ground water, a flat to gently rolling terrain, and the introduction of center pivot irrigation systems have spurred a remarkable increase in agricultural irrigation. Irrigated acreage in southwest Georgia increased 60 percent between 1970 and 1971, and by approximately 100 percent from 1976 through the fall of 1977. Ground-water use for irrigation between 1977 and 1980 increased from about 47 to 76 billion gallons per year (H.E. Gill, U.S. Geological Survey, written commun., 1981), an increase of 62 percent.

The availability of large quantities of ground water is partly a function of the same physical processes which produced the topographic features of the Dougherty Plain. Gradual dissolution of the Ocala Limestone, which lies at or near the land surface, has produced a cavernous limestone aquifer that serves as a reservoir for 4 to 8 inches of the 52 inches of rainfall that can be expected in an average year.

The purpose of this report is to define the hydrogeology of the principal artesian aquifer in the Dougherty Plain. Since ground water will be a significant aspect in the future development of the area, it is important to know how much water production the aquifer is capable of sustaining, and how to manage this important resource. The aquifer boundaries, thickness, and other physical characteristics are illustrated as an important first step to more advanced hydrologic modeling techniques, which will be used as aids in determining water management alternatives.

GEOLOGY

Residuum. — The surficial geology of the Dougherty Plain consists of a residual layer of sand and clay, derived from solution weathering of the Ocala Limestone. The ratio of sand and clay in the residuum varies throughout the study area. Test drilling data indicate that the residuum usually is clayey sand to slightly sandy clay. Clay content ranges from approximately 10 to 70 percent, and samples from 45 of 50 test wells consisted of more than 25 percent clay.

The thickness of the residual layer varies from just a few feet to slightly more than 100 feet, and has an average thickness of approximately 50 feet (fig. 2).

Cartography by Jeane S. Barrett and Willis G. Hester

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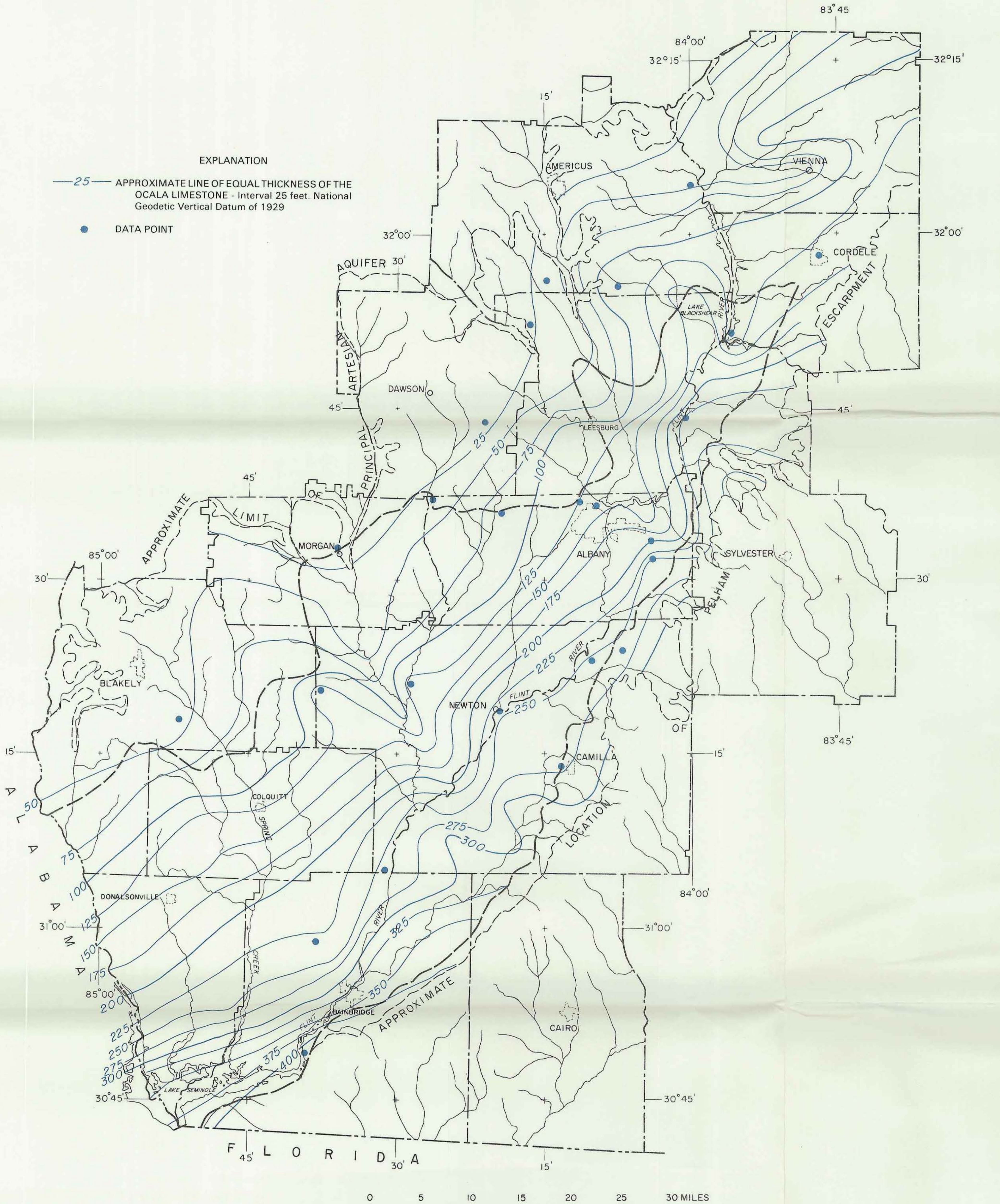

FIGURE 3. APPROXIMATE THICKNESS OF THE OCALA LIMESTONE

Ocala Limestone. — The Ocala is a light-colored, fossiliferous limestone of late Eocene age. The top of the limestone is a transitional zone where the sandy clay of the residuum grades into limestone. This transitional zone can be abrupt, or it may include several tens of feet of alternating weathered limestone and sandy clay. The parent limestone is exposed along sections of major streams such as the Chattahoochee River, Flint River, and Spring Creek, where erosion has removed the residuum. The Ocala is a wedge-shaped limestone formation trending from northeast to southwest across Georgia, thickening to the southeast. The Ocala varies in thickness from a few feet at the updip limit to 350 feet in the southeastern part of the Dougherty Plain (fig. 3).

The upper surface of the Ocala Limestone is highly irregular because of differential weathering (fig. 4). However, the approximate depth from land surface to the top of the Ocala Limestone in a given area can be estimated by subtracting the altitude of the limestone surface from the land surface altitude.

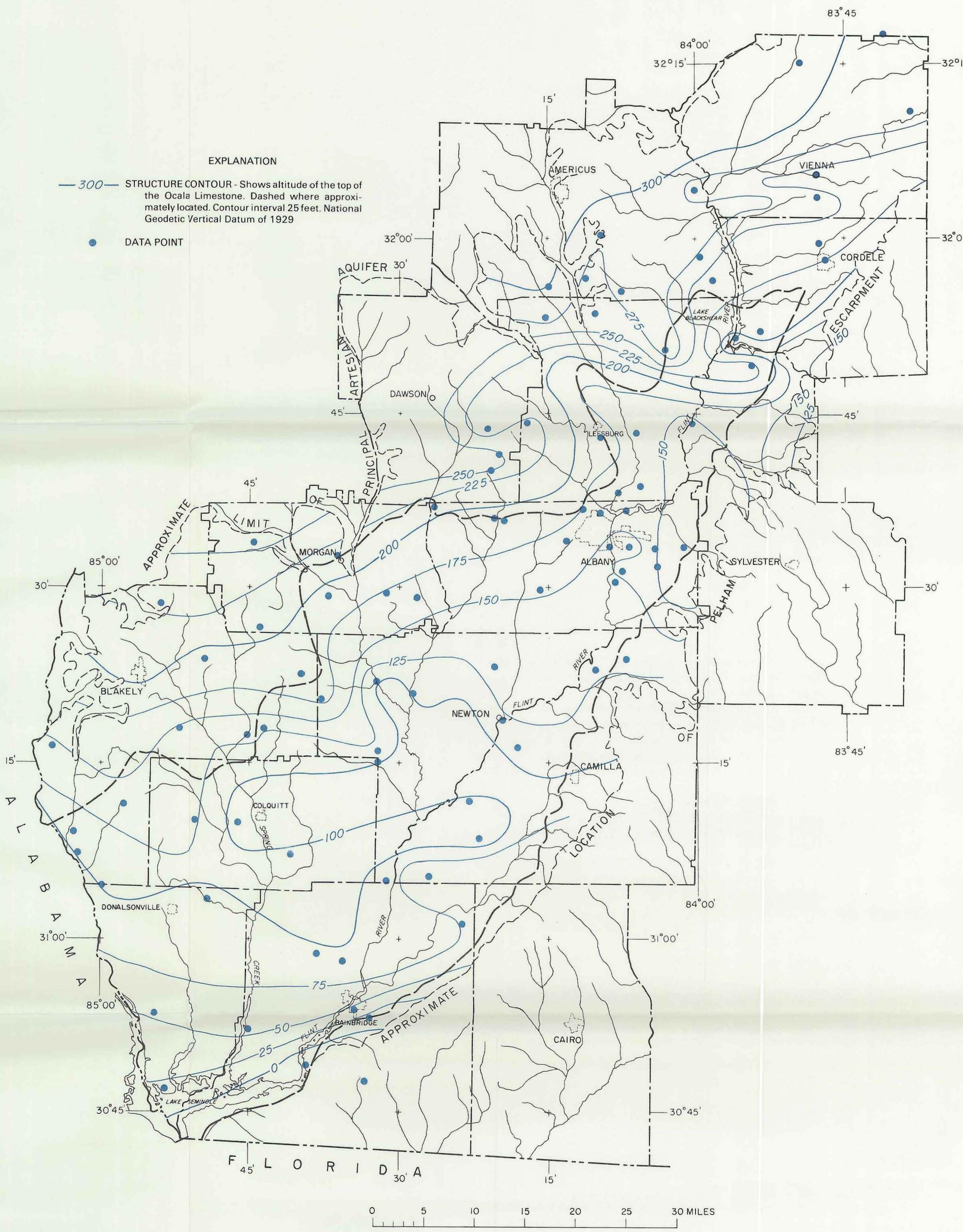

FIGURE 4. STRUCTURE CONTOUR OF THE TOP OF THE OCALA LIMESTONE

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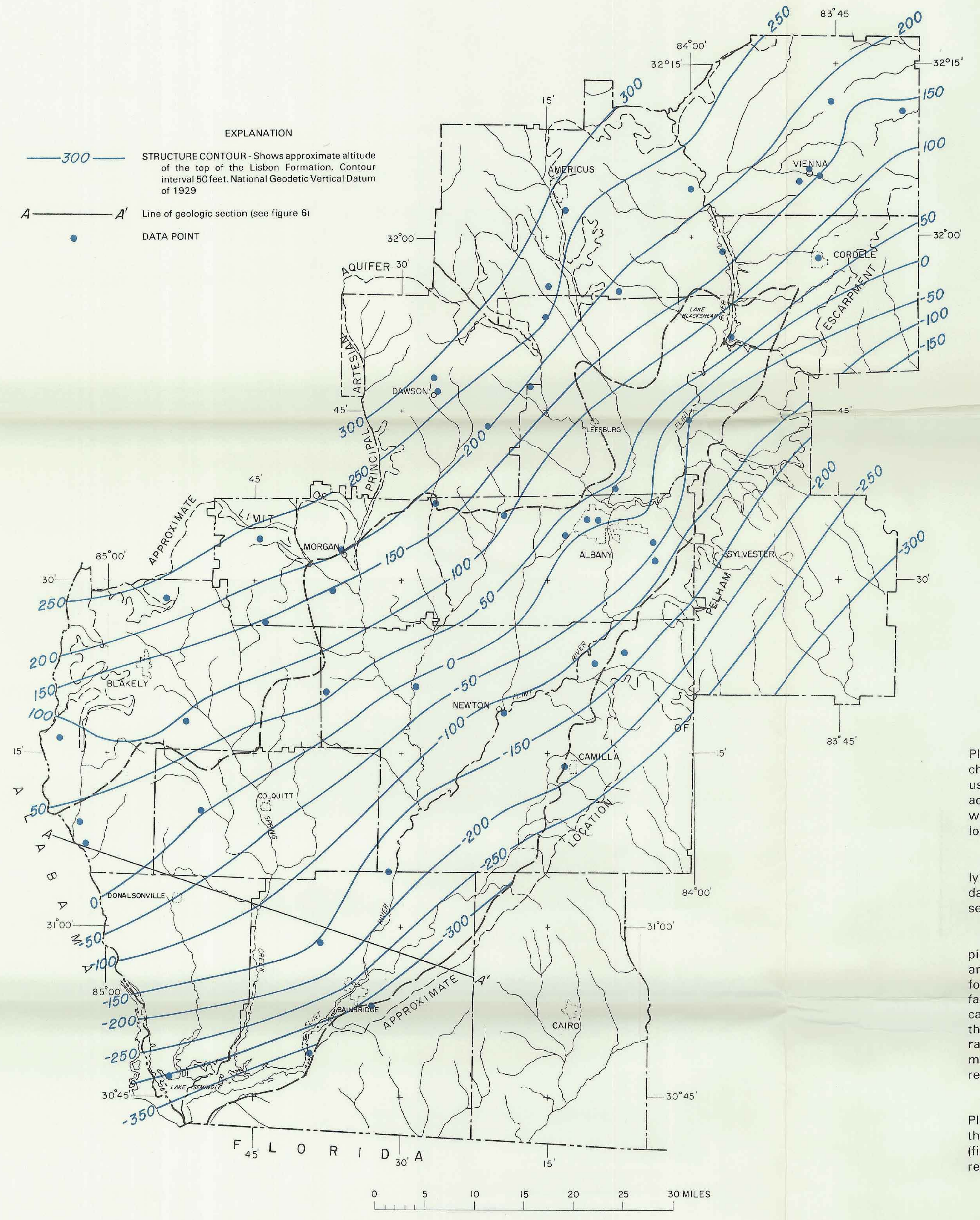


EXPLANATION

STRUCTURE CONTOUR - Shows approximate altitude of the top of the Lisbon Formation. Contour interval 50 feet. National Geodetic Vertical Datum of 1929

A — A' Line of geologic section (see figure 6)

● DATA POINT

FIGURE 5. GENERALIZED STRUCTURE OF THE TOP OF THE LISBON FORMATION

Lisbon Formation. — The Ocala is underlain by the Lisbon Formation of middle Eocene age. The Lisbon occurs at altitudes ranging from 300 feet above sea level in the northwestern part of the report area to 300 below in the southeastern part of the report area (fig. 5). In the report area, the top of the Lisbon is considered the lower boundary of the principal artesian aquifer because the Lisbon consists of hard, sandy, clayey limestone and has distinctly lower water-yielding characteristics than the Ocala Limestone.

A detailed description of the lithostratigraphy throughout the study area is given by Herrick (1961), Herrick and Vorhis (1963), and Stringfield (1966). An extensive listing of hydrogeologic data for the Dougherty Plain is presented by Mitchell (1981).

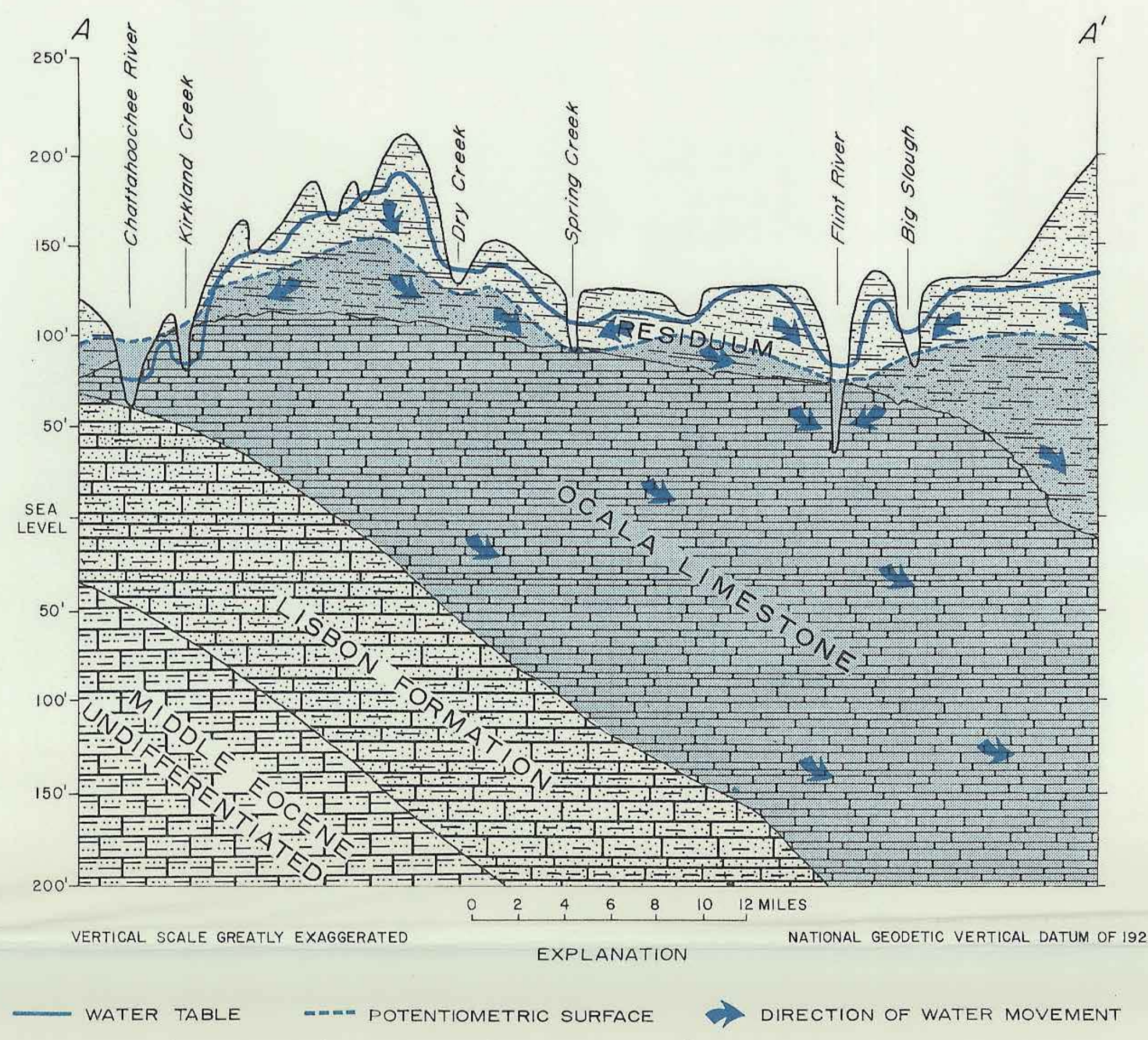


FIGURE 6. HYDROGEOLOGIC SECTION A-A'

HYDROGEOLOGY

The principal artesian aquifer beneath the Dougherty Plain consists primarily of the Ocala Limestone, which is the chief source of ground water for domestic and agricultural use. Municipal and industrial use of the principal artesian aquifer depends on geographic location, the amount of water desired, and the thickness of the Ocala at that location.

Hydraulic connection of the Ocala with any of the underlying aquifers is not well understood at present. Current data, however, indicate that the Ocala responds as a separate hydrologic unit.

Rainfall not lost as surface runoff or through evapotranspiration is the primary source of recharge to the principal artesian aquifer. Recharge of the aquifer depends upon the following: (1) the amount, distribution, and timing of rainfall, (2) the vertical permeability, or ease with which water can percolate downward through the residuum, and (3) the thickness of the residuum. Vertical hydraulic conductivity ranges between 0.001 and 0.005 feet per day throughout most of the study area and is the primary factor controlling recharge to the Ocala aquifer.

An idealized hydrogeologic cross section of the Dougherty Plain along the line from A to A' (trace shown in fig. 5) shows the relative positions and thicknesses of the geologic units (fig. 6). Direction of water movement is shown by arrows representing ground-water flow.

The capacity of the principal artesian aquifer to store and transmit large quantities of water is due largely to the cavernous nature of the Ocala Limestone. Water moving through small fractures or cracks in the limestone has slowly enlarged these features, through solution, forming a cavernous, highly porous labyrinth of subterranean channels. In many areas, ground water moves through the aquifer almost as if in a conduit or culvert.

Aquifer transmissivity is the rate at which water is transmitted through a unit width of the aquifer under a hydraulic gradient and is determined by measuring water-level declines in wells adjacent to pumping wells. Transmissivity of the principal artesian aquifer ranges from less than 25,000 ft^2/day to more than 75,000 ft^2/day (fig. 7). Transmissivity is lowest in the northwestern part of the report area where the aquifer is relatively thin, and increases to the southeast where the aquifer is thicker. Transmissivity also increases near the Chattahoochee River, Flint River, and Spring Creek because water moving between the surface-water system and the ground-water system adjacent to these major drainages has accelerated the erosion of ground-water conduits. In general, well yield is directly proportional to transmissivity. Other factors being equal (such as well diameter and pumping level), wells constructed within high transmissivity zones can be expected to yield more water than wells constructed within low transmissivity zones (fig. 7).

TABLE 1 — SUMMARY OF WATER QUALITY ANALYSES[1], PRINCIPAL ARTESIAN AQUIFER

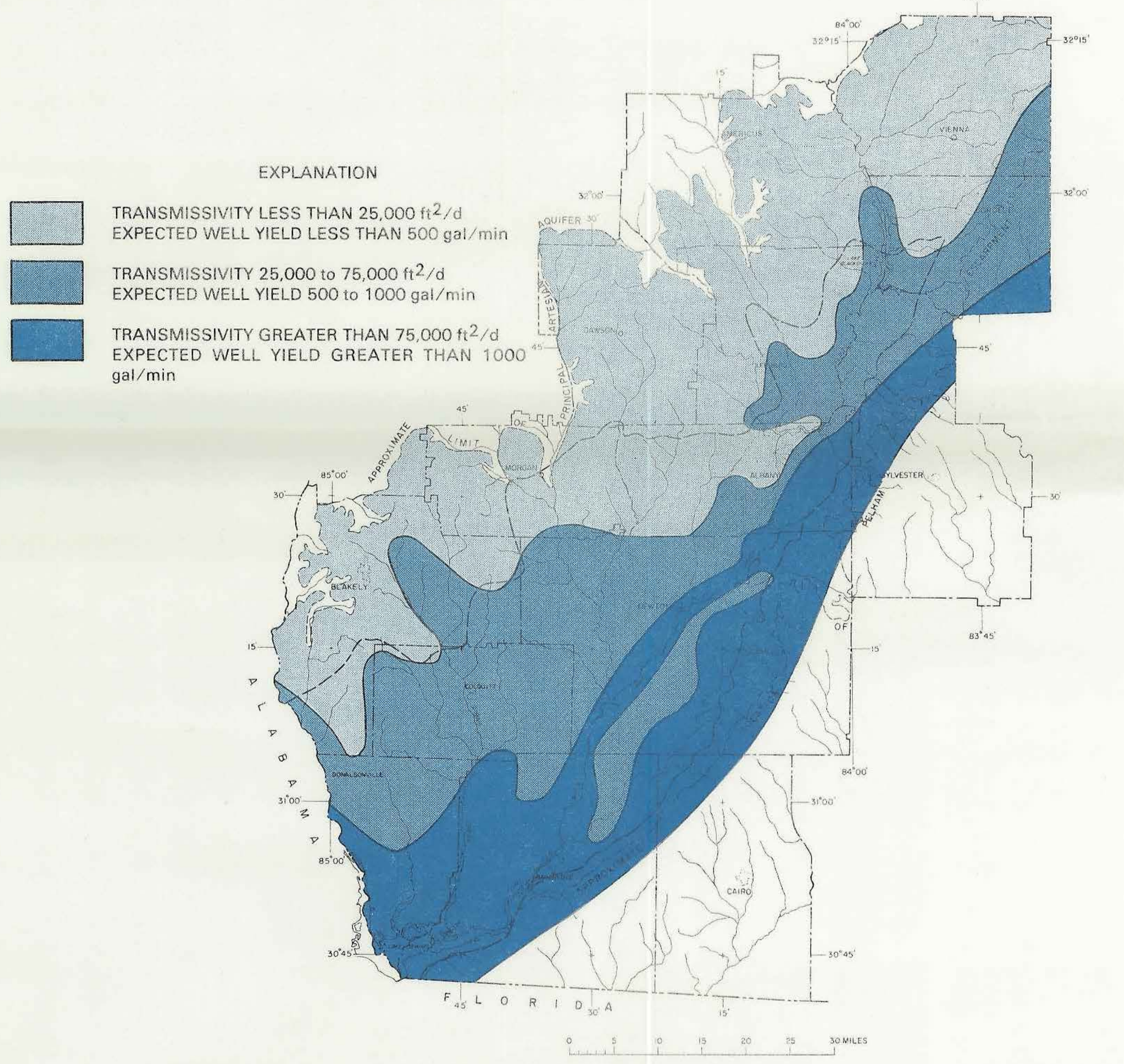
	Specific Conductance (Micromhos)	pH	Hardness as $CaCO_3$	Bicarbonate (HCO_3)	Dissolved Solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO3)
Maximum	293	8.1	185	167	184	39.0	0.130	56.0	13.0	13.0	3.8	11.0	7.4	2.3[2]	34.0[2]
Mean	196	7.3	106	120	117	9.0	0.027	39.0	1.0	2.0	0.5	2.0	3.1	0.1	4.0
Minimum	54	5.9	4	5	16	4.7	0.000	0.4	0.0	0.8	0.1	0.0	1.0	0.0	0.0
Number of Samples	42	39	42	39	42	42	12	42	42	42	42	42	42	42	38

[1] Values in milligrams per liter except pH

[2] Exceeds EPA Drinking Water Standards

WATER QUALITY

Dissolved minerals in ground water can affect its usefulness for various purposes. Table 1 shows the levels of some of the more common constituents dissolved in water from wells open only to the principal artesian aquifer. Water quality is generally suitable for domestic and agricultural use.



EXPLANATION

▨ TRANSMISSIVITY LESS THAN 25,000 ft^2/d
EXPECTED WELL YIELD LESS THAN 500 gal/min

▨ TRANSMISSIVITY 25,000 to 75,000 ft^2/d
EXPECTED WELL YIELD 500 to 1000 gal/min

▨ TRANSMISSIVITY GREATER THAN 75,000 ft^2/d
EXPECTED WELL YIELD GREATER THAN 1000 gal/min

FIGURE 7. POTENTIAL WELL YIELDS BASED ON TRANSMISSIVITY

Cartography by Jeane S. Barrett and Willis G. Hester

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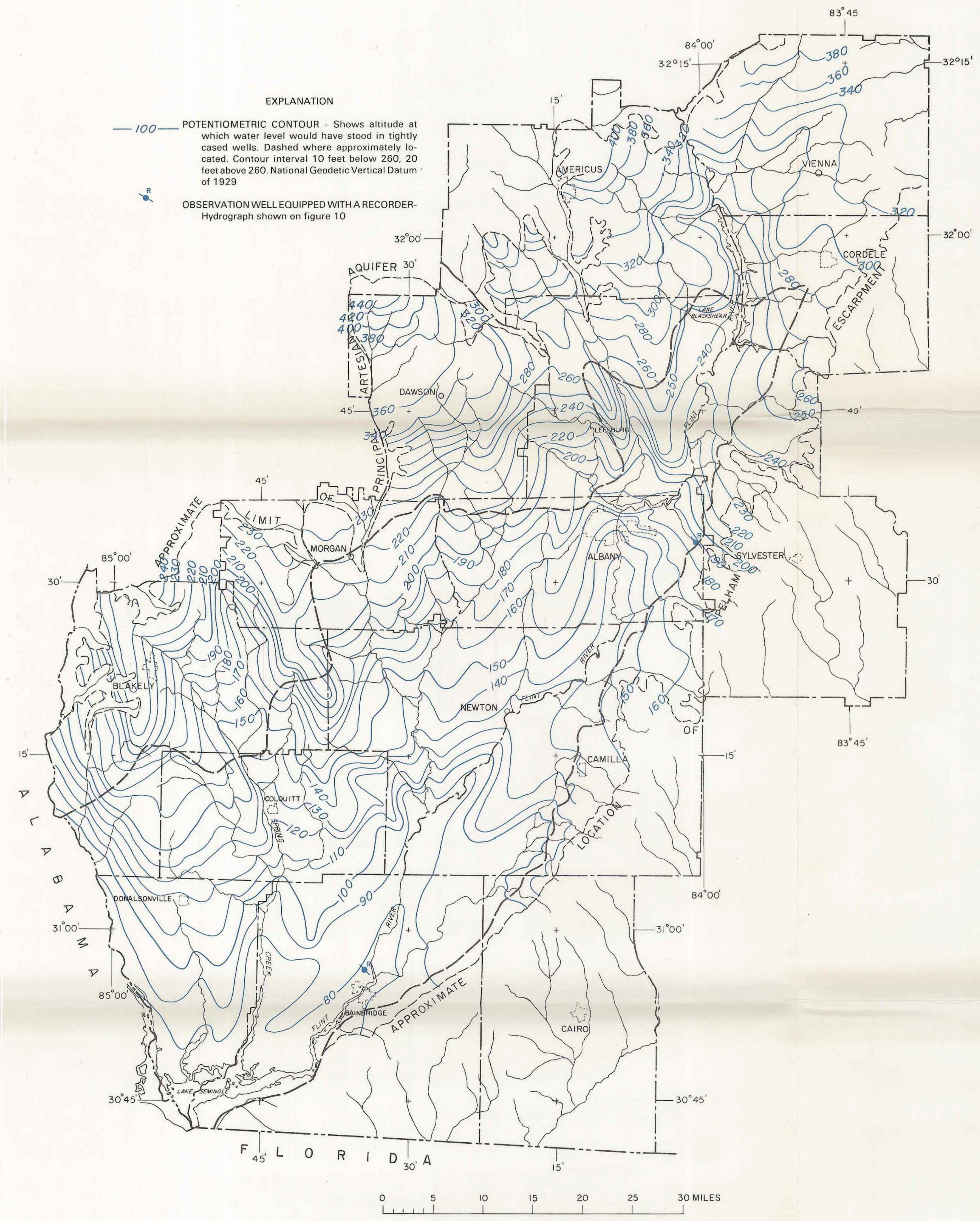

FIGURE 8. POTENTIOMETRIC SURFACE OF THE PRINCIPAL ARTESIAN AQUIFER, NOVEMBER 1979

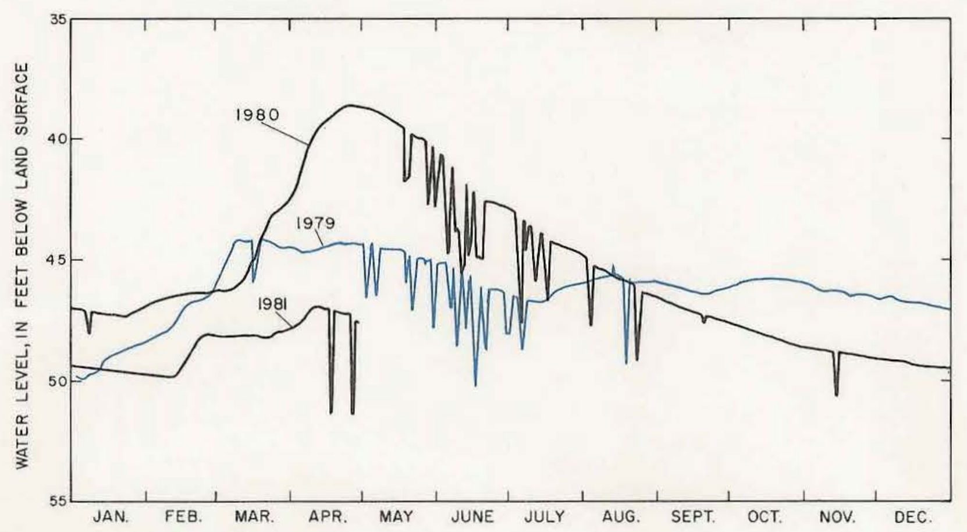

FIGURE 10a. WATER-LEVEL FLUCTUATIONS IN THE BOLTON OBSERVATION WELL, JANUARY 1979 - MAY 1981

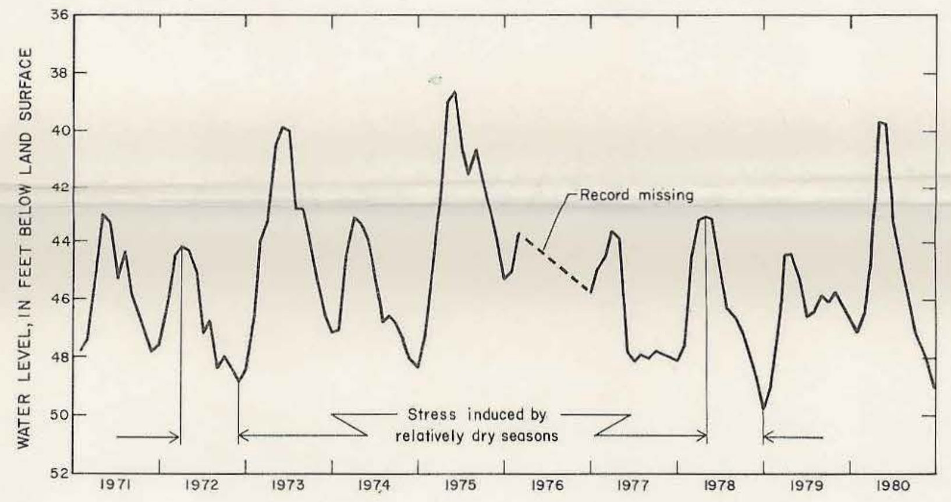

FIGURE 10b. WATER-LEVEL FLUCTUATIONS IN THE BOLTON OBSERVATION WELL, 1971-1980

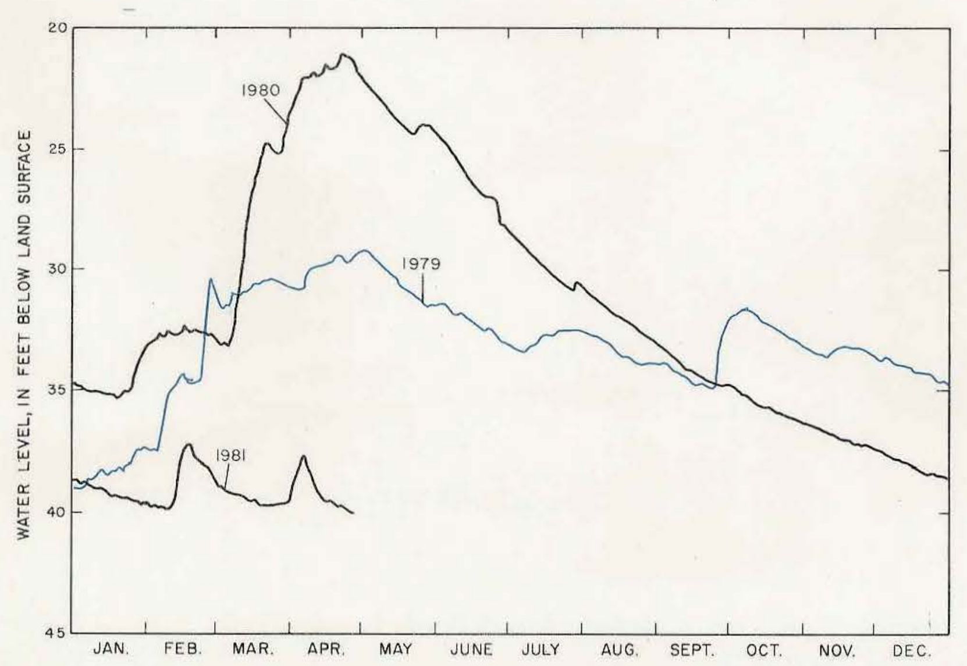

FIGURE 10c. WATER-LEVEL FLUCTUATIONS IN THE ALBANY-DOUGHERTY COUNTY OBSERVATION WELL, JANUARY 1979 - MAY 1981

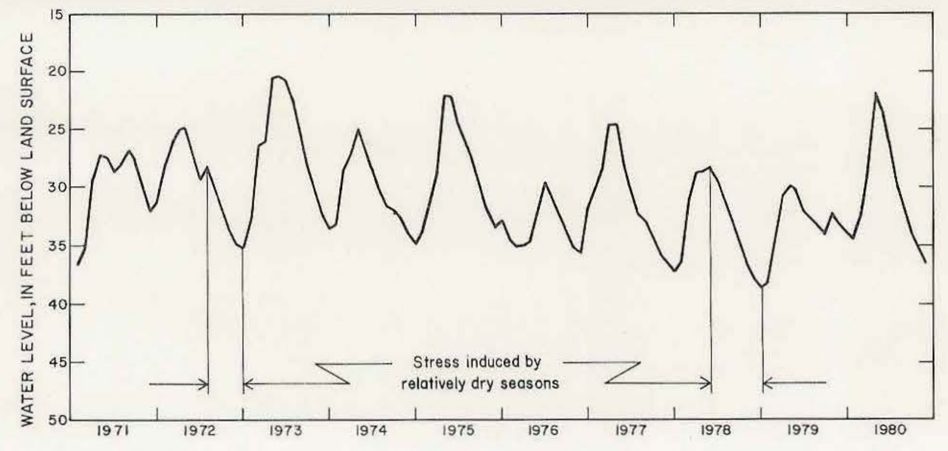

FIGURE 10d. WATER-LEVEL FLUCTUATIONS IN THE ALBANY-DOUGHERTY COUNTY OBSERVATION WELL, 1971 - 1980

FIGURE 9. POTENTIOMETRIC SURFACE OF THE PRINCIPAL ARTESIAN AQUIFER, MAY 1980

WATER LEVELS

Potentiometric surface maps indicate the level to which water will rise in wells cased into a confined or artesian aquifer. Potentiometric maps of the principal artesian aquifer for May 1980 and November 1979 show a smoothly undulating surface having no apparent areas of man-made stress, such as a cone of depression or ''dent'' in the potentiometric surface (figs. 8 and 9). The absence of any significant cones of depression on the potentiometric surface indicates that, at the times these measurements were made, recharge of the principal artesian aquifer was adequate to replenish the water being withdrawn from wells. The configuration of the potentiometric surface does, however, indicate that large quantities of ground water discharge into surface streams. Evidence of this naturally occurring phenomenon is shown by the potentiometric contour lines bending upstream at surface streams, demonstrating a hydraulic gradient toward the streams. Depth to water at a proposed well site can be estimated by subtracting the altitude of the potentiometric surface from the ground surface altitude of the site.

Continuous monitoring of water levels in a network of observation wells has shown a cyclic fluctuation of water levels in the principal artesian aquifer in response to seasonal variations in rainfall. This fluctuation can be seen on a regional basis by comparing the May 1980 potentiometric surface after spring rains with the November 1979 potentiometric surface after a dry summer. Water-level fluctuations in wells in Decatur and Dougherty Counties over 1-year and 10-year periods demonstrate recharge through late winter and early spring followed by a gradual depletion through summer and fall months, which are normally dry (fig. 10). The 1-year hydrographs also clearly show the effects of man-induced stresses of pumping and natural stresses of unusually dry seasons, such as the hydrologic droughts of 1972 and 1977-78.

SELECTED REFERENCES

Herrick, S.M., 1961, Well logs of the Coastal Plain of Georgia: Georgia Geological Survey Bulletin 70, 462 p.

Herrick, S.M., and Vorhis, R.C., 1963, Subsurface geology of the Georgia Coastal Plain: Georgia Geological Survey Information Circular 25, 78 p.

Mitchell, G.D., 1981, Hydrogeologic data of the Dougherty Plain and adjacent areas, southwest Georgia: Georgia Geologic Survey Information Circular 58, 124 p.

Owen, Vaux, Jr., 1963, Geology and gound-water resources of Lee and Sumter Counties, southwest Georgia: U.S. Geological Survey Water-Supply Paper 1666, 70 p.

________ 1963, Geology and ground-water resources of Mitchell County, Georgia: Georgia Geological Survey Information Circular 24, 40 p.

Pollard, L.D., Grantham, R.G., and Blanchard, H.E., Jr., 1978: A preliminary appraisal of the impact of agriculture on ground-water availability in southwest Georgia: U.S. Geological Survey Water-Resources Investigations 79-7, 22 p.

Sever, C.W., 1965, Ground-water resources and geology of Seminole, Decatur, and Grady Counties, Georgia: U.S. Geological Survey Water-Supply Paper 1809-Q, 30 p.

Sonderegger, J.L., Pollard, L.D., and Cressler, C.W., 1978: Quality and availability of ground water in Georgia: Georgia Geological Survey Information Circular 48, 25 p.

Stringfield, V.T., 1966, Artesian water in the southeastern States: U.S. Geological Survey Professional Paper 517, 226 p.

Wait, R.L., 1960, Source and quality of ground water in southwestern Georgia: Georgia Geological Survey Information Circular 18, 74 p.

________ 1963, Geology and ground-water resources of Dougherty County, Georgia: U.S. Geological Survey Water-Supply Paper 1539-P, 102 p.

Cartography by Jeane S. Barrett and Willis G. Hester