GEOHYDROLOGY

OF THE

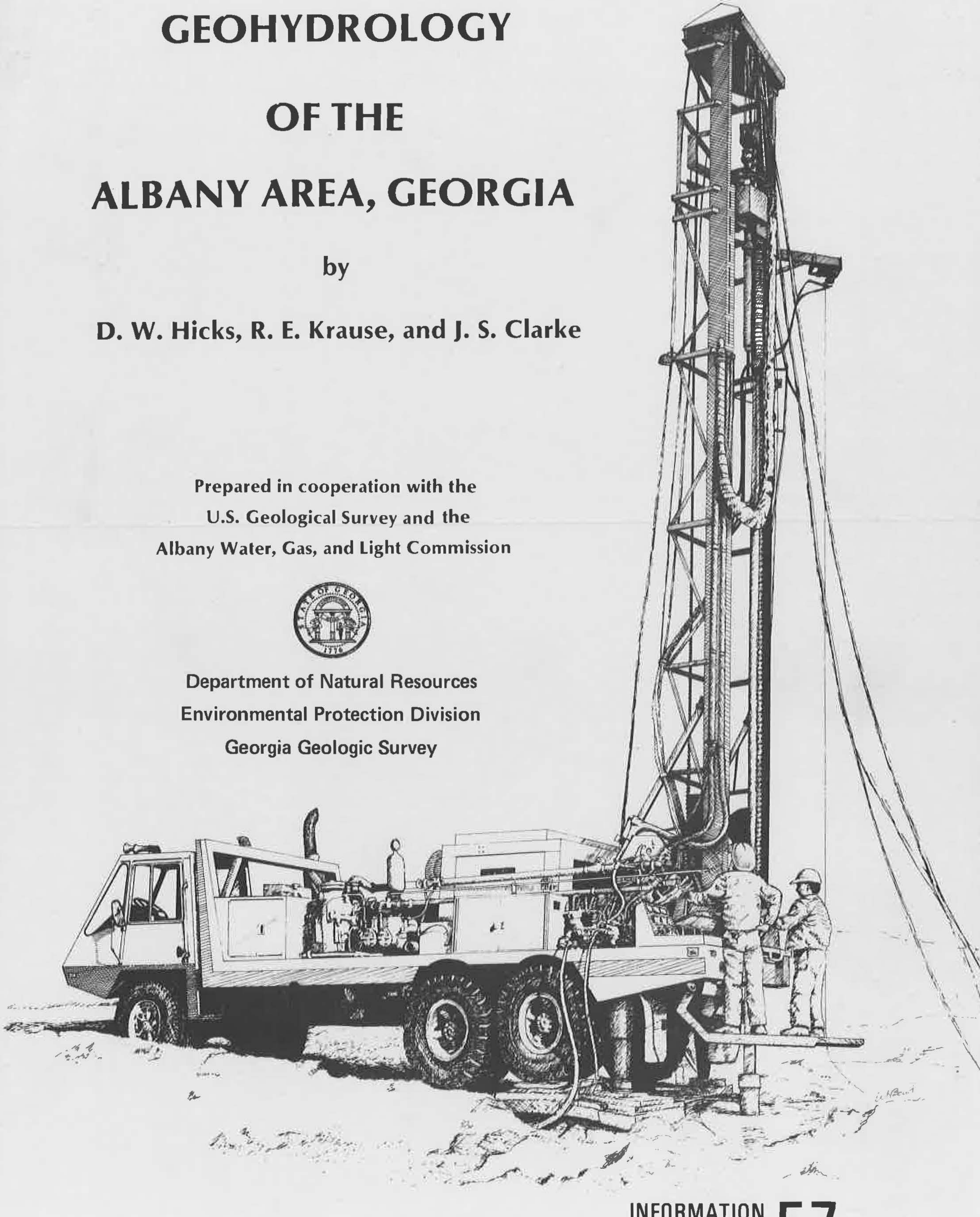
ALBANY AREA, GEORGIA

by

D. W. Hicks, R. E. Krause, and J. S. Clarke

Prepared in cooperation with the
U.S. Geological Survey and the
Albany Water, Gas, and Light Commission

Department of Natural Resources
Environmental Protection Division
Georgia Geologic Survey



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DEPARTMENT OF NATURAL RESOURCES
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ENVIRONMENTAL PROTECTION DIVISION
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[Plate is in pocket]

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply	By	To obtain
feet (ft)	0.3048	meters (m)
inches (in)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
square miles (m^2)	2.590	square kilometers (km^2)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
	43.81	liters per second (L/s)
	Transmissivity	
feet squared per day (ft^2/d)	0.0929	meters squared per day (m^2/d)

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. It was formerly called "Sea Level Datum of 1929" or "mean sea level" in this series of reports. Although the datum was derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico, and Pacific Coasts, it does not necessarily represent local mean sea level at any particular place.

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ABSTRACT

From 1960 to the present (1978), the Albany-Dougherty County Metropolitan Area of southwest Georgia has experienced a period of rapid growth. This rapid growth has caused ground-water use to more than triple during the past 20 years, presently averaging about 39.4 million gallons per day. Large withdrawals in the Albany area have caused water levels to decline in one aquifer as much as 135 feet since 1940.

Ground water in the Albany area is obtained from four aquifers of Late Cretaceous to middle Tertiary age that range in depth from about 40 to 960 feet below land surface. From deepest to shallowest the aquifers are: the Providence (sand), the Clayton (limestone), the Tallahatta (sand), and the Ocala (limestone). Ground water is present in the underlying Cusseta Sand at depths of about 1,250 to 1,500 feet; however, high drilling costs, low yields, and excessive concentrations of chloride (422 milligrams per liter) and dissolved solids (1,610 milligrams per liter) in Cusseta waters make development of this unit undesirable.

Well yields range from less than 25 gallons per minute in the Providence and Clayton aquifers, to more than 2,000 gallons per minute in the Ocala aquifer. Areal variations in the hydraulic conductivity of the Providence, Clayton, and Ocala aquifers cause yields to vary throughout the Albany area. The productivity of the Providence and Clayton aquifers progressively increases toward the west and northwest parts of the area, where well yields of about 2,000 gallons per minute are reported from the Clayton. The Tallahatta aquifer generally yields from 1,000 to 1,400 gallons per minute to wells and does not exhibit significant areal variations in hydraulic conductivity throughout the report area. The productivity of the Ocala aquifer decreases in the west and northwest parts of the area where the limestone comprising the aquifer becomes thinner and less permeable.

Due to the relatively low hydraulic conductivity of the Providence, Clayton, and Tallahatta aquifers, large ground-water withdrawals in the Albany area have produced widespread depressions in the potentiometric surface of each aquifer. Accelerated agricultural use of the Clayton aquifer to the northwest in parts of Dougherty, Terrell, and Calhoun Counties has elongated and expanded the cone of depression at Albany about 14 miles in that direction. Increased pumpage could limit the availability of water from the Clayton aquifer.

Heavy pumping has increased the naturally occurring head differences between the Providence, Clayton, Tallahatta, and Ocala aquifers in the Albany area and has enhanced the possibility of leakage of water through the intervening confining layers that separate these aquifers. The total amount of leakage from the Providence into the Clayton and from the Ocala into the Tallahatta, and the areal extent of this leakage, is presently unknown. Brine-trace studies made in eight wells at Albany indicate that in addition to leakage through confining layers, about 1.1 million gallons of water per day recharge the Clayton aquifer through idle multiaquifer wells that also penetrate the Providence and Tallahatta aquifers of higher head.

Water in the Providence, Clayton, Tallahatta, and Ocala aquifers is suitable for most uses and generally contains no constituent concentrations that exceed the Georgia Environmental Protection Division and U.S. Environmental Protection Agency standards for safe drinking water. However, in areas where the Ocala is poorly confined or is in direct contact with surface water, localized water-quality changes are possible.

INTRODUCTION

From 1960 to the present (1978), the Albany-Dougherty County Metropolitan Area in southwest Georgia has experienced a period of rapid growth. This rapid growth has caused ground-water use to more than triple during the past 20 years. Long-term large ground-water withdrawals have caused the water level in one aquifer to decline as much as 135 ft since 1940.

The use of ground water for irrigation is rapidly increasing to the west and northwest of Albany in parts of Dougherty, Terrell, and Calhoun Counties. The increased agricultural use in these areas could affect ground-water availability in Albany.

Most municipal wells in the Albany area tap two or more of the four ground-water reservoirs present. Because of multiaquifer well construction, almost nothing was known about the water-bearing or water-quality characteristics of individual aquifers prior to this investigation.

Although waters from the four aquifers tapped in the Albany area generally are of good quality, the deeper water-bearing zones underlying these aquifers yield water having concentrations of chloride and dissolved solids that exceed the safe drinking water standards. Head differentials resulting from declining water levels in the heavily used aquifers may accelerate the infiltration of poor-quality water from the underlying zones.

To better manage the water resources in the Albany area, municipal, industrial, agricultural, and other water users need to know the development potential of the vital ground-water resource. Recognizing this, in 1976 the city of Albany and the Georgia Department of Natural Resources, in cooperation with the U.S. Geological Survey, began an investigation to evaluate the ground-water resources of the Albany area.

Purpose and Scope

The purpose of this study was to evaluate the development potential of the ground-water resources in the Albany area. To properly analyze the ground-water system the following hydrologic factors were evaluated: the head and water quality in each aquifer utilized; the head and water quality of the underlying water-bearing zones; and the relative yields supplied by the Providence, Clayton, and Tallahatta aquifers to multiaquifer production wells.

Methods

Since this investigation began in 1976, the U.S. Geological Survey has drilled a total of 12 test wells in the Albany area (pl. 1), each tapping one of the four aquifers used for water supply in the area or the underlying water-bearing unit. Geophysical logs were made in these and other wells throughout the study area to gain a better understanding of the stratigraphy, the nature of the hydrologic system, and the water quality. Continuous drill cores were collected in test well 95-01 from land surface to a depth of about 1,400 ft. Flowmeter surveys were made in six multiaquifer city wells to estimate the relative yields from specific water-bearing zones. Borehole-flow analyses were made in eight multiaquifer production wells where the direction and velocity of flow in the well bores were recorded in order to estimate the relative head in each aquifer under pumping stress. Continuous water-level recorders were installed on 11 test wells to monitor water-level fluctuations. Water-use and water-quality data were collected to gain a better understanding of the long-term effects of heavy pumpage on the ground-water system.

Location and Description of the Study Area

The study includes parts of Lee, Terrell, and Mitchell Counties and most of Dougherty County, encompassing a total area of approximately 390 mi^2 (fig. 1).

With the exception of the extreme southeast and northwest corners, the entire study area lies within the Dougherty Plain district (fig. 1) of the Coastal Plain province of Georgia (LaForge and others, 1925). The Dougherty Plain is bordered on the east by the Tifton Upland and on the west by the Fall Line Hills. The study area is characterized by a relatively level or gently undulating topography, where altitudes range from 160 to 280 ft. Conspicuous round to irregularly shaped depressions mark the southwest and northeast parts of the study area. These depressions are sinkholes caused by solution of limestone bedrock followed by subsurface collapse, and are typical surface features in karst terrane.

The Flint River and its tributaries, including Kinchafoonee, Muckalee, Kiokee, Cooleewahee, and Piney Woods Creeks, drain the study area.

Well-Numbering System

This report utilizes a well-locating system in which the wells are numbered serially in each county. Each well is assigned a county number and a sequence number within that county. Accordingly, well number 95-01 represents well number 1 located in county 95. From this number the exact location of each well can be obtained from the index of ground-water sites on plate 1. Counties and their respective numbers used in the well-numbering system are: Calhoun, 37; Dougherty, 95; Lee, 177; and Terrell, 273.

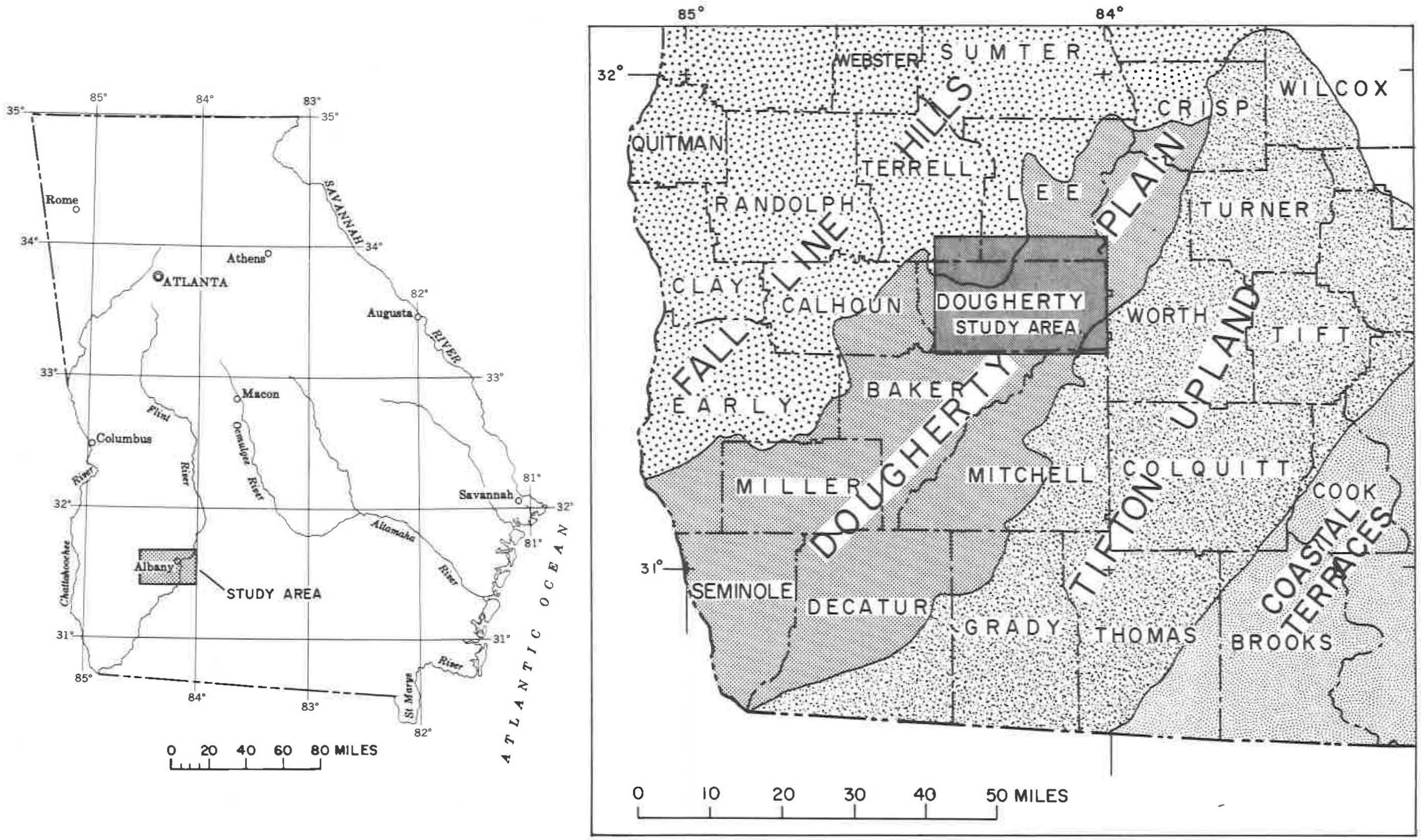


Figure 1. Location of the study area and physiographic districts of the western Georgia Coastal Plain.

Previous Studies

Little detailed hydrologic investigation has been done in the Albany area. Stephenson and Veatch (1915) discussed the geology, hydrology, and water quality in a general context. Herrick (1961) presented paleontologic and lithologic descriptions of three wells in the Albany area. The most complete study in the Albany area was done by Wait (1963), with the resulting report containing data collected through 1957. However, the hydrologic data in Wait's report were obtained primarily from multiaquifer wells.

Acknowledgments

This investigation was conducted by the U.S. Geological Survey in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, and the city of Albany Water, Gas, and Light Commission.

The Layne-Atlantic Co. (Albany) staff was extremely helpful in furnishing historical records, and provided many opportunities to conduct borehole investigations in the area. Special thanks are due Miller Brewing Co., Georgia Power Co., and St. Joe Paper Co. for allowing the U.S. Geological Survey to drill test wells on their properties, and to Miller Brewing Co. for the opportunity to participate in aquifer tests on their property in Albany.

The writers wish to extend special thanks to Mr. Walter Rodemann, General Manager of the Albany Water, Gas, and Light Commission, for his assistance, and to the many cordial people of the Albany area who provided useful historic information and allowed the use of their wells for water-level measurements.

GEOLOGY

The Coastal Plain sediments underlying the study area consist of alternating units of sand, clay, shale, and limestone (table 1 and fig. 2). The sediments extend to a depth of at least 5,000 ft and dip to the southeast by as much as 25 ft/mi, progressively thickening in that direction.

The sedimentary units show lateral variations in lithology and thickness that represent changing environments throughout the depositional history of the area. Transgressions and regressions of the sea caused the depositional environment at any given locality to change from one depositional cycle to the next. Where changes in sea level were rapid, a transitional sequence may be missing from the sedimentary record.

The original thicknesses of the individual lithologic units were controlled by the length of deposition and the sedimentation rate. Moreover, since deposition, the units have been modified in thickness and composition by weathering, erosion, compaction, and chemical alteration.

Stratigraphy

Gulfian Series (Upper Cretaceous)

The Upper Cretaceous Series in the outcrop area can be divided into six formations (Cooke, 1943). From oldest to youngest they are: the Tuscaloosa, Eutaw, and Blufftown Formations, the Cusseta Sand, the Ripley Formation, and the Providence Sand (table 1). The Cusseta Sand, Ripley Formation, and Providence Sand were the only Upper Cretaceous formations investigated during this study. Due to similar lithologies, these formational contacts in the Albany area are not definite and figure 2 represents only the approximate stratigraphy of this series. Figure 3 shows the Cusseta, Ripley, and Providence stratigraphic sequence partially penetrated by test well 95-08 in Albany, along with selected geophysical logs that reflect the different lithologies. The Cusseta, Ripley, and Providence sequence was penetrated fully at oil-test well 95-12 in western Dougherty County, where the thickness of the sequence is about 640 ft.

Cusseta Sand equivalent

In the report area the Cusseta Sand is a silty, micaceous, calcareous sand containing thin layers of interbedded shale. Glauconite is abundant in the deeper zones, but becomes less prominent higher in the section.

Ripley Formation equivalent

Overlying the Cusseta Sand is a sedimentary unit that corresponds stratigraphically to the Ripley Formation. The absence of definite lithologic breaks makes establishing formational contacts difficult, if not impossible. The lower part of the Ripley consists of fossiliferous claystone containing interbedded sand partings and fine sand. The claystone grades upward into a massive siltstone that is slightly calcareous and clay rich. In the upper part of the formation the clay is completely absent, and the Ripley consists of light, fine to medium, micaceous sand.

Providence Sand equivalent

The Ripley Formation is overlain unconformably by the Providence Sand. The basal unit of the Providence consists of a slightly dolomitic coquina that grades upward into a fossiliferous siltstone. The upper part of the Providence is a very fine- to coarse-grained calcareous, clayey, micaceous sandstone.

Figure 4 was constructed using geophysical logs from 10 wells in the Albany area and shows the approximate altitude of the top of the Providence

Table 1. Generalized stratigraphy, water-bearing properties, and water-quality characteristics of formations underlying the Albany area.

Era	System	Series	Gulf Coast Stage	Group	Formation	Thickness (feet)	Lithology	Water-bearing properties	Water-quality characteristics
CENOZOIC	Quaternary	Pleistocene			Dune sand	0-35	Fine to coarse, well sorted, angular to subangular quartz sand	Not water bearing	
					Terrace deposits	0-20	Poorly sorted gravel, sand, and clay	Not water bearing	
	Tertiary	Oligocene	Vicksburgian		Flint River Formation		Light-gray, cherty limestone	Properties unknown	Quality unknown
		Eocene	Jacksonian		Ocala Limestone	150-200	White to light-pink, fossiliferous limestone	Ocala aquifer is a very productive water-bearing unit throughout the Dougherty Plain. Reported well yields of more than 2,000 gal/min. Yields decrease north and west of Albany	Water is generally a hard calcium bicarbonate type that meets all State drinking water standards (1977)
			Claibornian	Claiborne Group	Lisbon Formation	235-340	Slightly glauconitic, fine, calcareous sand, clay, and interbedded limestones	Limited water-bearing potential--used only in multiaquifer wells where other aquifers are tapped	Water is a hard calcium bicarbonate type that meets all State drinking water standards (1977) and is suitable for most uses
					Tallahatta Formation		Fine to medium sand, clayey sand, and interbedded limestone layers that are very fossiliferous at the top of the formation	Tallahatta aquifer is a major aquifer in the Albany area; used for municipal, agricultural, and industrial supplies. Reported well yields of as much as 1,400 gal/min	
			Sabinian	Wilcox Group	Hatchetigbee Formation		Very fine, green-stained quartz sand, locally calcareous and glauconitic	Aquifer is tapped by many multiaquifer wells; however, water-bearing properties unknown	
		Upper Paleocene			Tuscahoma Sand and Nanafalia Formation, undifferentiated	110-120	Fine to medium, micaceous, clay-rich sand. Glauconite is abundant throughout. Lower part is nonfossiliferous, clay-rich sand (occasionally greater than 50 percent clay)	Used in some multiaquifer wells; water-bearing properties unknown	Quality unknown
		Lower Paleocene	Midwayan	Midway Group	Clayton Formation (upper unit)	40-120	Fine to medium, calcareous quartz sand and interbedded thin limestones	Used in some multiaquifer wells; water-bearing properties unknown	The Clayton aquifer produces water that is suitable for municipal, agricultural, and industrial supply. It is generally a soft sodium bicarbonate type that meets all State drinking water standards (1977)
					Clayton Formation (limestone unit)	70-125	Massive, light-gray, recrystallized limestone. Very fossiliferous at the top of the unit	Clayton aquifer is a major aquifer in the Albany area. East of Albany the aquifer is a poor producer; however, to the west and northwest, well yields as great as 2,000 gal/min have been reported	
					Clayton Formation (lower unit)	15-40	Fine to medium, arkosic sand, locally glauconitic and silty	Water-bearing properties unknown	
MESOZOIC	Cretaceous	Gulfian	Navarroan		Providence Sand	>2,500	Upper part of unit is a dense, gray, clayey sand. Middle part is generally a coquina. Lower part is sand containing varying amounts of silt	Providence aquifer is used in the Albany area for municipal and industrial supply. Yields range from less than 25 to about 500 gal/min	Water from this aquifer is a soft sodium bicarbonate type that is suitable for most uses and meets State drinking water standards (1977)
					Ripley Formation		Fine to medium, calcareous sand and fossiliferous claystone	Not water bearing	
			Tayloran		Cusseta Sand		Fine, micaceous, calcareous sand containing varying amounts of silt and clay	Not used as an aquifer in the Albany area; however, in other areas of Georgia yields as great as 500 gal/min have been reported	Water is a soft sodium bicarbonate type that has concentrations of chloride and dissolved solids that exceed State drinking water standards (1977)
					Blufftown Formation				
			Austinian		Eutaw Formation		Alternating layers of sand, sandy clay, and clay	Not used in the Albany area	Water quality is about the same as that in the Cusseta and does not significantly change through the Tuscaloosa. Below the Tuscaloosa, the concentration of sodium chloride is reported to increase significantly
			Eaglefordian Woodbinian		Tuscaloosa Formation				
		Comanchean	Washitan, Fredericksburgian, and Trinitian		Undifferentiated				

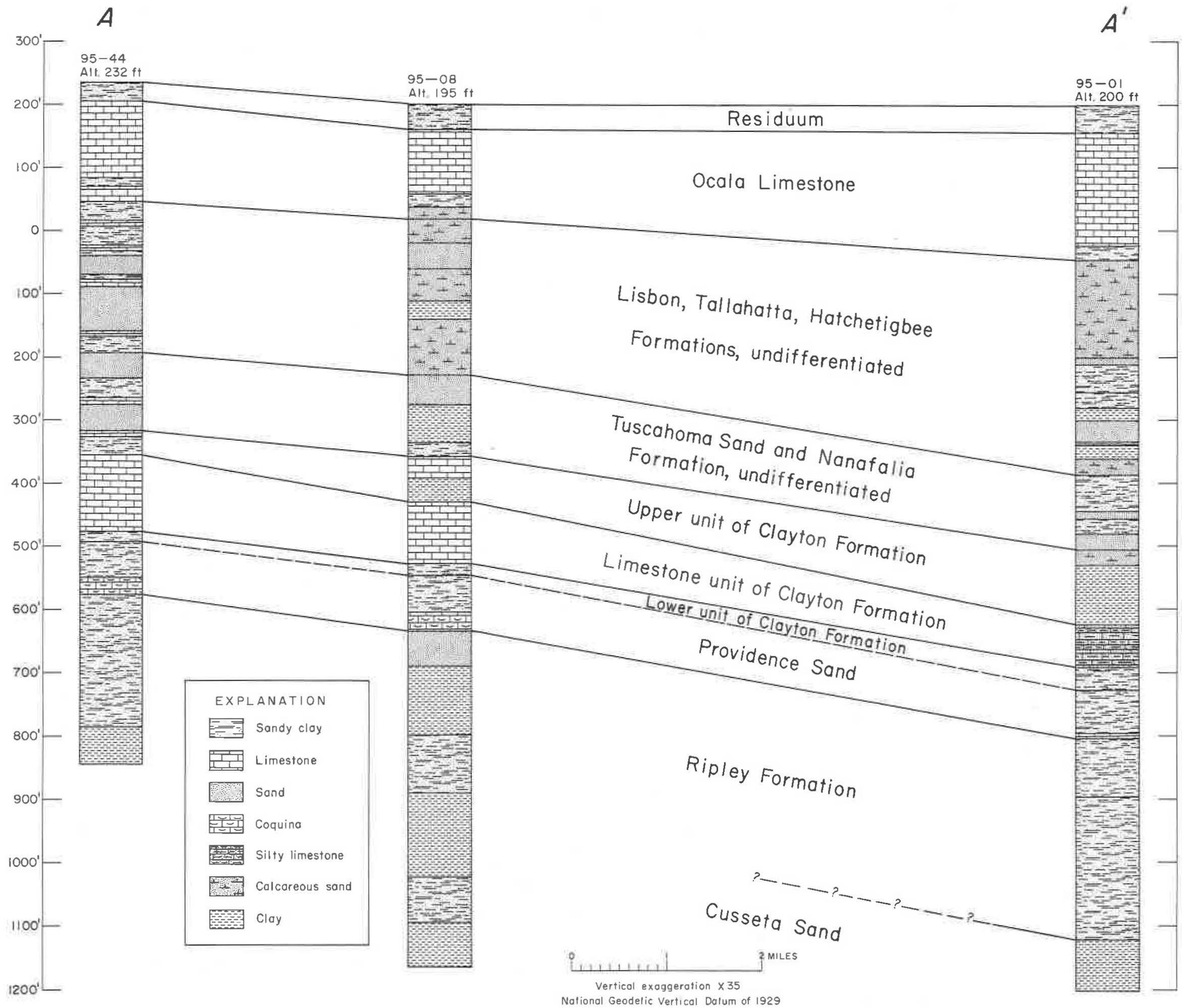


Figure 2. Geologic section of the Albany area.

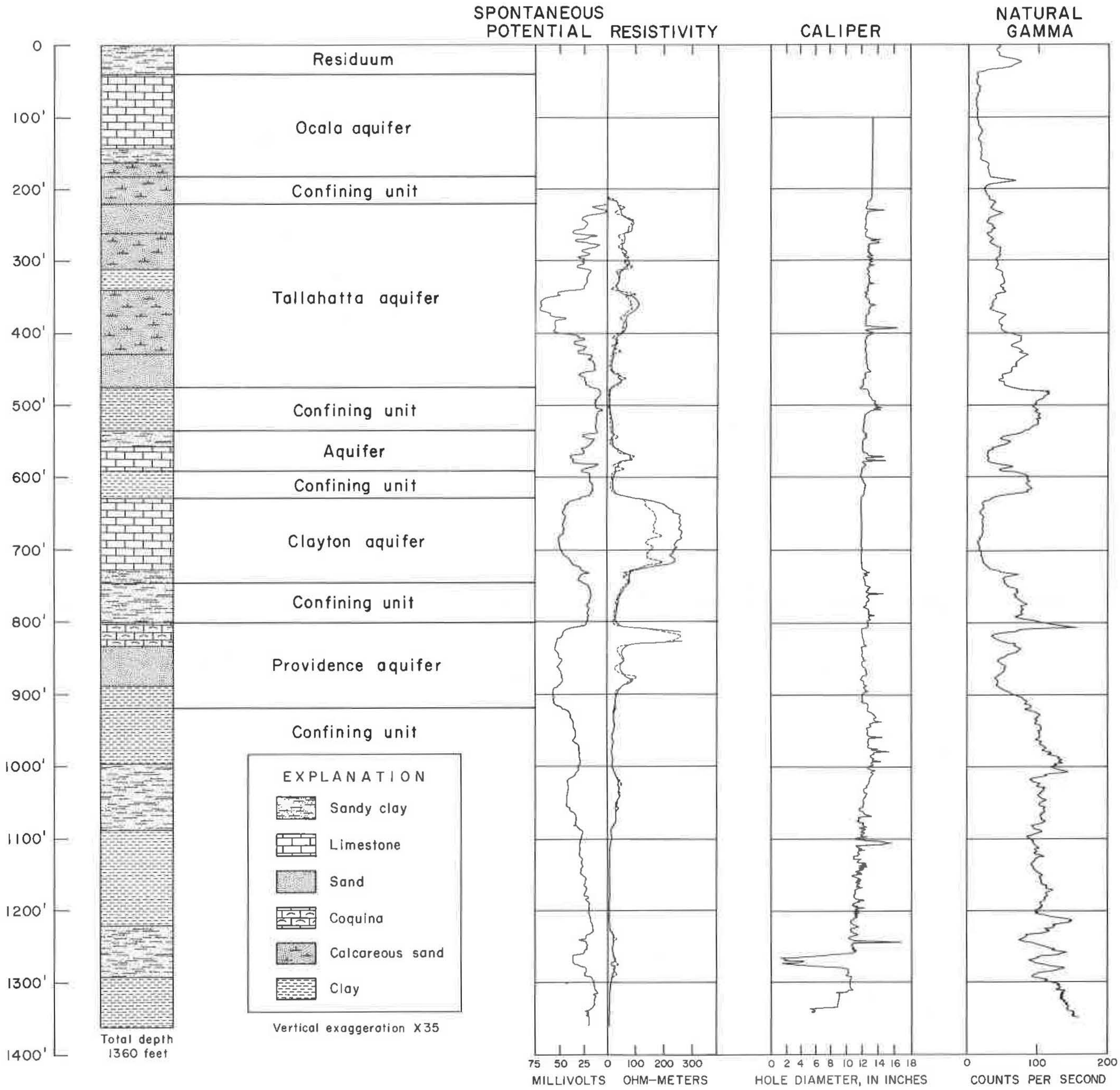


Figure 3. Stratigraphic section and geophysical well logs for well 95-08 at Albany..

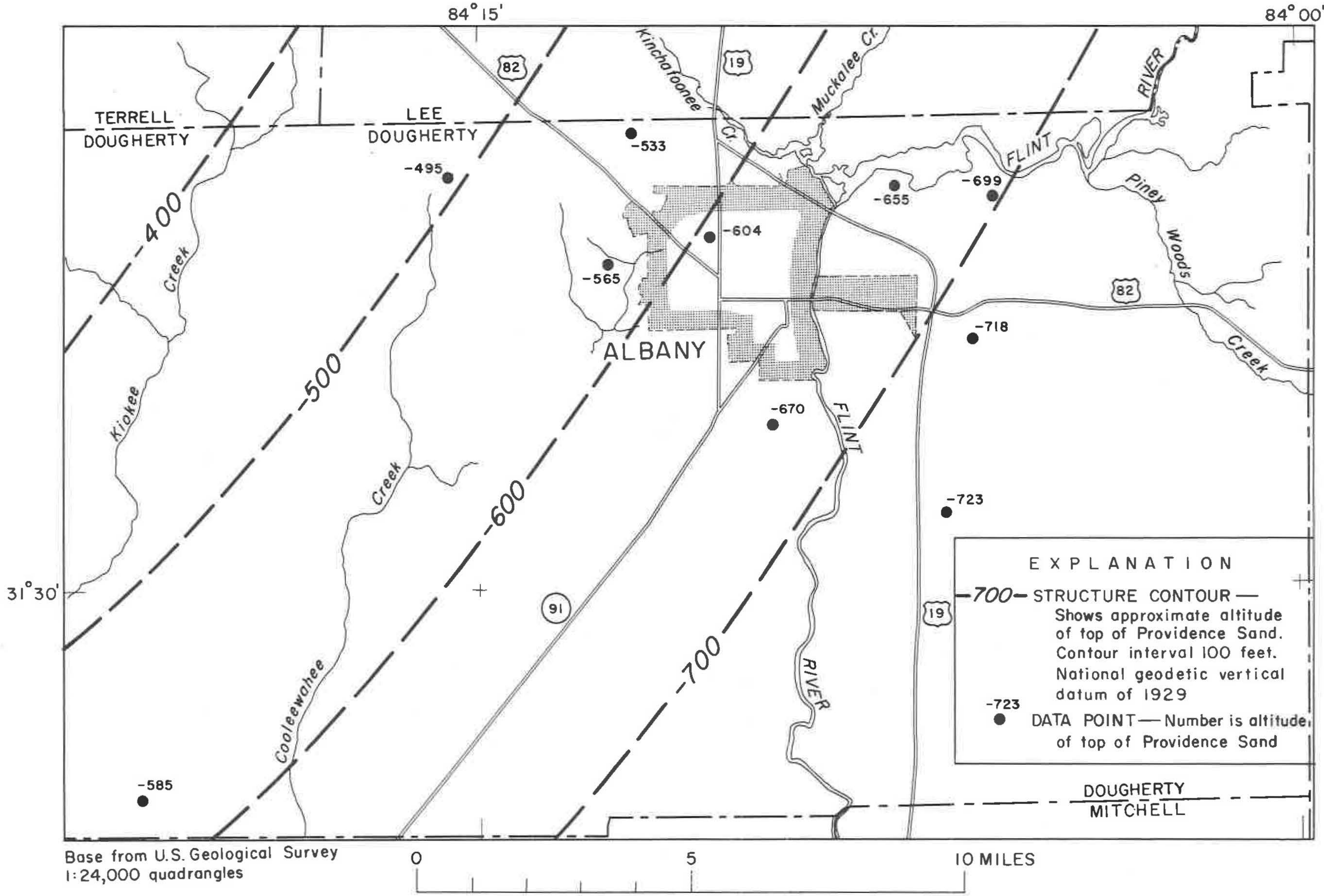


Figure 4. Approximate altitude of the top of the Providence Sand.

Sand. Depths to the Providence can be estimated throughout the study area by reading from figure 4 the approximate altitude of the formation and subtracting this from the land-surface altitude.

Geophysical well logs indicate that the Providence thickens downdip to the southeast. From figure 4, an average dip of about 23 ft/mi was computed for the top of the Providence Sand.

Paleocene Series

The Paleocene Series consists of the Midway Group and part of the Wilcox Group (table 1). The Clayton Formation is the only unit of the Midway Group recognized beneath the study area, and it unconformably overlies the Upper Cretaceous Providence Sand. The Nanafalia Formation and Tuscahoma Sand undifferentiated represent the lower part of the Wilcox Group in the study area, and unconformably overlie the Clayton.

Clayton Formation

The Clayton Formation in the study area can be divided into three lithologic units. The lowermost unit is a fine to medium calcareous sand containing varying amounts of silt and glauconite. The middle unit is a massive limestone composed of highly calcitized fossils in a recrystallized, slightly sandy limestone matrix that forms a tough, coherent rock. The sand content of the limestone increases upward, with the rock becoming less coherent. The upper unit consists of fine to medium, calcareous, quartz sand containing minor glauconite and varying amounts of silt and clay.

Variations in lithology also occur laterally in the Clayton Formation. Downdip, to the southeast, the clay and silt content in the limestone increases sharply, filling the pore spaces and causing a decrease in effective porosity and permeability.

Due to irregularities developed on the surface of the underlying formations prior to deposition of the Clayton, to extensive post-Clayton erosion, and to solution of the middle limestone unit, the surface configuration and thickness of the Clayton Formation vary throughout the study area. The average thickness of the entire formation ranges from about 180 ft in the northwest part of the area to about 245 ft in the southeast part. The limestone part of the formation ranges in thickness from about 125 ft in the northwest to about 70 ft in the southeast. Figure 5 shows that the Clayton Formation generally dips to the southeast at a rate of about 17 ft/mi. The dip rate increases in the southeast part of the area to about 22 ft/mi.

Nanafalia Formation and Tuscahoma Sand, undifferentiated

The Clayton Formation is unconformably overlain by the Nanafalia Formation and the Tuscahoma Sand, undifferentiated. The basal part of this sequence grades upward from a nonfossiliferous sand and clay to a fine to medium, calcareous, fossiliferous sand. The upper part consists of a fine, slightly micaceous, clay-rich sand. Glauconite is abundant throughout, composing approximately 50 percent of the sediment in some clay-rich zones.

The thickness of the Nanafalia-Tuscahoma sequence is fairly uniform in the study area, increasing only slightly downdip to the southeast where it attains a maximum thickness of about 120 ft (fig. 2).

Eocene Series

Eocene sediments of the Hatchetigbee, Tallahatta, and Lisbon sequence represent the entire Claiborne Group and the upper part of the Wilcox Group in the study area, and unconformably overlie the Paleocene Tuscahoma Sand. The sequence is difficult to subdivide in the report area because it consists throughout of lithologically similar alternating layers of thin- to medium-bedded sands, sandy clays, and siltstones, all of which are highly glauconitic and commonly calcareous (fig. 2). Minor beds of white- to medium-gray limestone are present. Coarse, broken oyster shells are prominent in the limestones and calcareous sands and are the only macrofauna that occur in the sequence.

Hatchetigbee, Tallahatta, and Lisbon Formations, undifferentiated

In the absence of any definite lithologic or faunal breaks, the following informal subdivision of the Hatchetigbee-Tallahatta-Lisbon sequence is used in this report. The predominantly clayey section immediately overlying the Tuscahoma Sand is thought to be the Hatchetigbee Formation in the study area. Overlying the predominantly clayey Hatchetigbee Formation is a section that consists primarily of fine to medium sands and clayey sands. Thin limestone beds are interlayered throughout the middle and upper parts of the section. In the study area the limestone beds are more fossiliferous near the top of the section where they are replaced by a thick layer of coquina. The sand, limestone, and coquina section is the part of the Eocene most commonly used as an aquifer and is herein referred to as the Tallahatta Formation. The uppermost part of the sequence is predominantly clay, much like the Hatchetigbee, and contains prominent beds of calcareous, glauconitic sand and limestone. This section is herein correlated with the Lisbon Formation.

The Hatchetigbee, Tallahatta, and Lisbon Formations, as subdivided here, are considered to be "operational" stratigraphic units whose gross lithologic characteristics can be correlated for reasonable distances and which generally fit a currently accepted stratigraphic division.

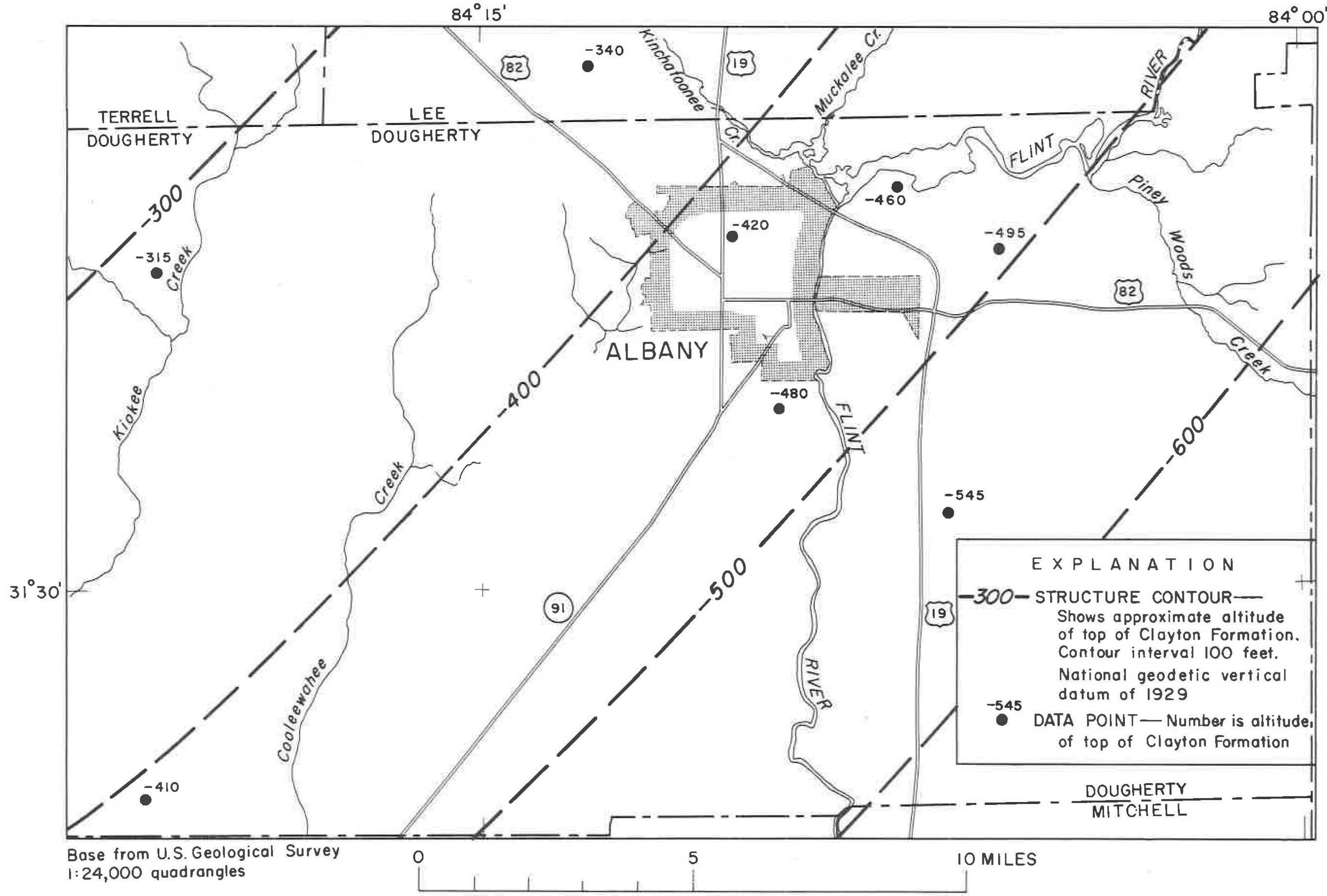


Figure 5. Approximate altitude of the top of the Clayton Formation.

The top of the Hatchetigbee-Tallahatta-Lisbon sequence dips to the southeast at approximately 10 ft/mi (fig. 6) and undergoes a marked increase in thickness downdip (fig. 2). The thickness of this sequence ranges from about 235 ft in the northwest part of the area to about 340 ft in the southeast.

Ocala Limestone

The Ocala Limestone comprises the upper Eocene Jackson Group in the report area and unconformably overlies the Lisbon Formation. The Ocala Limestone crops out in the study area along the Flint River and Kinchafoonee, Muckalee, and Piney Woods Creeks where erosion has removed the overburden.

The basal section of the Ocala consists of a tough fine- to medium-grained recrystallized, dolomitic, moderately fossiliferous limestone. The limestone is more sandy in the middle of the section where fossils are less abundant. Limestone near the top of the section is variably fine to coarse grained, chalky, and coarsely fossiliferous (P. F. Huddlestun, oral commun., 1980).

The Ocala dips slightly to the southeast at 2 to 5 ft/mi and generally thickens in that direction. The formation ranges in thickness from about 150 to 200 ft throughout the report area.

Residuum

Most of the Dougherty Plain part of the report area is covered by 40 to 70 ft of unconsolidated residuum developed from weathering of the Ocala Limestone and Oligocene limestones. This residuum is generally a red sandy clay that, in the southeast part of the area, may contain siliceous boulders as large as 3 ft in diameter. The flood plain of the Flint River is covered by 20 to 70 ft of unconsolidated river-terrace deposits.

HYDROLOGY

Water in the Albany area is obtained primarily from four ground-water reservoirs, or aquifers (table 1). From deepest to shallowest, the aquifers are: the Providence, Clayton, Tallahatta, and Ocala. Although ground water is present in the underlying Cusseta Sand, high drilling costs, low yields, and excessive concentrations of chloride and dissolved solids make development of this unit undesirable.

Recharge waters enter the aquifers where they occur near land surface and percolate downgradient to become confined between relatively impermeable beds of clay, sandy clay, or shale. Thus, confined ground water is under a constant pressure known as hydrostatic, or artesian, pressure. When a well penetrates a confined aquifer downdip from the recharge area, artesian pressure causes the water in the aquifer to rise above the top of the aquifer. An imaginary surface connecting points to which water would rise in tightly cased wells is called the potentiometric surface (Lohman, 1972, p. 8). The altitude of the potentiometric surface is controlled by the artesian pressure and is a function of the rate of recharge, the hydraulic gradient (slope of the imaginary water surface), and the rate of discharge.

The transmissivity of an aquifer is defined as the rate at which water will flow through a unit width of material under a unit hydraulic gradient. It is, thus, a measure of the aquifer's ability to transmit water. Transmissivities used in this report are estimated from specific capacity data and, because of well losses, are generally lower than values calculated from aquifer tests. The hydraulic conductivity is also a term used to define the water-transmitting ability of an aquifer. Like the transmissivity, it is influenced primarily by permeability and hydraulic gradient, but is also influenced by the viscosity of the water.

The ability of many carbonate aquifers to transmit water is enhanced by the development of secondary permeability. Circulating ground water containing carbon dioxide dissolves calcium carbonate along joints and bedding planes in the aquifer, thus enlarging the primary flow channels as well as creating new channels.

Aquifer Properties

Providence Aquifer

The Providence aquifer receives recharge where it occurs near land surface along a northeast-trending line about 50 mi north-northwest of Albany. Ground water is confined in the aquifer from below by the dense clay of the Ripley Formation, and from above by the silty upper Providence-lower Clayton sequence (fig. 2). Ground water is obtained from the Providence aquifer in the Albany area at depths ranging from about 640 to 960 ft below land surface.

Artesian pressure in the Providence was sufficient during 1978 to produce an average water level of about 110 ft below land surface at well 95-08 at Albany, near the center of municipal pumpage. Water levels become higher with increased distance from the pumping center.

Estimates of transmissivity for the Providence aquifer range from about 250 ft^2/d at well 95-01, 3 mi southeast of Albany, to 1,000 ft^2/d at well 95-48, approximately 12 mi updip to the northwest. The hydraulic conductivity is lowest in the upper part of the formation and highest in the coquina bed (fig. 2) where most of the water is produced. The Providence

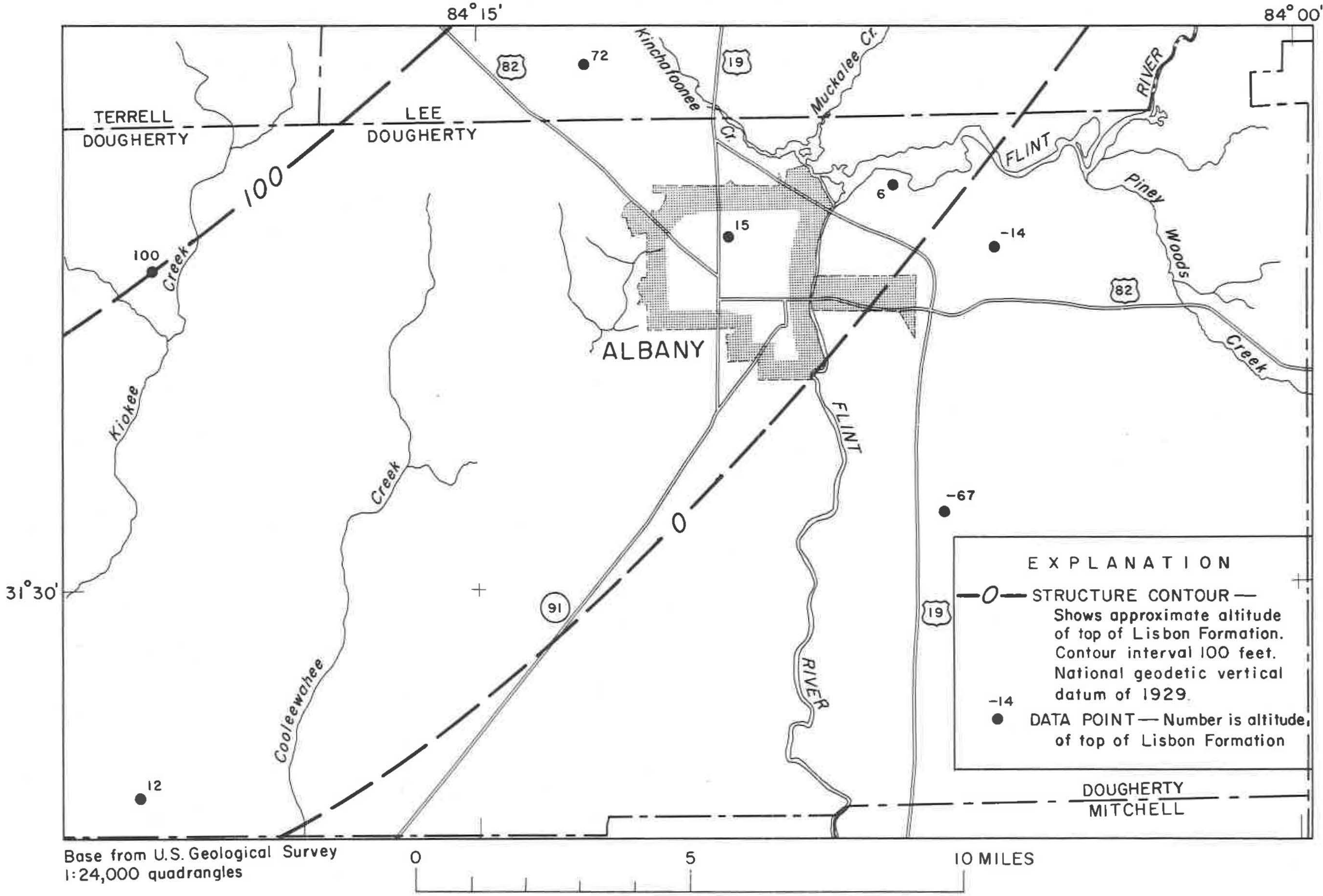


Figure 6. Approximate altitude of the top of the Lisbon Formation.

yields less than 25 gal/min to wells in the south and southeast parts of the report area where the transmissivity is low; however, updip to the northwest, yields to wells of about 500 gal/min have been reported.

The Providence aquifer produces a soft sodium bicarbonate type water that contains no constituent concentrations that exceed the Georgia Environmental Protection Division standards (1977) for safe drinking water (table 2). The average calcium, magnesium hardness of 6 mg/L (milligrams per liter) and low average dissolved iron concentration of 50 ug/L (micrograms per liter) make water from this aquifer ideal for domestic use.

Clayton Aquifer

The Clayton aquifer is recharged primarily where it occurs near land surface and where the formation is exposed in steep valley walls along a northeast-trending line about 35 to 40 mi north-northwest of Albany. The topography of the Clayton recharge area is not conducive to the influx of large quantities of water. Ground water is obtainable from the Clayton aquifer in the Albany area at depths ranging from about 550 to 840 ft below land surface. The Clayton is artesian in the Albany area and water in the aquifer is confined from below by the silty upper Providence-lower Clayton sequence and from above by the clayey Tuscahoma Sand.

During 1978 the Clayton aquifer had an average water level of 140 ft below land surface at well 95-06 (pl. 1) near the center of pumpage in Albany. This was the lowest water level recorded in the Albany area.

Figure 7 shows how the transmissivity of the Clayton aquifer varies laterally, increasing from the area east of Albany, northwest to Sasser. Estimates of transmissivity, made from specific-capacity data (Lohman, 1972, p. 52), range from about 200 ft^2/d at well 95-07, approximately 3 mi southeast of Albany, to about 11,000 ft^2/d at well 273-03, to the northwest at Sasser. Yields to wells tapping the Clayton aquifer, like those of the Providence, vary areally. Well 95-09, approximately 3 mi northeast of Albany, produces about 250 gal/min, whereas well 273-05 near Sasser has a reported production of about 2,000 gal/min. This progressive increase in transmissivity and yield toward the northwest is due largely to a directional increase in hydraulic conductivity and the thickening of the water-bearing part of the Clayton Formation.

Water from the Clayton aquifer generally is a soft sodium bicarbonate type that contains no constituent concentrations that exceed the State standards (1977) for drinking water (table 2). Although the average dissolved iron concentration of 152 ug/L is higher than that in the Providence aquifer, the level is not excessive and has not been reported to cause staining or encrustation problems.

The sodium bicarbonate water in the Clayton aquifer is nontypical of carbonate aquifers, which generally yield water of a calcium bicarbonate type. The uncharacteristically high concentration of sodium (average 44 mg/L) in water from the Clayton in Albany could result from the leakage of sodium bicarbonate water from the underlying Providence aquifer.

Tallahatta Aquifer

The Tallahatta aquifer is recharged primarily by rainfall where the sediments occur near land surface along a northeast-trending line 20 to 30 mi north-northwest of Albany. The Tallahatta aquifer is comprised of several hydraulically interconnected water-bearing zones in the Hatchetigbee-Tallahatta-Lisbon sequence. Ground water can be obtained from this aquifer in the Albany area at depths ranging from about 125 to 350 ft below land surface. The aquifer is confined from below by the clayey Tuscahoma Sand and from above by the upper part of the Lisbon Formation. During 1978, artesian pressure in the Tallahatta aquifer was sufficient to produce an average water level at well 95-05, near the center of pumpage in Albany, of about 90 ft below land surface.

Limited areal testing indicates that the transmissivity and yield of the Tallahatta aquifer does not vary significantly in the Albany area. Estimates of transmissivity, made from specific-capacity data, range from about 2,400 to 3,500 ft^2/d. The water-bearing potential of the Tallahatta aquifer is good where tested and yields to wells of 1,000 to 1,400 gal/min have been reported. However, the relatively low transmissivity of the aquifer results in large drawdowns when pumpage exceeds about 750 gal/min.

The Tallahatta aquifer produces a hard calcium bicarbonate type water that contains no constituent concentrations that exceed the State 1977 drinking water standards (table 2). The dissolved calcium concentration ranges from 18 to 52 mg/L and is uncharacteristically high for a predominantly sand aquifer. Although dissolution of calcite could account for part of the dissolved calcium, the relatively high calcium levels observed in water samples from the Tallahatta aquifer in the Albany area could result from the vertical leakage of calcium bicarbonate water from the overlying Ocala aquifer.

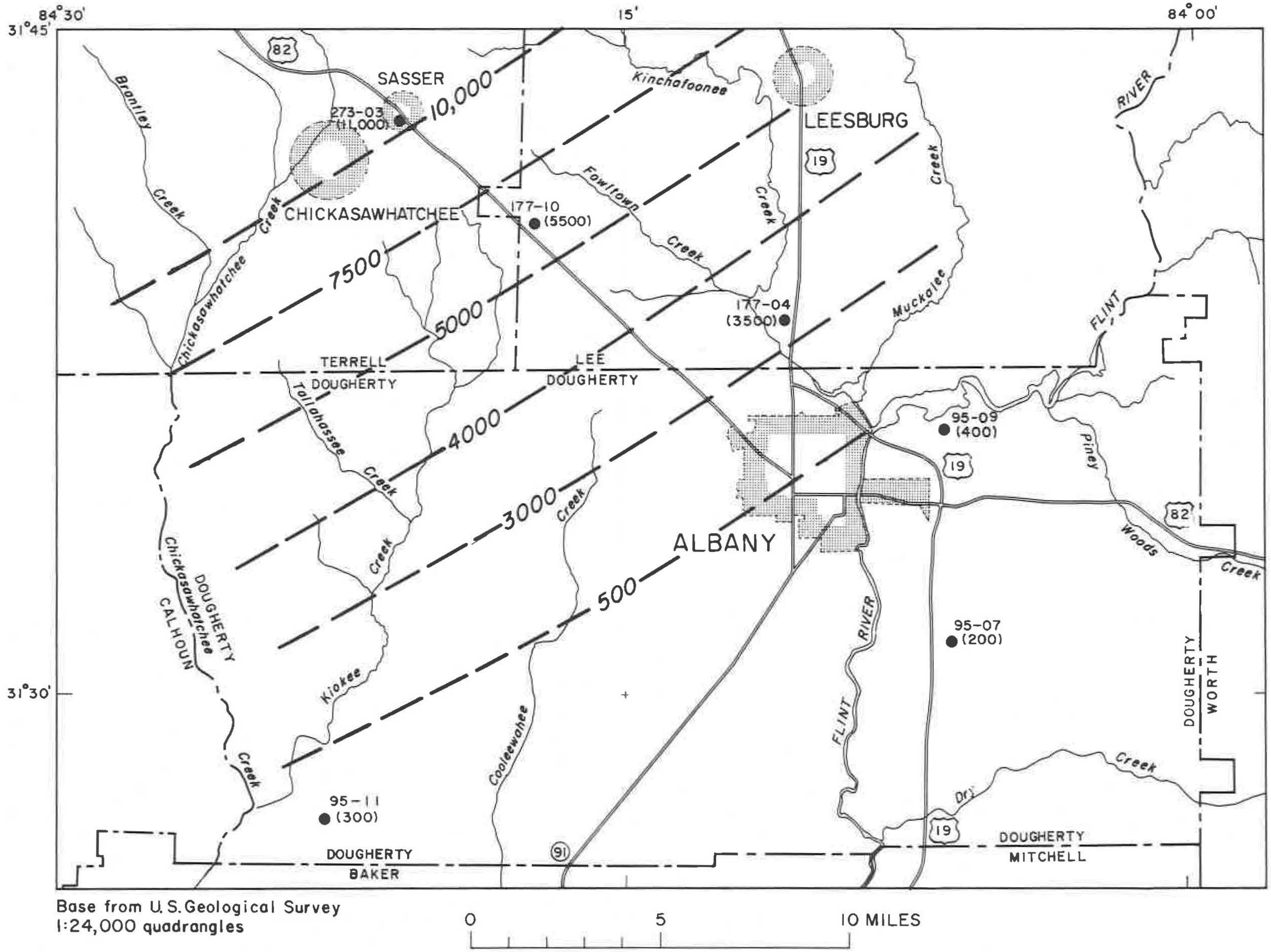
Ocala Aquifer

The Ocala aquifer is recharged, in the Albany area and throughout much of the Dougherty Plain, chiefly

Table 2. Chemical analysis of well and river water, Albany area.
(Analyses by U.S. Geological Survey. <, less than)

Site number	Owner or name	Aquifer	Date sampled	Milligrams per liter												Dissolved solids		Hardness							Micrograms per liter											
				Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Alkalinity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Residue at 180°C	Sum of constituents	Calcium, magnesium	Noncarbonate	Specific conductance, in micromhos at 25°C	pH	Temperature, in degrees Celsius	Color, in platinum-cobalt units	Carbon dioxide (CO_2)	Aluminum (Al)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Selenium (Se)	Strontium (Sr)	Zinc (Zn)
	Drinking water standards[1]										250	250				500	500						15			50	10	50	1,000	300	50	50	2.0	10		5,000
95-12	Sealy, J. R., 2	Cusseta	10-15-57	15	5.2	2.3	586	5.6	820	689	0.0	435	2.6	-	-	1,500	1,470	22	0	2,490	8.4	22.0	22	5.2	-	-	-	-	-	-	-	-	-	-	-	-
95-12	Do.	do.	06-27-78	11	6.9	2.2	620	5.7	850	700	7.8	420	4.0	0.09	0.00	1,510	1,500	27	0	2,100	7.5	25.0	20	43	30	2	0	0	0	20	3	30	<0.5	0	430	10
95-01	USGS TW 1, Albany	do.	06-17-77	13	4.3	.8	660	.2	1,040	850	4.3	410	3.2	-	-	-	1,610	14	0	2,575	8.2	21.0	60	10	10	1	0	0	0	10	0	0	0	0	360	0
95-08	USGS TW 10, Albany	Providence	11-21-78	12	1.7	.4	85	1.6	200	190	7.6	2.4	.6	.09	.00	214	223	6	0	358	9.2	24.0	0	.2	40	0	3	1	0	50	10	0	.6	0	-	0
95-06	USGS TW 6, Albany	Clayton	03-07-78	20	12	6.0	33	2.8	140	110	13	1.5	.2	.04	.00	160	158	55	0	231	7.2	22.8	10	14	20	0	0	0	0	180	11	10	<.5	0	360	0
95-07	USGS TW 7, Albany	do.	05-31-78	25	8.6	2.4	80	3.1	230	190	4.2	4.5	.7	.00	.00	241	243	32	0	284	8.0	21.7	10	-	40	2	0	0	7	110	0	10	<.5	0	380	0
177-02	USGS TW 9, Albany	do.	09-28-78	19	15	6.0	30	2.9	140	110	14	1.9	.2	.00	.00	157	159	63	0	252	7.7	21.9	5	45	0	0	1	0	0	120	13	10	<.5	0	410	0
95-09	Turner City, Ga., 2	do.	08-16-55	21	11	5.7	40	2.8	-	-	12	2.5	.2	.40	-	162	169	50	0	256	7.6	22.7	8	-	-	-	-	-	-	80	-	-	-	-	-	-
95-09	Do.	do.	04-28-76	18	11	5.1	39	3.3	146	120	12	2.7	.3	.00	.03	170	164	49	0	263	6.7	24.0	0	47	0	0	0	0	0	170	0	0	.1	0	270	0
95-09	Do.	do.	06-21-78	18	10	4.9	34	2.8	140	110	9.4	1.7	.2	.09	.00	163	156	45	0	259	6.6	24.0	5	-	20	1	-	0	0	250	8	10	<.5	0	260	10
95-02	USGS TW 2, Albany	Tallahatta	06-17-77	40	30	10	13	4.3	177	150	6.3	4.5	.1	-	-	188	196	120	0	288	7.6	22.5	5	-	10	1	0	0	0	60	0	10	0	0	420	0
95-04	USGS TW 4, Albany	do.	10-20-77	32	50	2.6	4.0	1.4	170	140	5.1	2.5	.1	.04	.00	190	182	140	0	276	7.1	21.0	2	22	0	1	0	1	0	190	3	0	<.5	0	410	10
95-05	USGS TW 5, Albany	do.	02-09-78	33	52	8.3	9.0	3.2	210	170	6.0	4.1	.1	.00	.00	212	220	160	0	350	7.6	21.0	10	8.4	40	4	0	0	1	230	0	0	<.5	0	320	10
177-01	USGS TW 8, Albany	do.	09-25-78	34	37	6.9	16	2.5	170	140	10	3.0	.2	.00	.00	187	194	120	0	289	7.6	22.0	0	6.8	0	0	0	0	0	70	1	10	<.5	0	420	0
95-10	USGS TW 11, Albany	do.	05-09-79	32	18	7.4	8.6	3.6	180	150	7.6	3.1	.1	-	-	183	191	130	0	296	7.7	22.8	5	18	50	2	1	2	0	240	2	10	<.5	0	350	10
273-10	Sasser, Ga., 2	do.	05-04-78	9	43	.4	1.7	.1	133	109	.8	3.0	.0	1.60	-	-	125	109	0	218	7.5	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
95-14	PW 2, Miller Brewing Co.	do.	04-11-79	36	49	4.5	7.1	2.1	180	150	3.9	3.6	.1	.00	.00	199	195	140	0	304	7.7	23.5	0	-	20	1	0	2	1	30	5	1	<.5	0	290	10
95-22	Albany-Dougherty Co., USMC	Ocala	06-21-78	12	50	1.3	2.2	.5	150	120	.2	3.5	.1	4.20	.00	158	148	130	7	239	7.1	32.0	5	19	20	0	1	2	2	1	3	10	<.5	0	80	10
95-23	Merck and Co., Inc., 1	do.	08-01-61	8	50	.7	2.0	.1	154	126	.4	2.0	.6	.70	-	139	141	128	2	244	7.7	21.0	0	4.9	-	-	-	-	-	-	-	-	-	-	-	-
95-24	Herty Nursery, 4	do.	08-09-57	10	45	1.1	2.7	.3	140	115	1.0	3.5	.3	6.10	-	145	139	117	0	233	7.7	24.0	4	4.5	-	-	-	-	-	-	-	-	-	-	-	-
95-03	USGS TW 3, Albany	do.	06-17-77	8	45	.9	1.8	.2	147	120	.5	2.6	.0	-	-	131	132	120	0	234	7.4	21.5	5	-	10	1	0	0	0	10	3	10	.0	0	50	10
95-43	Albany, Ga., 21	Multiaquifer[2]	06-18-70	34	40	6.1	17	2.7	182	149	5.6	4.0	.4	.00	.00	227	200	126	0	308	8.0	23.0	5	2.9	-	10	-	0	0	10	0	0	-	-	320	-
95-37	Albany, Ga., 15	do.	06-23-76	24	16	6.0	42	5.7	178	146	10	6.0	.7	.00	-	197	-	65	-	256	8.4	-	0	-	-	-	-	-	-	100	-	0	-	-	-	-
-	Flint River at Albany	Surface water	04-16-69	8	7.3	.9	3.7	1.8	-	40	2.0	3.7	-	.10	-	-	-	21	-	66	7.5	21.0	40	-	-	-	-	-	-	1,100	-	50	-	-	-	-
CSST[4]	Average values for each aquifer	Cusseta		13	5.2	1.6	622	3.8	903	746	4.0	422	3.3	.10	.00	1,505	1,527	21	0	2,522	-	22.7	34	19	20	2	0	0	0	15	1	15	<.5	0	395	5
PVDC		Providence		12	1.7	.4	85	1.6	200	190	7.6	2.4	.6	.10	.00	214	223	6	0	358	-	24.0	0	.2	40	0	3	1	0	50	10	0	<.5	0	-	0
CLTN		Clayton		20	12	5.0	44	3.0	159	128	12	2.5	.3	.10	.00	175	174	49	0	258	-	22.9	6	26	26	1	1	0	0	152	6	10	<.5	0	336	0
TLLT		Tallahatta[3]		34	40	6.6	9.6	2.8	181	165	6.5	3.9	.1	.30	.00	193	196	135	0	300	-	22.1	3	14	20	2	0	2	2	137	2	5	<.5	0	368	7
OCAL		Ocala		9.5	43	10	22	.3	148	120	.5	2.9	.3	3.70	.00	143	140	124	2	238	-	22.1	4	9.0	15	1	1	1	3	10	3	7	<.5	0	65	10

1/ Georgia Environmental Protection Division standards for safe drinking water, 1977.
2/ Analysis represents a composite of water from the Providence, Clayton, and Tallahatta aquifers.
3/ Averages do not include analysis from site 273-03 because of the proximity of well to recharge area.
4/ CSST - Cusseta Sand
PVDC - Providence Sand
CLTN - Clayton Formation
TLLT - Tallahatta Formation
OCAL - Ocala Limestone



EXPLANATION

—— *500* —— LINE OF EQUAL TRANSMISSIVITY — Interval is 1000 and 2500 feet squared per day

● 95-07 (200) DATA POINT — Top number is well identification. Number in parentheses is estimated transmissivity in feet squared per day

Figure 7. Approximate transmissivity of the Clayton aquifer.

by the infiltration of rainfall. The Ocala is generally covered in the Dougherty Plain area by a thin layer of unconsolidated residuum ranging in thickness from about 40 to 70 ft. Where the residuum is present, the aquifer is confined and is artesian; where the residuum has been removed by stream erosion or through sinkhole collapse, the aquifer is unconfined. Because of the varying conditions of confinement and pressure, average water levels in the Ocala during 1978 ranged areally from about 2 ft above land surface to 45 ft below.

Aquifer tests show that in areas near the Flint River where the Ocala Limestone is very cavernous, the transmissivity may exceed 100,000 ft^2/d (L. R. Hayes, oral commun., 1980). This high transmissivity allows the movement of large quantities of ground water, and yields to wells of 2,000 gal/min have been reported. However, away from the river in areas where solution openings are not well developed and to the northwest where the aquifer is thinner, the transmissivity of the Ocala can be as low as 2,000 ft^2/d and wells are reported to produce about 500 gal/min.

Water from the Ocala aquifer is moderately hard and is classified as a calcium bicarbonate type (table 2). Water samples from wells 95-22, near the Worth-Dougherty County line, and 95-24, at the Herty Nursery in Albany, had higher concentrations of nitrate than samples from the underlying aquifers. Well 95-24 produced water having a nitrate concentration of 6.10 mg/L, the highest level detected in the report area. These anomously high nitrate concentrations probably are due to the leaching of soil which has been treated with nitrogen-base fertilizer.

Water from the Ocala generally is of good chemical quality and contains no constituent concentrations that exceed 1977 State drinking water standards. However, the quality of the water could change rapidly in areas where the aquifer is unconfined or is in direct contact with surface water.

Influence of the Flint River

During periods of normal streamflow, the Ocala aquifer discharges into the Flint River through cavernous zones in the limestone that have been exposed by stream erosion. Figures 8 and 9 are graphs showing precipitation and the stage of the Flint River at Albany during 1978. Comparison of these figures shows the effect of heavy rainfall on the Flint River. When the river stage is increased, ground water that normally discharges into the river backs up into the aquifer, causing the water level to rise in Ocala wells near the river. Extended periods of heavy rainfall cause the river stage to rise above the altitude of the potentiometric surface in the Ocala aquifer. When this occurs, normal ground-water discharge points become recharge points and river water rapidly enters the cavernous zones in the aquifer. Comparison of figure 10 with figure 9 shows that the water level in well 95-03, 4 mi southeast of Albany and about 1.7 mi east of the Flint River, is very "flashy" and responds almost instantaneously to significant changes in river stage. By contrast at well 95-22, near the Worth-Dougherty County line and about 5.1 mi from the river, the altitude of the potentiometric surface of the Ocala aquifer is higher than the maximum river stage, and the water level in this well (fig. 11) is less affected by the increased stage of the river.

Leakage

Although rainfall entering the aquifers where they occur near land surface is the primary source of recharge, another source of recharge exists in the Albany area. Pumpage that reduces the head, or artesian pressure, in an aquifer may promote increased vertical flow through the confining beds separating the pumped aquifer from aquifers of higher artesian pressure. The amount of leakage per unit area depends on three factors: (1) the vertical hydraulic conductivity of the confining layer; (2) the thickness of the confining layer; and (3) the head difference between the aquifers. In and near the city of Albany, heavy pumpage from the Providence, Clayton, and Tallahatta aquifers has produced head differences that could enhance leakage. Water-quality analyses indicate that water may be leaking from the Providence aquifer into the Clayton and from the Ocala aquifer into the Tallahatta. Additional test drilling and monitoring would be necessary to estimate the amount and areal extent of the leakage.

MULTIAQUIFER HYDROLOGY

When developed individually, the Providence, Clayton, and Tallahatta aquifers in the Albany area yield water to production wells in insufficient quantities to be cost efficient. For this reason, the city of Albany uses wells that tap two or more aquifers simultaneously. Multiaquifer wells maximize yield, and minimize drawdown and drilling costs. Throughout much of the Albany area, properly constructed multiaquifer wells can produce a sustained yield greater than 1,500 gal/min and generate smaller drawdowns than wells tapping a single aquifer.

Well Construction

The telescoping construction design of two typical multiaquifer wells is shown in figure 12. Construction of each well is begun by drilling and driving a large-diameter surface casing through the residuum. Drill-

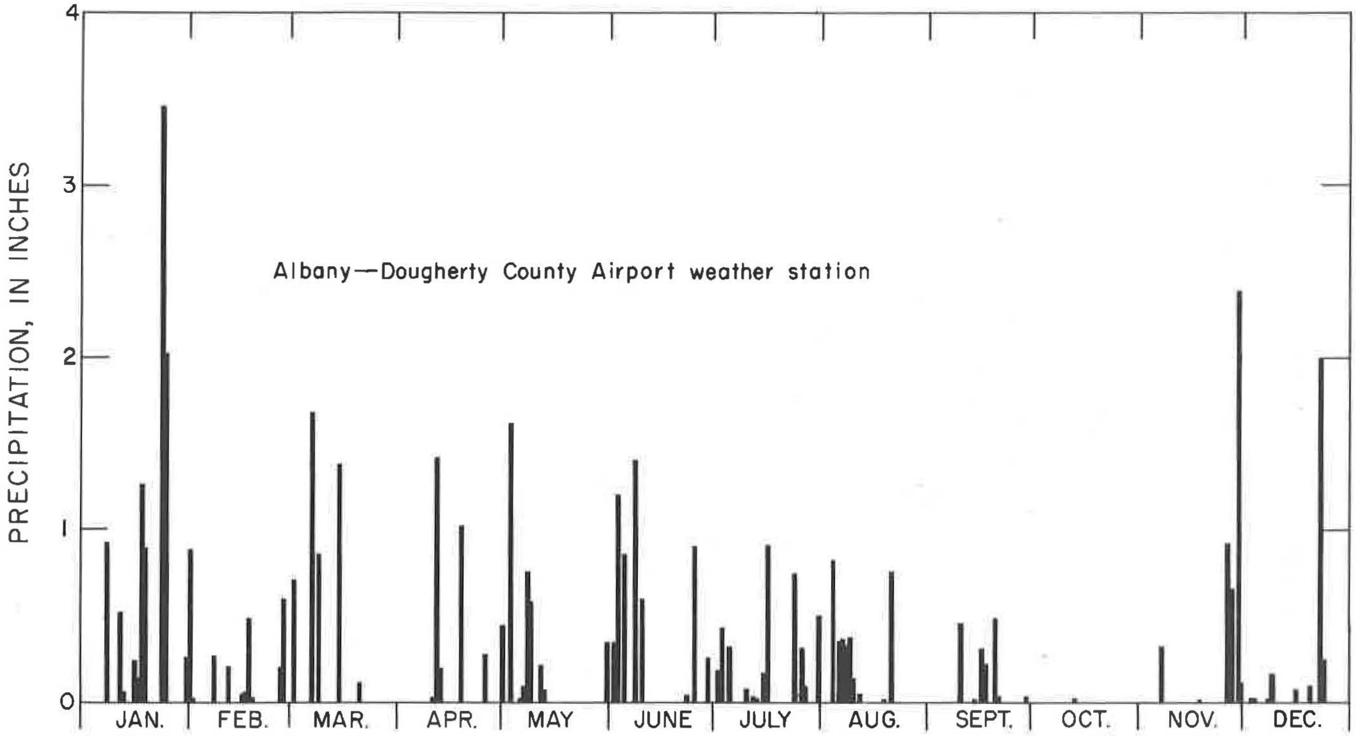


Figure 8. Daily precipitation at Albany-Dougherty County airport, 1978.

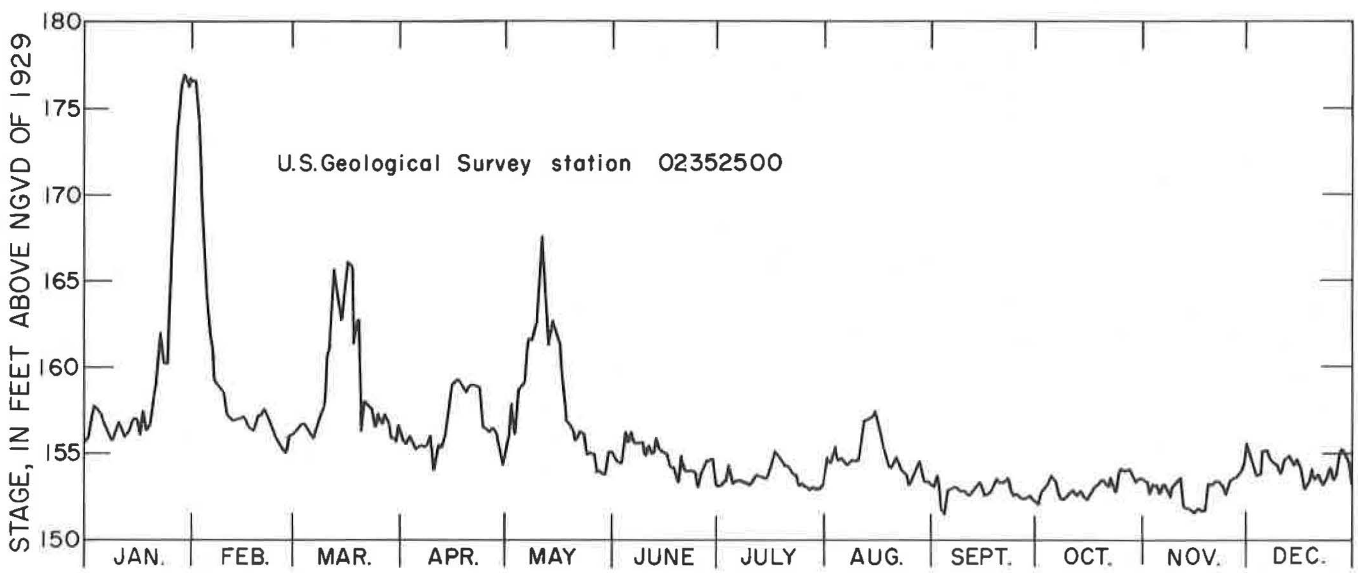


Figure 9. Mean daily stage of the Flint River at Albany, 1978.

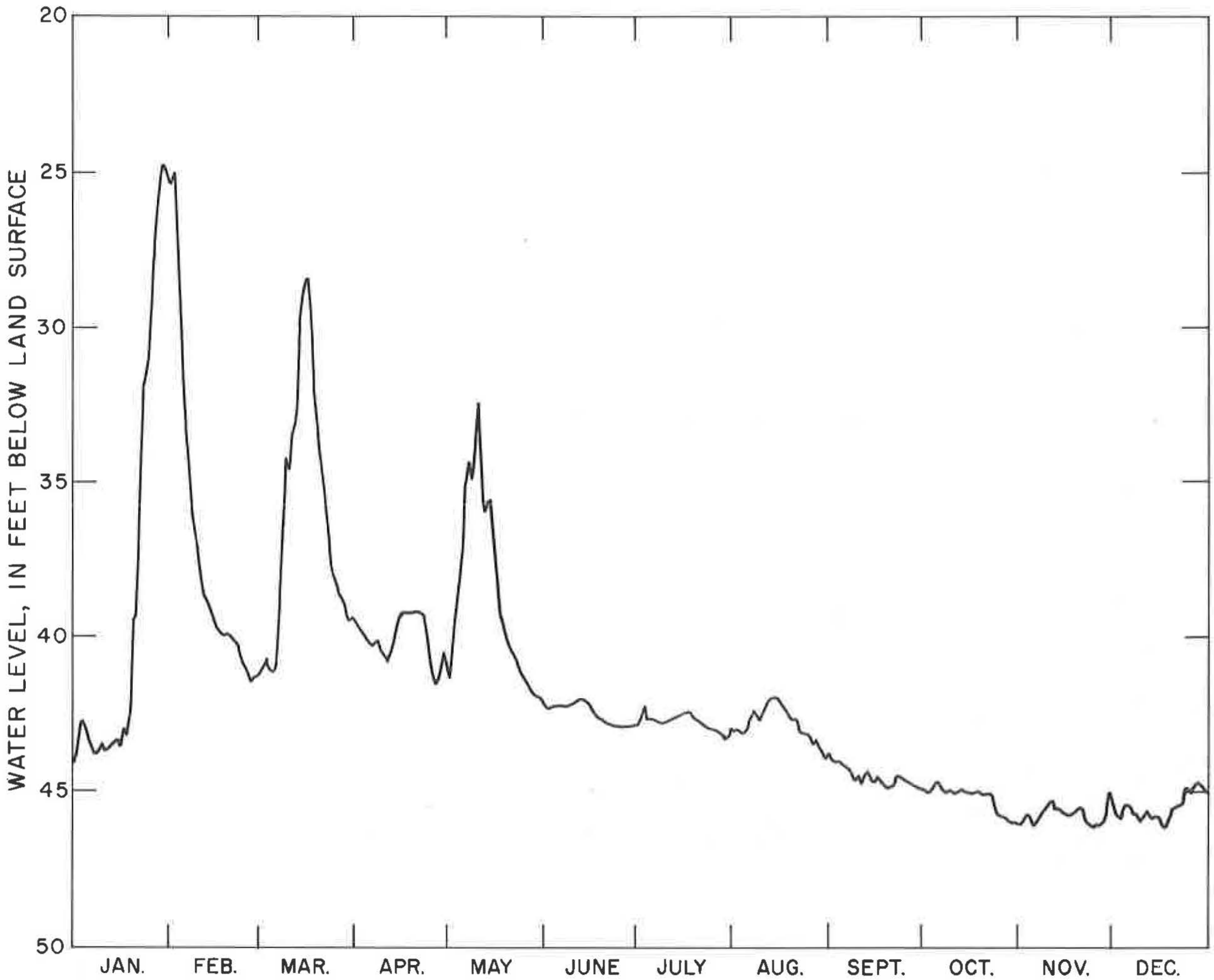


Figure 10. Daily water-level fluctuations in the Ocala aquifer at well 95-03, 4 miles southeast of Albany, 1978.

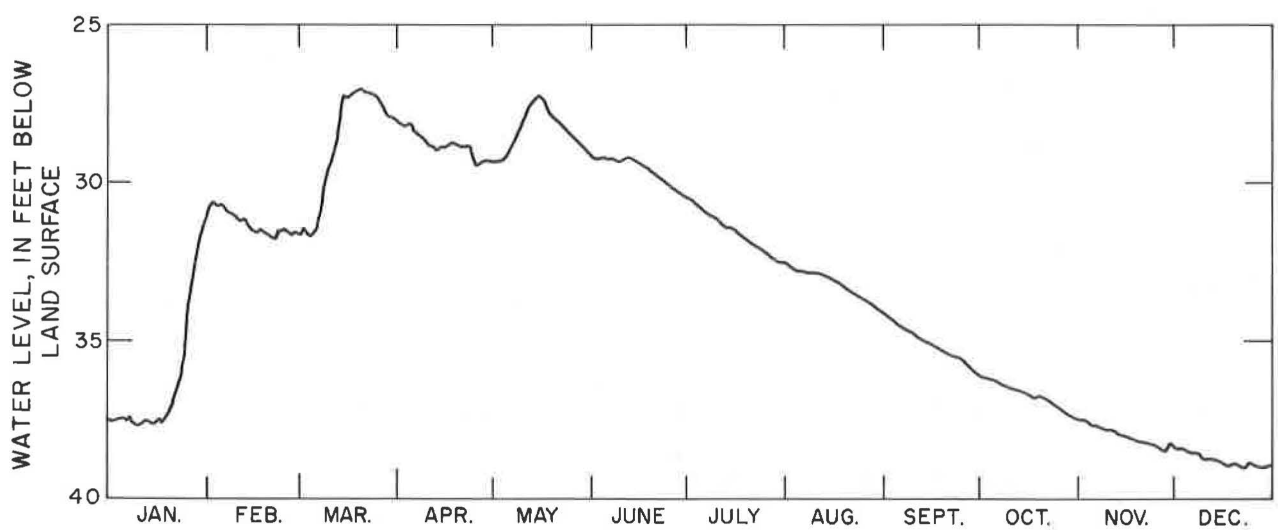


Figure 11. Daily water-level fluctuations in the Ocala aquifer at well 95-22, near the Worth-Dougherty County line, 1978.

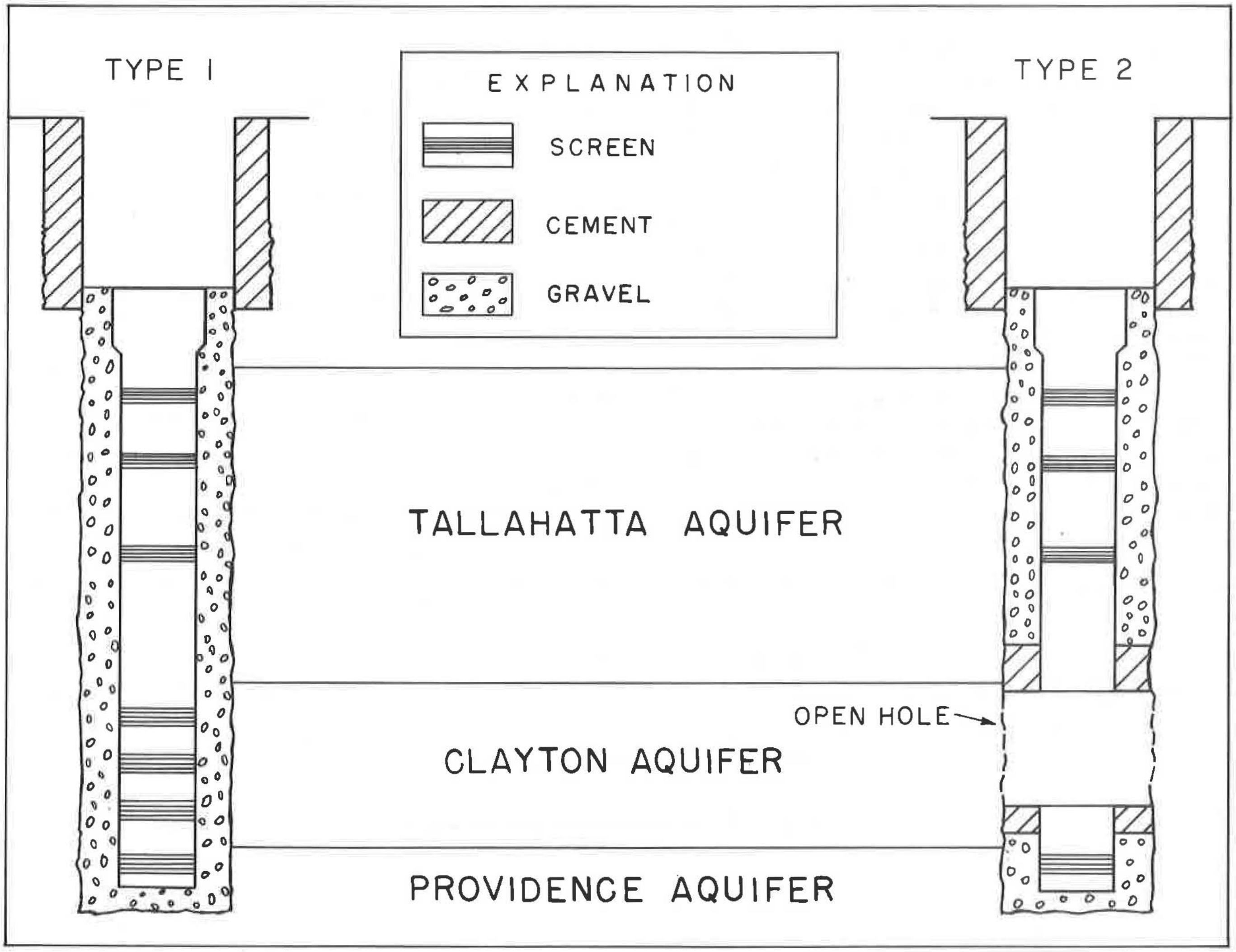


Figure 12. Typical multiaquifer well construction.

ing is then continued and another section of casing is installed through the Ocala to prevent subsidence and to seal out water from the Ocala.

After drilling is completed to the desired depth in the type 1 well, the screen line is assembled above ground by welding alternating sections of blank casing and well screen at intervals corresponding to the water-bearing zones in the well. The assembled screen line is then positioned in the well and the space between the screen line and borehole wall is packed with coarse sand or gravel.

The second construction method (type 2 in fig. 12) is used in areas where the Clayton aquifer consists of competent limestone that does not require screening. In these wells, similar telescoping construction is used, except that in the Clayton Limestone the well bore is left as an open hole. A screen line, where utilized, is continued through the Providence aquifer.

The U.S. Geological Survey test wells drilled for this study (pl. 1) were constructed as single-aquifer wells, using either screened or open-hole construction. Wells tapping the Cusseta, Providence, and Tallahatta aquifers were screened to prevent the entry of sand. Because the Clayton and Ocala aquifers are composed of limestone, wells tapping these aquifers were not screened.

After completion, each well was developed to remove drilling mud and fine sand from the well bore and adjacent aquifer material. Drillers emphasize this phase of well construction because well yield and aquifer response can be greatly increased if wells are properly developed.

Flow Through Idle Multiaquifer Wells

Brine-trace studies made in eight nonpumping production wells in and near the city of Albany indicate that due to head differentials, a significant amount of ground water is transferred from the Providence and Tallahatta aquifers into the Clayton aquifer through idle multiaquifer wells. The brine-trace studies were done by injecting a concentrated sodium chloride solution into the boreholes at specified depths. Special geophysical sensors monitored the brine's velocity and direction of movement in the boreholes. Figure 13 shows the approximate velocity and the direction of flow measured in the boreholes of wells 95-33 and 95-34.

Recharge to the Clayton aquifer through well 95-33 was calculated to be about 12 gal/min, or 17,000 gal/d, from the Providence aquifer and about 46 gal/min, or 66,000 gal/d, from the Tallahatta aquifer. Thus, about 83,000 gal/d recharges the Clayton aquifer through this multiaquifer well. To approximate the total recharge to the Clayton aquifer through idle wells, borehole velocities, based on brine-trace studies and well-construction data, were estimated for each multiaquifer city well. These velocities, together with pumping-frequency data, indicate that the 25 multiaquifer wells in the Albany water system recharge the Clayton aquifer at the rate of about 1.1 Mgal/d.

Areal Trends in Aquifer Yields

Flowmeter tests were conducted in six city supply wells to determine the relative percentage of water contributed by the Providence, Clayton, and Tallahatta aquifers to each multiaquifer well. The tests were done by first removing the turbine pump and pump column from the well and lowering a flowmeter, suspended by a thin steel cable, into the well.

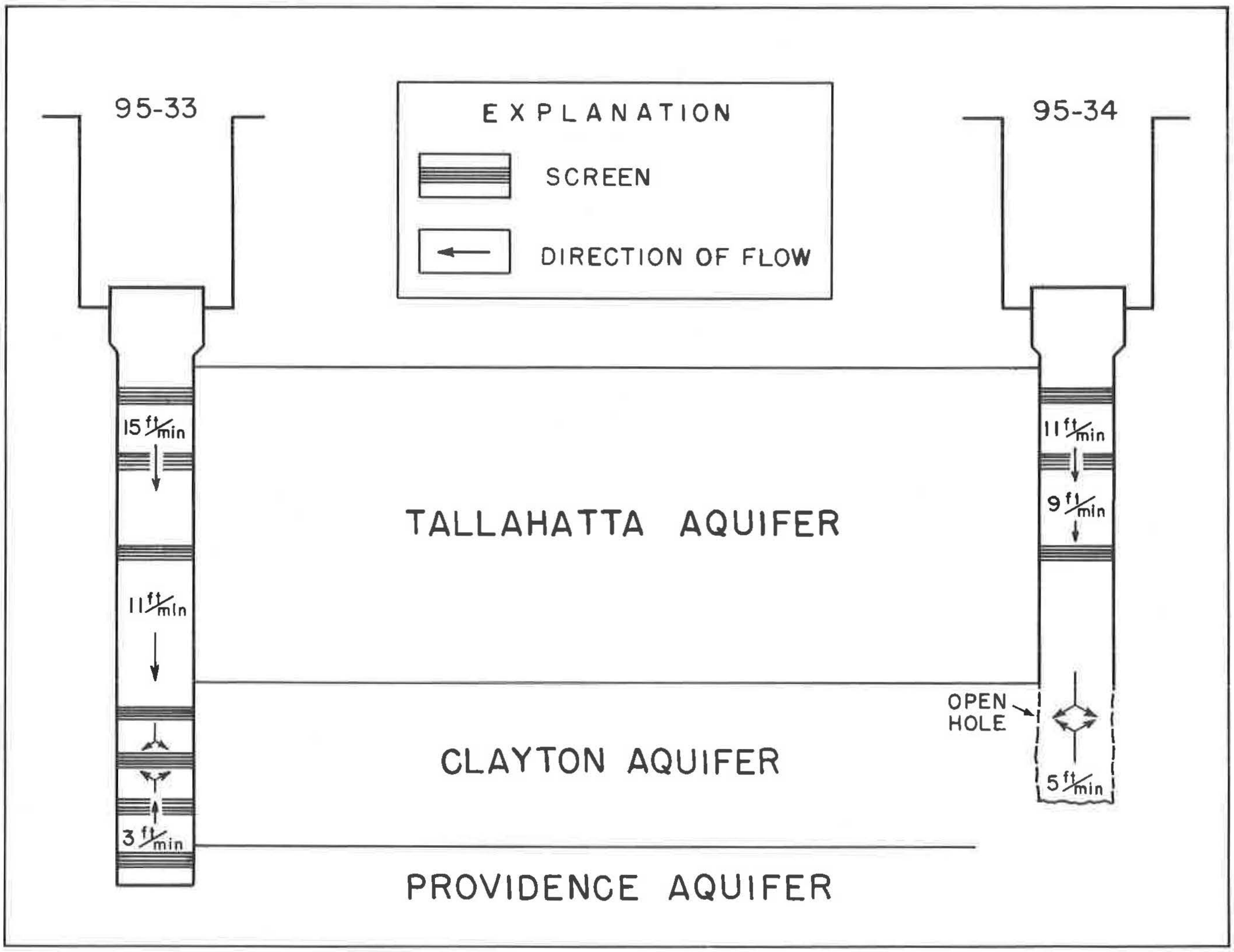


Figure 13. Direction and velocity of flow in city of Albany wells 95-33 and 95-34 when wells were not pumping.

The pump assembly was then reinstalled and the well pumped at a constant rate until the water level in the well stabilized. The flowmeter was then traversed up the well to record the velocity of flow in the well bore at specified depths. By knowing the rate of discharge (gallons per minute), the diameter of the well bore (inches), the depth of each water-bearing zone (feet), and the measured velocity (feet per minute), the relative percentage of total discharge from the Providence, Clayton, and Tallahatta aquifers was calculated using the following equations:

Point discharge = Point velocity X diameter of well bore X 0.0408 (well constant),

then

$$\text{Aquifer yield (percent)} = \frac{\text{Point discharge X 100.}}{\text{Total discharge}}$$

The flowmeter tests revealed that the percentage of total yield that each aquifer contributes to multiaquifer wells depends not only on the well construction and development but, more importantly, on the well location. Figures 14 and 15, constructed using flowmeter test data, show lines of equal yield for the Clayton and Tallahatta aquifers, respectively. In the east and southeast parts of the Albany area, the Providence and Clayton aquifers combined contribute less than 10 percent of the total yield of multiaquifer wells. In these areas the Tallahatta aquifer supplies the remaining 90 percent of the well yield. However, in the west and northwest parts of the Albany area, the Providence and Clayton aquifers are more productive and at well 95-46, 2 mi west of Albany, each of the three aquifers contributes about one-third of the yield (figs. 14 and 15).

GROUND-WATER USE

According to Wait (1963), ground-water use in the Dougherty County area in 1957 was estimated to be about 8.94 Mgal/d. Since that time ground-water use has increased about 440 percent and is presently (1978) estimated to average about 39.4 Mgal/d (table 3).

Industrial

Due to the large number of new industries that have moved into the Albany area and to increased production at existing industries, water withdrawn from industrial wells has increased from about 1 Mgal/d in 1957 (Wait, 1963, p. 75) to the current (1978) pumpage of about 15.5 Mgal/d. Additionally, the city of Albany sells water to many industries that do not own wells. The latter pumpage is included in the municipal figures on table 3.

Ground water used for industrial purposes within the study area is obtained primarily from the Ocala aquifer (table 3).

Table 3. Estimated ground-water use in the Albany area, 1978.

Aquifer	Ground-water use (Mgal/d)			
	Agricultural[1/]	Industrial	Municipal	Total
Providence	--	--	0.9	0.9
Clayton	0.5	0.5	6.8	7.8
Tallahatta	.5	--	7.3	7.8
Ocala	7.9	15.0	--	22.9
TOTAL	8.9	15.5	15.0	39.4

1/ Values are estimated growing-season withdrawals averaged over a 365-day period.

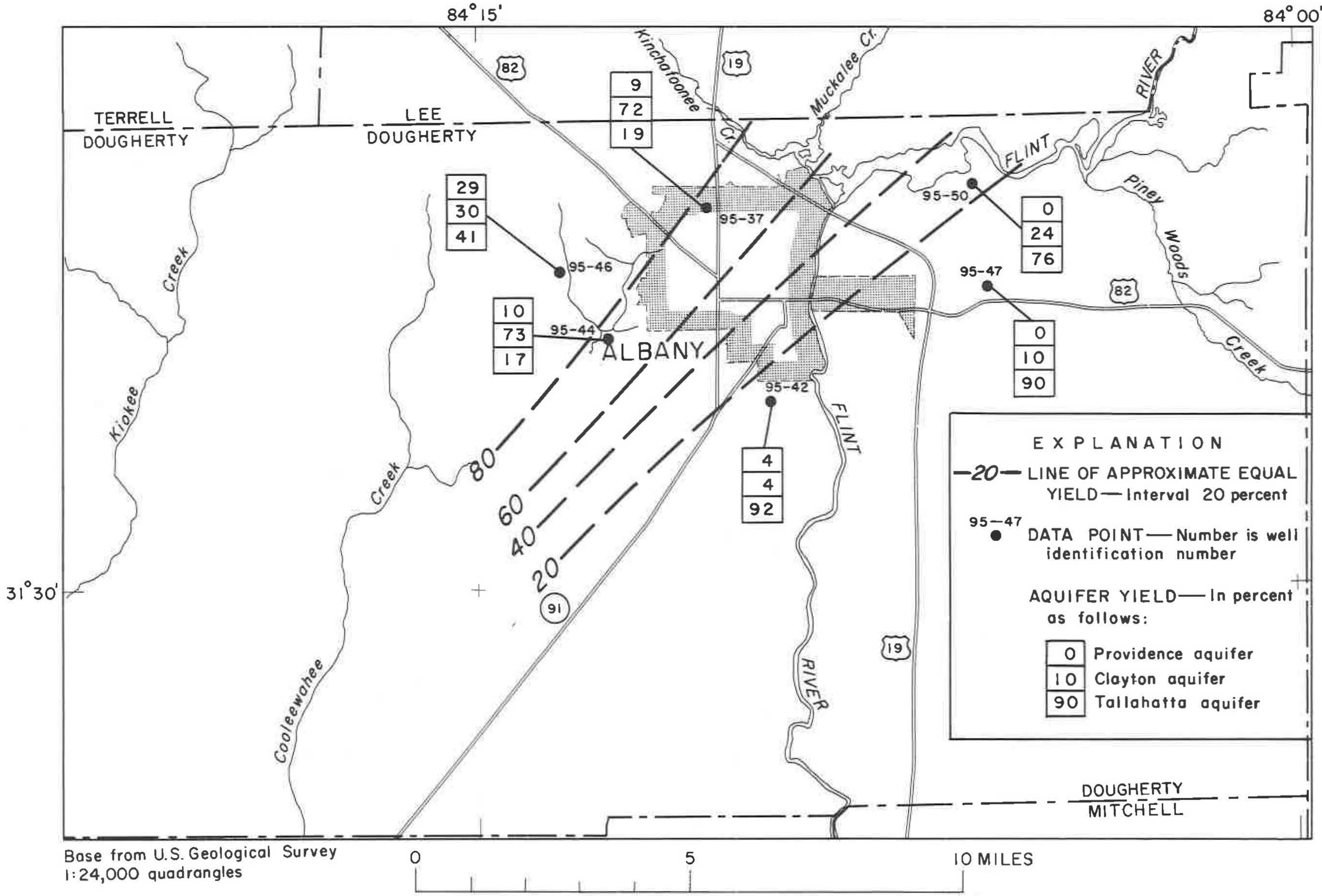


Figure 14. Results of flowmeter tests and the percentage of multiaquifer well yield from the Clayton aquifer.

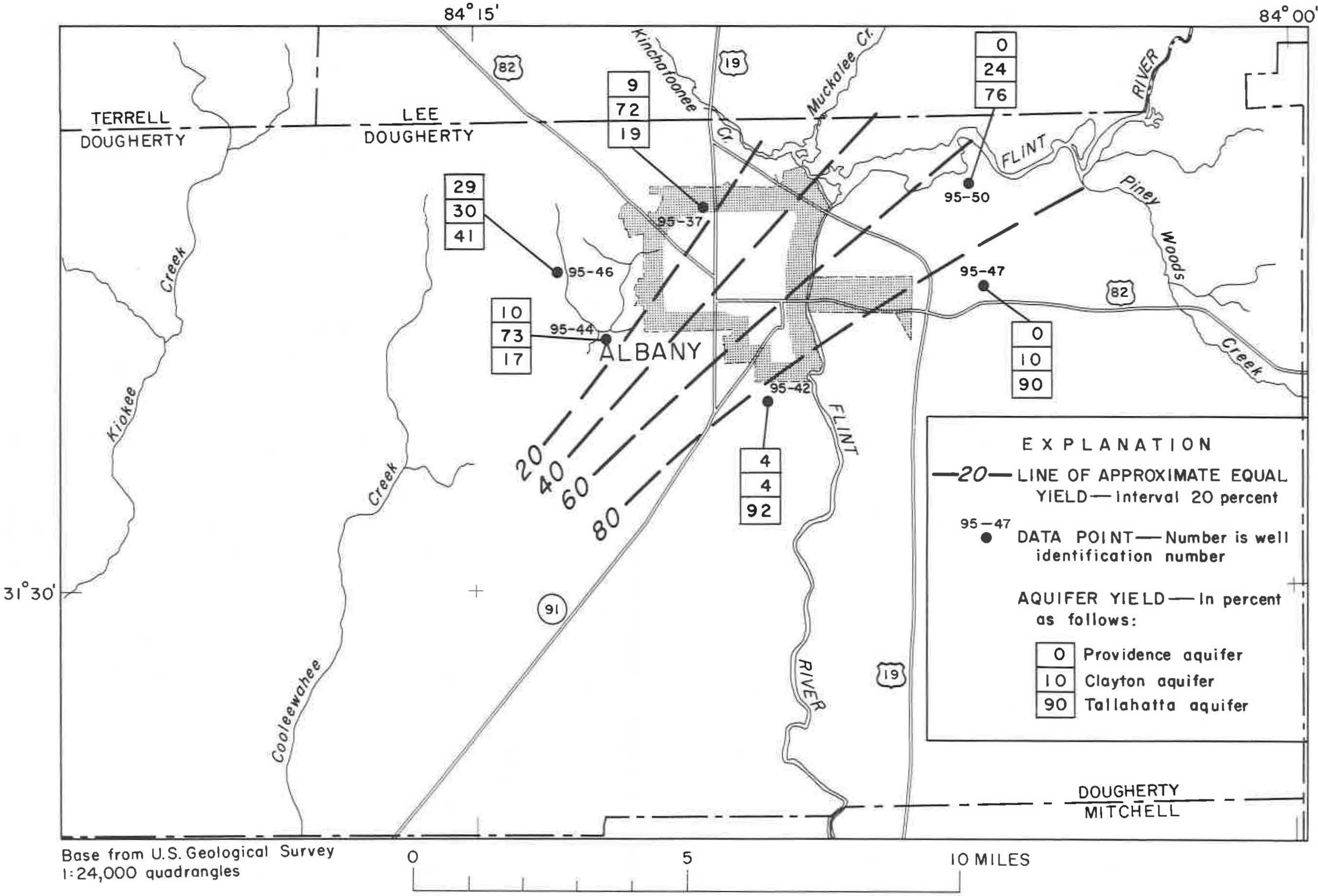


Figure 15. Results of flowmeter tests and the percentage of multiaquifer well yield from the Tallahatta aquifer.

Agricultural

Total irrigated cropland in the study area reported in the 1954 agricultural census was 200 acres. By 1978 the irrigated cropland had increased to about 8,650 acres. According to Pollard and others (1978), ground water represented about 92 percent of the water used for irrigation in 1977 and it is assumed that this percentage did not change appreciably for the 1978 crop season. Thus, during 1978 about 8,000 acres were irrigated by ground water.

The availability of sufficient ground water and the suitability of center-pivot systems has greatly enhanced the use of irrigation in the Albany area. The gentle slopes and large fields permit the use of self-propelled center-pivot irrigation systems. Many center-pivot systems used in the study area are designed to distribute water at rates of 1,000 to 1,500 gal/min and are capable of irrigating several hundred acres.

Ground water for irrigation in the Dougherty Plain province is obtained primarily from the Ocala aquifer. However, the Ocala is not productive to the northwest of Albany in parts of Dougherty, Terrell, and Calhoun Counties, and use of the Clayton aquifer for irrigation is rapidly increasing. Agricultural use of ground water is presently (1978) not regulated by the State of Georgia. Because permitting is not required, agricultural use of the Clayton is limited only by the productivity of the aquifer. Heavy withdrawals from the Clayton in this area could limit the availability of water from this aquifer.

Municipal

In 1898 the city of Albany's water system pumped an estimated 25,000 gal/d from 14 wells (McCallie, 1898, p. 179-181). As municipal and industrial demands increased, more wells were drilled, and the city has used at least 30 wells since initiation of the Albany water system. The city of Albany was the largest single ground-water user in the study area during 1978, withdrawing a total of about 5.4 billion gallons per year, from 23 multiaquifer wells (fig. 16).

The increase in population and industry in the Albany area is reflected in the water requirements. Figure 16 shows that the annual ground-water demand has increased from about 4.2 billion gallons in 1969 to more than 5.4 billion gallons in 1978. On August 28, 1978, the ground-water withdrawal peaked at over 22 Mgal/d, the highest single day of pumpage recorded by the city of Albany (fig. 17).

The rate of ground-water withdrawal by the city varies seasonally and is greatest during the summer and fall. Figure 17 shows an increase in ground water withdrawals from April through October 1978. The duration of peak withdrawal periods and the amounts of withdrawal are influenced by climatic conditions; thus, increases in precipitation decrease the demand for city water.

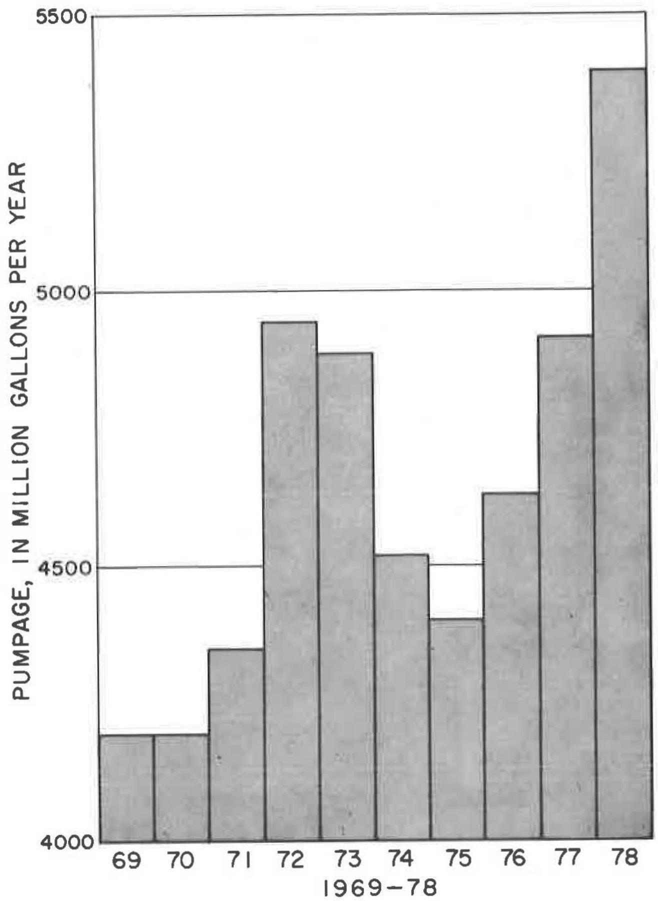


Figure 16. Yearly ground-water withdrawal by Albany supply wells, 1969-78.

Municipal Pumpage from the Providence, Clayton, and Tallahatta Aquifers

The total amount of water withdrawn from the Providence, Clayton, and Tallahatta aquifers was estimated for the Albany supply wells based on flowmeter tests and well construction data. Figure 18 shows that an average of about 0.9 Mgal/d was withdrawn from the Providence aquifer during 1978, or about 6 percent of the Albany municipal supply. The Clayton aquifer contributed about 45 percent of the city supply, or an average of about 6.8 Mgal/d. Approximately 7.3 Mgal/d was withdrawn from the Tallahatta aquifer during 1978, representing about 49 percent of the total Albany municipal pumpage.

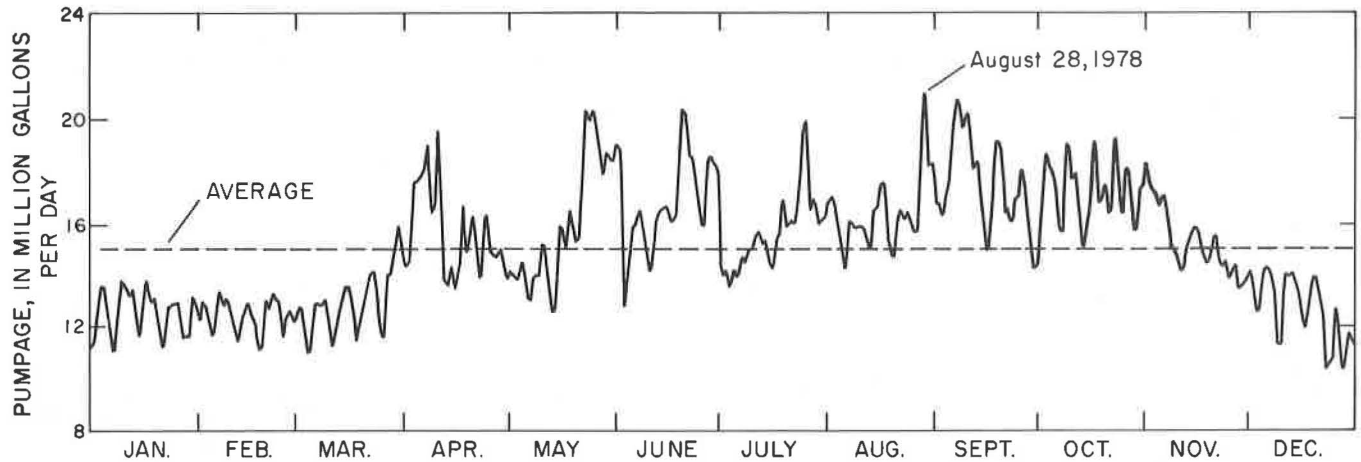


Figure 17. Total daily ground-water withdrawal by Albany supply wells, 1978.

GROUND-WATER LEVELS

Potentiometric Surface Characteristics

The altitude of the potentiometric surface of an aquifer is highest in recharge areas. Ground water flows laterally downgradient from the recharge areas, in a direction perpendicular to the potentiometric coutour lines, to discharge areas where the potentiometric surface is lower. When discharge exceeds recharge, the potentiometric surface will be depressed.

Clayton Aquifer

During the period of September 4-6, 1979, 21 wells tapping the Clayton aquifer were measured to obtain data for constructing a potentiometric map (pl. 1). The closed contours on the Clayton potentiometic surface in the Albany area define a pumpage cone resulting from many years of heavy ground-water withdrawal. Increased agricultural pumpage in the northwest part of the study area has also depressed the potentiometric surface of the Clayton there, and has caused the pumpage cone at Albany to elongate about 14 mi in that direction. The potentiometric contour lines indicate that the primary direction of ground-water flow in the Clayton aquifer is toward the area of greatest withdrawal, which at present is the city of Albany.

Tallahatta Aquifer

Water-level measurements were made in 14 wells tapping the Tallahatta aquifer, concurrently with measurements in the Clayton wells. From plate 1 it can be seen that the potentiometric surface of the Tallahatta aquifer is not depressed as deeply as that of the Clayton; however, the broad areal extent of the pumpage cone reflects the stress placed on the aquifer. The southwest elongation of the pumpage cone probably is a function of the water-bearing characteristics of the Tallahatta aquifer rather than of stress. Additional hydrologic testing in the southwest part of the report area could better define the pumpage cone. The indicated direction of ground-water flow in the Tallahatta aquifer is toward the city of Albany.

Ocala Aquifer

A potentiometric map of the Ocala aquifer was constructed from measurements made in November 1979 (fig. 19). The potentiometric contours indicate that the aquifer receives recharge throughout much of the report area and discharges through springs and into streams where erosion has removed the confining layer. Abundant local recharge has prevented the development of widespread pumpage cones in the Ocala potentiometric surface.

Long-Term Water-Level Declines

Records indicate that ground-water levels in the Providence, Clayton, and Tallahatta aquifers have been declining in the Albany area since 1898 and probably before (McCallie, 1898, p. 180). During the 1800's, ground-water withdrawals were small and natural recharge probably maintained a state of water-level equilibrium in the aquifers. As ground-water demand increased, recharge no longer kept pace with withdrawals and ground water began to be mined from aquifer storage, resulting in declining water levels.

According to records maintained by drilling contractors, wells tapping the Providence aquifer flowed

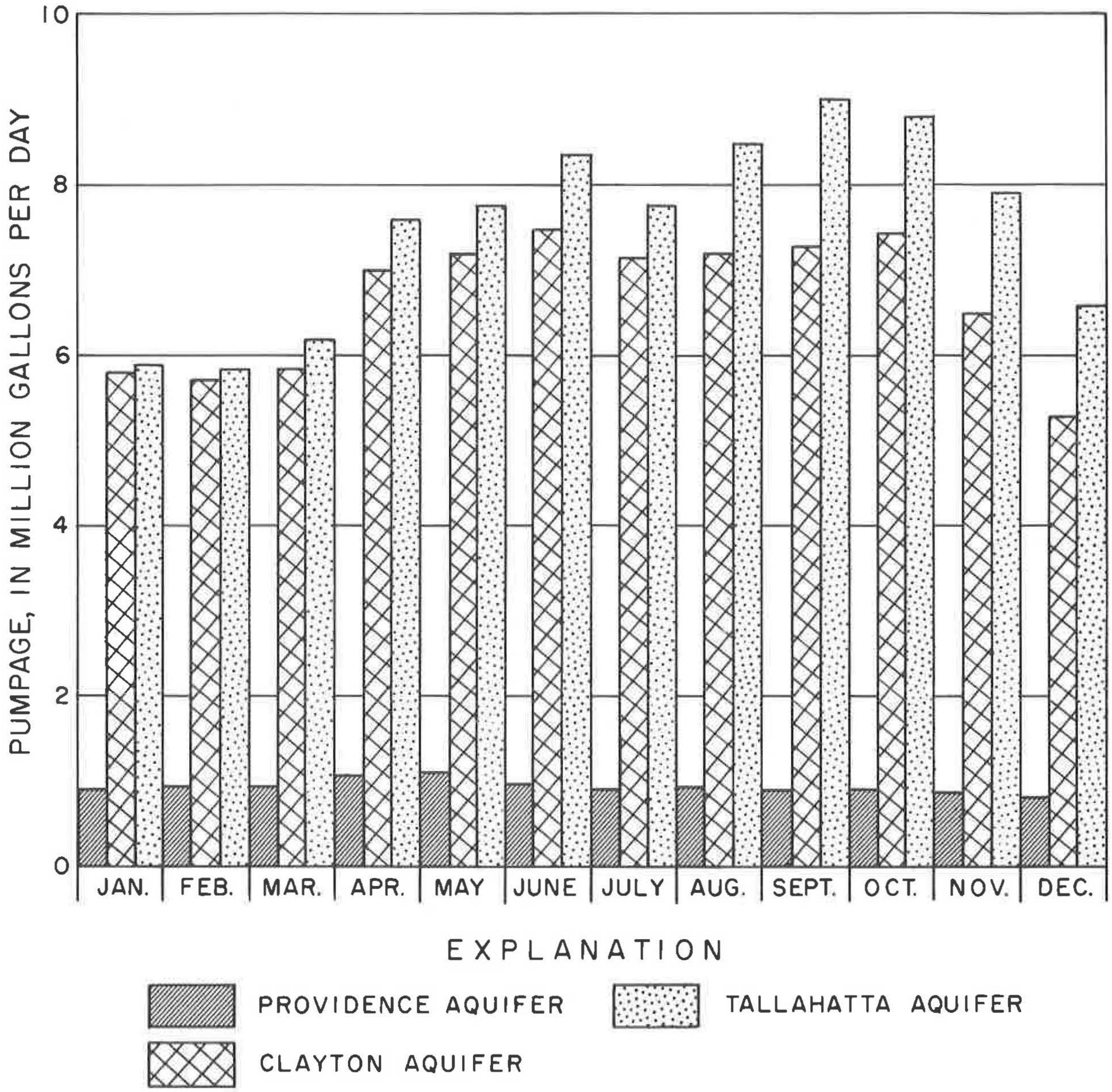


Figure 18. Estimated monthly mean pumpage by the city of Albany from the Providence, Clayton, and Tallahatta aquifers, 1978.

during the early 1900's. Heavy municipal and industrial pumpage have lowered ground-water levels, and wells in this aquifer no longer flow. Since 1940, ground-water levels in the Providence aquifer have declined as much as 100 ft in the Albany area (R.E. Faye, oral commun., 1980).

Before 1940, artesian pressure in the Clayton aquifer was sufficient to produce many flowing wells. However, heavy municipal and agricultural pumpage has lowered water levels in the Clayton aquifer, near the center of pumpage at Albany, more than 135 ft and wells no longer flow. Figure 20 shows how increased city pumpage since 1975 has resulted in a declining trend in the water level in well 95-09 near Albany. The water level in this well has declined about 25 ft since 1975.

Few single-aquifer wells penetrated the Tallahatta prior to 1960 and historical water-level data are minimal. However, water levels in the Tallahatta aquifer probably have declined significantly since 1940 in the Albany area. Water levels in the Tallahatta aquifer at well 177-07, about 10 mi north of Albany at Leesburg,

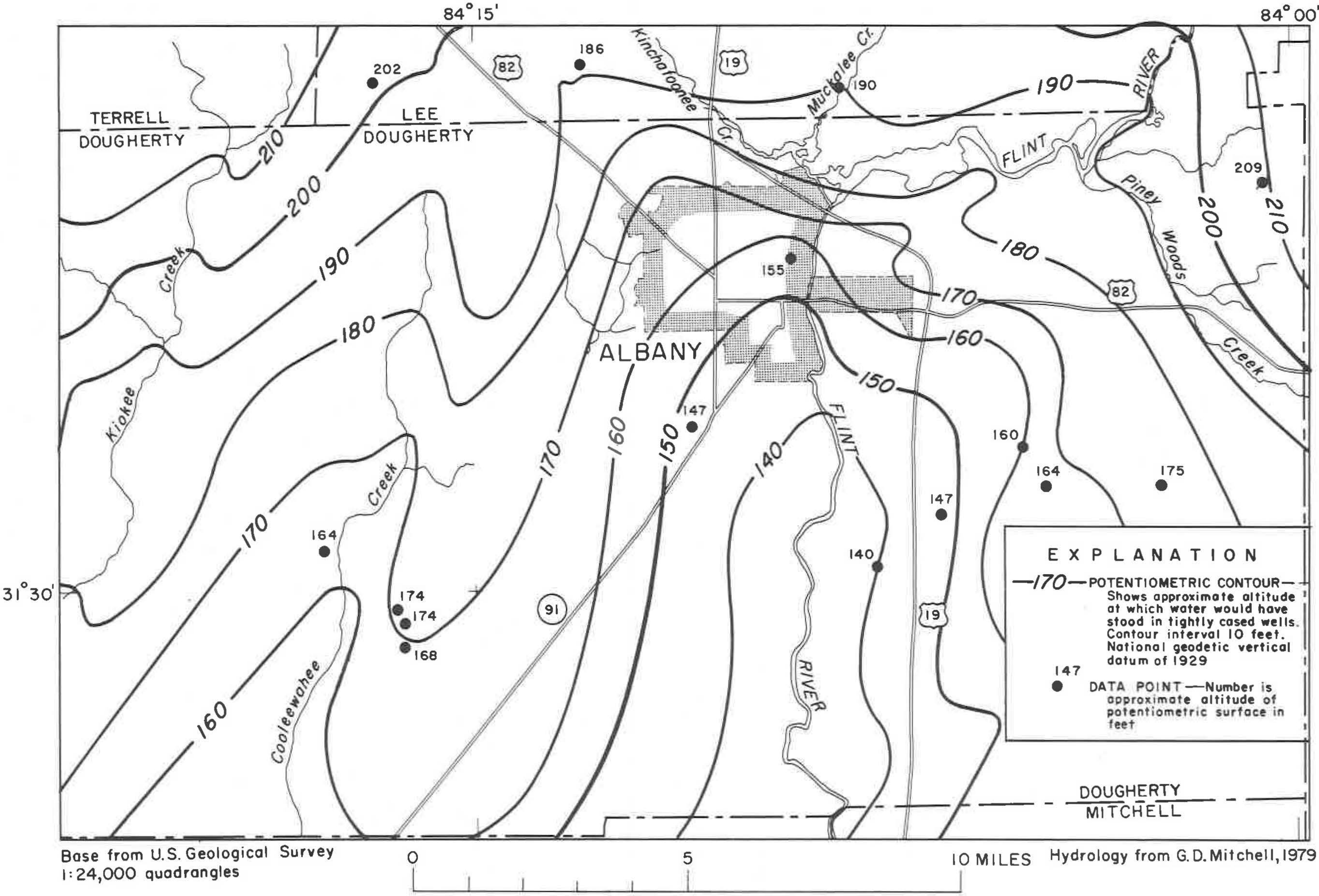


Figure 19. Potentiometric surface of the Ocala aquifer in the Albany area, November 1979.

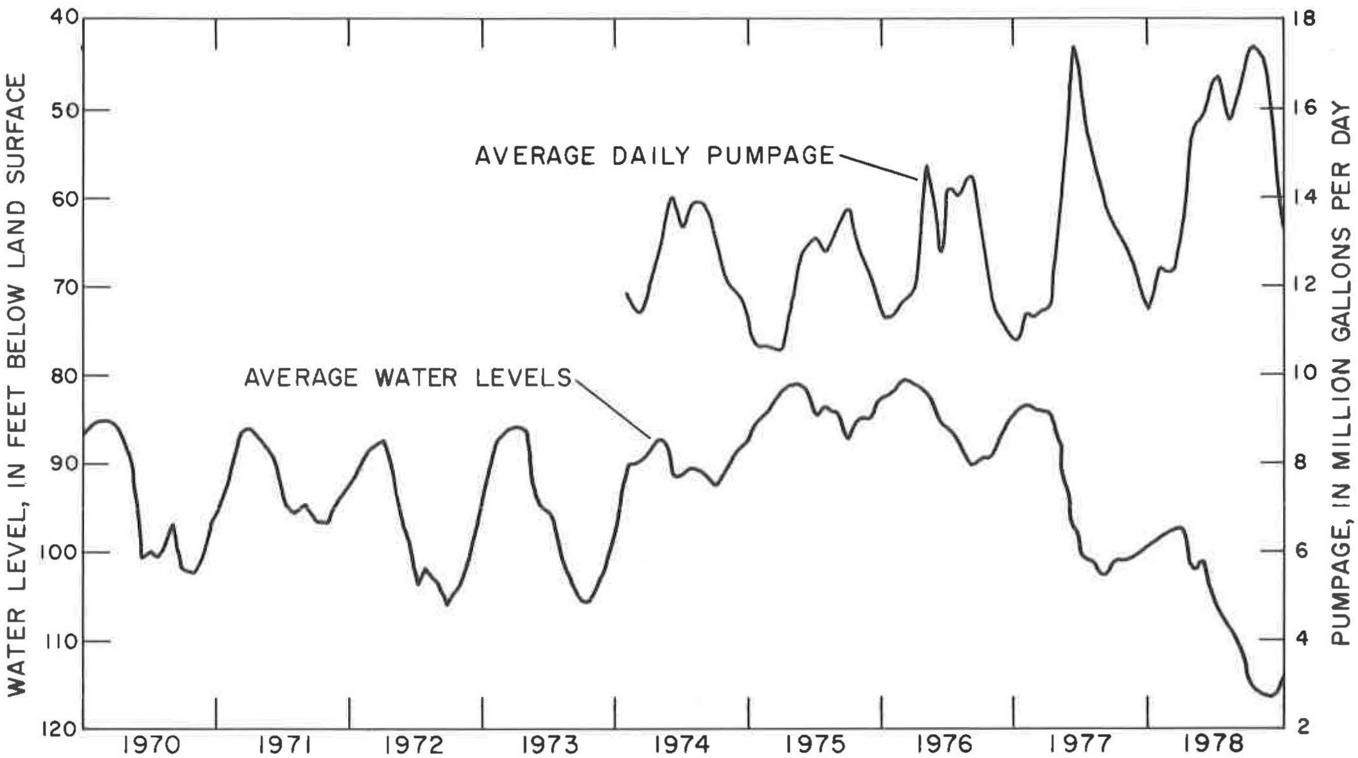


Figure 20. **Average daily pumpage from Albany supply wells, 1974-78, and average water-level fluctuations in the Clayton aquifer at well 95-09 near Albany, 1970-78.**

have declined about 15 ft since 1940. Therefore, because ground-water withdrawals in Albany are significantly larger than at Leesburg, it can be assumed that water-level declines in the Tallahatta at Albany have been greater.

Seasonal Fluctuations In Ground-Water Levels

Ground-water levels in the study area fluctuate in response to seasonal variations in precipitation, streamflow, evapotranspiration, and pumpage. Figure 8, 9, and 10 compare precipitation data collected at the Albany-Dougherty County airport with streamflow recorded at the U.S. Geological Survey gage on the Flint River at Albany and water levels in the Ocala aquifer at wells 95-03, 4 mi southeast of Albany, and 95-22, near the Worth-Dougherty County line. Abundant winter rainfall increases the potential for recharge of the Ocala aquifer throughout the area. During the winter months, when vegetation growth and solar radiation are at a minimum, evapotranspiration is low and the aquifer receives the maximum annual recharge. Accordingly, water levels in the Ocala aquifer recover from the previous year's minimum by early spring. Although precipitation is generally heavy from April through September, water lost to evapotranspiration is greatest during the growing season and the amount of water available for recharge is reduced. Thus, reduced recharge and increased agricultural pumpage during the spring and summer seasons cause ground-water levels in the Ocala to decline to a minimum by late fall.

Because the Clayton and Tallahatta aquifers are recharged 20 to 40 mi north and northeast of the Albany area, water levels in these aquifers are affected primarily by changes in local pumpage. During November through March, a 3.3 Mgal/d decrease in municipal pumpage (fig. 17), and a substantial decrease in agricultural pumpage during this period, results in a reduction in total ground-water withdrawal. Due to this reduced pumpage, and a slight increase in recharge, ground-water levels in the Clayton and Tallahatta aquifers attain a maximum by late winter (figs. 21 and 22). During the spring and summer, increased municipal and agricultural pumpage causes water levels to decline to a minimum by late fall.

CONCLUSIONS AND SUGGESTIONS

Ground water in the Albany area is obtained from four aquifers. From deepest to shallowest the aquifers are: the Providence, the Clayton, the Tallahatta, and the Ocala. Although ground water is available from the underlying Cusseta, high drilling costs, low yields, and excessive concentrations of chloride and dissolved solids make development of this unit undesirable.

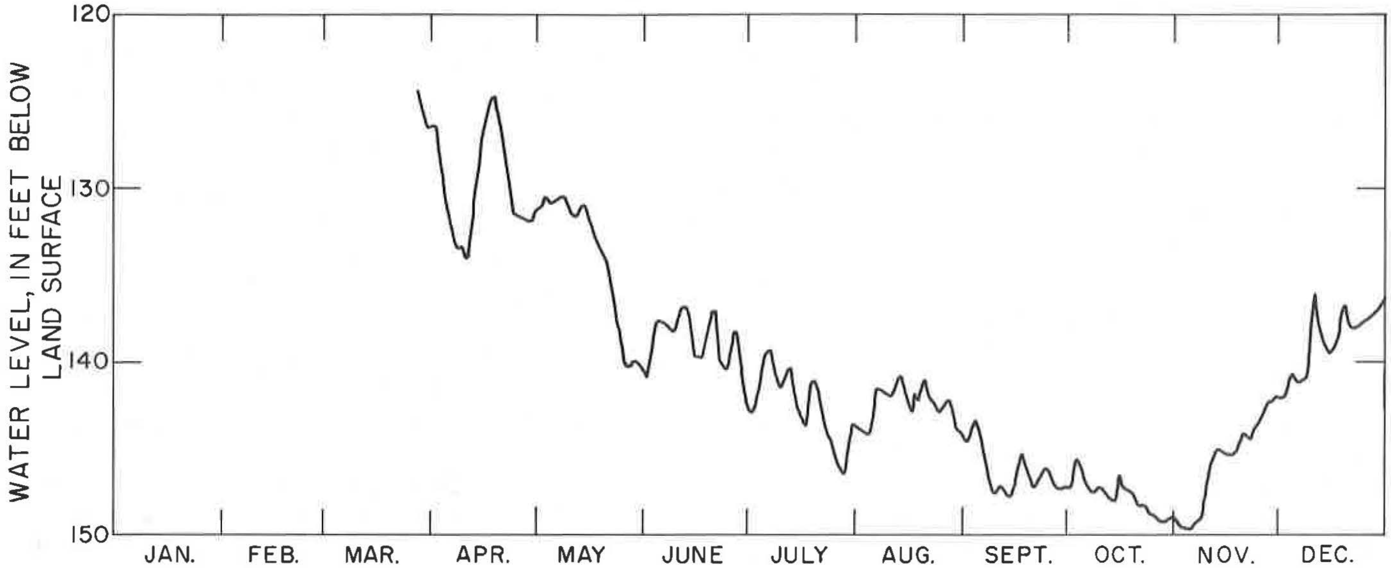


Figure 21. Daily water-level fluctuations in the Clayton aquifer at well 95-06 at Albany, 1978.

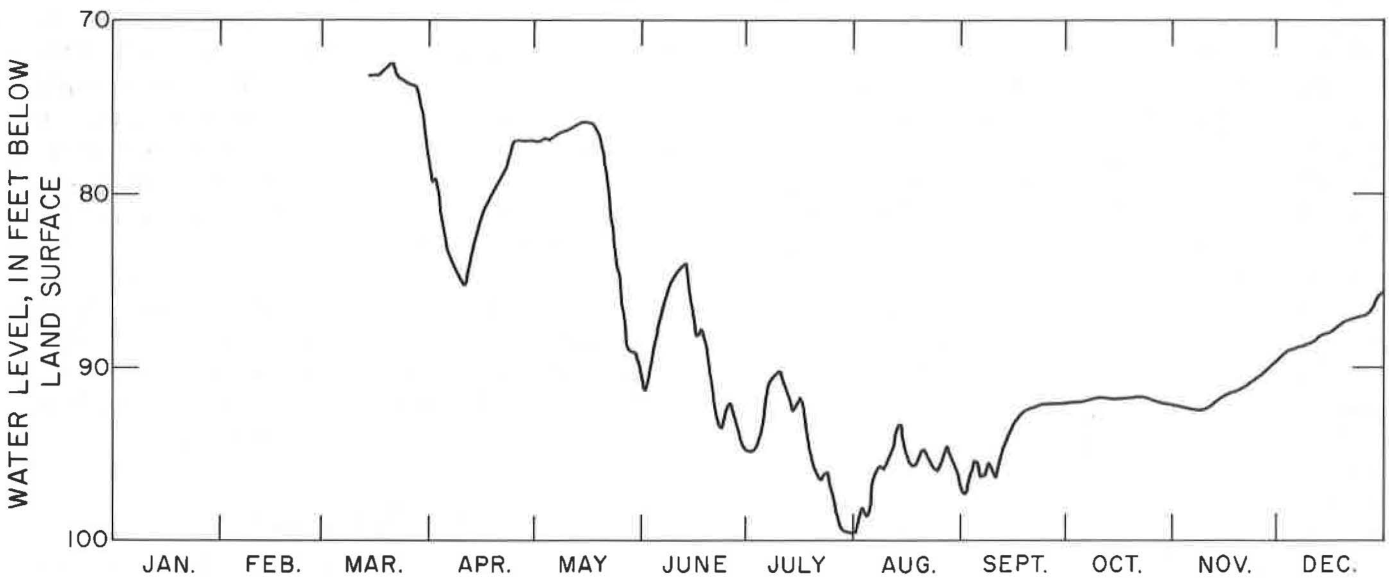


Figure 22. Daily water-level fluctuations in the Tallahatta aquifer at well 95-05 at Albany, 1978.

Providence Aquifer

Water from the Providence coquina and sand aquifer is obtained at depths ranging from about 640 to 960 ft below land surface. The Providence dips to the southeast at about 23 ft/mi and progressively thickens in that direction.

The aquifer is confined from below by the clayey Ripley Formation and from above by the silty upper Providence-lower Clayton sequence. Water levels in the Providence during 1978 averaged about 110 ft below land surface near the center of pumpage in Albany.

Transmissivity estimates for the Providence aquifer range from about 250 ft^2/d in the southeast part of the area to about 1,000 ft^2/d updip in the northwest. In the south and southeast, wells produce less than 25 gal/min; however, updip to the northwest, yields to wells of about 500 gal/min have been reported. Throughout the report area pumpage from the Providence generates large drawdowns due to the low transmissivity of the aquifer, especially in the southeast.

The Providence yields a soft sodium bicarbonate type water that contains no concentrations of constituents that exceed the State standards (1977) for drinking water.

Water from the Providence is used chiefly for municipal supplies in the Albany area, where an average of 0.9 Mgal/d was withdrawn during 1978. Withdrawals from the aquifer have caused water levels to decline about 100 ft since 1940.

Clayton Aquifer

Water is obtained from the limestone part of the Clayton Formation at depths ranging from 550 to 840 ft below land surface. The limestone part of the Clayton ranges in thickness from about 70 ft downdip to the southeast to about 125 ft to the northwest.

The aquifer is confined from below by the silty upper Providence-lower Clayton sequence and from above by the clayey Tuscahoma Sand. Measurements made during 1978 revealed that water levels in the Clayton were the lowest in the Albany area, averaging about 140 ft below land surface in well 95-06 at Albany, near the center of pumpage.

At well 95-09, 3 mi east of Albany, the transmissivity of the Clayton aquifer is about 400 ft^2/d and well yields average about 250 gal/min. However, to the northwest near Sasser, the transmissivity of the Clayton aquifer is about 11,000 ft^2/d and yields to wells of about 2,000 gal/min have been reported. The progressive increase in transmissivity and yield to the northwest is due largely to thickening of the aquifer and a directional increase in hydraulic conductivity.

The Clayton aquifer produces a soft sodium bicarbonate water that is suitable for most uses and contains no constituent concentrations that exceed State standards (1977) for drinking water. The average sodium concentration of 44 mg/L is uncharacteristically high for a carbonate aquifer and could result from leakage of sodium bicarbonate water from the Providence aquifer through an intervening confining layer into the Clayton.

Brine-trace studies indicate that in the Albany area about 1.1 Mgal/d is being artificially recharged to the Clayton, through idle multiaquifer wells, from the Providence and Tallahatta aquifers of higher head.

An average of about 7.8 Mgal/d was withdrawn from the Clayton aquifer during 1978 for municipal, industrial, and agricultural supplies in the Albany area. Heavy withdrawals have resulted in a water-level decline near the Albany pumping center of about 135 ft since 1940. Increased municipal pumpage of about 3.0 Mgal/d since 1975 has lowered water levels in the Clayton aquifer about 25 ft at well 95-09 near Albany. Accelerated agricultural use of the Clayton to the west and northwest in parts of Dougherty, Terrell, and Calhoun Counties has produced significant water-level declines in that area and could limit the availability of water from this aquifer.

Tallahatta Aquifer

The Tallahatta aquifer underlies the report area at depths of 125 to 350 ft below land surface. The aquifer dips to the southeast at about 12 ft/mi and thickens in that direction.

The Tallahatta is confined from below by the clayey Tuscahoma Sand and from above by part of the Lisbon Formation. Water levels during 1978 at well 95-05 in Albany averaged about 90 ft below land surface.

Estimates of transmissivity range from 2,400 to 3,500 ft^2/d and reported yields to wells range from about 1,000 to 1,400 gal/min. However, withdrawal rates greater than about 750 gal/min produce large drawdowns.

Water from the Tallahatta is a hard calcium bicarbonate type and contains no concentrations of constituents that exceed the Georgia Environmental Protection Division standards (1977) for safe drinking water. The average dissolved calcium concentration of 40 mg/L is uncharacteristically high for a predominantly sand aquifer and could result from vertical leakage of water from the Ocala through the intervening Lisbon Formation.

During 1978 an average of 7.8 Mgal/d was withdrawn from the Tallahatta aquifer for agricultural, municipal, and industrial supplies in the Albany area. Long-term withdrawal in the Albany area has caused water levels in the Tallahatta to decline, probably as much as 40 ft near the center of pumpage.

Ocala Aquifer

Water can be obtained from the Ocala aquifer throughout the Dougherty Plain part of the report area at depths ranging from about 40 to 70 ft below land surface.

The Ocala aquifer is unconfined where stream erosion has exposed the limestone and in areas of sinkhole development. Elsewhere, the aquifer is confined from below by the Lisbon Formation and from above by 40 to 70 ft of residuum. Because of the varying conditions of confinement, average water levels in the Ocala during 1978 ranged areally from about 2 ft above to 45 ft below land surface.

In areas near the Flint River where the Ocala is cavernous, transmissivities exceed 100,000 ft^2/d and wells tapping the aquifer are reported to produce as much as 2,000 gal/min with minimal drawdowns. In other areas the transmissivities are as low as 2,000 ft^2/d and yields to wells may be as low as 500 gal/min.

Water from the Ocala generally is of good quality and contains no concentrations of constituents that exceed State drinking water standards; however, in areas where the aquifer is poorly confined and in direct contact with surface water, the quality could rapidly change.

An average of 22.9 Mgal/d was withdrawn from the Ocala aquifer in 1978 for industrial and agricultural supply in the Albany area. Because of abundant local recharge, no long-term water-level declines have been observed.

Suggestions

A supply of good quality ground water is presently available in the report area. The following considerations could help evaluate the effects of future ground-water development in the area, prolong the productivity of the aquifers, and protect the quality of the ground water.

1. Due to the low productivity of the Providence and Clayton aquifers in the east and southeast parts of the report area, the development of supply wells tapping only the Tallahatta aquifer could produce yields comparable to multi-aquifer wells and cut construction costs.
2. To reduce local drawdown, supply wells could be spaced over a larger area. Testing indicates that multiaquifer wells developed in the north-west part of the report area produce good yields with relatively small drawdowns.
3. The development potential of the Ocala aquifer could be considered in areas where the aquifer is confined and is not in direct contact with surface water. The high yield and normal good quality of water from the Ocala make it a viable water source in many areas.
4. Because artesian pressure is lower in the Providence aquifer than in the underlying water-bearing units, wells that penetrate the confining Ripley Formation should be sealed subsequent to testing and sampling to prohibit the upward movement of poor-quality water.

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Prepared in cooperation with the
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Well number	Well identification	Owner's name	Date drilled	Depth of well (ft)	Depth of casing (ft)	Aquifer	Construction	Yield (gal/min)	Specific capacity (gal/min/ft)
37-01	313530084282701	Graham, E.R., 2	--	580	470	Clayton	Open hole	--	--
37-02	313226084294101	Adams, C., 2	--	580	460	do.	do.	--	--
95-01	313050084064201	USGS TW1, Albany	1977	1,474	1,474	Cusseta	Screened	5	
95-02	313105084064301	USGS TW2, Albany	1977	418	418	Tallahatta	do.	--	--
95-03	313105084064302	USGS TW3, Albany	1977	218	54	Ocala	Open hole	--	--
95-04	313530084203202	USGS TW4, Albany	1977	251	251	Tallahatta	Screened	--	--
95-05	313534084103001	USGS TW5, Albany	1977	257	257	do.	do.	10	--
95-06	313534084103002	USGS TW6, Albany	1977	690	619	Clayton	Open hole	--	--
95-07	313105084064202	USGS TW7, Albany	1978	882	716	do.	do.	--	--
95-08	313534084103001	USGS TW10, Albany	1978	1,346	1,346	Providence	Screened	--	--
95-09	313554084062501	Turner City, 2	1951	760	713	Clayton	Open hole	250	1.7
95-10	312654084210102	DNR TW11, Albany	1979	320	320	Tallahatta	Screened	30	--
95-11	312654084210103	DNR TW12, Albany	1979	690	630	Clayton	Open hole	--	--
95-12	312654084210101	Sealy, J.R., 2	[1]1978	1,200	1,100	Cretaceous	do.	--	--
95-13	313527084044601	PW1, Miller Brewing Co.	1978	942	942	Multiaquifer	Screened	1,599	13.7
95-14	313551084044001	PW2, Miller Brewing Co.	1979	560	560	Tallahatta	do.	1,404	9.1
95-15	313609084043501	PW3, Miller Brewing Co.	1979	550	550	do.	do.	1,370	7.0
95-16	313527084045201	OW1, Miller Brewing Co.	1978	942	942	Multiaquifer	do.	--	--
95-17	313545084044701	OW2, Miller Brewing Co.	1979	560	560	Tallahatta	do.	--	--
95-18	313606084044001	OW3, Miller Brewing Co.	1979	550	550	do.	do.	--	--
95-19	313551084044002	USGS OW2, Miller Brewing Co.	1979	105	60	Ocala	Open hole	--	--
95-20	313609084043502	USGS OW3, Miller Brewing Co.	1979	105	60	do.	do.	--	--
95-21	313625084041501	Firewell-SAC Apron, Miller Brewing Co.	[1]1979	350	350	Tallahatta	Screened	--	--
95-22	313748084002901	Albany-Dougherty Co., U.S. Marine Corps	1949	243	206	Ocala	Open hole	--	--
95-23	312958084074601	Merck and Co., Inc., 1	1951	247	80	do.	do.	--	--
95-24	313246084105601	Herty Nursery, 4	1954	165	69	do.	do.	465	11.3
95-25	313530084203201	Tallahassee Plantation, DNR	1973	656	542	Clayton	do.	--	--
95-26	313007084184801	St. Joe Paper Co., Barnett Well	1942	795	542	Cretaceous	do.	--	--
95-27	312741084010801	Barlow, D.	--	442	442	Tallahatta	Screened	--	--
95-28	313454084083801	Albany, 6	1937	955	640	Multiaquifer	Screened and open hole	1,083	6.9
95-29	313444084090301	Albany, 7	1939	1,022	1,022	do.	do.	700	--
95-30	313449084085901	Albany, 8	1941	768	653	do.	do.	1,677	8.6
95-31	313436084081801	Albany, 9	1947	795	695	do.	do.	1,258	12.4
95-32	313452084093901	Albany, 10	1949	868	680	do.	do.	1,415	13.9
95-33	313455083102501	Albany, 11	1950	915	915	do.	Screened	638	5.8
95-34	313525084111401	Albany, 12	1952	725	635	do.	Screened and open hole	911	5.6
95-35	313445084092201	Albany, 13	1952	800	676	do.	do.	870	7.7
95-36	313429084112301	Albany, 14	1954	855	855	do.	do.	899	5.4
95-37	313610084105001	Albany, 15	1954	895	895	do.	do.	1,318	12.3
95-38	313550084093001	Albany, 16	1955	865	865	do.	do.	1,034	8.0
95-39	313555084062601	Albany, 17	1951	470	470	Tallahatta	Screened	608	9.2
95-40	313621084122801	Albany, 18	1960	855	855	Multiaquifer	Screened and open hole	1,092	9.7
95-41	313414084060301	Albany, 19	1962	965	965	do.	do.	1,272	13.8
95-42	313255084095101	Albany, 20	1963	900	900	do.	do.	556	6.4
95-43	313147084072201	Albany, 21	1966	1,000	1,000	do.	Screened	1,202	6.2
95-44	313403084130101	Albany, 22	1967	891	891	do.	do.	1,102	5.9
95-45	313702084113101	Albany, 23	1969	840	840	do.	do.	1,136	19.1
95-46	313507084132801	Albany, 24	1970	890	890	do.	do.	1,300	11.7
95-47	313428084044901	Albany, 25	1971	955	955	do.	do.	1,336	10.7
95-48	313554084143901	Albany, 26	1973	820	820	do.	do.	1,500	13.2
95-49	313650084122901	Albany, 27	1976	820	820	do.	do.	1,404	16.7
95-50	313615084055001	Albany, 28	1967	1,010	1,010	do.	do.	1,500	--
95-51	313519083594901	Albany, 29	1977	1,178	1,178	do.	do.	1,529	9.5
95-52	313446084065701	Albany, 30	1977	940	940	do.	do.	1,500	11.5
95-53	313252084022201	U.S. Marine Corps, 2	1952	997	997	do.	Screened and open hole	1,700	13.9
95-54	313244084051101	U.S. Marine Corps, 3	1954	900	900	do.	do.	1,515	9.9
95-55	313154084244101	Fort, J.P.	1881	547	--	Clayton	Open hole	--	--
95-56	313425084192301	Graham, E.R., 1	1911	650	540	do.	do.	--	--
95-57	313349084100601	Virginia-Carolina Chemical Co.	1918	594	--	do.	do.	--	--
177-01	313813084125001	USGS TW8, Albany	1978	385	385	Tallahatta	Screened	--	--
177-02	313812084125001	USGS TW9, Albany	1978	650	567	Clayton	Open hole	--	--
177-03	314237084103601	Wingfield, J.	1952	700	555	Providence	do.	200	--
177-04	313829084103601	Leehigh Acres, 1	1971	675	555	Clayton	do.	572	9.7
177-05	313801084105001	Leehigh Acres, 2	1973	668	560	do.	do.	536	13.3
177-06	314002084122801	Fowltown Plantation	--	680	560	do.	do.	697	20.5
177-07	314353084100201	Leesburg, 3	1938	320	320	Tallahatta	Screened	180	--
177-08	314150084131601	Haley Brothers Farm	--	300	--	do.	Open hole	--	--
177-09	314010084172501	Fryer, W.H.	1957	213	143	do.	do.	850	--
177-10	314030084171701	Lilliston Implement Co.	1967	644	520	Clayton	do.	656	19.9
273-01	314012084180401	Piedmont Plant Farm	--	626	515	do.	do.	--	--
273-02	314118084190901	Daniel Brothers, 2	--	320	320	Tallahatta	Screened	--	7.5
273-03	314313084205801	Sasser, 3	--	620	475	Clayton	Open hole	350	38.9
273-04	314413084242401	Brown's Dairy	--	496	394	do.	do.	--	--
273-05	314322084231601	Locke, B.	1979	530	420	do	do.	2,000	28.0
273-06	314127084234701	Daniel Brothers,3	--	540	430	do.	do.	--	--
273-07	314053084233601	Whittaker, B., 2	--	545	425	do.	do.	--	--
273-08	314132084255501	Reese, S.	--	200	200	Tallahatta	Screened	--	--
273-09	313856084295501	Bangs, J.	--	500	400	Clayton	Open hole	--	--
273-10	314314084205701	Sasser, 2	--	202	202	Tallahatta	Screened	--	--
273-11	314402084235901	Whittaker, B., 1	--	520	400	Clayton	Open hole	--	--

[1] Date of well modification

EXPLANATION

—150— POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased wells tapping the Clayton aquifer. Dashed where approximately located. Contour interval 25 feet. National geodetic vertical datum of 1929

—100— POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased wells tapping the Tallahatta aquifer. Dashed where approximately located. Contour interval 50 feet. National geodetic vertical datum of 1929

A———A' GEOLOGIC SECTION

95-11(156) / 95-10(157) DATA POINT—Number outside parenthesis is well identification. Number inside parenthesis is altitude of potentiometric surface in feet

WELL IDENTIFICATION BY AQUIFER
- Cretaceous
- Clayton
- Tallahatta
- Ocala
- Multiaquifer

POTENTIOMETRIC SURFACES OF THE CLAYTON AND TALLAHATTA AQUIFERS AND WELL LOCATIONS IN THE ALBANY AREA, GEORGIA, SEPTEMBER 1979.

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