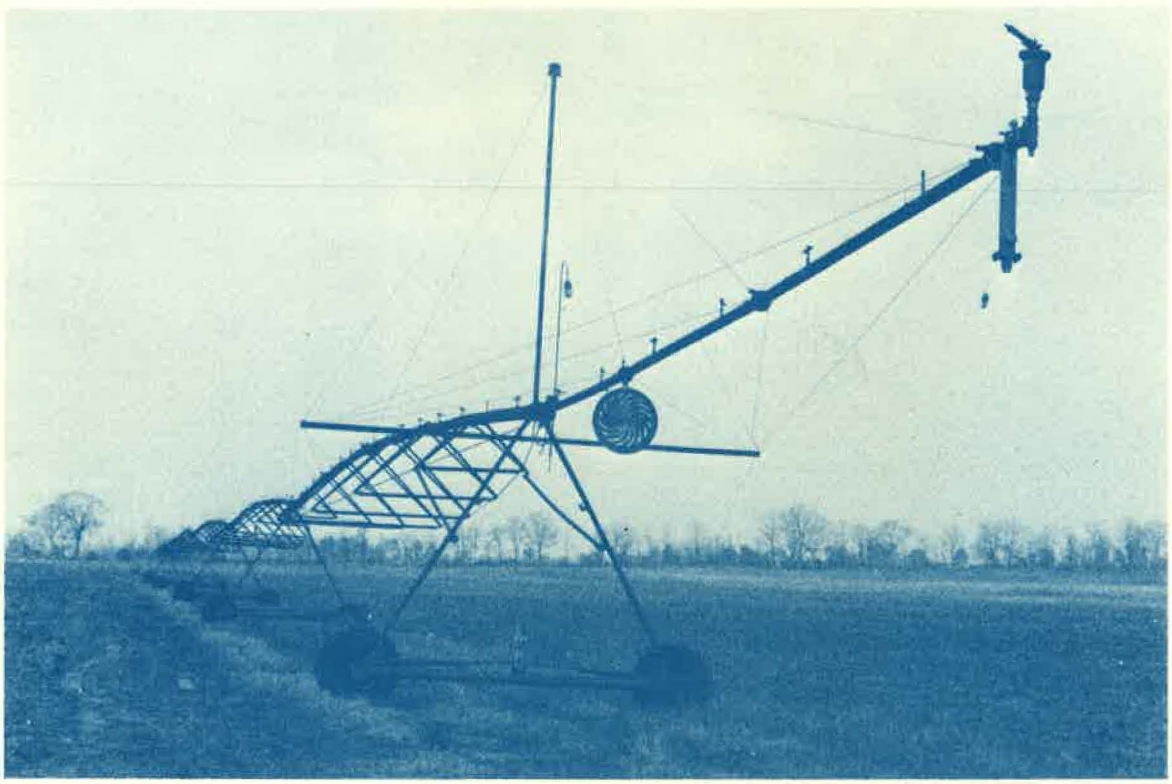
HYDROGEOLOGY OF THE CLAYTON AND CLAIBORNE AQUIFERS IN SOUTHWESTERN GEORGIA

by

Stephen S. McFadden and P. Dennis Perriello



Department of Natural Resources
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COVER PHOTO: Center pivot irrigation system in Randolph County, Georgia.

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Prepared as part of the Accelerated Ground-Water Program

GEORGIA DEPARTMENT OF NATURAL RESOURCES
Joe D. Tanner, Commissioner

ENVIRONMENTAL PROTECTION DIVISION
J. Leonard Ledbetter, Director

GEORGIA GEOLOGIC SURVEY
William H. McLemore, State Geologist

ATLANTA
1983

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ILLUSTRATIONS

FACTORS FOR CONVERTING INCH-POUND UNITS

TO METRIC (SI) UNITS

MULTIPLY	BY	TO OBTAIN
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.589	square kilometer (km^2)
gallon per minute (gpm)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)

ABSTRACT

The Clayton and Claiborne aquifers of southwestern Georgia are locally important sources of ground water in a fifteen-county study area. With the exception of the Dougherty Plain district, these aquifers are more productive than the Principal Artesian Aquifer and are the major sources of municipal, industrial, agricultural, and domestic water for the area.

Comparison of historic and recent water-level measurements indicates declines of hydraulic head in the Clayton aquifer. During the period from 1885 to 1981, the hydraulic head in the city of Albany declined approximately 170 feet. Potentiometric maps of the Clayton aquifer show that a cone of depression centered at Albany existed as early as the 1950's. As of March, 1982, this cone had deepened and its radius of influence had spread into neighboring counties. Records from throughout the area show that the declines in hydraulic head are widespread, and hydrographs indicate that the rate of decline has increased in recent years. Reasons for the decline are increased municipal, industrial, and agricultural withdrawals; limited recharge; and the time-independent hydraulic properties of the aquifer. Growth in agricultural usage has been especially rapid with the number of irrigation wells in the study area more than doubling since 1977. Total water use from the Clayton aquifer is estimated to be 26 Mgal/d while recharge from rainfall infiltration averages about 14.7 Mgal/d. The area over which the hydraulic properties of the Clayton aquifer are conducive to the construction of high-yielding wells is relatively small. Because of these factors, the declining potentiometric levels in the Clayton aquifer can be expected to continue. Problems associated with these declines can also be expected to continue or worsen.

Measurements of water levels in Claiborne aquifer wells indicate that some localized declines in hydraulic head have occurred. A cone of depression is present around the city of Albany, where the hydraulic head has declined 70 feet from the 1950's to 1981. Lesser declines have occurred in the vicinity of the city of Cordele. Declines in this aquifer are due mostly to local municipal, industrial, and agricultural withdrawls, coupled with the hydraulic properties of the aquifer. Recharge to the Claiborne aquifer is greater and more uniformly distributed than recharge to the Clayton aquifer. Total water use from the Claiborne aquifer is estimated to be 36 Mgal/d while recharge from rainfall infiltration is estimated to average 100-133 Mgal/d. Hydraulic properties of the aquifer are such that large withdrawals concentrated in relatively small areas can cause large declines in the potentiometric surface. Although potentiometric declines have as yet not been widespread, the rate of decline and area affected are increasing. Such declines in areas where the Claiborne aquifer crops out along streams could cause reduced base flow in streams.

No single aquifer in the study area is capable of producing the water necessary to meet current and future demands. In order to reduce continued potentiometric declines and the problems associated with them, particularly in the Clayton aquifer, it is recommended that future high-yielding wells in the area be of multiaquifer design and that concentrations of wells producing from a single aquifer be avoided.

INTRODUCTION

SCOPE OF STUDY

This investigation of the Clayton and Claiborne aquifers in southwestern Georgia is a part of the Governor's Accelerated Ground-water Program. In the late 1970's, water-level declines as a result of increased municipal, industrial, and agricultural ground-water use prompted this study. A survey of available data indicated the need for an organized and comprehensive study of water-level trends, ground-water quality, ground-water use, aquifer geometry, lithologic and hydrologic characteristics, recharge and discharge mechanisms, and ground-water budgets.

The goals of the study were to assimilate existing knowledge, to produce new hydrogeologic data, to interpret water-level trends in the Clayton and Claiborne aquifers, and to present these data in a useful format. Prior to this study, information on these aquifers was limited and scattered in various files and publications. Unpublished data were obtained from files of the Georgia Geologic Survey (GGS); Georgia Environmental Protection Division (EPD); Georgia Game and Fish Division; Georgia Parks, Recreation, and Historic Sites Division; U.S. Geological

Survey (U.S.G.S.); U.S. Soil Conservation Service; Georgia Cooperative Extension Service; and municipal governments. Additional information was obtained from the files of well drillers, consulting engineers, farmers, industries, and domestic-well owners.

Historical water-level data were obtained from files of the U.S.G.S., GGS, and other files. Maps of the potentiometric surfaces of the Clayton and Claiborne aquifers were constructed using these data.

An observation well network consisting of over 100 municipal, industrial, irrigation, domestic, and test wells (some of which were constructed especially for this study) was established for both the Clayton and Claiborne aquifers. Water-level measurements were made semiannually during periods of approximate seasonal potentiometric highs and lows. The test wells were drilled at selected sites in order to continuously monitor water-level fluctuations both in areas remote from pumping as well as near areas of large ground-water withdrawals. The test wells were constructed in order to compute quantitative aquifer characteristics (i.e., transmissivity, storage coefficient, specific capacity, and others).

Test-well cuttings and other GGS well cuttings and cores were examined to define the lithology and geometry of the aquifers and confining units. Where available, geophysical logs were used in conjunction with lithologic descriptions to estimate the vertical limits of the aquifers. Specific capacity and aquifer test data were used to estimate transmissivity.

Existing ground-water chemistry data were collected and analyzed for significant areal trends. Maps showing the distribution of water quality in the Clayton and Claiborne aquifers were prepared.

An analysis was made of water use and recharge to the aquifers. Water-use data were supplied by the Georgia Geologic Survey's Water-Use Data Collection Project. Recharge was estimated from flow-net analysis and by rainfall and surface discharge analysis in areas of aquifer outcrop. Water losses and gains from inter-aquifer leakage, while discussed in this report, were not quantified. Water-use and recharge patterns coupled with a knowledge of the variations in hydraulic properties were used to analyze the ground-water availability from the Clayton and Claiborne aquifers.

PREVIOUS INVESTIGATIONS

Several reports have discussed ground-water availability in the Coastal Plain of Georgia. Limited hydrogeologic information and historic water-level measurements of the Clayton and Claiborne aquifers are included in reports by McCallie (1908), Stephenson and Veatch (1915), and Thomson and others (1956). Owen (1963) and Wait (1963a) published detailed geologic and ground-water studies of Lee and Sumter, and Dougherty Counties, respectively. These reports include historic water-level and stratigraphic data. Wait (1958, 1960a, 1960b, 1960c) also briefly described the ground-water resources of Clay, Calhoun, Crisp, and Terrell Counties. A separate report by Wait (1960d) discussed the source and quality of municipal ground-water supplies in southwestern Georgia. Vorhis (1972) contributed information on outcrop geology and structure of the Tallahatta Formation (Claiborne Group) and Clayton limestone, composite water levels, and general hydrologic characteristics of aquifers in Crisp, Lee, Dooly, and Sumter Counties. Stewart (1973) discussed aquifer characteristics of the Clayton Formation in the Ft. Gaines area, near the Chattahoochee River. More recently, Hicks and others (1981) discussed the Clayton and Claiborne aquifers in the Albany area.

In addition to the above ground-water studies, several other reports have advanced the knowledge of the geologic framework in southwest Georgia. Geologic and paleontologic logging by Herrick (1961) established much of the baseline control for the subsurface stratigraphy of the Coastal Plain. Toulmin and LaMoreaux (1963) described classic exposures of Tertiary rocks along the Chattahoochee River prior to the impoundment of the Walter F. George Reservoir. Recent contributions by Marsalis and Friddell (1975), Swann and Poort (1979), Gibson (1980), Cramer and Arden (1980), and Rice (1980) have added to the understanding of the geologic history of the area.

ACKNOWLEDGEMENTS

We would like to express our thanks to the many individuals, those representing industries and municipalities as well as private landowners in the study area, who have helped by supplying information and allowing access to their wells. Without their interest and cooperation, this study would not have been possible. The cooper-

ation of county agents, Agricultural Stabilization and Conservation employees, and U.S. Soil Conservation Service personnel is also deeply appreciated.

We thank Harry Blanchard, Frank Boucher, John S. Clarke, Robert E. Faye, and David W. Hicks of the U.S. Geological Survey. Mr. Blanchard was very helpful with historical records, water-level measurement techniques, and water-level recorder operations. Mr. Boucher assisted in pump tests of the wells drilled for this project. Mr. Clarke and Mr. Faye shared valuable data and knowledge of the study area and Mr. Clarke's review of this report resulted in numerous improvements. Mr. Hicks loaned equipment to our field efforts and also shared important data and knowledge of the Clayton and Claiborne aquifers in the Albany area. Without the help of these people, completion of this study would have been more difficult.

GEOGRAPHY OF THE STUDY AREA

LOCATION AND DEMOGRAPHY

Figure 1 shows the 15-county area in southwestern Georgia included in the study. These counties are: Calhoun, Clay, Crisp, Dooly, Dougherty, Early, Lee, Macon, Quitman, Randolph, Schley, Stewart, Sumter, Terrell, and Webster. In this area, the Clayton and Claiborne aquifers are used for municipal, industrial, and agricultural water supplies. The population of the area was about 245,000 in 1980 (U.S. Bureau of Census, 1981). Albany, Americus, and Cordele are the only cities with populations greater than 10,000. Albany (population 78,000) is the largest city in the study area and the commercial center of southwestern Georgia. The city of Dawson (population 5,700) is the center of much of the agricultural activity in the area. Figure 2 illustrates the population growth of Albany and Dawson from 1920 to 1980. During this time period, the population of Albany increased over 6 times, while the population of Dawson remained relatively stable.

Figure 1. Location of the Study Area

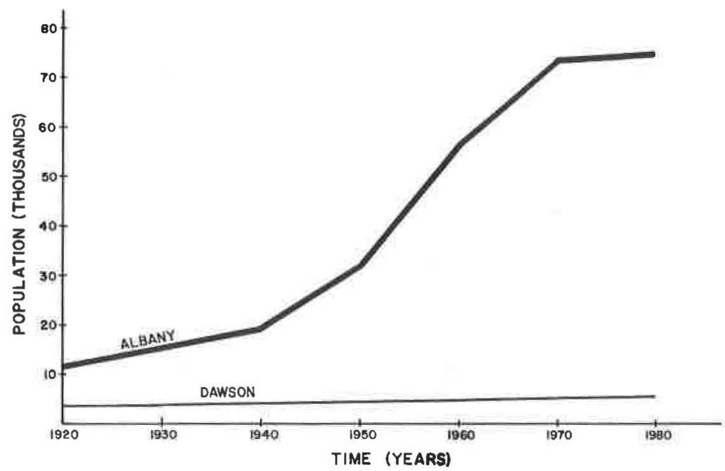


Figure 2. Population Growth of Albany and Dawson, 1920 - 1980.

PHYSIOGRAPHY AND DRAINAGE

Most of the study area lies within the Dougherty Plain and Fall Line Hills Districts of the Coastal Plain Physiographic Province (Fig. 3). The Fall Line Hills District is highly dissected by stream erosion. Relief ranges from 50 to 250 ft, with lower values occurring in the south and southeastern areas adjacent to the Dougherty Plain. The Dougherty Plain District is generally gently rolling to nearly flat. This district is an area of karst topography, where sinkholes are often the sites of ponds and marshes.

Figure 3 also shows the drainage pattern of surface streams in southwestern Georgia. Two of Georgia's largest rivers flow through the study area. The Chattahoochee River, which has been dammed at Ft. Gaines to form the Walter F. George Reservoir, forms the western boundary of the study area. The Flint River, which has been dammed at the juncture of Crisp, Lee, and Worth Counties to form Lake Blackshear and at Albany to form a Georgia Power Company reservoir, flows through the eastern counties of the study area. In general, drainage density is greater in the Fall Line Hills than in the Dougherty Plain.

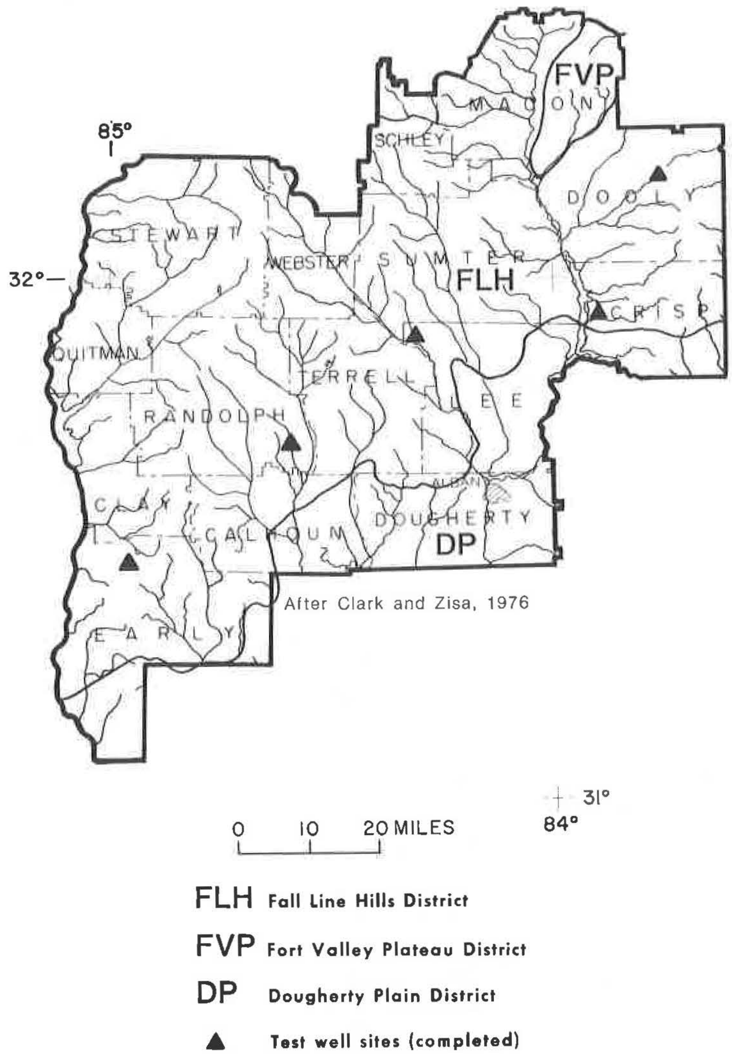


Figure 3. Physiographic Districts and Streams of Southwest Georgia.

CLIMATE

The climate of southwestern Georgia is influenced by the Gulf of Mexico. Winters are generally mild while summers are warm and humid. The mean monthly temperature for the period of record 1941-1970 was 67.1°F (19.5°C) at the Albany station of the National Oceanic and Atmospheric Administration (NOAA). The mean annual precipitation was 48.84 in. for the same period. March and July are generally the wettest months of the year; the fall months are the driest. Evapotranspiration rates are highest in spring and summer.

Southwest Georgia experienced a period of below normal rainfall in the late 1970's through 1981, including short-term agricultural droughts during the growing seasons of some recent years. Rainfall departure curves (monthly departure from the 30-year norm) for the NOAA rainfall stations within the study area are shown in Figure 4.

GEOLOGY

STRATIGRAPHY

Table 1 is a generalized upper Cretaceous and Paleogene stratigraphic column of the study area. Units in this area generally strike along a NE-SW line and dip to the southeast. Although the upper Cretaceous Tuscaloosa, Eutaw, Blufftown, Cusseta, and Ripley Formations and lower Miocene Hawthorne Group (Huddlestun, 1981) are present in the study area, these strata are not relevant to this paper and will not be discussed.

Providence Sand and Providence Sand Equivalent

The Providence Sand is divided into two members, the lower Perote Member and an upper unnamed member. The Perote Member is a dark-gray, highly micaceous, carbonaceous silt to very fine sand of marine origin (Eargle, 1955, p. 70). The Perote Member thins to the east and is not recognized east of the Flint River (Huddlestun, personal communication, 1982). Updip, the upper member consists of medium to coarse-grained, micaceous, feldspathic, cross-bedded sands (Marsalis and Friddell, 1975, p. 9). Downdip, the stratigraphic equivalent of the upper member consists of interbedded sand, clay, chalk, and limestone, which represents a more open-marine depositional environment.

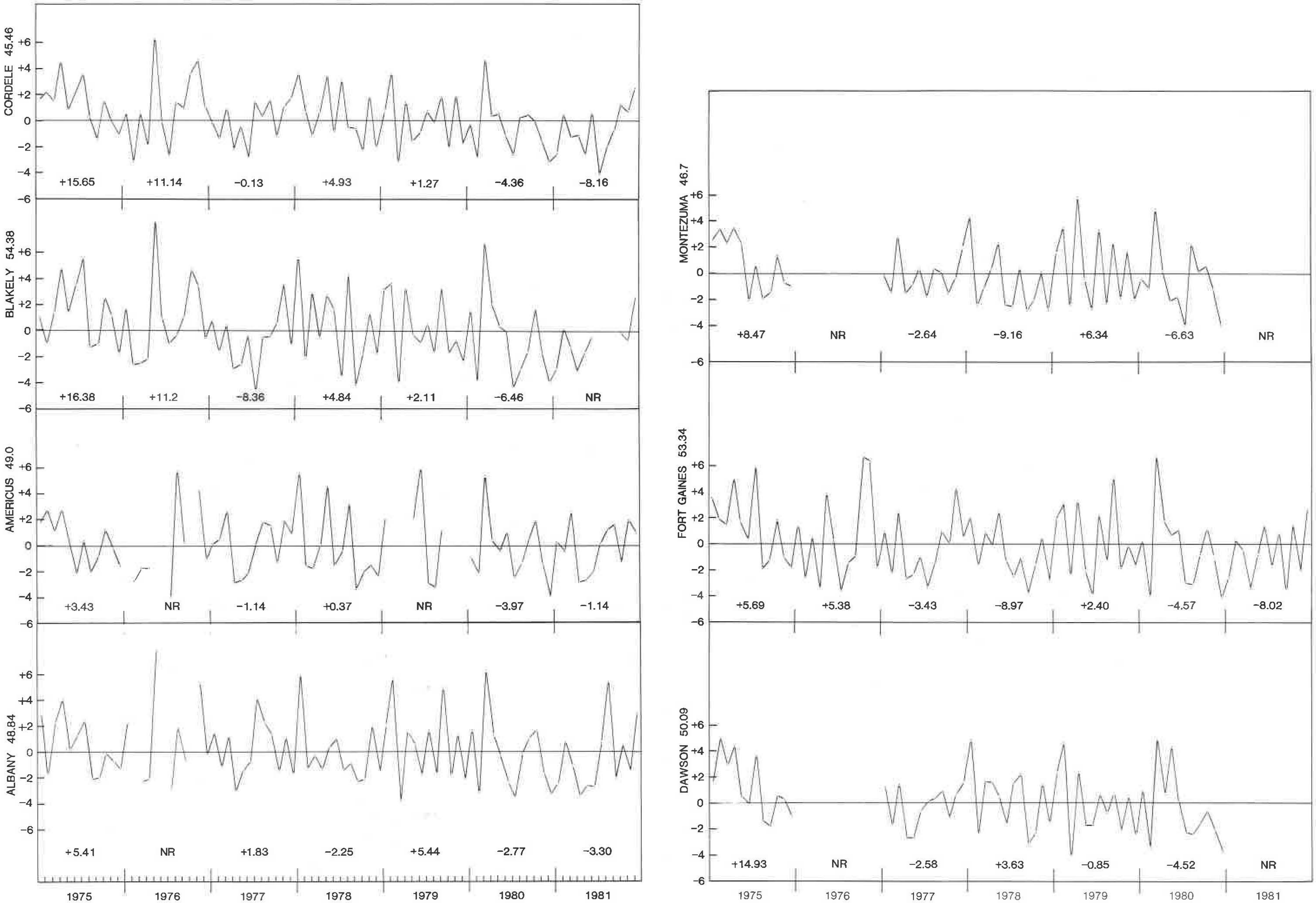


Figure 4. Rainfall Departure Curves - Cities in Study Area. Plotted are the monthly rainfall departures from the 30-year norm. Annual departures are shown below the curve for each city. The 30-year norm is shown next to the city name. All numbers are in inches. Data from the National Oceanic and Atmospheric Administration.

Table 1. Stratigraphic Column of the Study Area.

SYSTEM	EPOCH /SERIES	RADIOMETRIC AGE(M.Y.)/STAGE	GROUP and FORMATION	
		25.0		
TERTIARY	Oligocene	Chickasawhayan		Unnamed Oligocene Limestone
		33.0		
		Vicksburgian		
		38.0		
	Eocene	Jacksonian		Ocala Limestone
				Clinchfield Sand
		41.0		
		Claibornian	Claiborne Group	Lisbon Formation
				Tallahatta Formation
		50.0		
		Sabinian	Wilcox Group	Hatchetigbee Formation
		55.0		
	Paleocene			Tuscahoma Sand
				Nanafalia Formation
		58.0		
		Midwayan		Clayton Formation
		67.0		
UPPER CRETACEOUS	Gulfian	Navarroan		Providence Sand
				Ripley Formation
		72.0		
		Tayloran		Cusseta Sand
				Blufftown Formation
		±79.0		
		Austinian		Eutaw Formation
		±90.0		
		Eagle Fordian		Tuscaloosa Formation / Atkinson Formation
		±94.0		
		Woodbinian		
		±95.0		

(Modified from Huddlestun, 1981)

Clayton Formation

The Clayton Formation of Paleocene age unconformably overlies the Providence Sand. The lithology of the Clayton Formation varies considerably. It ranges from a white to gray, glauconitic, recrystallized limestone to a gray, calcareous clay in the Porters Creek Clay facies (Huddlestun, personal communication, 1981). The Clayton Formation is divided into three lithologic units (Toulmin and LaMoreaux, 1963, p. 394). The lower division of the Clayton Formation consists of a basal conglomerate and overlying beds of firm calcareous sand and sandstone. The middle division of the Clayton Formation is a coquinoid limestone containing abundant mollusk shells and bryozoans. The upper division is a grayish-yellow to white, silty, microfossiliferous, marine, soft limestone. Although sand may be present locally, the Clayton Formation is generally sand-starved and consists mainly of limestone and clay. In updip areas the limestone has weathered to an iron-rich sandy clay.

Deposition on an irregular surface and post-depositional erosion and solutioning have caused the thickness of the Clayton Formation to vary considerably within the study area. Thickness ranges from less than 50 ft in eastern Dooly and Crisp Counties to approximately 450 ft in southern Early and Miller Counties.

Wilcox Group

The Wilcox Group of late Paleocene and early Eocene age consists of the Nanafalia Formation, the Tuscahoma Formation, and the Hatchetigbee Formation. The Nanafalia Formation is a massively bedded fine- grained, glauconitic sand and sandy clay. The Tuscahoma Formation consists of a basal quartz sand overlain by olive-gray, thinly bedded, laminated, carbonaceous silt and clay interbedded with fine quartzose sand (Toulmin and LaMoreaux, 1963, p. 396, 401, 402). The lower Eocene Bashi Marl Member of the Hatchetigbee Formation consists of massively bedded, olive-gray, glauconitic, fossiliferous, calcareous sand (Marsalis and Friddell, 1975, p. 20). The Bashi Marl is discontinuous in outcrop; the overlying Hatchetigbee sands also are sporadic in occurrence.

Claiborne Group

The Claiborne Group of middle Eocene age unconformably overlies the Wilcox Group. The Claiborne Group consists of the Tallahatta and Lisbon Formations. Along the Chattahoochee River, the Tallahatta Formation is a light-gray, fossiliferous, slightly calcareous, glauconitic, clayey sand (Marsalis and Friddell, 1975, p. 20-22). The Lisbon Formation unconformably overlies the Tallahatta Formation. The Lisbon Formation consists of calcareous, fossiliferous, glauconitic sands; limestone; sandy limestone; and clayey sands. Locally some of the sands are indurated. In updip areas, the Tallahatta Formation and the Lisbon Formation are difficult to distinguish from one another; and they are, therefore, mapped as Claiborne undifferentiated (Georgia Geologic Survey, 1976). The Tallahatta and Lisbon Formations crop out along streams in the western and northern parts of the study area. The Claiborne Group generally thickens toward the south and southwest. Thickness ranges from 50 ft in the northeast part of the study area to about 200 ft in southwestern Calhoun County and Early County.

Ocala Limestone

The Ocala Limestone of late Eocene age overlies the Claiborne Group throughout most of the study area. In the extreme northeast corner of the study area the Clinchfield Sand of late Eocene age unconformably overlies the Claiborne Group. The Ocala Limestone is a white to yellow, soft, fossiliferous, porous limestone. It crops out on the banks of the Flint River in Dougherty County and along the northern edge of the Dougherty Plain. Ocala Limestone residuum crops out as clays along hilltops and uplands in the southern Fall Line Hills District and throughout the Dougherty Plain District. An unnamed Oligocene limestone residuum overlies the Ocala Limestone in eastern Dooly and Crisp Counties (Huddlestun, personal communication, 1981).

STRUCTURE

The Clayton Formation has been cut by an east-west trending normal fault near Andersonville in the northeast part of the study area (Zapp, 1965). South of the fault the Clayton Formation has been displaced upward by 100 ft relative to the north side. Cramer and Arden (1980) postulate a fault trending about N75°W from southern Early County eastward to Colquitt County based on the possible absence of the Clayton Formation in south Early County.

AQUIFERS IN THE STUDY AREA

An aquifer is a body of rock which stores a significant amount of water and is able to transmit that water in usable quantities to municipal, industrial, agricultural, or domestic wells. An artesian aquifer is confined between relatively impermeable layers; consequently, the water level in a well penetrating the upper confining unit will rise above the top of the aquifer due to hydraulic head. Several artesian aquifers are present in the study area including the Providence, Clayton, Claiborne, and Principal Artesian Aquifers.

CRETACEOUS AQUIFERS

Underlying the Clayton Formation in the study area are saturated, permeable sands of the upper Cretaceous Providence Sand. Other Cretaceous aquifers exist in deeper formations, but the greater expense of constructing wells in these aquifers and problems of water quality restrict their use. These deeper aquifers may offer a viable future source of ground water, but their evaluation is beyond the scope of this project. The Providence Sand aquifer, however, is an important source of ground water. It is utilized in multiaquifer wells in Albany and in the updip part of the study area where the Clayton and Claiborne aquifers are not productive.

CLAYTON AQUIFER

The Clayton aquifer consists mostly of saturated, permeable limestone within the middle limestone unit of the Clayton Formation. In some areas, saturated, permeable sands in the upper and lower Clayton Formation are in hydraulic continuity with the limestone and are considered part of the aquifer. The Clayton aquifer is confined above by relatively impermeable clay-rich layers in the upper Clayton Formation and Nanafalia Formation and below by silt and clay layers in the lower Clayton Formation and upper Providence Sand. In the updip part of the study area, the Clayton limestone is reduced in thickness or missing entirely as a result of solution and erosion. Here the Clayton Formation crops out as a sandy clay residuum along streams and on hillsides. In the extreme updip portions of the study area, the confining units are more sandy and permeable; as a result, the Clayton aquifer may be unconfined and include parts of adjacent formations.

Figures 5 through 7 are maps illustrating the geometry of the Clayton aquifer in the study area. Figure 5 is a structure contour map showing the elevation of the top of the Clayton aquifer in feet above or below mean sea level. This contact is the top of the permeable Clayton limestone or contiguous permeable sand as determined by well cuttings, cores, and geophysical logs. The top of the aquifer dips to the southeast at a rate of approximately 20 ft/mi, with a more southerly dip along the Chattahoochee River in the extreme western part of the study area. This map can be used to estimate the depth to the top of the Clayton aquifer by subtracting the elevation indicated by the map from the land surface elevation at a given location.

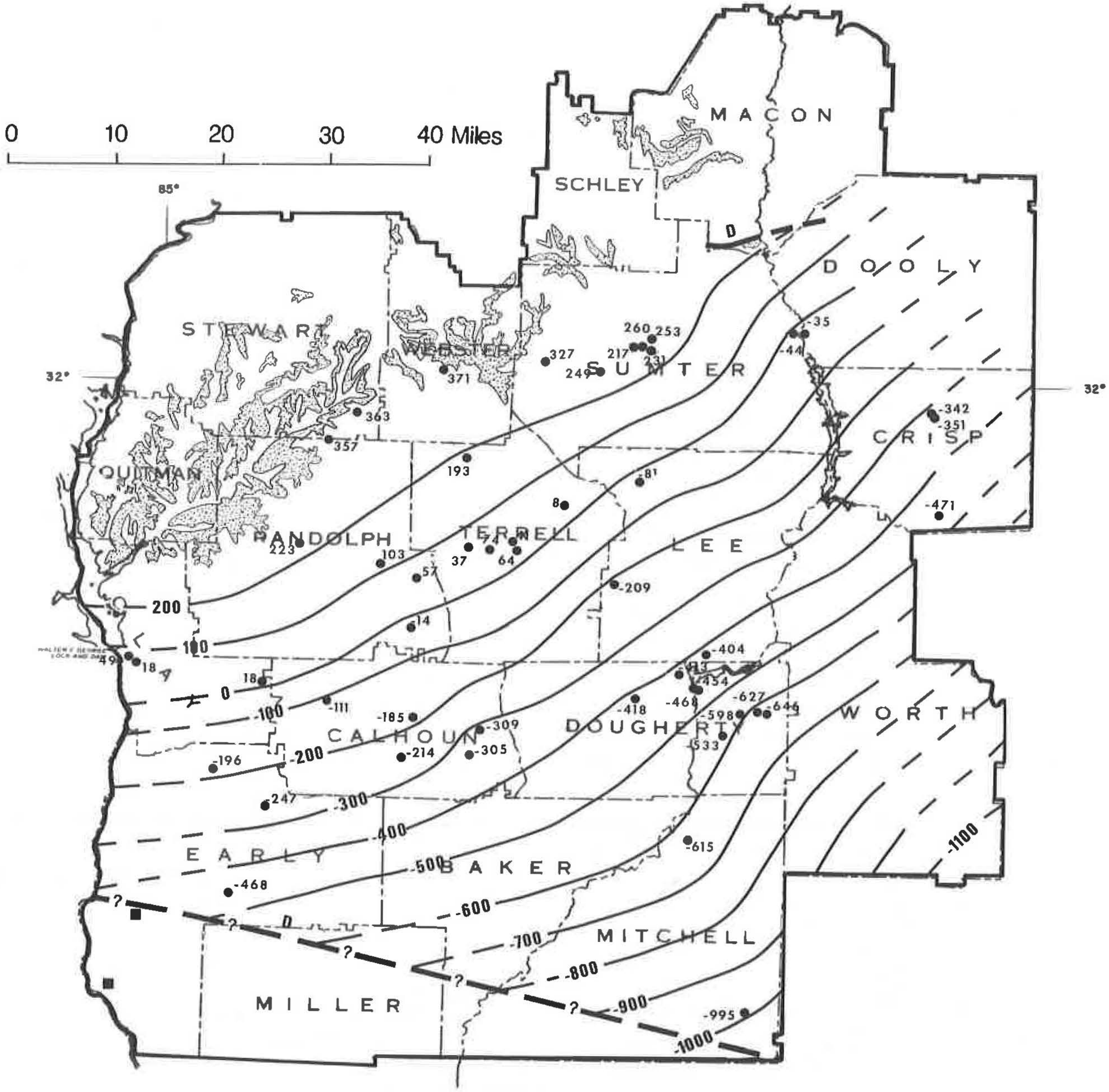
Figure 6 is an isopach map of the Clayton aquifer in the study area and shows the thickness of the aquifer in feet. The thickness of the aquifer generally increases from the outcrop area to the south, although due to the erosional nature of the Clayton Formation, thicknesses may vary considerably over relatively short distances in the study area.

Figure 7 is a structure contour map showing the elevation of the base of the Clayton aquifer in feet above or below mean sea level. This contact is the bottom of the permeable Clayton limestone or contiguous permeable sand as determined by well cuttings, cores, and geophysical logs. The base of the Clayton aquifer also dips to the southeast, but at a slightly greater rate than the top of the aquifer. Figure 7 can be used to determine the maximum depth at which the Clayton aquifer will be encountered by subtracting the elevation indicated by the map from the land surface elevation at a given location.

The relationship of the Clayton aquifer to the Clayton Formation and other stratigraphic units in the study area is illustrated by the three geologic sections in Plate 1. The southeasterly dip and the general southwesterly thickening are apparent in these sections. Facies changes through the study area are illustrated by changing lithologies recorded in the well logs.

CLAIBORNE AQUIFER

The Claiborne aquifer generally consists of saturated, permeable sands in the Tallahatta Formation, but in some areas may include saturated permeable sands of the lower Lisbon Formation and Hatchetigbee Formation which are in hydraulic continuity. These sands may be separated by less permeable sequences of fine sand, silt and clay. The aquifer is confined above by



EXPLANATION

—— 100 — — STRUCTURE CONTOUR - Shows altitude of top of aquifer. Dashed where approximately located. Datum is mean sea level. Contour interval 100 feet.

AREA OF OUTCROP - Includes Clayton undifferentiated, Nanafalia, and Porters Creek Formations.

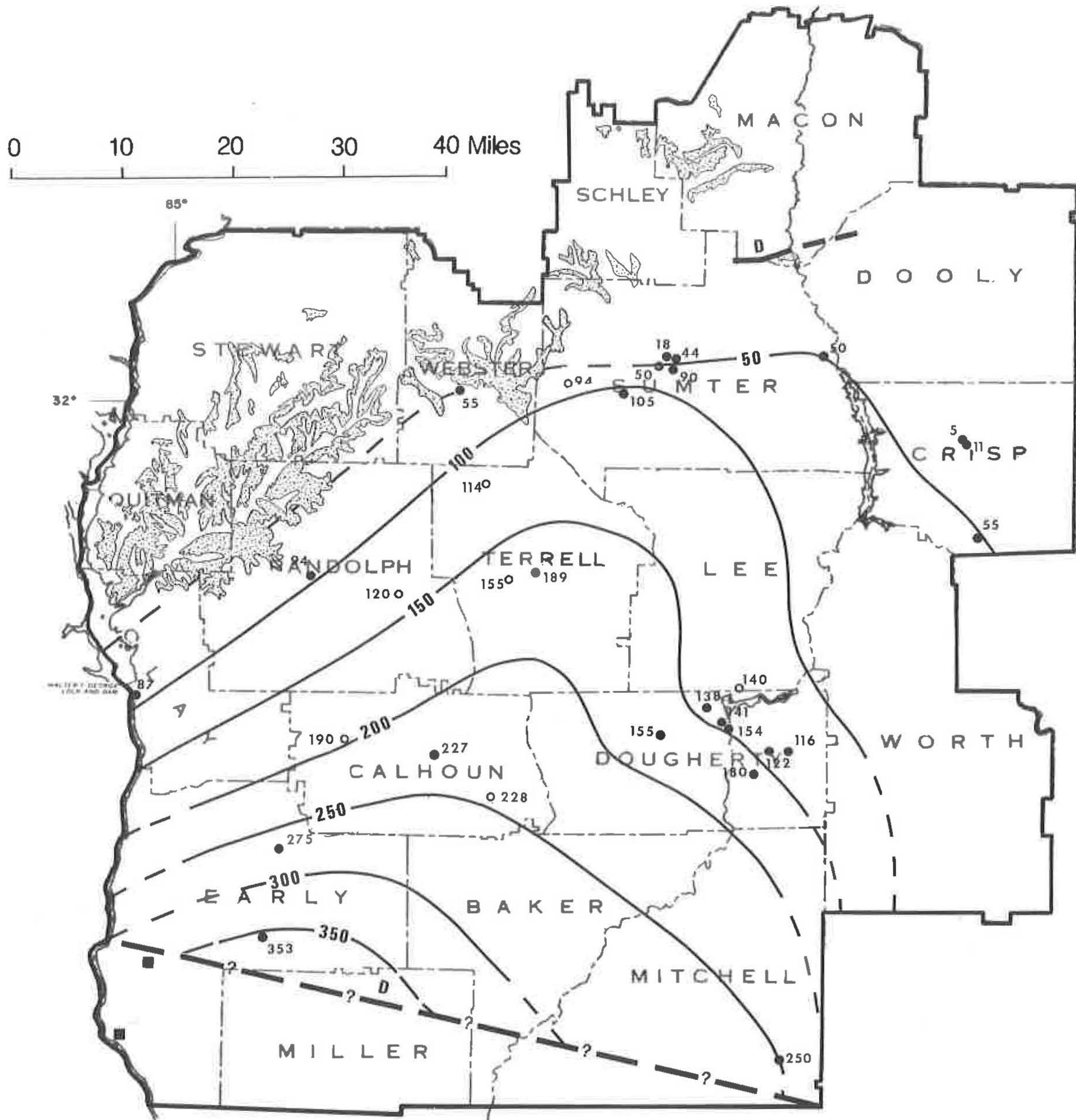
●-468 WELL - Number represents altitude of top of the Clayton aquifer.

■ WELL - Location of well which penetrates Cretaceous strata. No Clayton strata encountered.

— — — FAULT - Dashed where approximately located. D indicates downthrown side. ? indicates possible fault.

N

Figure 5. Structure Contour Map of the Top of the Clayton Aquifer (from Tuohy, M.A., 1983b).



EXPLANATION

—— 100 — — LINE OF EQUAL THICKNESS - Shows thickness of entire aquifer. Dashed where approximately located. Contour interval 50 feet.

AREA OF OUTCROP - Includes Clayton undifferentiated, Nanafalia, and Porters Creek Formations.

●353 WELL - Number represents thickness of aquifer.

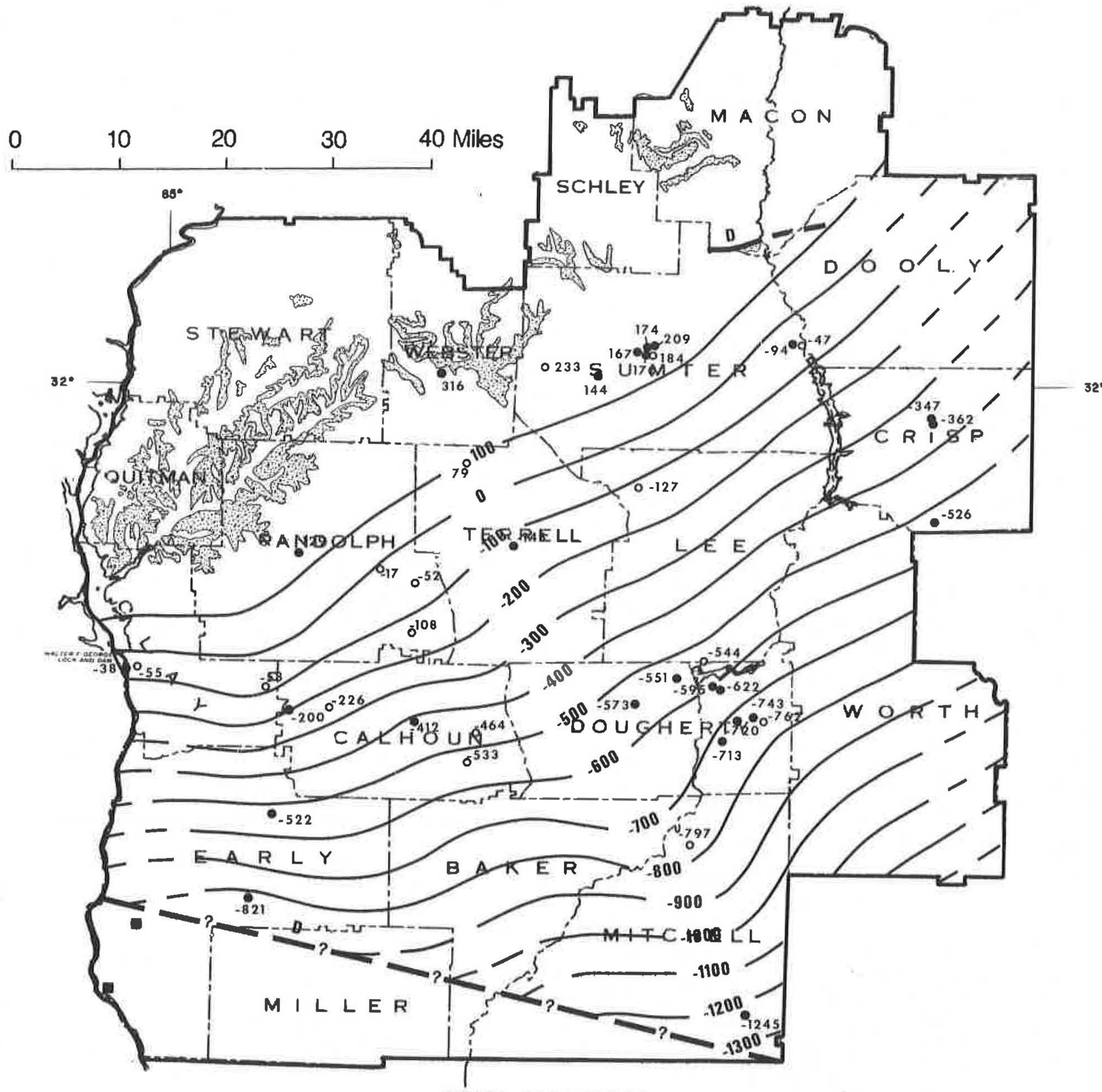
○248 WELL - Number represents minimum thickness of aquifer for well which did not penetrate base of Clayton aquifer.

■ WELL- Location of well which penetrated Cretaceous strata. No Clayton strata encountered.

—— —— FAULT - Dashed where approximately located. D indicates downthrown side. ? indicates possible fault.

N

Figure 6. Isopach Map of the Clayton Aquifer (from Tuohy, M.A., 1983c).



EXPLANATION

—— 100 — — STRUCTURE CONTOUR - Shows altitude of base of aquifer. Dashed where approximately located. Datum is mean sea level Contour interval 100 feet.

AREA OF OUTCROP - Includes Clayton undifferentiated, Nanafalia, and Porters Creek Formations.

●-821 WELL - Number represents altitude of base of the Clayton aquifer.

o-533 WELL - Number represents altitude of bottom of well which did not penetrate the base of the Clayton aquifer.

■ WELL - Location of well which penetrated Cretaceous strata. No Clayton strata encountered.

—— — — FAULT - Dashed where approximately located. D indicates downthrown side. ? indicates possible fault.

N

Figure 7. Structure Contour Map of the Base of the Clayton Aquifer (from Tuohy, M.A., 1983d).

relatively impermeable clay layers in the upper Lisbon Formation and below by the clay-rich Tuscahoma Sand and Nanafalia Formation. The aquifer crops out along streams in a band running from southwest to northeast through the central and north-central parts of the study area, and is locally influenced by stream flow there.

Figures 8 through 10 are maps illustrating the geometry of the Claiborne aquifer in the study area. Figure 8 is a structure contour map showing the elevation of the top of the Claiborne aquifer, in feet above or below mean sea level. This contact is the top of the uppermost saturated, permeable sand in the upper Tallahatta Formation or the lower Lisbon Formation as determined by well cuttings, cores, and geophysical logs. The top of the aquifer dips to the southeast at a rate of about 14 ft/mi with a more southerly dip along the Chattahoochee River in the western part of the study area. This map can be used to estimate the depth to the top of the Claiborne aquifer by subtracting the elevation indicated by the map with the land surface elevation at a given location.

Figure 9, an isopach map of the Claiborne aquifer, shows the thickness of the aquifer in feet. The thickness of the aquifer generally increases from the outcrop area to the southeast and east of the Flint River in Crisp and Dooly Counties. Note that the thickness indicated on this map is from the top of the uppermost saturated, permeable sand to the bottom of the lowermost saturated, permeable sand in the aquifer and therefore may not represent actual permeable thickness.

Figure 10 is a structure contour map showing the elevation of the base of the Claiborne aquifer, in feet above or below mean sea level. This contact is the bottom of the lowermost saturated, permeable sand in the lower Tallahatta Formation or upper Hatchetigbee Formation as determined by well cuttings, cores, and geophysical logs. The base of the aquifer also dips to the southeast. This map may be used to estimate the maximum depth at which the aquifer will be encountered by subtracting the elevation indicated by the map from the land surface elevation at a given location.

The relationship of the Claiborne aquifer to the Claiborne Group and other stratigraphic units in the study area is illustrated by three geologic sections shown in Plate 2. The southeasterly dip and general southerly thickening are shown. Lithologic descriptions of wells used for the sections indicate facies changes occurring in the study area.

PRINCIPAL ARTESIAN AQUIFER

Overlying the Claiborne Group in the southern part of the study area is the saturated, permeable Ocala Limestone. The Ocala Limestone almost exclusively constitutes the Principal Artesian Aquifer in this area. South of Albany, this aquifer is the main source of ground water for all purposes. North of Albany, however, it thins and becomes less productive, necessitating the use of the deeper Claiborne and Clayton aquifers for high-yielding wells. Nevertheless, in the southern part of the study area, particularly in Dougherty County, the Principal Artesian Aquifer supplies large quantities of water for industry and irrigation.

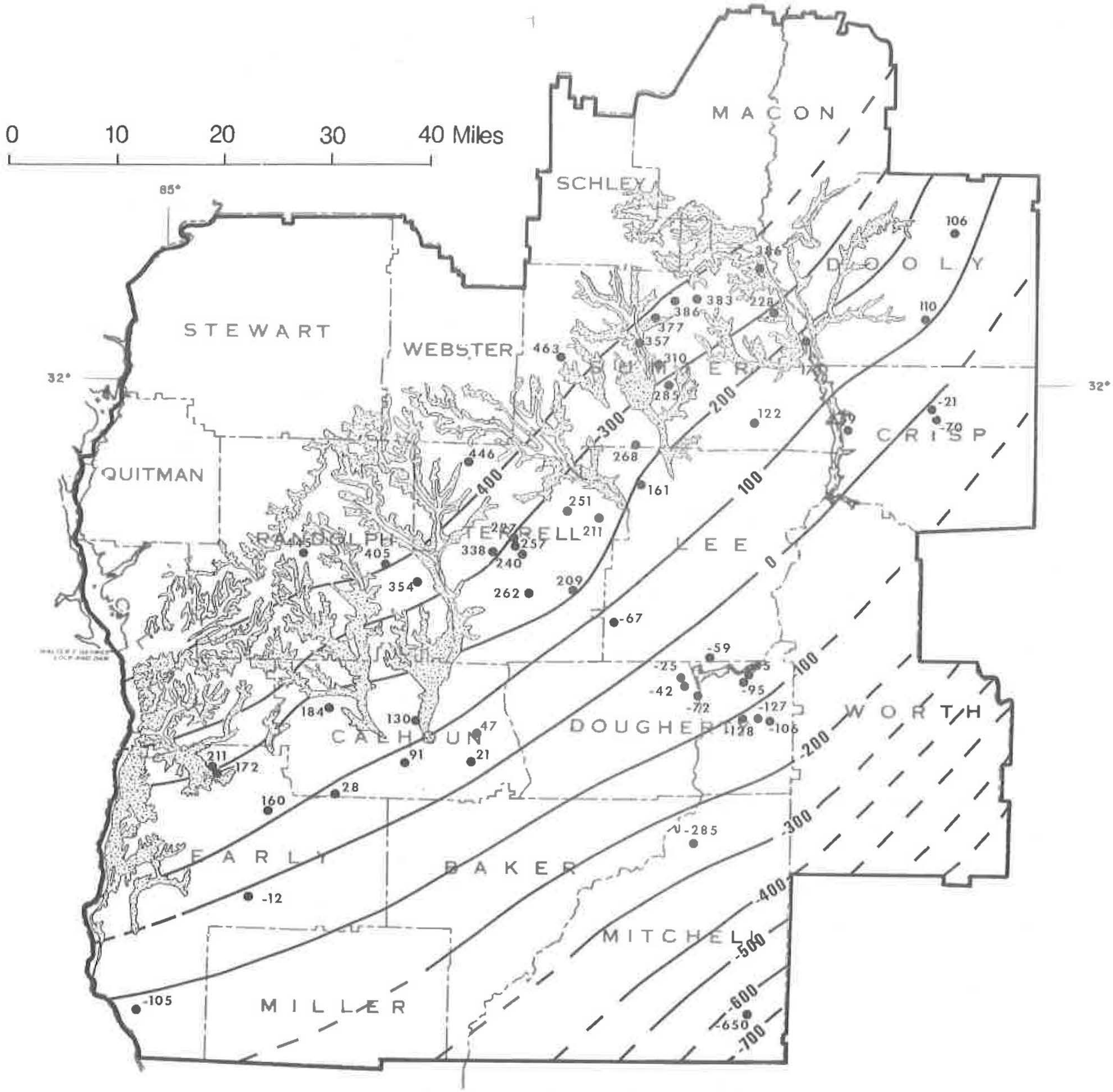
GROUND-WATER USE

GENERAL

Ground-water use patterns in southwestern Georgia have undergone rapid change since the turn of the century and particularly in the last 5 to 10 years. During the early 1900's, municipalities were the major ground-water users. By the 1950's, industrial ground-water use had become significant. The use of ground water for irrigation began during the 1960's, but did not become common until the late 1970's. The majority of irrigation systems were installed after 1975.

Irrigation systems reduce the risk of crop loss due to drought and significantly increase crop yields. Several years of below normal rainfall in the mid-1970's through 1981 combined with development of affordable irrigation systems have led to rapid growth in their use. Figure 11 illustrates this growth. Figure 11a shows that the number of ground-water irrigation systems in the State increased from less than 300 wells in 1955 to over 4,000 wells in 1981. Figure 11b shows the increase in the number of irrigation wells in the 39 counties of southwestern Georgia and in the 15-county study area from 1977 through 1981. During this period, the number of irrigation wells in the study area grew from less than 200 to about 800.

Water-use data in this report were supplied by the Georgia Geologic Survey Water-Use Data Collection Project. When the project is complete, water-use data will be catalogued according to type of use (i.e., municipal, industrial, irrigation, etc.) as well as being subdivided by



EXPLANATION

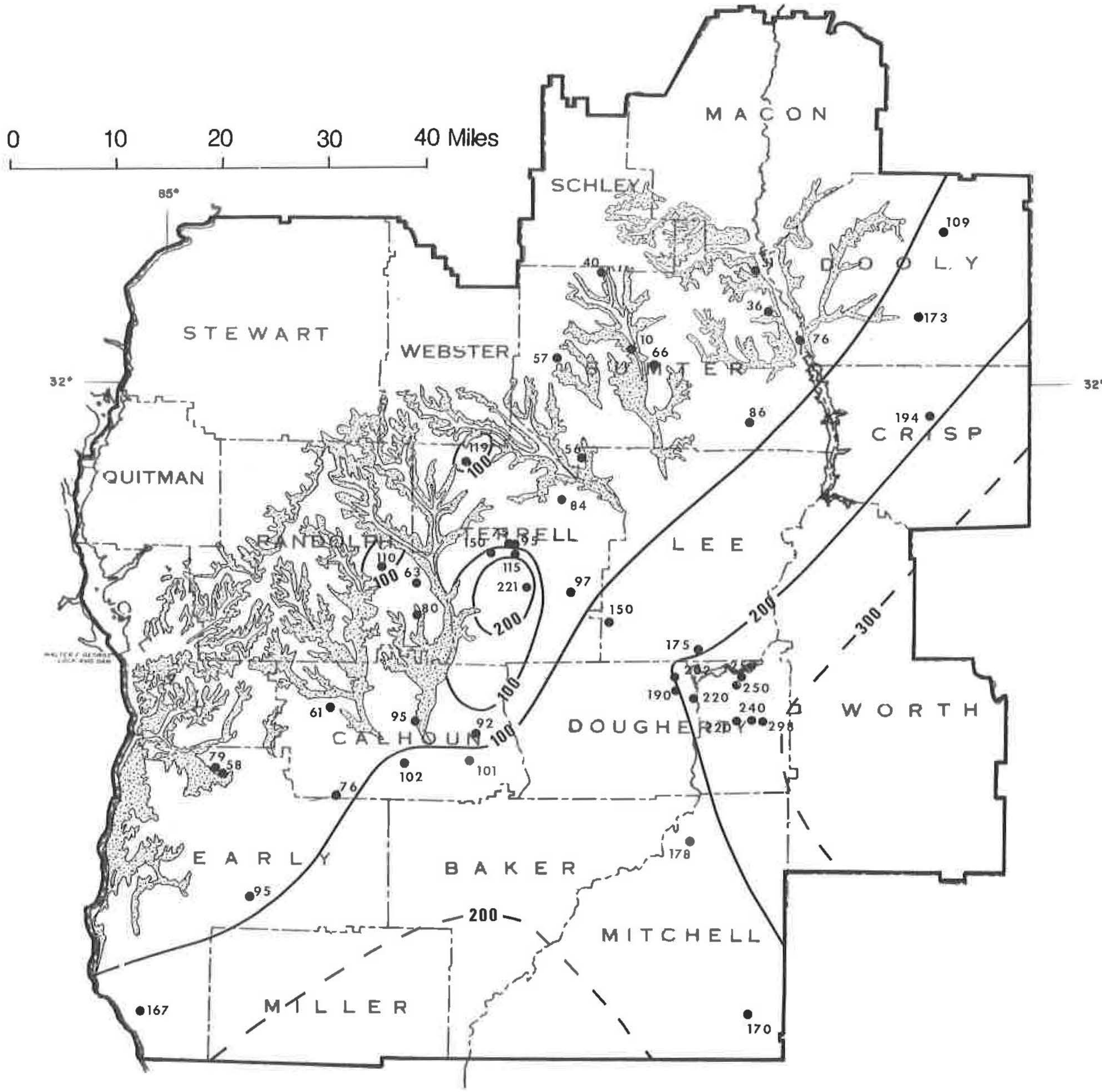
——100 — — STRUCTURE CONTOUR - Shows altitude of top of aquifer. Datum is mean sea level. Dashed where approximately located.Contour interval 100 feet.

AREA OF OUTCROP - Includes Claiborne undiffferentiated, Lisbon, and Tallahatta Formations.

•-105 WELL - Number represents altitude of top of the Claiborne aquifer.

N

Figure 8. Structure Contour Map of the Top of the Claiborne Aquifer (from McKoy, M.L., and Mack, D.M., 1983c).



EXPLANATION

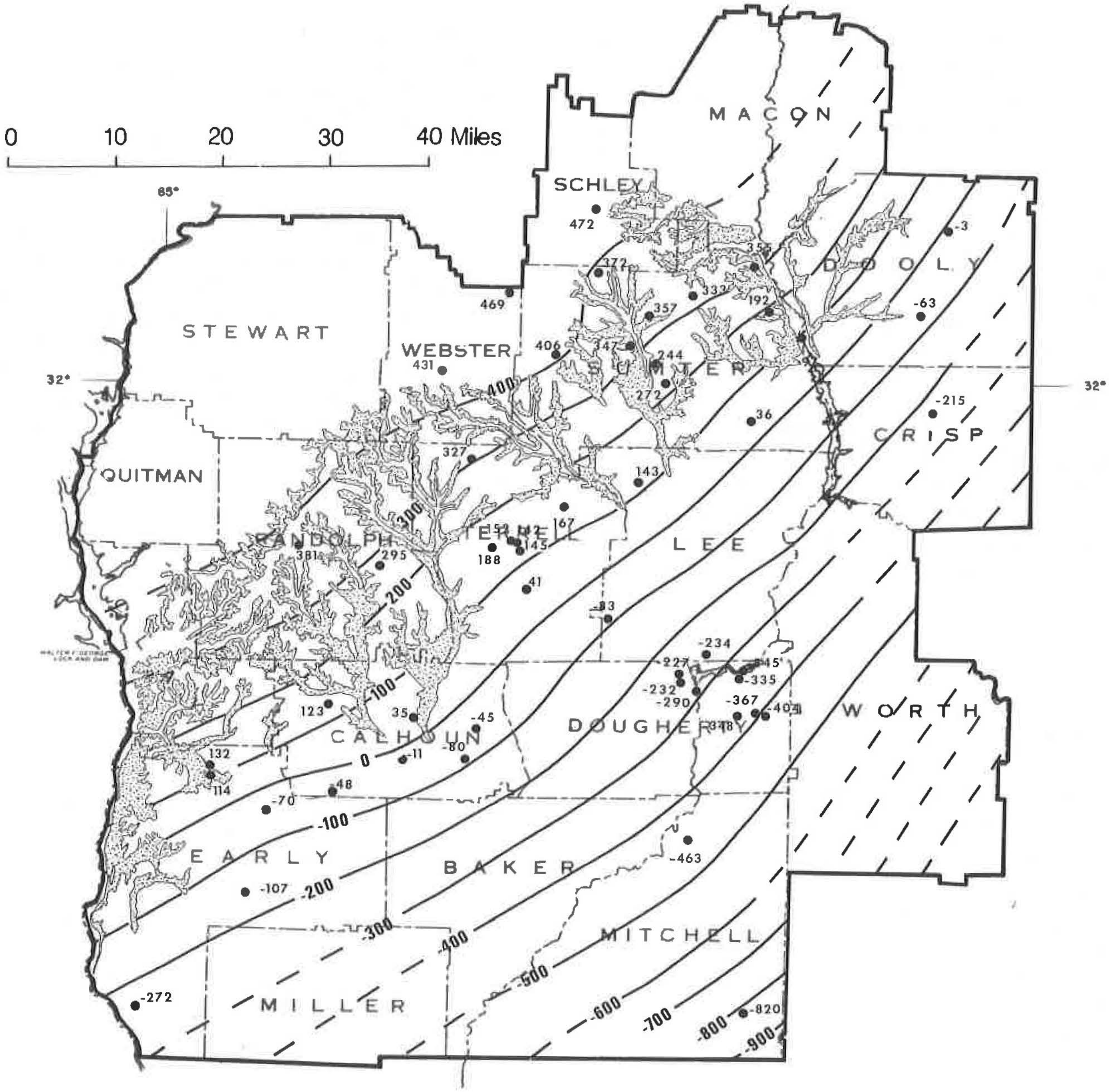
100 — LINE OF EQUAL THICKNESS - Shows thickness of entire aquifer. Dashed where approximately located. Contour interval 100 feet.

AREA OF OUTCROP - Includes Claiborne undifferentiated, Lisbon, and Tallahatta Formations.

●167 WELL - Number represents thickness of aquifer.

N

Figure 9. Isopach Map of the Claiborne Aquifer (from McKoy, M.L., and Mack, D.M., 1983a).



EXPLANATION

100 STRUCTURE CONTOUR - Shows altitude of base of aquifer. Datum is mean sea level. Dashed where approximately located. Contour interval 100 feet.

AREA OF OUTCROP - Includes Claiborne undifferentiated, Lisbon, and Tallahatta Formations.

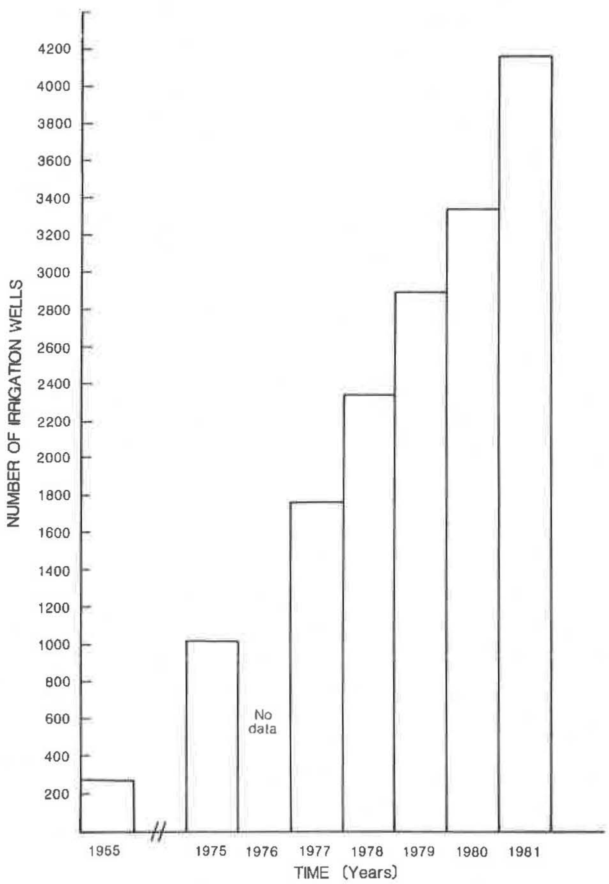
•-272 WELL - Number represents altitude of base of the Claiborne aquifer.

N

Figure 10. Structure Contour Map of the Base of the Claiborne Aquifer (from McKoy, M.L., and Mack, D.M., 1983b).

both county and water source (aquifer or surface water). Only municipal, industrial, and irrigation uses are considered here. Data for domestic and other categories of use are lacking since few records are kept by State and local governments or drillers. Water use by domestic and other categories, however, is estimated to be small when compared to municipal, industrial, and irrigation use. Municipal and industrial ground-water use data are more accurate because large users (over 100,000 gal/d) in these categories are required under the Georgia Ground Water Use Act of 1972 to supply quarterly reports of water use to the Georgia EPD. Irrigation use, however, was exempted from this act and accurate, current data are not available. Irrigation use for 1980 was estimated by the Georgia Geologic Survey Water-Use Data Collection Project using known acreage under irrigation and type of crop planted (Pierce and Barber, 1981, 1982). A listing of irrigation wells is also available from the Water Use Data Collection Project[1]

[1] This listing is unavoidably incomplete; also, it is sometimes not possible to determine the aquifer used due to lack of well construction information. The irrigation estimates used in this report are, therefore, divided into two groups: (a) use from wells of known construction and therefore known aquifer utilitzation and (b) use from wells of uncertain construction. Use in this latter category was estimated by assuming that the group of wells of unknown construction utilized the aquifers in the study area in the same ratio as the group of wells of known construction.



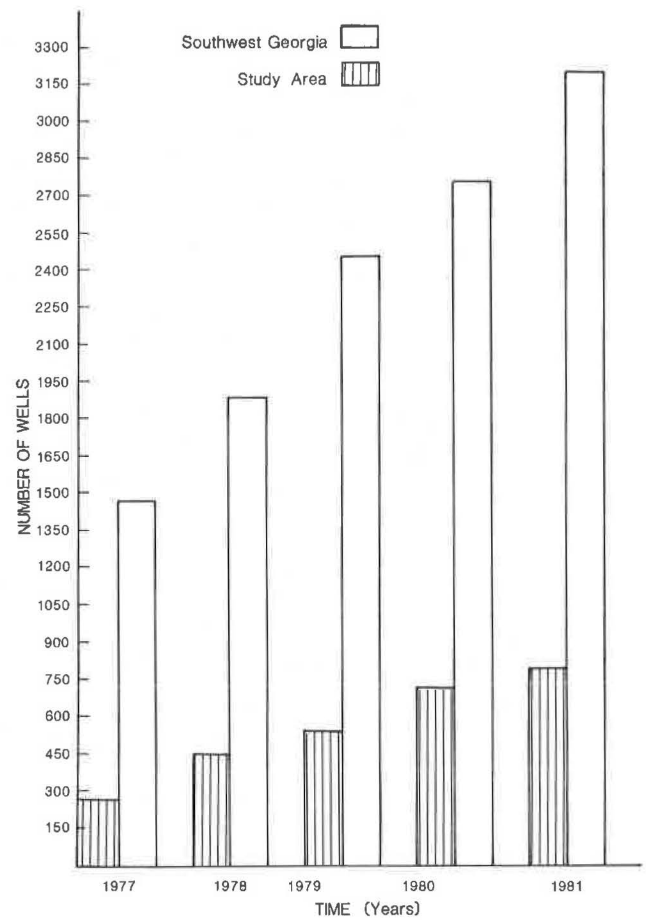


Figure 11. Irrigation Trends in Georgia and the Study Area. a). Number of ground-water irrigation systems in Georgia, 1955, 1975-1981. b). Number of ground-water irrigation systems in southwest Georgia and the study area. (Data from Skinner, R.E., 1977, 1978, 1979, and Harrison, K.A., 1980, 1981).

The municipal, industrial, and irrigation water-use data reported here are generally for the year 1980. However, where available, municipal and industrial water-use figures were updated with 1981 and 1982 data from the Georgia EPD files. Figure 12 shows ground-water use in the study area by aquifer, and the municipal, industrial, and irrigation withdrawals from the Clayton and Claiborne aquifers. The Clayton and Claiborne aquifers supply about 50 percent of the ground water used in the study area. Table 2 lists water use from the Clayton and Claiborne aquifers by category of use and by county in the study area. Note that these figures are average daily use and do not reflect the highly seasonal nature of water use, particularly for irrigation. During the spring and summer seasons, daily irrigation withdrawals are much larger than those shown in Table 2, while in the fall and winter months they approach zero. Municipal withdrawals, although not as variable as irrigation withdrawals, are also greatest in summer and lowest in winter.

CLAYTON AQUIFER

The largest municipal and industrial withdrawals of ground water from the Clayton aquifer occur in the Albany area. The population of Albany had grown to 78,000 in 1980 (Fig. 2). Table 2 shows that 7.69 million gallons per day (Mgal/d) were withdrawn from the Clayton aquifer in Dougherty County, coming almost entirely from Albany's municipal wells. Industrial use of the Clayton aquifer in Dougherty County was about 0.10 Mgal/d, a figure which is somewhat misleading because some industries in Albany use

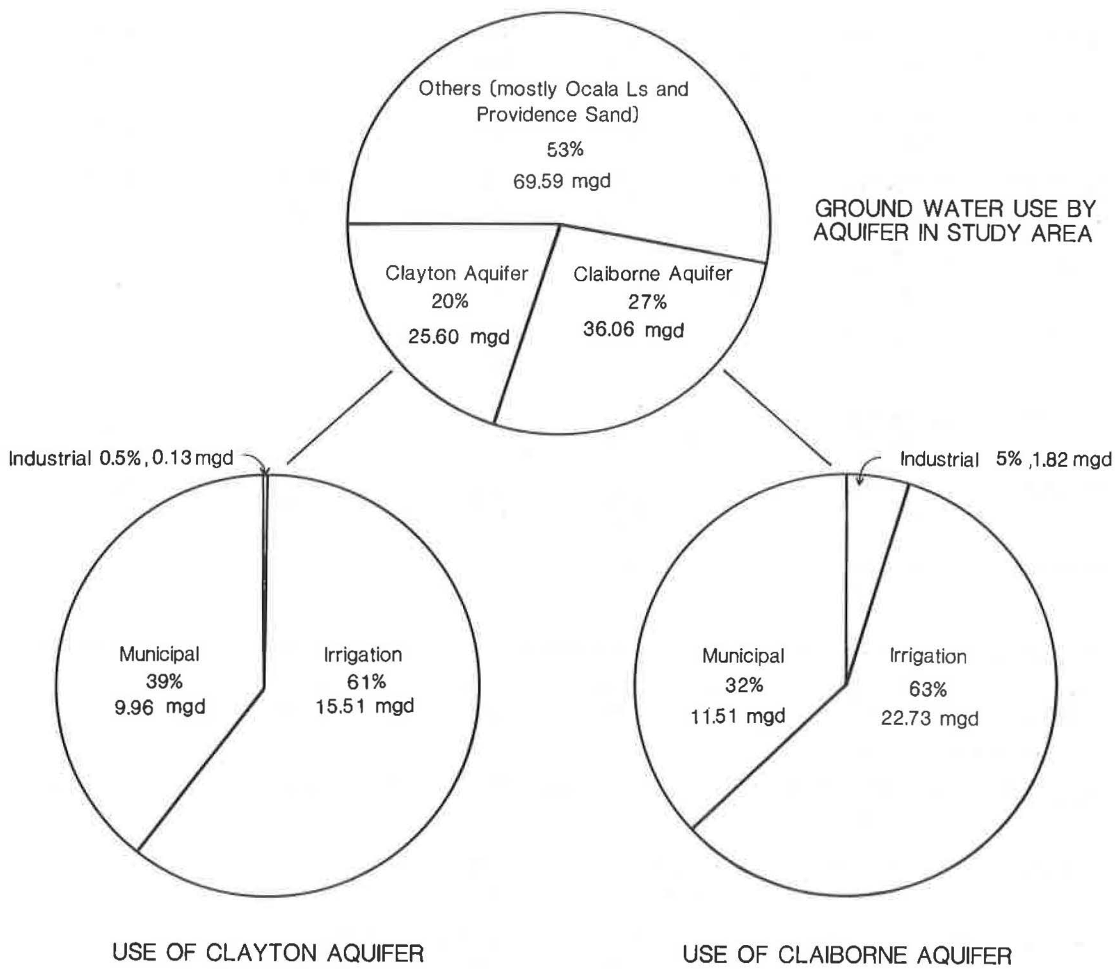


Figure 12. Ground-water Use in the Study Area. Irrigation use is from 1980 data. Municipal and industrial use are from 1981-82 data.

Table 2. Water Use from the Clayton and Claiborne Aquifers.

Consumptive Use of the Clayton and Claiborne Aquifers in the Study Area
(units are millions of gallons per day)

COUNTY	AQUIFER	INDUSTRIAL	IRRIGATION known[1]	IRRIGATION extrapolated[2]	MUNICIPAL	TOTAL
Calhoun	Claiborne	-	0	0	0.03	0.03
	Clayton	-	1.42	0	0.35	1.77
Clay	Claiborne	-	0	0	-	-
	Clayton	-	1.01	0	0.01	1.02
Crisp	Claiborne	-	0.45	0.12	0.71	1.28
	Clayton	-	0	0	-	-
Dooly	Claiborne	0.01	4.99	1.37	0.13	6.50
	Clayton	-	0.06	0	-	0.06
Dougherty	Claiborne	1.71	0.24	0	9.40	11.35
	Clayton	0.10	0.24	0	7.69	8.03
Early	Claiborne	0.10	3.04	1.22	-	4.36
	Clayton	-	1.06	0.15	0.79	2.00
Lee	Claiborne	-	0.14	0	0.76	0.90
	Clayton	-	1.42	0	-	1.42
Macon	Claiborne	-	1.58	0.23	-	1.81
	Clayton	-	0.33	0.07	-	0.40
Quitman	Claiborne	-	-	-	-	-
	Clayton	0.03	-	-	-	0.03
Randolph	Claiborne	-	0.47	0	0.10	0.57
	Clayton	-	4.53	0	0.33	4.86
Schley	Claiborne	-	0	0	-	-
	Clayton	-	0	0	-	-
Stewart	Claiborne	-	0	0	-	-
	Clayton	-	0	0	-	-
Sumter	Claiborne	0	2.43	4.31	0.23	6.97
	Clayton	0.002	0.24	0.51	-	0.75
Terrell	Claiborne	-	1.43	0.71	-	2.14
	Clayton	-	1.22	1.73	0.79	3.74
Webster	Claiborne	-	0	0	0.15	0.15
	Clayton	-	0.41	1.11	-	1.52
Study Area Totals	Claiborne	1.82	14.77	7.96	11.51	36.06
	Clayton	0.13	11.94	3.57	9.96	27.60

Use of 0: Information on file indicates zero consumption in this category and aquifer.

Use of -: No record of aquifer use in this category exists, but use may not be ruled out.

1) Known irrigation figures were calculated assuming that individual system consumption is directly proportional to acres irrigated.

2) These irrigation figures are based on the assumption that the group of wells with unidentified aquifers have an identical ratio of Clayton:Claiborne:other aquifer wells as the group of wells with aquifer identification.

the city's water. In addition to Albany, other municipal users of the Clayton aquifer include: Arlington, Edison, Leary, and Morgan in Calhoun County; Bluffton and Ft. Gaines in Clay County; Cordele in Crisp County; Blakely in Early County; Cuthbert in Randolph County; Sasser, Parrott, Bronwood, and Dawson in Terrell County; and Weston in Webster County. Total municipal and industrial use from the Clayton aquifer in the study area was about 10.1 Mgal/d for the time period reported in Table 2.

Irrigation systems using the Clayton aquifer are scattered throughout the study area, but they are most concentrated in northern Calhoun, southern Clay, northeastern Early, eastern and southern Randolph, southern Terrell, and southern Lee Counties. Yields from the Clayton aquifer are generally highest in these areas. Table 2 shows the total irrigation use from the Clayton aquifer was about 15.5 Mgal/d. Because 1980 data were used and ground-water use for irrigation is constantly increasing, this number is probably less than actual current use.

CLAIBORNE AQUIFER

The largest municipal and industrial withdrawals from the Claiborne aquifer also occur in the Albany area. The city of Albany withdrew about 9.4 Mgal/d from the Claiborne aquifer during the period reported. In 1979, the Miller Brewing Company constructed a plant in Albany and received a permit to withdraw 3.0 Mgal/d from their three supply wells. Two of these wells tap only the Claiborne aquifer; the third produces water from both the Clayton and Claiborne aquifers. The Miller Plant currently (1982) withdraws about 1.5 Mgal/d. A Georgia Pacific Corporation plant located near Vienna in Dooly County is another industrial user of the Claiborne aquifer, although its use has been greatly reduced by conservation efforts. The company's permit for 2.5 Mgal/d was dropped by the Georgia EPD because its withdrawals fell below 100,000 gal/d, an indication of what effective conservation measures can accomplish.

Other municipal users of the Claiborne aquifer include: Leesburg and Smithville in Lee County; Plains, Leslie, and DeSoto in Sumter County; Vienna in Dooly County; Cordele in Crisp County; and Shellman in Randolph County. Total municipal and industrial use of the Claiborne aquifer in the study area was about 13.3 Mgal/d.

In the past, the high cost of constructing large-capacity, screened wells in the sandy Claiborne aquifer restricted its use. However, the Claiborne aquifer has been heavily developed for irrigation in areas where yields from the Clayton aquifer are not adequate for irrigation supply. These areas include southern Early, eastern Terrell, Sumter, Lee, Crisp, Dooly, and southeastern Macon Counties. Yields from the Claiborne aquifer are especially high in Crisp and Dooly Counties. Total irrigation use of the Claiborne aquifer in the study area was about 22.7 Mgal/d during the period reported in Table 2.

WELL CONSTRUCTION IN THE STUDY AREA

Typical well construction of Clayton and Claiborne aquifer wells and a multiaquifer well in the study area are shown in Figure 13. Although the Clayton aquifer is deeper than the Claiborne aquifer, wells tapping the Clayton aquifer may be of simple construction and are generally less costly than Claiborne aquifer wells. Typically, a well tapping the Clayton aquifer is constructed by drilling to the top of the aquifer, installing and grouting casing, and then drilling into the aquifer, leaving the bottom of the well as an open hole. The dense, fractured Clayton limestone usually will remain open. After drilling is completed, the well is developed to remove drilling fluids from the well and aquifer.

Construction of a Claiborne aquifer well is more complex because the loose sands of the aquifer normally must be screened to prevent collapse of the well. A typical Claiborne aquifer well is first drilled to the top of the aquifer and casing is installed and grouted. A hole is then drilled into the aquifer and screens are installed opposite water-producing sands, which are best determined from geophysical logs. The screened interval may or may not be gravel packed depending on the intended use of the well. Yields generally will be higher in gravel packed wells. After drilling is completed the well is developed to remove drilling fluids from the well and aquifer.

The construction of a Clayton and Claiborne multiaquifer well also is shown in Figure 13. The well is screened in the Claiborne aquifer and completed open-hole in the Clayton aquifer. Multiaquifer construction has the advantage of the increasing well yields while reducing the impact on each aquifer and can, in addition, serve to act as a point of recharge from one aquifer to the other. Note that only the Clayton and Claiborne aquifers have been considered here. In parts of the study area where

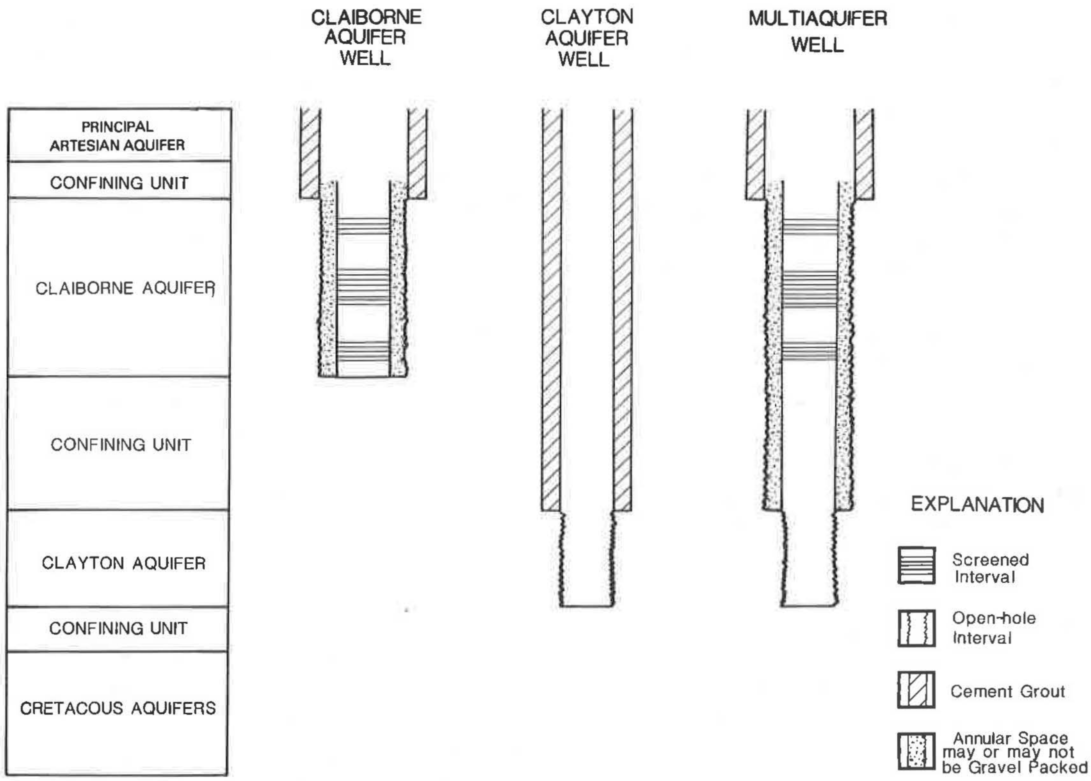


Figure 13. Typical Well construction in the Study Area.

they are viable aquifers, the Principal Artesian and/or Cretaceous aquifers also may be included in multiaquifer wells. In order to make the best use of multiaquifer wells, it is recommended that these wells be geophysically logged prior to completion so that the well can be designed to take advantage of the water-bearing units encountered.

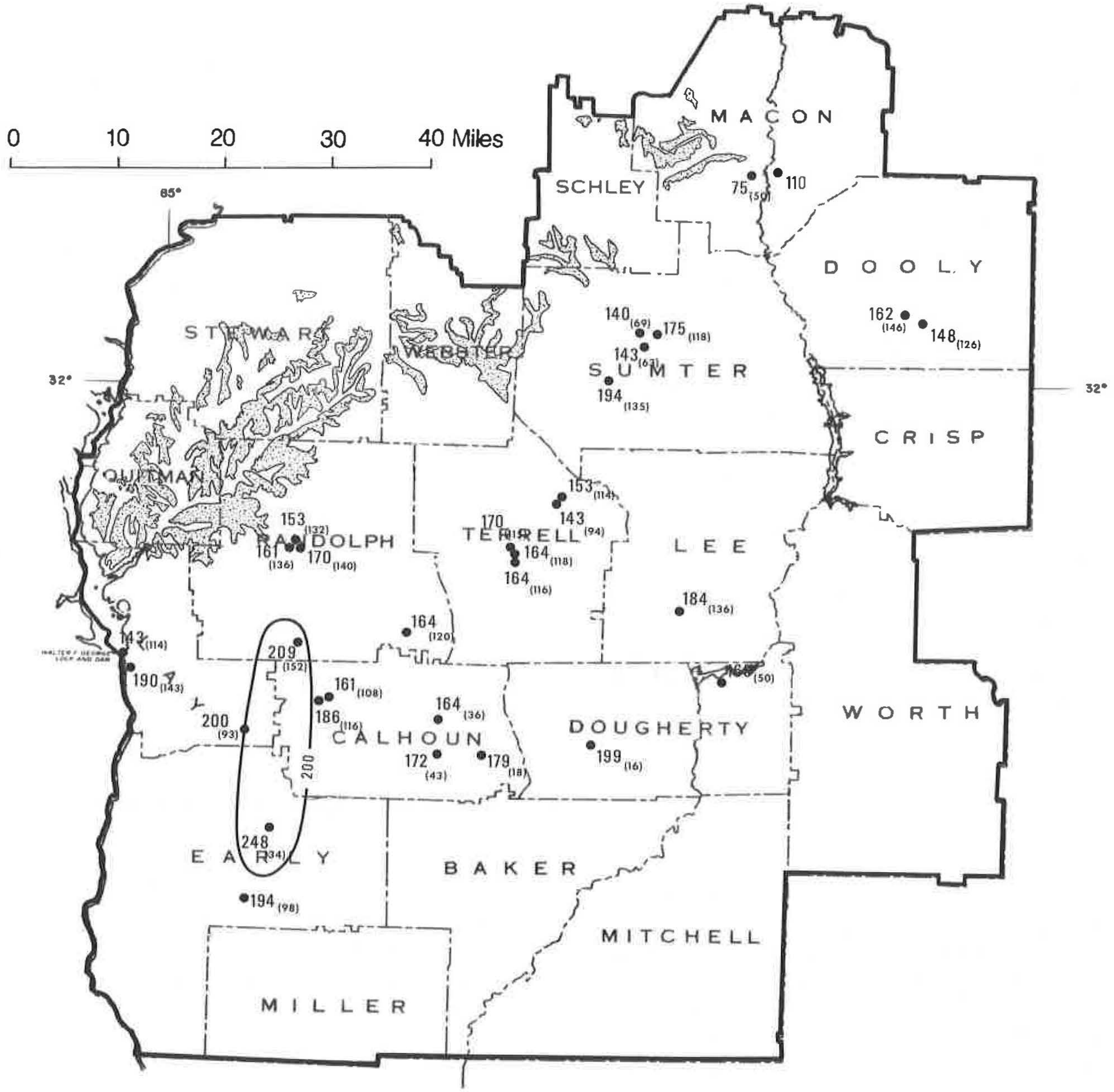
The many possible variations and alternatives to the constructions shown in Figure 13 are beyond the scope of this study. Depending on conditions encountered in drilling and the intended use of the well, construction may vary considerably.

GROUND-WATER QUALITY

CLAYTON AQUIFER

Ground water from the Clayton aquifer in the study area is a soft to moderately hard, calcium bicarbonate to sodium-calcium bicarbonate type. The quality is generally very good, and meets all standards established by the Georgia EPD in its 1977 "Rules for Safe Drinking Water". Figure 14 shows the distribution of total dissolved solids (TDS) and carbonate hardness in the Clayton aquifer. TDS concentrations are generally less than 200 milligrams per liter (mg/l) and nowhere in the study area exceed 250 mg/l.

The sodium content from some Clayton aquifer wells is not typical of limestone aquifers, which generally contain little or no sodium. Upper Cretaceous sands, which contain sodium feldspar, are known as having sodium bicarbonate water (Wait, 1960d, p. 20). This discrepancy has been cited as evidence that water is leaking from the upper Cretaceous Providence Sand aquifer to the Clayton aquifer (Hicks and others, 1981, p. 13). Leakage has been documented through idle multiaquifer wells in the Albany area (Hicks and others, 1981, p. 19-20) and may also occur through the confining unit separating the Clayton aquifer from the Providence Sand aquifer. Feldspathic basal sands in the Clayton Formation which may be in hydrologic continuity with the limestone aquifer also may be the source of the sodium in water from Clayton aquifer wells (Wait, 1960d, p. 12).



EXPLANATION

—— 200 —— LINE OF EQUAL DISSOLVED SOLIDS CONCENTRATION - Shows concentration in milligrams per liter dissolved solids. Hardness values are not contoured.

AREA OF OUTCROP - Includes Nanafalia, Porters Creek, and Clayton Formations, undifferentiated.

●194 (98) WELL - Number represents dissolved-solids concentration. Subscript represents carbonate hardness value.

N

Figure 14. Water Quality in the Clayton Aquifer (from Crews, P.A., 1983c).

CLAIBORNE AQUIFER

Ground water from the Claiborne aquifer in the study area is generally a moderately hard to hard calcium bicarbonate type. The quality is good, meeting the drinking water standards of the Georgia EPD. Figure 15 shows the distribution of TDS and carbonate hardness in the Claiborne aquifer. TDS concentrations are generally less than 200 mg/l and nowhere in the study area exceed 250 mg/l. South of the study area, however, the chloride content of the Claiborne aquifer increases and the water is no longer of good quality. Chlorides of 11,900 parts per million (ppm) and TDS of 22,200 ppm have been reported in Thomasville, Thomas County (Wait, 1960d, p. 13).

Calcium bicarbonate water is not typical of a pure sand aquifer and, in the case of the Claiborne aquifer, has been attributed to coquina and sandy limestone beds interlayered with the sands of the Claiborne Group and upper Hatchetigbee Formation. This atypical chemistry has also been cited as evidence of possible leakage to the Claiborne aquifer from the overlying Principal Artesian Aquifer (Hicks and others, 1981, p. 13).

POTENTIOMETRIC TRENDS

GENERAL

A potentiometric surface is the level to which water in a properly constructed well (one which is tightly cased from the water-bearing zone to the surface) will rise due to hydraulic head.[1] Contour maps of this surface were constructed for the Clayton and Claiborne aquifers by plotting and contouring water-level measurements from a network of observation wells. Potentiometric maps for different time periods were constructed to illustrate long-term trends in the potentiometric surface. The direction of ground-water flow generally is perpendicular to the potentiometric contours, from higher to lower heads, and is indicated by flow arrows on the potentiometric maps.

A ground-water divide is a ridge on the potentiometric surface from which ground water flows in both directions and is represented on the maps by a patterned line. Ground-water divides often coincide with or roughly parallel surface water divides.

The configuration of the potentiometric surface of an aquifer is affected by ground-water withdrawals. A cone of depression may develop in the vicinity of pumping wells and is represented on potentiometric maps by closed contour lines with hatch marks pointing inward. Water levels are successively lower toward the center of the cone, and ground-water flow is toward the center. When there is a concentration of pumping wells in an area, a cone of depression may become evident on a regional scale.

Water-level changes in aquifers are determined by several interrelated factors. These include the hydraulic properties of the aquifer, the recharge to the aquifer, and the discharge from the aquifer. The hydraulic properties of the aquifer, such as transmissivity, storage coefficient, and gradient affect the quantity and rate of groundwater movement through an aquifer. The recharge to an aquifer depends on the hydraulic properties listed above, climate (precipitation, evapotranspiration, and streamflow conditions), infiltration rate (which depends on outcrop area, slope, and permeability), and relationship to other aquifers (head potential and effectiveness of confining units). Discharge can be either natural (into surface streams or through intervening confining zones into other aquifers) or artificial (through wells constructed by man). Discharge also depends on the hydraulic properties of the aquifer, climatic conditions, stream base flow, relationships to other aquifers, and withdrawals from wells.

LONG-TERM POTENTIOMETRIC TRENDS

Clayton aquifer

Maps of the potentiometric surface of the Clayton aquifer have been constructed for four time periods: 1950-1959; December 1979; October-November, 1981; and March, 1982. These maps illustrate the impact of development on the Clayton aquifer.

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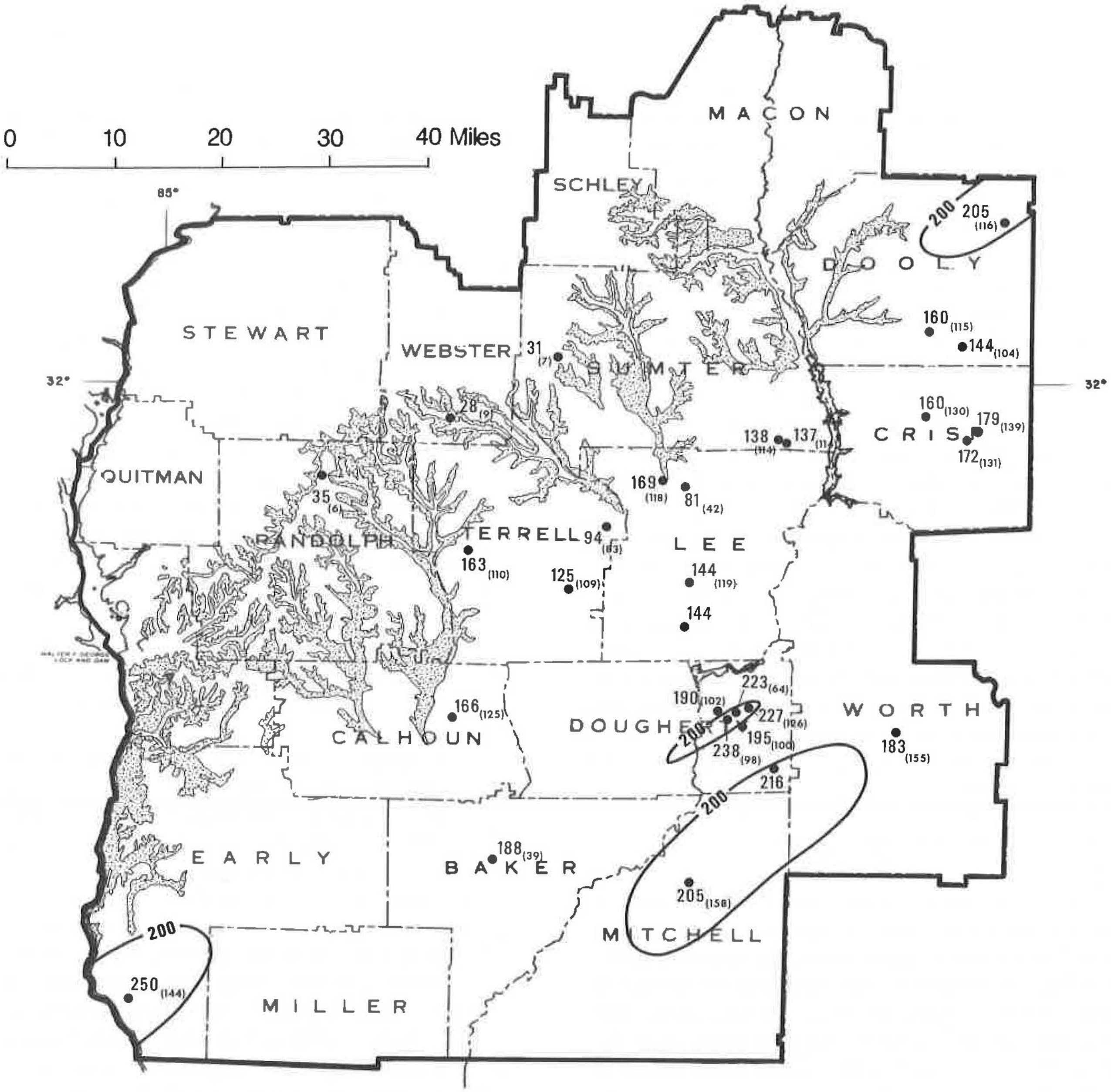
1 Hydraulic head is the sum of pressure head and elevation head. It is a measure of the potential energy of a unit mass of water in an aquifer expressed in terms of length. For a more complete discussion of this term, see Freeze and Cherry, 1979, p. 18-26.

In this report, hydraulic head is assumed equal to the altitude of the static water surface in wells completed in the Clayton or Claiborne Aquifers.



EXPLANATION

—— 200 —— LINE OF EQUAL DISSOLVED-SOLIDS CONCENTRATION - Shows concentration in milligrams per liter dissolved solids. Hardness values are not contoured.

AREA OF OUTCROP - Includes Claiborne undifferentiated, Lisbon and Tallahatta Formations.

● 250 (144) WELL - Number represents dissolved-solids concentration. Subscript represents carbonate hardness value.

Figure 15. Water Quality in the Claiborne Aquifer (from Crews, P.A., 1983b).

Figure 16 is a map showing the potentiometric surface of the Clayton aquifer during the period 1950-1959. The impact of withdrawals can be seen even during this time of comparatively little development. Municipal use of the aquifer was becoming significant and industrial users were developing the aquifer in Albany and Dawson at this time. A cone of depression had developed around Albany, where the lowest hydraulic head, 92 ft, was measured in 1955 at the Virginia-Carolina Chemical Company well near the center of the cone. Clayton aquifer wells in the Albany area which were free-flowing in the late 1800's and early 1900's, with hydraulic heads up to 220 ft, had stopped flowing by the 1950's. The hydraulic head in the city of Dawson was 225 ft, compared with 324 ft in the early 1900's. Contours indicate two ground-water divides which generally coincide with surface water divides. Along the westernmost ground-water divide, flow was to the southwest toward the Chattahoochee River and to the south toward Miller County. The other ground-water divide separated water moving to the southwest from water moving to the southeast toward Dougherty County.

Figure 17 is a map of the potentiometric surface of the Clayton aquifer in December, 1979. This map shows the heavy impact of development on the aquifer. In addition to increased municipal and industrial withdrawals, agricultural withdrawals had become significant by 1979. The cone of depression at Albany had deepened and its radius of influence had spread to several nearby counties. The cone is elongated toward the northwest in part because of heavy agricultural withdrawals in Calhoun, Randolph, Terrell, and Lee Counties. The lowest measured hydraulic head was 57 ft at the Virginia-Carolina Chemical Company well in Albany. The hydraulic head in Dawson had dropped to 155 ft. Reductions in the elevation of the potentiometric surface were significant throughout most of the study area, except in areas of outcrop and stream control.

Figure 18 is a map showing the potentiometric surface of the Clayton aquifer in October-November, 1981. Hydraulic heads measured at this time were the lowest encountered to date. The fall of 1981 followed a winter of below normal rainfall (see Fig. 4) and a dry summer during which irrigation withdrawals probably were greater than any previously. The Albany cone of depression had extended northwest and merged with a smaller cone around Dawson. The lowest measured hydraulic head, 37 ft, was measured at the center of the Albany cone, while in Dawson the hydraulic head had declined to 125 ft.

Figure 19 is the most recent potentiometric map of the Clayton aquifer and was constructed from measurements taken in March, 1982. Compared to the October-November, 1981 map, significant increases in hydraulic heads were encountered. Most of this increase can be traced to the highly seasonal nature of withdrawals. In an area of high irrigation use, the potentiometric surface of the aquifer will rebound when pumps are shut off at the end of the irrigation season. In addition, rainfall during the winter of 1981-82 was slightly above normal following several years of comparative drought and the water-level rise may, in some areas, reflect an increase in recharge from this rainfall. The hydraulic head at the center of the Albany cone of depression was 50 ft, while in Dawson it was 148 ft.

Long-term hydrographs also serve to illustrate the changes in water levels in the Clayton aquifer. Long-term hydrographs show trends over a period of years but do not reflect seasonal fluctuations in hydraulic heads. Figure 20 shows three such hydrographs. Figure 20a is a composite hydrograph of three wells in the city of Dawson for the time period 1903 to 1981. In 1981, the hydraulic head in Dawson well No. 4 was 125 ft, compared to 324 ft in well No. 1 in 1903. This represents a decline of 199 ft, an average of 25 ft per decade. Figure 20b is a composite hydrograph of two wells in the city of Edison spanning the years from 1910 to 1981. It shows a decline of 100 ft, an average of 14 ft per decade. Figure 20c is a hydrograph of the Atlantic Ice and Coal Company well in Albany from 1885 to 1955, after which the well was destroyed. During the period shown, the hydraulic head declined 88 ft, an average of 14 ft per decade.

Claiborne aquifer

Maps of the potentiometric surface of the Claiborne aquifer have been constructed for four periods: 1950-1959; December, 1979; October-November, 1981; and March, 1982. This sequence illustrates trends in the potentiometric surface. Although withdrawals have caused some

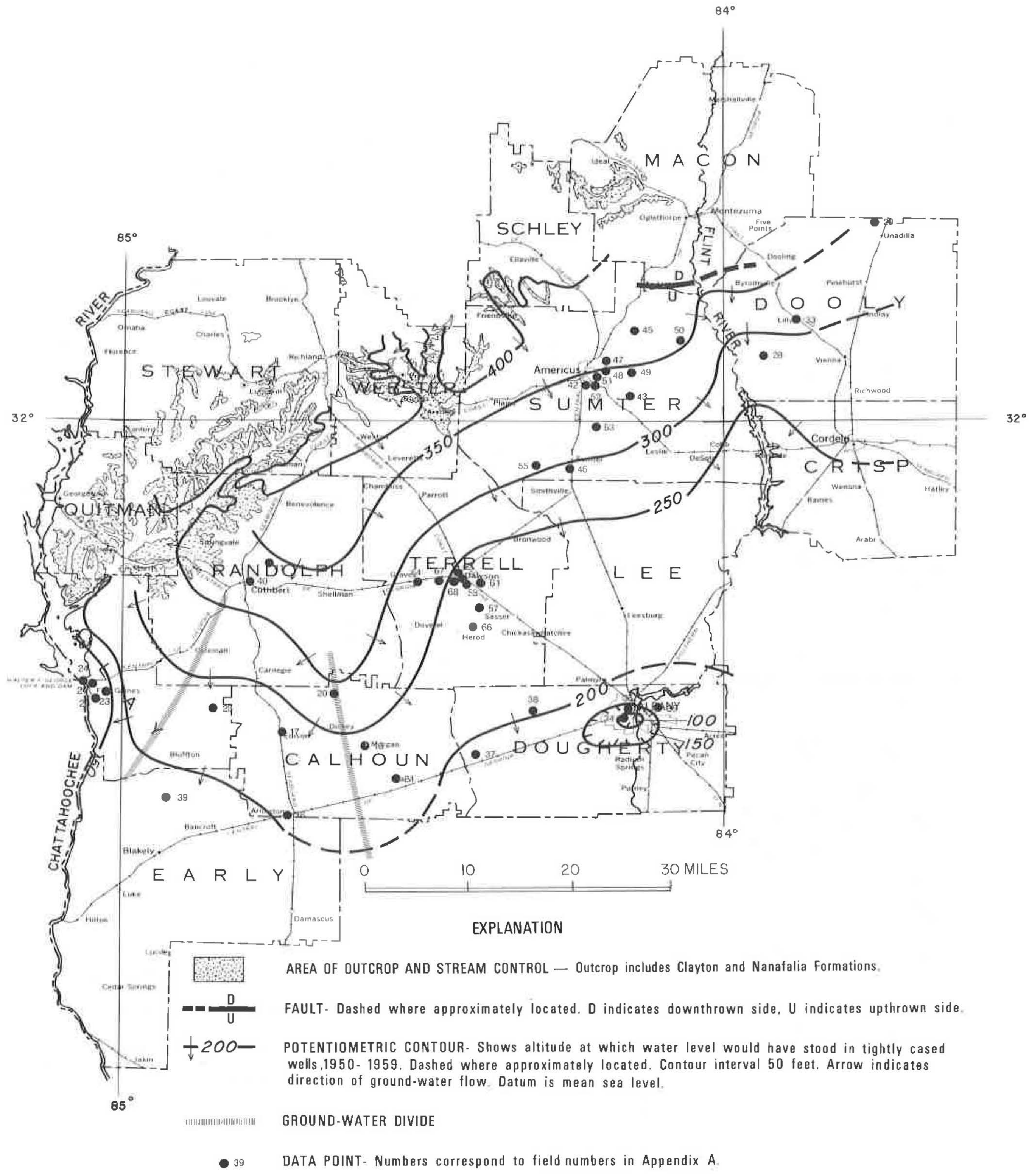


Figure 16. Potentiometric Surface of the Clayton Aquifer, 1950-1959 (modified from Ripy and others, 1981).

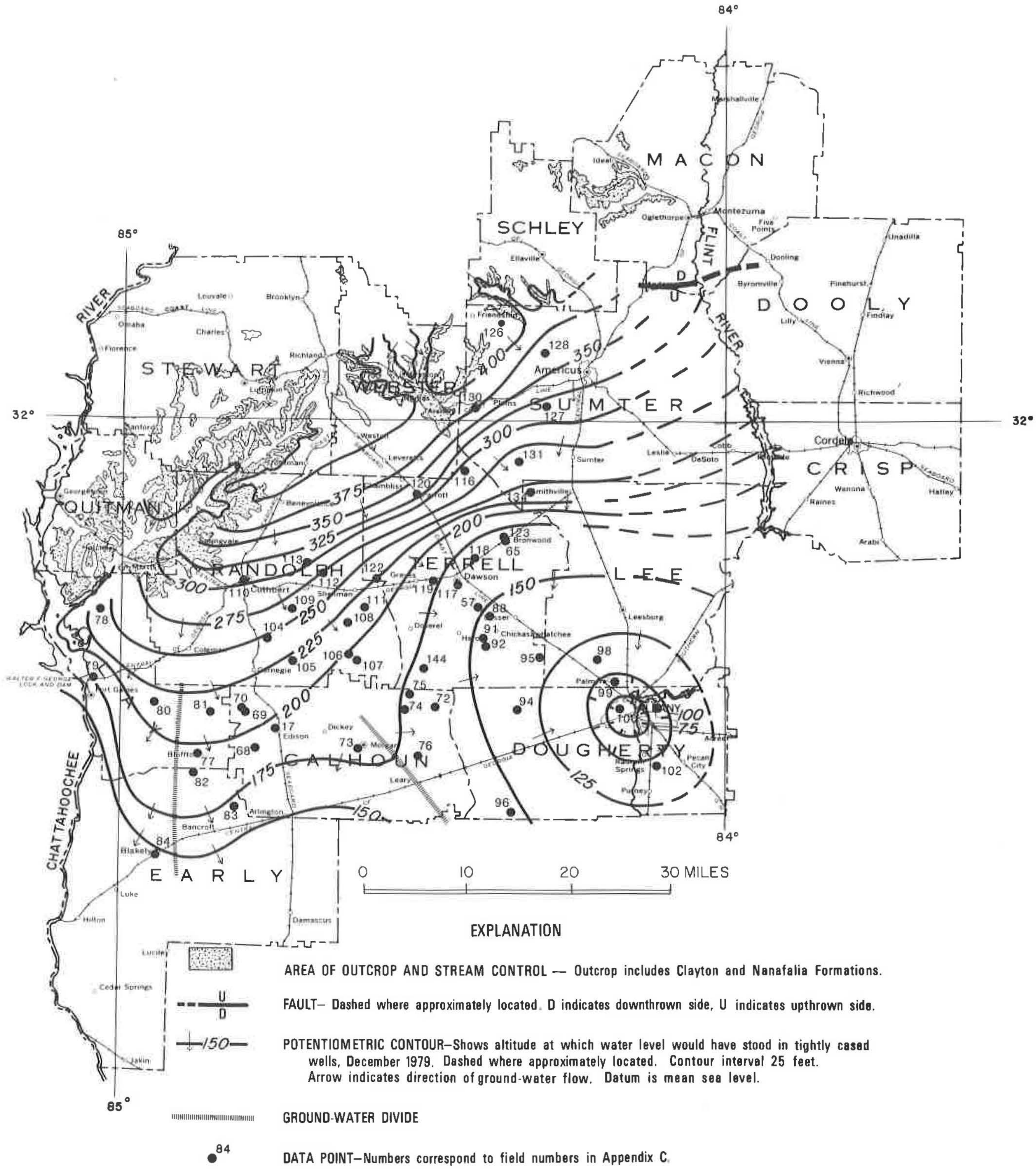


Figure 17. Potentiometric Surface of the Clayton Aquifer, December 1979 (modified from Ripy and others, 1981).

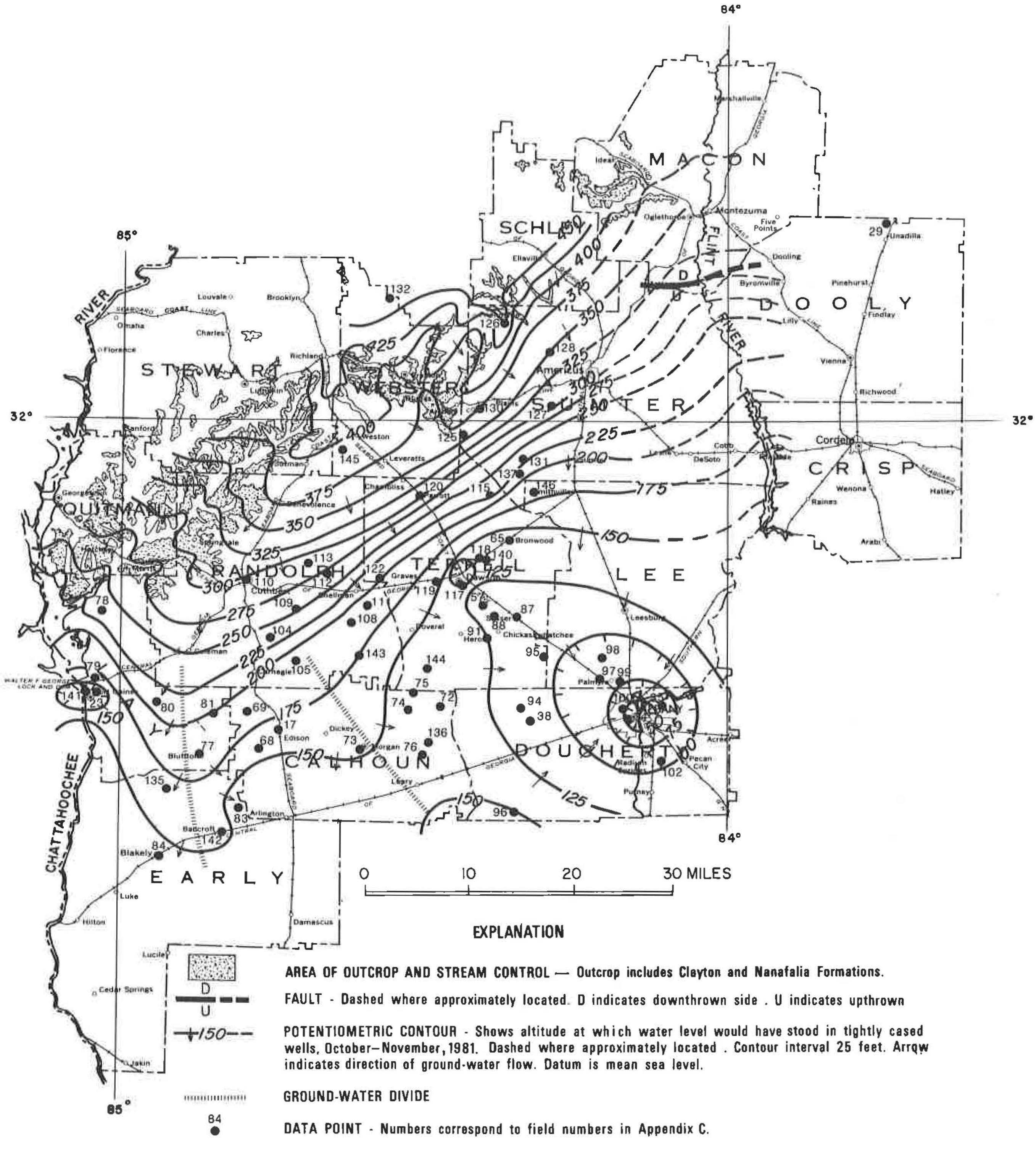


Figure 18. Potentiometric Surface of the Clayton Aquifer, October - November, 1981.

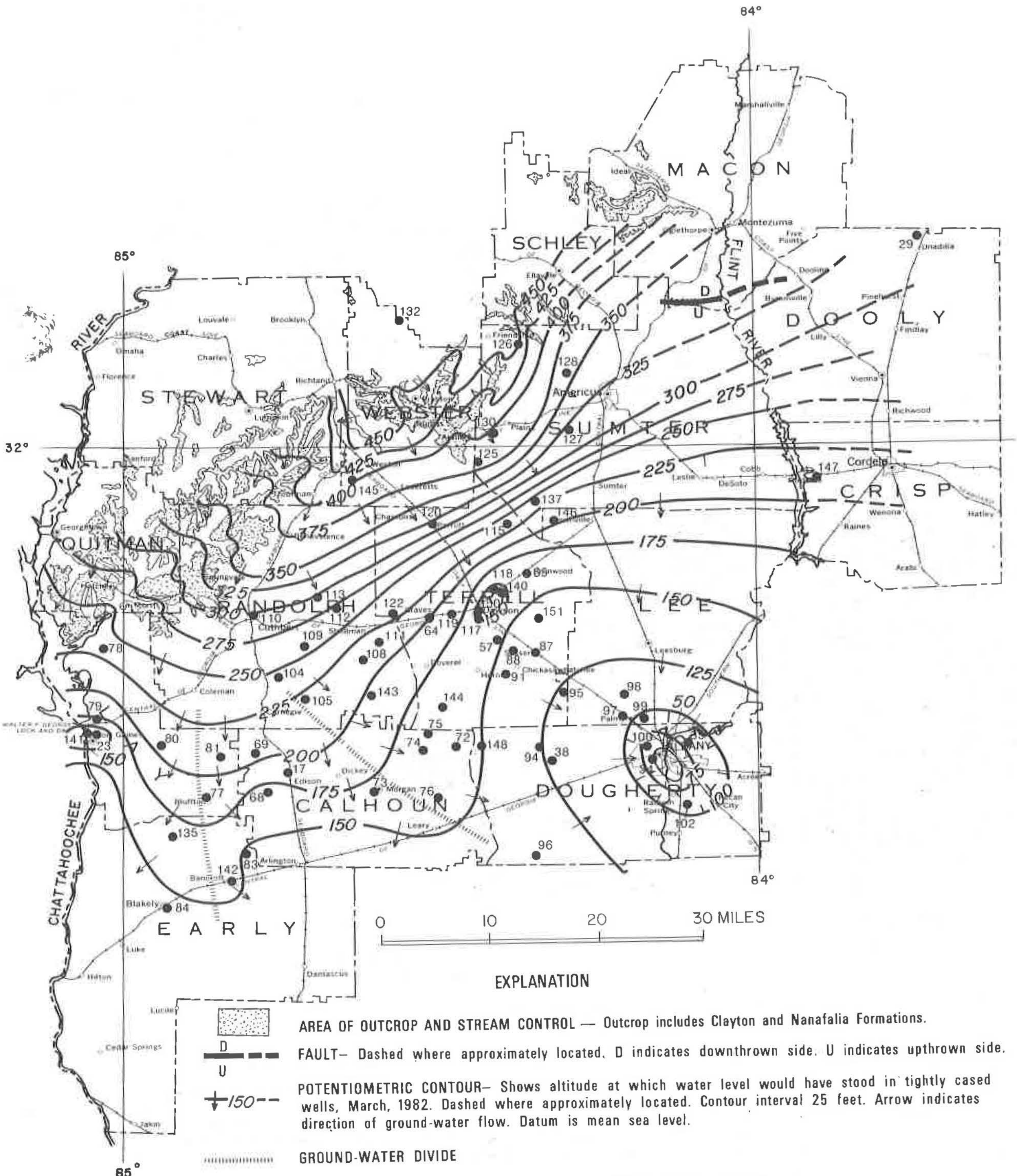
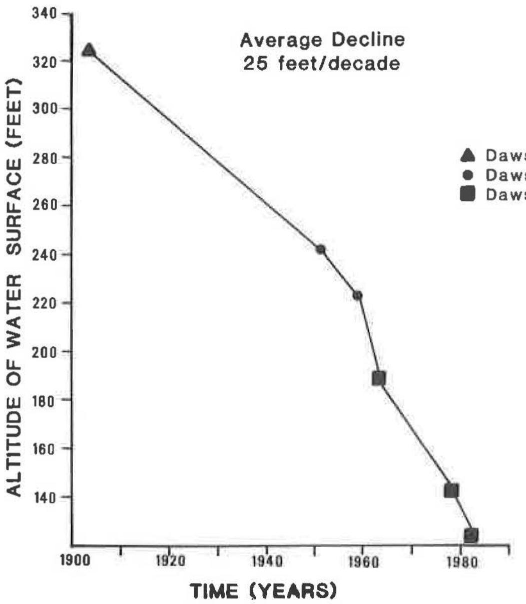
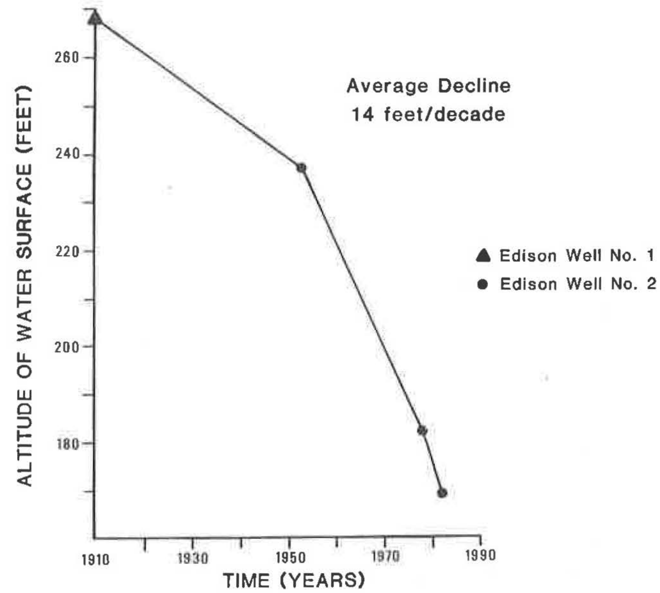


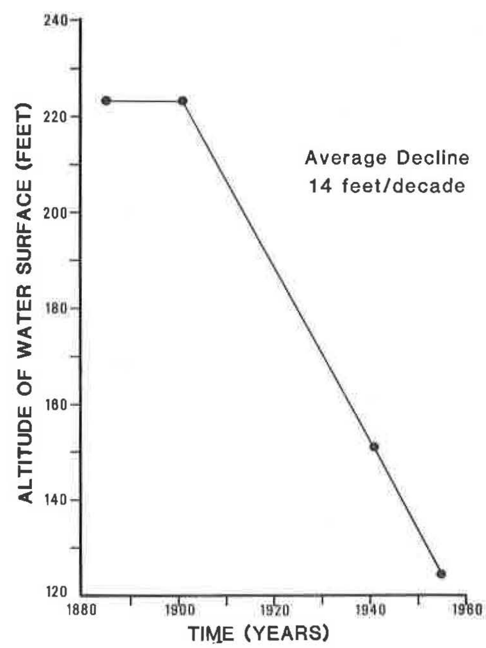
Figure 19. Potentiometric Surface of the Clayton Aquifer, March 1982.



Sources: Stevenson and Veatch, 1915; Wait, 1960 (c); U.S. Geological Survey, unpublished data.



Sources: Stevenson and Veatch, 1915; Wait, 1969 (a); Georgia Geologic Survey open-file data.



Sources: Stevenson and Veatch, 1915; Wait, 1963; U.S. Geological Survey, unpublished data.

Figure 20. Long-term Hydrographs of Clayton Aquifer Wells. a). Composite hydrograph of Dawson City wells. b). Composite hydrograph of Edison City wells. c). Hydrograph of Atlantic Ice and Coal Co. well. (Modified from Ripy and others, 1981).

local declines, the Claiborne aquifer has remained relatively stable throughout most of the study area.

Figure 21 is a map of the potentiometric surface of the Claiborne aquifer for the time period 1950-1959, when the aquifer was relatively unaffected by development. Hydraulic heads ranged from approximately 500 ft in the extreme northern section of the study area to 163 ft in Albany. The map shows the influence of surface streams on the potentiometric surface. The Claiborne aquifer crops out along many streams in the western and northern parts of the study area. Under most streamflow conditions, the aquifer discharges into these streams.

Figure 22 is a map of the potentiometric surface of the Claiborne aquifer for December, 1979. Impact on the aquifer by this date had been mostly local. The most prominent change was the cone of depression which had developed around the city of Albany due primarily to municipal withdrawals. Approximately 49 percent of withdrawals from Albany city wells in 1978 was from the Claiborne aquifer (Hicks and others, 1981). The hydraulic head in Albany City Well No. 17 was 95 ft in 1979 compared to 163 ft in 1951, a decline of 68 ft in 28 years. The only other area of significant decline from the 1950's to 1979 was near the city of Cordele, where the Claiborne aquifer is used extensively due to low yields from the Clayton aquifer. The hydraulic head in Cordele City Well No.4 was 239 ft in 1979 compared to 266 ft in 1954, a decline rate of 11 ft per decade. In most other parts of the study area, declines in the Claiborne aquifer were less than 10 ft for this time period.

Figure 23 is a map of the potentiometric surface of the Claiborne aquifer for October-November, 1981. Some of the lowest hydraulic heads measured to date were recorded in the fall of 1981. The radius of influence of the cone of depression around Albany had spread into neighboring counties. In Albany, the hydraulic head had declined to 95 ft; in Cordele it was 238 ft.

Figure 24 is the most recent potentiometric map of the Claiborne aquifer, constructed from measurements taken in March, 1982. As with the Clayton aquifer, the seasonal nature of withdrawals and its effect on water levels is illustrated. Significant increases in hydraulic head were observed throughout most of the study area in the March, 1982 measurements. However, the hydraulic head in Albany declined slightly to 93 ft. In Cordele the hydraulic head was 247 ft, up 9 ft from the previous fall. Comparison with earlier potentiometric maps again shows that throughout most of the study area the Claiborne aquifer has remained relatively stable.

SHORT-TERM POTENTIOMETRIC FLUCTUATIONS

Potentiometric levels in aquifers vary seasonally because of fluctuations in recharge and discharge. Municipal and agricultural withdrawals are greatest during the dry months of July through October. More than 25 continuously operating water-level recorders have been installed on observation wells by the U.S. Geological Survey and the Georgia Geologic Survey to monitor water-level fluctuations in the Clayton and Claiborne aquifers. Although the greatest rainfall amounts occur in spring and early summer months, this is also a period of high evapotranspiration. This limits the rainfall available for recharge to aquifers. Winter is the season when most recharge to the aquifers occurs. Rainfall events are steady and evenly distributed and evapotranspiration rates low. Fall is generally the driest season and also follows the season of greatest ground-water use. Therefore, potentiometric levels are usually highest in early spring and lowest in fall.

Clayton aquifer

Figure 25a is a hydrograph of an unused municipal well located in Cuthbert, 45 mi northwest of Albany, for the period 1972 to 1981. This hydrograph reflects both the increased seasonal fluctuation and the long-term decline in potentiometric levels due to variations in rainfall and pumpage. Potentiometric lows occur during the dry months of late summer and early fall while highs occur during the peak recharge months of winter and early spring. Since 1975, the seasonal lows have been below those of each preceding year while seasonal highs have not returned to former levels. This is due to a combination of reduced rainfall and increased withdrawals, particularly for irrigation, resulting in a net loss in aquifer storage (see Fig. 4, rainfall departure curve for Cuthbert).

Figure 25b is a hydrograph of a Clayton aquifer observation well located near the center of the Albany cone of depression. A record low hydraulic head of 63 ft was observed in August 1981. This hydrograph also shows the increased seasonal fluctuations and long-term declines.

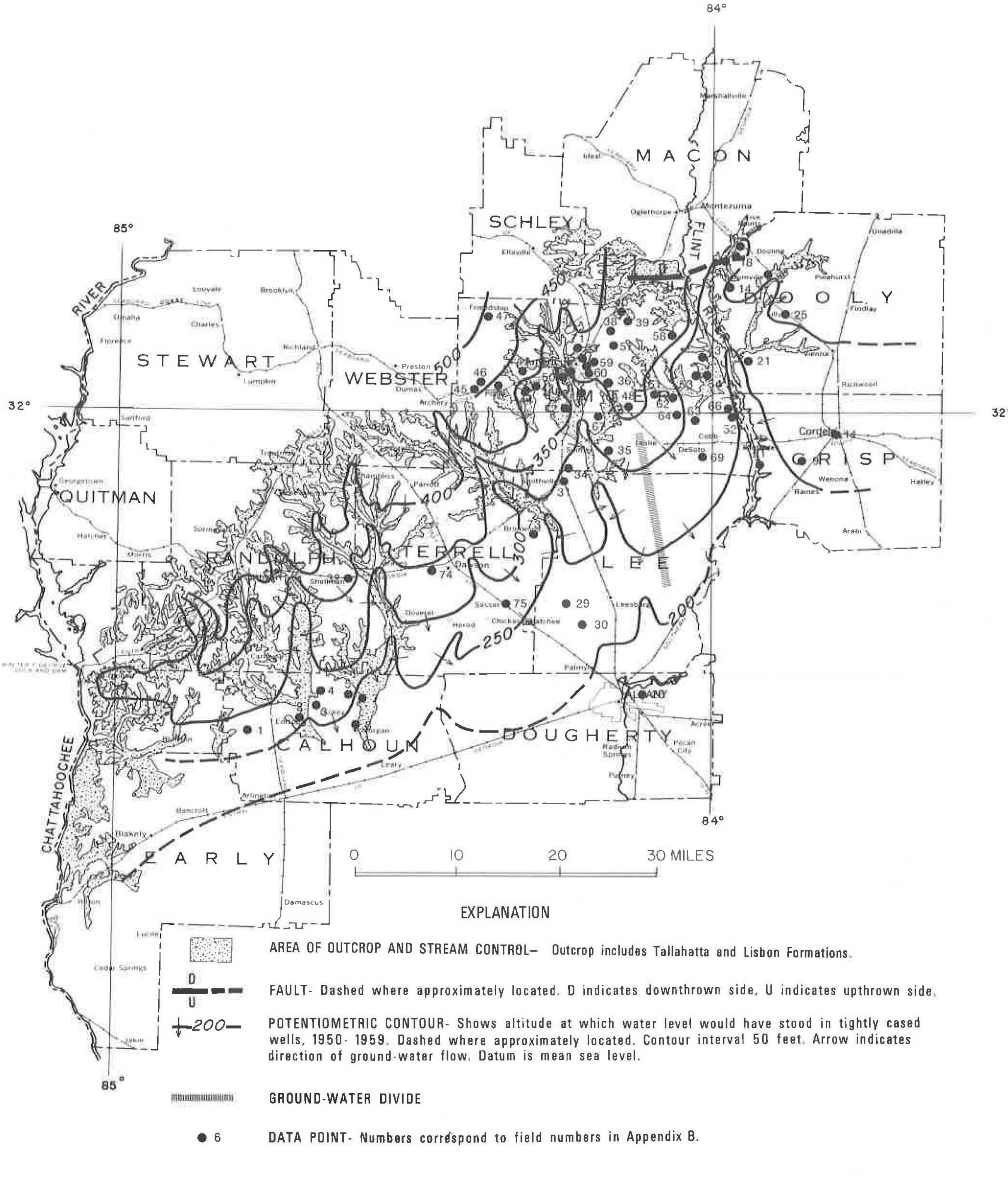


Figure 21. Potentiometric Surface of the Claiborne Aquifer, 1950-1959. (Modified from Ripy and others, 1981).

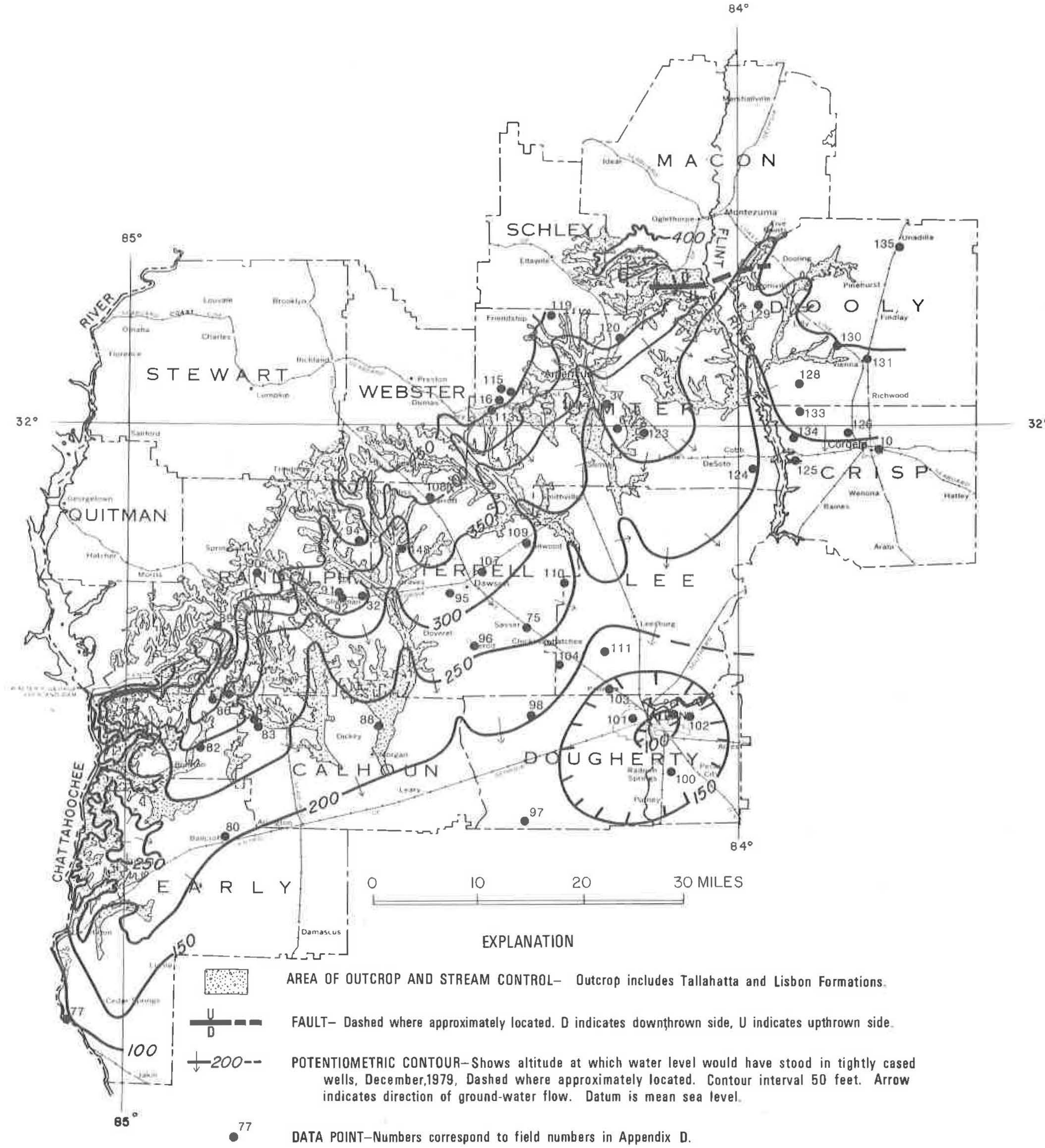


Figure 22. Potentiometric Surface of the Claiborne Aquifer, December 1979. (Modified from Ripy and others, 1981).

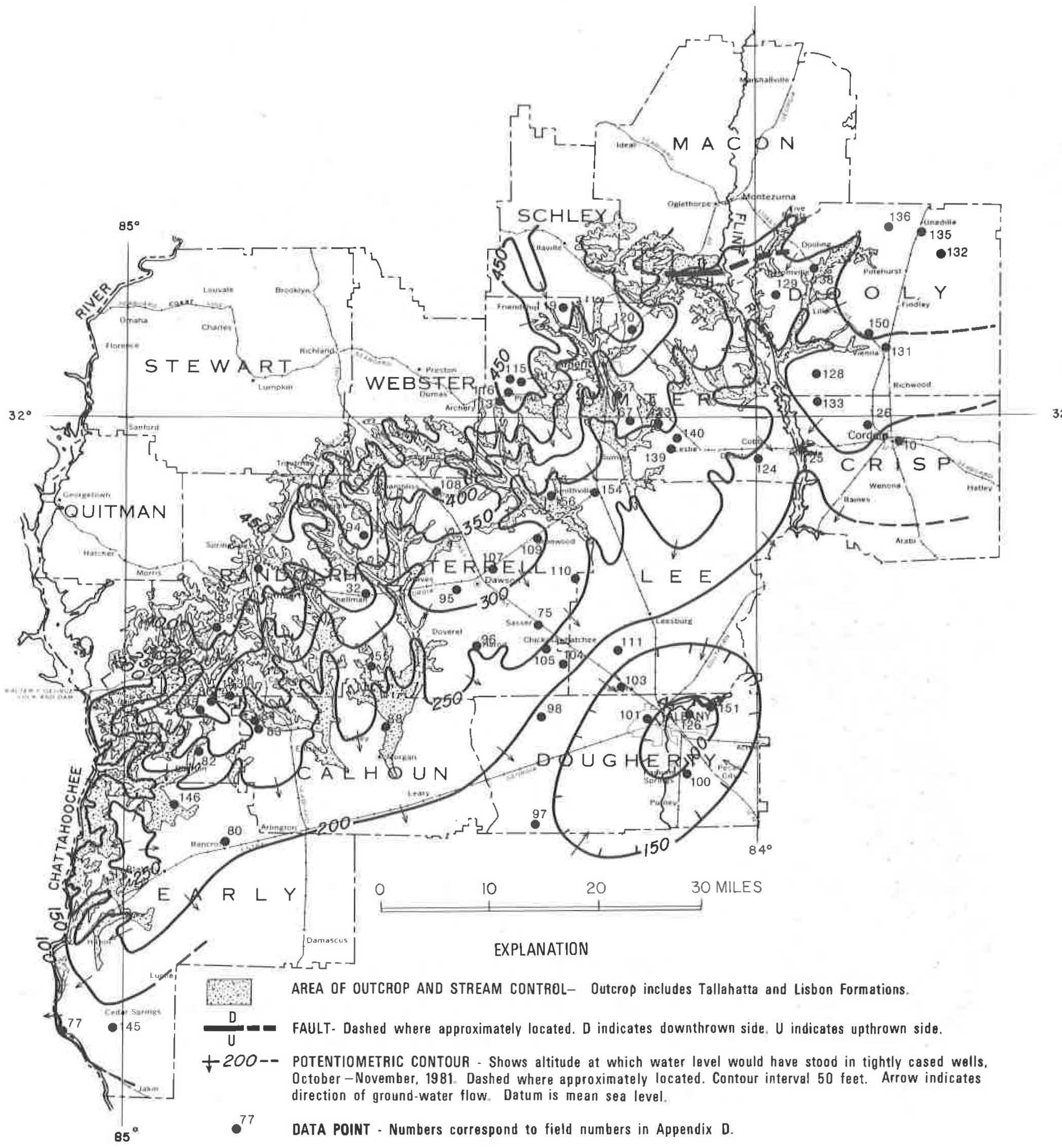


Figure 23. Potentiometric Surface of the Claiborne Aquifer, October-November, 1981.

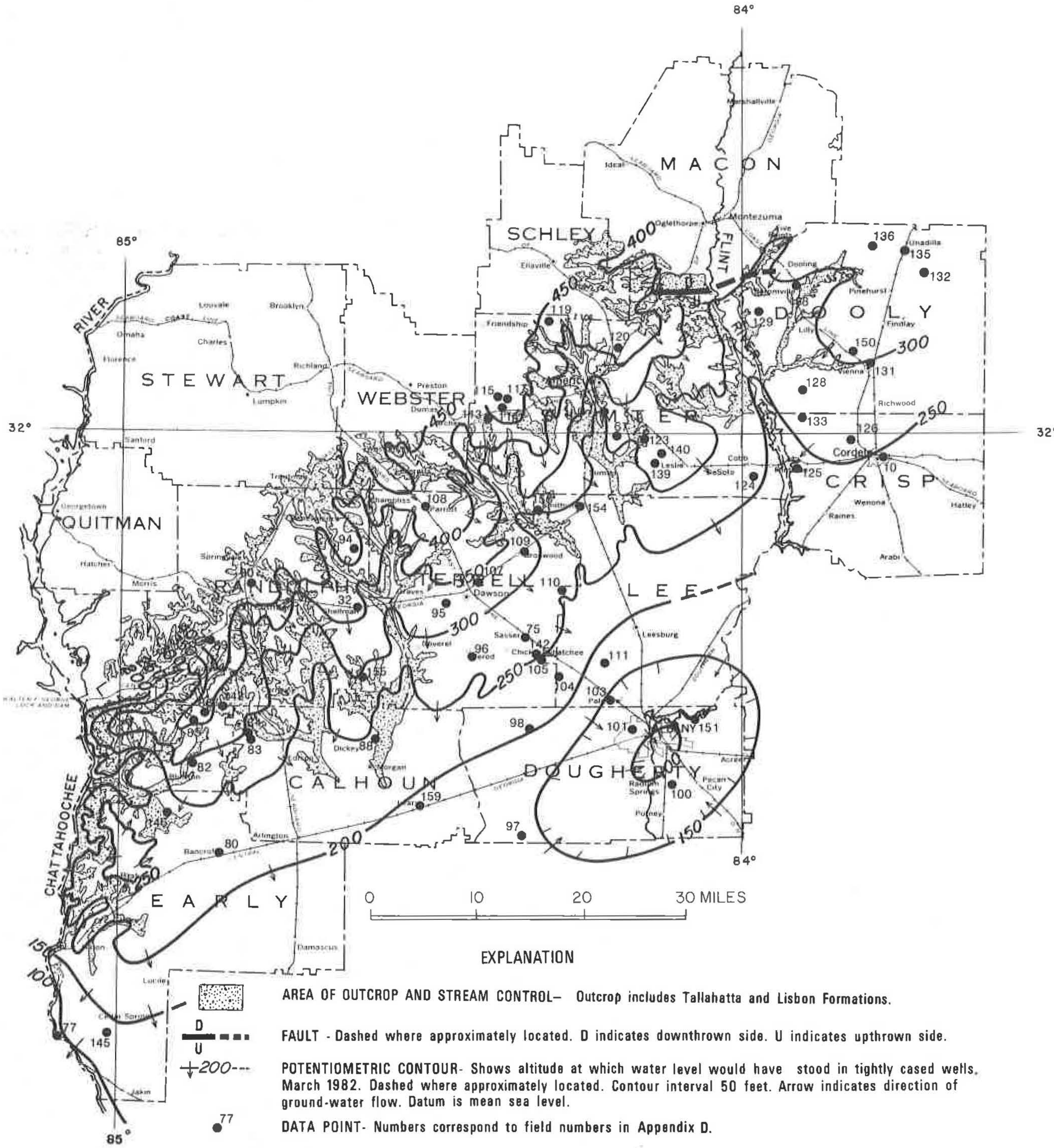


Figure 24. Potentiometric Surface of the Claiborne Aquifer, March 1982.

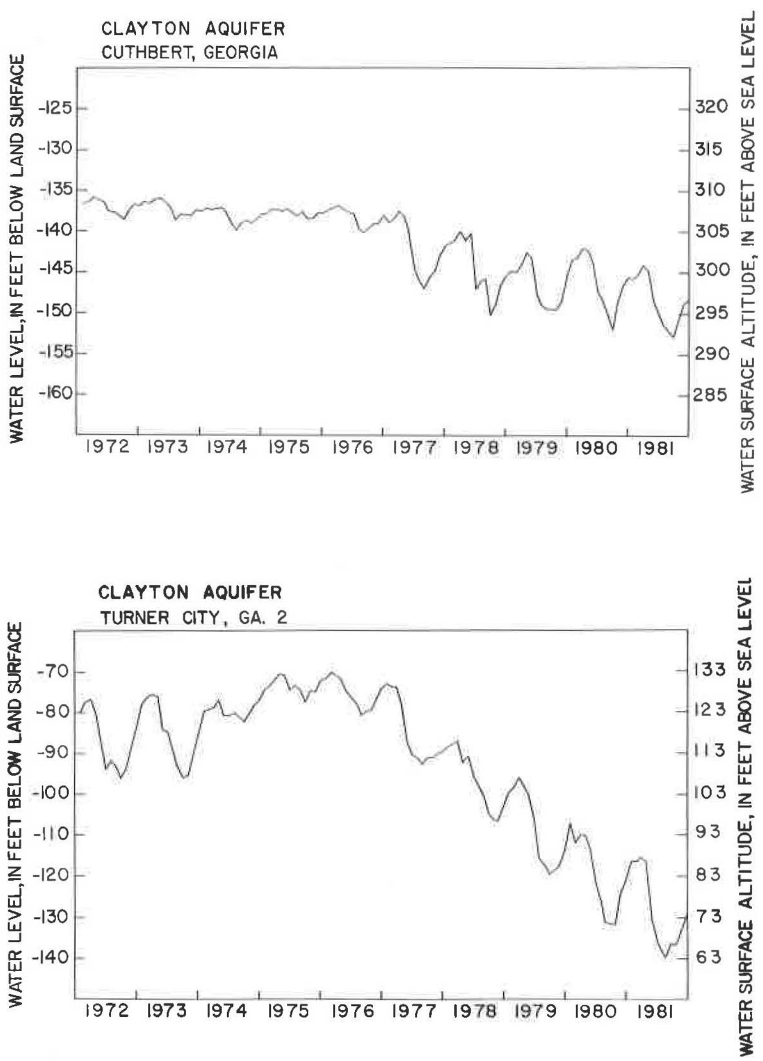


Figure 25. **Hydrographs of Clayton Aquifer Wells. a). City of Cuthbert, Randolph County. b). Turner City, Dougherty County. (Source of data U.S. Geological Survey).**

Claiborne aquifer

Prior to 1977, water levels in the Claiborne aquifer were essentially unmonitored. The U.S. Geological Survey now maintains several observation wells in and near Albany. Seasonal fluctuations of 10 to 16 ft have been observed within the Albany cone of depression. Figure 26a is a hydrograph of Test Well 2, located east of the Flint River and within the Albany cone of depression. Seasonal lows occur in the dry months of late summer and fall while seasonal highs occur in the early spring. Seasonal fluctuations vary from 7 to 16 ft; however, the period of record is too short to establish any long-term trends. Figure 26b is a hydrograph of a Claiborne aquifer well located in Kolomoki State Park in Early County. Seasonal fluctuations are 1 to 3 ft although, again, the period of record is too short to establish any long-term trends. This hydrograph illustrates the effect of below- normal rainfall at this site, which is near the outcrop of the Claiborne aquifer. Recovery of water levels was very slight during the relatively dry winter of 1980-81. Water levels then dropped sharply during the spring and summer of 1981.

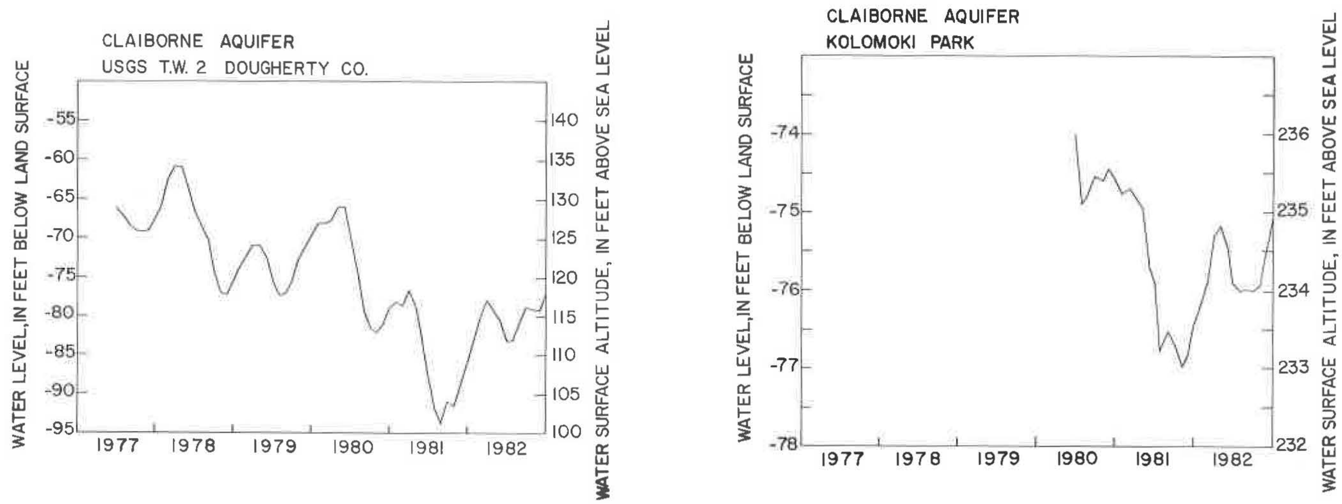


Figure 26. Hydrographs of Claiborne Aquifer Wells. a). U.S. Geological Survey TW 2, located south of Albany, Dougherty County. b). Georgia Geologic Survey test well located in Kolomoki Park, Early County.

GROUND-WATER AVAILABILITY

GENERAL

The availability of water from an aquifer is dependent on the complex interaction of many factors including volume of the aquifer, hydraulic properties, relationship to overlying and underlying aquifers and surface streams, the amount and distribution of recharge and the amount and distribution of withdrawals. While it is not possible to evaluate all these relationships in this report, the following sections will discuss some of these relationships and provide some insight into the availability of ground water from the Clayton and Claiborne aquifers.

The hydraulic properties of aquifers are quantified in terms of transmissivity and storage coefficient. Transmissivity is the rate at which water will move through a unit width of aquifer under a unit hydraulic gradient. It is, therefore, an indication of how an aquifer will transmit water and is commonly expressed in units of feet squared per day (ft^2/d). Aquifers with transmissivity values of less than 150 ft^2/d are suited only for domestic or other use not requiring high yields. Transmissivity values of 1500 ft^2/d or greater are adequate for most municipal, industrial, or agricultural purposes (Johnson, Inc., 1975, p. 102). Storage coefficient is the volume of water which an aquifer releases from storage per unit surface area of aquifer per unit change in head. It is, therefore, a measure of the quantity of usable water stored in an aquifer and is a dimensionless number. Values of this coefficient vary greatly in nature and range from 10^{-5} to 10^{-2} in confined aquifers. There is no direct relationship between storage coefficient and availability of water from an aquifer.

Another useful term in discussing ground-water availability is specific capacity. Specific capacity is defined as the rate of withdrawal (volume per unit time) per unit drop in water level in a pumping well. Specific capacity is therefore a measure of the yield of a pumping well in a given aquifer. Units are commonly gallons per minute per foot of drawdown (gpm/ft). Note that specific capacity is dependent not only on the hydraulic properties of the aquifer but also on the construction of the well. Variations in specific capacity may or may not indicate changes in the hydraulic properties of the aquifer.

CLAYTON AQUIFER

Hydraulic properties

The range and distribution of transmissivity and specific capacity within the Clayton aquifer are shown in Figure 27.[1] The transmissivity of the Clayton aquifer varies greatly in the study area. Low values (200-600 ft^2/d) occur south of Albany and east of the Flint River in Crisp and Dooly Counties. The yield of the Clayton aquifer in these areas is too low for municipal, industrial, or irrigation use. High values (5,000-12,000 ft^2/d) occur in the relatively small area of central Clay County, central and southern Randolph and Terrell Counties, and southern Lee County. Intermediate values of 1000-5000 ft^2/d are present in the Albany area west through Calhoun and northern Early Counties. The areas of greatest use of the aquifer correspond to areas of intermediate to high transmissivity. Note that the boundaries of the areas indicated in Figure 27 are indefinite. It is possible that for an individual well in any given location, transmissivities and specific capacities may differ from the range given.

The large range of transmissivity values in the Clayton aquifer is the result of several factors. Because the Clayton Formation was deposited on an erosional surface and was itself eroded after deposition, its thickness varies greatly over relatively short distances. Facies changes also occur in the Clayton Formation. East of the Flint River and south of Albany the limestone which makes up the aquifer thins and increases in clay content, greatly reducing transmissivity. In the northern part of the study area, the limestone has been partly or completely removed through solution and erosion, leaving a sandy clay residuum which also has a relatively low transmissivity. Only in the relatively small area indicated in Figure 27 as having intermediate to high (for the Clayton aquifer) transmissivity is the aquifer suitable for high-yielding wells.

Few values of storage coefficient in the Clayton aquifer have been calculated due to a lack of complete aquifer tests. An aquifer test performed on the Clayton aquifer during construction of the Walter F. George Dam near Ft. Gaines resulted in calculated storage coefficients of 2.5×10^{-3} to 2.8×10^{-5} (Stewart, 1973). At the Georgia Department of Natural Resources fish hatchery west of Dawson, an aquifer test yielded a storage coefficient of 1.3×10^{-4}. One of the test wells drilled for this study, located on the C.T. Martin farm in southeastern Randolph County, recorded the drawdown produced by a nearby irrigation well. The calculated storage coefficient from this record was 1.7×10^{-4}.

Recharge

Recharge to the Clayton aquifer occurs in the outcrop area by infiltration of rainfall and by leakage of ground water into the Clayton aquifer from other aquifers in the study area.

Recharge due to rainfall infiltration is limited for several reasons. The outcrop area of the Clayton aquifer is of limited extent. Estimating from a geologic map of the area (Georgia Geologic Survey, 1976) and cross sections (Plate 1), the outcrop area is only about 70/80 mi^2. Also, the relatively low permeability of the weathered residuum of the Clayton limestone coupled with relatively steep slopes along stream valleys where the outcrops occur results in most of the rainfall which is not evapotranspired leaving the outcrop area as surface runoff. It is possible that the outcrop areas of adjacent formations, which are confining units downdip but are sandy and relatively permeable in the updip areas, also contribute recharge to the Clayton aquifer.

A flow-net analysis of the Clayton aquifer was conducted using the 1950's potentiometric map (Fig. 16) and the transmissivity data available for the aquifer (Fig. 27). The analysis indicates that 16.6 Mgal/d flow south out of the outcrop area of the Clayton aquifer into the area of greatest use. About 1.9 Mgal/d of this flows to the Chattahoochee River, leaving only 14.7 Mgal/d effectively recharging the aquifer. The accuracy of a flow-net analysis is determined by the accuracy of the transmissivity data and the potentiometric map as well as by the assumptions inherent in the method. (See Bennett, 1962 for a more complete discussion).

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1 The transmissivities within the Clayton and Claiborne aquifers given in Figures 27 and 28 were calculated by several different methods, depending on the amount of data available. The accuracy of these methods varies; although due to the large number of variables involved, it is not possible to place numerical limits on the error. All methods involve some error, depending on the degree to which the assumptions of the method are met in nature. The reader may study the references cited on Figures 27 and 28 for a more complete discussion of the assumptions and errors of the different methods used for calculating transmissivity.

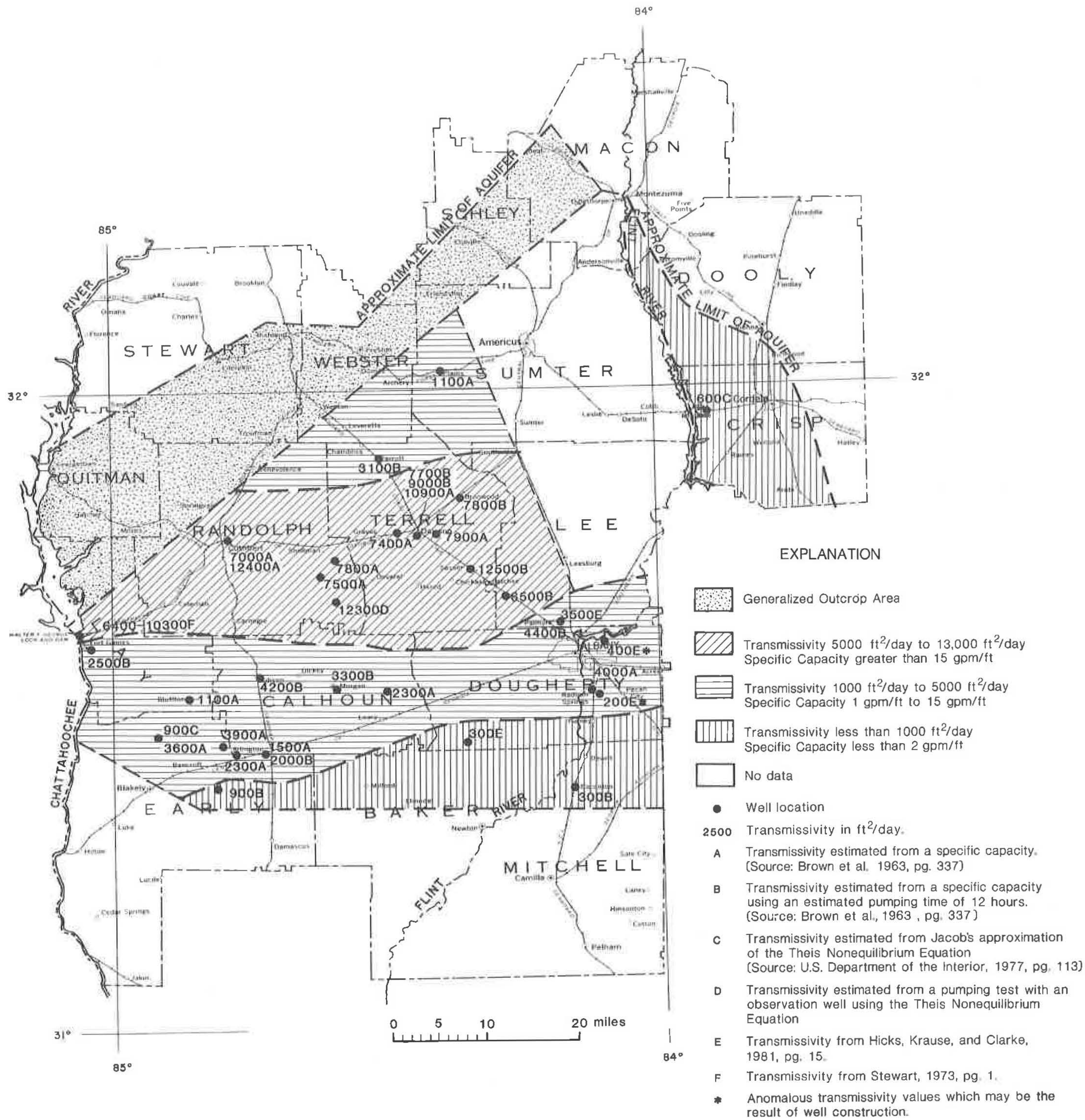

Figure 27. Transmissivity of the Clayton Aquifer.

Recharge to the Clayton aquifer may also occur from other aquifers in the study area. Where potentiometric heads of other aquifers are higher than those of the Clayton aquifer, water can move from the other aquifers into the Clayton aquifer if some pathway exists. This can occur through leaky confining units, improperly constructed wells, or multiaquifer wells which are not pumping. Potentiometric head relationships are such that leakage to the Clayton aquifer from the Principal Artesian, Claiborne, and Providence Sand aquifers is possible. However, the Principal Artesian and Claiborne aquifers are effectively confined from the Clayton aquifer and it is unlikely that any significant amount of leakage occurs. The confining unit separating the Clayton and Providence Sand aquifers, on the other hand, may permit significant amounts of ground water to move from the Providence Sand into the Clayton aquifer. As mentioned previously, some water quality data suggest that leakage occurs (page 12). The amount of this leakage is not known.

Leakage through idle multiaquifer wells has been documented in the Albany area. Hicks and others (1981, p. 20) estimated that 1.1 Mgal/d flows from the Claiborne and Providence Sand aquifers into the Clayton aquifer through idle multiaquifer wells in the Albany area. Added to the 14.7 Mgal/d from rainfall infiltration, the known recharge to the Clayton aquifer is at least 15.8 Mgal/d.

Analysis of ground-water availability

The area in which the Clayton aquifer is productive is relatively small and has been extensively developed for municipal and irrigation use. Withdrawals total about 26 Mgal/d, probably a conservative number, while known recharge to the aquifer is only about 15.8 Mgal/d. Although leakage to the Clayton aquifer from the Providence Sand aquifer may be significant, it is still probable that withdrawals from the Clayton aquifer exceed recharge. This explains the rapidly declining potentiometric surface in the Clayton aquifer illustrated by hydrographs and potentiometric maps. The highest concentration of withdrawals from the Clayton Aquifer, the Albany area, is located at the extreme southeastern edge of the productive area of the aquifer. Albany also is removed from recharge from the outcrop area because the most direct line of recharge, through northern Terrell and southern Webster Counties, is restricted by relatively low transmissivities. The elongate cone of depression centered at Albany is the result not only of Albany's large withdrawals, but of higher transmissivities and large irrigation withdrawals in the more productive area of the Clayton aquifer to the northwest of Albany.

It is not possible at this time to predict the future of the Clayton aquifer. Future rainfall and growth in ground-water use are not known and, as the aquifers in the study area are further developed, potentiometric relationships may change to either increase or decrease the amount of leakage to the Clayton aquifer. However, it is unlikely that the long-term declines in water levels will cease. Declines in potentiometric levels can be expected to cause problems of reduction in well yields while pumping costs increase. Users in some areas may find it necessary to reset pumps, increase the depth of existing wells, or drill new wells.

CLAIBORNE AQUIFER

Hydraulic properties

The range and distribution of transmissivity within the Claiborne aquifer are shown in Figure 28. Ranges of specific capacity also are indicated. Transmissivity in the Claiborne aquifer is more evenly distributed than in the Clayton aquifer, although significant variations can be seen. Transmissivity values throughout most of the study area are in the 2000-6000 ft^2/d range. In Albany, the range is 2800-6000 ft^2/d. Highest values occur east of the Flint River in Crisp and Dooly Counties, where transmissivity values in excess of 10,000 ft^2/d have been calculated. The Claiborne aquifer is widely used in these two counties to supply municipal and irrigation wells. For a large part of the study area little or no data are available. Note that the boundaries indicated in Figure 28 are indefinite. It is possible that for an individual well in a given location transmissivities and specific capacities may differ from the range given.

The uniform distribution of transmissivity in the Claiborne aquifer when compared to the Clayton aquifer is the result of a more uniform thickness and lithology. The thickness of the Claiborne aquifer does not vary as greatly over short distances as that of the Clayton aquifer. East of the Flint River in Crisp and Dooly Counties, the saturated, permeable thickness of sand units within the Claiborne aquifer increases to over 100 ft. Transmissivity and well yields in-

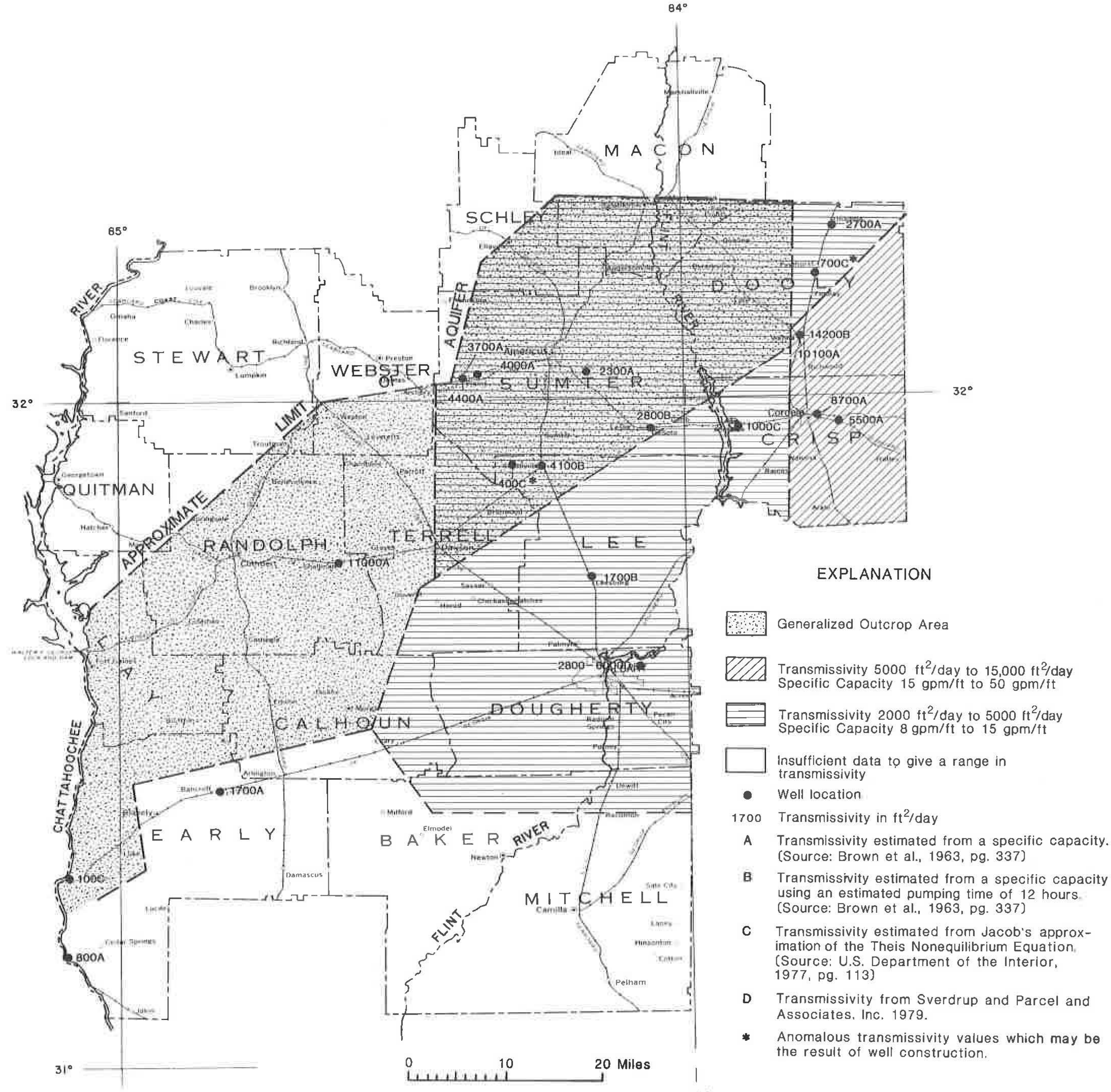

Figure 28. Transmissivity of the Claiborne Aquifer.

crease in the same area. Throughout most of the study area, it is possible that properly constructed wells can be relatively high-yielding (several hundred to 1000-2000 gpm), although large drawdowns are to be expected.

The value of storage coefficient in the Claiborne aquifer is known in only two locations. An aquifer test at the Miller Brewing Company plant in Albany resulted in storage coefficients calculated in the range of 2.84×10^{-4} to 1.12×10^{-3} (data from Severdrup, Parcel and Associates, 1979). During construction of the Columbia lock and dam on the Chattahoochee River in Early County, an aquifer test resulted in storage coefficients within the range of 4.3×10^{-4} to 9.9×10^{-4}.

Recharge

Recharge to the Claiborne aquifer occurs mostly as infiltration of rainfall in areas of outcrop. The area of outcrop of the Claiborne aquifer has been estimated from a geologic map of the area (Georgia Geologic Survey, 1976) and cross sections (Plate 2) to be about 350 mi^2. U.S. Geological Survey computer models of aquifers near this area indicate that of the 48 to 52 in. of annual rainfall, 30 to 35 in. are lost through evapotranspiration while about 12 in. go to the runoff of surface streams. This leaves approximately 6 to 8 in. of rainfall annually to recharge the aquifer (L.R. Hayes, U.S. Geological Survey, oral communication, 1982). In the case of the Claiborne aquifer, this would amount to an average recharge of 100-133 Mgal/d. Note that this is a very rough estimate.

Recharge to the Claiborne aquifer also may occur from other aquifers in the study area when potentiometric head relationships are favorable and pathways exist. It is possible that significant quantities of water are moving from the Principal Artesian Aquifer to the Claiborne aquifer in this manner, particularly in the Albany area where the potentiometric head difference between these two aquifers has been increased by heavy use of the Claiborne aquifer. Hicks and others (1981) have cited water quality evidence indicating possible leakage from the Principal Artesian Aquifer to the Claiborne aquifer in the Albany area. The amount of this leakage is not known, although it is probably not large when compared to recharge through infiltration of rainfall. The Principal Artesian Aquifer does not extend over exactly the same area as the Claiborne aquifer and only in the Albany area are head differences highly favorable to leakage.

Analysis of ground-water availability

Ground water is distributed more uniformly in the Claiborne aquifer than in the Clayton aquifer. Although a conservative estimate of ground-water withdrawals from the Claiborne aquifer in the study area is 36 Mgal/d, this estimate is still only about one-third to one-quarter of the estimated recharge of 100-133 Mgal/d. However, the hydraulic properties of the aquifer are such that large withdrawals concentrated in relatively small areas can be expected to cause locally severe potentiometric declines, as can be seen on the recent potentiometric maps in the Albany area.

Before extensive development, it is probable that a large part of the 100-133 Mgal/d recharge to the Claiborne aquifer supported the base flow of the many streams in the study area along which the aquifer crops out. If the 7-day, 10-year recurrence-interval minimum stream flow is taken as an estimate of base flow (Thomson and Carter, 1963; Carter and Putman, 1978), then the estimated discharge of the Claiborne aquifer into surface streams in the study area is an average 45 to 68 Mgal/d. In the undeveloped aquifer, the rest of the recharge either leaked to other aquifers or flowed out of the study area. It is therefore possible that development of the aquifer could adversely affect the base flow of streams in the study area. Potentiometric heads of the aquifer in the outcrop area have thus far remained stable, as this is not the most heavily developed area of the aquifer. Potentiometric heads are stabilized by rapid recharge from rainfall infiltration and the effect of the streams themselves. However, if potentiometric levels in the Claiborne aquifer are lowered through withdrawals, base flow of streams could be reduced.

This study indicates that the Claiborne aqu fer can sustain current withdrawals and possibly sustain even greater withdrawals if they were evenly distributed throughout the aquifer. The Claiborne aquifer has the advantage of uniform distribution of hydraulic properties and rapid recharge from a relatively large outcrop area. Large withdrawals concentrated into small areas can be expected to cause rapidly declining potentiometric levels (and the associated problems) and reduced aquifer discharge to surface streams.

SUMMARY AND RECOMMENDATIONS

CLAYTON AQUIFER

The Clayton aquifer consists mostly of saturated limestone which makes up the middle unit of the Clayton Formation. The aquifer dips southeast in the study area. Because of the erosional nature of the upper and lower contacts of the formation, the thickness of the aquifer varies greatly over relatively short distances.

The Clayton aquifer is used extensively in the study area for municipal, industrial, and agricultural ground-water supplies. Water use in these three categories has increased in recent years, but the most dramatic increases have been for irrigation. Total water use from the Clayton aquifer is estimated to be 26 Mgal/d.

Severe potentiometric declines have occurred in the Clayton aquifer. A cone of depression has formed around Albany, where the potentiometric head has declined about 170 ft since 1885. The rate of decline has increased since the 1950's and the Albany cone of depression has spread into nearby counties.

The area in which the hydraulic properties of the Clayton aquifer will support large withdrawals is relatively small. In addition, recharge to the Clayton aquifer from rainfall infiltration is restricted for several reasons, and is estimated to average only about 14.7 Mgal/d. While recharge from other sources, particularly leakage from the underlying Providence aquifer, may be significant, it is apparent that withdrawals from the Clayton aquifer exceed recharge. In light of this condition and the distribution of hydraulic properties, the rapid potentiometric declines which have occurred in the past in the Clayton aquifer can be expected to continue in the future. The rate of this decline will depend on several factors, the combined effects of which are not known.

CLAIBORNE AQUIFER

The Claiborne aquifer consists mostly of saturated sands and sandy limestones within the Claiborne Group and the Hatchetigbee Formation. The aquifer dips to the southeast in the study area and generally thickens to the south and southeast.

Within the study area, the Claiborne aquifer is used for municipal, industrial, agricultural, and domestic ground-water supplies. Use of the Claiborne aquifer for irrigation is limited mostly to areas where yields from the Clayton aquifer are insufficient for irrigation wells. Total water use from the Claiborne aquifer is estimated to be 36 Mgal/d.

Potentiometric declines in the Claiborne aquifer are less widespread than in the Clayton aquifer, and are due mostly to local municipal, industrial, and agricultural withdrawals. The hydraulic head dropped 70 ft in Albany and 28 ft in Cordele from the 1950's to 1981. Declines throughout the rest of the study area have been small, but have increased in recent years.

Hydraulic properties of the Claiborne aquifer are more evenly distributed than in the Clayton aquifer. However, large withdrawals concentrated in small areas can be expected to cause large potentiometric declines. Recharge to the Claiborne aquifer from rainfall infiltration is well distributed throughout the study area and is estimated to average 100-133 Mgal/d, far in excess of current withdrawals. The Claiborne aquifer is able to sustain current withdrawals; however, significant potentiometric declines could adversely affect stream base flow.

RECOMMENDATIONS

Declining potentiometric levels in the Clayton and Claiborne aquifers have already caused some of the problems listed below. These problems can be expected to continue or worsen, while others listed may arise, if potentiometric levels continue to decline.

(1) Well yields may be reduced and pumping costs increased.

(2) Shallow wells may go dry, requiring that the well be drilled deeper or a new well be drilled.

(3) Ground-water levels may drop below the level of pumps, necessitating the expense of resetting pumps or possibly causing damage to the pumps.

(4) Wells may collapse if water levels drop below the well casing.

(5) Ground-water levels may be reduced to a depth at which it will no longer be economical to pump the water.

(6) Flow in some streams and springs may be reduced or cease altogether.

It is apparent that, although the ground-water resources in the study area are adequate to sustain current withdrawals and provide for some future growth, no single aquifer in the study area can supply all the ground water needed. In order to make the best use of the ground-water resources available in the study area, the following recommendations are made.

(1) The use of multiaquifer construction should be encouraged for municipal, industrial, and irrigation wells requiring high yields. This will increase well yields and reduce the impact on each aquifer. Multiaquifer wells may include any advantageous combination of the aquifers in the study area (Principal Artesian, Clayton, Claiborne, and Providence) where they are productive and where water quality problems are not a possibility. These wells would relieve some of the stress on the most heavily impacted aquifer, the Clayton, and may also serve as points of recharge to the Clayton aquifer.

(2) Construction of new high-yielding wells should avoid concentrating heavy ground-water demand in relatively small areas, particularly if these wells would be producing from the same aquifer.

(3) Long-range ground-water monitoring is recommended so that effects of future development of the Clayton and Claiborne aquifers can be evaluated continuously. The test wells equipped with continuous water-level recorders which were constructed for this project will serve part of this function.

(4) Maintain records of water use. Evaluation of the ground-water resources of this or any area is not possible without accurate, up-to-date knowledge of the distribution and amount of ground-water withdrawals.

(5) Assess the possibility of using deeper Cretaceous aquifers as possible future sources of ground water in the area. Developing deeper aquifers may have a detrimental effect on the quality of water from shallower aquifers.

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APPENDICES

The latitude, longitude, land surface elevation, total depth, casing depth, static water level, and date measured in Appendices A through D are from the following list of references:

a. Herrick (1961)
b. Water Supply Section, Environmental Protection Division Georgia Deparment of Natural Resources
c. Georgia Geologic Survey open-file data
d. U.S. Geological Survey unpublished data
e. Owen (1963)
f. Wait (1957), (1958), (1960a)
g. Stephenson and Veatch (1915)
h. U.S. Army Corps of Engineers (1956)
i. Land surface elevations from U.S. Geological Survey 7 1/2 - minute topographic map series
j. McCallie (1908)

The same alphabet symbol will be used in Appendices A through D.

GC No. is a field number assigned to a well by Mr. George W. Chase. GGS is an abbreviation for Georgia Geologic Survey.

Many of the data points used in A and B were field located by Mr. George W. Chase and Mr. Robert L. Wait while working for the U.S. Geological Survey. The data points were located on Georgia Department of Transportation county road maps or located on a grid system on a field inventory form. Locations of those wells checked are accurate.

Locations of wells in Appendices C and D have been field checked by personnel from the Georgia Geologic Survey and/or the U.S. Geological Survey.

APPENDIX A - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAYTON AQUIFER (1950-1959)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (feet below land surface)	DATE MEASURED
4	John Fort			Dougherty	Holt	31°31'53" - 84°24'42"	220	547d		- 27d	1957
6	Atlantic Ice & Coal			Dougherty	Albany W.	31°35'08" - 84°09'03"	197	710d		- 64d	1957
16	Morgan #1	331		Calhoun	Morgan	31°32'21" - 84°36'00"	245a	667a	485d	- 6d	1952
17	Edison #2	353		Calhoun	Edison	31°33'34" - 84°44'15"	289d	515d	395f	- 53f	1953
18	Arlington #2	330		Calhoun	Arlington	31°26'22" - 84°43'37"	306d	757d	600b	-103d	1953
20	J.D. Cowarts			Calhoun	Edison	31°37'01" - 84°38'52"	319	430d		- 20d	1959
21	Harvey Jordan			Calhoun	Leary	31°29'32" - 84°32'40"	220	500d		-.28d	1959
23	Speight School	402		Clay	Ft Gaines	31°36'37" - 85°02'06"	390	500a	340c	-250d	1954
24	W.F. George Dam TW 2			Clay	Ft. Gaines N.E.	31°37'33" - 85°03'48"	145	75h		- 25h	1954
25	H.B. Hightower	464		Clay	Bluffton	31°35'08" - 84°50'30"	410	555d	436d	-169d	1955
26	Fort Gaines	435		Clay	Ft. Gaines	31°36'29" - 85°02'25"	400	455a	313c	-266d	1955
27	E.R. Gray			Clay	Ft. Gaines N.E.	31°37'33" - 85°02'43"	160	130d		- 18d	1956
28	J.R. Carroll		124	Dooly	Drayton	32°06'07" - 83°56'43"	300	320d		- 13d	1951
29	W.S. Stuckey	305	164	Dooly	Unadilla	32°17'03" - 83°44'38"	412	408d	373d	- 80d	1951
33	Lilly		155	Dooly	Byromville	32°08'33" - 83°52'43"	352	350d	300d	- 42d	1951
34	Va. - Carolina Chemical Co.			Dougherty	Albany W.	31°34'48" - 84°10'06"	197	594d		-105d	1955
35	Turner City #2			Dougherty	Albany E.	31°35'53" - 84°06'26"	213	760f	713f	- 43f	1953
38	E.R. Graham			Dougherty	Pretoria	31°34'28" - 84°19'26"	222	650d		- 25d	1957
39	Kolomoki CCC			Early	Blakely N.	31°27'44" - 84°55'37"	270	548d	505	- 85d	1951
40	Cuthbert #3	552		Randolph	Cuthbert	31°46'08" - 84°47'43"	445	350d		-135d	1958
41	Co. Prison Farm			Randolph	Cuthbert	31°47'37" - 84°45'21"	477	329c	270c	-146d	1951
42	Rock of Ages	281	187	Sumter	Americus	32°02'48" - 84°13'28"	391	190c	180c	- 77d	1952
43	D.A. Carrison	247		Sumter	Americus	32°02'17" - 84°09'27"	395	312d		- 70d	1951
45	C.E. Reeves		16	Sumter	Andersonville	32°07'38" - 84°09'17"	429	210d		- 69d	1953
46	Henry Williams		72	Sumter	Smithville W.	31°56'07" - 84°15'35"	331	357c	320c	- 34.8d	1951
47	R.D. McNeill		100	Sumter	Americus	32°05'18" - 84°10'33"	474	297d		-119d	1951
48	Olive Woodruff		101	Sumter	Americus	32°05'08" - 84°10'37"	461	300d		-120d	1951
49	V.R. Murphy		106	Sumter	Americus	32°04'43" - 84°08'32"	422	332d		- 91d	1951
50	Geo. L. Mathews		109	Sumter	Methvins	32°05'53" - 84°04'12"	424	318d		- 59d	1951
51	G.B. Howard		116	Sumter	Americus	32°04'13" - 84°11'18"	425	180d		- 99d	1951
52	Peter Bahnsen		137	Sumter	Americus	32°02'55" - 84°13'13"	394	175d		- 89d	1951
53	Ford Reddick		141	Sumter	Smithville E.	31°59'02" - 84°12'50"	350	300d		- 39.5d	1951
55	T.J. Suggs		98	Sumter	Smithville W.	31°55'46" - 84°18'23"	385	337d		- 59.7d	1951
57	Brown's Dairy			Terrell	Chickasawhatchee	31°44'11" - 84°24'23"	315	496d		- 95d	1956
58	Terrell Co. Grain & Elev.			Terrell	Dawson	31°45'55" - 84°25'12"	330	445c	391c	-103c	1959
60	Mathew Williams	407		Terrell	Dawson	31°46'15" - 84°26'07"	345	434a		-140c	1954
61	Circle J. Ranch	710		Terrell	Dawson	*31°46'32" - 84°24'33"	330	470c		-125c	1959
62	Stevens Ind.	352		Terrell	Dawson	31°46'58" - 84°26'54"	342	433c	334c	-116c	1953
64	Graves School	350		Terrell	Shellman	31°46'08" - 84°31'07"	351	433d		- 83c	1953
66	Julian Lay	614		Terrell	Chickasawhatchee	31°43'04" - 84°25'36"	341	494d	440c	-127d	1958
67	Steve Cocke F.H. #1	503		Terrell	Dawson	31°46'18" - 83°28'50"	388	597d	369	-127d	1950
139	Dawson #3	213		Terrell	Dawson	31°46'52" - 84°26'47"	349	475d	345f	-124.9f	1950

* Well location may not be accurate

Appendix B. - Well Data for the Potentiometric Surface of the Claiborne Aquifer (1950-1959)

(Land surface elevations are from U.S. Geological Survey 7 1/2 -minute topographic map series, except as indicated).

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (feet below land surface)	DATE MEASURED
1	A.J. Eubanks			Calhoun	Bluffton	31°32'13" - 84°46'52"	330	175d		- 35.07d	1959
2	Raymond Bonner			Calhoun	Edison	31°33'27" - 84°42'01"	283	260d		- 15.53d	1959
3	B.R. Bailey			Calhoun	Edison	31°34'23" - 84°40'12"	302	200d		- 51.08d	1959
4	J.R. Durr			Calhoun	Edison	31°35'08" - 84°39'22"	295	114d		- 20d	1959
5	Ed Chaney			Calhoun	Morgan	31°35'49" - 84°36'21"	285	100d		- 8.3	1959
6	J.A. Calhoun			Calhoun	Morgan	31°33'18" - 84°36'13"	254	140d		- 10d	1959
7	Tom Sinquefield			Calhoun	Morgan	31°34'52" - 84°35'18"	270	159d		- 25d	1959
9	R.M. McKinney		51	Crisp	Cordele	31°55'44" - 83°50'29"	294	315d		- 32.5d(avg.)	1950
11	Cordele #2		168	Crisp	Cordele	31°58'13" - 83°47'10"	303	396d	180d	- 18d	1952
14	C.C. Raper		108	Dooly	Byromville	32°11'07" - 83°59'27"	320	38d		- 18d	1951
17	J.D. Lester		111	Dooly	Byromville	32°13'12" - 83°58'19"	360	100d		- 84.3d	1951
18	J.D. Lester		112	Dooly	Byromville	32°13'36" - 83°57'49"	382	105d		- 84d	1951
19	J.D. Lester		113	Dooly	Byromville	32°13'59" - 83°57'33"	362	98d		- 85.4d	1951
21	M.T. Brown		127	Dooly	Drayton	32°04'27" - 83°57'18"	298	65d		- 20d	1951
23	Byromville		146	Dooly	Byromville	32°12'14" - 83°54'30"	380	150d	100d	- 50d	1951
25	Tex Summerford		156	Dooly	Byromville	32°08'55" - 83°52'45"	346	260d	140d	- 30d	1951
26	Albany #17			Dougherty	Albany E.	31°35'55" - 84°06'26"	208d	700d		- 45d	1951
29	H.N. Smith			Lee	Sasser	31°43'19" - 84°15'13"	250d	300d		- 20d	1951
30	Haley Bros. Farm			Lee	Leesburg	31°41'17" - 84°13'07"	245d	300d		- 12d	1945
31	Smithville			Lee	Smithville W.	31°54'14" - 84°15'07"	326	180e	170e	- 33e	1950
32	City of Shellman #2			Randolph	Shellman	31°45'31" - 84°36'58"	393	135c		- 33b	1949
33	W. Perry		50	Sumter	Americus	32°03'33" - 84°12'16"	403	65d		- 49d	1950
34	M. Shakleford	335	229	Sumter	Smithville W.	31°55'04" - 84°15'14"	313	110d		- 17c	1953
35	A.A. Ellis #2	284	189	Sumter	Smithville E.	31°56'24" - 84°10'46"	334	100d		- 27.9d	1952
36	J. Deriso	326	222	Sumter	Americus	32°02'17" - 84°10'31"	395	80d	50d	- 30.2d	1952
37	F. Waltsman #1	282	188	Sumter	Americus	32°01'48" - 84°13'05"	373	129d	106d	- 49d	1952
38	E.N. Grant		14	Sumter	Americus	32°07'12" - 84°09'47"	423	75d		- 31.7d	1950
39	Tharpe Grant		19	Sumter	Andersonville	32°07'59" - 84°08'59"	446	114c		- 79.6c	1950
40	Alex Harden		21	Sumter	Andersonville	32°08'10" - 84°08'49"	449	97d		- 66.68d	1950
41	W.W. Revell		22	Sumter	Lake Collins	32°03'19" - 84°19'16"	472	78d		- 39.2d	1950

Appendix B. - Well Data for the Potentiometric Surface of the Claiborne Aquifer (1950-1959)

(Continued)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (feet below land surface)	DATE MEASURED
42	Claude Harvey		25	Sumter	Lake Collins	32°02'30" - 84°17'58"	451	103d		- 59.23d	1950
43	Brown Small #1		218	Sumter	Methvins	32°04'03" - 84°00'39"	304	220d	200d	- 40d	1952
44	M. Turner		27	Sumter	Lake Collins	32°02'28" - 84°18'22"	434	86d		- 43.4d	1950
45	Thad Jones		30	Sumter	Plains	32°02'05" - 84°24'10"	505	65d		- 40d	1950
46	Dave Murray		32	Sumter	Plains	32°03'00" - 84°23'25"	506	63d		- 45d	1950
47	M.H. Grant		47	Sumter	Draneville	32°08'30" - 84°23'13"	548	75d		- 49.3d	1950
48	Pleasant Grove Church		76	Sumter	Americus	32°01'00" - 84°08'21"	369	132d		- 14.7d	1951
49	W.L. Dupris		51	Sumter	Americus	32°03'33" - 84°12'23"	398	64d		- 51d	1950
50	H.T. Williams		56	Sumter	Lake Collins	32°02'55" - 84°16'26"	469	135d		-129.3d	1950
51	John Ferguson		62	Sumter	Cobb	*31°55'53" - 84°55'54"	250±10	260d		- 11.85d	1951
52	J.B. Dorsey		66	Sumter	Drayton	32°00'01" - 83°57'15"	245	184c		+ 5.6d	1950
53	F.S. Sheppard		69	Sumter	Methvins	32°03'00" - 84°01'18"	314	160d		- 29.2d	1951
54	F.S. Sheppard		70	Sumter	Methvins	32°02'45" - 84°00'56"	321	100d		- 28.3d	1951
55	J.F. Hartsfield		99	Sumter	Americus	32°04'50" - 84°12'26"	435±5	93d		- 63.9d	1951
57	R.D. McNeil		104	Sumter	Americus	32°05'20" - 84°10'23"	474	107c		- 74.5d	1951
58	Albert Adams		112	Sumter	Methvins	32°06'44" - 84°04'09"	442	127d		- 79.2d	1951
59	G.B. Howard		117	Sumter	Americus	32°04'17" - 84°11'10"	434	80d		- 49.2d	1951
60	E.A. Drew		123	Sumter	Americus	32°03'19" - 84°11'33"	374	62d		- 15.7d	1951
61	W.R. Veatch		125	Sumter	Methvins	32°01'50" - 84°06'44"	357	80d		- 24d	1951
62	C. Roy Wade		127	Sumter	Methvins	32°00'58" - 84°04'17"	325±4	85d		- 18.8d	1951
63	Standard Elev.		130	Sumter	Leslie	31°59'18" - 84°01'47"	322	125d		- 34.2d	1951
64	A.L. Cheek		132	Sumter	Leslie	31°59'43" - 84°03'21"	318	140d		- 16.5d	1951
65	T.M. Furlow		135	Sumter	Americus	32°02'49" - 84°13'23"	390	80d		- 19.3d	1951
66	W.B. Perry	298	192	Sumter	Drayton	32°00'06" - 83°57'24"	245	100d	64c	+ 7d	1951
67	Powell Farms K.G. Kindred	310	200	Sumter	Smithville E.	31°59'57" - 84°11'59"	357	85d		- 44.6d	1952
69	Deseret Farm #1			Sumter	Leslie	31°56'12" - 84°00'33"	300	179d		- 43d	1958
70	S.W. Ga. Exp. Station	701		Sumter	Lake Collins	32°02'10" - 84°22'02"	498	88d	68e	- 50d	1958
71	John O'Hearn		207	Sumter	Americus	32°05'37" - 84°13'46"	458	105d		- 69.5d	1952
72	Highland Cafe		87	Sumter	Smithville W.	31°59'53" - 84°15'01"	405	111d		- 35d	1951
73	A.P. Lane	285		Terrell	Bronwood	31°49'04" - 84°18'44"	311	127c	78c	- 19.6c	1952
74	Steve Cocke Fish Hatchery #2	683		Terrell	Dawson	31°46'21" - 84°28'54"	388	202c		- 45.6c	1954
75	City of Sasser #1	368		Terrell	Sasser	31°43'08" - 84°20'52"	315	201d		- 40d	1955

* Approximate Location: Latitude ± 1' Longitude ± 5"

APPENDIX C - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAYTON AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
17	City of Edison #2	353		Calhoun	Edison	31°33'34" - 84°44'15"	289	515	395	- 103.3 12/79	-104.0 3/81	-121.2 11/81	-104.5 3/82
23	(Speight School) Clay Co. Elem. School	402		Clay	Ft. Gaines	31°36'37" - 85°02'06"	390	500	340	- 270.3 11/81	-259.6 3/82		
29	W.S. Stuckey	305	164	Dooly	Unadilla	32°17'03" - 83°44'38"	412	408	373	- 68.8 4/81	- 93.0 3/82		
34	Swift & Co. (Virginia-Carolina Chemical Co.)			Dougherty	Albany W.	31°34'48" - 84°10'06"	197	594		- 151 3/81	-159.8 10/81	-146.9 3/82	
35	Turner City #2			Dougherty	Albany E.	31°35'53" - 84°06'26"	213	760	713	- 134.0 11/79	-123.0 3/81	-146.0 10/81	-127.6 3/82
38	(E.R. Graham) Graham Angus #1			Dougherty	Pretoria	31°34'28" - 84°19°26"	222	650		- 96.0 3/81	-118.6 10/81	-104.5 3/82	
57	Brown's Dairy			Terrell	Chickasawhatchee	31°44'11" - 84°24'23"	315	496		- 161.2 12/79	-171.5 3/81	-197.2 10/81	-164.4 3/82
64	Graves School	350		Terrell	Shellman	31°46'08" - 84°31'07"	351	433	332	- 152.5 3/82			
65	City of Bronwood #1	406		Terrell	Bronwood	31°49'48" - 84°21'49"	368	453	390	- 204.0 12/79	-226.2 10/81	-207.3 3/82	
68	Calvin Eubanks #1			Calhoun	Bluffton	31°31'56" - 84°46'24"	292	647	424	- 112.8 12/79	-117.1 3/81	-130.5 10/81	-120.5 3/82
69	H.T. McLendon #1			Calhoun	Bluffton	31°34'58" - 84°47'34"	365	480	440	- 160.9 12/79	-160.1 3/81	-174.21 10.81	-161.7 3/82
70	H.T. McLendon #2			Calhoun	Bluffton	31°35'13" - 84°47'40"	352	565	450	- 144.4 12/79			
72	(E.R. Graham) Graham Angus #2			Calhoun	Holt	31°35'28" - 84°28'25"	230	580		- 71.0 12/79	- 75.1 3/81	- 97.3 10/81	- 75.8 3/82
73	City of Morgan #2			Calhoun	Morgan	31°31'56" - 84°36'02"	240	636	485	- 61.3 12/79	- 64.4 3/81	- 85.4 11/81	- 67.2 3/82
74	Adams Brothers #1			Calhoun	Morgan	31°35'17" - 84°31'32"	260	540	440	- 92.1 12/79	-95.8 3/81	-119.0 10/81	- 97.6 3/82

APPENDIX C - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAYTON AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
75	Alvin Sudderth #3			Calhoun	Morgan	31°36'46" - 84°31'08"	281	520	420	- 113.5 12/79	-117.4 3/81	-142.3 10/81	-119.1 3/82
76	Wildmeade Plantation	997		Calhoun	Morgan	31°31'26" - 84°30'11"	211	676	534	- 40.3 12/79	- 45.7 3/81	- 73.8 10/81	- 47.2 3/82
77	City of Bluffton			Clay	Bluffton	31°31'16" - 85°52'01"	325	555	480	- 133.0 12/79	-136.7 3/81	-144.5 11/81	-139.7 3/82
78	E.E. Watson			Clay	Ft. Gaines N.E.	31°43'28" - 85°01'26"	275	100	85	- 28.2 12/79	- 31.6 3/81	- 32.9 11/81	- 31.0 3/82
79	Giles Brothers #1			Clay	Ft. Gaines N.E.	31°37'59" - 85°02'17"	252	215	126	- 74.5 12/79	- 75.7 3/81	- 78.2 11/81	- 74.9 3/82
80	Bill Lindsey			Clay	Zetto	31°35'39" - 84°56'35"	390	560	450	- 180.8 12/79	-180.5 3/81	-188.1 10/81	-181.2 3/82
81	Randal Richardson			Clay	Bluffton	31°34'44" - 84°50'46"	395	555	435	- 185.1 12/79	-185.0 3/81	-196.2 10/81	-186.2 3/82
82	Kolomoki Plantation			Early	Bancroft	31°29'46" - 84°52'20"	310	635	472	- 114.7 12/79			
83	Singletary Farms Fairfield	3152		Early	Bancroft	31°26'57" - 84°48'16"	230	675	509	- 74.0 12/79	- 78.1 3/81	- 90.9 11/81	- 83.0 3/82
84	City of Blakely #2			Early	Blakely N.	31°22'43" - 84°55'57"	250	792		- 102.0 12/79	-100.7 3/81	-107.3 11/81	-105.1 3/82
87	City of Sasser #3	3100		Terrell	Sasser	31°43'16" - 84°21'00"	312	620	475	- 172.6 3/81	-199.5 10/81	-172.5 3/82	
88	Bob Locke			Terrell	Chickasawhatchee	31°43'21" - 84°23'15"	290	530	420	- 148.1 12/79	-174.1 10/81	-153.0 3/82	
91	John Daniels #3			Terrell	Chickasawhatchee	31°41'26" - 84°23'45"	280	430		- 139.2 12/79	-155.4 10/81	-134.7 3/82	
92	Bill Whitaker #2			Terrell	Chickasawhatchee	31°40'53" - 84°23'38"	268	520	400	- 128.5 12/79	-136.0 3/81		
94	DNR Fish and Game Well			Dougherty	Pretoria	31°35'29" - 84°20'32"	220	656	542	- 87.0 12/79	- 92.0 3/81	-110.7 10/81	- 91.76 3/82
95	Piedmont Plant Co.			Terrell	Sasser	31°40'01" - 84°18'04"	270	625	515	- 141.0 12/79	-146.0 3/81	-164.6 10/81	-146.5 3/82

APPENDIX C - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAYTON AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
96	T.W. #12	3390		Dougherty	Red Store Crossroads	31°26'54" - 84°21'01"	184	690	630	- 27.0 12/79	- 33.0 3/81	- 34.5 10/81	- 36.88 3/82
97	T.W. #9			Lee	Leesburg	31°38'12" - 84°12'50"	238	650	567	- 131.0 3/81	-148.3 10/81	-131.7 3/82	
98	Fowltown Plantation #3	969		Lee	Leesburg	31°40'02" - 84°12'25"	245	680	560	- 122.7 12/79	-140.0 3/81	-150.1 10/81	-131.0 3/82
99	(Lee High Acres) Creekwood Apts.#2	3142		Lee	Leesburg	31°38'01" - 84°10'49"	204	668	560	- 120.3 12/79	-124.5 10/81	-113.5 3/82	
100	T.W. #6			Dougherty	Albany	31°35'35" - 84°10'30"	198	690	619	- 141.0 12/79	-135.0 3/81	-148.5 10/81	-135.9 3/82
102	T.W. #7			Dougherty	Albany E.	31°31'05" - 84°-06'42"	195	882	716	- 88.0 12/79	-104.5 3/81	-114.1 10/81	-115.98 3/82
104	James Grubbs #2			Randolph	Carnegie	31°41'11" - 84°45'24"	385	440	330	- 142.0 12/79	-143.2 3/81	-155.6 11/81	-147.2 3/82
105	James Grubbs and sons #1			Randolph	Martins Crossroad	31°39'33" - 84°42'40"	370	470	350	- 158.5 12/79	-158.3 3/81	-180.1 11/81	-163.7 3/82
106	C.T. Martin #2			Randolph	Doverel	31°40'12" - 84°37'21"	330	415	330	- 140.4 12/79			
107	C.T. Martin #1			Randolph	Doverel	31°39'52" - 84°36'10"	322	430	360	- 124.3 12/79			
108	T.E. Allen, III			Randolph	Doverel	31°42'37" - 84°37'14"	370	475	338	- 165.7 12/79	-159.7 3/81	-178.2 10/81	-158.2 3/82
109	Bob Lovett			Randolph	Martins Crossroads	31°43'53" - 84°42'51"	410	405	297	- 143.8 12/79	-132.7 3/81	-150.2 11/81	-143.7 3/82
110	City of Cuthbert USGS Recorder			Randolph	Cuthbert	31°46'09" - 84°47'42"	445	309		- 145.0 12/79	-144.0 3/81	-149.1 10/81	-147.27 3/82
111	Bruce Bynum	3069		Randolph	Doverel	31°44'06" - 84°35'44"	375	435	320	- 158.8 12/79	-156.9 3/81	-176.5 10/81	-155.2 3/82
112	Melvin Peavay #1			Randolph	Brooksville	31°46'47" - 84°39'37"	435	410	315	- 162.8 12/79	-162.0 3/81	-180.0 10/81	-172.8 3/82
113	Earl Nisley			Randolph	Brooksville	31°47'43" - 84°41'42"	463	350	290	- 163.4 12/79	-162.1 3/81	-174.3 10/81	-164.5 3/82

APPENDIX C - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAYTON AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
115	Don Foster			Terrell	Bottsford	31°53'25" - 84°23'39"	360	305	225	- 103.8 3/81	-129.2 10/81	-109.7 3/82	
116	Dick & Jack Hammer			Terrell	Bottsford	31°55'44" - 84°25'42"	400	340	280	- 112.0 12/79			
117	City of Dawson #4	944		Terrell	Dawson	31°46'06" - 84°26'13"	330	553	355	- 175.5 12/79	-207.2 3/81	-205.4 10/81	-182.5 3/82
118	Vernon Copeland			Terrell	Dawson	31°48'19" - 84°24'42"	375	500	385	- 212.5 12/79	-213.0 3/81	-241.2 10/81	-225.7 3/82
119	Steve Cocke Fish Hatchery #3	2251		Terrell	Dawson	31°46'24" - 84°28'53"	375	500	378	- 197.0 12/79	-197.0 3/81	-201.9 12/81	-188.2 3/82
120	City of Parrott	3119		Terrell	Parrott	31°53'48" - 84°30'46"	480	401	290	- 152.0 12/79	-151.0 3/81	-158.1 10/81	-155.0 3/82
122	Thomas Bentley			Terrell	Shellman	31°46'29" - 84°34'21"	350	380	231	- 121.7 12/79	-110.5 3/81	-141.6 10/81	-121.2 3/82
123	City of Bronwood #2			Terrell	Bronwood	31°49'55" - 84°21'45"	355	465	390	- 203.0 12/79	-199.0 3/81		
125	Gene Sutherland			Sumter	Bottsford	31°58'45" - 84°26'17"	445	190		- 66.5 3/81	- 71.0 10/81	- 68.2 3/82	
126	Harold Darden			Sumter	Ellaville S.	32°08'16" - 84°22'14"	530	140	122	- 74.8 12/79	- 78.6 10/81	- 76.0 3/82	
127	Mr. Bowen	693		Sumter	Lake Collins	32°01'05" - 84°17'33"	461	305		- 143.7 12/79	-142.2 3/81	-154.3 10/81	-148.0 3/82
128	James Hart #1			Sumter	Lake Collins	32°05'53" - 84°17'45"	475	240		- 111.6 12/79	-109.9 3/81	-122.6 10/81	-115.7 3/82
130	Senator Hugh Carter			Sumter	Plains	32°00'58" - 84°24'40"	480	230	200	- 96.3 12/79	- 96.7 3/81	-101.2 10/81	- 95.2 3/82
131	James Short #2			Sumter	Smithville W.	31°56'40" - 84°20'22"	390	350	300	- 125.2 3/81	-150.4 10/81		
132	South River Farms			Webster	Church Hill	32°10'27" - 84°33'42"	602	170		- 130.3 3/81	-132.5 10/81	-132.3 3/82	
134	Pete Long #3			Lee	Smithville W.	31°53'54" - 84°19'24"	339	400	280	- 92.2 12/79	- 89.0 3/81		

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FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
135	Kolomoki State Park TW-1	3443		Early	Blakely N.	31°28'27" - 84°55'15"	310	612	491	- 141.7 3/81	-148.2 10/81	143.0 3/82	
136	Adams Brothers #2			Calhoun	Holt	31°32'27" - 84°29'40"	222	580	460	- 92.4 10/81			
137	Bert Thomas			Sumter	Smithville W.	31°55'25" - 84°20'48"	432	466	360	- 176.8 3/81	-216.1 10/81	-203.0 3/82	
140	Webb #1			Terrell	Dawson	31°48'02" - 84°24'04"	348	465	407	- 196.3 3/81	-216.2 10/81	-196.7 3/82	
141	USGS Recorder			Clay	Ft. Gaines	31°36'42" - 85°03'21"	147	120	44	- 32.4 10/81	- 29.32 3/82		
142	Singletary Farms (Bancroft)	1163		Early	Bancroft	31°24'45" - 84°49'42"	230	770	672	- 67.6 3/81	- 77.0 11/81	- 72.9 3/82	
143	C.T. Martin O.W. #2	3449		Randolph	Doverel	31°39'53" - 84°36'12"	322	430	356	- 126.4 3/81	-148.2 10/81	-127.0 3/82	
144	Jimmy Bangs #2			Terrell	Chickasawhatchee	31°38'55" - 84°29'55"	300	500	400	- 128.8 12/79	-137.0 3/81	-157.9 10/81	-132.7 3/82
145	Raymond Goodman			Webster	Benevolence	31°57'25" - 84°38'03"	530	240		- 141.5 3/81	-144.1 10/81	-130.5 3/82	
146	Pete Long O.W. #1	3517		Lee	Smithville W.	31°53'53" - 84°19'25"	338	384	332	- 151.8 10/81	-133.8 3/82		
147	Veterans' Memorial Park TW - 1	3518		Crisp	Cobb	31°57'31" - 83°54'23"	252	550	510	- 39.8 4/82			
148	Featherfield Farms			Dougherty	Holt	31°35'41" - 84°26'05"	228	585	485	- 78.4 3/82			
150	City of Dawson Maintenance Barn			Terrell	Dawson	31°46'36" - 84°26'13"	355			- 215.7 3/82			
151	Ben Arthur			Terrell	Bronwood	31°46'01" - 84°20'32"	325	543	440	- 177.65 3/82			

APPENDIX D - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAIBORNE AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
10	City of Cordele #4	390		Crisp	Cordele	31°58'16" - 83°46'28"	316	600	270	- 76.5 12/79	- 76.5 3/81	- 78.5 10/81	- 69.5 3/82
26	City of Albany #17			Dougherty	Albany E.	31°35'55" - 84°06'26"	208	700	200	- 113.4 1/80	-114.0 2/81	-115.0 4/82	
32	City of Shellman #2			Randolph	Shellman	31°45'31" - 84°36'58"	393	135		- 35.5 12/79	- 35.5 3/81	- 31.5 10/81	- 34.5 3/82
37	F. Waltsman #1	282	188	Sumter	Americus	32°01'48" - 84°13'05"	373	129	106	- 51.5 12/79	- 23.1 3/81	- 53.6 10/81	- 51.9 3/82
67	(K.G. Kindred) (J. Derlso) Powell Farms	310	200	Sumter	Smithville E.	31°59'57" - 84°11'59"	357	85		- 43.2 12/79	- 39.9 3/81	- 45.5 10/81	- 40.4 3/82
75	City of Sasser #1	368		Terrell	Sasser	31°43'08" - 84°20'52"	314	201	181	- 40.0 12/79	- 44.5 3/81	- 46.9 10/81	- 35.3 3/82
77	Great Southern Paper Company	729		Early	Gordon	31°09'52" - 85°05'45"	120	380	380	- 21.2 12/79	- 19.5 3/81	- 15.0 11/81	- 22.9 3/82

APPENDIX D - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAIBORNE AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
80	Singletary Farms	3151		Early	Bancroft	31°25'13" - 84°50'01"	250	200	188	- 42.8 12/79	- 43.3 3/81	- 32.4 11/81	- 15.9 3/82
82	Grady Milliner			Clay	Zetto	31°32'37" - 84°52'43"	355	150		- 59.9 12/79	- 61.8 3/81	- 62.1 10/81	- 59.7 3/82
83	McNair #1	3388		Calhoun	Bluffton	31°34'35" - 84°47'15"	352	140	103	- 54.6 12/79	- 55.2 3/81	- 56.2 10/81	- 53.0 3/82
84	H.T. McLendon #4			Calhoun	Bluffton	31°35'00" - 84°47'29"	365	140	120	- 71.4 12/79	- 69.2 3/81	- 70.0 10/81	- 66.8 3/82
85	Isler Farms Flying Service			Clay	Zetto	31°36'07" - 84°52'39"	420	142	80	- 64.3 3/81	- 64.6 10/81	- 64.2 3/82	
86	E. Alday (G. Chapman)			Clay	Bluffton	31°36'49" - 84°51'37"	405	122	87	- 44.4 12/79	- 45.5 3/81	- 45.7 10/81	- 44.7 3/82
88	W.D. Beard #1	3386		Calhoun	Morgan	31°34'45" - 84°35'02"	254	140		- 14.0 11/79	- 16.8 3/81	- 16.6 10/81	- 11.8 3/82
89	W. Stanley			Randolph	Carnegie	31°43'04" - 84°51'15"	470	50		- 42.8 12/79	- 42.7 3/81	- 44.3 11/81	- 42.1 3/82
90	Gene Kennedy			Randolph	Cuthbert	31°47'26" - 84°47'10"	474	68	50	- 39.0 12/79	- 39.3 3/81	- 40.3 11/81	- 38.0 3/82
91	Melvin Peavay #2			Randolph	Brooksville	31°45'51" - 84°39'23"	425	110		- 38.6 12/79			
92	Dean Whaley #2			Randolph	Brooksville	31°45'36" - 84°39'10"	418	110		- 33.8 12/79			
94	Dean Whaley #1			Randolph	Shellman	31°50'21" - 84°37'09"	470	90	60	- 63.9 12/79	- 69.6 3/81	- 67.7 10/81	- 68.2 3/82
95	Bob Chambliss			Terrell	Dawson	31°45'56" - 84°28'23"	371	180		- 35.5 12/79	- 37.5 3/81	- 38.9 10/81	- 41.4 3/82
96	Sonny Reese			Terrell	Chickasawhatchee	31°41'33" - 84°25'57"	270	200	60	- 7.9 12/79	- 7.2 3/81	- 9.4 10/81	- 5.9 3/82
97	T.W. #11	3384		Dougherty	Redstore Crossroads	31°26'54" - 84°21'01"	182	320	300	- 22.9 12/79	- 29.0 3/81	- 27.6 10/81	- 27.34 3/82
98	T.W. #4			Dougherty	Pretoria	31°35'30" - 84°20'32"	220	251	232	- 17.0 12/79	- 22.0 3/81	- 26.3 10/81	- 18.27 3/82

APPENDIX D - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAIBORNE AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
100	T.W. #2			Dougherty	Albany East	31°31'05" - 84°06'43"	195	418	398	- 70.3 12/79	- 88.0 3/81	- 90.4 10/81	- 79.55 3/82
101	T.W. #5			Dougherty	Albany West	31°35'34" - 84°10'30"	198	257	237	- 84.6 12/79	- 83.0 3/81	- 88.2 10/81	- 79.94 3/82
102	O.W. #2 Miller Brewery			Dougherty	Albany East	31°35'45" - 84°04'47"	205	560	300	- 66.0 12/79			
103	T.W. #8			Lee	Leesburg	31°38'13" - 84°12'50"	238	385		- 97.0 12/79	- 99.0 3/81	-106.7 10/81	- 94.5 3/82
104	W.H. Fryer			Lee	Sasser	31°40'08" - 84°17'26"	258	263	100	- 37.0 12/79	- 29.5 3/81	- 46.3 10/81	- 32.2 3/82
105	J. Daniels #2			Terrell	Sasser	31°41'20" - 84°19'09"	290	320	100	- 52.9 3/81	- 54.0 10/81	- 40.9 3/82	
107	Sheriff J. Dean			Terrell	Dawson	31°47'48" - 84°25'05"	340	120±5	84	- 23.5 12/79	- 24.0 3/81	- 26.3 10/81	- 19.9 3/82
108	Jack Balentine			Terrell	Parrott	31°54'01" - 84°30'19"	450	60		- 34.5 12/79	- 38.4 3/81	- 40.6 10/81	- 40.0 3/82
109	John Wills			Terrell	Bronwood	31°50'26" - 84°20'55"	362	120	89	- 51.4 12/79	- 49.4 3/81	- 52.6 10/81	- 44.1 3/82
110	John Wise			Terrell	Bronwood	31°47'08" - 84°17'21"	301	135		- 39.7 12/79	- 35.5 3/81	- 43.6 10/81	- 31.9 3/82
111	Haley Brothers Farm			Lee	Leesburg	31°41'13" - 84°13'22"	220	300		- 35.9 12/79	- 35.1 3/81	- 57.2 10/81	- 50.4 3/82
113	Gloria Spann			Sumter	Plains	32'01'17" - 84°24'09"	503	60	40	- 42.3 12/79	- 44.2 3/81	- 44.5 10/81	- 42.5 3/82
114	City of Plains #4			Sumter	Plains	32°02'09" - 84°23'12"	491	90	80	- 31.7 3/82			
115	Dru or Dave Murray	314	210	Sumter	Plains	32°03'00" - 84°23'25"	509	86	76	- 50.1 12/79	- 49.3 3/81	- 51.3 10/81	- 52.0 3/82
116	City of Plains #3			Sumter	Plains	32°02'07" - 84°23'20"	494	91	80	- 32.5 12/79	- 30.2 3/81	- 33.9 10/81	
117	S.W. Ga. Experiment Station #1	2157		Sumter	Lake Collins	32°02'48" - 84°22'16"	510	107	70	- 56.6 12/79	- 53.5 3/81	- 57.4 10/81	- 58.4 3/82

APPENDIX D - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAIBORNE AQUIFER (1979-1982)

FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
119	R.S. Moore	296		Sumter	Ellaville	32°09'14" - 84°18'25"	512	154	70	- 67.6 12/79	- 69.7 3/81	- 69.5 10/81	- 68.7 3/82
120	Clark Rainbow Center - Purina	709		Sumter	Americus	32°07'11" - 84°11'46"	461	136	126	- 42.2 12/79	- 41.7 3/81	- 45.4 10/81	- 45.4 3/82
123	Henry Hart #1A			Sumter	Smithville E.	31°59'37" - 84°09'09"	343	90		- 27.3 12/79	- 26.6 3/81	- 36.9 10/81	- 21.5 3/82
124	Charles Miller	3358		Sumter	Cobb	31°56'37" - 83°58'59"	285	310	230	- 26.5 12/79	- 22.6 3/81	- 39.4 10/81	- 17.9 3/82
125	Ga. Veterans Mem. State Park	2252		Crisp	Cobb	31°57'17" - 83°54'50"	262	300		- 25.5 12/79	- 26.5 3/81	- 28.6 10/81	- 24.8 3/82
126	W.T. Greene			Crisp	Cordele	31°59'27" - 83°49'38"	312	400	200	- 35.4 12/79	- 34.6 3/81	- 37.1 10/81	- 32.1 3/82
128	E.D. Cannon			Dooly	Drayton	32°03'28" - 83°54'03"	310	200		- 39.9 12/79	- 40.4 3/81	- 45.5 10/81	- 37.4 3/82
129	Dr. James Minor			Dooly	Byromville	32°10'17" - 83°58'33"	325	290	70	- 40.7 12/79	- 41.6 4/81	- 49.9 10/81	- 42.2 3/82
130	Hardigree #1			Dooly	Vienna	32°06'42" - 83°50'40"	340	340	240	- 40.6 1/80			
131	City of Vienna #1	143		Dooly	Vienna	32°05'39" - 83°47'31"	355	571	571	- 65.8 12/79	- 64.5 3/81	- 67.2 10.81	- 60.5 3/82
132	William Sparrow			Dooly	Pineview N.W.	32°13'15" - 83°42'23"	370	280?	175	- 41.0 4/81	- 48.4 10/81	- 37.5 3/82	
133	George McKay	1805		Crisp	Drayton	32°01'20" - 83°54'05"	288	170	125	- 25.4 12/79	- 26.5 3/81	- 30.4 10/81	- 24.3 3/82
134	Judge Horn			Crisp	Cobb	31°59'10" - 83°54'55"	265	300		- 16.1 12/79			
135	City of Unadilla #3			Dooly	Unadilla	32°15'06" - 83°44'23"	376	315	315	- 57.1 12/79	- 57.2 3/81	- 63.9 10/81	- 53.5 3/82
136	Terrill Hudson			Dooly	Henderson	32°15'27" - 83°47'25"	430	400	200	- 100.3 3/81	-104.4 10/81	- 97.75 3/82	
138	City of Byromville #1			Dooly	Byromville	32°12'14" - 83°54'29"	380	203		- 91.0 4/81	-105.1 10/81	- 92.7 4/82	

APPENDIX D - WELL DATA FOR THE POTENTIOMETRIC SURFACE OF THE CLAIBORNE AQUIFER (1979-1982)

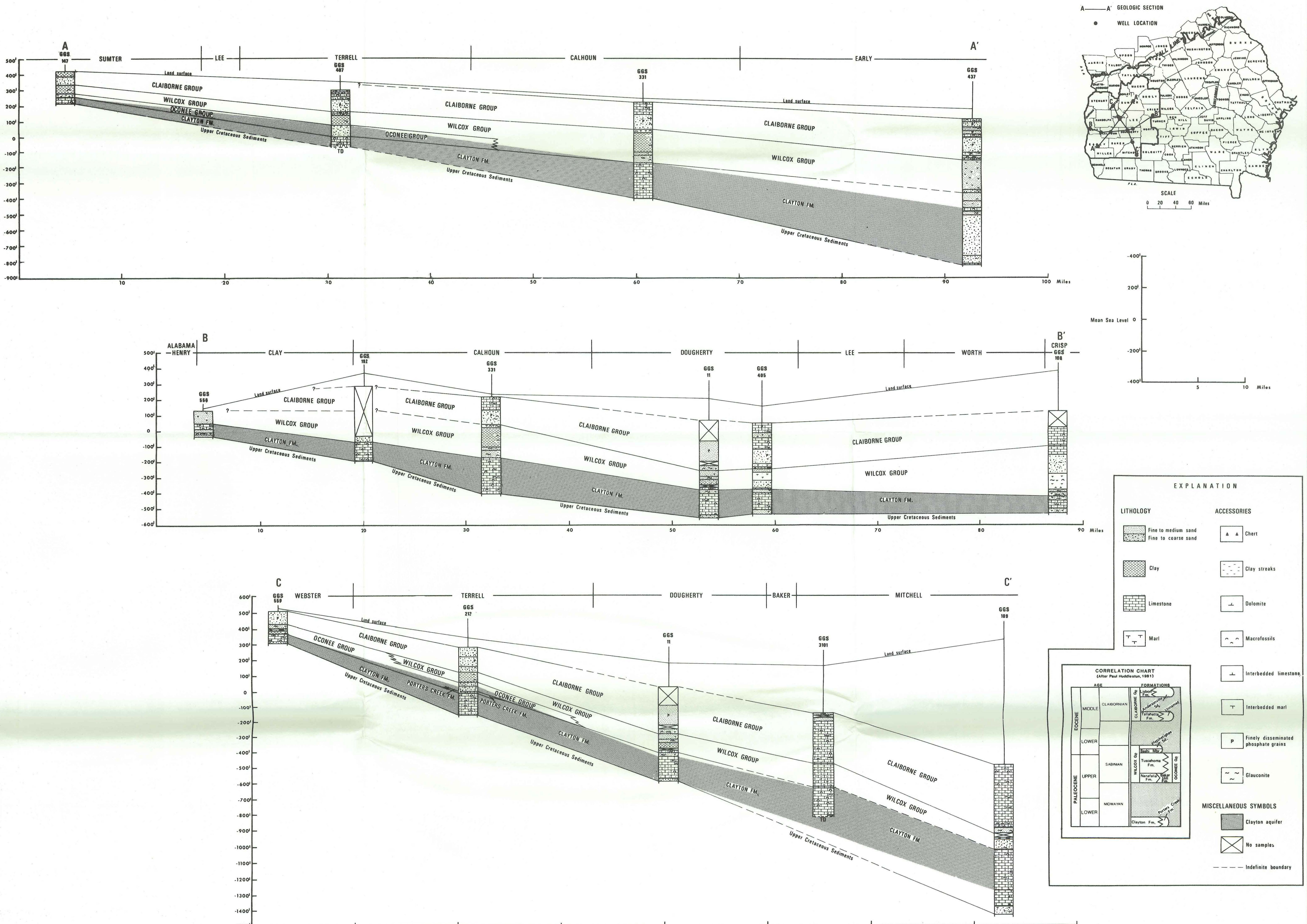
FIELD NO.	OWNER	GGS NO.	GC NO.	COUNTY	QUAD	LAT. - LONG.	LAND SURFACE ELEVATION (feet)	TOTAL DEPTH (feet)	CASING DEPTH (feet)	STATIC WATER LEVEL (SWL) DATE MEASURED	SWL DATE	SWL DATE	SWL DATE
139	Henry Hart #2A			Sumter	Smithville E.	31°57'54" - 84°08'08"	348	125		- 53.5 10/81	- 33.6 3/82		
140	Boots Lyles			Sumter	Smithville E.	31°58'34" - 84°07'43"	365	300		- 70.4 10/81	- 50.4 3/82		
142	John Daniels #1			Terrell	Sasser	31°41'42" - 84°19'34"	309	320		- 34.6 3/82			
143	Marcus Regans			Randolph	Bluffton	31°37'17" - 84°49'51"	360	124	103	- 45.3 12/79	- 45.2 3/81	- 46.5 11/81	-44.9 3/82
145	Shingler & Reed			Early	Gordon	31°10'15" - 85°00'43"	211	460	280	- 85.8 11/81	- 78.3 3/82		
146	Kolomoki State Park T.W. #3			Early	Blakely N.	31°28'27" - 84°55'15"	310	140	120	- 74.8 3/81	- 76.9 11/81	- 75.4 3/82	
148	Shiloh Church			Terrell	Shellman	31°49'35" - 84°33'11"	365	60		- 36.8 12/79			
150	Hardigree #2			Dooly	Vienna	32°06'46" - 83°49'23"	341	360	300	- 32.1 3/81	- 35.5 10/81	- 28.5 3/82	
151	Firewell Miller Brewery			Dougherty	Albany E.	31°36'25" - 84°04'15"	200	350		- 72.0 3/81	-104.5 10/81	- 90.63 3/82	
154	City of Smith-ville #2	2137		Lee	Smithville W.	31°54'02" - 84°15'29"	328	195	195	- 36.5 3/81	- 39.4 10/81	- 34.3 3/82	
155	C.T. Martin O.W. #1			Randolph	Doverel	31°39'53" - 84°36'12"	322	94	77	- 29.5 3/81	- 30.6 10/81	- 27.4 3/82	
156	Pete Long O.W. #2			Lee	Smithville W.	31°53'53" - 84°19'25"	338	143	112	- 39.2 10/81	- 36.8 3/82		
159	City of Leary	2239		Calhoun	Leary	31°29'12" - 84°30'47"	205	556		- 31.7 3/82			

GEORGIA GEOLOGIC SURVEY

GEOLOGIC SECTIONS OF THE CLAYTON AQUIFER

INFORMATION CIRCULAR 55
PLATE I

From Tuohy, M.A., 1983a



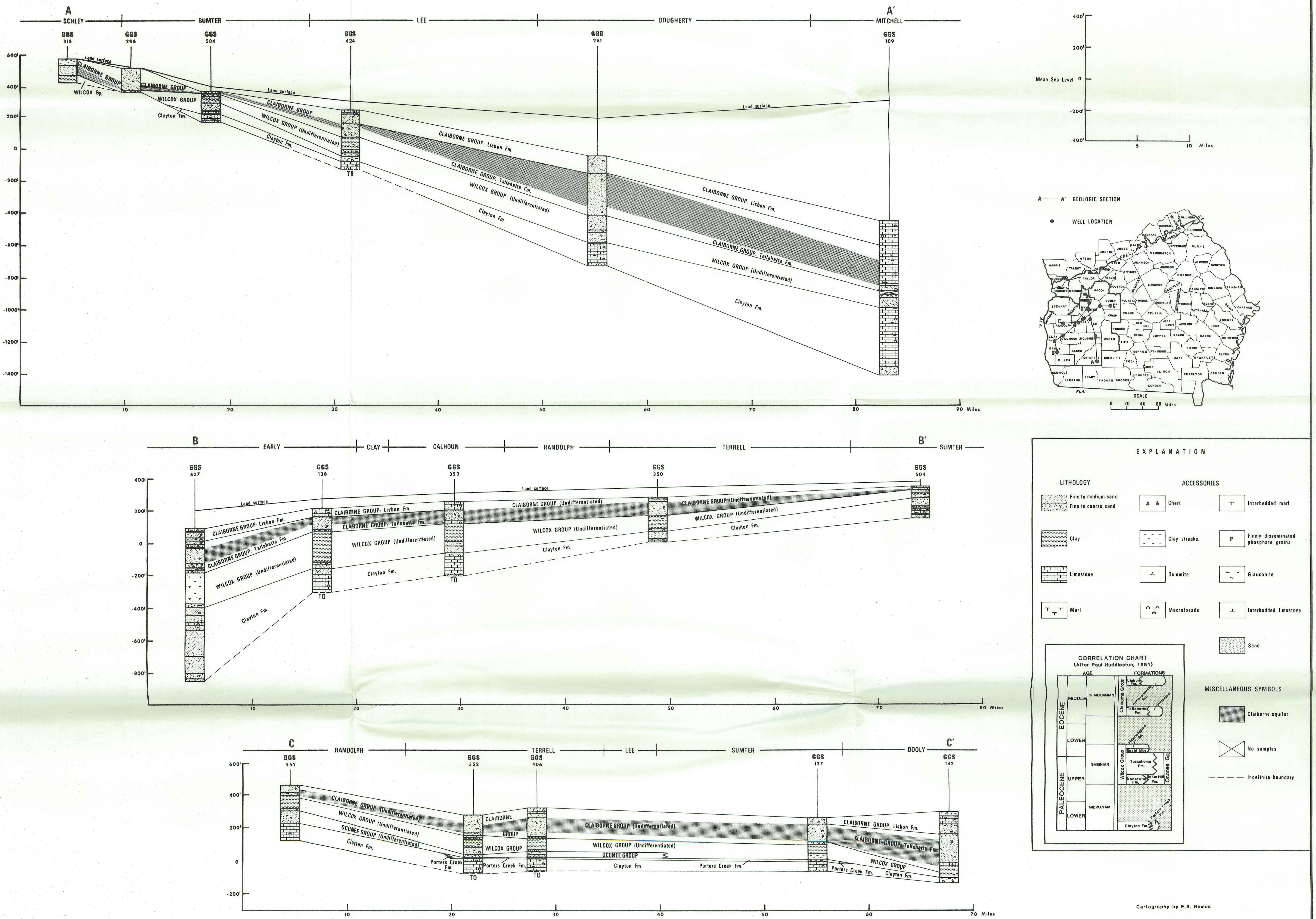
Cartography by E.S. Ramos

GEORGIA GEOLOGIC SURVEY

INFORMATION CIRCULAR 55
PLATE 2

GEOLOGIC SECTIONS OF THE CLAIBORNE AQUIFER

From Crews, P.A., 1983a



Cartography by E.S. Ramos