Table 1.—*Description and hydrologic significance of major geologic units*

Geologic unit	Remarks
Quaternary alluvial deposits	Occur as valley fill and floodplain deposits of major streams. Generally grade finer upward, consisting of poorly sorted gravels, sands, silts, and clays. Can be highly productive aquifer where sufficiently thick to sustain large withdrawals, as in the Mississippi River valley.
Quaternary terrace and coastal deposits	Occur as dissected remnants of upland terraces and as a gulfward-thickening wedge of coastal deposits. The terrace deposits are generally gravelly and can be locally important aquifers. The coastal deposits that comprise the Chicot aquifer consist of thick sands with clay interbeds of varying thickness. The sands are coarse and may contain gravel; along the coast they are important aquifers for municipal, industrial, and agricultural uses.
Pliocene and Miocene deposits	Continental and deltaic deposits of interbedded sands and clays. Thicker and more areally extensive sandy sections form major regional aquifers, as in southwestern Louisiana and Texas where the Evangeline aquifer (Pliocene and Miocene) and Jasper aquifer (Miocene) are important sources of water. The Burkeville confining system, a clayey layer, separates the two aquifers. In southeastern Louisiana and southern Mississippi thick Pliocene and Miocene sands form the Miocene aquifer system.
Catahoula Tuff or Sandstone	Deposits thought to be Miocene and Oligocene in age; vary considerably in lithology. In south Texas they are pyroclastic and tuffaceous. Eastward, they become interbedded sand and clay. The sands are probably only of local hydrologic significance, as in at least part of the area the overall effect of the Catahoula beds is thought to be that of a confining system.
Vicksburg Group and other Oligocene deposits	Chiefly represent a marine cycle of deposition and consist predominantly of clays, marls, and limestones. Except for the Forest Hill Formation, which is sandy and locally an aquifer in Mississippi, Oligocene deposits are not considered water bearing.
Jackson Group	Deposits similar in origin and lithology to those of the overlying Oligocene. Together, they generally form a thick confining layer. Minor sands in the Jackson that are local aquifers are not of regional significance.
Cockfield Formation and Yegua Formation	Predominantly sandy deposits with interbedded clay. The units thicken and are sandy for considerable distance downdip. The discontinuous, interconnected sands constitute a regional aquifer.
Cook Mountain Formation	Typically a marine clay but contains varying amounts of sand locally. Generally is a confining layer.
Sparta Sand	Contains irregular sand beds that range from massive to thin with varying amounts of interbedded clay. One of the most widely used aquifers in the study area, chiefly for municipal industrial purposes. Well yields are large where thicker sands are present.
Cane River Formation and equivalent units	A marine clay that is a confining layer in much of the central part of the area. The Queen City Sand, widespread in Texas is equivalent to the middle part of the Cane River and is an aquifer in that State; this sandy section extends for a distance into southwestern Arkansas. In Mississippi, the equivalent part of the section is occupied by the Winona Sand; it and underlying sandy beds of the Tallahatta Formation are aquifers.
Carrizo Sand and Meridian Sand Member of the Tallahatta Formation	A generally massive sand with few or no clay interbeds. It varies in thickness and is discontinuous in part of the area because of deposition over eroded Wilcox surface. A very important aquifer in Texas and Mississippi, it is little used elsewhere. In places, it combines with underlying sands in the Wilcox to form a very thick massive aquifer.
Memphis Sand	A massive sand unit in the northern part of the Mississippi embayment. It is equivalent to the Carrizo Sand and Meridan Sand Member, a sand facies of the Cane River Formation and its Mississippi equivalents, and the Sparta Sand. It is a very important aquifer in the area and supplies almost all municipal and industrial pumpage in the Memphis metropolitan area.
Wilcox Group or Formation	A thick sequence of complexly interbedded continental and deltaic sands, silts, and clays. A massive sand occurs in the lower part of the Wilcox in the northern and eastern part of the area (Fort Pillow Sand of the northern Mississippi embayment) and is a major aquifer where it contains fresh water. Otherwise, sands in the Wilcox are generally discontinuous and are of regional significance only in the aggregate.
Midway Group	Massive marine clay, generally calcareous in basal part; entire section becomes calcareous in extreme southeastern part of the study area. The thick clay of the Midway is a regional confining layer separating Tertiary aquifers from underlying Cretaceous units.

Table 2.—*Correlation chart of Cenozoic units in the Gulf Coastal Plain*

Erathem	System	Series	TEXAS: Southern	TEXAS: Southeastern and northeastern	LOUISIANA	ARKANSAS: Southern	ARKANSAS: Northeastern	MISSOURI	ILLINOIS	KENTUCKY	TENNESSEE	MISSISSIPPI: Northern	MISSISSIPPI: Central and southern	ALABAMA	FLORIDA
CENOZOIC	QUATERNARY	HOLOCENE	Alluvium and terrace deposits	Alluvium and terrace deposits	Alluvium and terrace deposits	Alluvium and terrace deposits	Alluvium and terrace deposits	Alluvium and terrace deposits	Alluvium and terrace deposits	Alluvium and loess deposits	Alluvium and loess deposits	Alluvium, terrace, and loess deposits	Alluvium, terrace, and loess deposits	Alluvium and terrace deposits	Alluvium and terrace deposits
		PLEISTOCENE													
	TERTIARY	PLIOCENE	Goliad Sand	Goliad Sand	Citronelle Formation								Citronelle Formation Graham Ferry Formation	Citronelle Formation	Citronelle Formation
		MIOCENE	Fleming Formation Oakville Sandstone	Fleming Formation	Fleming Formation Blounts Creek Member Castor Creek Member Williamson Creek Member Dough Hills Member Carnahan Bayou Member Lena Member								Pascagoula Formation Fort Adams Member Homochitto Member Hattiesburg Formation	Undifferentiated	Pensacola Clay Escambia Sand Member Tampa Limestone
		OLIGOCENE	Catahoula Tuff Frio Clay	Catahoula Sandstone	Catahoula Sandstone Vicksburg Formation								Catahoula Sandstone Tatum Limestone Member Paynes Hammock Formation Chickasawhay Limestone Vicksburg Group: Bucatunna Formation, Byram Formation, Glendon Formation, Marianna Formation and Mint Spring Formation Forest Hill Formation and Red Bluff Formation	Catahoula Sandstone Tatum Limestone Member Paynes Hammock Formation Chickasawhay Limestone Vicksburg Group: Bucatunna Formation, Byram Formation, Glendon Formation, Marianna Formation and Mint Spring Formation Red Bluff Formation and Bumpnose Formation	Catahoula Sandstone Tatum Limestone Member Chickasawhay Limestone Bucatunna Formation Byram Formation Marianna Formation Bumpnose Formation
		EOCENE	Jackson Group: Whitsett Formation, Manning Clay, Wellborn Sandstone, Caddell Formation	Jackson Group: Whitsett Formation, Manning Clay, Wellborn Sandstone, Caddell Formation	Jackson Group: Yazoo Formation, Moodys Branch Marl	Jackson Group: Undifferentiated	Jackson Group: Undifferentiated	Jackson Formation		Jackson Formation	Jackson Formation	Jackson Group: Undifferentiated	Jackson Group: Yazoo Formation, Shubuta Member, Pachuta Marl Member, Cocoa Sand Member, North Twistwood Creek Member, Moodys Branch Marl	Jackson Group: Yazoo Formation, Shubuta Member, Pachuta Marl Member, Cocoa Sand Member, North Twistwood Creek Member, Moodys Branch Marl	Ocala Limestone Moodys Branch Formation
			Claiborne Group: Yegua Formation, Laredo Formation, El Pico Clay, Bigford Formation, Carrizo Sand	Claiborne Group: Yegua Formation, Cook Mountain Formation, Sparta Sand, Weches Formation, Queen City Sand, Reklaw Formation, Carrizo Sand	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Sparta Sand, Cane River Formation, Carrizo Sand	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Sparta Sand, Cane River Formation, Carrizo Sand	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Sparta Sand, Cane River Formation, Carrizo Sand	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Sparta Sand, Cane River Formation, Carrizo Sand	Claiborne Group: Cockfield(?) Formation, Cook Mountain(?) Formation, Memphis Sand	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Sparta Sand, Tallahatta Formation	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Memphis Sand	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Sparta Sand, Zilpha Clay, Winona Sand, Tallahatta Formation	Claiborne Group: Cockfield Formation, Cook Mountain Formation, Gordon Creek Shale Member, Potterchitto Sand Member, Archusa Marl Member, Sparta Sand, Zilpha Clay, Winona Sand, Tallahatta Formation, Neshoba Sand Member, Basic City Shale Member, Meridian Sand Member	Claiborne Group: Gosport Sand, Lisbon Formation, Tallahatta Formation, Meridian Sand Member	Claiborne Group: Lisbon Formation, Tallahatta Formation
		PALEOCENE	Wilcox Group: Undifferentiated	Wilcox Group: Undifferentiated	Wilcox Group: Undifferentiated, Dolet Hills Formation, Naborton Formation	Wilcox Group: Undifferentiated	Wilcox Group: Undifferentiated	Wilcox Group: Undifferentiated	Wilcox Formation: No Wilcox deposits identified as being of Paleocene age.	Wilcox Formation: No Wilcox deposits identified as being of Paleocene age.	Wilcox Group: Flour Island Formation, Fort Pillow Sand, Old Breastworks Formation	Wilcox Group: Undifferentiated	Wilcox Group: Hatchetigbee Formation, Bashi Formation, Tuscahoma Formation, Nanafalia Formation, Fearn Springs Member	Wilcox Group: Hatchetigbee Formation, Bashi Formation, Tuscahoma Sand, Bells Landing Marl Member, Greggs Landing Marl Member, Nanafalia Formation, Grampian Hills Member, "Middle" member, Gravel Creek Sand Member	Wilcox Group: Undifferentiated
			Midway Group: Wills Point Formation, Kincaid Formation	Midway Group: Wills Point Formation, Kincaid Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Clayton Formation	Midway Group: Porters Creek Clay, Tippah Sand Lentil, Clayton Formation	Midway Group: Porters Creek Clay, Matthews Landing Marl Member, Clayton Formation	Midway Group: Naheola Formation, Coal Bluff Member, Oak Hill Member, Porters Creek Clay, Matthews Landing Marl Member, Clayton Formation, McBryde Limestone Member, Pine Barren Member	Midway Group: Undifferentiated

This correlation chart shows geologic names of Cenozoic units in the Gulf Coast as used by the U.S. Geological Survey. Horizontal alignment implies at least general correlation where exact equivalency is not obvious. Vertical space occupied by a unit has no relation to any physical parameter of the unit but was dictated by space requirements for listing units and accommodating geologic-age boundaries.

GEOLOGIC AND HYDROLOGIC UNITS

Because of the long-term cyclic nature of much of Tertiary deposition in the Gulf Coastal Plain, many of the major geologic units are either predominantly sand or predominantly clay; therefore, many can be characterized as being primarily an aquifer or a confining layer (table 1). A few major aquifer systems have been given aquifer—not stratigraphic—names that are now well established and in general usage; table 2, a correlation chart, shows stratigraphic nomenclature in each State as recognized by the U.S. Geological Survey.

Most of the water in these aquifers occurs under artesian conditions. Water in the outcrop areas may be under water-table conditions, especially prior to development. The water-table map (fig. 4) shows predevelopment water levels in shallow aquifers and outcrop areas of artesian aquifers. The water-table altitude was calculated by subtracting estimated depth to water (averaging about 20 feet) from land-surface altitude taken from a detailed computer data base (Godson, 1981). The depth to water was estimated by a linear regression developed using altitude and well-depth data from more than 7,000 wells less than 100-feet deep (Williamson, A. K., U.S. Geological Survey, written commun., 1985).

Sands of the Wilcox Group (Wilcox Formation in Tennessee) comprise the lowermost aquifer system to be studied. The sands, underlain by several hundred feet of clay of the Midway Group, are mostly thinly interbedded with clays and silts and are interconnected to varying degrees. Thicker sands do occur but generally are not sufficiently extensive to warrant individual attention in a regional study; the entire Wilcox, therefore, is considered a major aquifer for purposes of this study. One exception is a persistent massive sand in the lower part of the Wilcox that can be traced southward from the apex of the Mississippi embayment over a significant part of the area. This sand has different hydrologic characteristics from the overlying Wilcox. Originally called the "1400-foot" sand locally in western Tennessee and eastern Arkansas, it was named the "lower Wilcox aquifer" in a regional study of the Mississippi embayent (Hosman and others, 1968). Later, as a result of a test hole drilled in western Tennessee, it was formally named the Fort Pillow Sand (Moore and Brown, 1969) in Tennessee and geographically extended into Arkansas and Missouri. Thus, a unit whose original recognition was as a hydrological entity eventually attained formational status.

The Carrizo Sand (Meridian Sand Member of the Tallahatta Formation in Mississippi and Alabama) is a massive, generally very clean sand that overlies the Wilcox Group in most places. Deposited on an eroded Wilcox surface, it is not present over what were probably high spots in Wilcox topography. The Carrizo (Meridian) is overlain in most of its area of occurrence by marine clays of the lower part of the Cane River Formation or its equivalents, the Reklaw Formation in Texas and the Basic City Shale Member of the Tallahatta Formation in Mississippi. These clays act as a confining layer for the Carrizo (Meridian). In places, massive sands in the upper Wilcox underlie the Carrizo (Meridian) to form one aquifer.

The Cane River Formation and its equivalents are characterized by diverse lithologies over the area. In the central part of the Mississippi embayment and southward, the Cane River is almost entirely marine clay several hundred feet thick that acts as a confining layer. To the west, in Texas, it is represented by three formational units. The basal unit, the Reklaw Formation, is mostly clay. The middle unit, the Queen City Sand, is a thick sand that is an important aquifer. The upper unit, the Weches Formation, is composed mostly of clay and glauconitic sand. To the east, the Cane River equivalents also become sandier. The Basic City Shale Member and the overlying Neshoba Sand Member of the Tallahatta Formation are equivalent to the lower part of the Cane River. The Winona Sand is an aquifer that overlies the Neshoba Sand. In places, the Meridian, Basic City, Neshoba, and Winona combine to form one aquifer. The Zilpha Clay overlies and confines the Winona Sand.

The Sparta Sand is a major water-bearing geologic unit in sediments of Eocene age. It is present in most of the area and attains thicknesses of several hundred feet. Sand content of the Sparta varies greatly. Although it occurs as a single massive sand in some places, in other places the sand content is considerably less than half of the total thickness. The Sparta may contain more than one thick sand separated by clays of varying thickness and extent. Water levels in these individual sands may differ locally as the result of pumping. The clays are discontinuous, and all of the Sparta sands are interconnected at one place or another. Therefore, the Sparta Sand acts as a regional aquifer. In places, over- and underlying confining layers have sandy zones in contact with the Sparta. Where this occurs, these sandy zones act as part of the Sparta aquifer.

Northward from an east-west line located just south of the 35th parallel the Cane River Formation (and its equivalents) undergoes a facies change to sand. This sand combines with sand of the underlying Carrizo (Meridian) and sand of the overlying Sparta to form a massive sand aquifer hundreds of feet thick. First referred to as the "500-foot" sand in the Memphis area, it was later named "Memphis aquifer" during the study of the water resources of the Mississippi embayment (Hosman and others, 1968). As a result of stratigraphic studies in western Tennessee it was renamed the Memphis Sand (Moore and Brown, 1969) in Arkansas, Missouri, and Tennessee.

The Cook Mountain Formation, which is a marine clay that is partly sandy and glauconitic, overlies the Sparta Sand. The formation is generally less than 200 feet thick and acts as a confining layer to water in the Sparta aquifer.

The Cockfield Formation (Yegua Formation in Texas), lithologically similar to Wilcox deposits in that it is composed of interfingering sands and clays and is lignitic, overlies the Cook Mountain Formation and is the youngest Eocene aquifer of regional significance. It is several hundred feet thick in the subsurface and is generally sandier in the lower part.

The predominantly clay and marl Jackson Group (Jackson Formation in Kentucky, Missouri, and Tennessee) overlies and confines water in the Cockfield Formation and is the uppermost Eocene unit. The Jackson Group is in turn overlain by the Oligocene Forest Hill Formation of the Vicksburg Group. The Forest Hill Formation is an aquifer of only local importance. The Vicksburg deposits in some areas can be difficult to distinguish from Jackson in the subsurface on the basis of electrical logs and are commonly referred to as Jackson and Vicksburg, undivided, although they represent two different geologic epochs. Together, the units constitute a thick confining system. In places, where the upper part of the Vicksburg is sufficiently sandy, it acts as part of the overlying Miocene aquifer.

Miocene and Pliocene deposits present difficulties to regional hydrological investigations. Lithologically nearly identical, the sediments are difficult to impossible to differentiate in the subsurface. Although sands are traceable in restricted areas and are very important aquifers, from a regional viewpoint the complexly interbedded sands and clays do not lend themselves to logical hydrologic grouping or subdivision in much of the area.

In Texas and part of Louisiana the Miocene has been differentiated on the basis of both lithology and hydrology. The lower part of the Miocene, the Catahoula Tuff or Sandstone, in much of the updip part acts as a confining system. Downdip, the lower more permeable part of the Catahoula has been named the "Frio" Formation. Overlying the Frio, is the Anahuac Formation (Ellisor, 1944) a clay wedge that occurs only in the subsurface and thickens gulfward. Above the Catahoula, a thick sequence of interbedded sands and clays that has been named the Jasper aquifer (Wesselman, 1967) may include permeable beds of the upper part of the Catahoula. A predominantly clayey section overlying the Jasper aquifer has been named the Burkeville confining system (Wesselman, 1967). The Burkeville, considered to be the top or near the top of the Miocene deposits, separates the Jasper aquifer from the overlying Evangeline aquifer (Jones and others, 1956). The Evangeline aquifer is considered to be Pliocene (partly Miocene in eastern Texas and southwestern Louisiana) and is very similar lithologically to the Jasper. The two aquifers constitute important regional aquifer systems.

The Chicot aquifer (Jones and others, 1956), a gulfward-thickening wedge of Pleistocene sediments that overlies the Evangeline aquifer in southwestern Louisiana and Texas, is several hundred feet thick at the margin of the Gulf. The water-bearing strata are thick beds of sand or sand and gravel that are separated by discontinuous interbeds of clay. The Chicot is a very productive aquifer and is an extensive source of ground water.

The Citronelle Formation is the apparent correlative of the Chicot aquifer east of the Mississippi River and is similar lithologically; however, the age of the unit has been in dispute since it was first named and designated Pliocene in Alabama in 1916. A succession of workers variously assigned the Citronelle to Pliocene, Pleistocene, and Pliocene and Pleistocene age. In Alabama, Louisiana, Mississippi, and Florida the U.S. Geological Survey follows the Pliocene usage. However, the same deposits in southeastern Louisiana are shown as Pleistocene on the geologic map of Louisiana (Louisiana Geological Survey, 1984).

In this regional study, an approach was chosen that would best fit the regional framework and be compatible with subsurface correlations in the several States. The surficial post-Miocene deposits east of the Mississippi River that are mapped as Pleistocene on the geologic map of Louisiana and designated the Citronelle Formation by the U.S. Geological Survey in Louisiana, Mississippi, Alabama, and Florida are shown as Pleistocene in illustrations in this report.

The upland terrace aquifers are in dissected remnants of terrace sands and gravels composed of Pleistocene glacial outwash deposits. The aquifers are of regional significance only where they are in hydraulic connection with adjacent major alluvial aquifers. Smaller isolated terrace aquifers can be important local sources of ground water, but their impact on regional hydrology is negligible.

Alluvial and coastal aquifers of Holocene age constitute the youngest aquifers in the Gulf Coastal Plain. The alluvial aquifers vary in size and significance with width and extent of the floodplains they occupy. The largest alluvial aquifer is that of the Mississippi River. It is composed of sand and gravel grading finer upward to silt and clay. The aquifer is one of the most important in the area and is capable of yielding very large amounts of water. Direct recharge in areas proximate to the Mississippi River can be easily induced by heavy pumping of wells located near the river. Coastal aquifers occur in fine-grained sediments associated with the Mississippi River delta.

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)

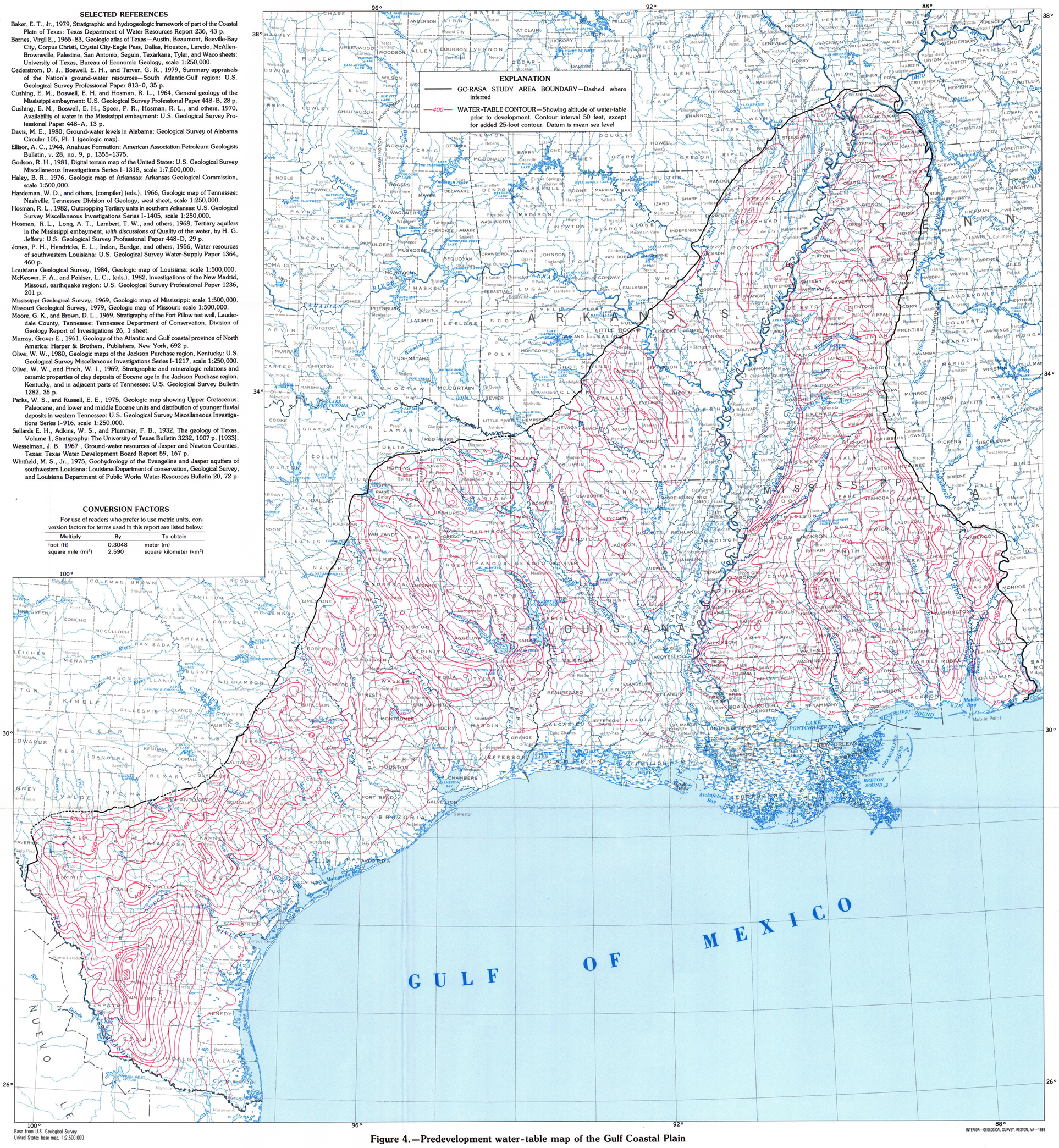

Figure 4.—Predevelopment water-table map of the Gulf Coastal Plain

SCALE 1:2 500 000

50 0 50 100 150 200 250 MILES

50 0 50 100 150 200 250 KILOMETERS

GEOHYDROLOGIC FRAMEWORK OF THE GULF COASTAL PLAIN

By
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1988