HYDROGEOLOGY OF THE MIDDLE WILCOX AQUIFER SYSTEM IN MISSISSIPPI

INTRODUCTION

This report describes the hydrogeology of the middle Wilcox aquifer system in Mississippi and its present use and potential for future freshwater development. The purpose of this report is to provide water-resource planners and managers with hydrogeologic data on this predominantly undeveloped aquifer system and to describe its potential as an alternative source of water in the State. This report was prepared to complete a series of map reports describing the hydrogeology of the major aquifers in Mississippi.

This report was prepared as part of the Gulf Coast Regional Aquifer System Analysis (RASA) project using hydrogeologic data assembled for the flow analysis of aquifers in Tertiary sediments in the Mississippi embayment study area (Arthur and Taylor, 1989).

LOCATION, STRATIGRAPHY, AND THICKNESS

Sediments of the Wilcox Group in Mississippi are exposed in a crescent-shaped belt extending from Benton and Tippah Counties in the north to Clarke, Kemper, and Lauderdale Counties in the east (fig. 1). The subsurface beds dip westward in the northern and western parts of the State because of the influence of the Mississippi embayment trough, which roughly parallels the Mississippi River. In the southern part of the study area, the direction of dip gradually shifts to the southwest toward the Gulf Coast geosyncline. The rate of dip ranges from about 20 feet per mile in the northern part of the study area to more than 50 feet per mile in the southern part. In the Jackson area, the trend of the dip is interrupted by the Jackson dome, a local structural uplift (fig. 1).

In Mississippi, the Wilcox Group of Paleocene and Eocene ages includes, in ascending order, the Nanafalia, Tuscahoma, and Hatchetigbee Formations (table 1). The Wilcox Group generally is undifferentiated throughout most of Mississippi. However, in areas where the Wilcox Group contains freshwater, sand beds that make up an important regional aquifer - the Meridian-upper Wilcox aquifer - mark the upper part of the Wilcox Group and the overlying Meridian Sand Member of the Tallahatta Formation (Boswell, 1976). The lower part of the Wilcox Group and the uppermost part of the underlying Midway Group in this area are also marked by thick sand beds that make up the important regional aquifer, the lower Wilcox aquifer (Boswell, 1975). In much of the area, numerous sand beds occur between the lower Wilcox and the Meridian-upper Wilcox aquifer. These sand beds are often irregular, discontinuous, and of local extent; however, the sand beds function as a single hydraulic unit and are collectively referred to as the middle Wilcox aquifer system and may represent a significant source of ground water. The intervening confining units consist mainly of clay. For a more detailed description of the units, the reader is referred to the report by Arthur and Taylor (1989).

The thickness of the middle Wilcox aquifer system increases from a few hundred feet in the outcrop area to more than 1,000 feet in the extreme downdip sections of the study area (sheet 2). Downdip from the outcrop area, total accumulated thickness of sand beds that are at least 20 feet thick ranges from less than 100 feet in the northern part of the study area to more than 400 feet in three localities in the central and south-central part of the study area (fig. 2). At least one sand bed 100 feet or more thick is present in a 15-county area that extends from Rankin and Smith Counties in the south to Tate County in the north.

GROUND WATER

The principal source of recharge to the middle Wilcox aquifer system is from precipitation in the outcrop area (fig. 1). Precipitation in the area ranges from about 50 to 56 inches per year, but of that amount about 16 to 20 inches per year leaves the area as surface runoff. Most of the water that percolates into the ground is lost by evapotranspiration or ground-water discharge to local streams.

Regional movement of ground water in the middle Wilcox aquifer system is from areas of high potentiometric levels to areas of low potentiometric levels--generally westward except in the southern part of the study area where movement is to the south-southwest. Locally, the rate and direction of ground-water movement are controlled by the hydraulic conductivity of the sand bed and by withdrawal from wells.

The potentiometric surface shown in figure 3 represents the approximate altitude of water levels in wells screened in the middle Wilcox aquifer system in 1983. Although the contours were based on water-level measurements throughout the year, the contours are considered representative because seasonal water-level changes are generally small (less than 5 feet) and because of the large contour interval (50 feet). Because the potentiometric map is based on water-level measurements from wells screened in different sand beds within the aquifer system, the water level of an individual sand bed could differ from that shown.

Near some pumping centers in and near the recharge area, water-level declines in recent years have been in the range of about 0.5 to 1.0 foot per year (fig. 4). Generally, however, the middle Wilcox aquifer system is unstressed (Arthur and Taylor, 1989) and no significant cones of depression occur in the aquifer.

WATER WELLS AND AQUIFER CHARACTERISTICS

Water wells have been completed in sand beds of the middle Wilcox aquifer system in 23 counties in Mississippi. Most of the several thousand water wells in this aquifer system are small-diameter domestic wells located in or immediately downdip from the outcrop area. Although yields from most of these wells are small, the aquifer system is capable of yielding large quantities of freshwater to larger wells. More than 90 wells in the middle Wilcox aquifer system yielded more than 100 gallons per minute; some wells yielded as much as 500 gallons per minute.

The availability of freshwater at shallower depths has limited the development of this aquifer system farther downdip. However, some water wells in the aquifer are more than 700 feet deep in the southern part of the study area and more than 800 feet deep in the western and northern parts of the study area. A few wells are more than 1,000 feet deep. More than 100 public and industrial wells in 18 counties in Mississippi obtain water from the middle Wilcox aquifer system.

Results of aquifer tests in the middle Wilcox aquifer system are sparse, but tests have been completed at 7 sites in 5 counties (Newcome, 1971), and specific capacity data are available for 15 sites in 9 counties (fig. 5). Well and aquifer characteristics obtained at these sites are summarized in the following table.

	Transmissivity (feet squared per day)	Hydraulic conductivity (feet per day)	Specific capacity (gallons per minute per foot)
Maximum	2,800	46	22
Median	530	16	3
Minimum	260	4	0.5
No. of tests	7	7	15

Although aquifer characteristics in the middle Wilcox aquifer system are variable, results from aquifer tests can be used to estimate water-level drawdowns in pumped wells and to plan well-spacing to minimize well interference. If transmissivity values of the aquifers and pumping rates of wells are known or can be estimated, evaluations of water-level drawdown during pumping can be made from figure 6. A well that is being pumped influences the water levels in nearby wells. The extent of the influence is a function of the rate of discharge, the transmissivity of the aquifer, and the time that has elapsed since pumping began. The influence that pumping a well will have on other wells in the same aquifer may be determined if the transmissivity and coefficient of storage of an aquifer are known or can be estimated (fig. 7). In planning well-spacing and withdrawal rates, consideration of drawdown effects for various combinations of time and distance is necessary.

GROUND-WATER QUALITY

Ground water in the outcrop area of the middle Wilcox aquifer system generally is of a mixed, calcium sodium bicarbonate type. Dissolved-solids concentrations generally are very small in the outcrop area but increase downdip to the west and southwest. As the water becomes more mineralized with increased distance from the outcrop area, sodium and bicarbonate become the major constituents in the water. On the basis of interpretation of geophysical log data, primarily during the Gulf Coast RASA investigation (Arthur and Taylor, 1989), freshwater -- water with a dissolved-solids concentration of less than 1,000 milligrams per liter -- extends about 70 miles from the outcrop in central Mississippi but only extends about 20 miles from the outcrop area in extreme northern and east-central Mississippi (fig. 1). Freshwater may be obtained from the middle Wilcox aquifer system in all or parts of 31 counties in Mississippi.

There is a general trend of increasing pH values and concentrations of dissolved sodium, bicarbonate, nitrate, and iron with increasing depth for the aquifer system. Typically, water in the middle Wilcox aquifer system has concentrations much smaller than the recommended limits for drinking water for nitrate (10 milligrams per liter as nitrogen), sulfate (250 milligrams per liter), and fluoride (2 milligrams per liter) (U.S. Environmental Protection Agency, 1986a, b).

Excessive concentrations of iron and color are common water-quality problems in parts of the lower Wilcox and the Meridian-upper Wilcox aquifers (Boswell, 1975, 1976), and it seems logical to assume they may be problems in some parts of the middle Wilcox aquifer system. Although iron concentrations have been determined in water from only a few wells in the middle Wilcox aquifer system, these concentrations did not exceed the recommended limit of 300 micrograms per liter (U.S. Environmental Protection Agency, 1986b) for drinking water. The recommended limit for color in drinking water (15 units) was exceeded in water from about 20 percent of the wells in the middle Wilcox aquifer system; the color of water from one well in Lauderdale County was 200 units (table 2).

Temperature of shallow ground water (about 100 feet or less deep) ranges from about 15.5 °C (60 °F) in Benton County to about 18.5 °C (65 °F) in Lauderdale County, and on an annual basis, approximates the mean annual air temperature. Ground-water temperature increases with depth at a rate of about 2.5 °C per 100 meters or about 1.4 °F per 100 feet (fig. 8).

WATER USE

In 1985, the middle Wilcox aquifer system was the source of water for about 38 public-supply systems and 7 large industries in Mississippi. [Data are from the U.S. Geological Survey Mississippi Site-specific Water-Use Data System (SWUDS)]. Total withdrawal of water for these uses was about 10 Mgal/d (million gallons per day) in 1985 (fig. 9 and table 3). About 4.0 Mgal/d were withdrawn for public supply and about 3.9 Mgal/d were used for irrigation. The largest withdrawals were in Grenada County where 5.2 Mgal/d were withdrawn primarily for irrigation and industry. The largest public-supply system was the town of Ackerman, in Choctaw County, which withdrew about 0.6 Mgal/d in 1985. Although thousands of small wells obtain water from this aquifer system for domestic and other uses, the total withdrawal for these uses is probably less than 1 Mgal/d.

POTENTIAL FOR FUTURE DEVELOPMENT

Regionally, the middle Wilcox aquifer system is a relatively undeveloped source of ground water in Mississippi. Although well yields in excess of 100 gallons per minute are possible, pumpage from this aquifer system is less than from any other of the extensive aquifers in the State. For this reason, water levels have not declined in this aquifer system as they have in other large aquifer systems. Water from this aquifer system generally is suitable for most uses.

The middle Wilcox aquifer system has the capability of serving as a source of water for much of Mississippi. Water from this aquifer system could augment existing water-supply systems locally if the adjacent lower Wilcox and Meridian-upper Wilcox aquifers cannot supply the demand for water or contain water of unsuitable quality.

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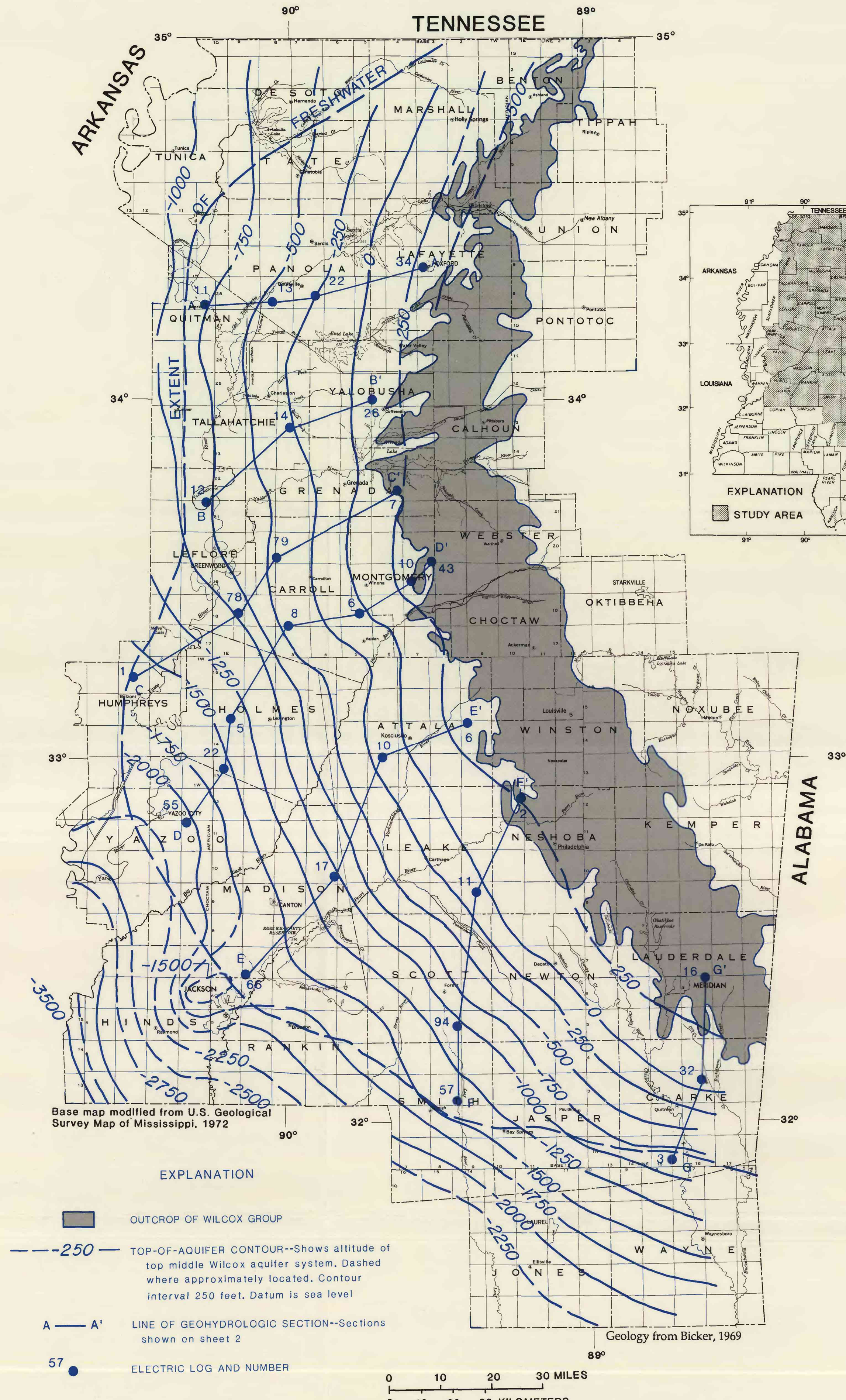

Figure 1.--Location of study area, outcrop of the Wilcox Group, configuration of the top of the middle Wilcox aquifer system, and locations of geohydrologic sections.

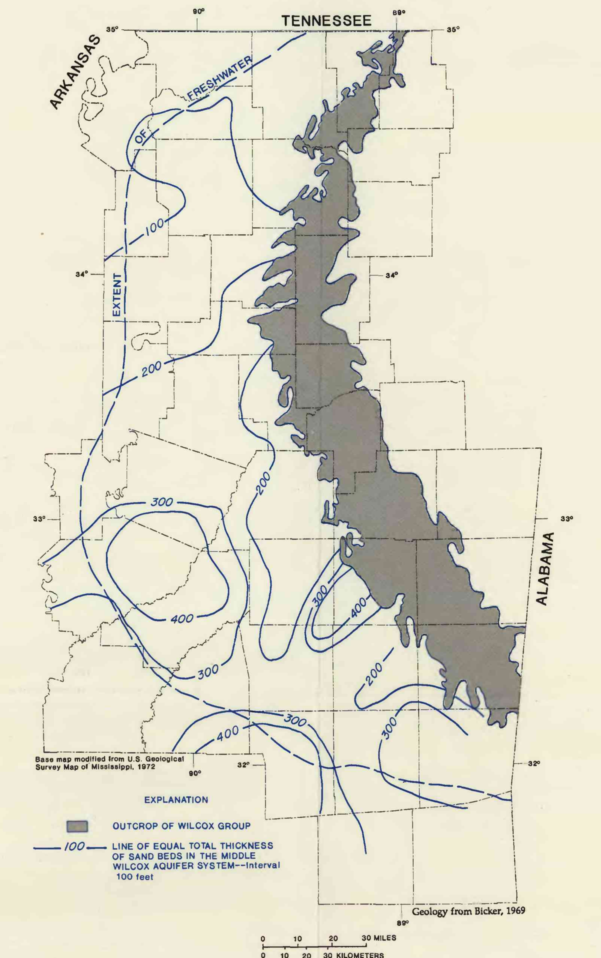

Figure 2.--Total thickness of sand beds in the middle Wilcox aquifer system.

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

The inch-pound units used in this report may be converted to metric (International System) units by the following factors.

Multiply inch-pound unit	by	To obtain metric unit
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
million gallons per day (Mgal/d)	0.04381	cubic meters per second
foot per mile (ft/mi)	18.9	centimeter per kilometer
foot squared per day (ft^2/d)	0.09290	meter squared per day
gallons per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter

Throughout this report water temperatures are reported in degrees Celsius (°C). Temperatures may be converted to degrees Fahrenheit (°F) equivalent with the following formula:

$$°F = 1.8\,°C + 32$$

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

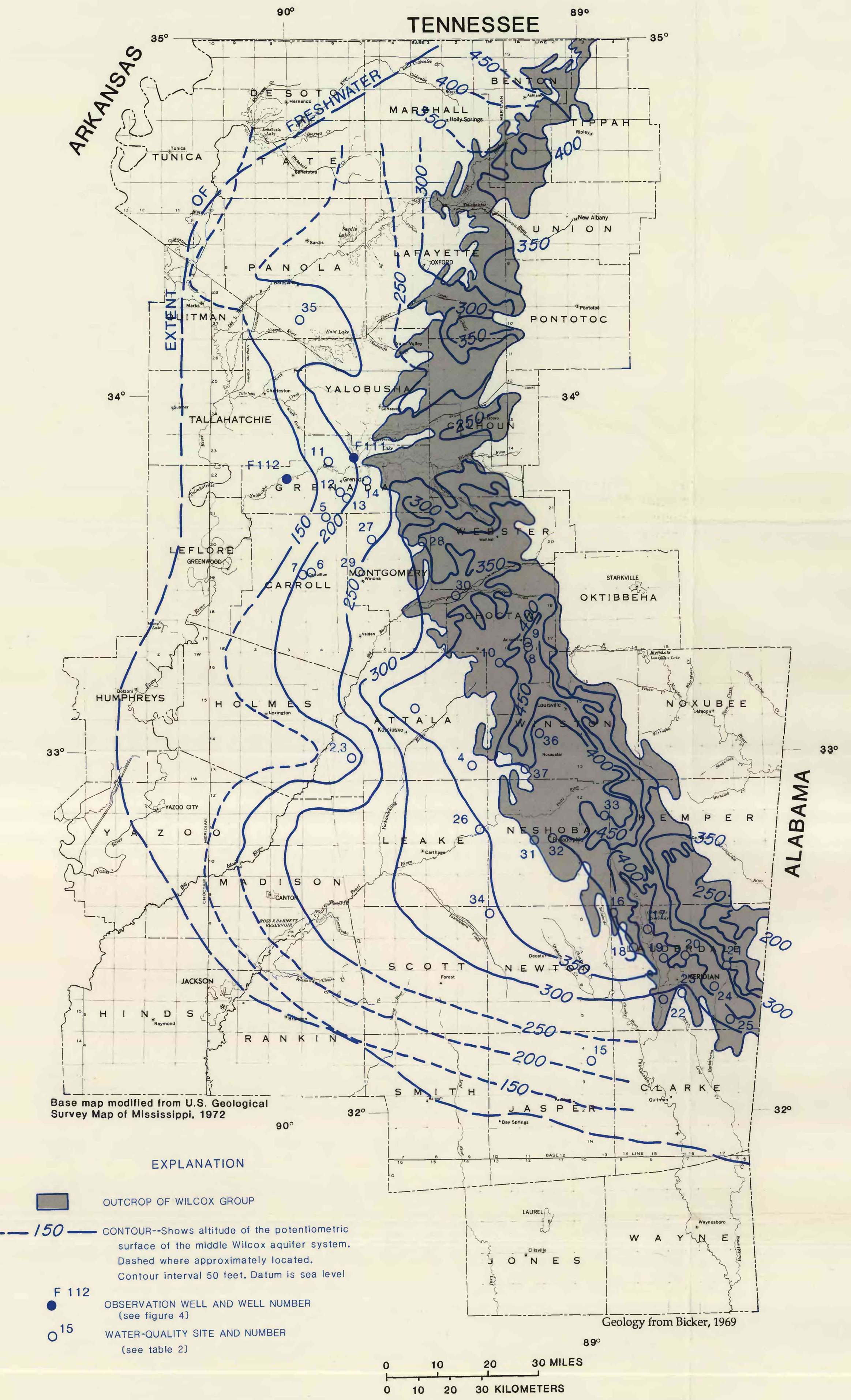

Figure 3.--Potentiometric surface of the middle Wilcox aquifer system.

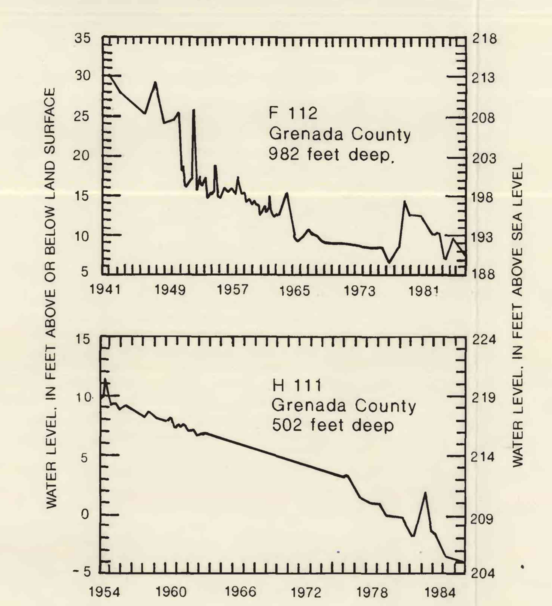

Figure 4.--Water-level trends in observation wells in the middle Wilcox aquifer system.

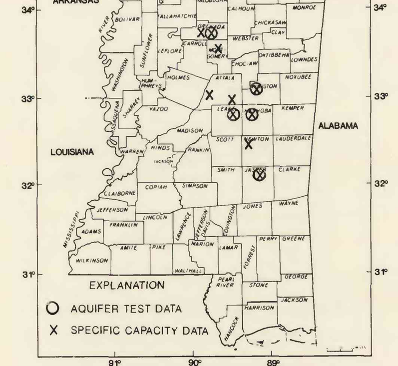

Figure 5.--Location of well sites with aquifer and specific capacity data.

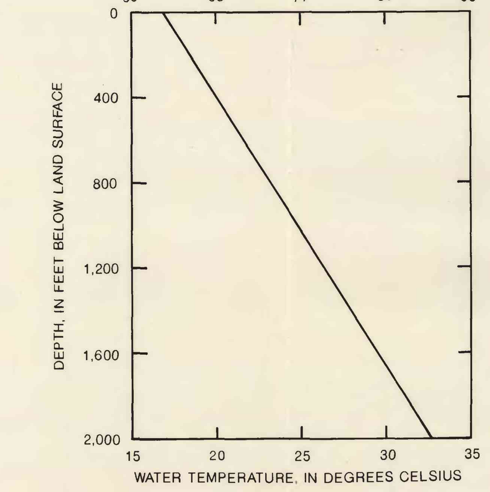

Figure 8.--Typical depth-temperature relation for the middle Wilcox aquifer system. (Modified from Dalsin, 1978)

Table 1.--Stratigraphic units and major aquifers and aquifer system

Erathem	Systems	Series	Group	Mississippi: Northern part	Mississippi: Central part	Major aquifers and aquifer systems
Cenozoic	Quaternary	Pleistocene and Holocene		Mississippi River alluvium and terrace deposits	Alluvium and terrace deposits, undifferentiated	Mississippi River valley alluvial aquifer
Cenozoic	Tertiary	Eocene	Jackson Group	Undifferentiated	Undifferentiated	
			Claiborne Group	Cockfield Formation	Cockfield Formation	Cockfield aquifer
				Cook Mountain Formation	Cook Mountain Formation Gordon Creek Shale Member Potterchitto Sand Member Archusa Marl Member	
				Sparta Sand	Sparta Sand	Sparta aquifer
				Zilpha Clay	Zilpha Clay	
				Winona Sand	Winona Sand	
				Tallahatta Formation	Tallahatta Formation Neshoba Sand Member Basic City Shale Member Meridian Sand Member	Meridian-upper Wilcox aquifer
		Eocene / Paleocene	Wilcox Group	Undifferentiated	Hatchetigbee Formation Bashi Marl Member	
					Tuscahoma Formation	middle Wilcox aquifer system
					Nanafalia Formation Fearn Springs Member	lower Wilcox aquifer
		Paleocene	Midway Group	Porters Creek Clay Tippah Sand Lentil	Naheola Formation Porters Creek Clay Matthews Landing Marl Member	
				Clayton Formation	Clayton Formation	
Mesozoic	Cretaceous	Upper Cretaceous	Selma Group	Undifferentiated	Undifferentiated	

(Modified from Boswell, 1975, table 1)

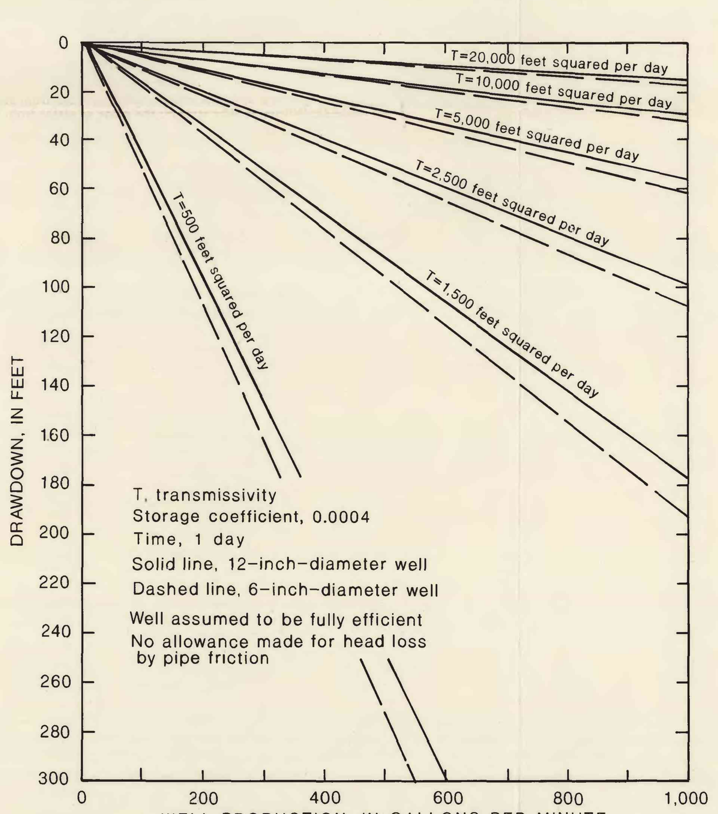

Figure 6.--Drawdown to be expected in pumped wells tapping an artesian aquifer of the study area (modified from Dalsin, 1978).

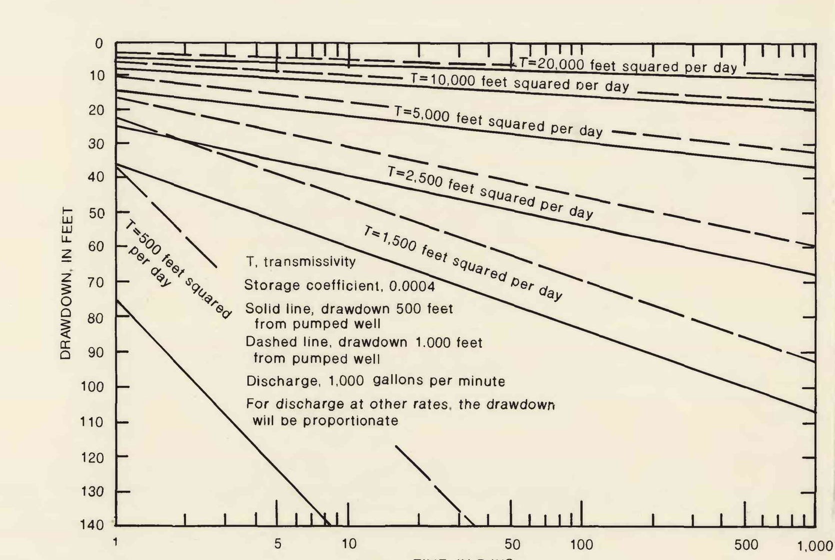

Figure 7.--Theoretical time-distance-drawdown relations for pumping from an artesian aquifer of the study area (modified from Dalsin, 1978).

Table 2.--Physical and chemical characteristics of water from selected wells in the middle Wilcox aquifer system in Mississippi

[Units in milligrams per liter, except as noted: ft, feet; ug/L, micrograms per liter; dashes indicate missing values]

Site no.	Depth (ft)	Date (y-m-d)	pH (units)	Color (units)	Dissolved: Solids (sum)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3, as N)	Iron (Fe) (ug/L)
							ATTALA COUNTY								
1	561	63-11-07	7.3	1	130	19	6.2	11	4.0	108	7.2	2.8	0.1	0.09	–
2	1,180	82-07-07	8.2	20	320	1.2	.2	130	.8	–	2.0	4.9	.1	–	160
3	1,000	84-09-17	7.9	1	190	21	1.9	43	2.2	–	15	2.4	.1	–	220
4	520	72-03-29	7.0	5	170	31	5.5	14	3.4	130	15	7.9	.1	.02	–
							CARROLL COUNTY								
5	858	85-05-27	8.3	30	280	2.2	.6	110	1.3	–	.9	14	.2	–	200
6	727	72-10-19	8.2	5	308	3.1	.5	120	3.0	292	1.0	13	.2	–	40
7	849	79-06-28	8.6	5	400	2.1	.4	160	1.5	380	.9	17	.2	–	10
							CHOCTAW COUNTY								
8	114	70-03-12	5.4	–	43	4.8	.0	9.7	1.8	–	3.2	12	.0	–	–
9	112	65-08-29	5.4	–	31	1.6	1.7	–	–	–	.0	–	.0	–	–
10	3	76-01-30	5.4	0	34	3.0	.8	2.9	.9	16	.6	4.8	.3	–	10
							GRENADA COUNTY								
11	653	71-03-10	8.4	20	430	4.4	1.2	162	2.2	314	.2	67	.2	.16	–
12	610	71-03-10	7.6	10	370	2.1	1.2	147	1.3	348	.2	33	.2	.20	–
13	530	69-04-30	8.4	15	260	4.4	1.9	102	.5	–	.0	25	.0	–	–
14	482	71-03-10	7.5	5	240	3.4	1.8	88	1.5	224	2.4	16	.1	.14	–
							JASPER COUNTY								
15	886	67-05-31	8.1	40	230	2	.2	32	.8	344	9.0	2.4	.2	.04	–
							LAUDERDALE COUNTY								
16	185	68-09-26	6.6	20	100	10	2.4	8.4	1.5	56	6.4	2.4	.1	.02	–
17	240	68-09-26	7.2	10	150	23	3.8	22	1.9	152	.4	1.5	.0	.00	–
18	350	68-09-26	7.2	10	160	21	.6	37	1.1	152	10	2.0	.0	.00	–
19	365	68-09-27	7.4	5	180	40	1.7	14	1.0	162	6.8	2.2	.0	.02	–
20	420	68-09-27	6.9	200	140	17	6.0	5.7	2.7	100	.0	2.8	.2	.07	–
21	270	68-09-27	7.4	10	220	27	13	33	1.5	230	.0	7.0	.0	.04	–
22	300	67-05-23	7.8	10	190	5	.4	73	.7	176	12	2.9	.1	.00	–
23	745	61-10-25	7.4	5	150	31	3.1	10	2.1	132	5.6	2.2	.0	.00	–
24	420	68-09-19	7.4	5	170	16	.5	45	1.2	158	13	2.1	.0	.02	–
25	510	68-09-19	7.2	5	170	29	.4	29	1.2	156	10	2.8	.0	.02	–
							LEAKE COUNTY								
26	849	85-07-11	–	5	170	12	1.1	48	1.3	–	9.7	1.9	.1	–	18
							MONTGOMERY COUNTY								
27	530	85-07-29	–	4	190	2.6	.6	72	1.3	–	2.8	5.8	.1	–	130
28	586	78-05-24	8.3	40	180	4.4	1.2	65	2.2	180	3.2	6.1	.1	–	10
29	569	71-02-16	7.0	25	150	15	4.3	26	3.0	116	14	3.1	.1	.09	–
30	73	13-08-14	–	–	300	22	18	–	–	183	28	33	–	.00	–
							NESHOBA COUNTY								
31	727	70-03-12	8.5	0	180	18	3.4	42	3.9	161	5.8	1.0	.1	.20	–
32	267	16-09-27	–	–	115	9.9	1.9	–	–	29	13	12	–	.00	–
33	312	71-05-19	6.2	–	50	17	1.2	5.1	1.2	21	29	8.9	–	–	–
							NEWTON COUNTY								
34	525	85-05-07	8.3	5	180	1.6	.4	64	1.8	–	8.4	2.5	.1	–	63
							PANOLA COUNTY								
35	823	72-10-17	7.4	0	160	9.9	2.5	44	3.2	152	5.2	1.1	.1	–	–
							WINSTON COUNTY								
36	467	70-05-05	7.8	5	210	47	6.5	18	2.8	218	.0	4.3	.1	.02	–
37	505	70-03-18	8.1	2	170	33	6.2	11	2.1	150	3.8	2.2	.0	.07	–

Table 3. -- Water withdrawals from the middle Wilcox aquifer system, Mississippi, 1985

[Data are in million gallons per day. (Data are from the U.S. Geological Survey Site-specific Water-Use Data System.)]

County	Public supply	Industrial and commercial	Irrigation	Livestock	Total
Attala	0.372	0.001	0.000	0.000	0.373
Carroll	.294	.238	.000	.000	.532
Choctaw	.583	.000	.000	.000	.583
Grenada	.211	.363	3.940	.696	5.210
Holmes	.057	.000	.000	.000	.057
Jasper	.100	.000	.000	.000	.100
Kemper	.199	.000	.000	.000	.199
Lafayette	.037	.019	.000	.000	.056
Lauderdale	.358	.000	.000	.000	.358
Leake	.193	.000	.000	.000	.193
Montgomery	.400	.000	.000	.000	.400
Neshoba	.046	.000	.000	.703	.749
Panola	.452	.000	.000	.000	.452
Scott	.263	.000	.000	.000	.263
Tallahatchie	.191	.000	.000	.000	.191
Webster	.013	.000	.000	.000	.013
Winston	.143	.000	.000	.000	.143
Yalobusha	.121	.000	.000	.000	.121
TOTAL	4.033	.621	3.940	1.399	9.993

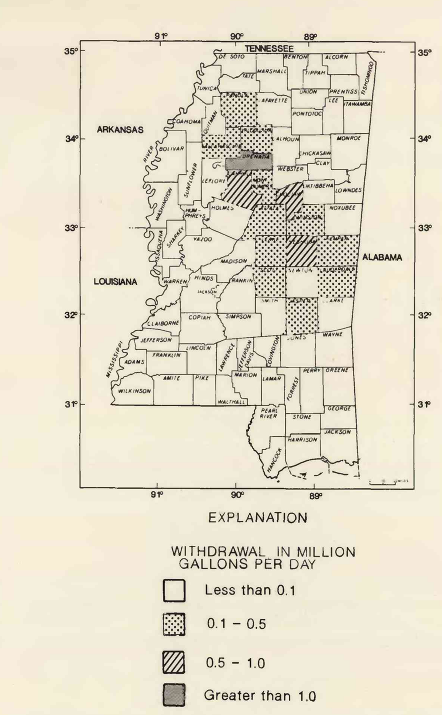

Figure 9.--Ground-water withdrawals from the middle Wilcox aquifer system, 1985.

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R.E. TAYLOR AND J.K. ARTHUR

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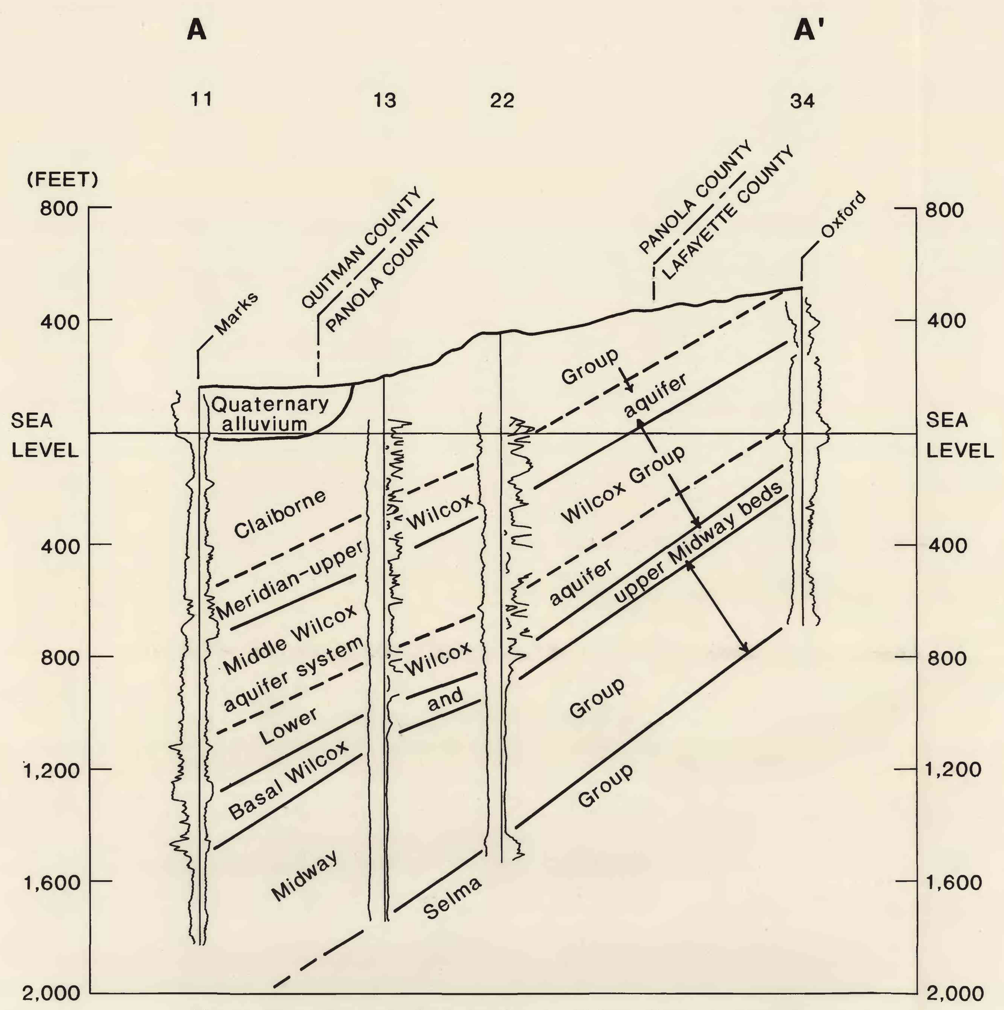


Figure 10.--Geohydrologic section A-A' from Quitman County to Lafayette County, Mississippi.

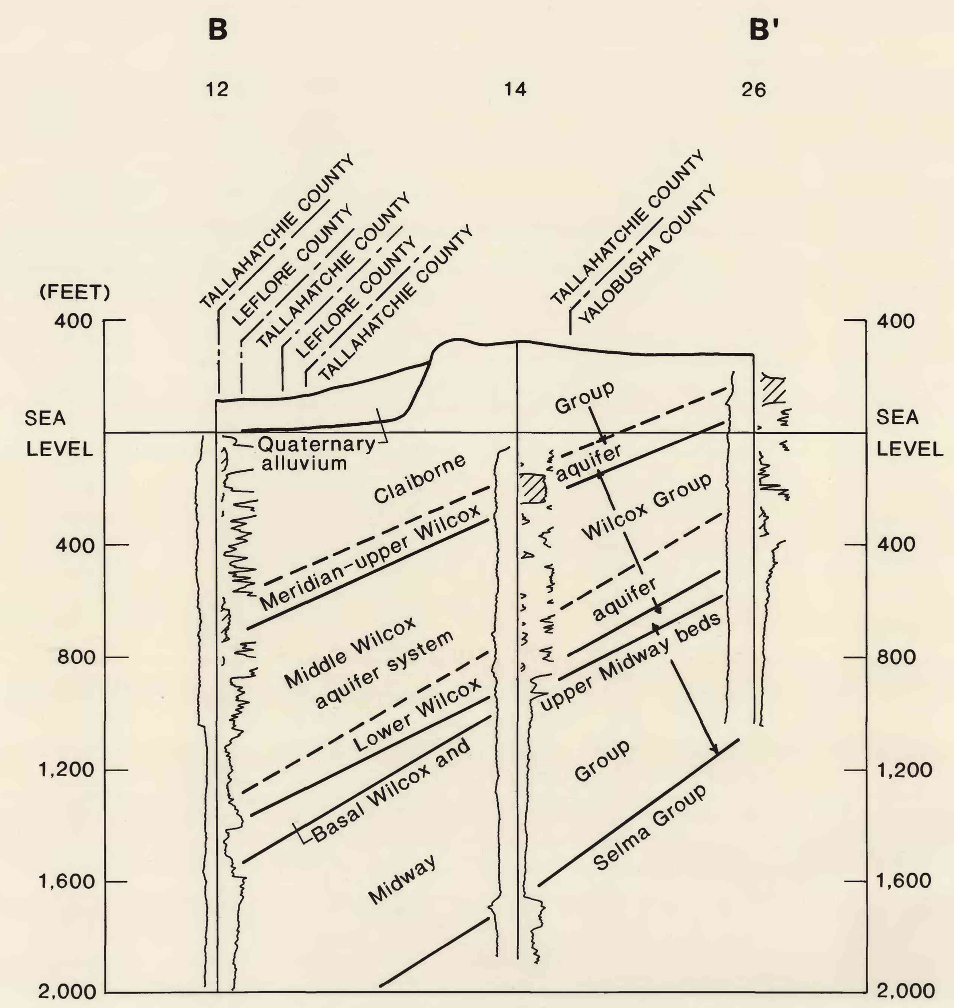


Figure 11.--Geohydrologic section B-B' from Tallahatchie County to Yalobusha County, Mississippi.

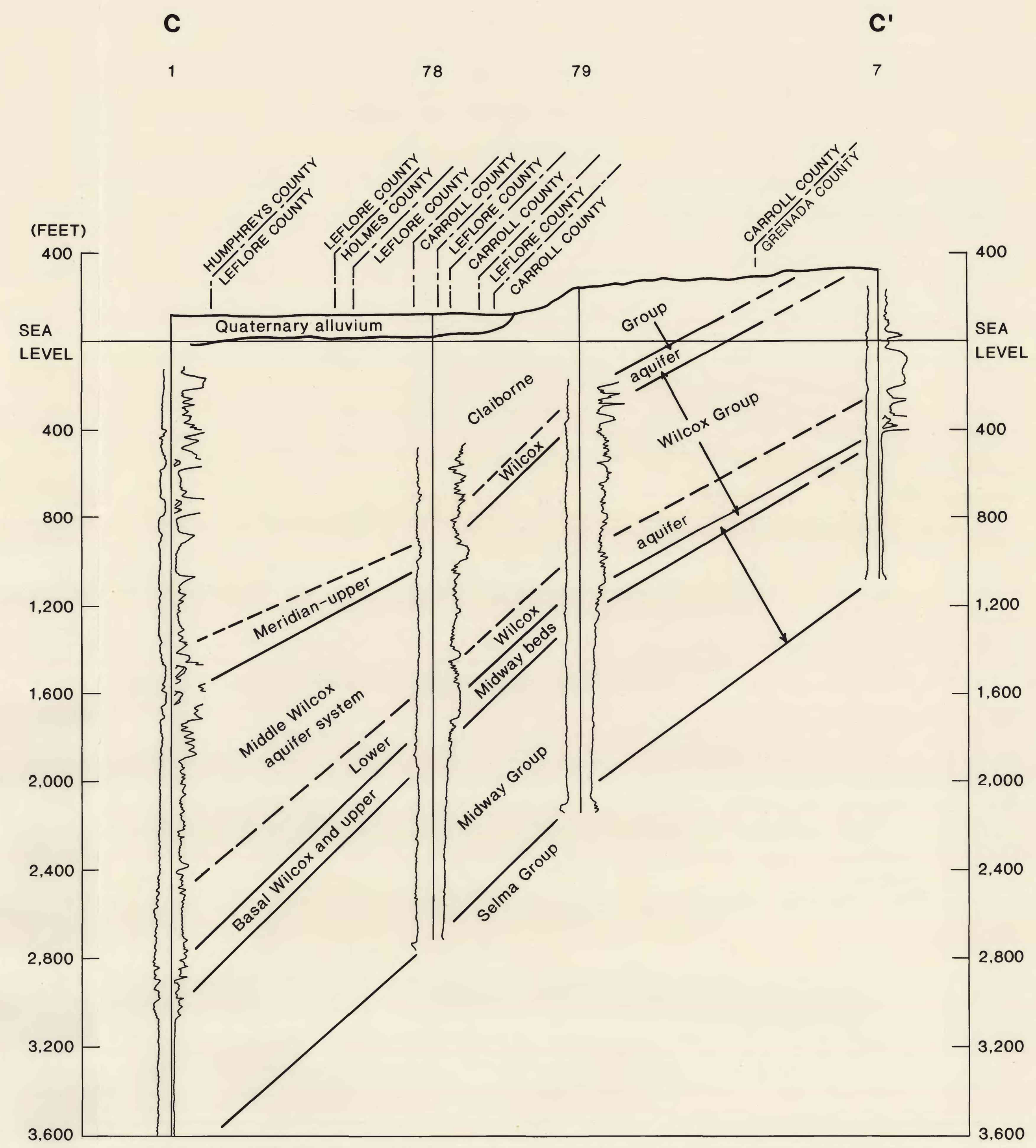


Figure 12.--Geohydrologic section C-C' from Humphreys County to Grenada County, Mississippi.

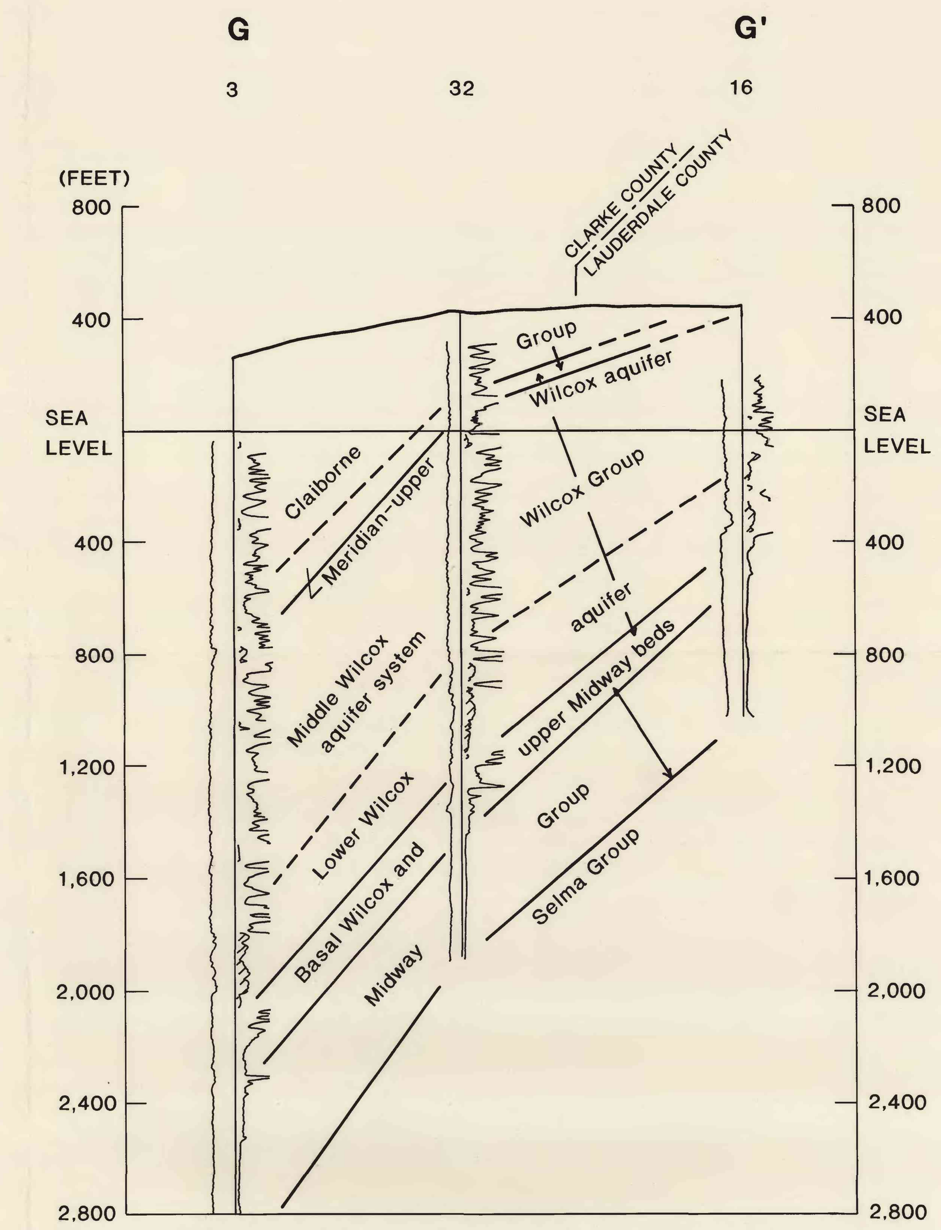
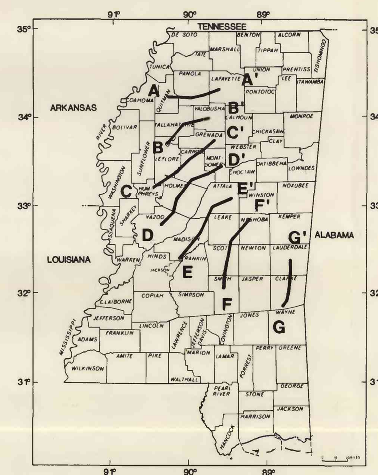
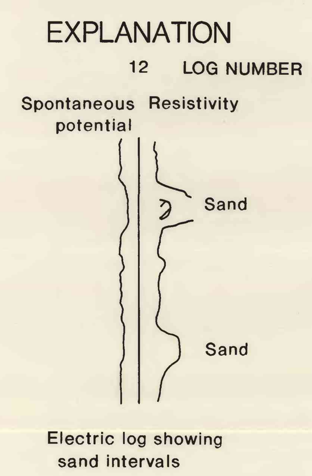


Figure 16.--Geohydrologic section G-G' from Clarke County to Lauderdale County, Mississippi.



GENERALIZED LOCATION OF SECTION LINES



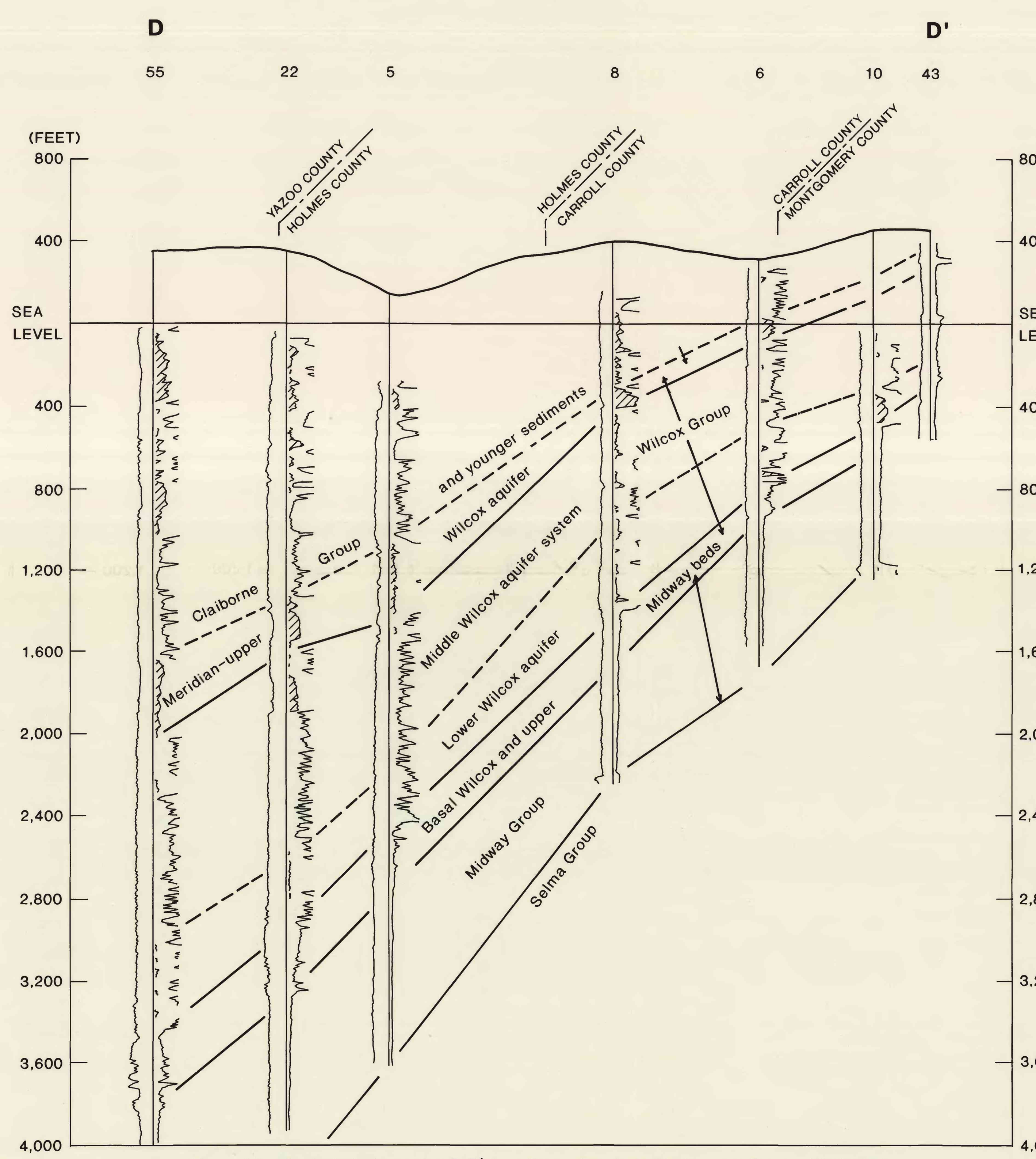


Figure 13.--Geohydrologic section D-D' from Yazoo County to Montgomery County, Mississippi.

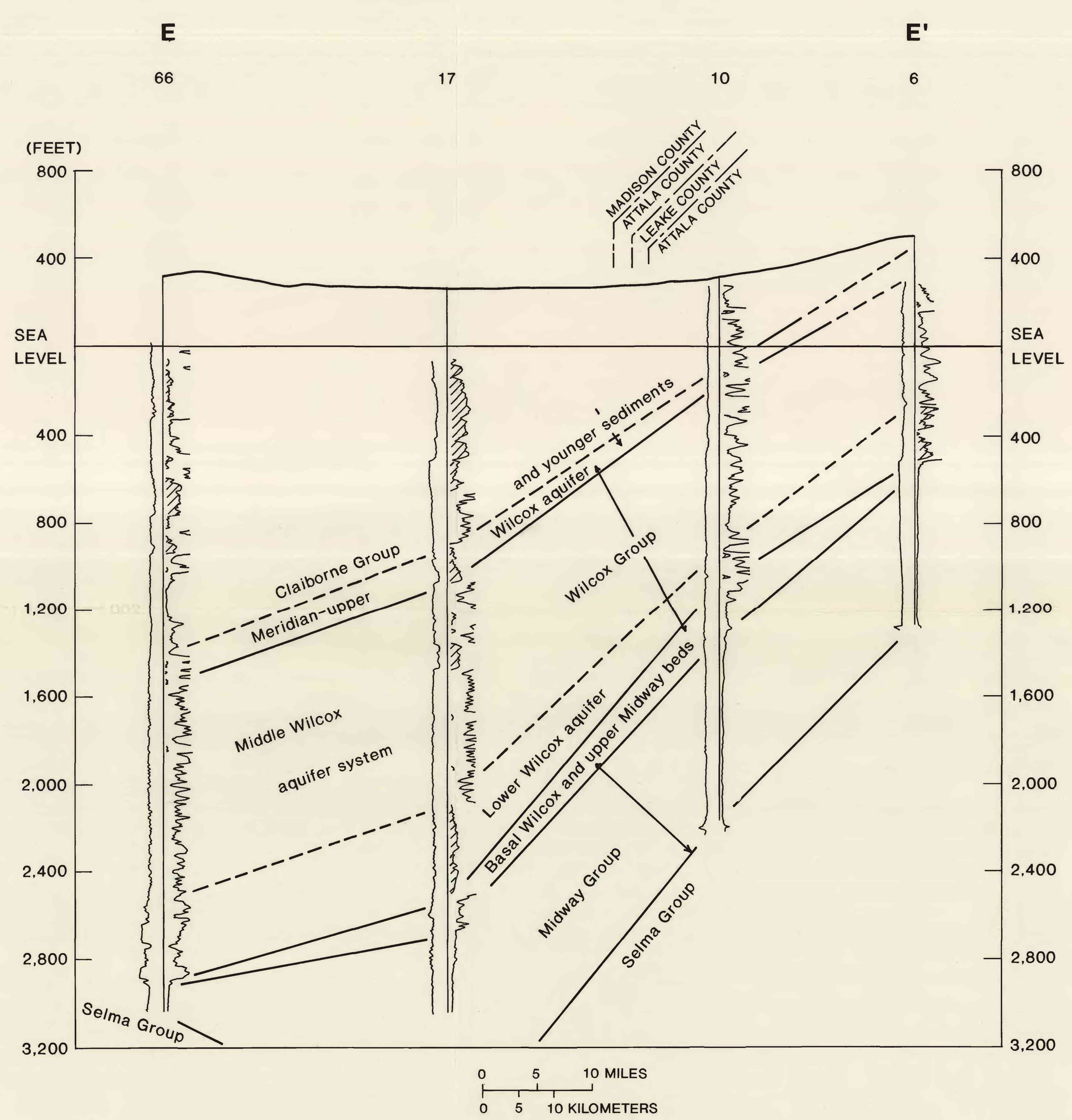


Figure 14.--Geohydrologic section E-E' from Madison County to Attala County, Mississippi.

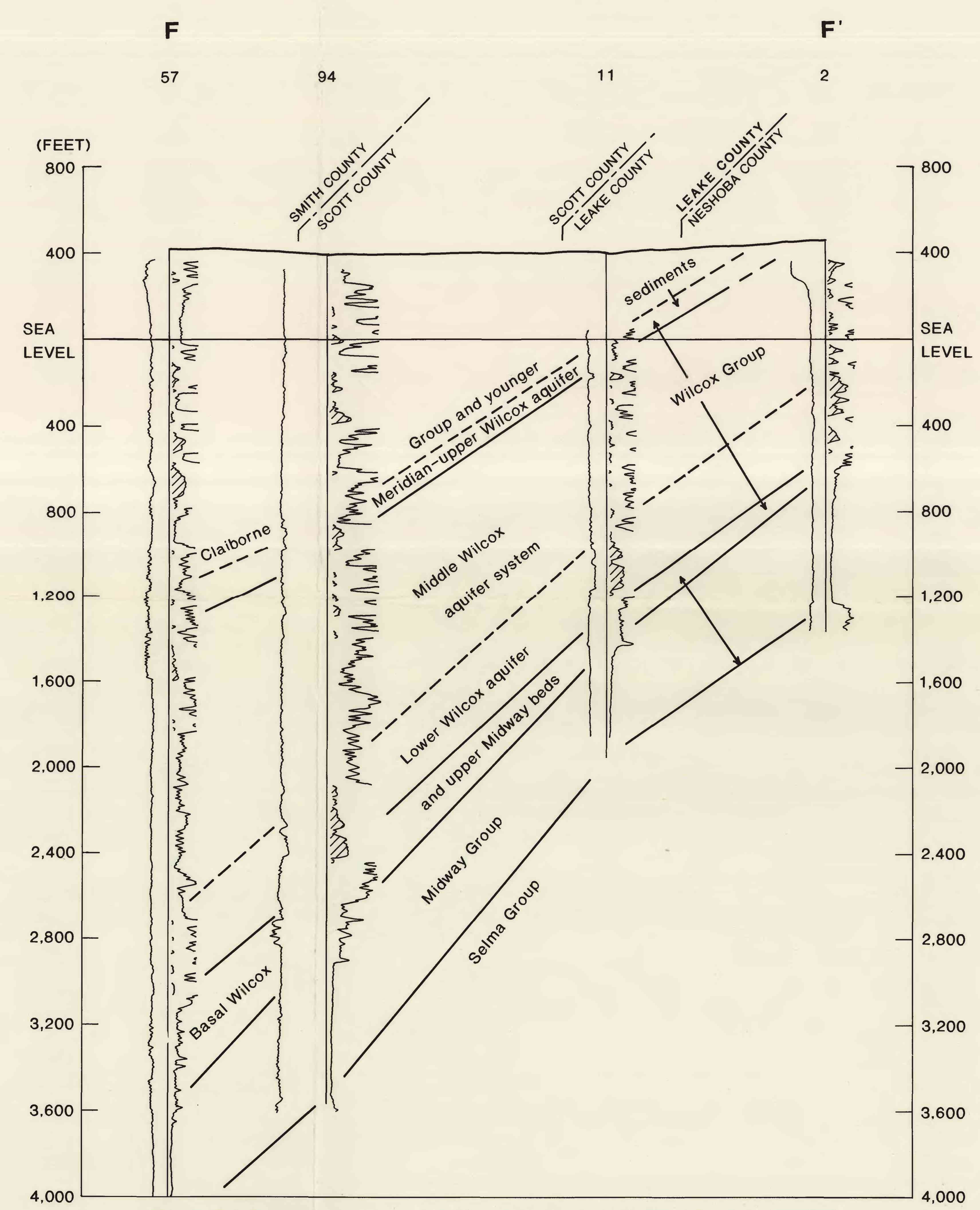


Figure 15.--Geohydrologic section F-F' from Smith County to Neshoba County, Mississippi.

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