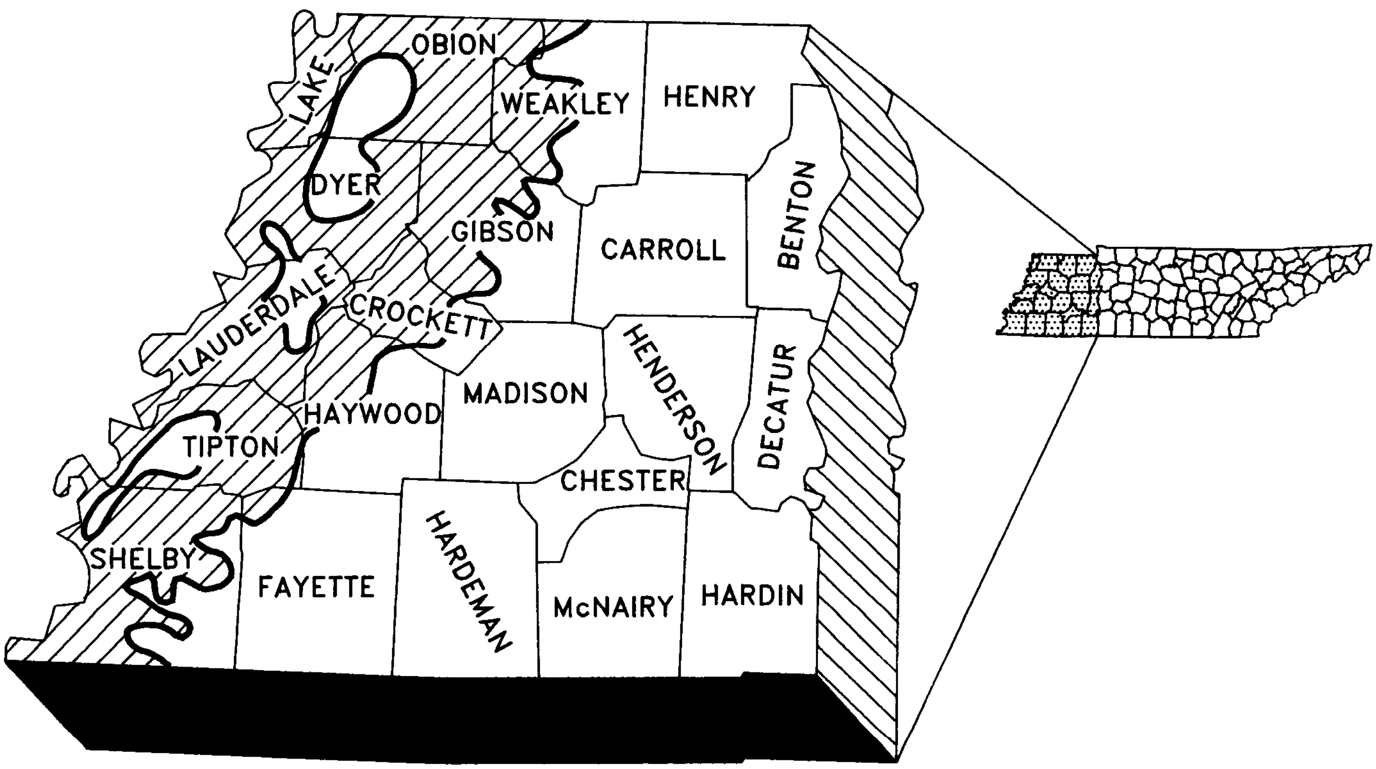
science for a changing world

Water-Resources Investigations Report 88-4181

GEOLOGY AND GROUND-WATER RESOURCES OF THE COCKFIELD FORMATION IN WESTERN TENNESSEE



Prepared by the
U.S. GEOLOGICAL SURVEY

Click here to return to USGS Publications

GEOLOGY AND GROUND-WATER RESOURCES OF THE COCKFIELD FORMATION IN WESTERN TENNESSEE

By W.S. Parks and J.K. Carmichael

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 88-4181

Memphis, Tennessee
1990

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
A-413 Federal Building
U.S. Courthouse
Nashville, Tennessee 37203

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center, Building 810
Box 25425
Denver, Colorado 80225

CONTENTS

PLATES (in pocket)

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

Factors for converting inch-pound units used in this report to metric units are as follows:

Multiply inch-pound units	By	To obtain metric units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
foot per year (ft/yr)	30.48	centimeter per year (cm/yr)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	0.00379	cubic meter (m^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)

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."

Well-Numbering System: Wells are identified according to the numbering system used by the U.S. Geological Survey throughout Tennessee. The well number consists of three parts: (1) an abbreviation of the name of the county in which the well is located; (2) a letter designating the $7^1/_2$-minute topographic quadrangle on which the well is plotted; and (3) a number generally indicating the numerical order in which the well was inventoried. The symbol Ld:L-2, for example, indicates that the well is located in Lauderdale County on the "L" quadrangle and is identified as well 2 in the numerical sequence. Quadrangles are lettered from left to right, beginning in the southwest corner of the county.

GEOLOGY AND GROUND-WATER RESOURCES OF THE COCKFIELD FORMATION IN WESTERN TENNESSEE

W.S. Parks and J.K. Carmichael

ABSTRACT

The Cockfield Formation of the Claiborne Group of Tertiary age underlies approximately 4,000 square miles in western Tennessee. The formation consists primarily of lenticular beds of very fine to coarse sand, silt, clay, and lignite. The Cockfield Formation has been extensively eroded, and the original thickness is preserved only in a few areas where the formation ranges from 235 to 270 feet in thickness. Saturated beds or lenses of sand in the formation make up the Cockfield aquifer.

Recharge to the Cockfield aquifer is from precipitation on sparse outcrops or by downward infiltration of water from the overlying fluvial deposits of Tertiary(?) and Quaternary age and alluvium of Quaternary age or, where present, the overlying Jackson Formation of Tertiary age. Data from two observation wells indicate that water levels have risen at average rates of about 0.5 and 0.7 foot per year during the period 1980-85. Water from the Cockfield aquifer is a calcium bicarbonate type that contains low concentrations of most major constituents and generally is suitable for most uses. Dissolved-solids concentrations range from 44 to 218 milligrams per liter. Data from two aquifer tests indicate transmissivities of 2,500 and 6,000 feet squared per day and storage coefficients of 0.0003 and 0.0007, respectively.

The Cockfield aquifer provides small to moderate quantities of water for several public and industrial water supplies and small quantities to numerous domestic and farm wells. Withdrawals for public and industrial supplies in 1983 averaged about 3.3 million gallons per day. Although the Cockfield aquifer locally contains sands that are thick and coarse enough to yield moderate quantities of water to wells, at most places the aquifer probably would yield only enough water for domestic and farm use.

INTRODUCTION

This report was prepared by the U.S. Geological Survey as part of the Gulf Coast Regional Aquifer-System Analysis (GC RASA) program. The GC RASA study area covers about 230,000 mi^2 onshore in Louisiana and parts of Alabama, Arkansas, Florida, Illinois, Kentucky, Mississippi, Missouri, Tennessee, and Texas. About 60,000 mi^2 offshore on the continental shelf also are included, because the aquifers extend beyond the coast line beneath the Gulf of Mexico. The study is limited to the Coastal Plain sediments of Tertiary and younger age, except for an area in the Mississippi embayment where Upper Cretaceous sediments supply ground water in parts of several states. The objectives of the GC RASA study are to define the geohydrologic framework, to describe the chemistry of the ground water, and to analyze the regional ground-water flow system (Grubb, 1984).

Background Information

Information interpreted or compiled for use in the GC RASA study aquifers in Tertiary sediments in western Tennessee as a part of the GC RASA study included: (1) geophysical-log correlations of the stratigraphic and geohydrologic units, (2) thicknesses of sand and clay beds in the geohydrologic units, (3) maps of the water-table and potentiometric surfaces in the aquifers, (4) data showing long-term water-level changes, (5) historic pumpage from the aquifers, (6) hydraulic characteristics of the aquifers, (7) water-quality data, and (8) locations of pumping centers. Much of this information was interpreted or compiled from existing geophysical logs, water-level data, pumpage inventories, aquifer-test records, and water-quality analyses. New data collected for GC RASA included: (1) water-quality data from about 40 wells, (2) water-level measurements in about 70 wells, (3) location of currently used public and industrial water-supply wells, and (4) field verification of the locations of wells for which important historic data are available.

Purpose and Scope

This report summarizes and interprets the information and data collected on the geology and ground-water resources of the Cockfield Formation in western Tennessee as part of the larger GC RASA investigation. Similar reports were prepared for the Memphis Sand and the Fort Pillow Sand (Parks and Carmichael, 1989; 1990). Reports also were prepared to show the altitude of the potentiometric surfaces in the Memphis and Fort Pillow aquifers for the fall of 1985 and to describe historic water-level changes in these aquifers (Parks and Carmichael, in press a,b).

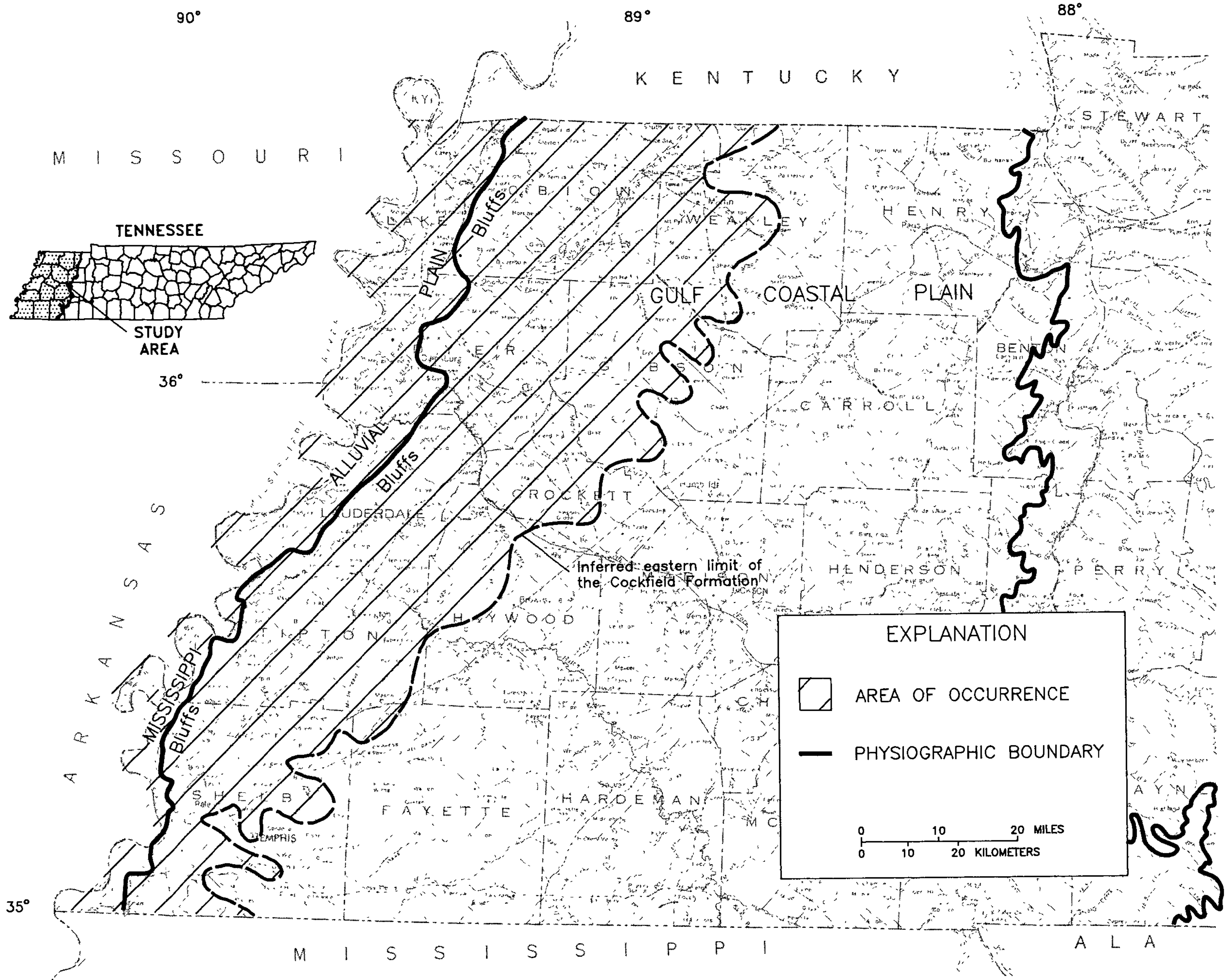
GEOLOGY

The Cockfield Formation (Vaughan, 1895, p. 220) of the Claiborne Group of Tertiary age underlies about 4,000 mi^2 in the Gulf Coastal Plain of western Tennessee (fig. 1). Outcrops of the formation are sparse because it is covered at most places by fluvial deposits of Tertiary(?) and Quaternary age and loess and alluvium of Quaternary age. Post-Cretaceous geologic units in western Tennessee and their hydrologic significance are given in table 1.

Stratigraphy

The Cockfield Formation has been recognized only in recent years in the northern part of the Mississippi embayment, including western Tennessee. In a report on the geology and hydrology of the Claiborne Group in western Tennessee, Moore (1965) included in the "unnamed clay unit," "unnamed sand unit," and his Jackson(?) Formation the sequence of strata now known to be the upper part of the Memphis Sand and the Cook Mountain, Cockfield, and Jackson Formations. On the most recent geologic map of Tennessee, Hardeman and others (1966) assigned the youngest Tertiary strata to the Jackson(?) Formation. This sequence is now known to include the Cockfield and Jackson Formations.

The presence of the Cockfield Formation in Tennessee and Kentucky was suspected by Hosman and others (1968), who state that "Plate 8 does not show the Cockfield Formation north of lat 35 N., because positive identification of the Cockfield deposits has not been established in this area." They state further that "...the Cockfield may be present in the northern part of



Base from U.S. Geological Survey, State base map, 1:500,000, 1973

Figure 1.--Occurrence of the Cockfield Formation as related to major physiographic subdivisions in western Tennessee.

Table 1.--*Post-Cretaceous geologic units underlying western Tennessee and their hydrologic significance*

System	Series	Group	Stratigraphic unit	Thickness (in feet)	Lithology and hydrologic significance
Quaternary	Holocene and Pleistocene		Alluvium (alluvial deposits)	0-200	Sand, gravel, silt, and clay. Underlies the Mississippi Alluvial Plain and the alluvial plains of streams in the Gulf Coastal Plain upland areas. Thickest beneath the Mississippi Alluvial Plain where it commonly is between 100 and 150 feet thick and makes up the Mississippi River Valley alluvial aquifer. Generally less than 50 feet thick elsewhere. Provides water to farm and domestic wells and to some industrial and irrigation wells in the Mississippi Alluvial Plain.
	Pleistocene		Loess	0-70	Silt, silty clay, and minor sand. Principal unit at the surface in upland areas of the Gulf Coastal Plain, concealing the older Quaternary and Tertiary units at most places. Thickest on the bluffs that border the Mississippi Alluvial Plain; generally thinner eastwards. Retards downward movement of the water that provides recharge to the water-table aquifers.
Quaternary and Tertiary(?)	Pleistocene and Pliocene(?)		Fluvial deposits (terrace deposits)	0-100	Sand, gravel, minor clay and ferruginous sandstone. Generally underlie the loess in upland areas, but are locally absent. Thickness varies greatly because of erosional surfaces at top and base. Provides water to farm and domestic wells in rural areas.
Tertiary	Eocene	?	Jackson Formation	0-150	Sand, silt, clay, and lignite. Because of similarities in lithology, the Jackson and Cockfield cannot be reliably subdivided based on available information. Preserved sequence mostly Cockfield, but locally is overlain by the Jackson. Thicknesses are estimates based on tentative geophysical log correlations. The Jackson and Cockfield provide water to farm and domestic wells in rural areas and the Cockfield provides water for some public and industrial supplies.
		Claiborne	? Cockfield Formation ?	0-270	
			Cook Mountain Formation ?	40-200	Clay, silt, and sand. Generally consists of clay and silt, but locally may consist predominately of fine sand. Probably averages about 70 feet in thickness. Unit can be confused with clay lenses in the lower part of the Cockfield or upper part of the Memphis Sand. Serves as upper confining unit for the Memphis Sand.
			Memphis Sand ("500-foot" sand)	400-890	Sand, silt, clay, and minor lignite. Consists of a thick body of sand with clay lenses at various horizons. Sand is fine to very coarse. Upper part commonly contains fine sediments, particularly north of the Hatchie River where it is generally necessary to drill to the middle or lower parts of the aquifer to install large capacity wells. Thickest in Shelby County where it is the principal aquifer supplying water to the City of Memphis. Major aquifer providing water for most public and industrial supplies in the western part of western Tennessee.
	?	Wilcox	Flour Island Formation	0-310	Clay, silt, sand, and lignite. Not an aquifer. Consists predominantly of clay and silt. Where present, serves as lower confining unit for the Memphis Sand and the upper confining unit for the Fort Pillow Sand.
	Paleocene		Fort Pillow Sand ("1400-foot" sand)	0-350	Sand and minor clay. Sand is fine to very coarse. Thickest in the Dyer-Lake County area. Once used as the second principal aquifer to supply water for the City of Memphis; now used by an industry at Memphis and the City of Millington. Provides water for some municipal and industrial supplies just downdip from its outcrop belt. Major aquifer in rudimentary stage of development.
			Old Breastworks Formation[1]	0-310	Clay, silt, sand, and lignite. Not an aquifer. Consists predominantly of clay and silt. Where present, serves as the lower confining unit for the Fort Pillow Sand along with Porters Creek Clay and Clayton Formation.
		? Midway	Porters Creek Clay	40-320	Clay and minor sand. Consists of a widespread and generally thick body of clay with local interbeds or lenses of fine sand. Serves as the major confining unit between the Fort Pillow Sand of Tertiary age and the McNairy Sand of Cretaceous age.
			Clayton Formation	40-110	Clay, sand, and limestone. Generally consists of clay with local interbeds or lenses of fine sand and limestone. North of Hardeman County in a narrow belt paralleling and including the outcrop area, the Clayton is predominantly sand and provides water to some farm and domestic wells. Underlain by the Owl Creek Formation and McNairy Sand of Cretaceous age.

[1]Frederiksen and others (1982) tentatively placed the Old Breastworks Formation in the Midway Group, but for the purposes of this report the Old Beastworks Formation of the Wilcox Group as defined by Moore and Brown (1969) is used.

the embayment east of the axis where the land surface is at a higher altitude." Moore and Brown (1969) first identified the Cockfield Formation in their study of the stratigraphy of the Fort Pillow test well in Lauderdale County, Tenn. They referred to the sequence as the "Jackson through Cockfield, undivided."

Parks (1978) recognized strata equivalent to the Cockfield Formation in the Memphis area. This strata was included in a unit referred to as the "Jackson, Cockfield, and Cook Mountain Formations." Parks and others (1985) mapped the Cockfield Formation in the subsurface of Lauderdale County. During the present investigation, the Cockfield Formation was mapped on a regional scale in the subsurface of western Tennessee. The Cockfield Formation is underlain by the Cook Mountain Formation of the Claiborne Group and is overlain by the Jackson Formation (table 1).

Lithology and Thickness

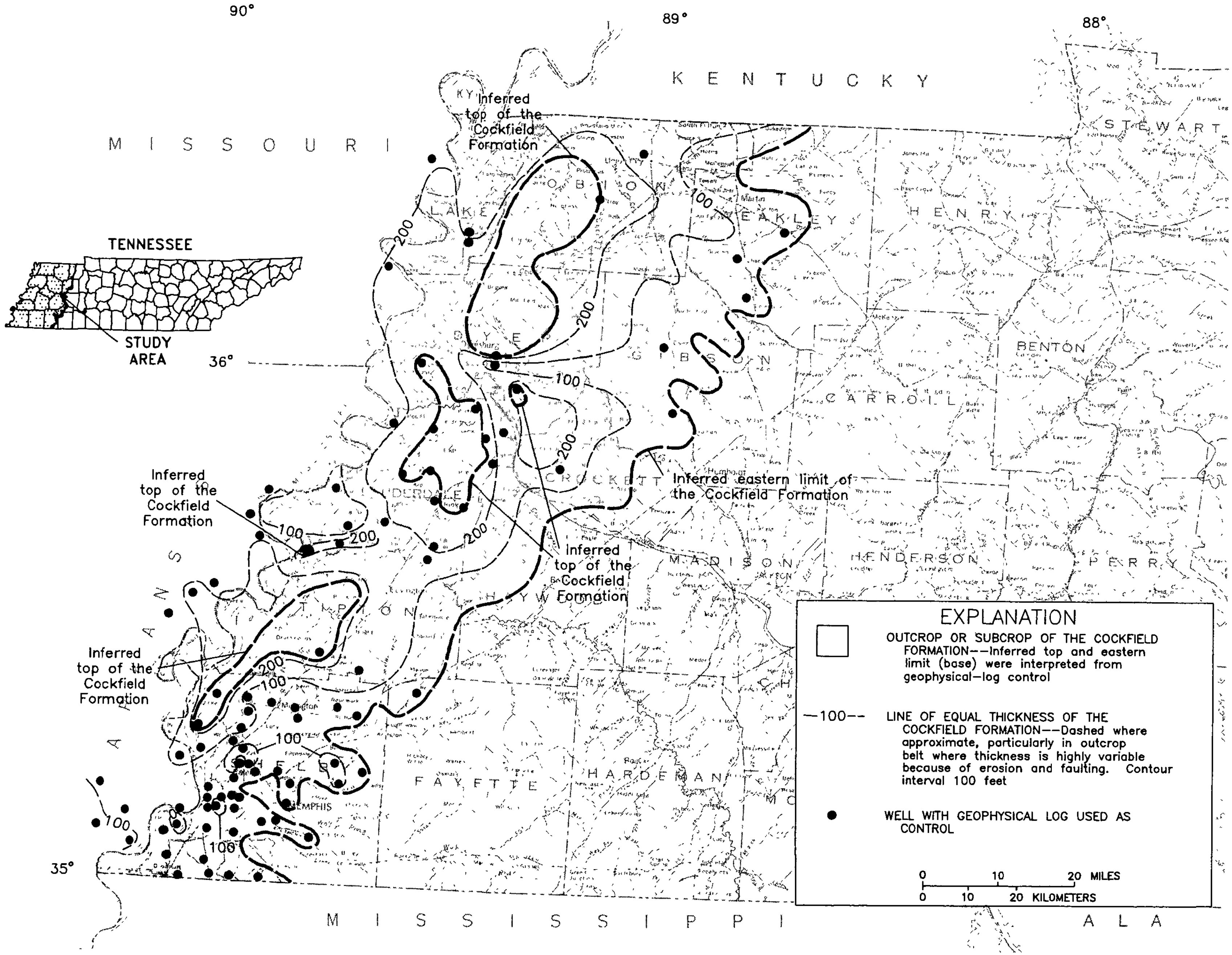
The Cockfield Formation commonly consists of clay and silt in the upper part and sand in the lower part. Locally, however, the upper part contains thick sand beds, and the lower part contains thick clay and silt beds that are difficult to distinguish from the underlying Cook Mountain Formation. Individual beds in the Cockfield Formation generally are lenticular and may be discontinuous over short distances. The sand ranges from very fine to coarse, but it commonly is locally very fine, fine, or fine to medium. The sediments locally are carbonaceous and lignitic. Lignite beds commonly are associated with the clays and silts, but also occur in the sands. The lignite beds range from a few inches to over 10 feet in thickness.

The thickness of the Cockfield Formation is highly variable (fig. 2) because, except where the original thickness is preserved beneath the Jackson Formation, the formation has been subjected to extensive erosion. Consequently, the Cockfield Formation locally may be absent or as much as 270 feet thick. Where overlain by the Jackson Formation, the Cockfield Formation ranges from about 235 to 270 feet in thickness. Because of the large number of wells in Shelby County for which geophysical logs are available, only selected logs were used in the preparation of figure 2. Closely spaced wells indicate that the thickness of the Cockfield Formation is much more variable than is shown.

Geologic Structure

In western Tennessee, the base of the Cockfield Formation dips westward at rates of 10 to 40 ft/mi, and it is faulted at many places (plates 1 and 2). Identification and location of faults that displace the Tertiary formations are difficult because they are covered at most places by Quaternary surficial deposits and subsurface information is sparse. A study of the likelihood of post-Cretaceous faulting in the northern Mississippi embayment, including western Tennessee, has shown that faults that displace the Cretaceous and Tertiary formations probably are relatively common (Stearns and Zurawski, 1976). Correlation and interpretation of geophysical logs made in test holes drilled in Lauderdale County, Tenn., indicate several faults that displace the upper part the Memphis Sand and the Cook Mountain and Cockfield Formations (Parks and others, 1985).

Faults identified during the present investigation that displace the Cockfield Formation are shown in plate 1. Most of these faults are based on an interpretation of the geologic structure using correlations of geophysical logs of wells. Faults in Lake County, however, are based partly on the interpretation of seismic reflection profiles by Zoback (1979) and Hamilton and Zoback (1982). The geophysical log correlations are highly interpretive, but are supported by paleontological evidence from the Fort Pillow



Base from U.S. Geological Survey, State base map, 1:500,000, 1973

Figure 2.--Generalized thickness of the Cockfield Formation.

test well in Lauderdale County, Tenn. (Moore and Brown, 1969), and the New Madrid test wells in New Madrid County, Mo. (Frederiksen and others, 1982).

HYDROLOGY

Saturated beds or lenses of sand in the Cockfield Formation make up the Cockfield aquifer. In the larger multistate GC RASA investigation, the Cockfield aquifer is included in the upper Claiborne aquifer for studying the regional aspects of the ground-water system (Grubb, 1986).

Recharge and Potentiometric Surface

Recharge to the Cockfield aquifer is by precipitation on sparse outcrops or downward infiltration of water from the overlying fluvial deposits and alluvium and, where present, the overlying Jackson Formation. Because the Cockfield aquifer generally is an unconfined water-table aquifer, the configuration of the potentiometric surface is complex (fig. 3) and conforms to the topography. Except at seeps and springs, the water table is lower than the land surface. The potentiometric surface is at higher altitudes but greater depths beneath the hills and ridges and at lower altitudes but shallower depths beneath the valleys and alluvial plains. In areas of some relief, perched water tables above clay or silt beds add to the complexity of the potentiometric surface. Where water-table conditions prevail, some water in the aquifer moves toward major streams, passes through the alluvium, discharges along the channels, and maintains base flows.

Water in the Cockfield aquifer may be unconfined or confined, depending on local conditions. Large differences in the altitude of the water-level surface occur between the uplands of the Gulf Coastal Plain and the lowlands of the Mississippi Alluvial Plain, particularly along the bluffs (fig. 1). Consequently, water from the Cockfield aquifer probably provides recharge to the alluvium beneath the Mississippi Alluvial Plain laterally along the buried lower parts of the bluffs and vertically as upward seepage under the Alluvial Plain. In the upland area of the Gulf Coastal Plain, water locally may be under pressure (confined) where clay or silt beds are thick and widespread enough to serve as confining units.

The Cook Mountain Formation is the lower confining unit of the Cockfield aquifer, separating it from the deeper Memphis aquifer. Where the Cook Mountain Formation is displaced by faults, the Cockfield and Memphis aquifers locally are in direct hydraulic connection, and interchange of water may occur between these aquifers.

Water-Level Changes

Water-level changes in the Cockfield aquifer are evident from the records of observation wells. Hydrographs for two observation wells, Ld:L-2 and Ld:J-5, in the Cockfield aquifer are shown in figure 4; locations of the wells are shown in figure 3. These wells were installed during a recent investigation of the ground-water resources of Lauderdale County (Parks and others, 1985), and the period of the water-level record is too short to show long-term trends. The hydrographs (fig. 4) indicate that the water level has risen about 2.6 feet in 5 years (1980-85) in well Ld:L-2 and about 2.2 feet in 3 years (1982-85) in well Ld:J-5, average rates of about 0.5 and 0.7 ft/yr, respectively. These rises in water-levels probably are the result of increased recharge to the Cockfield aquifer from many years of above normal precipitation during the period 1972-85.

Seasonal fluctuations of water levels in Ld:L-2 and Ld:J-5 indicate that water levels rise

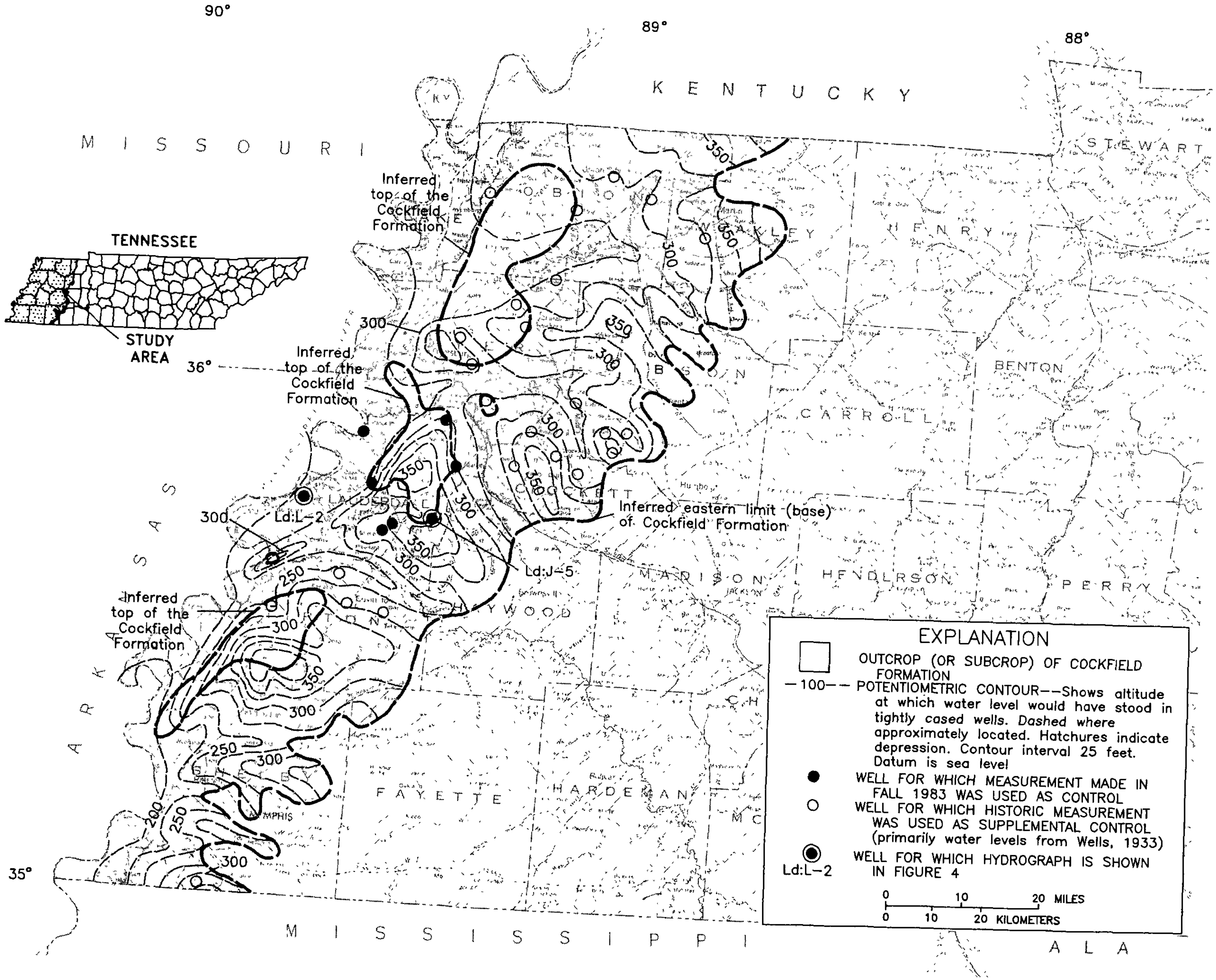


Figure 3.--Generalized potentiometric surface in the Cockfield aquifer, fall 1983.

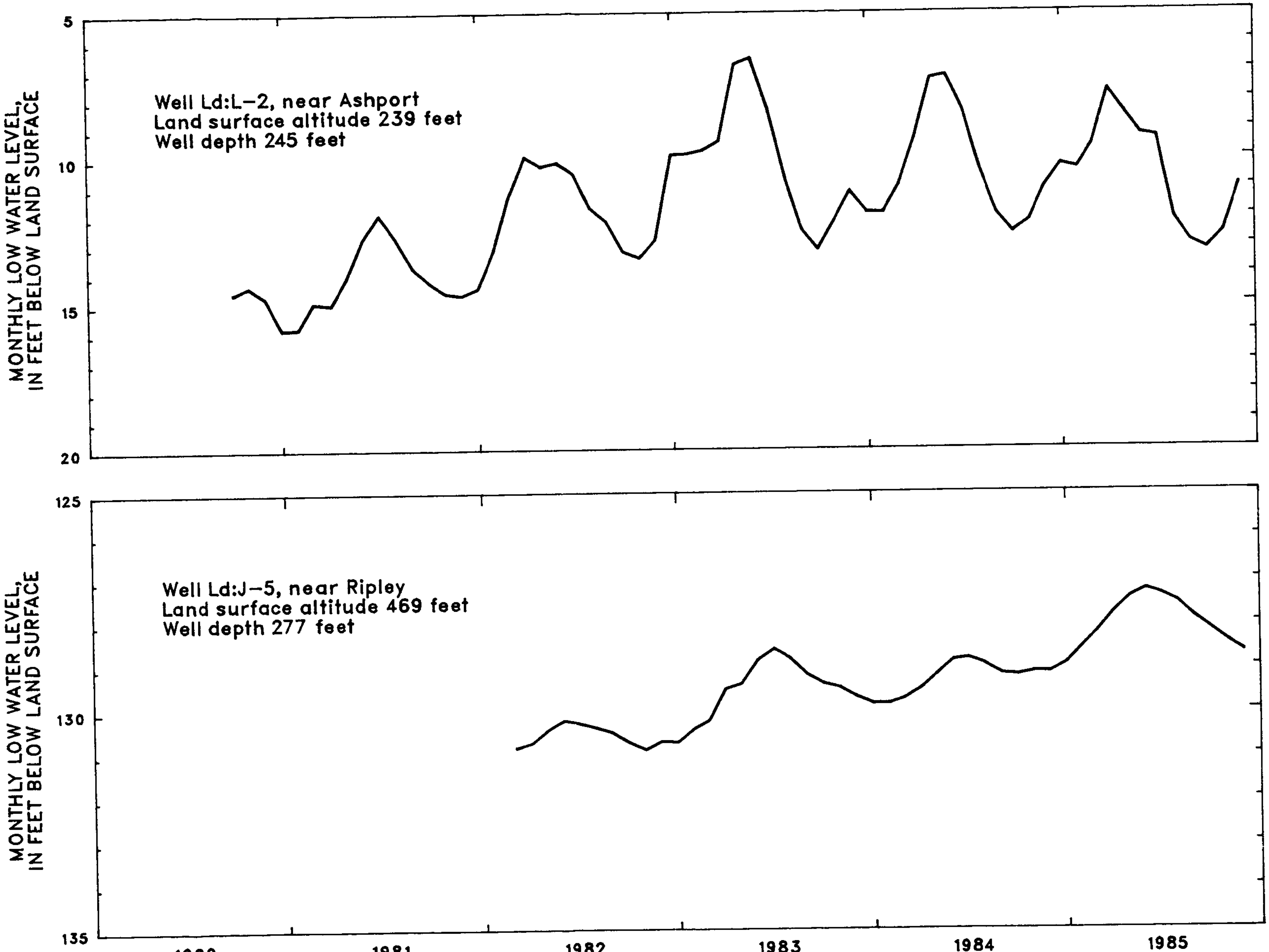


Figure 4.--Water levels in observation wells Ld:L-2 and Ld:J-5 (See figure 3 for location of wells).

from February to July and decline from July to January. High water levels generally occurred in June or July, but in well Ld:L-2 near the Mississippi River, high water levels sometimes occur earlier (April) during large floods on the river, probably as a result of a loading effect.

Water Quality

Water from the Cockfield aquifer is a calcium bicarbonate type (table 2). It contains low concentrations of most major constituents and generally is suitable for most uses. Dissolved-solids concentrations range from 44 to 218 milligrams per liter (mg/L) with a median of 140 mg/L. Hardness ranges from soft (minimum--28 mg/L as $CaCO_3$) to very hard (maximum--201 mg/L), but commonly is moderately hard (median--98 mg/L). Iron concentrations range from 3 to 40,990 μg/L (micrograms per liter) with a median of 1,350 μg/L. Temperature of the water ranges from 15.5 to 17.5 degrees Celsius (^{o}C) with a median of 16.5 ^{o}C.

Water quality in the Cockfield aquifer probably varies greatly (within minimum and maximum limits) from place to place within its area of occurrence (fig. 1), because the aquifer contains sand lenses or beds that may not be areally extensive. The Cockfield aquifer is under water-table conditions in much of the area (fig. 3), and the sand beds or lenses may not be hydraulically connected. Consequently, the water quality in individual sand beds or lenses may be the result of a complex set of geochemical conditions related to the local geology and sources of recharge.

Specifics concerning the quality of water from the Cockfield aquifer are unknown for the greater part of its area of occurrence because of the lack of water-quality data, which would have to be collected from many domestic and farm wells. Nevertheless, a water-quality relation is evident from available data (table 2). Dissolved solids, iron concentrations, and hardness generally increase in the direction from Crockett County to Dyer County to Lauderdale County to Obion County. Temperature of the water, which generally increases with well depth, does not follow this relation but instead increases in the direction from Dyer and Obion Counties to Crockett and Lauderdale Counties. Water-quality data and geohydrologic information are inadequate to provide an explanation for this relation.

Trace constituents in the water from the Cockfield aquifer include arsenic, barium, cadmium, chromium, copper, lead, mercury, strontium, and zinc (table 3). Most of these constituents are present in very small concentrations, and all are below the maximum concentrations recommended by the U.S. Environmental Protection Agency (1986a,b) for drinking-water supplies.

Aquifer Characteristics

Data from only a few aquifer tests are available on which to base a range of transmissivities and storage coefficients for the Cockfield aquifer, and those few tests were conducted under less than ideal conditions. One aquifer test and one pumping test have been made in Lauderdale County (Parks and others, 1985, p. 29). An aquifer test made in 1961 at the U.S. Military Reservation near Halls, involving two wells screened in a Cockfield sand, indicated a transmissivity of about 2,500 ft^2/d and a storage coefficient of 0.0003. A single-well pumping test made in observation well Ld:L-2 provided an estimated transmissivity of 1,500 ft^2/d. This value may represent the transmissivity of the 46-foot-thick fine sand in which the 20-foot-long screen was set.

Another aquifer test, involving two wells, was conducted at Troy in Obion County in 1962 (Moore, 1965, p. F22-F23). This test indicated a

Table 2.--*Minimum, median, and maximum values for selected major constituents and properties of water from the Cockfield aquifer*

[mg/L, milligrams per liter; ug/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; values given as 0 (zero) or < (less than) indicate that the concentration was below the level of detection for the analytical method used and do not indicate the presence or absence of a constituent; --, median values not determined for less than three wells]

	Specific conductance (uS/cm at 25 °C)	pH (units)	Temperature (°C)	Color (platinum cobalt units)	Hardness (mg/L as CaCO3)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium dissolved (mg/L as Na)	Potassium dissolved (mg/L as K)
Crockett County									
Minimum	--	--	16.5	--	28	8.0	2.0	2.0	--
Median	--	--	--	--	--	--	--	--	--
Maximum	--	--	16.5	--	38	12	2.0	4.0	--
Number of wells	0	0	1	0	2	2	2	2	0
Dyer County									
Minimum	140	6.1	16.0	<1	44	9.4	5.0	2.0	0.3
Median	184	6.3	16.0	4	78	21	6.2	9.3	.9
Maximum	344	7.0	17.0	22	142	29	17	11	5.8
Number of wells	4	4	5	4	6	6	6	6	4
Lauderdale County									
Minimum	229	6.1	16.5	5	76	15	8.0	4.4	0.2
Median	255	6.5	17.0	-	127	28	14	7.1	1.7
Maximum	370	6.8	17.5	5	184	41	20	9.8	7.1
Number of wells	7	7	9	1	9	9	9	9	9
Obion County									
Minimum	246	6.5	15.5	<1	85	16	4.0	1.0	5.2
Median	252	6.5	16.0	--	152	36	8.9	10	--
Maximum	362	6.6	16.5	5	201	74	15	13	5.4
Number of wells	3	3	3	2	5	5	5	4	2
All Counties									
Minimum	140	6.1	15.5	<1	28	8.0	2.0	1.0	0.2
Median	250	6.5	16.5	5	98	25	9.2	7.9	1.4
Maximum	370	7.0	17.5	22	201	74	20	13	7.1
Number of wells	14	14	18	7	22	22	22	21	15

Table 2.--*Minimum, median, and maximum values for selected major constituents and properties of water from the Cockfield aquifer*--Continued

	Alkalinity (mg/L as $CaCO_3$)	Carbon dioxide, dissolved (mg/L as CO_2)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C (mg/L)	Iron, (µg/L as Fe)	Manganese (µg/L as Mn)
				Crockett County					
Minimum	23	--	1.0	4.0	--	6.0	44	200	--
Median	--	--	--	--	--	--	--	--	--
Maximum	36	--	3.0	6.0	--	8.0	60	1,300	--
Number of wells	2	0	2	2	0	2	2	2	0
				Dyer County					
Minimum	46	71	1.0	1.5	0	4.0	99	3	0
Median	75	--	8.5	4.8	0	21	110	500	0
Maximum	172	85	17	9.8	.1	43	208	14,000	6
Number of wells	6	2	6	6	4	6	6	6	4
				Lauderdale County					
Minimum	84	54	<1.0	1.6	0	14	94	16	5
Median	140	78	4.0	2.0	.2	19	142	1,900	106
Maximum	220	91	7.1	3.5	.2	25	188	40,990	400
Number of wells	9	4	8	8	6	9	6	9	6
				Obion County					
Minimum	123	97	2.0	0.5	0.2	7.0	140	400	300
Median	199	--	3.0	4.0	--	7.9	204	5,600	--
Maximum	221	97	5.9	12	.2	14	218	12,000	410
Number of wells	5	1	5	5	1	4	4	5	2
				All Counties					
Minimum	23	54	<1.0	0.5	0	4.0	44	3	0
Median	126	85	4.0	3.5	.1	17	140	1,350	60
Maximum	221	97	17	12	.2	43	218	40,990	410
Number of wells	22	7	21	21	11	21	18	22	12

Table 3.--*Minimum, median, and maximum values for selected trace constituents in water from the Cockfield aquifer*

[Concentrations in micrograms per liter; values given as (< less than) indicate that the concentration was below the level of detection for the analytical method used and do not indicate the presence or absence of a constituent]

	Arsenic, dissolved (as As)	Barium, dissolved (as Ba)	Cadmium, dissolved (as Cd)	Chromium, dissolved (as Cr)	Copper, dissolved (as Cu)	Lead, dissolved (as Pb)	Mercury, dissolved (as Hg)	Strontium, dissolved (as Sr)	Zinc, dissolved (as Zn)
				Dyer County					
Minimum	<1	42	<1	<10	<10	<1	<0.1	14	<3
Median	<1	78	<1	20	<10	2	< .1	--	3
Maximum	<1	83	<1	20	10	3	.1	14	8
Number of wells	3	3	3	3	3	3	3	1	3
				Lauderdale County					
Minimum	1	--	<1	10	1	<1	< .1	--	10
Median	1	--	<1	10	2	4	< .1	--	20
Maximum	1	--	5	20	7	7	.1	--	80
Number of wells	6	0	6	6	6	6	6	0	6
				Obion County					
Minimum	1	700	<1	10	<10	9	< .1	--	<3
Median	--	--	--	--	--	--	--	--	--
Maximum	1	700	<1	10	<10	9	< .1	--	<3
Number of wells	1	1	1	1	1	1	1	0	1
				All Counties					
Minimum	<1	42	<1	<10	1	<1	< .1	14	<3
Median	1	80	<1	10	2	4	< .1	--	10
Maximum	1	700	5	20	<10	9	.1	14	80
Number of wells	10	4	10	10	10	10	10	1	10

maximum transmissivity of about 6,000 ft^2/d and a storage coefficient of 0.0007. Moore concluded that this value for transmissivity was reasonable for the entire 170-foot thickness of the aquifer at Troy.

Water Use

In the area of present use, the Cockfield aquifer provides small to moderate quantities of water for some public and industrial supplies in Crockett, Dyer, Lauderdale, and Obion Counties (fig. 5). Withdrawals for these supplies averaged about 3.3 Mgal/d in 1983 (table 4). Public and industrial supply wells in the Cockfield aquifer range from 90 to 353 feet deep, and well yields range from 50 to 880 gal/min. The aquifer also provides water to numerous domestic and farm wells.

In much of the area of potential use, yields of water from wells in the Cockfield aquifer probably would be adequate only for domestic and farm use. In the Memphis area, fine sand, silt, and clay in the Cockfield Formation, where present, are considered to be a part of the confining bed overlying the Memphis Sand (Graham and Parks, 1986).

SUMMARY AND CONCLUSIONS

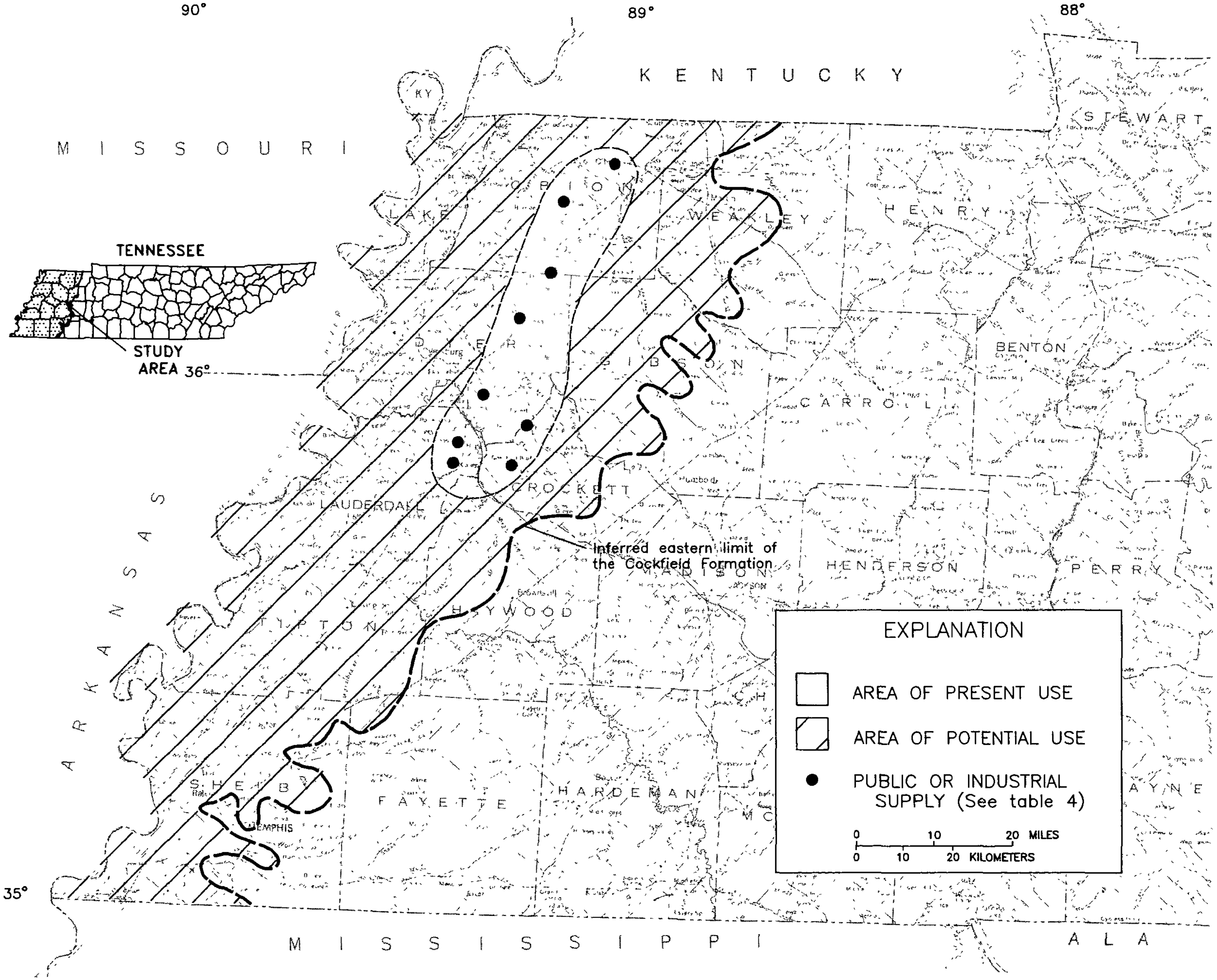
The Cockfield Formation of the Claiborne Group of Tertiary age underlies approximately 4,000 mi^2 in western Tennessee. The formation primarily consists of lenticular beds of sand, silt, clay, and lignite. The sand ranges from very fine to coarse, but commonly is locally very fine, fine, or fine to medium. The Cockfield Formation has been extensively eroded, and the original thickness is preserved only in a few areas where the formation ranges from about 235 to 270 feet in thickness. The base of the Cockfield Formation dips westward at rates of 10 to 40 ft/mi, but it is faulted at many places. Saturated beds or lenses of sand in the Cockfield Formation make up the Cockfield aquifer.

Recharge to the Cockfield aquifer is from precipitation on sparse outcrops or by downward infiltration of water from the overlying fluvial deposits and alluvium and, where present, the overlying Jackson Formation. The Cockfield generally is unconfined and makes up part of the water-table aquifer. Consequently, the configuration of the potentiometric surface is complex and conforms to the topography. Short-term records from two observation wells show that water levels have risen at average rates of about 0.5 and 0.7 ft/yr during the period 1980–85.

Water from the Cockfield aquifer is a calcium bicarbonate type. It contains low concentrations of most major constituents and generally is suitable for most uses. Dissolved-solids concentrations range from 44 to 218 mg/L, hardness ranges from soft (28 mg/L as $CaCO_3$) to very hard (201 mg/L), and iron concentrations range from 3 to 40,990 μg/L. Temperature of the water ranges from 15.5 to 17.5 °C.

Data from two aquifer tests indicate transmissivities of 2,500 and 6,000 ft^2/d. Storage coefficients derived from these tests were 0.0003 and 0.0007, respectively.

The Cockfield aquifer provides small to moderate quanities of water for several public and industrial supplies in western Tennessee. Withdrawals for these supplies averaged about 3.3 Mgal/d in 1983. Public and industrial supply wells range from 90 to 353 feet deep, and well yields range from 50 to 880 gal/min. The aquifer also provides small quanities of water to numerous domestic and farm wells. Although the Cockfield aquifer locally contains sands that are thick and coarse enough to yield moderate quantities of water to wells, at most places the aquifer probably would yield only enough water for domestic and farm use.



Base from U.S. Geological Survey, State base map, 1:500,000, 1973

Figure 5.--Areas of present and potential use of the Cockfield aquifer in western Tennessee.

Table 4.--*Public and industrial water supplies from the Cockfield aquifer in western Tennessee, 1983*

County	Water user U D - utility district	Number of wells in use	Reported depth of wells (ft)	Reported pumping rates of wells (gal/min)	Reported average daily withdrawal in 1983 (thousand gallons)	Technical data available: Chemical analysis (R-recent, H-historic)	Technical data available: Geophysical log[1] (E-electric, G-gamma ray)	Technical data available: Aquifer test (Year of test)
Crockett	County-Wide U D[2]							
	Old Field (#4)	2	221-232	100-250	72		E(226)	
	Friendship	3	90-330	50-90	89	H-R		
Dyer	County-Wide U D							
	Bonicord (#3)	3	125-132	100	62	R	E(391)	
	Newbern	3	144-160	350	576	H-R	G(249)	
	Trimble	2	180	250	112	H-R		
Lauderdale	Gates	2	345-353	100-225	52	R	G(347)	
	Halls	2	196-197	320-375	130 [3]	H-R		1961
Obion	Troy	3	230-285	210-500	194	H-R	E(728)	1962
	Self-supplied industry	2	160-169	650-880	2,000			

[1]More than one geophysical log may be available for each well field; number in parenthesis indicates the maximum depth, in feet, logged by either electric or gamma-ray methods.

[2]County-Wide Utility District has well fields in both Crockett and Dyer Counties with wells in both the Cockfield aquifer and the Memphis aquifer; name and number (in parenthesis) indicate well field as designated by the Utility District.

[3]Withdrawal shown is from the Cockfield aquifer; part of supply is from the Memphis aquifer.

REFERENCES

Frederiksen, N.O., Bybell, L.M., Christopher, R.A., Crone, A.J., Edwards, L.E., Gibson, T.G., Hazel, J.E., Repetski, J.E., Russ, D.P., Smith, C.C., and Ward, L.W., 1982, Biostratigraphy and paleoecology of lower Paleozoic, Upper Cretaceous, and lower Tertiary rocks in U.S. Geological Survey New Madrid test wells, southeastern Missouri: Tulane Studies in Geology and Paleontology, v. 17, no. 2, pp. 23-45.

Graham, D.D., and Parks, W.S., 1986, Potential for leakage among principal aquifers in the Memphis area, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 85-4295, 46 p.

Grubb, H.F., 1984, Planning report for the Gulf Coast Regional Aquifer-System Analysis in the Gulf of Mexico Coastal Plain, United States: U.S. Geological Survey Water-Resources Investigations Report 84-4219, 30 p.

----- 1986, Gulf Coast Regional Aquifer-System Analysis--a Mississippi perspective: U.S. Geological Survey Water-Resources Investigations Report 86-4162, 22 p.

Hamilton, R.M., and Zoback, M.D., 1982, Tectonic features of the New Madrid seismic zone from seismic-reflection profiles, *in* Investigations of the New Madrid, Missouri, earthquake region: U.S. Geological Survey Professional Paper 1236-F, p. 54-82.

Hardeman, W.D., Miller, R.A., and Swingle, G.D., compilers, 1966, Geologic map of Tennessee: Tennessee Division of Geology, scale 1:250,000, 4 sheets.

Hosman, R.L., Long, A.T., Lambert, T.W., and others, 1968, Tertiary aquifers in the Mississippi embayment, *with discussions of* Quality of the water by H.G. Jeffery: U.S. Geological Survey Professional Paper 448-D, 29 p.

Moore, G.K., 1965, Geology and hydrology of the Claiborne Group in western Tennessee: U.S. Geological Survey Water-Supply Paper 1809-F, 44 p.

Moore, G.K., and Brown, D.L., 1969, Stratigraphy of the Fort Pillow test well, Lauderdale County, Tennessee: Tennessee Division of Geology Report of Investigations 26, 1 sheet.

Parks, W.S., 1978, Geologic map of the Tennessee portion of the Fletcher Lake quadrangle, Tennessee (including portions of adjacent quadrangles to the north, west, south): Tennessee Division of Geology GM 404-SW, scale 1:24,000. 1 sheet

Parks, W.S., and Carmichael, J.K., 1989, Geology and ground-water resources of the Fort Pillow Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4120, 20 p.

----- 1990, Geology and ground-water resources of the Memphis Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4182, 30 p.

----- in press a, Altitude of potentiometric surface, fall 1985, and historic water-level changes in the Memphis aquifer in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4180.

----- in press b, Altitude of potentiometric surface, fall 1985, and historic water-level changes in the Fort Pillow aquifer in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4048.

Parks, W.S., Carmichael, J.K., and Graham, D.D., 1985, Preliminary assessment of the ground-water resources of Lauderdale County, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 84-4104, 35 p.

Stearns, R.G., and Zurawski, Ann, 1976, Post-Cretaceous faulting in the head of the Mississippi embayment: Southeastern Geology, v. 17, no. 4, p. 207-229.

U.S. Environmental Protection Agency, 1986a, Maximum contaminant levels (subpart B of part 141, National interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised July 1, 1986, p. 524-528.

----- 1986b, Secondary maximum contaminant levels (section 143.3 of part 143, National secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised July 1, 1986, p. 587-590.

Vaughan, T.W., 1895, The stratigraphy of northwestern Louisiana: American Geologist, v. 15, p. 205-229.

Wells, F.G., 1933, Ground-water resources of western Tennesssee, *with a discussion of* Chemical character of water by F.G. Wells and M.D. Foster: U.S. Geological Survey Water-Supply Paper 656, 319 p.

Zoback, M.D., 1979, Recurrent faulting in the vicinity of Reelfoot Lake, northwestern Tennessee: Geological Society of America Bulletin, v. 90, p. 1019-1024.

☆U. S. GOVERNMENT PRINTING OFFICE: 1990/750-369