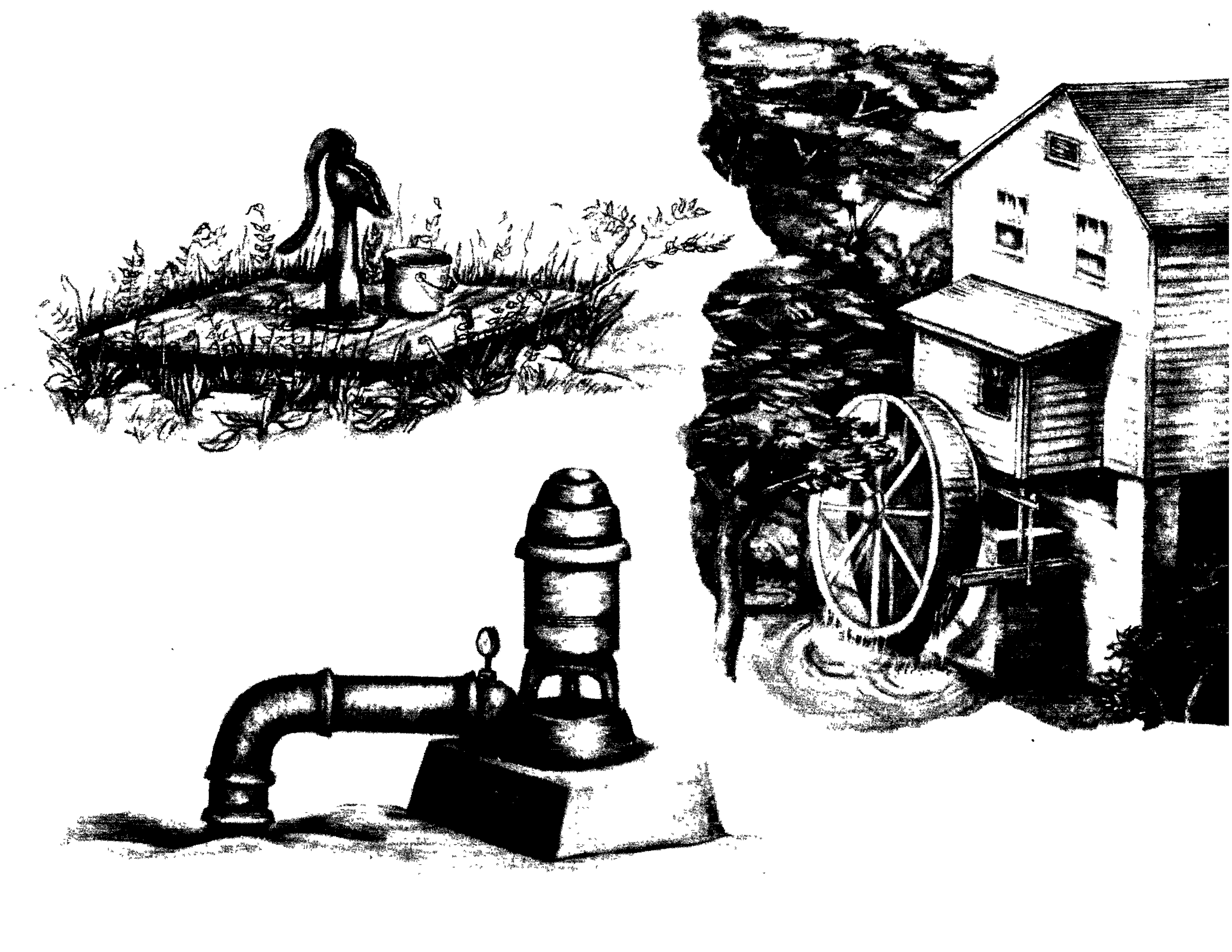
WATER-RESOURCES INVESTIGATIONS REPORT 83-4011

PRELIMINARY
DELINEATION AND DESCRIPTION OF THE REGIONAL AQUIFERS OF TENNESSEE--
TERTIARY AQUIFER SYSTEM



Prepared by
U.S. GEOLOGICAL SURVEY
in cooperation with the
U.S. ENVIRONMENTAL PROTECTION AGENCY

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J.V. Brahana, Michael W. Bradley, and Dolores Mulderink

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Nashville, Tennessee
1986

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

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

For the convenience of readers who may want to use International System of Units (SI), the data may be converted by using the following factors:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallons per minute (gal/min)	0.06309	liters per second (L/s)

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 mean sea level. NGVD of 1929 is referred to as sea level in the text of this report.

PRELIMINARY DELINEATION AND DESCRIPTION OF THE REGIONAL AQUIFERS OF TENNESSEE--TERTIARY AQUIFER SYSTEM

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ABSTRACT

The Tertiary aquifer system is composed of sands and clays of Quaternary and Tertiary age. The aquifer system occurs in West Tennessee from the Mississippi River east to the outcrop of the Porters Creek Clay. Ground water is recharged at outcrops and through overlying permeable deposits. The underlying Porters Creek Clay acts as the lower confining unit.

The Tertiary aquifer system is the most prolific source of ground water in Tennessee. The city of Memphis uses the Memphis Sand, which is a major water-bearing unit in the Tertiary aquifer system, as a primary source of drinking water. The water quality is excellent with generally less than 200 milligrams per liter dissolved solids.

INTRODUCTION

The Safe Drinking Water Act (Public Law 93-523) includes provisions for the protection of underground sources of drinking water. Specifically, Part C of the Act authorizes the U.S. Environmental Protection Agency (EPA) to establish regulations to insure that underground injection of contaminants will not endanger existing or potential sources of drinking water. As set forth by EPA, the regulations require that all underground sources of water with less than 10,000 milligrams per liter (mg/L) dissolved solids be designated for protection whether they are or are not currently being used as a source of drinking water.

The geologic formations of Tennessee (Miller, 1974) have been subdivided into eight major regional aquifers separated from each other by confining units which have a broad areal extent and a significant effect on the regional hydrology.

The purpose of this report is to describe the formations that comprise the Tertiary aquifer system of western Tennessee and to delineate zones within this aquifer that are actual or potential drinking-water sources.

This report on the Tertiary aquifer system provides generalized information on the (1) areal and stratigraphic occurrence, (2) dissolved-solids concentrations in ground water, (3) area of use and potential use, (4) aquifer hydraulic characteristics, (5) areas of known ground-water contamination, and (6) known locations of current and potential hydrocarbon, mineral, and geothermal resources. The sequence of geologic units include loess, terrace deposits, and the Jackson, Claiborne, and Wilcox Formations (or Groups where divided) in western Tennessee.

The Tertiary aquifer system is composed of unconsolidated sand and gravel beds that are separated by clays and are of Quaternary as well as Tertiary age. The Quaternary aquifers consist of the alluvial and terrace deposits. The Jackson, Claiborne, and Wilcox Formations are the primary Tertiary aquifers. On a regional basis, however, the entire thickness of these Quaternary and Tertiary formations acts as a single aquifer system, with similar geology, hydrology, and water quality. Because of the similarities and since the Tertiary sands are the major aquifers in terms of areal extent, productivity, and use, the Quaternary and Tertiary aquifers are referred to in this report as the Tertiary aquifer system. The approximate areal extent of the Tertiary aquifer system is shown in figure 1.

Hydraulic interchange occurs among formations that make up this aquifer, and the aquifer is used throughout its area of occurrence in Tennessee. Water quality is generally good to excellent, with less than 1,000 mg/L dissolved solids. Thus, the Tertiary aquifer system is classified as an underground drinking-water source under the criteria defined by EPA, and as such, does not qualify for receiving injected wastes.

GEOLOGY

The geologic formations that make up the framework of the aquifer system are unconsolidated sediments of Quaternary and Tertiary age. The formations possess high primary (intergranular) porosity and consist of interbedded sands and clays, with minor zones of gravel and silt. They were deposited in the structural trough of the Mississippi embayment, which has its axis approximately coincident with the Mississippi River; thus in Tennessee, the aquifer is thickest at the western edge of the State. There are two major water-bearing units in the Tertiary aquifer system. They are the "500-foot sand," also known as the Memphis Sand, of the Claiborne Group and the "1,400-foot sand," or Fort Pillow Sand, of the Wilcox Group. Contours on the base of the aquifer (top of the Porters Creek Clay) and the locations where lines of cross section have been constructed for this report are shown in figure 2. The cross sections (figs. 3-6) show the generalized structure of the formations that occur in western Tennessee. The geologic and hydrologic character of the formations that comprise the Tertiary aquifer system are described in table 1.

The geology of the Tertiary and younger formations has been described in detail in a number of published reports, including Schneider and Cushing (1948), Schneider and Blankenship (1950), Stearns and Armstrong (1955), Shreurs and Marcher (1959), Cushing and others (1964), Moore (1965), Boswell and others (1968), Hosman and others (1968), Moore and Brown (1969), Wilson and Criner (1969), and Russell and Parks (1975). Data in Milhous (1959) were used to supplement unpublished geophysical logs in constructing the cross sections.

HYDROLOGY

The Tertiary aquifer system can be summarized as being a highly permeable groundwater reservoir with a huge storage capacity. It is recharged by rainfall on the outcrops of the formations that comprise the aquifer system and in areas where they are overlain by permeable deposits. Water in the permeable formations of the aquifer system is under confined conditions except in the outcrop areas or in terrace deposits and alluvium that are overlain by loess.

Ground-water flow in the confined aquifers is generally toward the west and south, downdip away from the outcrop. Flow in unconfined aquifers is toward local streams where it is discharged. Water levels vary seasonally in response to changes in natural discharge and recharge, and to a lesser extent to withdrawals from wells. Ground-water flow and the significant components of the geohydrologic system are shown in figures 7 and 8. Interformational flow between the Claiborne and Wilcox is generally not a significant part of the regional flow pattern. Previous studies in Mississippi have separated the units that comprise the Claiborne and Wilcox Formations into several distinct aquifers (Hosman and others, 1968; Boswell, 1976; Newcome, 1976; Gandl, 1981). For this study, the two formations are considered as one system because they have similar hydrology and similar water quality. Modeling studies (Brahana, U.S. Geological Survey, written commun., 1982) and field evaluations (D.R. Rima, Tennessee Department of Health and Environment, oral commun., 1980) indicate that the confining unit between the Claiborne and the Wilcox, while effective through most of the area, does allow hydraulic interchange on a local basis.

Major wells in the Tertiary aquifer system range in depth from less than 100 to more than 1,700 feet. Wells screened in the Memphis Sand of the Claiborne Group in Shelby County yield as much as 2,000 gal/min. Wells are rarely screened through the full thickness of the aquifer; therefore, the reported yields are not the maximum yields that the aquifer is capable of providing.

The detailed hydrology of the component formations have been described in a number of published reports. The following were used to compile this atlas: Glenn (1906); Wells (1933); Schneider and Cushing (1948); Criner and Armstrong (1958); Schreurs and Marcher (1959); Criner and others (1964); Moore (1965); Nyman (1965); Bell and Nyman (1968); Boswell and others (1968); Hosman and others (1968); Wilson and Criner (1969); and Cushing and others (1970).

WATER QUALITY

Analyses of water from the Tertiary aquifer system indicate relatively low dissolved-solids concentrations throughout the area of occurrence of the aquifer. The areal distribution of dissolved-solids concentrations of water from wells in the aquifer system is shown in figure 9, and the variation by depth and formation is given in table 2. Generalized water quality is also shown on the cross sections (figs. 3-6).

Water quality in the shallow aquifers of the alluvium and terrace deposits is locally influenced by surficial conditions and varies more in these formations than in the underlying Jackson, Claiborne, and Wilcox Formations. Ground water in the alluvium and in terrace deposits overlain by thick loess is generally hard and has high iron and dissolved-solids concentrations. Ground water in the terrace deposits overlain by gravel and thin, deeply weathered loess is soft and has low iron and dissolved-solids concentrations.

Water from the Jackson Formation generally is not utilized because it requires treatment for most uses and has objectionable taste and odor (Wells, 1933).

The water in the Claiborne Formation is low in dissolved solids, moderately soft, slightly acidic, and has a variable iron content. The variation in iron content is dependent on the contact of the water with clay lenses that contain iron sulfide. Nearly all municipal supplies taken from the Claiborne near the axis of the Mississippi embayment must go through aeration and filtration to remove iron.

The Wilcox Formation contains water of good quality, but is not widely used as a ground-water source except in the outcrop area and immediately downdip because potable water can be found at shallower depths. Water in the Wilcox is very soft and dissolved solids average about 100 mg/L.

In addition to much unpublished data, the following reports were used to compile information for this water-quality section: Wells (1933); Lanphere (1955); Criner and Armstrong (1958); Moore (1965); Cushing (1966); Bell and Nyman (1968); Boswell and others (1968); Hosman and others (1968); Wilson and Criner (1969); and Cushing and others (1970).

DRINKING-WATER USE

The Tertiary aquifer system is the most intensively used ground-water reservoir in the State, not only for drinking-water supplies, but for all uses of water. Of the total amount of water from the Tertiary aquifer system used for drinking-water supplies, more than 95 percent was pumped from sands of the Claiborne Formation, with 75 percent of the pumpage occurring in the metropolitan Memphis area. A summary of public water-supply systems that derive water from the aquifers comprising this system is listed in table 3. The location of these public supply wells and the area of use, which is coincident with the area of occurrence of the regional aquifer system, are shown in figure 10. Although the aquifer is used extensively, it is capable of supplying significantly larger withdrawals than it presently does (Hosman and others, 1968).

Most of the data for drinking-water supplies come from unpublished sources, primarily the Tennessee Department of Health and Environment. Historic use of water from the Tertiary aquifer is documented in Lanphere (1955), Moore (1965), Cushing and others (1970), and Criner and Parks (1976).

CONTAMINATION

The Tertiary aquifer system has seven sites where contamination presently has been documented (1982). The locations are shown in figure 11 and are described and documented in table 4. Each of these areas is limited geographically; and, at this time, none is thought to pose an immediate threat to the aquifer outside of a limited area.

CURRENT AND POTENTIAL HYDROCARBON, MINERAL, AND GEOTHERMAL RESOURCE USE

In 1982, little use was made of the hydrocarbon, mineral, or geothermal resources of the Tertiary aquifer system. Interest in future use is primarily concerned with the lignite deposits of the Wilcox, Claiborne, and Jackson Formations. Low-sulfur lignite, suitable for steam-powered generation of electricity, is near the land surface in several places in western Tennessee (fig. 12). Recent exploration in Tennessee has revealed reserves estimated in the amount of 1.0 billion tons (Parks, 1981).

SUMMARY

The Tertiary aquifer system is composed of unconsolidated sands and gravels with interbedded clay. The major aquifers are the Tertiary age Memphis Sand of the Claiborne Group and Fort Pillow Sand of the Wilcox Group. The shallow terrace and alluvial deposits are also used as aquifers. The Porters Creek Clay acts as the lower confining unit. The largest production comes from wells screened in the Memphis Sand in Shelby County where as much as 2,000 gal/min have been produced. The aquifers supply drinking water for most municipal water systems in West Tennessee.

Water in these aquifers generally has low concentrations of dissolved solids throughout West Tennessee. Water from the Claiborne Group has some problems with high iron concentrations in some areas.

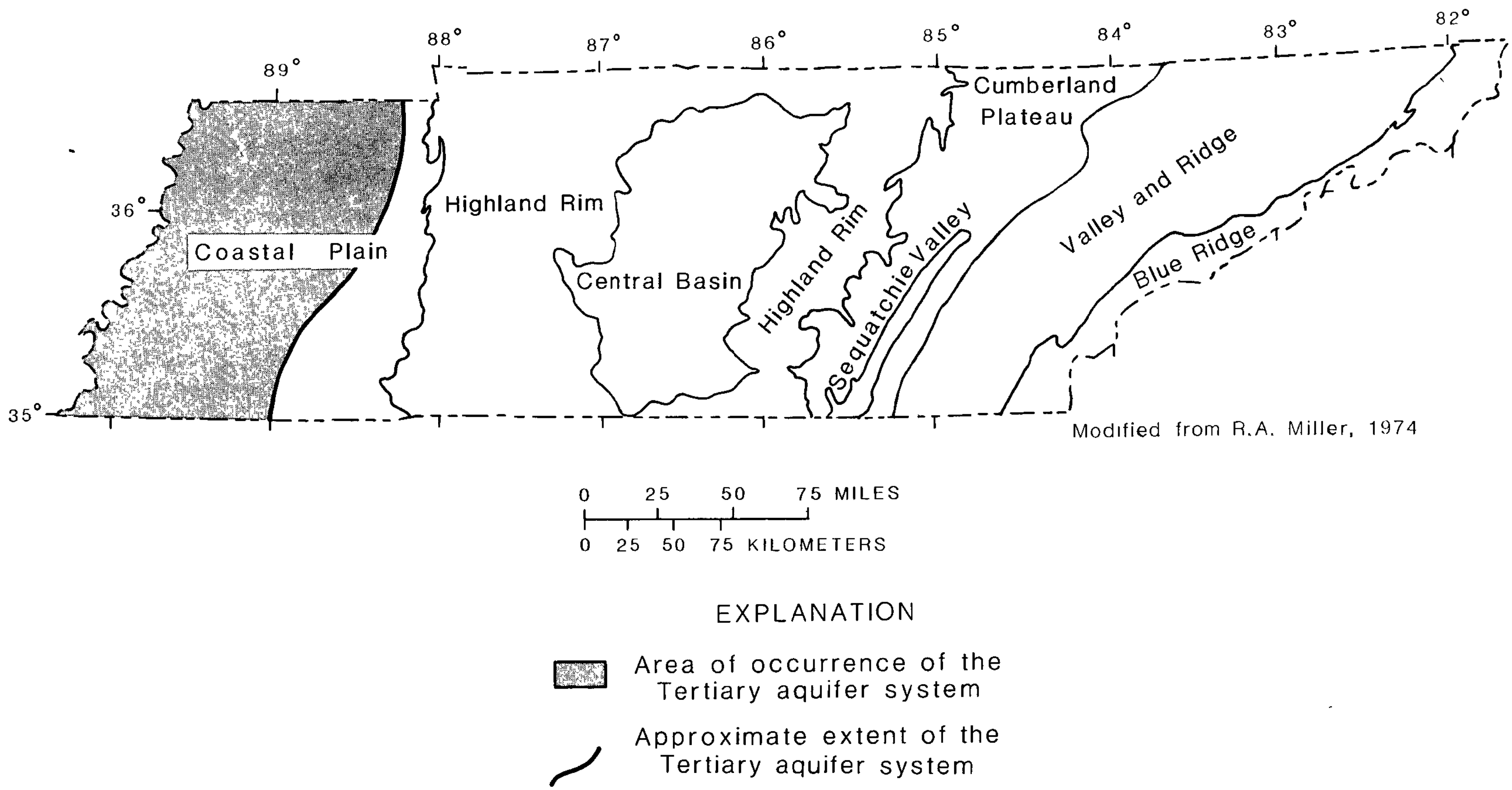
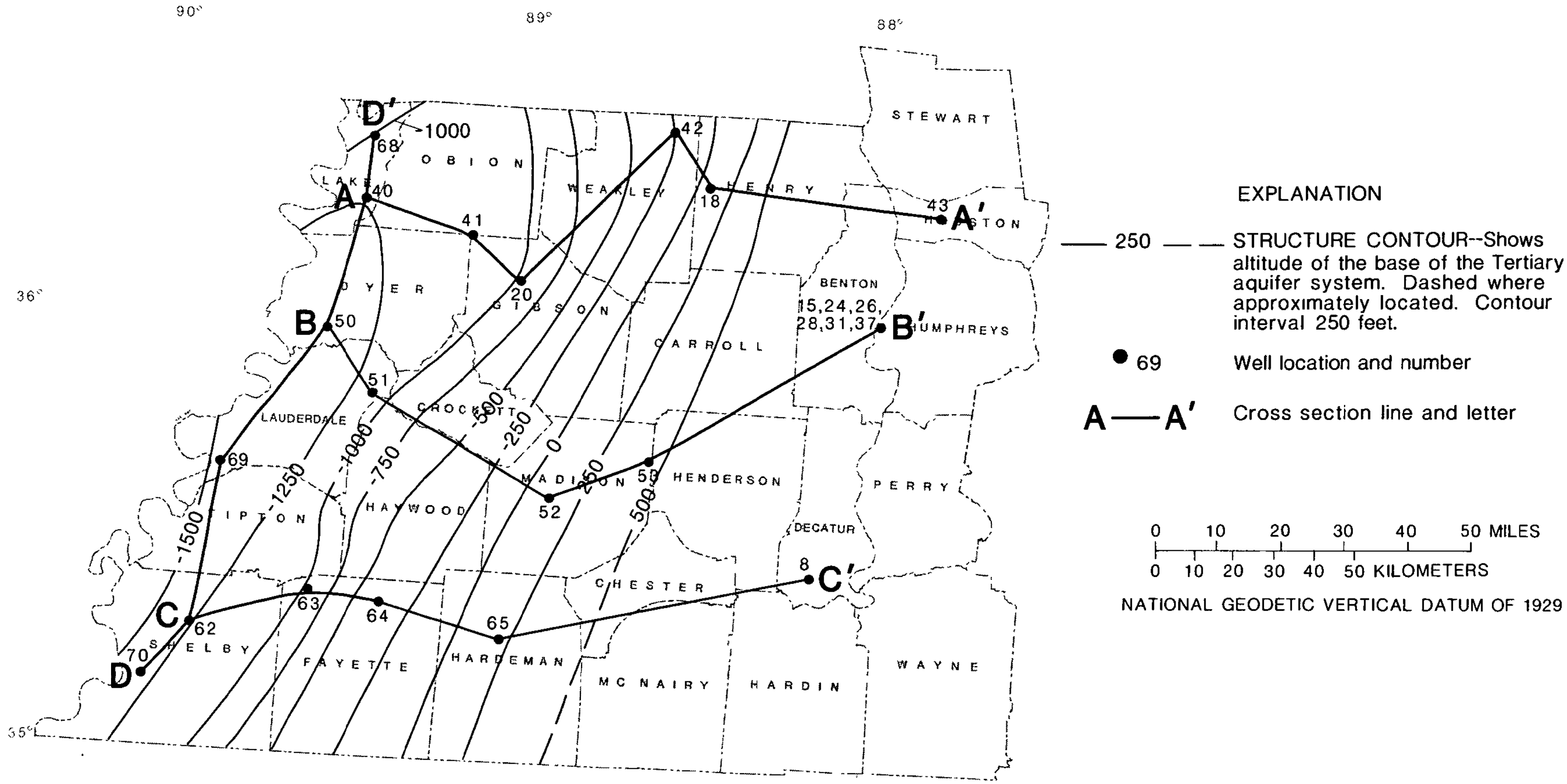


Figure 1.-- Areal extent of the Tertiary aquifer system and physiographic provinces in Tennessee.



Modified from E. M. Cushing, E. H. Boswell, and R. L. Hosman, 1964

Figure 2.-- Structure contours of the base of the Tertiary aquifer system.

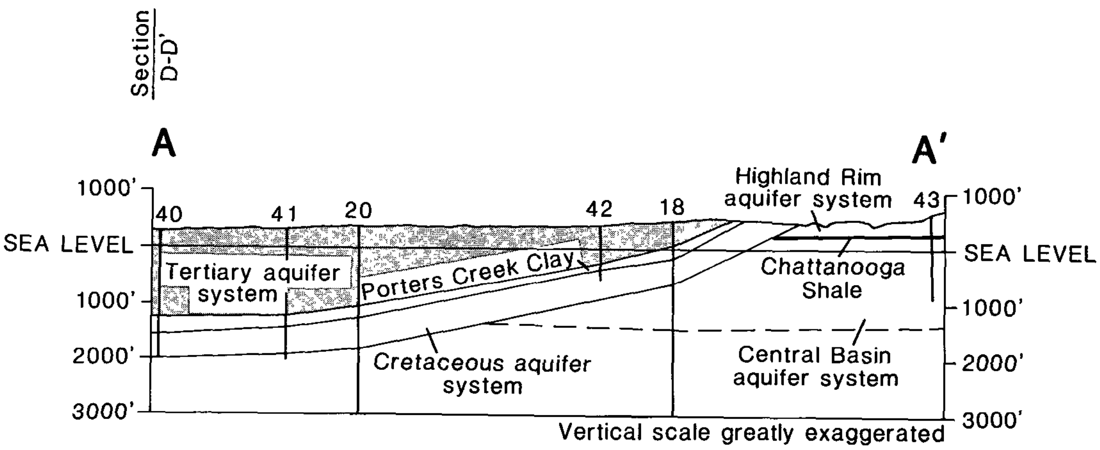


Figure 3.-- Geohydrologic section showing water quality in the Tertiary aquifer system along line A-A'.

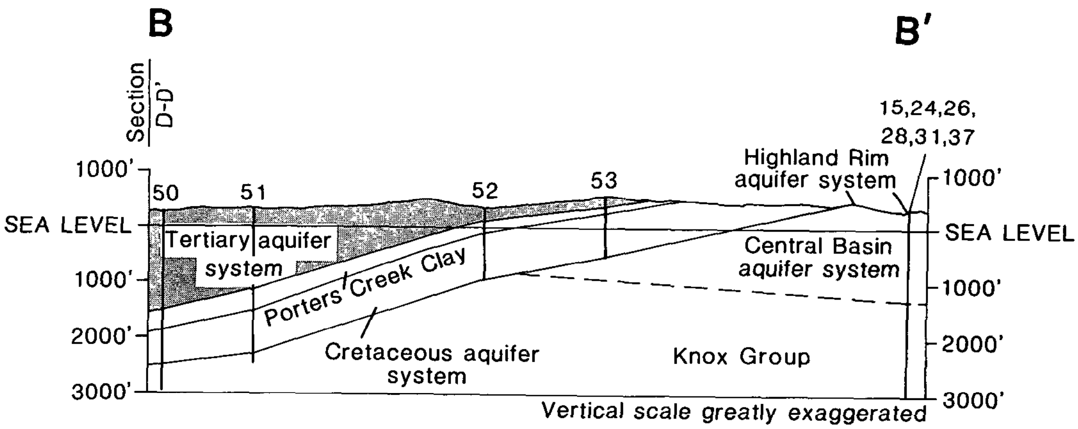


Figure 4.-- Geohydrologic section showing water quality in the Tertiary aquifer system along line B-B'.

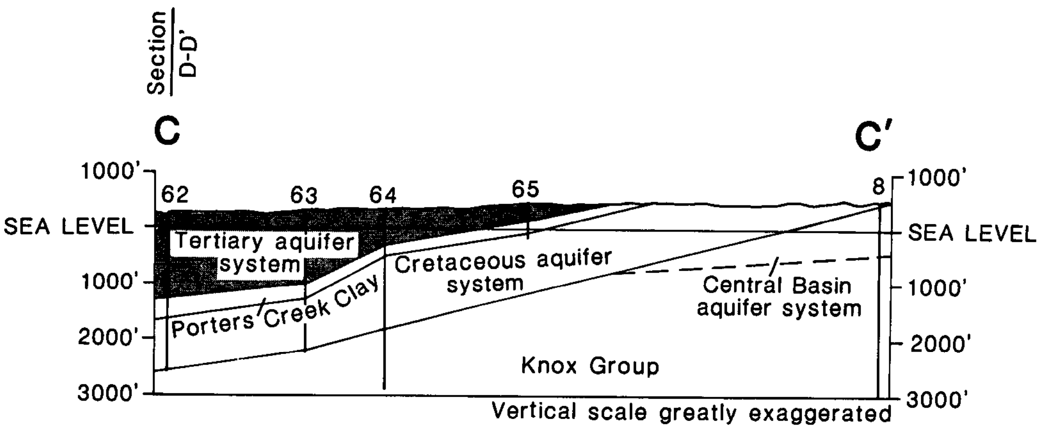


Figure 5.-- Geohydrologic section showing water quality in the Tertiary aquifer system along line C-C'.

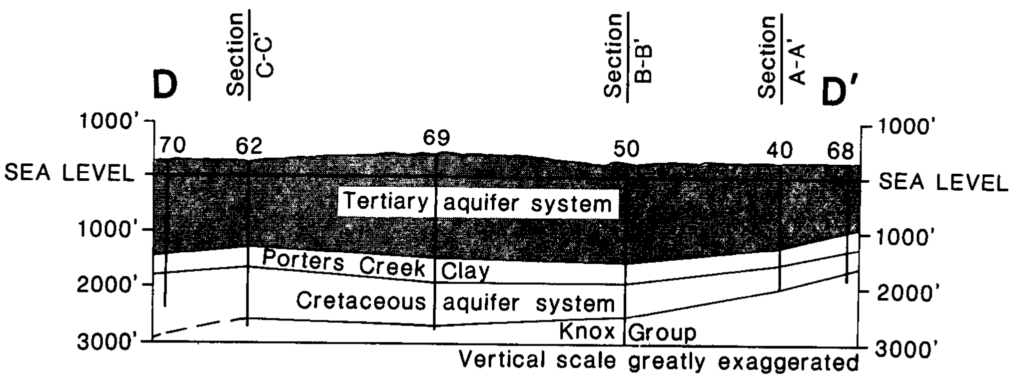
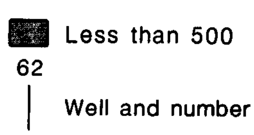
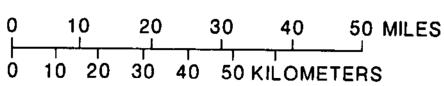


Figure 6.-- Geohydrologic section showing water quality in the Tertiary aquifer system along line D-D'.

EXPLANATION

DISSOLVED-SOLIDS CONCENTRATION, IN MILLIGRAMS PER LITER





NATIONAL GEODETIC VERTICAL DATUM OF 1929

Table 1.--Geohydrology of the formations comprising the Tertiary aquifer system

[Modified from Wells (1933), Hardeman (1966), Miller (1974), Russell and Parks (1975), Criner and Parks (1976)]

SYSTEM	SERIES	*Stratigraphic* unit	Geologic description	Hydrologic significance		
				Occurrence in Tennessee	Hydrologic classification and character	Yield
QUATERNARY	HOLOCENE AND PLEISTOCENE	Alluvial Deposits	Sand, gravel, silt, and clay. 0 to 175 feet thick. Thickest beneath the Mississippi River alluvial plain; probably no more than 50 feet elsewhere.	Underlies the Mississippi River flood plain and flood plains of other major streams. The Mississippi River alluvium occurs along the western part of Lake, Dyer, Lauderdale, Tipton, and Shelby Counties.	Local aquifer in Tennessee. Provides water to domestic wells, recharges deeper aquifers.	Wells yields in Tennessee are generally less than 50 gallons per minute. Wells capable of 2,000 gallons per minute have been constructed in Arkansas and Mississippi.
QUATERNARY	PLEISTOCENE	Loess	Wind-deposited silt, silty clay, and minor sand. 0 to 65 feet thick. Thickest on bluffs that border the Mississippi River alluvial plain. Thins towards the east.	Forms a blanket over the terrace deposits and older formations in upland areas.	Local confining unit. Retards downward movement of water to shallow aquifers. Low permeability.	Wells are not known to be constructed in the loess.
QUATERNARY / TERTIARY	PLEISTOCENE AND PLIOCENE	Terrace Deposits	Sand, gravel, and minor clay. Thickness 0 to 100 feet.	Underlies the upland areas in a broad, irregular belt east of the Mississippi River alluvial *plain; may be* locally absent. Formations are not continuous.	Local aquifer capable of supplying domestic wells. High permeability.	Well yields are generally less than 50 gallons per minute. The potential for larger yields is good where the formation is thick.
TERTIARY	EOCENE	Jackson Formation	Formation is predominantly clay with lenses of fine sand and layers of lignite, which attain a thickness of several feet. The total thickness of the formation ranges from 0 to 350 feet. This formation is locally called *the "capping clay."*	Essentially continuous over most of the counties bordering the Mississippi River. Lithologically indistinguishable from the upper clay to the Claiborne Formation. Occurrence has not been mapped in detail.	Generally impermeable and considered to be the upper confining bed for water in the Claiborne Formation.	Fine-grained sand lenses yield several gallons per minute to domestic wells.
TERTIARY	EOCENE	Claiborne Formation	Sand, fine- to coarse-grained, minor amounts of lignite, clay, and silt. Thickness ranges from 200 to 750 feet and averages 450 feet. When divided, the upper clay forms part of the "capping clay," and the sand is also called the Memphis Sand or the "500-foot sand."	Present throughout the western part of West Tennessee.	Highly permeable sand of this formation is the most prolific aquifer in the State. Low permeability clay layers are common but are discontinuous.	A high yielding aquifer, capable of more than 2,000 gallons per minute.
TERTIARY	EOCENE	Wilcox Formation	Silt, clay, and sand, with a thickness of 150 to 350 feet.	Present throughout the western part of West Tennessee.	The upper and lower clay units are confining units. The upper clay unit serves as a *confining unit at the base of* the "500-foot sand" and at the top of the "1,400-foot sand." The lower clay unit is the basal confining unit of the "1,400-foot sand." The "1,400-foot sand" is a high permeability aquifer.	The "1,400-foot sand of the Wilcox may yield from 400 to 1,200 gallons per minute to large wells.
TERTIARY	EOCENE — ? — PALEOCENE	Wilcox Formation	Sand and minor clay, with a thickness of 150 to 300 feet. Known as the "1,400-foot sand."			
TERTIARY	PALEOCENE	Wilcox Formation	Silt, clay, sand, and lignite, with a thickness of 0 to 300 feet.			
TERTIARY	PALEOCENE	Porters Creek Clay	Clay, massive, pale brown to brownish-gray, locally contains glauconitic sand. Thickness 45 to 350 feet with slight thickening to the west and thinning to the north. In some areas, it is cut by sandstone dikes which range in width from a fraction of an inch to 22 feet.	Present throughout the western part of Tennessee in the subsurface, outcropping in a narrow band 1 to 5 miles wide.	Regional confining unit due to its fine texture and clay composition. Retards vertical movement of water and serves as the basal confining unit for this aquifer system.	The Porters Creek Clay is not known to be used as an aquifer, and no data exist for yields.

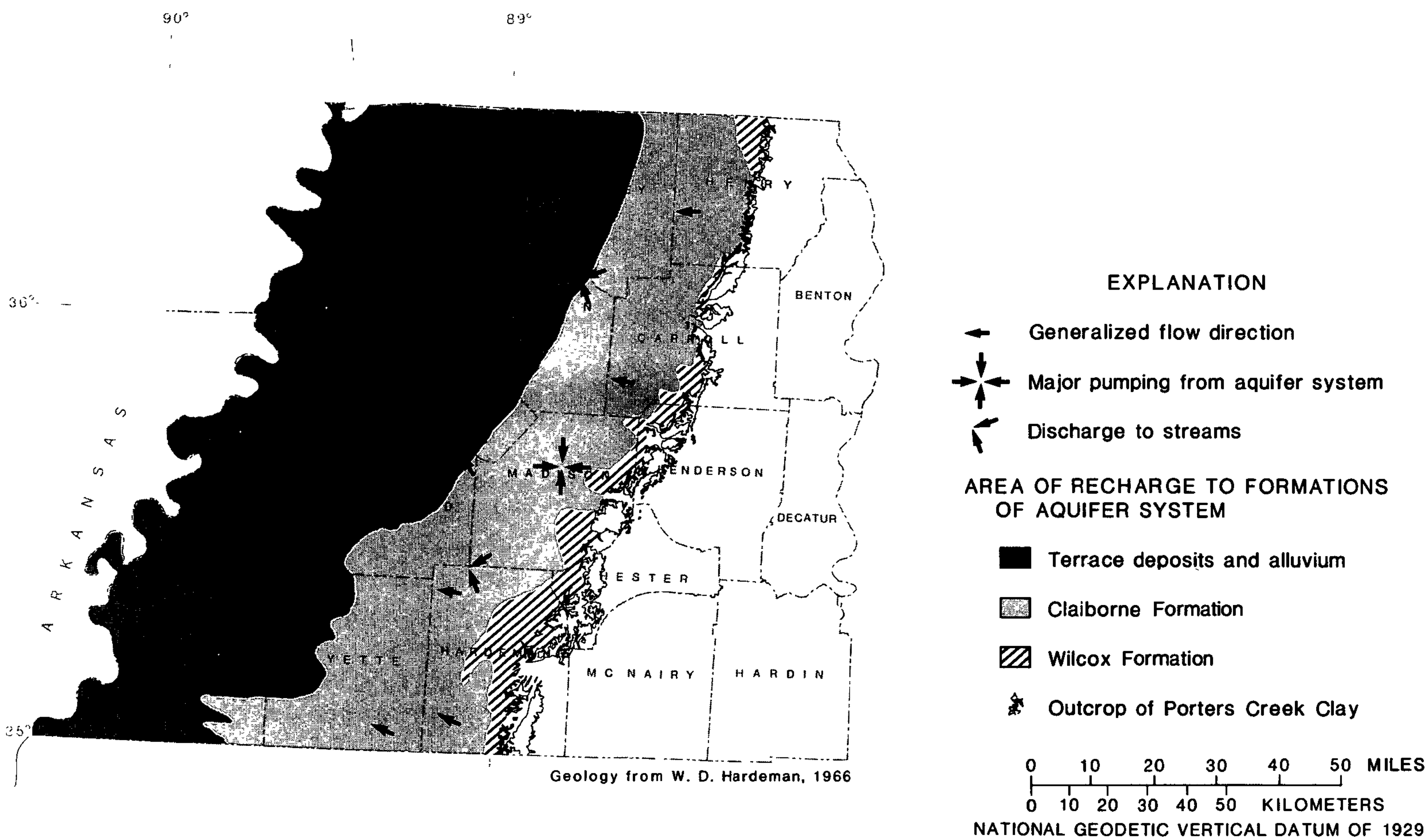


Figure 7.--Ground-water flow in the Tertiary aquifer system.

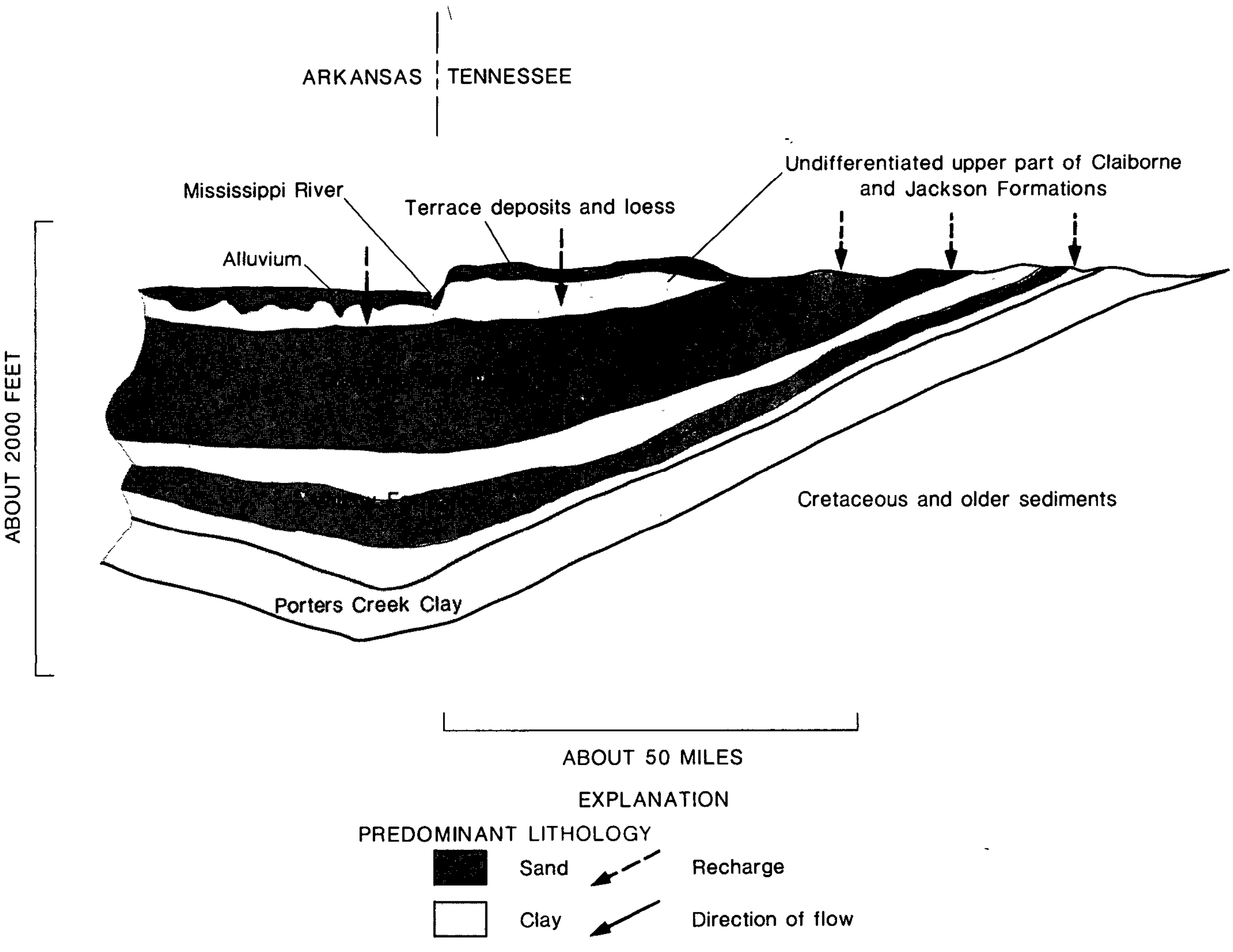
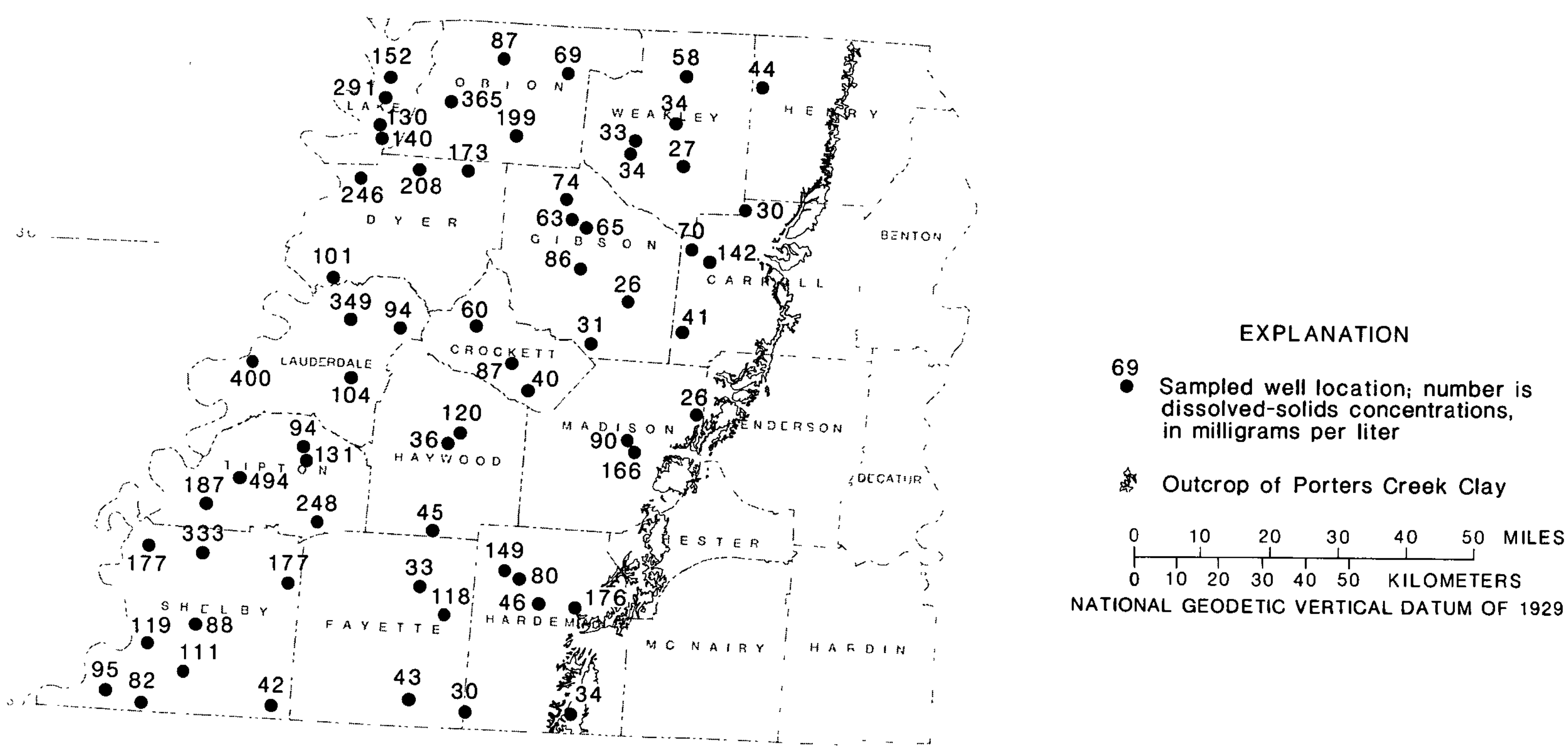


Figure 8.--Diagrammatic cross section of geohydrology of the Tertiary aquifer system.



Geology from W. D. Hardeman, 1966

Figure 9.--Dissolved-solids concentrations of water from selected wells in the Tertiary aquifer system.

Table 2.--Dissolved-solids concentrations of water from selected wells

[Data source codes: 1, Wells (1933); 2, Lanphere (1955); 3, Unpublished U.S. Geological Survey records; 4, Unpublished Memphis Light, Gas and Water records]

County	Location	Well depth (feet below land surface)	Water bearing unit	Dissolved solids (milligrams per liter)	Data source
Carroll	Lavinia	110	Claiborne	41	1
	McKenzie	341	Wilcox	30	3
	Trezevant	120	Claiborne	142	1
	Trezevant	142	Wilcox	70	2
Crockett	Alamo	98	Claiborne	87	1
	Bells	165	Claiborne	40	2
	Chestnut Bluff	96	Claiborne	60	1
Dyer	Lane	168	Claiborne	208	3
	Tennemo	29	Alluvium	246	3
	Tiger Tail	125	?	101	1
	Trimble	82	Jackson	173	1
Fayette	Laconia	125	Claiborne	33	1
	LaGrange	240	Claiborne	43	3
	Somerville	71	Claiborne	118	2
Gibson	Dyer	296	Claiborne	65	1
	Dyer	296	Claiborne	63	2
	Humboldt	229	Claiborne	31	3
	Milan	229	Wilcox	26	3
	Rutherford	288	Claiborne	74	2
	Trenton	189	Claiborne	86	3
Hardeman	Bolivar	71	Claiborne	176	1
	Grand Junction	200	Wilcox	30	3
	Middleton	72	Wilcox	34	3
	Western State Hospital	114	Wilcox	46	3
	Whiteville	180	Claiborne	80	1
	Whiteville	168	Wilcox	149	2
Haywood	Brownsville	250	Claiborne	36	1
	Brownsville	141	Claiborne	120	2
	Dancyville	130	Claiborne	45	1
Henry	Cottage Grove	175	Wilcox	44	2
Lake	Ridgely	670	Claiborne	140	1
	Ridgely	770	Claiborne	130	2
	Tiptonville	500	Claiborne	152	2
	Wynnburg	35	Alluvium	291	1

Table 2.--Dissolved-solids concentrations of water from selected wells--Continued

County	Location	Well depth (feet below land surface)	Water bearing unit	Dissolved solids (milligrams per liter)	Data source
Lauderdale	Ashport	36	Alluvium	400	3
	Edith	196	Claiborne	349	1
	Gates	100	Jackson	94	1
	Ripley	755	Claiborne	104	2
Madison	Claybrook	90	Claiborne	26	1
	Jackson	152	Claiborne	90	1
	Jackson	165	Wilcox	166	2
Obion	Gibbs	165	Jackson	69	1
	Hornbeak	105	Terrace deposits	365	1
	Obion	80	Terrace deposits	199	3
	Union City	554	Claiborne	87	2
Shelby	Arlington	291	Claiborne	177	1
	Bartlett	95	Terrace deposits	88	2
	Collierville	324	Claiborne	42	3,4
	Millington	250	Claiborne	333	1
	MLGW-Davis	446	Claiborne	95	3,4
	MLGW-Mallory	1376	Wilcox	119	3,4
	MLGW-Palmer	478	Claiborne	82	2
	MLGW-Sheahan	1310	Wilcox	111	3,4
	Shelby Co. Forest Campground	584	Claiborne	177	3,4
Tipton	Covington	540	Claiborne	131	2
	Covington	98	Claiborne	94	1
	Mason	30	Terrace deposits	248	3
	Munford	63	Terrace deposits	187	1
	Randolph	45	Terrace deposits	494	1
Weakley	Dresden	222	Claiborne	34	2
	Gleason	260	Claiborne	27	3
	Palmersville	110	Claiborne	58	1
	Sharon	276	Claiborne	34	1
	Sharon	255	Claiborne	33	2

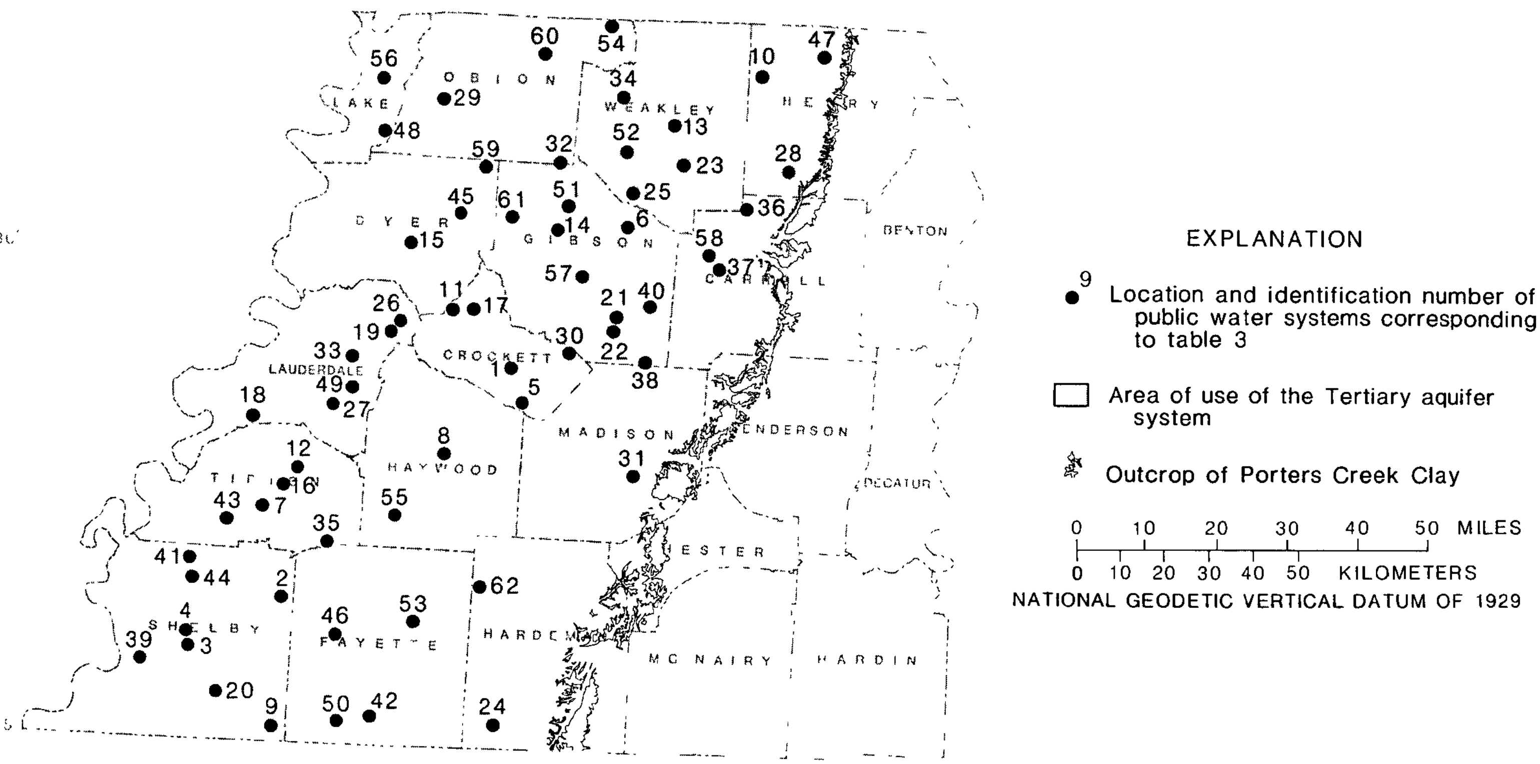
Table 3.--Summary of public-supply systems

[Data source codes: 1, Reported - Tennessee Division of Water Resources; 2, Reported - Tennessee Division of Water Quality Control; 3, Tennessee comprehensive joint water and related land resources planning, Tennessee Division of Water Resources]

Location No.	System	County	Data source
1	Alamo	Crockett	1,2,3
2	Arlington	Shelby	1,2,3
3	Bartlett	Shelby	1,2
4	Bartlett-Ellendale	Shelby	2,3
5	Bells	Crockett	1,2,3
6	Bradford	Gibson	1,2,3
7	Brighton	Tipton	1,2,3
8	Brownsville	Haywood	1,2,3
9	Collierville	Shelby	1,2,3
10	Cottage Grove	Henry	1,2,3
11	County Wide Utility District	Crockett	1,2,3
12	Covington	Tipton	1,2,3
13	Dresden	Weakley	1,2,3
14	Dyer	Gibson	1,2,3
15	Dyersburg	Dyer	1,2,3
16	First U. D. of Tipton Co.	Tipton	1,2,3
17	Friendship	Crockett	1,2,3
18	Ft. Pillow State Farm	Lauderdale	2,3
19	Gates Utility District	Lauderdale	1,2,3
20	Germantown	Shelby	1,2,3
21	Gibson	Gibson	1,2,3
22	Gibson County Municipal Water District #1 & 2	Gibson	2,3
23	Gleason	Weakley	1,2,3
24	Grand Junction	Hardeman	1,2,3
25	Greenfield	Weakley	1,2,3
26	Halls	Lauderdale	1,2,3
27	Henning	Lauderdale	1,2,3
28	Henry	Henry	1,2,3
29	Hornbeak Utility District	Obion	1,2,3
30	Humboldt	Gibson	1,2,3
31	Jackson	Madison	1,2,3
32	Kenton	Obion	1,2,3
33	Lauderdale County Water System	Lauderdale	1,2,3
34	Martin	Weakley	1,2,3
35	Mason	Tipton	1,2,3
36	McKenzie	Carroll	1,2,3
37	McLemoresville	Carroll	1,2,3
38	Medina	Gibson	1,2,3

Table 3.--Summary of public-supply systems--Continued

Location No.	System	County	Data source
39	Memphis Light, Gas & Water	Shelby	1,2,3
40	Milan	Gibson	1,2,3
41	Millington	Shelby	1,2,3
42	Moscow	Fayette	1,2,3
43	Munford	Tipton	1,2,3
44	Naval Air Station-Memphis	Shelby	2
45	Newbern	Dyer	1,2,3
46	Oakland	Fayette	1,2,3
47	Puryear	Henry	1,2,3
48	Ridgely	Lake	1,2,3
49	Ripley	Lauderdale	1,2,3
50	Rossville	Fayette	1,2,3
51	Rutherford	Gibson	1,2,3
52	Sharon	Weakley	1,2,3
53	Somerville	Fayette	1,2,3
54	South Fulton	Obion	1,2,3
55	Stanton	Haywood	1,2,3
56	Tiptonville	Lake	1,2,3
57	Trenton	Gibson	1,2,3
58	Trezevant	Carroll	1,2,3
59	Trimble	Dyer	1,2,3
60	Union City	Obion	1,2,3
61	West State Utility District	Gibson	1,2,3
62	Whiteville	Hardeman	1,2,3



Geology from W D. Hardeman, 1966

Figure 10.--Area of use of the Tertiary aquifer system.

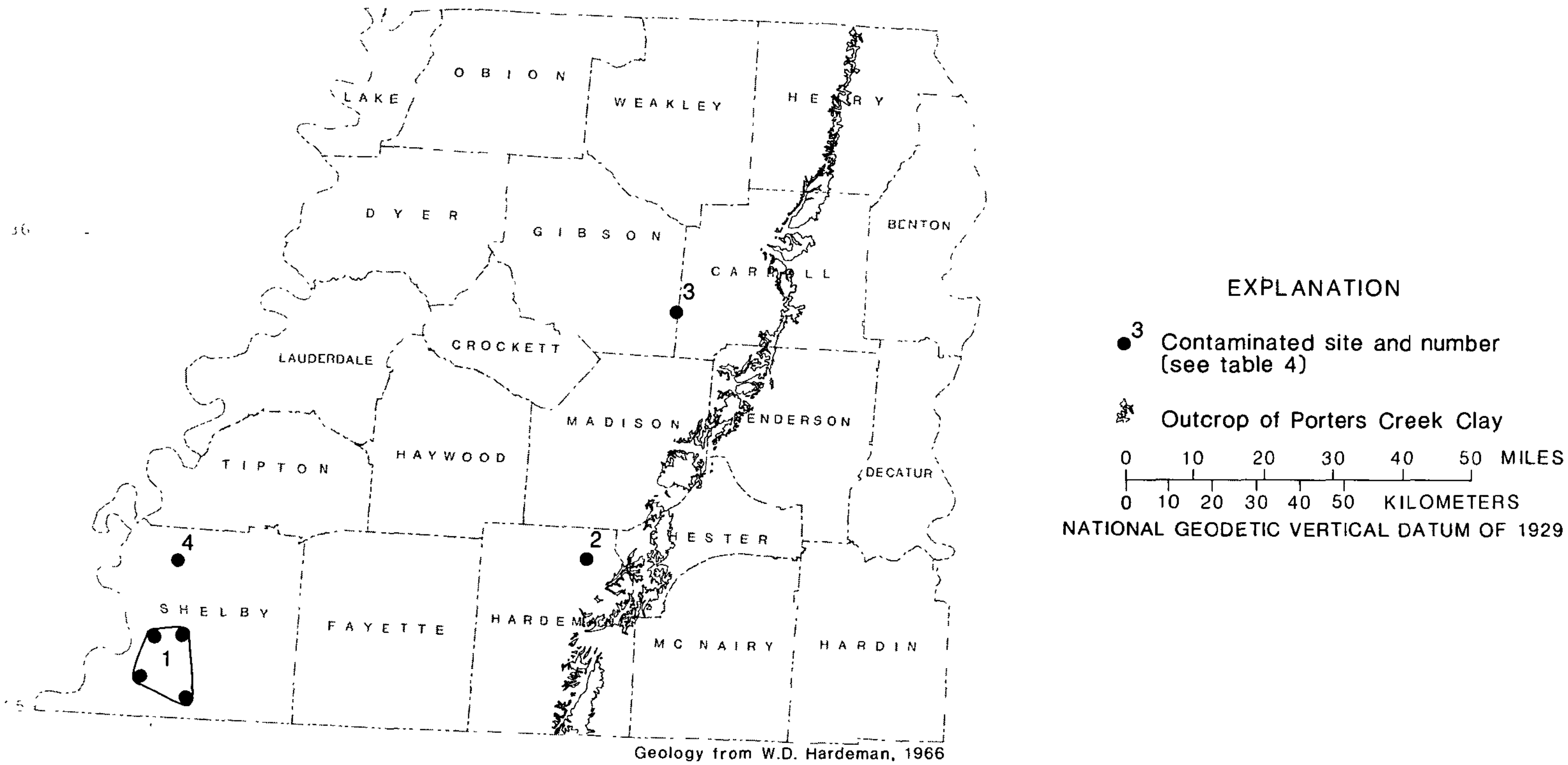
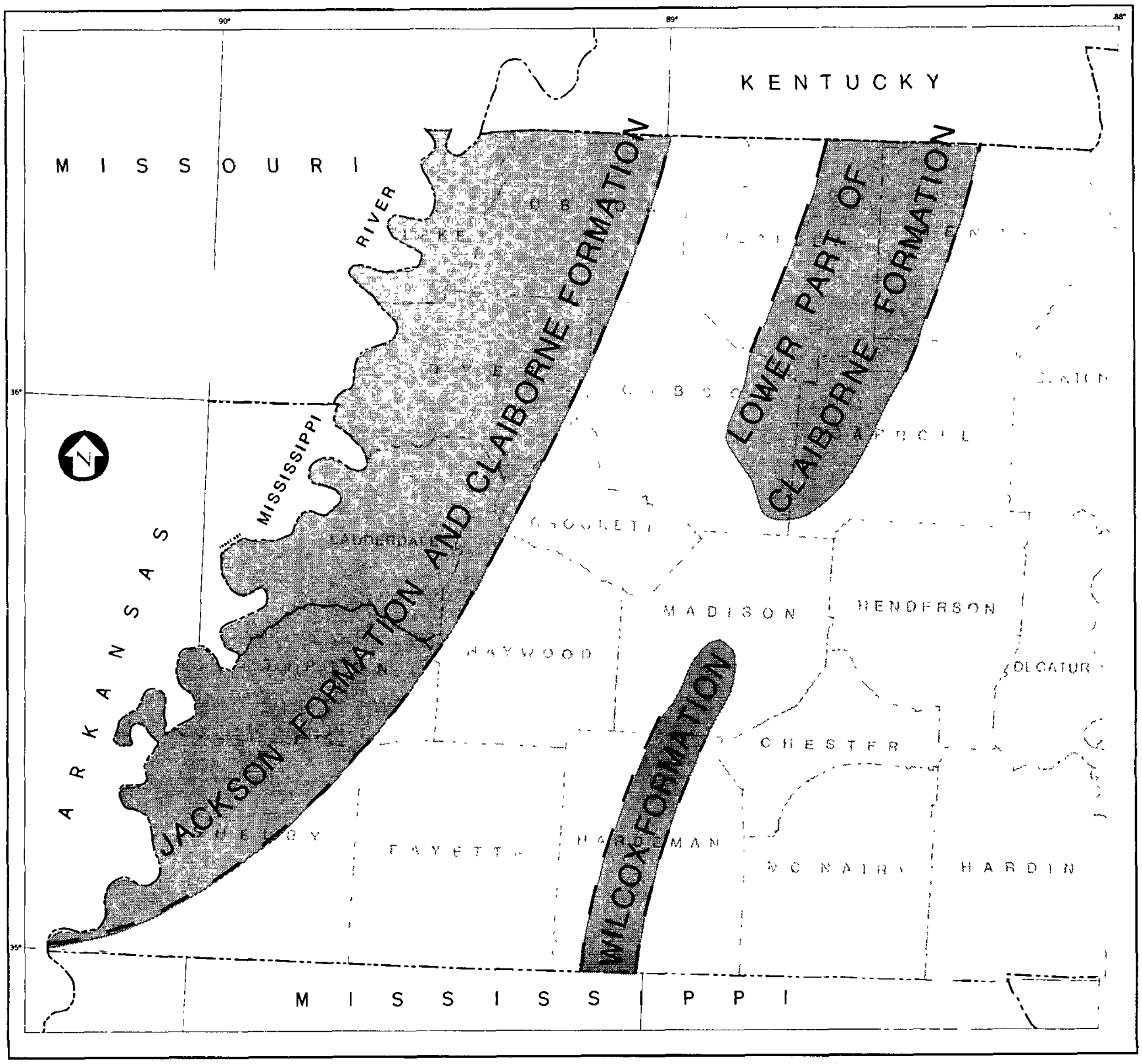


Figure 11.--Location of contaminated sites in the Tertiary aquifer system.

Table 4.--Description of contamination sites

Site identification No. (table 4)	Location	Type of contamination	Data source	Stratigraphic interval contaminated	Comments
1	Memphis area	Dumps and burial grounds, some of which may contain pesticide-herbicide wastes and toxic products from chemical manufacturing.	U.S. Environmental Protection Agency, 1979.	Shallow aquifers in alluvium and terrace deposits.	Current program to define exact areas and constituents. No present evidence for extensive migration of contaminants. Local residents near some burial grounds have reported health problems.
2	Hardeman County	Pesticide waste disposal site.	Sprinkle, C.F., 1978; Rima, D.R., Brown, Eugene, Goerlitz, D.F., and Law, L.M., 1967.	Shallow zones where the Wilcox Formation outcrops, terrace deposits and lower most part of Claiborne Formation.	Aromatic hydrocarbons have been observed in local, shallow wells.
3	Milan Army Arsenal near Milan.	Nitrate contamination	Richard Lanphere, oral commun., Tennessee Division of Water Resources.	Shallow zones in the alluvium, terrace deposits and shallow sands of the Claiborne Formation.	High nitrate levels have been observed in several wells. Current program of study is being undertaken by U.S. Army Environmental Section.
4	Millington Dump/Landfill, Old Ordnance Dump near Sloanville, Shelby County.	Pesticides, sulfuric acid, industrial- and ordnance-type wastes.	U.S. Environmental Protection Agency, 1979.	Shallow zones in alluvium and terrace deposits.	Site has been closed, currently under investigation.



Modified from W.S. Parks, 1981

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

Generalized areas of known lignite occurrence

Figure 12.--Areas of known lignite occurrence.

SELECTED REFERENCES

Bell, E.A., and Nyman, D.J., 1968, Flow pattern and related chemical quality of ground water in the "500-foot" sand in the Memphis area, Tennessee: U.S. Geolological Survey Water-Supply Paper 1853, 27 p.

Boswell, W.H., 1976, The lower Wilcox aquifer in Mississippi: U.S. Geological Survey Water-Resources Investigations 60-75, 3 sheets.

Boswell, E.H., Cushing, E.M., and Hosman, R.L., 1968, Quaternary aquifers in the Mississippi embayment, with a discussion of Quality of water by H.G. Jeffrey: U.S. Geological Survey Professional Paper 448-E, 15 p.

Criner, J.H., and Armstrong, C.A., 1958, Ground-water supply of the Memphis area: U.S. Geological Survey Circular 408, 20 p.

Criner, J.H., and Parks, W.S., 1976, Historic water-level changes and pumpage from the principal aquifers of the Memphis area, Tennessee: 1886-1975: U.S. Geological Survey Water-Resources Investigations 76-67, 45 p.

Criner, J.H., Sun, P-C.P., and Nyman, D.J., 1964, Hydrology of aquifer systems in the Memphis area, Tennessee: U.S. Geological Survey Professional Paper 1779-0, 54 p.

Cushing, E.M., 1966, Map showing altitude of the base of fresh water in coastal plain aquifers of the Mississippi embayment: U.S. Geological Survey Hydrologic Investigation Atlas HA-221.

Cushing, E.M., Boswell, E.H., and Hosman, R.L., 1964, General geology of the Mississippi embayment: U.S. Geological Survey Professional Paper 448-B, 28 p.

Cushing, E.M., Boswell, E.H., Speer, P.R., Hosman, R.L. and others, 1970, Availability of water in the Mississippi embayment: U.S. Geological Survey Professional Paper 448-A, 13 p.

Feth, J.H., and others, 1965, Preliminary map of the conterminous United States showing depth to and quality of shallowest ground water containing more than 1,000 parts per million dissolved solids: U.S. Geological Survey Hydrologic Atlas HA-199.

Gandl, L.A., 1981, Characterization of Mississippi aquifers designated as potential drinking water sources: U.S. Geological Survey Water-Resources Investigations 81-550, 89 p.

Glenn, L.C., 1906, Underground Waters of Tennessee and Kentucky west of Tennessee River and of an adjacent area in Illinois: U.S. Geological Survey Water-Supply Paper 164, 173 p.

Hardeman, W.D., 1966, Geologic map of Tennessee, west sheet: Tennessee Division of Geology, scale 1:250,000.

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.

Krieger, R.A., Hatchett, J.L., and Poole, J.L., 1957, Preliminary survey of the saline-water resources of the United States: U.S. Geological Survey Water-Supply Paper 1374, 172 p.

Lanphere, C.R., 1955, Geologic source and chemical quality of public ground-water supplies in western Tennessee: Tennessee Division of Geology Report of Investigations No. 1, 69 p.

Milhous, H.C., 1959, Well logs in Tennessee: Tennessee Division of Geology Bulletin 62, 606 p.

Miller, R.A., 1974, The geologic history of Tennessee: Tennessee Division of Geology Bulletin 74, 63 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 No. 26, (chart)

Newcome, Roy, Jr., 1976, The Sparta aquifer system in Mississippi: U.S. Geological Survey Water-Resources Investigations 76-7, 3 sheets.

Nyman, D.J., 1965, Predicted hydrologic effects of pumping from the Lichterman well field in the Memphis area, Tennessee: U.S. Geological Survey Water-Supply Paper 1819-B, 26 p.

Parks, W.S., 1981, Appraisal of hydrologic information needed in anticipation of lignite mining in Lauderdale county, Tennessee: U.S. Geological Survey Water-Resources Investigations 80-54, 67 p.

Russell, E.E., and Parks, W.S., 1975, Stratigraphy of the outcropping Upper Cretaceous, Paleocene, and Lower Eocene in western Tennessee (including descriptions of younger Fluvial deposits): Tennessee Division of Geology Bulletin 75, 53 p.

Schneider, Robert, and Blankenship, R.R., 1950, Subsurface geologic cross section from Claybrook, Madison County, to Memphis, Shelby County, Tennessee: Tennessee Division of Geology Ground-Water Investigations, Preliminary Chart 1.

Schneider, Robert, and Cushing, E.M., 1948, Geology and water-bearing properties of the "1,400-foot" sand in the Memphis area: U.S. Geological Survey Circular 33, 13 p.

Schreurs, R.L., and Marcher, M.V., 1959, Geology of ground-water resources of the Dyersburg quadrangle, Tennessee: Tennessee Division of Geology Report of Investigation No. 7, 61 p.

Sprinkle, C.L., 1978, Leachate migration from a pesticide waste disposal site in Hardeman County, Tennessee: U.S. Geological Survey Water-Resources Investigations 78-128, 35 p.

Statler, A.T., Bloss, P., and Zurawski, R.P., 1975, Subsurface information catalog of Tennessee 1866-1974: Tennessee Division of Geology Bulletin 76, 154 p.

Stearns, R.G., and Armstrong, C.A., 1955, Post-Paleozoic stratigraphy of western Tennessee and adjacent portions of the upper Mississippi embayment: Tennessee Division of Geology Report of Investigations No. 2, 29 p.

U.S. Environmental Protection Agency, 1979, Hit List, part two: Waste Age, v. 10, no. 8, p. 53-58.

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

Wilson, J.M., and Criner, J.H., 1969, Geohydrology of Henry and Weakley Counties: Tennessee Division of Water Resources, Water Resources Series 7, 49 p.

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