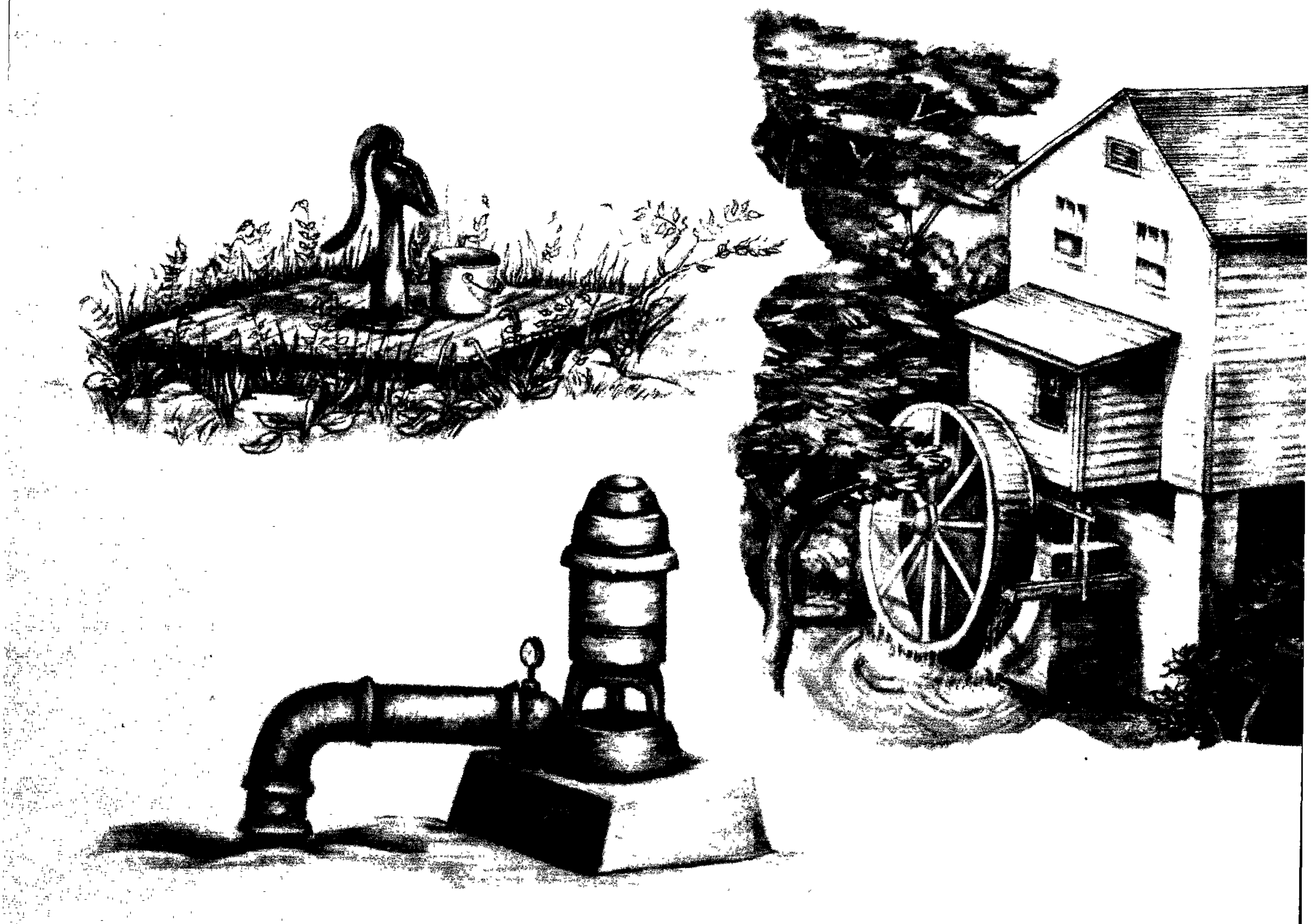
WATER-RESOURCES INVESTIGATIONS REPORT 82-4054

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



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

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

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UNITED STATES DEPARTMENT OF THE INTERIOR

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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)
mi (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallons per minute (gal/min)	0.004	cubic meters per minute (m^3/min)

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 this report.

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

J. V. Brahana and Michael W. Bradley

ABSTRACT

The Highland Rim aquifer system is primarily composed of Mississippian carbonates. This aquifer system occurs west of the Valley and Ridge province. It crops out in the Highland Rim and the Sequatchie Valley. It has been removed by erosion from the Central Basin. Ground water in the Highland Rim aquifer system occurs primarily in secondary openings. These openings include solution openings, joints, and faults. The Chattanooga Shale is the lower confining layer for the Highland Rim aquifer system. Under the Cumberland Plateau, this aquifer system is separated from the overlying Pennsylvanian formations by the Pennington Shale.

The Highland Rim aquifer system is an important source of drinking water. It supplies most of the rural, domestic and many public supplies of drinking water in the Highland Rim. Where there is a dynamic flow system, dissolved-solids concentrations are less than 500 milligrams per liter. However, isolated cells may exist where the ground water has dissolved-solids concentrations of more than 1,000 milligrams per liter.

INTRODUCTION

The Safe Drinking Water Act (P.L.93-523) includes provisions for the protection of underground sources of drinking water. Specifically, Part C of the Act authorizes the Environmental Protection Agency to establish regulations to insure that underground injection of contaminants will not endanger existing or potential sources of drinking water. As developed by EPA, the regulations require that all underground sources of ground water with less than 10,000 milligrams per liter (mg/L) dissolved solids that do not contain hydrocarbon, mineral, or geothermal resources 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 combined into eight major regional aquifer systems having a broad areal extent. Each aquifer is characterized by a unique set of hydrologic conditions and water quality.

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

This report provides generalized information on (1) the areal and stratigraphic occurrence of the Highland Rim aquifer, (2) dissolved-solids concentration of the ground water, (3) areas of use and potential use, (4) the hydraulic character of the aquifer, (5) the areas of known ground-water contamination, and (6) the known locations of hydrocarbon, mineral, and geothermal resources in the sequence of geologic formations between the Chattanooga Shale and the Pennington Formation.

Formation names used in this report are those of the Tennessee Division of Geology (Miller, 1974) and do not necessarily follow the usage of the U.S. Geological Survey.

GEOLOGY

The formations which comprise the Highland Rim aquifer system occur at land surface throughout the Highland Rim (fig. 1) and in the walls of the Sequatchie Valley. This aquifer system is in the subsurface beneath the Cumberland Plateau and the eastern part of the Coastal Plain of western Tennessee. These formations have been completely removed by erosion from the Central Basin (fig. 1). The aquifer system occupies the stratigraphic interval between the Upper Devonian Chattanooga Shale and the Upper Mississippian Pennington Formation. The formations are, in ascending order, the Maury Shale, Fort Payne Formation, Warsaw Limestone, St. Louis Limestone, Monteagle and St. Genevieve Limestones, Hartselle Formation (Tennessee usage), and the Bangor Limestone. These formations are described in table 1.

The aquifer system is composed almost exclusively of massively bedded limestone formations, some of which have interbedded chert nodules, stringers, or layers throughout their thickness. Within the St. Louis Limestone, the Warsaw Limestone, and the Fort Payne Formation are evaporite layers and nodules, some of which have been replaced by silica (Chowns and Elkins, 1974). The evaporites have a significant effect on water quality in parts of the aquifer. The occurrence of evaporites has not been mapped in detail. Based on water quality, the evaporites appear to be widespread, particularly in the Fort Payne Formation.

The rocks comprising the Highland Rim aquifer system have relatively low intergranular porosity and permeability. Bedding planes and fractures may be enlarged by solutioning to provide secondary permeability. Throughout much of the Highland Rim, these rocks weather to a clay regolith with some chert gravel. The regolith is formed by the chemical dissolution of the limestone, leaving a residual deposit of clay, chert, and angular silica-rich fragments above the bedrock. In the southwestern and southeastern Highland Rim, the Fort Payne Formation may weather to a gravel size cherty rubble that forms a permeable regolith above the bedrock (Burchett and Hollyday, 1974). This chert rubble is particularly well developed near the city of Manchester, in Coffee County.

The Mississippian formations are essentially flat-lying in most of the area of occurrence. The generalized configuration of the top of the aquifer system beneath the Cumberland Plateau is shown in figure 2, and the bottom of the aquifer system is shown in figure 3. The major regional structure, the Nashville Dome, is centered in southern Rutherford County. The Mississippian formations formerly overlying this feature have been completely removed by erosion. There is a slight regional dip to the north throughout most of the western Highland Rim, in addition to the westward dip (fig. 3). With the exception of joints, some minor faulting and some cryptoexplosive structures, the rocks of the Highland Rim aquifer system are essentially undeformed. Geohydrologic sections, showing the general geologic sequence and dissolved-solids concentrations are presented as figures 4 through 10.

The detailed geology of the component formations has been described in a number of published reports. The following were used to compile this report: Theis (1936); Hass (1956); Marcher (1962a); Marcher (1962b); Marcher (1963); Marcher and others (1964); Wilson and Stearns (1966); Smith (1967); Burchett and Hollyday (1974); Chowns and Elkins (1974); Ferm (1974); Burchett (1977); Moran (1977); Wiethe and Sitterly (1978); Milici and others (1979); and Burchett and others (1980).

HYDROLOGY

The Highland Rim aquifer system is an important source of water in the Highland Rim area with a wide range of well yields (less than 1 to more than 400 gal/min) and water quality (less than 100 to more than 10,000 mg/L dissolved solids). The complex anisotropic flow system of the aquifer is only partly understood.

The solid limestone skeleton of the Highland Rim aquifer system has low intergranular porosity and permeability, and as a result, most of the flow is along joints, fractures, and bedding planes. These secondary zones of porosity and permeability are concentrated generally within 300 feet of land surface. The weathering processes enhance development of secondary permeability in this shallow zone. Below 300 feet in depth, the weight of the overlying rocks tends to keep the fractures closed. However, some fractures and openings do occur.

Within the active zone of ground-water movement, flow is dynamic and tends to follow relatively local paths from points of recharge to points of discharge such as springs and rivers. Dissolution is active within this zone as slightly acidic water reacts with the limestone to enlarge openings. Within the dynamic flow system, dissolved-solids concentrations in the ground water are generally less than 1,000 mg/L. In some areas of the Highland Rim, the dynamic system may extend as deep as 400 feet. In other areas wells less than 100 feet deep may yield ground water with more than 3,000 mg/L dissolved solids.

Both within and below the zone of active flow, local pockets of ground water with high concentrations of dissolved solids commonly may be present. These pockets are characterized by moderately to highly mineralized water (from 1,000 to 10,000 mg/L dissolved solids) at shallow depths (several hundred feet) and the presence of the minerals gypsum and anhydrite. As gypsum and anhydrite are highly soluble and would be expected to dissolve under dynamic flow conditions, their presence indicates that no active ground-water flow system has existed in these locations. A conceptual model of flow in the Highland Rim aquifer system is shown in figure 11.

Coupled with ground-water flow in the limestones is a component of flow and ground-water storage in the regolith that overlies and is in direct hydraulic connection with the limestone bedrock. In parts of the Highland Rim, the regolith is a significant component of the ground-water system. Water in the regolith may be either confined or unconfined, whereas most of the water in the bedrock aquifer is confined. The regolith serves primarily as a storage reservoir for the underlying limestones. Where the regolith contains thick chert gravel (such as at Manchester), the regolith can be a dependable, high-yielding aquifer (Burchett and Hollyday, 1974). Figure 12 shows a conceptual model of ground-water occurrence in this part of the system.

In the Highland Rim, the aquifer system receives recharge from precipitation. Flow directions are generally from upland areas to major streams which act as drains. Springs are also important discharge points. In the highly dissected areas of the Highland Rim, most of the precipitation runs off the steep hillsides and little reaches the water table. In addition, the water table has a steep gradient, resulting in fairly rapid movement of ground water toward areas of discharge (Moore and Bingham, 1965). Water levels in the highly dissected areas show large fluctuations, and shallow wells commonly go dry in summer.

Flow in the Highland Rim aquifer system west of the Tennessee River is primarily toward the Tennessee River, which acts as a hydraulic drain. Below the northern part of the Cumberland Plateau, ground-water movement in the Highland Rim aquifer system is restricted by low primary porosity. Additional data are needed because flow directions in the Highland Rim aquifer system below the Cumberland Plateau are poorly documented. Large tubular springs issue from this aquifer system in the Sequatchie Valley in the southern Cumberland Plateau indicating a more dynamic regional flow system than exists to the north. The more dissected nature of the southern Plateau exposes the Mississippian formations at land surface and allows significantly more recharge to the aquifer system than farther north.

The hydrologic boundaries of the Highland Rim aquifer system play a significant, if incompletely defined, role in the development of the aquifer as a drinking-water source. Under the Cumberland Plateau, the aquifer is separated from the overlying Pennsylvanian sandstone and conglomerate aquifers by the Pennington Formation. Available data indicate that the Pennington is a very effective confining layer. Hydraulic interchange between the Pennsylvanian and Mississippian aquifers may occur along some faults, and through drill holes used for petroleum exploration that penetrate the confining layer. No major hydraulic interchange is known at this time.

The underlying Chattanooga Shale is the lower confining layer for the Mississippian aquifers. In middle and west Tennessee, it varies in thickness from several to more than 50 feet and has a major effect on the hydrogeology of the State. Although jointed and thin, the Chattanooga Shale effectively restricts vertical movement of water into or out of the base of the Highland Rim aquifer system. The Chattanooga contains considerable iron sulfide and many trace constituents. Water quality in and below this formation is characterized by high dissolved-solids concentrations.

The eastern limit of the Highland Rim aquifer system is marked by the outcrop of Mississippian formations along the eastern escarpment of the Cumberland Plateau. These formations also occur in isolated areas of the Valley and Ridge but are not included in the Highland Rim aquifer system because of the intense faulting and deformation which makes the Valley and Ridge hydrologically distinct. In west Tennessee, the Mississippian limestones are overlain by Cretaceous deposits. These deposits are highly variable in lithology, from clays to gravels, and the hydraulic connection between the two aquifers likewise varies. Generally, the permeability contrast between the two is great, and on a regional scale the ground-water interchange is minimal. Boswell and others (1970) have documented isolated water-quality variations in basal Cretaceous sediments that they feel may be due to the local interchange of ground water. The western valley of the Tennessee River forms a hydraulic drain for the western part of the Highland Rim aquifer system.

The major controlling influences on regional flow in the Mississippian limestones are (1) development of zones of secondary permeability in the limestone, (2) topographic location, (3) geomorphologic development, and (4) stratigraphic position in relation to the Chattanooga Shale.

The hydrology of areas and component formations has been described in the following published reports: Glenn (1903); Piper (1932); Theis (1936); Hass (1956); Conant and Swanson (1961); Smith (1962); Bingham and Moore (1963); Bingham (1964); Marcher and others (1964); Moore and Bingham (1965); Perry and Moore (1965); Moore and others (1969); Moore and Wilson (1972); Burchett and Hollyday (1974); Moran (1977); and Hollyday and Brahana (1980).

WATER QUALITY

Chemical analyses of water from the Highland Rim aquifer system indicate generally good quality throughout the Highland Rim in the zone of active ground-water flow. Dissolved-solids concentrations commonly are less than 500 mg/L. Figure 13 shows the areal distribution of dissolved solids in the aquifer and table 2 lists the variation by depth and formation. Water-quality data were selected on the basis of providing a thorough areal and stratigraphic coverage, in addition to providing a range of observed concentrations of dissolved solids from the formations that make up the Highland Rim aquifer system.

Water having dissolved-solids concentrations less than 100 mg/L is common in the regolith in some areas of the Highland Rim where the thickness of the regolith exceeds 40 feet. The ground water in the regolith is slightly acidic and low in dissolved solids. Ground water in solution channels and fractures of carbonate rocks on the Highland Rim tends to be harder, higher in dissolved solids, and slightly alkaline, because of dissolution of the limestones and carbonates.

Zones of more highly mineralized water (greater than 1,000 mg/L) are generally restricted to areas in the Fort Payne Formation and, to a lesser extent, the Warsaw and St. Louis Limestones which contain evaporites.

Ground water from one well in this aquifer system was extremely high in dissolved solids (greater than 10,000 mg/L). The cause of this anomaly is probably related to the absence of an active flow system. This water may be connate water modified by contact with evaporite layers.

The area in the Highland Rim aquifer system where water quality is least well known is the area beneath the Cumberland Plateau, particularly the northern part. Formations within the aquifer serve as reservoirs for petroleum. Although many wells have been drilled into these zones, quantitative water quality analyses are seldom made. Qualitatively, the drillers describe the water in the Mississippian formations as ranging from "fresh" to "saline". Few data exist, but because of the petroleum production from the Mississippian formations and the restricted flow caused by the overlying, flat-lying Pennsylvanian shales, it is likely that the water quality is poor (greater than 1,000 mg/L dissolved solids) throughout most of the northern Cumberland Plateau. Dissolved solids may even approach brine concentrations (greater than 35,000 mg/L) in some areas.

In addition to much unpublished data, the following reports were used to compile information for this water-quality section: Piper (1932); Wells (1933); Theis (1936); Smith (1962); Marcher and others (1964); Perry and Moore (1965); Moore and others (1969); Moore and Wilson (1972); Burchett (1977); Rima and Goddard (1979); and Burchett and others (1980).

DRINKING-WATER SUPPLIES

The Highland Rim aquifer system is one of the more areally extensive aquifers in the State. It is used for municipal or public drinking-water supplies throughout most of the Highland Rim. A summary of public supplies derived from the geologic formations that comprise this aquifer system is presented in table 3 and in figure 14. All counties in the Highland Rim use water from this aquifer system for domestic supplies. The Highland Rim aquifer system is capable of yielding water for both public and domestic use, and as such represents a valuable resource. The area of use and potential use is outlined in figure 14. While the Highland Rim aquifer system may contain ground water with very high concentrations of dissolved solids in some areas of the Cumberland Plateau, it may also contain relatively fresh water in other areas. Because of this, the Highland Rim aquifer system has some potential for being used as a source of drinking water under the Cumberland Plateau.

CONTAMINATION

There are four documented sites of ground-water contamination in the Highland Rim aquifer system (table 4 and fig. 15). One site is a municipal dump for Waynesboro in Wayne County. In 1970-72, waste capacitors and rags containing polychlorinated biphenyls (PCB's) were deposited. The impact on the ground water is not known, but remedial action has been taken to clean up the area. This is a geographically limited area and does not appear to pose a threat to the aquifer outside of the limited area.

The other three sites involved dumping of wastes into sinkholes. These wastes moved through solution openings and appeared at springs. In Robertson County, sulfuric acid and alums were dumped into a depression. At sites in Montgomery County, wastes containing trace constituents and petroleum products were dumped into sinkholes. Contamination at these three sites also occurred in a limited area and does not appear to threaten the aquifer system.

HYDROCARBON, MINERAL, AND GEOTHERMAL RESOURCE USE

At the present time (1982), the formations that make up the Highland Rim aquifer system are being tapped for their hydrocarbon resources in the northern Cumberland Plateau. The potential for hydrocarbon production at other locations at some time in the near future is good, and extensive exploration for both oil and gas is currently underway at selected sites on the Plateau and Highland Rim. A map of past and potential hydrocarbon development is shown on figure 16. No current mineral or geothermal resource use is reported, and none is expected based on present information.

The following published references were used to document this part of the report: Hardeman and Miller (1959); Burwell and Milhous (1967a); Burwell and Milhous (1967b); and Miller and others (1970).

SUMMARY

The Highland Rim aquifer system is an important source of drinking water throughout the Highland Rim physiographic province of central Tennessee. The aquifer consists primarily of Mississippian limestones. Ground water is transmitted along joints, fractures, bedding planes, and weathered zones in the limestone and through coarse gravel where it is present in the regolith. The flow system is dynamic, anisotropic, generally local, and for the most part, limited to the shallowest several hundred feet. Under the Cumberland Plateau where the Mississippian formations are overlain by many hundred feet of Pennsylvanian sandstones and low-permeability shales, ground-water conditions are unknown. Beneath the northern Cumberland Plateau, formations in this aquifer system yield significant hydrocarbons and the aquifer system has not been used as a drinking-water source.

Where the ground water of the aquifer system is part of a dynamic flow system, dissolved-solids concentrations are less than 1,000 mg/L. Below the zone of dynamic flow, ground-water flow is restricted, and dissolved-solids concentrations of more than 1,000 mg/L are not uncommon. The proximity of saline water to fresh water indicates a complex, anisotropic flow system.

The Mississippian formations crop out in the Highland Rim. In west Tennessee these formations dip beneath the Cretaceous deposits and have some hydraulic contact with them. In the east, the Mississippian rocks are separated from Pennsylvanian aquifers by the Pennington Formation. Mississippian formations crop out in the valley walls along the entire length of the Sequatchie Valley. In most of its area of occurrence, the Highland Rim aquifer system is underlain by the Chattanooga Shale.

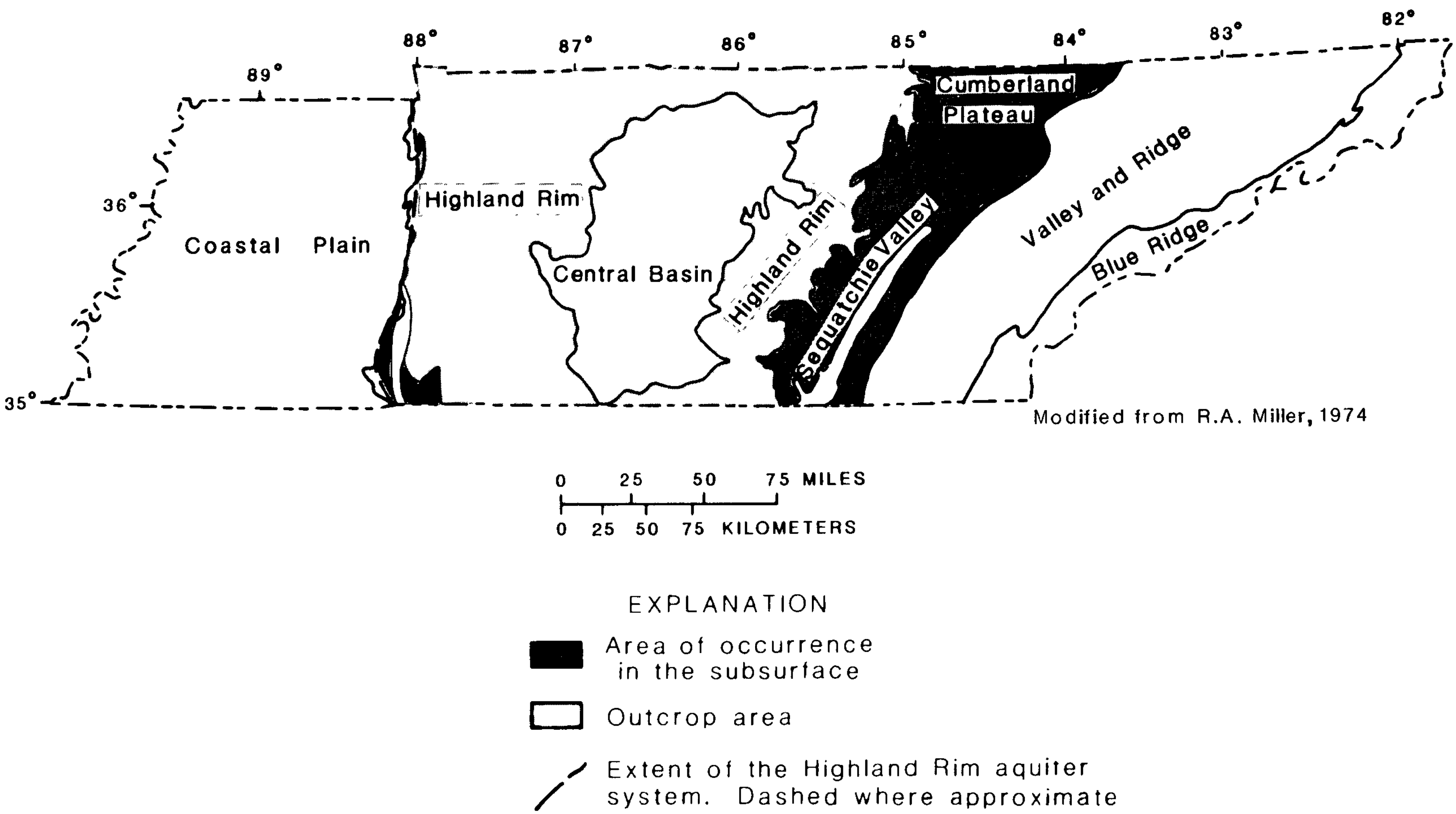


Figure 1.-- Areal occurrence of the Highland Rim aquifer system and physiographic provinces in Tennessee.

Table 1.--Geohydrology of the formations comprising the Highland Rim aquifer system, and confining beds

Stratigraphic unit	Geologic description	Hydrologic significance: Occurrence in Tennessee	Hydrologic significance: Hydrologic classification and character	Hydrologic significance: Yield
Pennington Formation	Shale, clayey, vari-colored, with sandstone partings. Contains massive limestone member. Thickness 200-400 feet.	Formation limited to eastern Highland Rim. Isolated occurrences in the southern Highland Rim.	Confining layer. Very low primary porosity and little or no development of secondary permeability.	Yields little or no water to wells.
Bangor Limestone	Limestone, dark-brownish-gray, thick-bedded. Thickness 70 to 400 feet. Includes Glen Dean Limestone.	Occurs in eastern and southeastern Highland Rim and beneath the Cumberland Plateau.	Local aquifer. Supplies water to domestic wells by solution openings. Porosity and permeability are low.	Yields generally range from 2 to 5 gallons per minute although more than 50 gallons per minute may be obtained.
Hartselle Formation	Sandstone, shale, and limestone. Thickness 0 to 80 feet.	Occurs in eastern and southeastern Highland Rim and beneath the Cumberland Plateau.	Local aquifer. Original porosity and permeability are low. Secondary permeability developed locally.	Yields generally range from 2 to 5 gallons per minute although more than 50 gallons per minute may be obtained.
Monteagle Limestone/ Ste. Genevieve Limestone	Limestone, oolitic, light-gray to white, massive-bedded. Thickness 80 to 500 feet. Includes Gasper Formation of others.	Occurs throughout Highland Rim and beneath Cumberland Plateau.	Local aquifer. Some intergranular porosity, but it is low. Secondary permeability developed locally.	Yields generally less than 10 gallons per minute.
St. Louis Limestone	Limestone, dark-gray to gray, coarse-grained, generally massively bedded. Conducive to caves and sinkholes on the western Highland Rim. Thickness 80 to 175 feet.	Occurs throughout Highland Rim and beneath Cumberland Plateau.	Large solution channels have developed in the northwest counties.	Generally yields are less than 10 gallons per minute. Some locations yield more than 50 gallons per minute.
Warsaw Limestone	Limestone, gray, massive, coarse-grained. Gray to red overburden. Thickness 100 feet.	Occurs throughout Highland Rim and beneath Cumberland Pleateau.	Water occurs locally in solution openings.	Generally yields are less than 20 gallons per minute. Some locations yield more than 200 gallons per minute.
Fort Payne Formation	Limestone, siliceous, gray to bluish-gray, dolomite, siltstone and chert stringers. Thickness 100 to 350 feet. Evaporites present at some locations. Lower part equivalent to New Providence Shale and Ridgetop Shale. Grades into Grainger Formation to east.	Occurs throughout Highland Rim and beneath Cumberland Plateau.	Local aquifer with low primary porosity and permeability. Weathers to a permeable chert rubble in eastern Highland Rim.	Yields range from 0 to more than 100 gallons per minute.
Maury Shale	Shale, mudstone, and siltstone. Glauconitic, gray to green, sandy with phosphatic nodules. Commonly 1 to 4 feet thick.	Occurs throughout Highland Rim beneath Cumberland Plateau.	Not an aquifer, fine-grained, shaly material retards vertical movement of water.	Yields little or no water to wells.
Chattanooga Shale	Shale, black fissile. Divided into three members. Thickness less than 5 to greater than 100 feet.	Occurs beneath Highland Rim and Cumberland Plateau. Absent in West Tennessee slightly west of the Tennessee River. Removed by erosion from the Central Basin.	Regional confining layer. Retards vertical movement of water	Yields little or no water to wells.

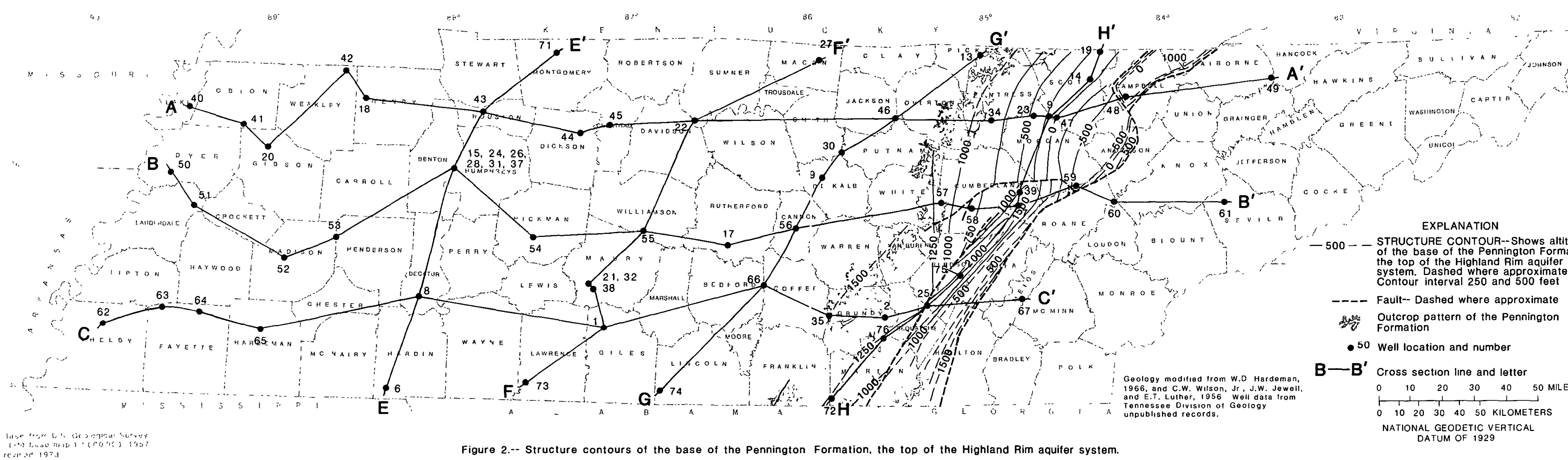


Figure 2.-- Structure contours of the base of the Pennington Formation, the top of the Highland Rim aquifer system.

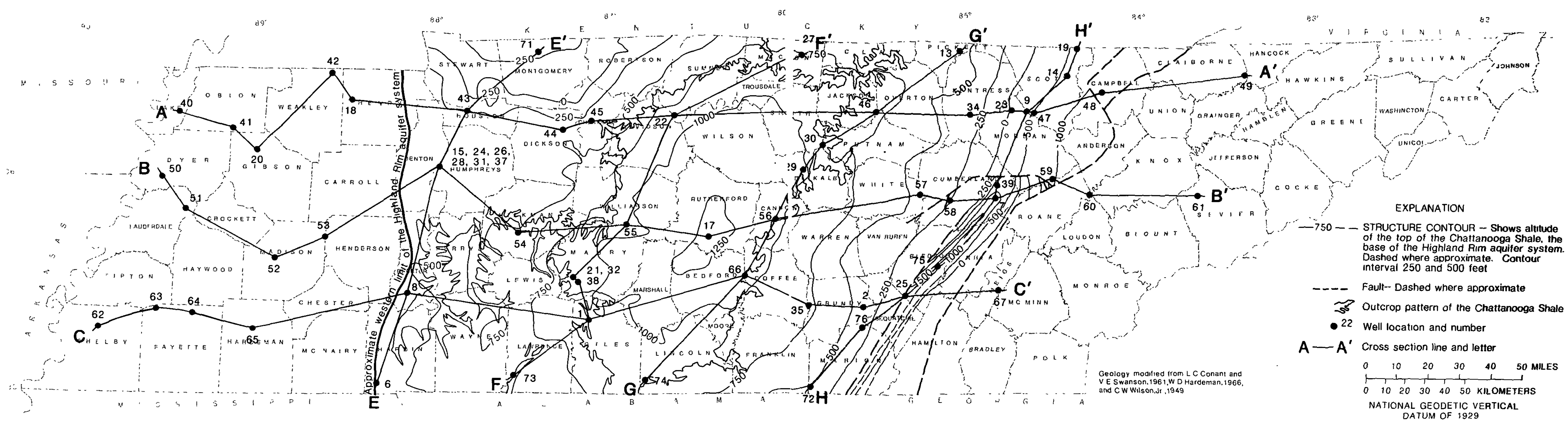


Figure 3 -- Structure contours of the top of the Chattanooga Shale, the base of the Highland Rim aquifer system

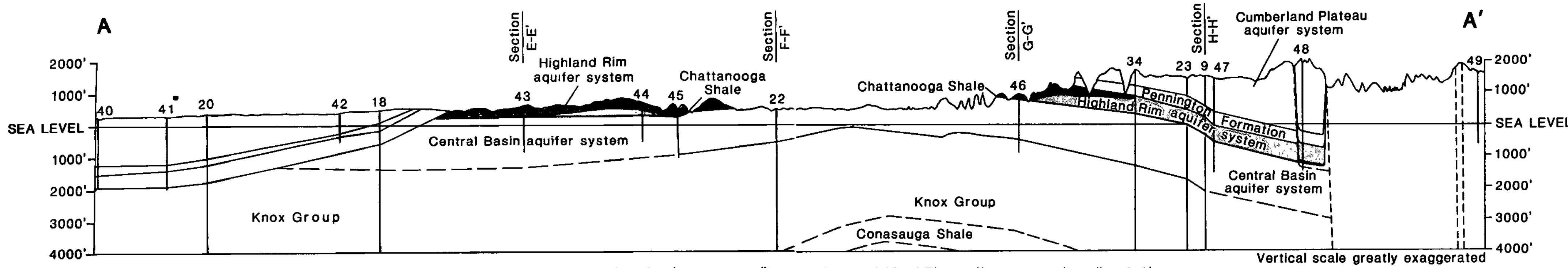


Figure 4 -- Geohydrologic section showing water quality in the Highland Rim aquifer system along line A-A'.

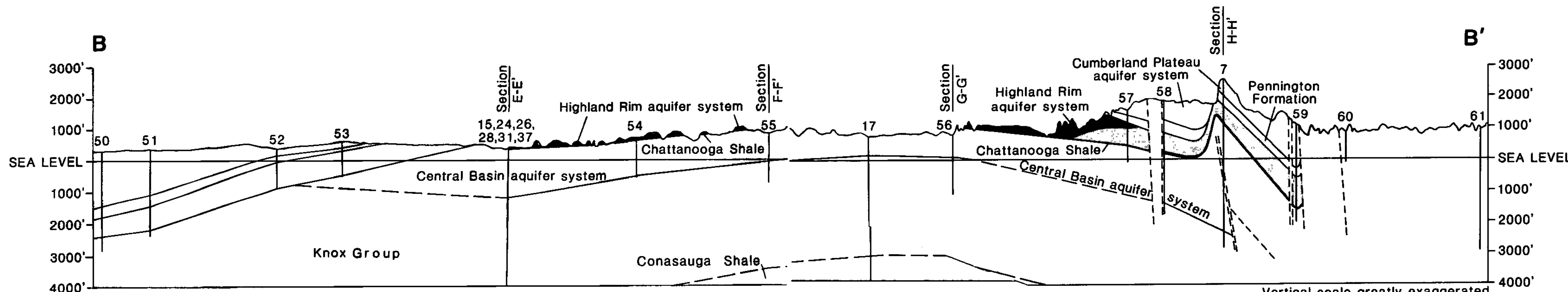


Figure 5 -- Geohydrologic section showing water quality in the Highland Rim aquifer system along line B-B'.

EXPLANATION

50 Well and number

Fault

DISSOLVED-SOLIDS CONCENTRATIONS, IN MILLIGRAMS PER LITER

■ 0 to 1000. Isolated pockets greater than 1000 may occur

□ Few analyses, estimated greater than 1000. May be greater than 10,000 with depth

0 10 20 30 40 50 MILES

0 10 20 30 40 50 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

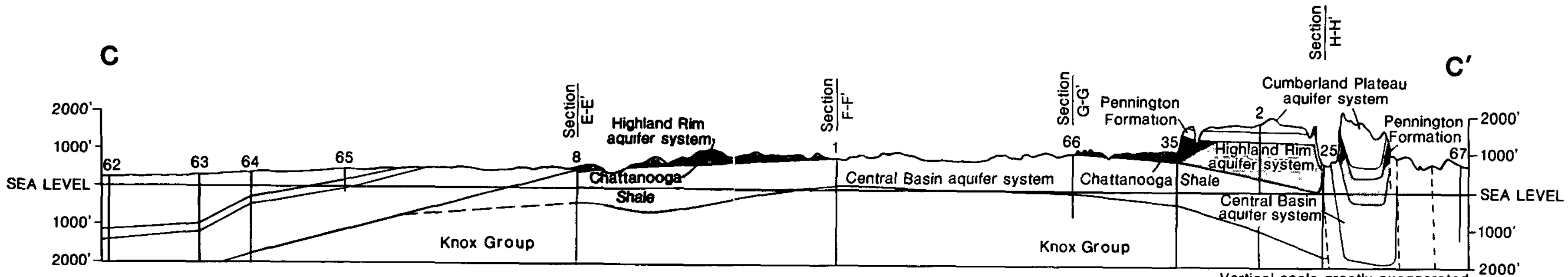


Figure 6.– Geohydrologic section showing water quality in the Highland Rim aquifer system along line C-C'.

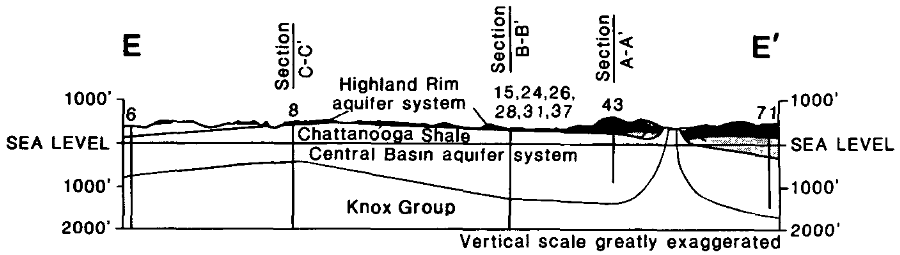


Figure 7 -- Geohydrologic section showing water quality in the **Highland Rim** aquifer system along line E-E'.

EXPLANATION

65
Well and number

Fault

DISSOLVED-SOLIDS CONCENTRATIONS, IN MILLIGRAMS PER LITER

0 to 1000. Isolated pockets greater than 1000 may occur

Few analyses, estimated greater than 1000. May be greater than 10,000 with depth

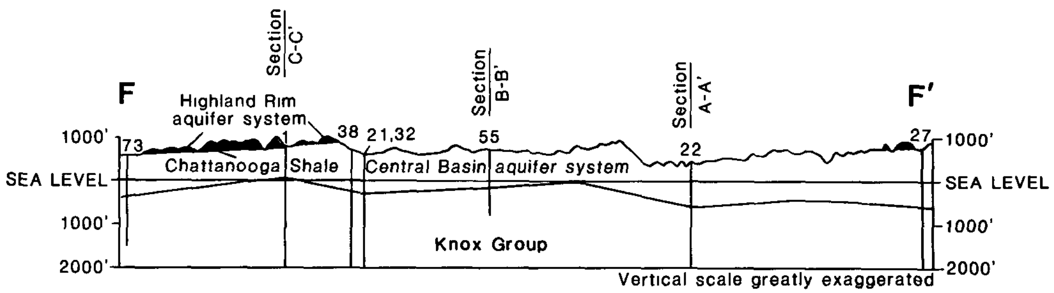


Figure 8.-- Geohydrologic section showing water quality in the **Highland Rim** aquifer system along line F-F'.

0 10 20 30 40 50 MILES

0 10 20 30 40 50 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

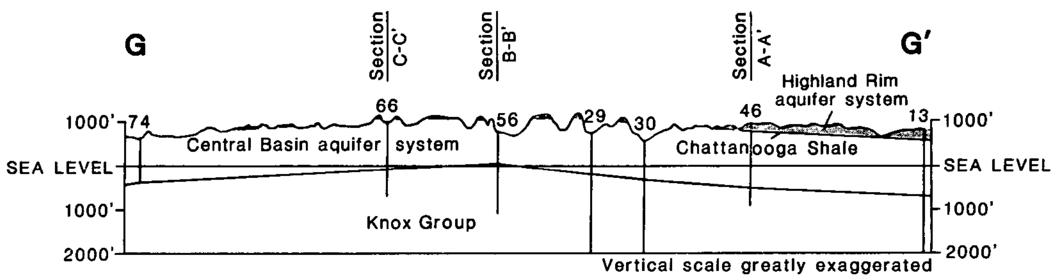


Figure 9.-- Geohydrologic section showing water quality in the Highland Rim aquifer system along line G-G'.

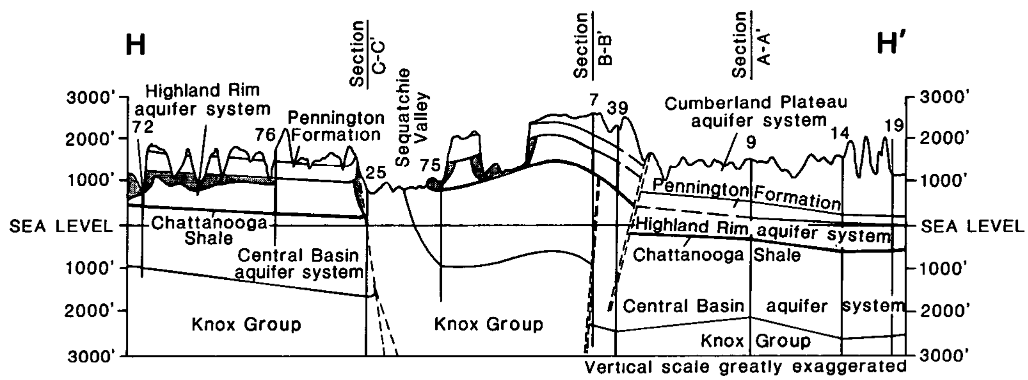
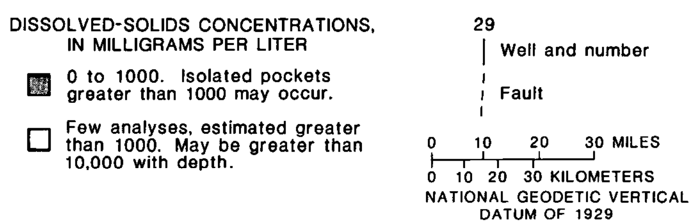


Figure 10.-- Geohydrologic section showing water quality in the Highland Rim aquifer system along line H-H'.

EXPLANATION



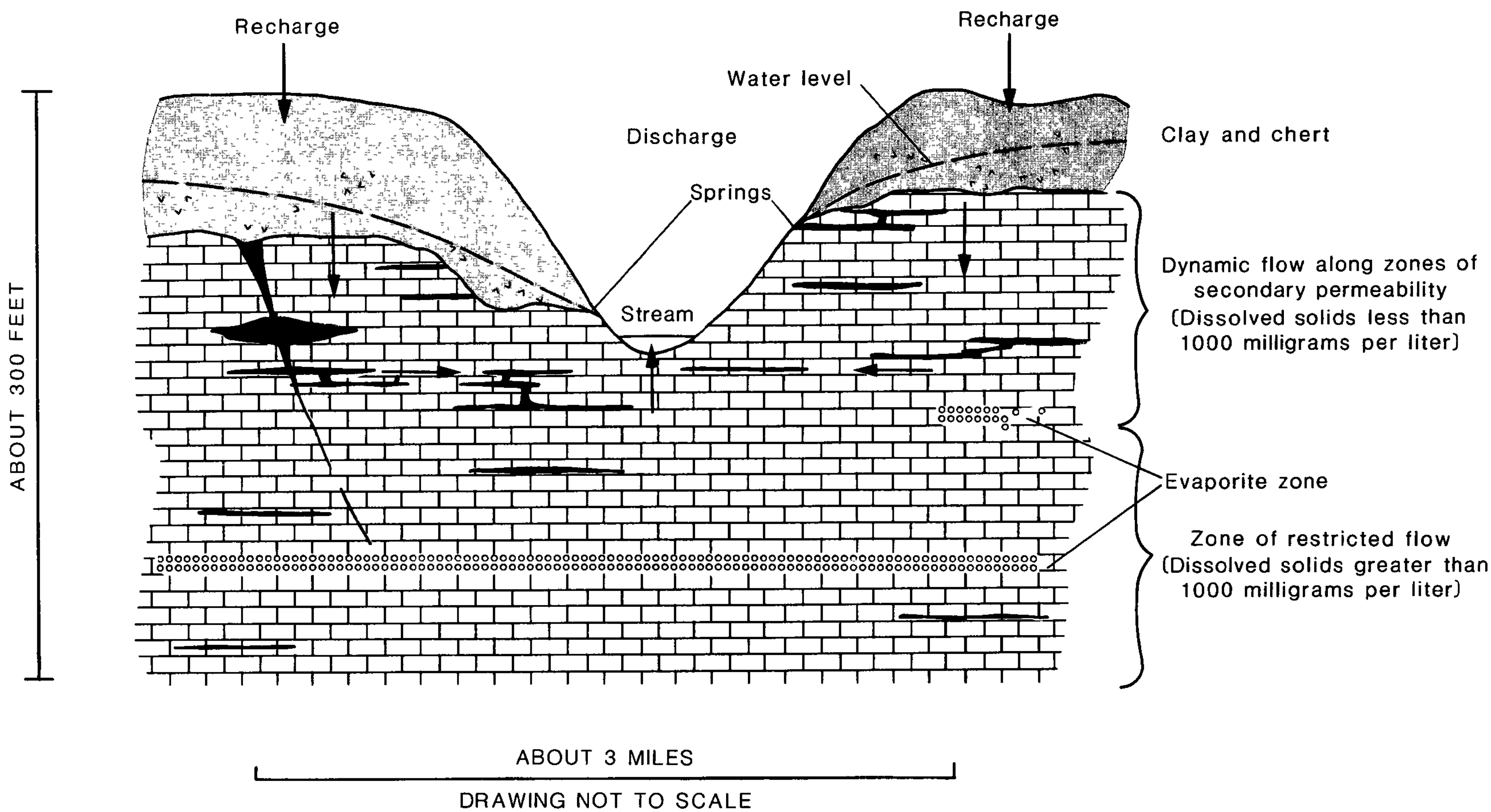


Figure 11.-- Conceptual model of ground-water occurrence in the limestones of the Highland Rim aquifer system.

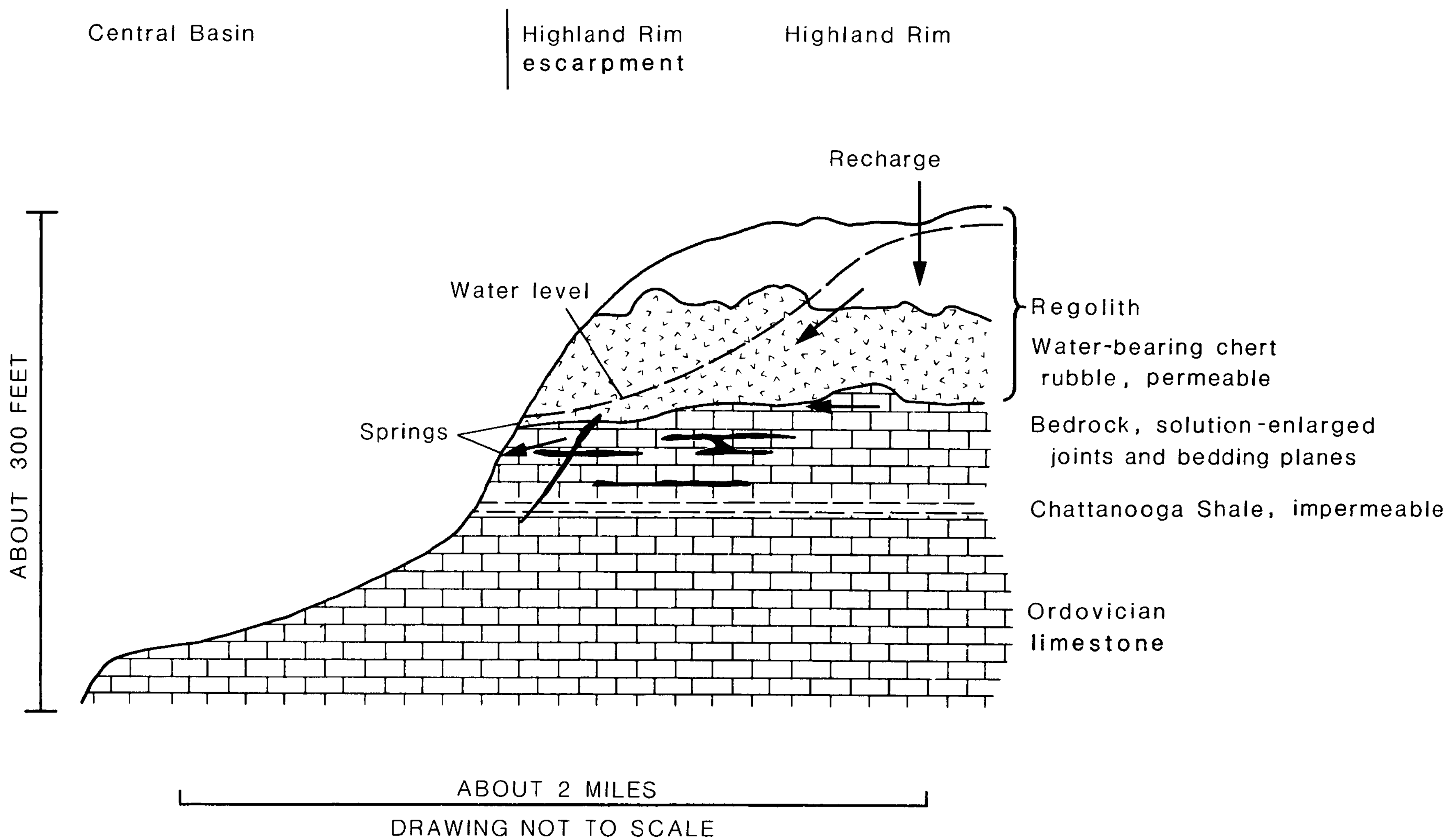


Figure 12.-- Conceptual model of ground-water occurrence in the regolith near the Highland Rim escarpment.

Table 2.--Dissolved-solids concentrations of water from selected wells in the Highland Rim aquifer system

[Data source codes: 1, Piper (1932); 2, Smith (1962); 3, Theis (1936); 4, Rima and Goddard (1979); 5, Wells (1933); 6, Unpublished USGS files; 7, Newcome and Smith (1958); 8, Marcher, Bingham, and Lounsbury (1964)]

County	Location	Depth (feet)	Water-bearing formation	Dissolved solids (milligrams per liter)	Data source
Benton	Faxon	18	Ft. Payne	57	5
Bledsoe	Brayton 7 mi W	57	St. Louis	62	7
Cannon	Woodbury 6 mi SE	105	Warsaw	395	[illegible]
Cheatham	Ashland City 1.75 mi S	120	Ft. Payne	10,068	1
	Ashland City 6 mi NE	105	Ft. Payne/Warsaw	1,130	2
	Kingston Springs 0.5 mi S	Spring	Ft. Payne	401	1
	Neptune 1.75 mi NE	165	St. Louis	274	1
Clay	Moss 1 mi SE	135	Warsaw	231	2
Coffee	Manchester 4 mi N	85	Warsaw	210	2
	Manchester 3 mi NW	97	Ft. Payne	57	2
Cumberland	Crab Orchard	160	St. Louis	333	7
Davidson	Joelton 2 mi S	230	Ft. Payne	488	2
	Whites Creek 3 mi NW	158	Ft. Payne	168	1
	Whites Creek 2.75 mi W	Spring	Chattanooga	844	1
	Joelton	238	Ft. Payne	282	4
Decatur	Sugartree	20	Ft. Payne	42	5
Dekalb	Smithville 3 mi NW	61	Warsaw	36	2
Dickson	Cumberland Fur. 2.5 mi N	140	Ft. Payne	742	2
	Dickson	427	St. Louis/Warsaw	256	1
	Stayton 2.75 mi N	65	Ft. Payne	222	1
	Stayton 3 mi N	40	Ft. Payne	2,505	1
	Vanleer 5 mi W	65	Ft. Payne	3,195	1
	White Bluff	61	St. Louis	258	1
	Burns 8 mi SW	215	Ft. Payne	1,620	6
	Tidwell 1.5 mi SW	75	St. Louis	284	4
	Dickson 2.75 mi SW	200	Warsaw	135	4,8
	Burns	175	Warsaw	202	4,8
	Dickson 3 mi S	217	Ft. Payne	238	4,8
	Tidwell 1 mi SW	328	Ft. Payne	220	4,8
	White Bluff 2 mi W	102	Ft. Payne	196	4,8

Table 2.--Dissolved-solids concentrations of water from selected wells in the Highland Rim aquifer system--Continued

County	Location	Depth (feet)	Water-bearing formation	Dissolved solids (milligrams per liter)	Data source
Franklin	Belvidere 1.5 mi N	118	Warsaw	1,212	3
	Belvidere	65	Ft. Payne	182	3
	Cowan	Spring	Warsaw	296	3
	Decherd	112	Ft. Payne	239	3
	Sherwood	Spring	Warsaw	214	3
	Winchester	Spring	Ft. Payne	156	3
Giles	Ardmore 1.5 mi NE	Spring	Ft. Payne	43	3
Hardin	Olive Hill	30	Ft. Payne	74	5
Hickman	Aetna 6 mi W	Spring	Ft. Payne	198	3
	Bon Aqua 0.5 mi SE	Spring	Ft. Payne	841	3
	Nunnelly 2 mi W	Spring	Ft. Payne	156	3
	Wrigley 2.5 mi S	230	Ft. Payne	144	2
	Wrigley 7 mi NE	130	Warsaw	184	2
Houston	Erin 9.25 mi SE	64	Ft. Payne	226	1
	Erin 6.5 mi SW	160	Ft. Payne	172	1
	Erin 0.6 mi W	Spring	St. Louis	186	1
	Stewart 1 mi W	Spring	St. Louis/Warsaw	97	1
Humphreys	Bold Spring	Spring	St. Louis	156	1
	Denver 4.75 mi E	Spring	Ft. Payne	160	1
	McEwen 0.5 mi NE	217	St. Louis	166	1
	Waverly 6.25 mi N	Spring	St. Louis	140	1
Lawrence	Ethridge 6 mi NE	Spring	St. Louis	57	3
	Iron City	Spring	Ft. Payne	75	3
	Iron City	200	Ft. Payne	3,857	2
	Lawrenceburg 1 mi W	Spring	Ft. Payne	70	3
	Lawrenceburg 7 mi N	120	Ft. Payne	60	2
Lewis	Hohenwald 2 mi N	Spring	St. Louis	55	3
	Hohenwald 5 mi NW	Spring	Ft. Payne	81	3
	Hohenwald 0.5 mi E	97	Ft. Payne	34	2
	Hohenwald 2 mi SW	167	Warsaw	35	2
	Summertown 2 mi N	Spring	St. Louis	65	3
Lincoln	Elora 0.5 mi S	Spring	St. Louis	189	3
	Flintville	80	Ft. Payne	42	2
Macon	Layfayette 6 mi NW	87	Ft. Payne	62	2
	Layfayette 7 mi SW	137	Ft. Payne	108	2

Table 2.--Dissolved-solids concentrations of water from selected wells in the Highland Rim aquifer system--Continued

County	Location	Depth (feet)	Water-bearing formation	Dissolved solids (milligrams per liter)	Data source
Maury	Santa Fe 3 mi N	80	Ft. Payne	95	3
	Theta	Spring	St. Louis	74	3
Montgomery	Clarksville 10 mi NE	195	Warsaw	326	2
	Clarksville 4.25 mi E	162	St. Louis/Warsaw	1,948	1
	Clarksville 9 mi SE	140	Ft. Payne	2,238	2
	Louise 5 mi SE	65	Ft. Payne	1,238	1
	Woodlawn 5 mi NW	136	St. Louis	262	1
	Oakwood 0.5 mi E	126	St. Louis	235	4
	Southside 1.75 mi E	80	Warsaw	215	4
	McAlisters' Crossroads 1.5 mi SE	145	Ft. Payne	322	4
Overton	Livingston 2 mi N	210	Ft. Payne/Warsaw	115	2
	Rickman	65	Ft. Payne	182	2
Perry	Flatwoods 6 mi NE	Spring	Ft. Payne	58	3
	Linden 4 mi S	90	Warsaw	53	2
Pickett	Byrdstown 2 mi SW	100	Ft. Payne	208	2
Putnam	Cookville 4 mi NW	105	Ft. Payne	595	2
	Goffton 1 mi S	150	Ft. Payne	125	2
Robertson	Adams 7 mi S	202	Warsaw	185	2
	Cedar Hill 9.25 mi S	119	St. Louis/Warsaw	1,158	1
	Orlinda 4.75 mi SW	54	St. Louis	362	1
	Springfield 3 mi W	Spring	St. Louis	146	1
	Springfield 10 mi N	71	St. Louis/Warsaw	2,101	1
	Springfield 2 mi S	96	Ft. Payne	180	2
Stewart	Dover 5.75 mi NW	75	Gravel	198	1
	Dover 6 mi SE	111	Warsaw	198	2
	Indian Mound	55	St. Louis	220	1
	Model 5.5 mi W	Spring	Ft. Payne	50	1
	Mulberry Hill 3 mi NE	182	Ft. Payne	202	2
Sumner	Portland 2 mi NE	Spring	St. Louis/Warsaw	162	1
	Westmoreland 0.5 mi E	65	Ft. Payne	214	1
	Westmoreland 5 mi W	100	Chattanooga Shale	4,502	1
	White House	56	Warsaw	204	2
Warren	McMinnville 1 mi SE	105	Ft. Payne	386	2
	McMinnville 3 mi NW	133	Ft. Payne	125	2

Table 2.--Dissolved-solids concentrations of water from selected wells in the Highland Rim aquifer system--Continued

County	Location	Depth (feet)	Water-bearing formation	Dissolved solids (milligrams per liter)	Data source
Wayne	Waynesboro	Spring	Ft. Payne	43	3
	Waynesboro 10 mi N	82	Ft. Payne	38	2
	Waynesboro 10 mi NE	122	Warsaw	24	2
	Westpoint 7 mi NW	Spring	Ft. Payne	104	3
White	Cassville 3 mi W	82	Ft. Payne	215	2
	Spring Hill 3 mi SW	140	Warsaw	185	2
Williamson	Boston 6.25 mi N	Spring	Ft. Payne	168	1
	Boston 2.25 mi W	54	St. Louis	77	1
	Fairview	200	Ft. Payne	211	6
	Fairview	206	Ft. Payne	946	6

Table 3.--Summary of public-water systems using ground water from the Highland Rim aquifer system

[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; 4, Reported from other unpublished sources]

System	County	Data source
Ardmore	Giles	1,2
Belvidere Utility District	Franklin	1,2,3
Big Sandy	Benton	1,2,3
Bon Aqua - Lyles Utility District	Hickman	1,2
Collinwood	Wayne	1,3
Cowan	Franklin	1,2,4
Cumberland City	Stewart	2
Cunningham	Montgomery	2
Dechard	Franklin	1,2,3
Dickson	Dickson	4
Erin	Houston	1,2,3
Estill Springs	Franklin	1,2
Fairview	Williamson	1,2,3
Fayetteville	Lincoln	1,2,3
Franklin	Williamson	1,2,3
Harpeth Valley Utility District	Dickson	1,3
Hohenwald	Lewis	1,2,3
Huntland	Franklin	1,2,3
Lafayette	Macon	1,2,3
Lawrenceburg	Lawrence	1,2,3
Leoma	Lawrence	1,2,3
Lincoln County	Lincoln	4
Loretto	Lawrence	1,2,3
Manchester	Coffee	1,2
McEwen	Humphreys	1,2,3
Orlinda	Robertson	1,2,3
Red Boiling Springs	Macon	1,2
Sherwood	Franklin	1,2,3
St. Joseph	Lawrence	1,2,3
Summertown	Lawrence	1,2,3
Tennessee Ridge	Houston	1,2,3
Tullahoma	Coffee	1,2,3
Van Leer	Dickson	1,3
Waverly	Humphreys	1,2,3
West Point Utility District	Lawrence	1,2,3

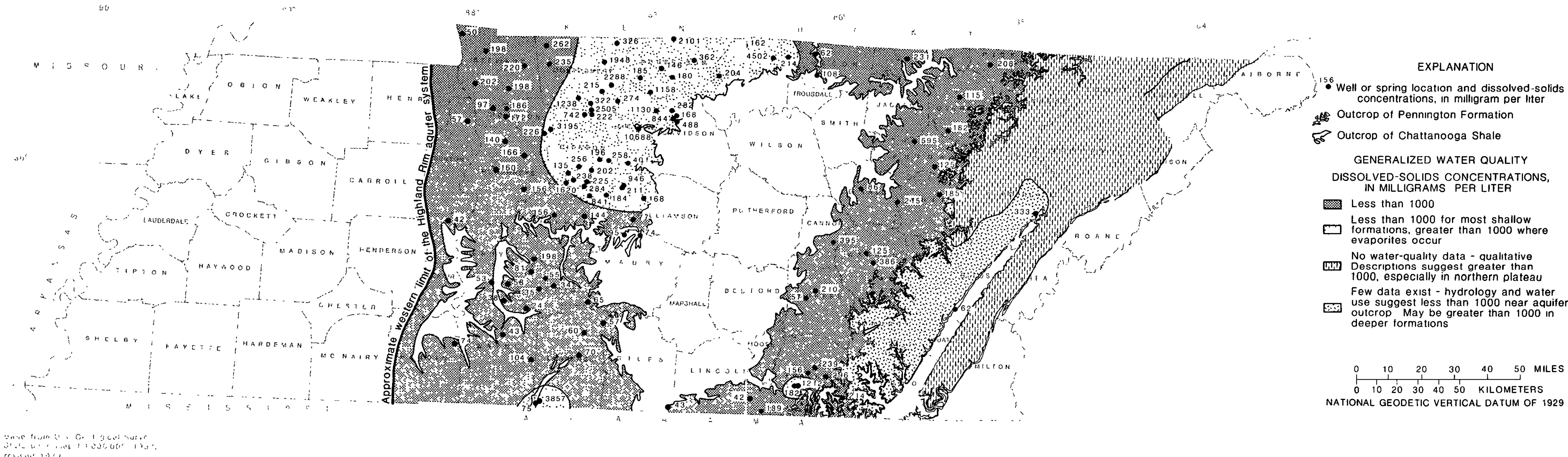


Figure 13.-- Concentration of dissolved solids in the Highland Rim aquifer system.

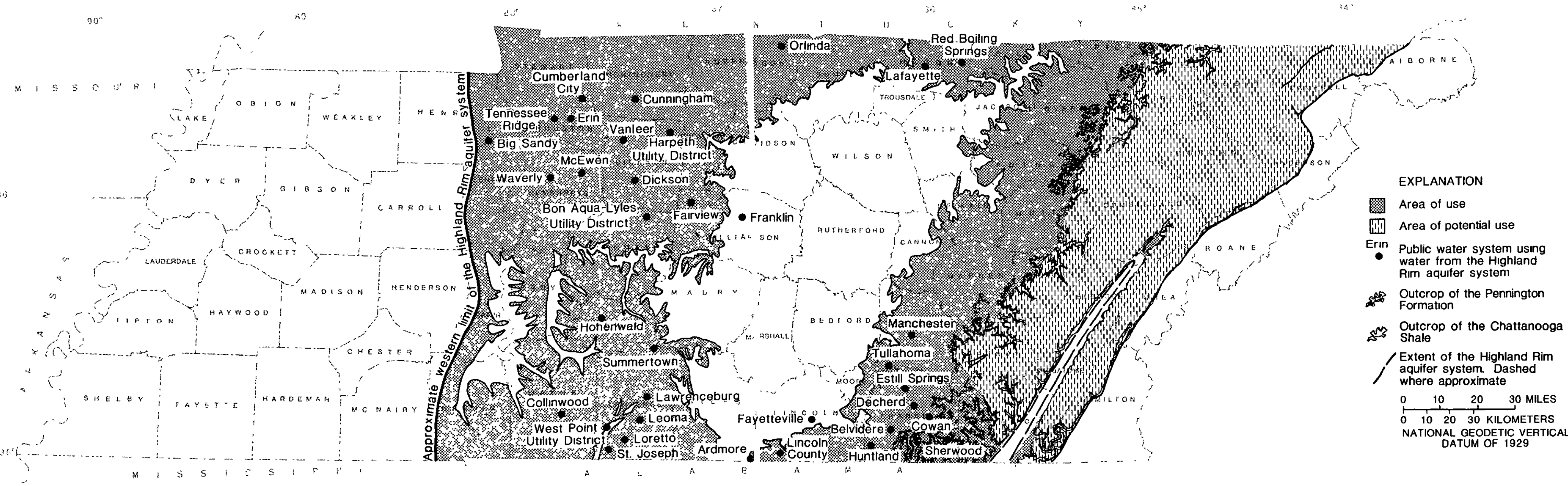


Figure 14.-- Areas of use and potential use of the Highland Rim aquifer system.

Base from U.S. Geological Survey State base map 1:500,000, 1957, revised 1973

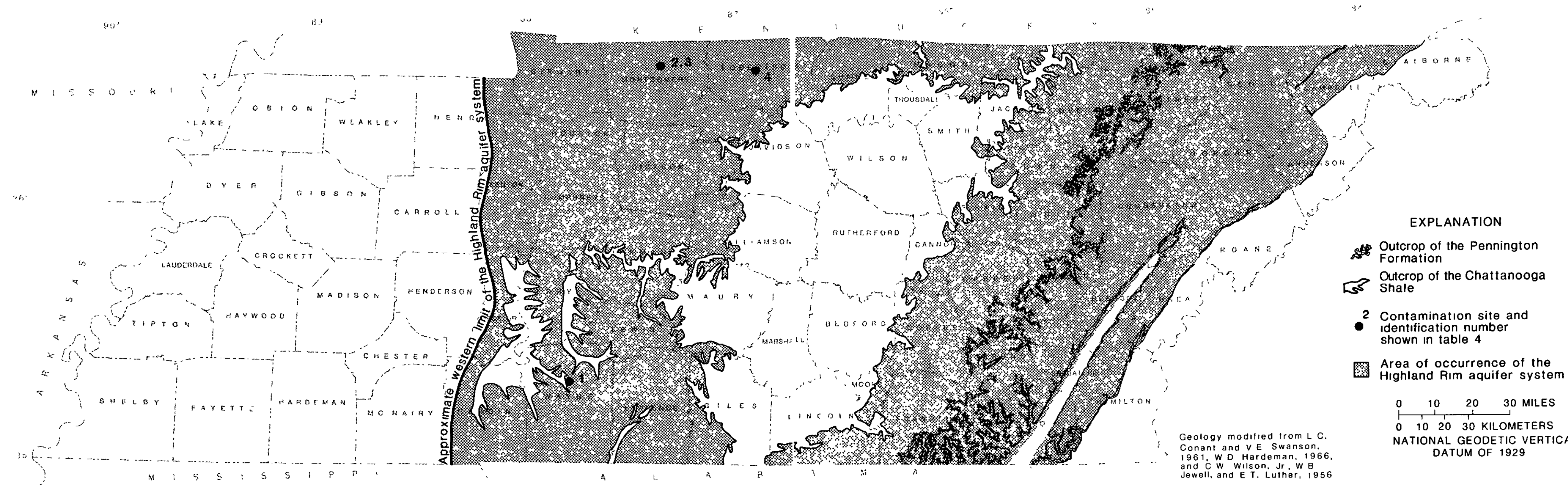


Figure 15.-- Contamination sites in the Highland Rim aquifer system.

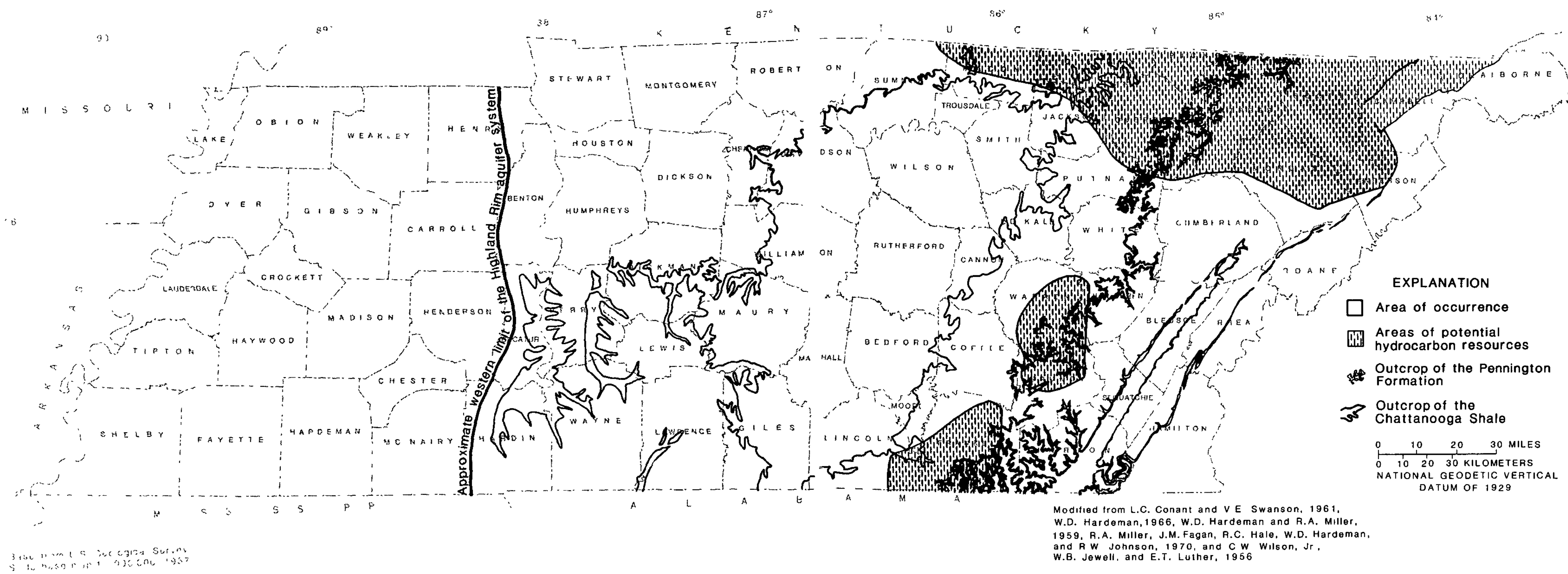


Figure 16.-- Hydrocarbon resources of the Highland Rim aquifer system.

Table 4.--Description of contamination sites in the Highland Rim aquifer system

Site identification No.	Location	Type of contamination	Documentation	Stratigraphic interval contamination	Comments
1	Waynesboro City Dump, Wayne Co.	Open dump	Residual Waste Study, Tennessee Division of Water Quality Control.	Fort Payne Formation	1970-1972 waste capacitors and rags containing PCB's were deposited. Impact on ground water unknown, remedial action has been taken to clean up the area, including monitoring of the ground-water quality from a natural spring nearby.
2	M&M Chemical Co. Springfield, Robertson County	Industrial wastes	Unpublished data, Tennessee Division of Water Quality.	St. Louis Limestone	Sulphuric acid and alum dumped into a depression appeared in a spring 1/2 mile away.
3	Clarksville, Montgomery County	Industrial wastes	do	St. Louis Limestone	An air-conditioner manufacturer dumped heavy metals into a sinkhole. The waste emerged at a spring.
4	Montgomery County Highway Department, Montgomery County	Waste petroleum	do	St. Louis Limestone	Petroleum products were used to wash out asphalt trucks. The waste was dumped into a sinkhole and appeared at a spring about 1/2 mile away.

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