GROUND-WATER RESOURCES OF THE ARKANSAS RIVER BASIN IN ARKANSAS

By John M. Kilpatrick and A.H. Ludwig

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, rather than the inch-pound units used in this report, the following conversion factors may be used:

Multiply inch-pound units	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
foot per mile (ft/m)	0.1894	meter per kilometer (m/km)
mile (mi)		kilometer (km)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	3,785	cubic meter per second (m^3/s)
		cubic meter per day (m^3/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."

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ABSTRACT

The Arkansas River basin in Arkansas lies almost entirely within the Interior Highlands physiographic division. The Interior Highlands consist of hilly to mountainous terrain underlain by sandstone, shale, limestone, and dolomite. That part of the basin southeast of Little Rock lies within the Gulf Coastal Plain physiographic province and is characterized by flat to hilly topography. Significant water-yielding units within the Arkansas River basin in Arkansas include subsurface Paleozoic rocks such as the Eminence and Potosi Dolomites, the Gasconade Dolomite and the Van Buren Formation, and Roubidoux Formation as well as outcrops of Paleozoic rocks, the Sparta Sand, and Quaternary deposits.

Ground-water withdrawals in the 15-county area approximating the study area totaled 257 million gallons per day in 1985. More than 70 percent of this total was withdrawn from the Sparta Sand and the Quaternary deposits in the Coastal Plain. Less than 10 percent was withdrawn from the Paleozoic units that underlie the Interior Highlands.

The quality of ground water withdrawn from the various aquifers in the study area generally is suitable for most uses. With the exception of the Sparta Sand, the major aquifers yield water that is commonly very hard and highly mineralized.

Yields from the different water-bearing units are highly variable. Several of the subsurface Paleozoic formations yield as much as 450 gallons per minute, whereas outcrops of Paleozoic rocks rarely yield more than 10 gallons per minute. In the Coastal Plain, the Sparta Sand and the Quaternary deposits yield as much as 2,000 and 2,500 gallons per minute, respectively.

In the northern part of the study area, the extensive fracturing of formation outcrops makes them more susceptible to contamination from the surface. Several studies have identified localized bacterial contamination of water from both wells and springs in this part of the study area.

Nitrate concentrations exceeding U.S. Environmental Protection Agency primary drinking water standards have occurred in some areas. No areas within the study area met the critical-use criteria established by the Arkansas Soil and Water Conservation Commission. Potential ground-water problems include potential contamination from one Resource Conservation and Recovery Act site, two Comprehensive Environmental Response, Compensation, and Liability Act sites, and numerous landfills and surface impoundments.

INTRODUCTION

This report was prepared in cooperation with the U.S. Army Corps of Engineers to describe the ground-water resources of the Arkansas River basin in Arkansas. The contents of this report will be incorporated by the Arkansas Soil and Water Conservation Commission (ASWCC) into the 1986 Arkansas State Water Plan. The 1986 Arkansas State Water Plan is intended to update the first State Water Plan published by ASWCC in 1975, and function as the basic document for defining water policy for the protection, development, and management of water resources in the State. ASWCC's specific objectives in revising the first State Water Plan are to incorporate more recent data and research, evaluate new and existing problems, and present solutions and recommendations.

The study area consists of the entire Arkansas River basin in Arkansas (fig. 1), most of which lies in the Interior Highlands physiographic division. The Interior Highlands is an area of hilly to mountainous terrain which is underlain by consolidated rocks consisting of sandstone, shale, limestone, and dolomite. The southeastern tip of the study area extends into the Gulf Coastal Plain physiographic province. The Coastal Plain is characterized by flat to hilly topography and is underlain by unconsolidated sediments that consist chiefly of sand, gravel, silt, and clay. The boundary between the Coastal Plain and the Interior Highlands trends northeast-southwest through Little Rock and is known as the Fall Line.

The Interior Highlands physiographic division is divided on the basis of physiographic expression into two provinces; the Ozark Plateaus province and the Ouachita province. The Ozark Plateaus province encompasses the northwestern corner of the study area north of the Arkansas Valley section of the Ouachita province. The Ozark Plateaus province is dominated by deeply dissected plateaus rising over 2,000 feet (ft) above sea level. Limestone, dolomite, shale, and sandstone, ranging in age from Pennsylvanian to Ordovician, crop out in the Ozark Plateaus (fig. 2). A more detailed description of the geologic units of the Ozark Plateaus is contained in the stratigraphic column in table 1. Small amounts of water, less than 10 gallons per minute (gal/min), are available in the area from outcrops of Paleozoic rocks, but as much as 500 gal/min may be obtained from the deeply buried sandstones and dolomites which constitute regionally important aquifers.

The Ouachita province, which encompasses most of the study area, consists of two sections; the Arkansas Valley to the north and the Ouachita Mountains to the south. The Arkansas Valley is an east-west trending synclinorium 30 to 50 miles wide with a surface generally lower than the Boston Mountains on the north and the Ouachita Mountains on the south (Fenneman, 1938). A synclinorium is a broad regional syncline on which is superimposed minor folds while an anticlinorium is a series of anticlines and synclines so arranged structurally that together they form a general arch or anticline. The rocks cropping out in the Arkansas Valley are gently dipping beds of Pennsylvanian sandstones and shales (fig. 2). In contrast, the Ouachita Mountains section is a faulted anticlinorium, with mountains and intermountain valleys being the dominant topographic features. The rocks which crop out in this part of the study area range in age from Pennsylvanian to Ordovician. The dominant

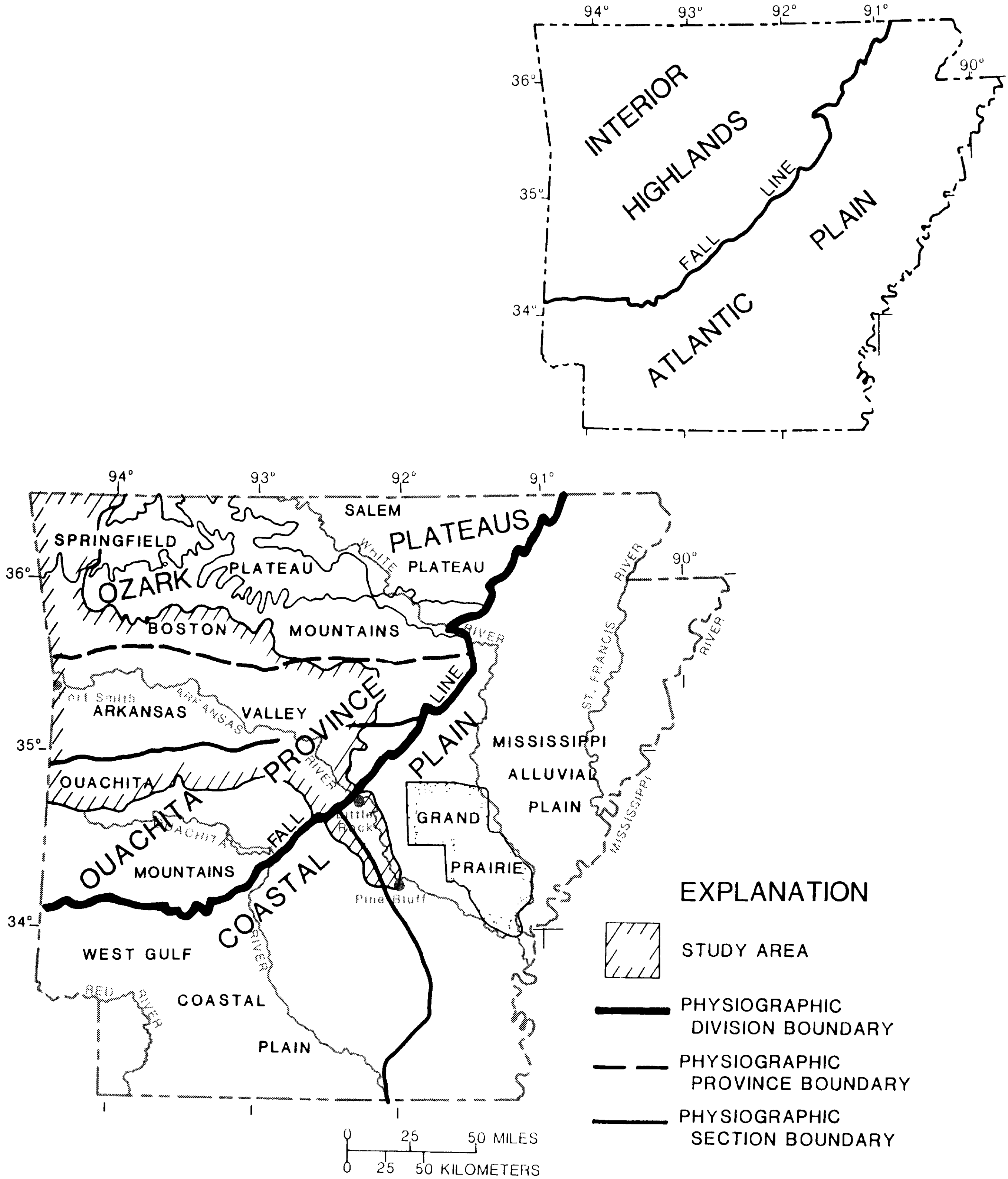

Figure 1.--Location and physiography of the study area (modified from Lamonds, 1972).

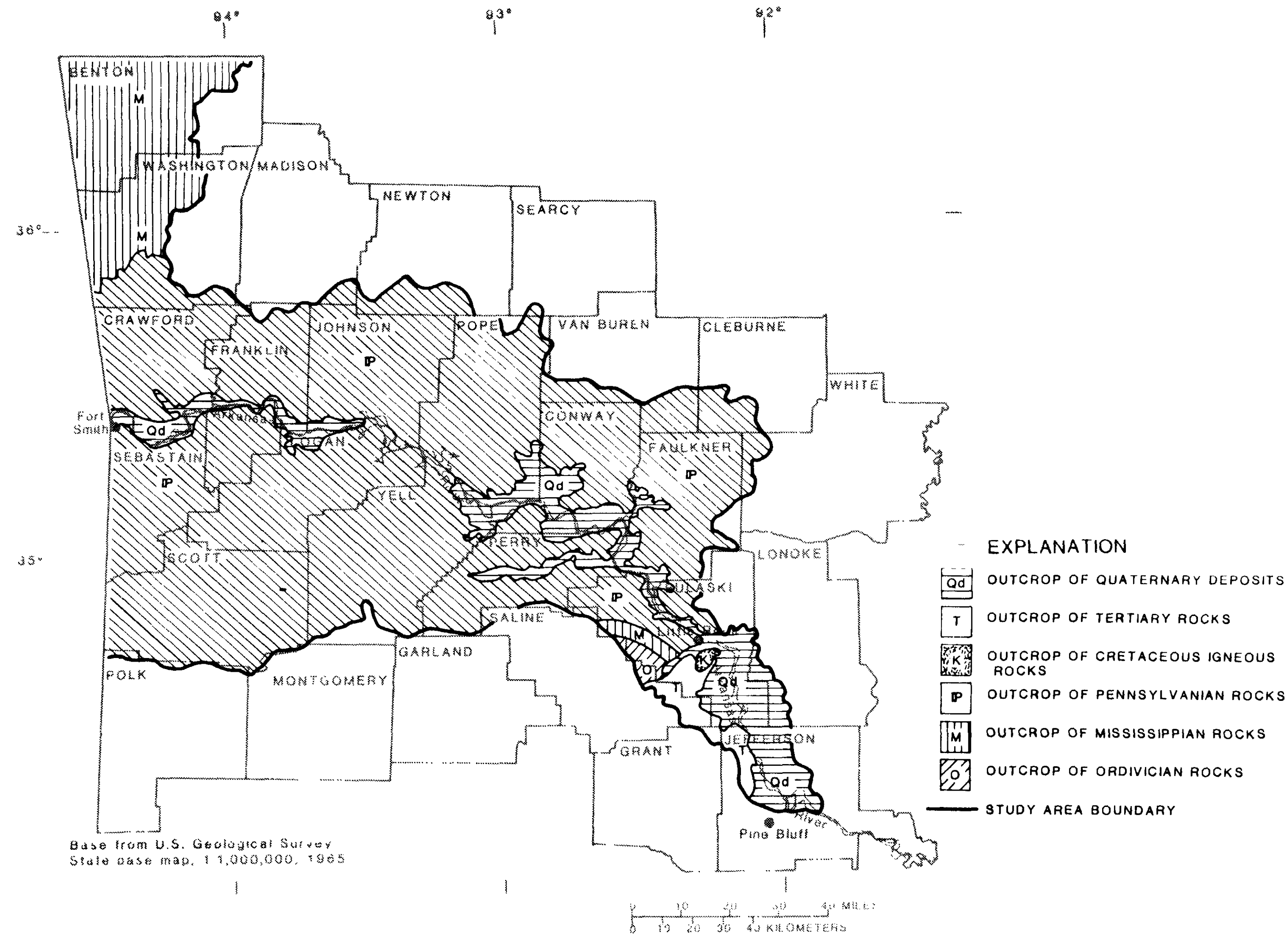

Figure 2.--Geology of the study area (modified from Haley, 1976 and Hosman, 1982).

Table 1.--Generalized stratigraphic column of the study area in the Ozark Plateaus physiographic province

(modified from Haley, 1976)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-yielding characteristics
Paleozoic	Pennsylvanian	Atoka Formation	0-4,600	Sandstone, medium-grained, interbedded with dark shale	
		Bloyd Shale	0-628	Shale, dark, fissile; contains beds of sandy, gray limestone	
		Hale Formation	0-980	Upper part - massive limestone, shaly layers; lower part - shale, fissile, dark	Yields small quantities of water to wells in the weathered zones in the outcrop area. Most wells yield yield 2 to 5 gallons per minute. In some areas, fracture zones and bedding planes may yield up to 25 gallons per minute.
	Mississippian	Pitkin Limestone	0-219	Limestone, crystalline, gray-black	
		Fayetteville Shale	0-297	Shale, dark; black sandstone beds near top	
		Batesville Sandstone	0-457	Sandstone, medium-grained with basal limestone	
		Ruddell Shale		Shale, fissile, dark gray-green	
		Moorefield Formation		Shale, platy, gray-black	
		Boone Formation (including St. Joe Limestone member)	0-388	Chert, dense, or cherty limestone; contains a basal pink to maroon, finely crystalline limestone	Weathered rubble of limestones yield 2 to 5 gallons per minute to wells. Wells tapping solution channels can yield as much as 25 gallons per minute.
		Chattanooga Shale	0-70	Shale, black, bituminous, with basal sandstone	
	Devonian	Penters Chert	0-260	Chert, gray to black, with interbedded limestone	
	Silurian	Lafferty Limestone	0-254	Limestone, earthy, thinly bedded, red to gray	
		St. Clair Limestone		Limestone, pinkish-gray	
		Brassfield Limestone		Limestone, light gray, containing vugs	

Table 1.--Generalized stratigraphic column of the study area in the Ozark Plateaus physiographic province -- Continued

Erathem	System	Geologic unit	Thickness in feet	Description	Water-yielding characteristics
	Ordovician	Cason Shale	0-57	Shale, platy to fissile, black and gray	
		Fernvale Limestone	0-108	Limestone, coarsely crystalline, white, gray, pink	Commonly yield 5 to 10 gallons per minute from solution channels, bedding planes, and fractures. Yields from some wells may exceed 50 gallons per minute.
		Kimmswick Limestone	0-400	Limestone, sacchroidal, white to gray, fossiliferous	
		Plattin Limestone		Limestone, dense, light gray to blue gray	
		Joachim Dolomite	0-117	Dolomite, silty, gray to brown, some sandstone	
		St. Peter Sandstone	0-158	Sandstone, medium-grained, white, frosted grains	
		Everton Formation	0-1,180	Dolomite, dense, gray to brown, and sandstone	
		Powell Dolomite	0-404	Dolomite, silty, shaly; sandstone and sandy dolomite	Solution channels and fractures yield 5 to 10 gallons per minute. Yields in some wells may exceed 50 gallons per minute.
		Cotter Dolomite	0-527	Dolomite, light gray to brown, cherty	
		Jefferson City Dolomite	100-496	Dolomite, cherty, silty, gray to brown. Minor beds of sandstone	
		Roubidoux Formation	132-455	Dolomite, dolomitic sandstone, and chert	Average yield is less than 150 gallons per minute but as much as 450 gallons per minute is possible
		Gasconade Dolomite and Van Buren Formation (including Gunter Sandstone Member)	319-600	Dolomite, cherty, light brown-gray. Basal Gunter Sandstone Member, white to gray quartz sandstone	Wells commonly yield 150 to 300 gallons per minute. Can yield as much as 500, gallons per minute.
	Cambrian	Eminence and Potosi Dolomites	307-389	Dolomite, cherty, light-colored	Little is known about water yields of these formations in Arkansas. With the exception of the Eminence and Potosi, these formations yield less than 50 gallons per minute in southern Missouri. The Eminence and Potosi have reportedly yielded as much as 230 gallons per minute in a Benton County well.
		Derby and Doe Run Formations	---	Dolomite, granular, cherty, sandy, silty	
		Davis Formation		Dolomite, sandy, shaly	
		Bonneterre Dolomite	0-71	Dolomite, light gray, glauconitic	
		Lamotte Sandstone	0-59	Quartzose sandstone, locally arkosic	
	Precambrian	Igneous Rocks			

lithologies are shale, sandstone, chert, and novaculite. A more detailed description of the geologic units of the Ouachita province is contained in the stratigraphic column in table 2.

The Arkansas River flows within a narrow valley 1 to 5 miles in width through the Arkansas Valley section. Alluvial deposits associated with the river occur in several disconnected areas along the river between Fort Smith and Little Rock. The coarse-grained basal section of the alluvium is a highly productive aquifer.

Except for the alluvial aquifer, there are no regionally significant water-yielding formations either at the surface or at depth in the Ouachita province.

The geologic units that crop out in the Coastal Plain province of the study area range in age from Tertiary to Quaternary (fig. 2). They consist of a series of sand, clay, and marl formations that outcrop in bands parallel to the Fall Line and dip to the southeast and, of alluvial deposits that blanket the area in the Coastal Plain from the Arkansas River east to the boundary of the study area. The alluvial deposits are part of the Mississippi River Valley alluvium and contain the most productive aquifer in the study area. The Sparta Sand of Tertiary age, which is part of the older sequence of beds underlying the Coastal Plain province, is also a highly productive unit in the study area as well as in much of the southeastern part of the State. Other Tertiary-age units, including the Cockfield Formation and the Midway Group, are of local significance. More detailed information describing the geologic units of the Coastal Plain is summarized in the stratigraphic column in table 3.

PURPOSE AND SCOPE

The purposes of this report are to (1) describe the general geologic and hydrologic characteristics of the basin, (2) describe the significant water-yielding units in more detail, and (3) examine specific ground-water problems and potential problems.

The study area includes all of the upper Arkansas River basin in Arkansas. For convenience, water-use figures were assembled by county for the 15-county area shown in figure 3. This 15-county area approximates but does not correspond exactly to the study area.

The general physiographic and geologic characteristics of the study area including topography, geologic structure, and lithologies present are described in this report. In addition, the general hydrologic characteristics of the study area including ground-water availability, ground-water use, and ground-water quality are described. Several regionally important water-yielding units are described in more detail. These units include subsurface rocks and outcrops in the Interior Highlands, Quaternary deposits throughout the study area, and the Sparta Sand in the Coastal Plain. The availability and quality of water from each of these units are discussed in detail. Ground-water availability and quality problems in the study area also are described in detail.

Table 2.--Generalized stratigraphic column of the study area in the Ouachita physiographic province

(modified from Haley, 1976)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-yielding characteristics
Cenozoic	Quaternary	Alluvial and terrace deposits	0-80	Gravel at the base, grading upward to sand, silt, and clay	Yields 300 to 700 gallons per minute
Paleozoic	Pennsylvanian	Boggy Formation	0-900	Shale, dark, contains three buff sandstone beds	Yields small quantities of water to wells in the weathered zones in the outcrop areas. Most wells yield less than 10 gallons per minute, but yields as high as 72 gallons per minute have been reported.
		Savanna Formation	0-1,610	Shale and sandstone with six coal beds and lenticular limestone bed	
		McAlester Formation	0-1,820	Shale, dark, gritty; sandstone; siltstone; coal	
		Hartshorne Sandstone	0-300	Sandstone, medium-grained, whitish to light gray, shaley in some areas	
		Atoka Formation	0-19,000	Shale, silty, dark; sandstone, light gray	
		Johns Valley Shale	0-1,000	Shale and claystone, gray and tan	
		Jackfork Sandstone	0-7,000	Sandstone, fine- to coarse-grained, light gray to brown	
	Mississippian	Stanley Shale	0-12,200	Shale, black, fissile; sandstone, fine-grained, green; basal Hot Springs Sandstone Member - sandstone, medium-grained, gray, quartzitic	
	Mississippian / Devonian	Arkansas Novaculite	0-950	Upper division: novaculite, gray to black, calcareous, massive. Middle division: novaculite, dark, thinly bedded, interbedded shale. Lower division: novaculite, white, dense, massive.	
	Silurian	Missouri Mountain Shale	0-300	Shale, red and green, contains thin beds of chert and sandstone	
		Blaylock Sandstone	0-500	Shale, black and green; interbedded sandstone, medium-grained	
	Ordovician	Polk Creek Shale	0-175	Shale, black, graphitic, contains abundant graphtolites	
		Bigfork Chert	0-800	Chert, gray to black; interbedded black limestone and shale	
		Womble Shale	0-1,000	Shale, black; some sandstone and blue-black limestone	
		Blakely Sandstone		Shale, black and green; interbedded sandstone, medium-grained	

Table 3.--Generalized stratigraphic column of the study area in the Coastal Plain physiographic province

(modified from Klein and others, 1950; Terry and others, 1979; and Petersen and others, 1985)

Erathem	System	Geologic unit		Thickness in feet	Description	Water-yielding characteristics
Cenozoic	Quaternary	Alluvium and terrace deposits		0-150	Gravel at the base grading upward to sand, silt, and clay	Yields up to 2,500 gallons per minute
	Tertiary	Jackson Group		0-380	Clay with some fine sand and silt	Does not yield water
		Claiborne Group	Cockfield Formation	0-175	Sand, fine, lignitic, carbonaceous	Commonly yields less than 100 gallons per minute but can yield as much as 750 gallons per minute
			Cook Mountain Formation	0-150	Clay, carbonaceous with lenses of fine sand	Does not yield water
			Sparta Sand	0-500	Sand, clay, and silt, fine-grained near top to coarse-grained at the bottom	Commonly yields 1,000 gallons per minute to wells. Yield from some wells may exceed 1,900 gallons per minute
			Cane River Formation	0-500	Clay, sand, and silt	Source of water only in or near its outcrop area. Yields as much as 35 gallons per minute
			Carrizo Sand	0-200	Sand, fine- to medium-grained	Generally yields less than 50 gallons per minute
		Wilcox Group		0-800	Sand and clay, interbedded	Commonly yields over 50 gallons per minute
		Midway Group		0-500	Clay with some calcareous sand and silt	Yields water in outcrop area
Mesozoic	Cretaceous				Sand, calcareous, and glauconitic, with thin beds of clay and lime	Does not yield potable water
		Igneous Rocks				Do not yield water

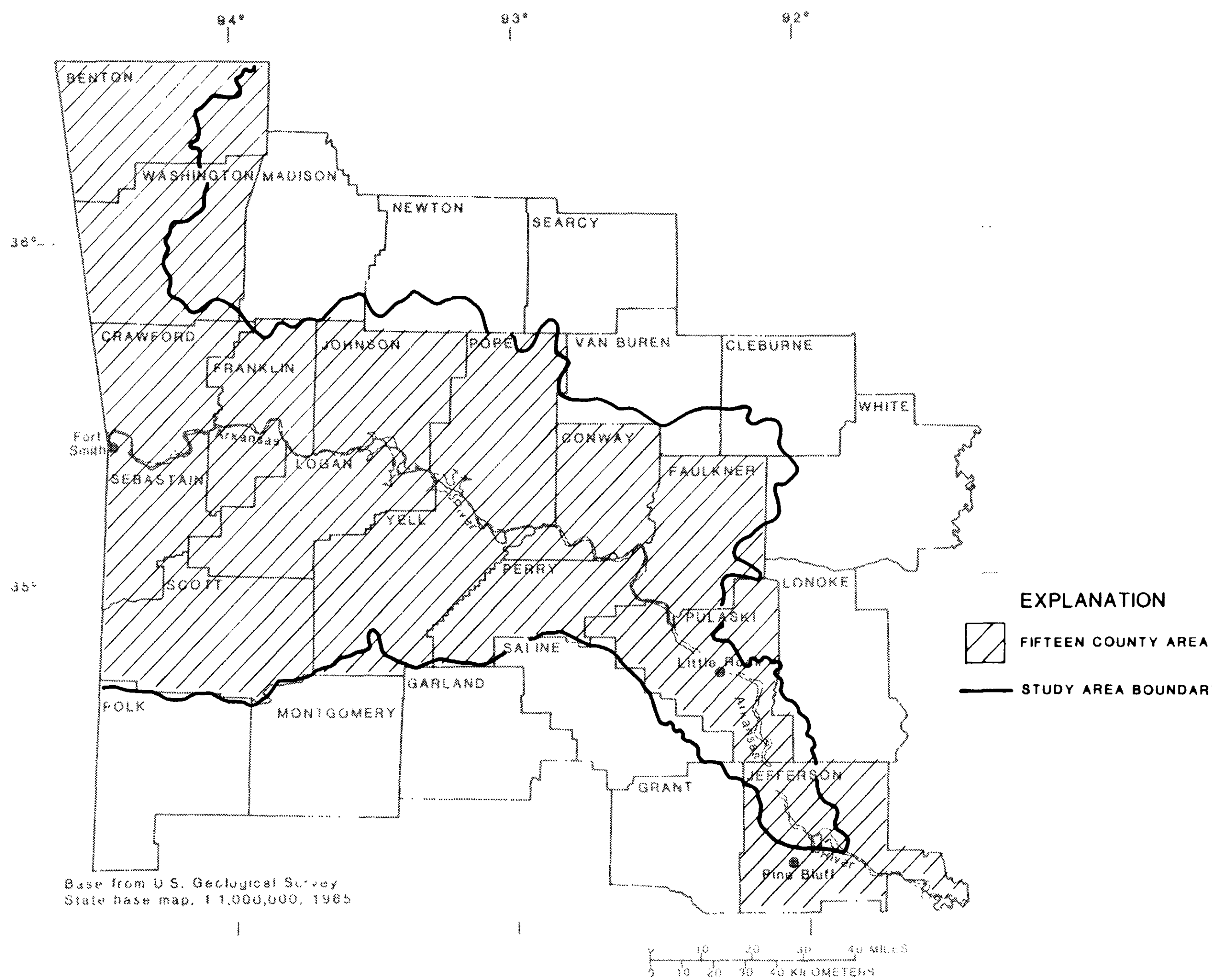

Figure 3.--Location of 15-county area used for water-use data compilation.

GENERAL HYDROLOGY OF THE STUDY AREA

Ground water is available from nearly all of the geologic units in the study area. However, many of the units do not yield enough water even for domestic use. Others, such as outcrops of Paleozoic rocks generally are marginally acceptable as sources of water, but are important because they are readily accessible and usually are the only available source of ground water.

Ground-water withdrawals (Holland, 1987) in the 15-county area approximating the study area totaled 257 million gallons per day (Mgal/d) in 1985 (table 4), which represented 7 percent of the ground water withdrawn from all aquifers statewide. More than 70 percent of the water withdrawn in the 15-county area was from wells penetrating Quaternary deposits and the Sparta Sand in southern Pulaski and Jefferson Counties. Less than 10 percent was withdrawn from the Paleozoic units that underlie the Interior Highlands.

Table 4.--Withdrawals of ground water from aquifers in the study area in 1985

[Holland, 1987; withdrawals in million gallons per day]

County	Deposits of Quaternary age	Sparta Sand	Rocks of Paleozoic age, undifferentiated	County total
Benton	--	--	6.76	6.76
Conway	4.19	--	.13	4.32
Crawford	4.15	--	1.46	5.61
Faulkner	.67	--	3.03	3.70
Franklin	.96	--	.78	1.74
Jefferson	120.59	51.68	--	172.27
Johnson	2.87	--	1.09	3.96
Logan	.33	--	2.93	3.26
Perry	--	--	.98	.98
Pope	6.53	--	.20	6.73
Pulaski	29.58	.85	.01	30.44
Scott	--	--	1.23	1.23
Sebastian	1.07	--	1.53	2.60
Washington	--	--	5.67	5.67
Yell	5.96	--	1.52	7.48
Study area total	176.90	52.53	27.32	256.75

More than 15 percent of the ground-water withdrawn was from the Quaternary deposits in the Arkansas River Valley between Fort Smith and Little Rock. Ground-water withdrawals from all aquifers in the 15-county area peaked in 1980 and declined between 1980 and 1985 (fig. 4).

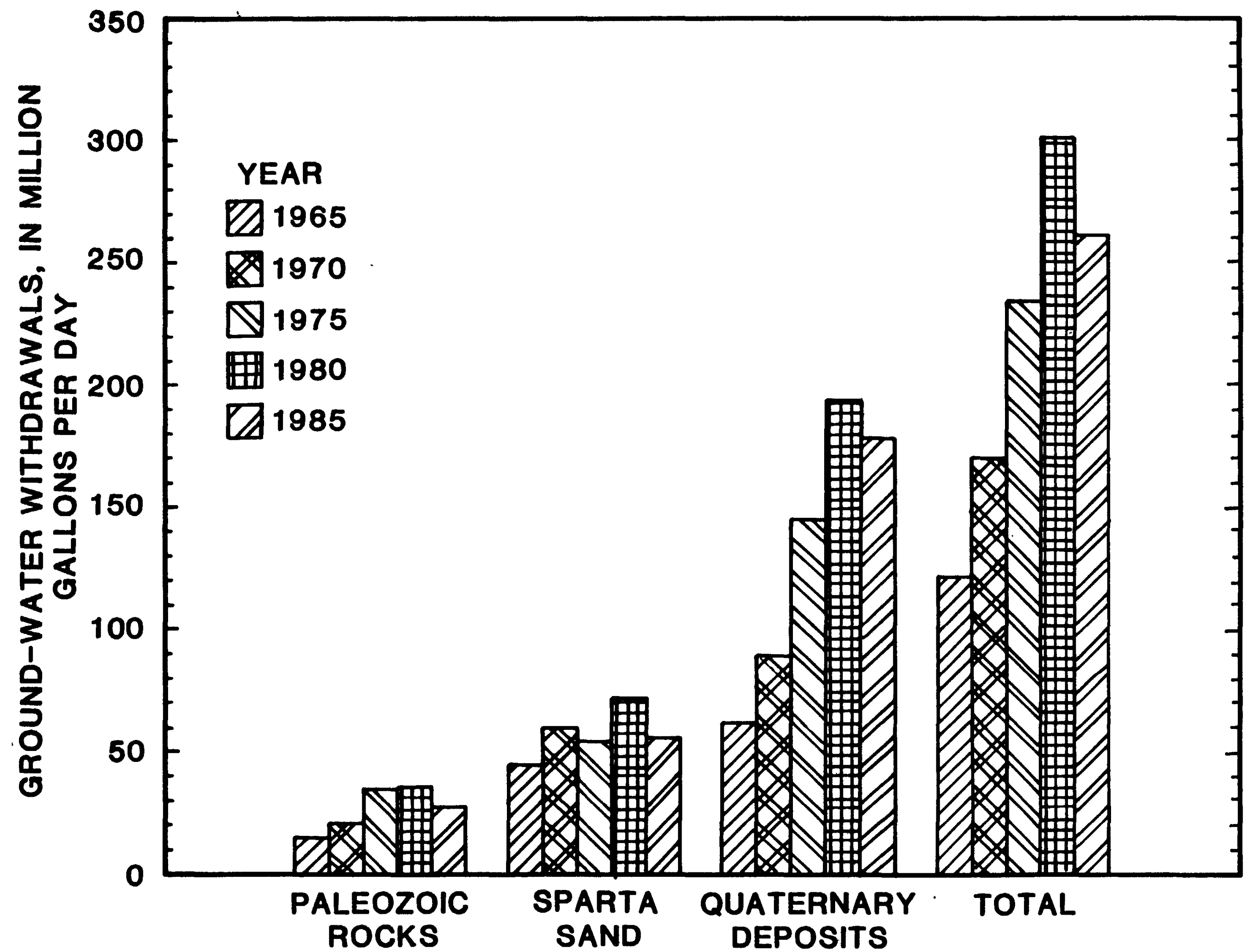

Figure 4.--Ground-water withdrawals, 1965 to 1985.

More than 60 percent (164 Mgal/d) of the water withdrawn in the 15-county area in 1985 was used for irrigation. Most of this use was in Jefferson County but a substantial amount was withdrawn from alluvial deposits adjacent to the Arkansas River upstream from Little Rock. The next largest use category was rural use with more than 15 percent (41 Mgal/d) of the 15-county area total. Self-supplied industry and public supply accounted for the remainder of the pumpage, most of which was in Jefferson County. Fluctuations in pumpage in each of these categories over the past 25 years are shown in figure 5. A more detailed breakdown of water use in the 15-county area by county and use category is contained in table 5.

In the Ozark Plateaus, ground-water quality in both the outcrops and subsurface rocks is similar and closely related to the mineral content of the rocks. The ground water in the limestones and dolomites that exist in this area is primarily of the calcium-magnesium-bicarbonate type and very hard (Lamonds and others, 1969). Ground water from these units is used without treatment for rural, domestic, and some industrial purposes; but requires softening to be used for municipal supplies and most industrial purposes. High nitrate concentrations, indicating contamination from septic tanks and barnyard wastes, are common local problems in the Ozark Plateaus.

In the Ouachita province, both the outcrops of Paleozoic rocks and the Quaternary deposits yield ground water of the calcium-bicarbonate type. The water from these units generally is hard and high in iron. In some areas water from the rock outcrops is slightly saline, whereas in other areas, high nitrate concentrations can be a problem in shallow wells.

South of the Fall Line, in the Coastal Plain, the Quaternary deposits yield a very hard calcium-bicarbonate water, which generally has a high iron content, while the Sparta Sand yields a very soft sodium-bicarbonate water. Soft water is described as water with a hardness range of 0 to 60 milligrams per liter (mg/L) of calcium carbonate (Hem, 1985). In most cases, ground water from the Quaternary deposits is more highly mineralized than that from the Sparta Sand, which is widely used for public supply with little or no treatment.

Ground-water-quality data are listed by geologic unit in table 6. The recommended limits for several of these constituents, as established by the U.S. Environmental Protection Agency under the Safe Drinking Water Act, can be found in tables 7 and 8. The Arkansas Department of Health uses the National Primary Standards to set State standards for public water-supply systems.

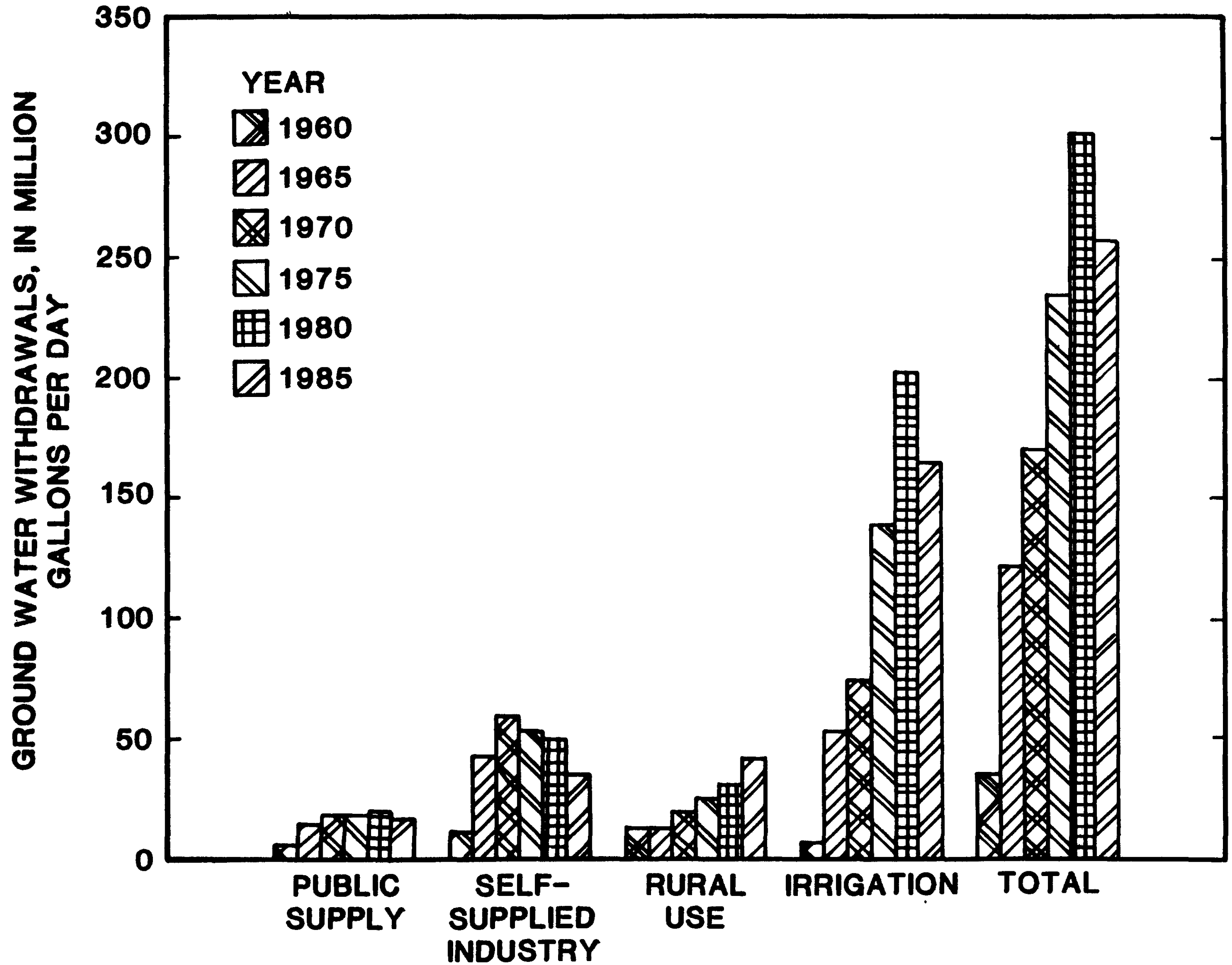

Figure 5.--Ground-water withdrawals for each use category, 1960 to 1985.

Table 5.--Ground-water withdrawals in the study area, 1960 to 1985

[Withdrawals in million gallons per day]

County	Public supply [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985	Self-supplied industry [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985
Benton	0.89	2.36	2.00	1.78	0.43	0.43	2.10	0.11	0.30	0.70	0.15	0.54
Conway	.53	1.02	1.07	1.29	1.39	1.12	.22	.02	5.40	5.02	.06	.06
Crawford	0	0	0	--	--	--	.78	0	.01	--	.03	.03
Faulkner	0	.02	.09	.32	.84	.82	.10	0	.01	0	.03	--
Franklin	.15	.52	1.26	--	--	--	.04	.02	.07	.23	.19	.22
Jefferson	--	5.40	7.83	8.86	11.63	10.97	--	38.96	51.23	44.83	45.45	30.98
Johnson	0	.04	0	--	--	--	.22	.01	.02	.03	.10	.10
Logan	0	.04	.11	.15	.10	.09	0	.01	.16	.01	.04	.06
Perry	0	.03	.05	.07	.10	.10	.02	0	.03	.02	.02	.15
Pope	.12	.21	.45	.43	--	--	.52	.05	.02	.04	.47	.21
Pulaski	2.20	3.17	3.76	4.19	3.38	1.81	6.73	2.98	1.63	1.50	1.74	.66
Scott	0	0	.01	--	--	--	0	0	.01	.01	.01	.01
Sebastian	.03	.08	.10	.08	.09	.13	0	0	.05	.04	.05	.07
Washington	.92	.25	.13	.31	.02	.02	0	0	.01	.02	.03	.15
Yell	.20	.74	.98	.56	.93	.93	.04	.03	.03	.46	1.26	1.34
Total	5.04	13.88	17.84	18.04	18.91	16.42	10.77	42.19	58.98	52.91	49.63	34.58

County	Rural [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985	Irrigation[g] [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985
Benton	2.11	1.87	2.78	3.67	4.42	5.79	0	0.77	0.91	5.54	0.61	--
Conway	.54	.60	.86	1.02	1.23	1.30	0.14	1.01	1.56	1.19	3.50	1.84
Crawford	.60	.70	1.02	1.04	1.53	1.90	0	1.08	1.64	.77	3.90	3.68
Faulkner	.72	.88	1.33	1.74	2.00	2.59	.91	0	1.84	.23	.43	.29
Franklin	.46	.49	.75	1.05	.83	1.20	0	.22	.07	--	1.13	.32
Jefferson	--	1.28	1.33	.84	.60	6.76	--	41.25	50.87	106.27	154.86	123.56
Johnson	.55	.46	.68	.94	1.18	1.43	0	.49	.93	1.19	2.59	2.43
Logan	.73	.75	.93	1.29	1.52	1.60	.04	.16	.47	.18	.93	1.51
Perry	.25	.26	.42	.52	.59	.73	0	0	1.71	.25	.01	--
Pope	1.27	.70	1.32	1.63	2.18	2.64	0	.60	1.00	2.81	2.57	3.88
Pulaski	.34	.35	2.45	2.14	5.91	5.78	5.37	6.49	10.92	15.59	24.55	22.19
Scott	.35	.42	.62	.82	1.05	1.22	0	0	.02	--	--	--
Sebastian	.36	.62	.63	2.41	1.23	1.37	0	.21	.04	.01	.61	1.03
Washington	2.95	1.93	3.11	3.96	4.72	5.50	0	.26	.17	3.46	3.97	--
Yell	.91	.69	1.06	1.52	1.61	1.59	.24	.40	1.44	.96	2.34	3.62
Total	12.14	12.00	19.29	24.59	30.60	41.40	6.70	52.94	73.59	138.45	202.0	164.35

Table 5.--Ground-water withdrawals in the study area, 1960 to 1985 -- Continued

[Withdrawals in million gallons per day]

County	Total					
	[a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985
Benton	5.10	5.11	5.99	11.69	5.61	6.76
Conway	1.43	2.65	8.89	8.52	6.18	4.32
Crawford	1.38	1.78	2.67	1.81	5.46	5.61
Faulkner	1.73	.90	3.27	2.29	3.30	3.70
Franklin	.65	1.25	2.15	1.28	2.15	1.74
Jefferson	--	86.89	111.26	160.80	212.54	172.27
Johnson	.77	1.00	1.63	2.16	3.87	3.96
Logan	.77	.96	1.67	1.63	2.59	3.26
Perry	.27	.29	2.21	.86	.72	.98
Pope	1.91	1.56	2.79	4.91	5.22	6.73
Pulaski	14.64	12.99	18.76	23.42	35.58	30.44
Scott	.35	.42	.66	.83	1.06	1.23
Sebastian	.39	.91	.82	2.54	1.98	2.60
Washington	3.87	2.44	3.42	7.75	8.74	5.67
Yell	1.39	1.86	3.51	3.50	6.14	7.48
Total	34.65	121.01	169.70	233.99	301.14	256.75

[a] Stephens and Halberg, 1961

[b] Halberg and Stephens, 1966

[c] Halberg, 1972

[d] Halberg, 1977

[e] Holland and Ludwig, 1981

[f] Holland, 1987

[g] Includes fish and minnow farms, wildlife improvements, and national fish hatcheries

Table 6.--Ground-water quality in the various geologic units

[Values are means; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

Geologic unit	Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)	Dissolved iron (µg/L as Fe) (01046)
Quaternary deposits	17.3	5.0	599	7.8	254	4	201	247	70.6	17.3	[a]204
Sparta Sand	24.6	9.0	142	7.2	56	0	44	27	7.5	2.1	[b]846
Outcrops of Paleozoic rocks	18.8	9.0	526	7.2	178	5	138	127	23.4	14.1	[c]814
Subsurface rocks	18.9	6.0	508	7.9	195	0	175	148	36.3	13.9	[d]451

Geologic unit	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Quaternary deposits	31.5	1.0	2.3	51.2	25.3	0.21	21.6	385.5	3.91
Sparta Sand	12.3	1.1	3.8	3.8	7.3	.10	14.2	80.8	.01
Outcrops of Paleozoic rocks	51.0	4.4	3.1	44.5	45.5	.23	11.4	284.3	1.06
Subsurface rocks	28.3	1.2	2.5	15.3	12.1	.43	7.1	196.9	4.06

[a] Median value was 60.
[b] Median value was 100.
[c] Median value was 8.
[d] Median value was 180.

Table 7.--National interim primary drinking-water regulations[1]

[Data in milligrams per liter; tu = turbidity; pCi/L = picocurie per liter; mrem = millirem (one thousandths of a rem)]

Constituent	Maximum concentration
Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10
Selenium	0.01
Silver	0.05
Fluoride	4.0
Turbidity	1.5 tu
Coliform bacteria	1/100 mL (mean)
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP (silvex)	0.01
Total trihalomethanes [The sum of the concentrations of bromodichloromethane, dicromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)]	0.10
Radionuclides:	
Radium 226 and 228 (combined)	5 pCi/L
Gross alpha particle activity	15 pCi/L
Gross beta particle activity	4 mrem/year

[1]U.S. Environmental Protection Agency, 1977; 1986a

Table 8.--National secondary drinking-water regulations[1]

[Data in milligrams per liter unless otherwise specified]

Constituent	Maximum level
Chloride	250
Color	15 color units
Copper	1
Corrosivity	Noncorrosive
Dissolved solids	500
Foaming agents	0.5
Iron	300 µg/L
Manganese	0.05
Odor	3 (threshold odor number)
pH	6.5-8.5 units
Sulfate	250
Zinc	5

[1] Modified from U.S. Environmental Protection Agency, 1986b

GROUND-WATER RESOURCES OF MAJOR WATER-YIELDING UNITS

Subsurface Paleozoic Rocks

Geology

Cambrian and Ordovician rocks, consisting primarily of dolomite and sandstone, crop out in southern Missouri and dip to the south into Arkansas where they are present only in the subsurface. They underlie the Ozark Plateaus province where they are sources of ground water. The Gunter Sandstone Member, which is the basal member of the Van Buren Formation, and the Roubidoux Formation are the most regionally significant water-yielding units present in the section. The Gunter Sandstone Member ranges from 20 to 100 ft in thickness (fig. 6) and is composed of dolomitic sandstone. The Roubidoux Formation is about 900 ft below land surface at the Arkansas-Missouri State line and ranges from 130 to 450 ft in thickness (fig. 7). It consists primarily of dolomite, sandstone, and chert. The two water-yielding units are separated by as much as 500 ft of dolomite. The Eminence and Potosi Dolomites, which are composed of crystalline dolomite with some associated chert, lie several hundred feet below the Gunter Sandstone Member and have not been penetrated by water wells in the study area.

Hydrology

Most of the water withdrawn from the subsurface rocks is from the Gunter Sandstone Member. Well yields from the Gunter Sandstone average more than 200 gal/min, with local yields as much as 500 gal/min. Wells in the Roubidoux Formation yield as much as 450 gal/min. Water levels in the Gunter Sandstone range from 27 to 465 ft below land surface in the study area and those in the

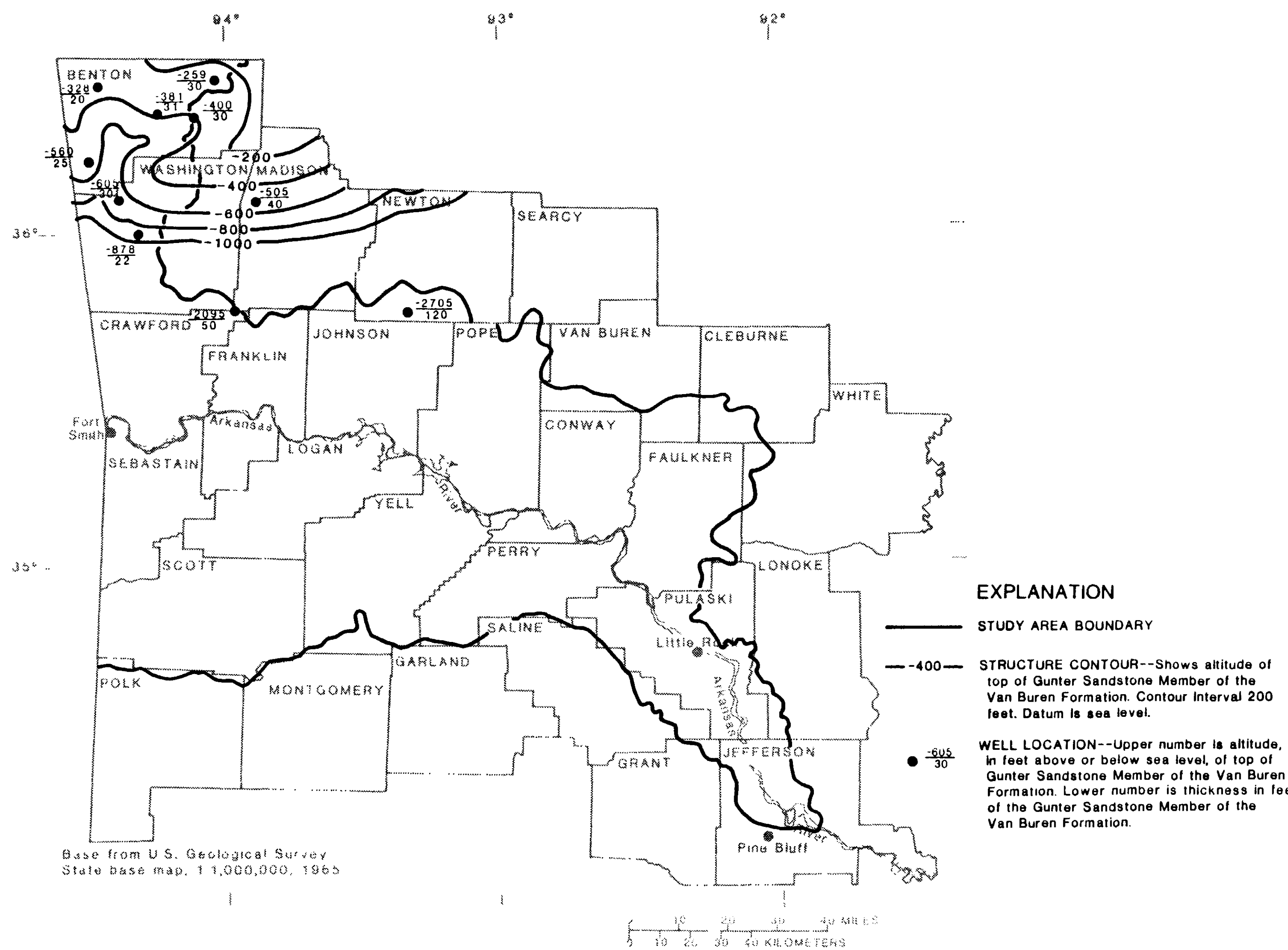

Figure 6.--Structure of the top of the Gunter Sandstone Member of the Van Buren Formation (modified from Lamonds, 1972).

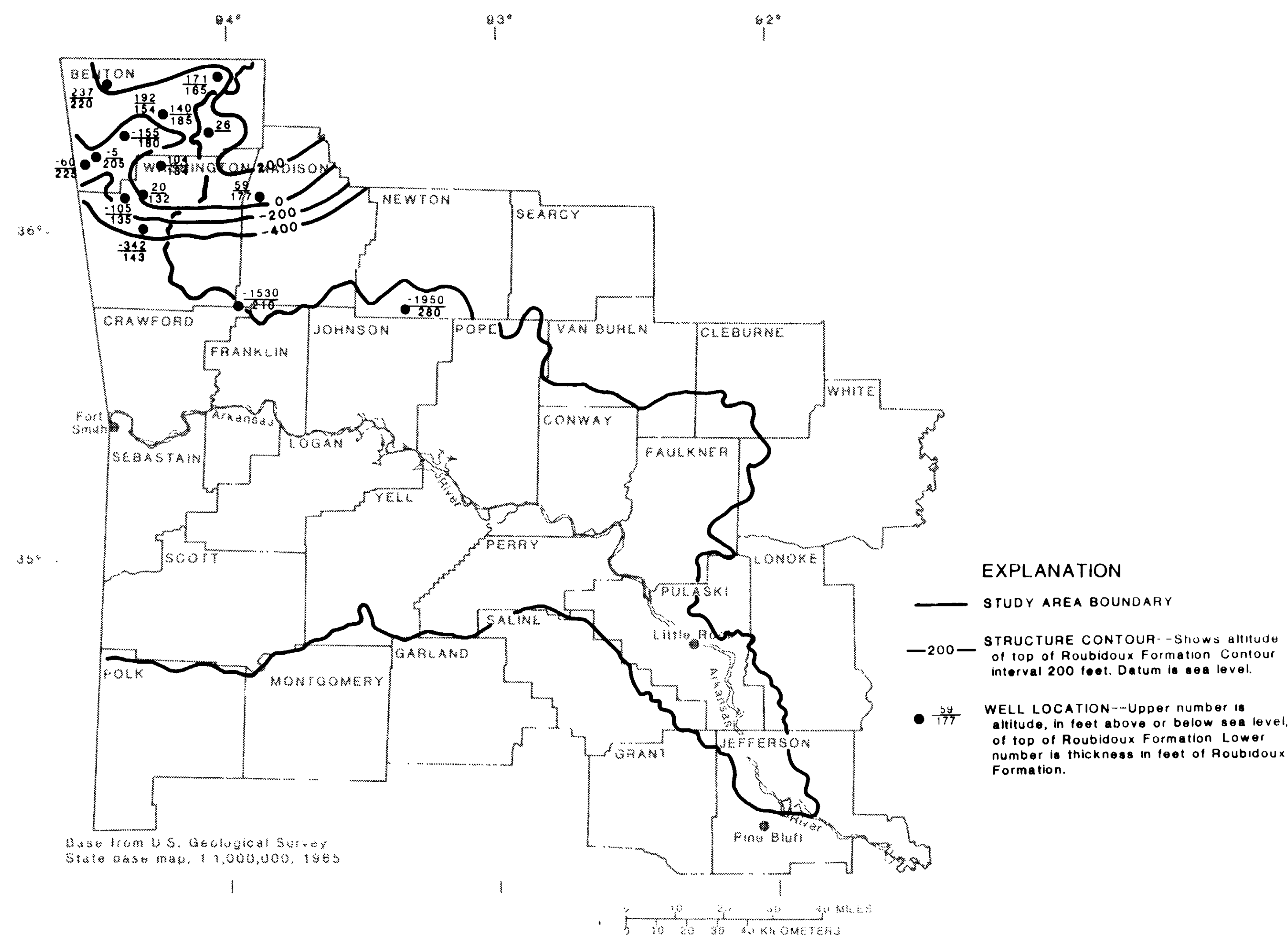

Figure 7.--Structure of the top of the Roubidoux Formation (modified from Lamonds, 1972).

Roubidoux Formation range from 90 to 200 ft below land surface. Annual water-level fluctuations are significant, as much as 70 ft in some wells. However, the fluctuations are due primarily to temporal variations in pumpage and do not represent long-term trends.

Water Quality

Analyses of samples from wells penetrating subsurface rocks show that water in these rocks is a moderately hard to very hard, calcium-magnesium-bicarbonate water. Hard water is defined as having a hardness range of 121 to 180 mg/L of calcium carbonate. Water with hardness of greater than 180 mg/L as calcium carbonate is described as very hard (Hem, 1985). The quality of water from these rocks is well within the established drinking water standards (tables 7 and 8) with the exception of high iron and nitrate concentrations in a few isolated Benton County wells. A summary of the available water-quality data can be found in table 9. The subsurface Paleozoic rocks will yield fresh-water in Benton and Washington Counties, but the water becomes mineralized and is unusable to the south.

Table 9.--Ground-water quality in subsurface Paleozoic rocks

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)
Benton	No. samples	4	11	8	9	7	7	9
	Minimum	17.0	0	332	7.4	200	0	166
	Maximum	20.5	20	413	8.2	220	0	182
	Mean	18.9	6	368	7.8	211	0	173
Washington	No. samples	0	1	3	3	3	3	2
	Minimum	--	1	459	7.7	23	0	155
	Maximum	--	1	1,640	8.2	260	0	211
	Mean	--	1	883	8.0	158	0	183

County		Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)	Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)
Benton	No. samples	11	9	9	8	8	7	7
	Minimum	110	25.0	6.6	0	5.0	0.2	0.4
	Maximum	260	64.0	26.0	3,000	38.0	2.0	3.7
	Mean	162	41.6	15.0	507	18.3	.7	2.3
Washington	No. samples	3	3	3	1	2	2	2
	Minimum	84	17.0	10.0	0	55.0	2.0	2.8
	Maximum	110	25.0	11.0	0	82.0	4.0	3.2
	Mean	96	20.3	10.7	0	68.5	3.0	3.0

Table 9.--Ground-water quality in subsurface Paleozoic rocks -- Continued

County		Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L as F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Benton	No. samples	10	11	11	8	7	7
	Minimum	3.4	7.0	0.10	1.7	184	0.00
	Maximum	24.0	39.0	.95	9.3	225	28.00
	Mean	10.0	13.1	.36	6.9	203	4.63
Washington	No. samples	3	3	1	1	2	1
	Minimum	5.8	6.0	1.2	8.8	93	0.05
	Maximum	49.0	11.0	1.2	8.8	257	.05
	Mean	32.9	8.3	1.2	8.8	175	.05

Outcrops of Paleozoic Rocks, Undifferentiated

Geology

Paleozoic rocks ranging in age from Ordovician to Pennsylvanian crop out throughout the Interior Highlands. Almost all sedimentary lithologies are represented, but sandstone and shale are the most common. These rocks crop out along an east-west-trending synclinorium, whose axis runs approxi- mately along the Arkansas River in western Arkansas, and north of the Arkansas River in central Arkansas. Consequently, the oldest Paleozoic rocks crop out to the north in the Ozark Plateaus and along the southern boundary of the study area in the Ouachita Mountains, whereas younger Paleozoic rocks crop out in the Arkansas Valley.

Hydrology

Ground water in outcrops of Paleozoic rocks occurs mostly in secondary openings such as fractures, joints, bedding planes, and solution channels. These secondary openings generally are larger and more numerous near the surface, consequently, the quantity of available ground water generally decreases with depth (Lamonds, 1972). Wells in these rocks generally are less than 300 ft deep and yield less than 10 gal/min. The yield of a well depends on the number and size of openings penetrated by the well bore. The water levels in these rocks form a subdued reflection of the land surface and are closest to the land surface in the valley (Lamonds, 1972). Shallow wells generally are adequate for domestic supplies during the wet months, but the well yields are marginal during droughts.

Water Quality

Outcrops of Paleozoic rocks yield a hard to very hard, calcium-bicarbonate water. The quality of this water is as variable as the litho-logies, but the water generally is suitable for most uses. Local concentra-tions of dissolved solids, nitrate, sulfate, iron and chloride can exceed allowable limits in some parts of the study area. Low pH values and colored water are problems in other areas. These problems are all of a local nature. In most areas, the quality of water from these rocks is well within the limits established for drinking water (tables 7 and 8). Additional quality data are summarized in table 10.

Table 10.--Ground-water quality in outcrops of Paleozoic rocks

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Benton	No. samples	2	3	3	3	3	3	3	3	3	3
	Minimum	16.0	5	299	7.1	190	0	154	160	61.0	1.3
	Maximum	18.5	5	332	7.7	210	0	171	180	65.0	4.7
	Mean	17.3	5	312	7.5	197	0	161	170	63.0	3.1
Conway	No. samples	1	2	5	5	3	3	3	3	2	2
	Minimum	18.5	5	236	6.0	28	0	23	33	8.4	2.8
	Maximum	18.5	8	602	8.1	110	0	90	120	19.0	8.3
	Mean	18.5	7	364	7.1	59	0	49	78	13.7	5.6
Crawford	No. samples	3	2	6	6	6	6	4	6	6	6
	Minimum	18.5	5	60	5.8	12	0	19	15	1.7	2.5
	Maximum	19.5	45	1,080	7.4	700	0	59	320	60.0	41.0
	Mean	18.8	25	290	6.6	151	0	39	86	16.8	10.6
Faulkner	No. samples	6	5	7	8	9	8	7	9	7	7
	Minimum	15.5	0	263	6.3	33	0	27	30	21.0	11.0
	Maximum	22.0	8	1,210	8.1	370	15	272	330	65.0	34.0
	Mean	19.0	4	616	7.1	246	2	189	186	39.1	21.6
Franklin	No. samples	6	8	12	12	12	12	3	12	11	11
	Minimum	15.0	5	64	6.7	19	0	23	3	0.9	0.1
	Maximum	22.0	12	983	8.8	520	460	171	280	74.0	24.0
	Mean	18.0	7	495	7.8	239	39	94	70	18.6	6.8
Johnson	No. samples	3	2	4	4	4	4	0	4	2	2
	Minimum	18.0	1	54	6.1	12	0	--	17	4.7	1.2
	Maximum	21.0	6	1,540	8.4	340	4	--	420	62.0	45.0
	Mean	19.0	4	854	7.5	213	1	--	282	33.4	23.1
Logan	No. samples	5	8	10	10	9	9	3	9	8	8
	Minimum	15.5	3	21	5.9	7	0	89	4	1.2	0.2
	Maximum	23.0	23	899	8.0	400	0	330	200	39.0	26.0
	Mean	18.9	9	381	7.1	153	0	180	74	14.5	6.2
Perry	No. samples	6	5	6	6	6	6	6	6	6	6
	Minimum	16.5	3	59	6.2	8	0	7	13	2.1	2.0
	Maximum	21.0	20	804	8.2	510	0	417	270	45.0	39.0
	Mean	18.9	9	256	7.2	126	0	103	84	14.9	11.5
Pope	No. samples	4	8	8	7	8	8	1	8	8	8
	Minimum	17.5	1	43	6.7	20	0	118	15	3.2	1.7
	Maximum	24.0	10	612	7.4	220	0	118	190	37.0	24.0
	Mean	20.4	5	244	7.0	93	0	118	80	17.9	8.8

Table 10.--Ground-water quality in outcrops of Paleozoic rocks -- Continued

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Pulaski	No. samples	4	5	6	6	5	5	6	6	6	6
	Minimum	14.0	2	134	6.9	39	0	32	46	2.3	9.7
	Maximum	18.5	6	1,230	8.2	590	0	485	360	50.0	57.0
	Mean	16.1	4	419	7.6	215	0	167	156	22.9	24.1
Saline	No. samples	0	1	0	1	1	0	1	1	1	1
	Minimum	--	5	--	6.6	260	--	216	270	89.0	12.0
	Maximum	--	5	--	6.6	260	--	216	270	89.0	12.0
	Mean	--	5	--	6.6	260	--	216	270	89.0	12.0
Scott	No. samples	23	8	25	12	10	10	9	12	11	11
	Minimum	16.5	3	126	6.7	18	0	15	11	3.3	0.6
	Maximum	24.0	35	3,050	8.1	380	0	315	290	50.0	40.0
	Mean	19.6	14	811	7.6	135	0	134	110	20.6	15.6
Sebastian	No. samples	7	10	15	15	13	13	4	14	13	13
	Minimum	16.0	6	175	3.2	0	0	0	6	1.5	0.5
	Maximum	19.5	45	1,400	8.5	760	20	624	410	46.0	28.0
	Mean	17.9	11	606	6.9	199	2	175	134	25.4	13.4
Van Buren	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	16.5	5	1,840	8.0	980	0	804	1,100	95.0	210.0
	Maximum	16.5	5	1,840	8.0	980	0	804	1,100	95.0	210.0
	Mean	16.5	5	1,840	8.0	980	0	804	1,100	95.0	210.0
Washington	No. samples	0	0	4	4	4	4	2	3	3	3
	Minimum	--	--	80	4.8	2	0	23	25	4.8	1.9
	Maximum	--	--	364	7.1	32	0	25	31	6.8	4.6
	Mean	--	--	160	6.2	23	0	24	27	5.5	3.2
White	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	20.0	3	154	6.3	44	0	36	37	7.9	4.3
	Maximum	20.0	3	154	6.3	44	0	36	37	7.9	4.3
	Mean	20.0	3	154	6.3	44	0	36	37	7.9	4.3
Yell	No. samples	3	5	10	10	10	10	7	10	8	8
	Minimum	18.0	5	101	5.7	17	0	14	4	1.6	0.0
	Maximum	20.0	45	1,150	8.2	360	0	236	410	78.0	53.0
	Mean	19.0	14	478	7.4	187	0	104	131	19.2	12.5

Table 10.--Ground-water quality in outcrops of Paleozoic rocks -- Continued

County		Dis- solved iron (µg/L as Fe) (01046)	Dis- solved sodium (mg/L as Na) (00930)	Sodium absorp- tion ratio (00931)	Dis- solved potassium (mg/L as K) (00935)	Dis- solved chloride (mg/L as Cl) (00940)	Dis- solved sulfate (mg/L as SO_4) (00945)	Dis- solved fluoride (mg/L as F) (00950)	Dis- solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis- solved nitrate (mg/L as N) (00618)
Benton	No. samples	3	3	3	3	3	3	3	3	3	3
	Minimum	0	2.5	0.1	0.8	2.5	2.8	0.30	5.3	183	0.18
	Maximum	10	3.0	.1	1.0	3.5	15.0	1.20	6.5	208	1.00
	Mean	7	2.7	.1	.9	2.8	8.7	.73	5.8	194	.47
Conway	No. samples	2	3	3	3	4	3	2	2	2	3
	Minimum	0	21.0	2.0	2.2	24.0	6.2	0.20	5.7	24	1.80
	Maximum	0	63.0	3.0	11.0	150.0	22.0	.30	6.3	126	3.40
	Mean	0	40.7	2.3	7.2	67.0	16.7	.25	6.0	75	2.57
Crawford	No. samples	5	6	6	6	6	6	6	6	5	4
	Minimum	0	3.2	0.3	0.9	2.5	2.4	0.00	7.5	35	0.02
	Maximum	150	150.0	4.0	4.8	20.0	42.0	.20	18.0	681	1.10
	Mean	34	30.6	1.1	1.8	11.0	12.3	.07	13.2	206	.62
Faulkner	No. samples	6	7	7	7	9	9	7	7	5	5
	Minimum	0	15.0	0.7	1.0	2.5	6.4	0.10	5.8	192	0.00
	Maximum	1,400	150.0	4.0	3.2	180.0	120.0	.40	22.0	790	.16
	Mean	280	59.6	2.0	1.8	49.4	36.1	.21	15.3	418	.09
Franklin	No. samples	11	8	8	8	12	12	3	3	8	3
	Minimum	0	5.7	0.5	1.2	3.8	0.2	0.10	8.5	55	0.00
	Maximum	6,000	220.0	55.0	4.9	60.0	170.0	.20	20.0	638	.34
	Mean	869	122.0	15.7	3.1	19.5	36.7	.17	13.5	379	.12
Johnson	No. samples	3	2	2	2	4	4	2	2	2	0
	Minimum	0	1.4	0.2	0.9	2.0	9.0	0.10	3.4	32	--
	Maximum	200	33.0	.8	2.0	340.0	170.0	.30	6.9	478	--
	Mean	67	17.2	.5	1.5	123.3	83.5	.20	5.2	255	--
Logan	No. samples	5	8	8	8	10	9	6	6	4	3
	Minimum	0	0.8	0.1	0.6	1.5	1.0	0.10	0.3	19	0.00
	Maximum	70	210.0	49.0	24.0	100.0	120.0	1.00	11.0	572	1.20
	Mean	16	52.8	7.4	5.2	20.9	34.1	.32	5.6	221	.45
Perry	No. samples	1	6	6	6	6	6	2	4	4	6
	Minimum	0	3.1	0.4	0.7	3.0	2.8	0.10	5.2	49	0.00
	Maximum	0	94.0	3.0	7.0	35.0	540.0	.60	23.0	545	6.80
	Mean	0	23.6	1.0	2.5	11.7	95.2	.35	11.4	204	1.57
Pope	No. samples	8	6	6	6	8	8	8	8	8	1
	Minimum	0	1.1	0.1	0.2	1.2	0.4	0.00	6.8	37	1.90
	Maximum	80	49.0	2.0	7.6	56.0	150.0	.50	19.0	385	1.90
	Mean	15	24.4	1.1	1.8	13.0	23.6	.19	11.8	160	1.90

Table 10.--Ground-water quality in outcrops of Paleozoic rocks -- Continued

County		Dis-solved iron (µg/L as Fe) (01046)	Dis-solved sodium (mg/L as Na) (00930)	Sodium absorp-tion ratio (00931)	Dis-solved potassium (mg/L as K) (00935)	Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L as F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Pulaski	No. samples	4	6	6	6	6	6	8	5	5	5
	Minimum	0	5.4	0.2	0.3	3.3	2.4	0.10	1.1	90	0.00
	Maximum	47	150.0	3.0	3.4	78.0	71.0	.30	14.0	819	.99
	Mean	12	32.2	.8	1.4	24.7	20.7	.18	6.6	281	.28
Saline	No. samples	1	1	1	0	1	1	1	0	1	0
	Minimum	620	4.2	0.1	--	6.5	74.0	0.08	--	341	--
	Maximum	620	4.2	.1	--	6.5	74.0	.08	--	341	--
	Mean	620	4.2	.1	--	6.5	74.0	.08	--	341	--
Scott	No. samples	4	11	12	11	25	12	12	3	11	9
	Minimum	0	12.0	0.4	0.5	6.0	2.8	0.00	9.7	70	0.00
	Maximum	9,600	170.0	23.0	14.0	500.0	130.0	.70	22.0	582	7.70
	Mean	3,184	50.8	3.2	4.2	98.4	33.1	.22	17.9	240	1.62
Sebastian	No. samples	11	13	13	13	15	13	6	6	13	2
	Minimum	0	6.2	0.3	0.9	2.1	3.4	0.10	7.3	163	0.00
	Maximum	32,000	280.0	53.0	9.0	160.0	300.0	.70	24.0	746	2.10
	Mean	2,953	66.9	6.7	3.1	37.5	91.4	.35	12.8	372	1.05
Van Buren	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	0	53.0	0.7	6.0	100.0	260.0	0.40	5.6	1,450	0.00
	Maximum	0	53.0	.7	6.0	100.0	260.0	.40	5.6	1,450	.00
	Mean	0	53.0	.7	6.0	100.0	260.0	.40	5.6	1,450	.00
Washington	No. samples	0	3	3	3	4	4	3	3	3	2
	Minimum	--	3.2	.3	.7	3.5	1.7	0.00	12.0	46	0.34
	Maximum	--	4.2	.3	1.6	51.0	8.0	.00	21.0	56	.34
	Mean	--	3.7	.3	1.1	16.0	3.9	.00	17.0	53	.34
White	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	0	9.4	0.7	0.8	9.5	5.6	0.10	13.0	7	0.68
	Maximum	0	9.4	.7	.8	9.5	5.6	.10	13.0	7	.68
	Mean	0	9.4	.7	.8	9.5	5.6	.10	13.0	7	.68
Yell	No. samples	5	8	8	8	10	10	7	5	6	7
	Minimum	0	3.0	0.2	0.5	2.0	0.6	0.00	8.2	176	0.09
	Maximum	80	140.0	27.0	9.7	100.0	240.0	.60	23.0	870	7.20
	Mean	20	57.5	7.2	4.2	31.1	53.1	.26	14.2	350	1.99

Sparta Sand

Geology

The Sparta Sand, of Tertiary age, is the middle sand in the Claiborne Group. It is underlain by the Cane River Formation and overlain by the Cook Mountain Formation, both of which are confining units. The Sparta Sand subcrops beneath Quaternary deposits in eastern Pulaski and western Lonoke Counties and is exposed at the surface in a thin band in southwestern Pulaski and in Saline Counties (fig. 8). It dips gently to the southeast and is more than 700 ft below land surface near Pine Bluff. The thickness of the formation ranges from less than 300 at the updip limit to 500 to 600 ft in the vicinity of Pine Bluff. The Sparta Sand consists mostly of beds of fine- to medium-grained sand in the lower half of the formation, and of beds of sand, clay, and lignite in the upper half.

Hydrology

The Sparta Sand is confined by overlying and underlying clay beds downslope from the outcrop areas producing artesian conditions in the aquifer. The sources of recharge to the Sparta Sand are precipitation on the outcrop, leakage through Quaternary deposits where it subcrops and leakage through confining layers, where the vertical hydraulic gradient is towards the Sparta. The lower half of the formation contains the most productive water-yielding zone. Production-well yields from the Sparta Sand range from a few hundred to as much as 2,000 gal/min.

The potentiometric surface in the Sparta Sand in 1985 (fig. 9) illustrates the steepness of the gradient toward the cone of depression at Pine Bluff. Water levels in the Pine Bluff area have declined almost 200 ft in the last 31 years (fig. 10), but water levels have shown a net increase in the last 5 years. Water levels near Pine Bluff are currently (1987) approximately 250 ft below land surface (40 ft below sea level).

Ground-water withdrawals from the Sparta Sand in 1985 totaled over 55 Mgal/d, with the majority of the water withdrawn being used for public supply and self-supplied industry in the Pine Bluff area. Use declined between 1980 and 1985 after increasing for the previous 15 years. More than 35 percent of the withdrawals made statewide from the Sparta Sand were in Jefferson and Pulaski Counties.

Withdrawals from the Sparta aquifer
[Withdrawals in million gallons per day; from Holland, 1987]

County	1965	1970	1975	1980	1985
Jefferson	44.36	59.30	53.82	71.13	54.44
Pulaski	--	.16	.20	.30	.85
Total	44.36	59.46	54.02	71.43	55.29

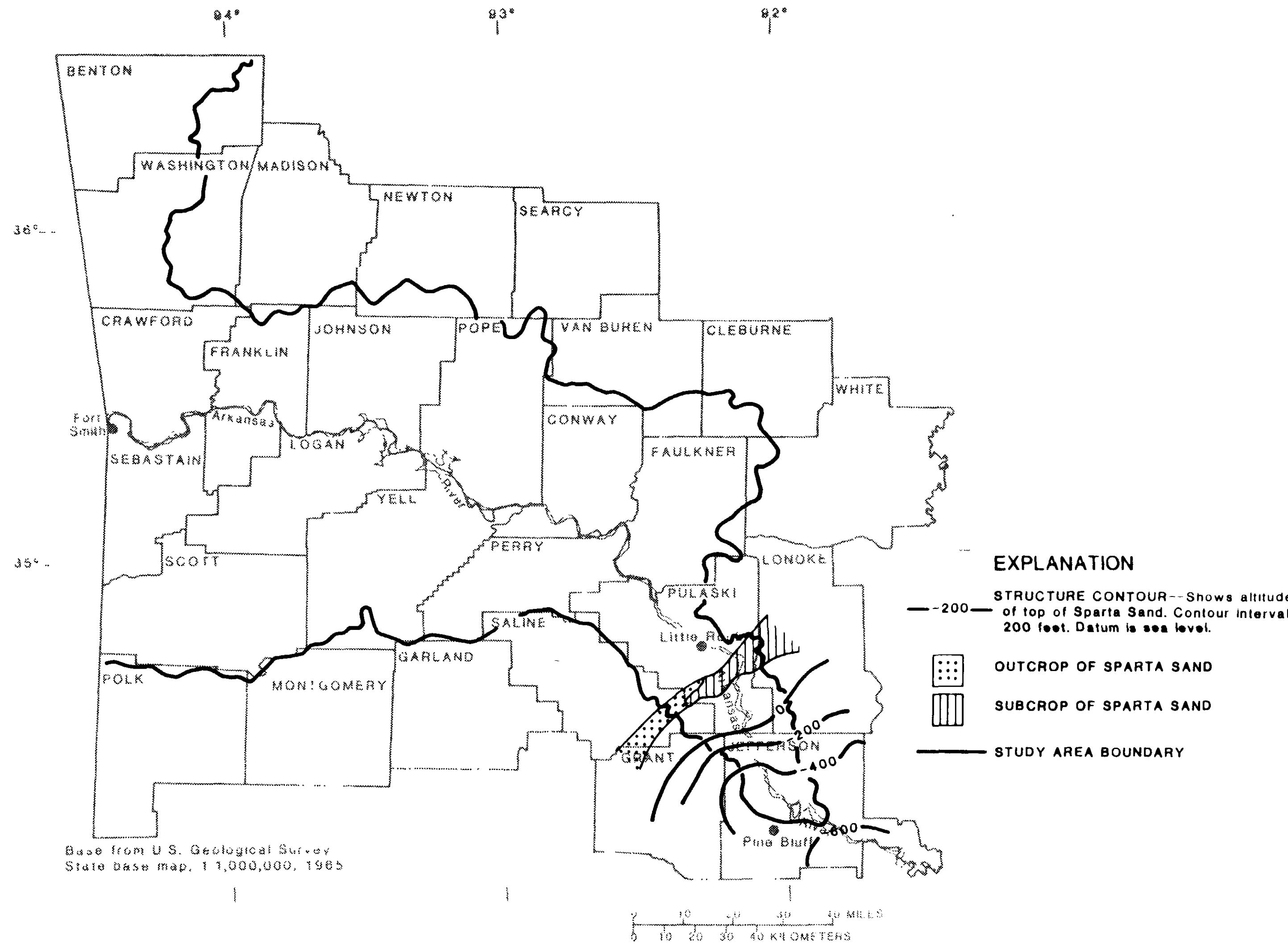

Figure 8.--Outcrop and subcrop of the Sparta Sand (modified from Hosman and others, 1968, and Petersen and others, 1985).

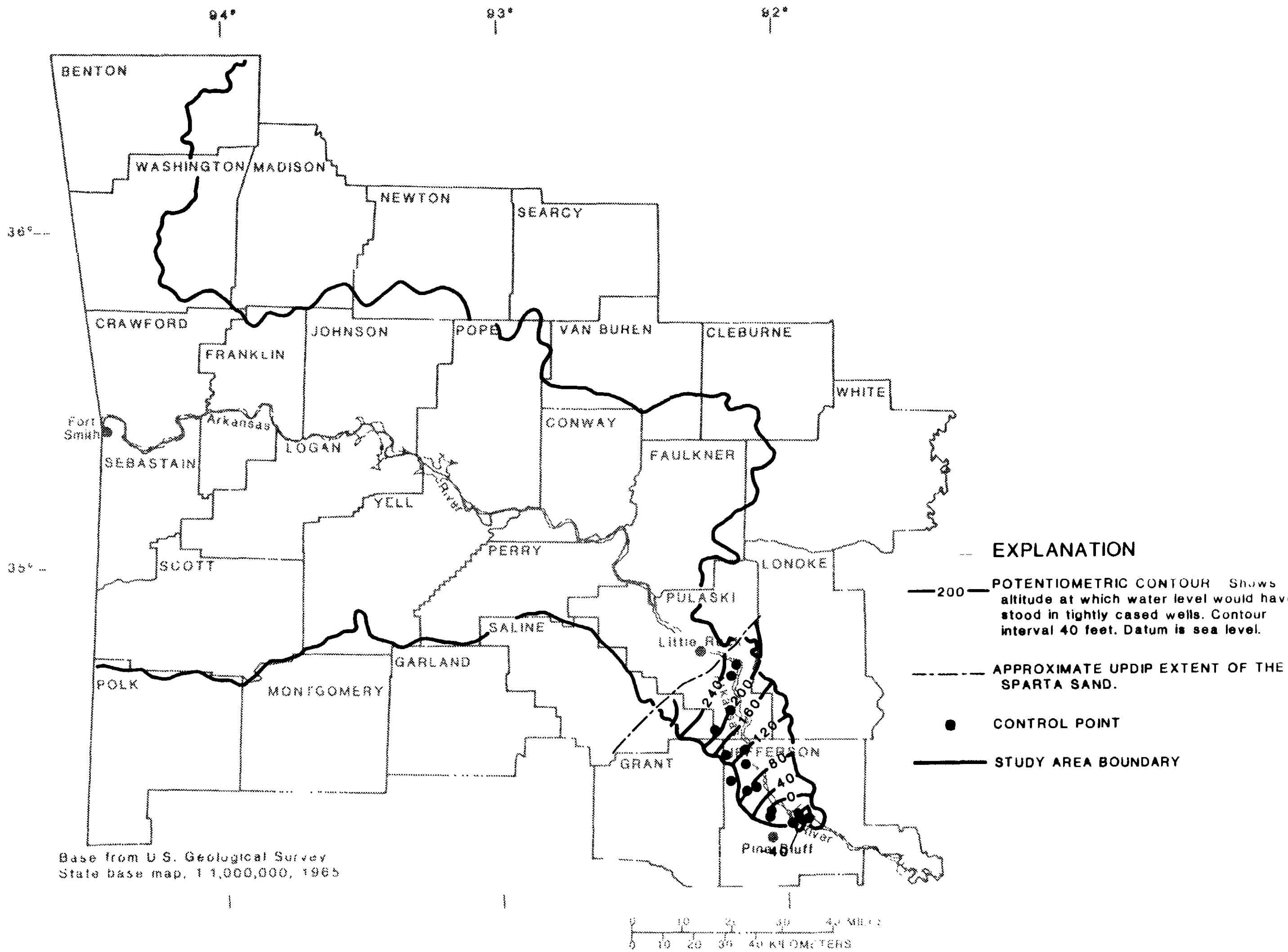

Figure 9.--Potentiometric surface in the Sparta Sand in 1985 (modified from Edds and Fitzpatrick, 1986).

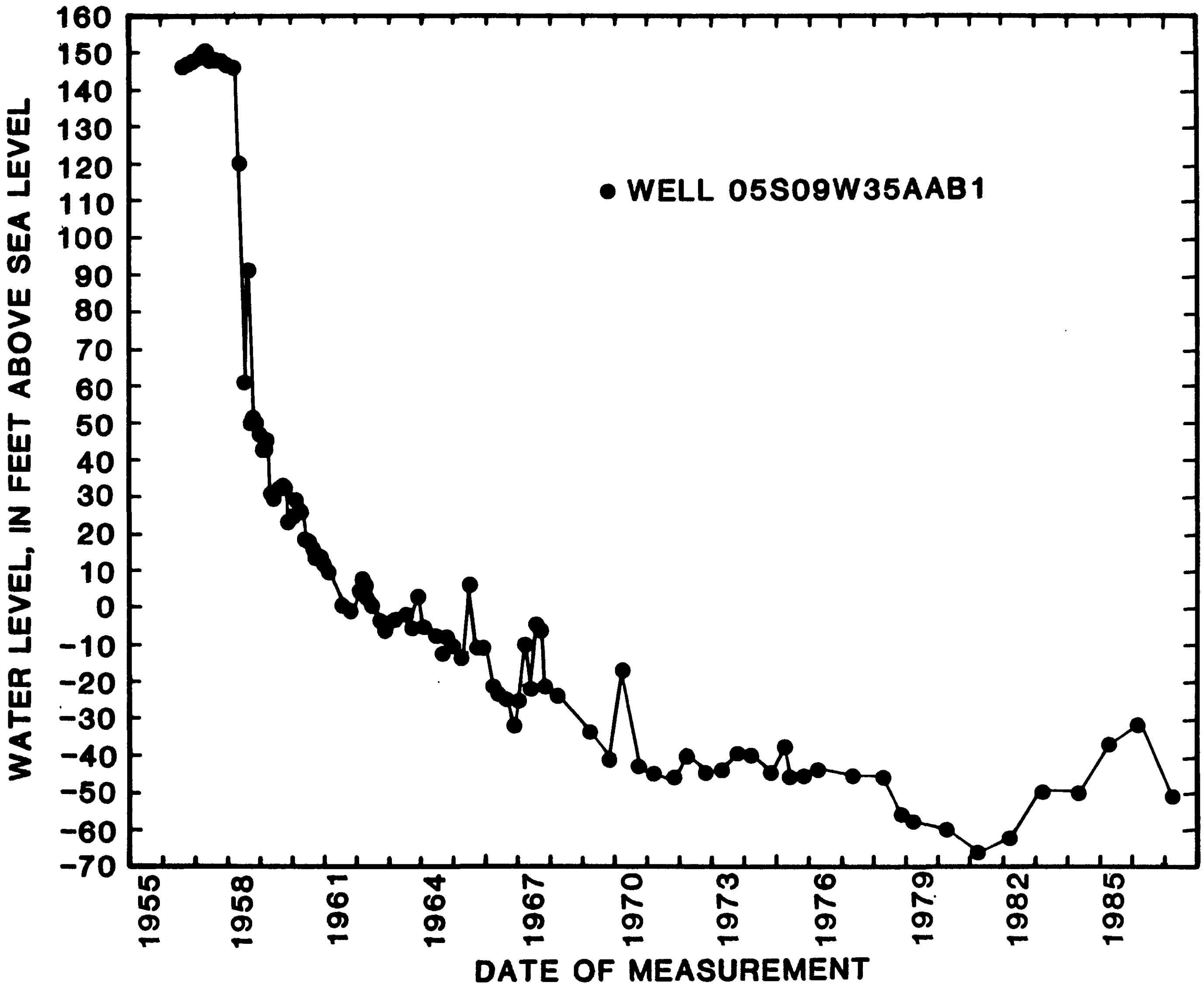

Figure 10.--Hydrograph of a well pentrating the Sparta Sand in the Pine Bluff area.

Water Quality

The Sparta Sand yields a soft, sodium-bicarbonate water of good quality. Water from the Sparta Sand is less mineralized than water from any other unit in the study area, and is suitable for most uses without treatment. Water-quality data for wells in the Sparta Sand are summarized in table 11.

Table 11.--Ground-water quality in the Sparta Sand

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Jefferson	No. samples	18	17	19	19	17	18	16	19	17	17
	Minimum	23.0	0	87	6.5	38	0	31	21	5.1	1.5
	Maximum	27.0	80	439	7.7	110	0	77	54	18.0	2.5
	Mean	24.6	9	142	7.2	57	0	44	27	7.5	2.1
Pulaski	No. samples	0	0	0	0	0	0	0	0	0	0
	Minimum	--	--	--	--	--	--	--	--	--	--
	Maximum	--	--	--	--	--	--	--	--	--	--
	Mean	--	--	--	--	--	--	--	--	--	--

County		Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio 00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Jefferson	No. samples	19	17	17	17	19	17	14	17	17	16
	Minimum	30	6.6	0.6	1.9	1.8	2.9	0.0	11.0	60	0.00
	Maximum	10,000	31.0	3.0	7.1	8.0	21.0	.2	17.0	150	.07
	Mean	[a]846	12.3	1.1	3.8	3.9	7.3	.1	14.2	81	.01
Pulaski	No. samples	0	0	0	0	1	0	0	0	0	0
	Minimum	--	--	--	--	2.5	--	--	--	--	--
	Maximum	--	--	--	--	2.5	--	--	--	--	--
	Mean	--	--	--	--	2.5	--	--	--	--	--

[a] Median value is 100

Quaternary Deposits

Geology

Quaternary deposits underlie the flood plain of the Arkansas River between Fort Smith and Little Rock and from the Arkansas River east to the study area boundary downstream from Little Rock (fig. 2). These deposits compose a coarse sand and gravel aquifer at the base grading upward to fine-grained sand, silt, and clay at the surface. They range in thickness from 40 ft at Fort Smith to 80 ft at Little Rock, and are about 150 ft thick where they occur in the Coastal Plain part of the study area (Klein and others, 1950; Cordova, 1963).

Hydrology

Recharge to Quaternary deposits is primarily by downward percolation of precipitation and by seepage of water from the Arkansas River. Average well yields upstream from Little Rock are 300 to 700 gal/min, while in the Coastal Plain, well yields average more than 1,000 gal/min with a maximum of about 2,500 gal/min. Ground-water levels in the flood plain of the Arkansas River are strongly influenced by the stage of the navigation pools on the river. Since completion of the navigation system, water levels have risen several feet in wells close to the river and lesser amounts at greater distances from the river. Because of the high degree of connection between the river and the Quaternary deposits, the river serves as a large reservoir to sustain water levels and well yields. Water levels in the flood plain range from 5 to 30 ft below land surface. Water levels in the Quaternary deposits east of the river in the Coastal Plain have been influenced by the large withdrawals from the Quaternary deposits in the Grand Prairie and are at progressively greater depth below land surface from the river eastward. Along the eastern boundary of the study area, water levels are more than 40 ft below land surface. The potentiometric surface in the Quaternary deposits in the Coastal Plain in 1985 is shown in figure 11.

Water use from Quaternary deposits in the study area in 1985 totaled 178.18 Mgal/d, accounting for only 5 percent of the statewide total from these deposits. Pumpage from these deposits in Pulaski and Jefferson Counties made up 85 percent of the total for the study area in 1985 (table 12). Use from these deposits in 1985 decreased almost 8 percent from 1980, after increasing between 1965 and 1980. Currently, these deposits are little used as a source of public supply in the study area. The primary use of water from Quaternary deposits is for irrigation.

Table 12.--Withdrawals from Quaternary deposits

[Withdrawals in million gallons per day; from Holland, 1987]

County	1965	1970	1975	1980	1985
Conway	2.10	8.06	7.53	5.44	4.19
Crawford	1.18	1.71	.84	2.51	4.15
Faulkner	--	1.93	.36	.53	.67
Franklin	.76	1.32	.27	.24	.96
Jefferson	42.01	51.60	106.79	141.14	121.91
Johnson	.60	.97	1.25	2.24	2.87
Logan	.31	.54	.29	.25	.33
Perry	--	1.74	.28	.24	--
Pope	1.02	1.49	3.25	3.45	6.53
Pulaski	12.78	16.80	21.69	33.50	29.54
Sebastian	.21	.12	.17	.15	1.07
Yell	.47	2.52	2.15	3.75	5.96
Total	61.44	88.80	144.87	193.44	178.18

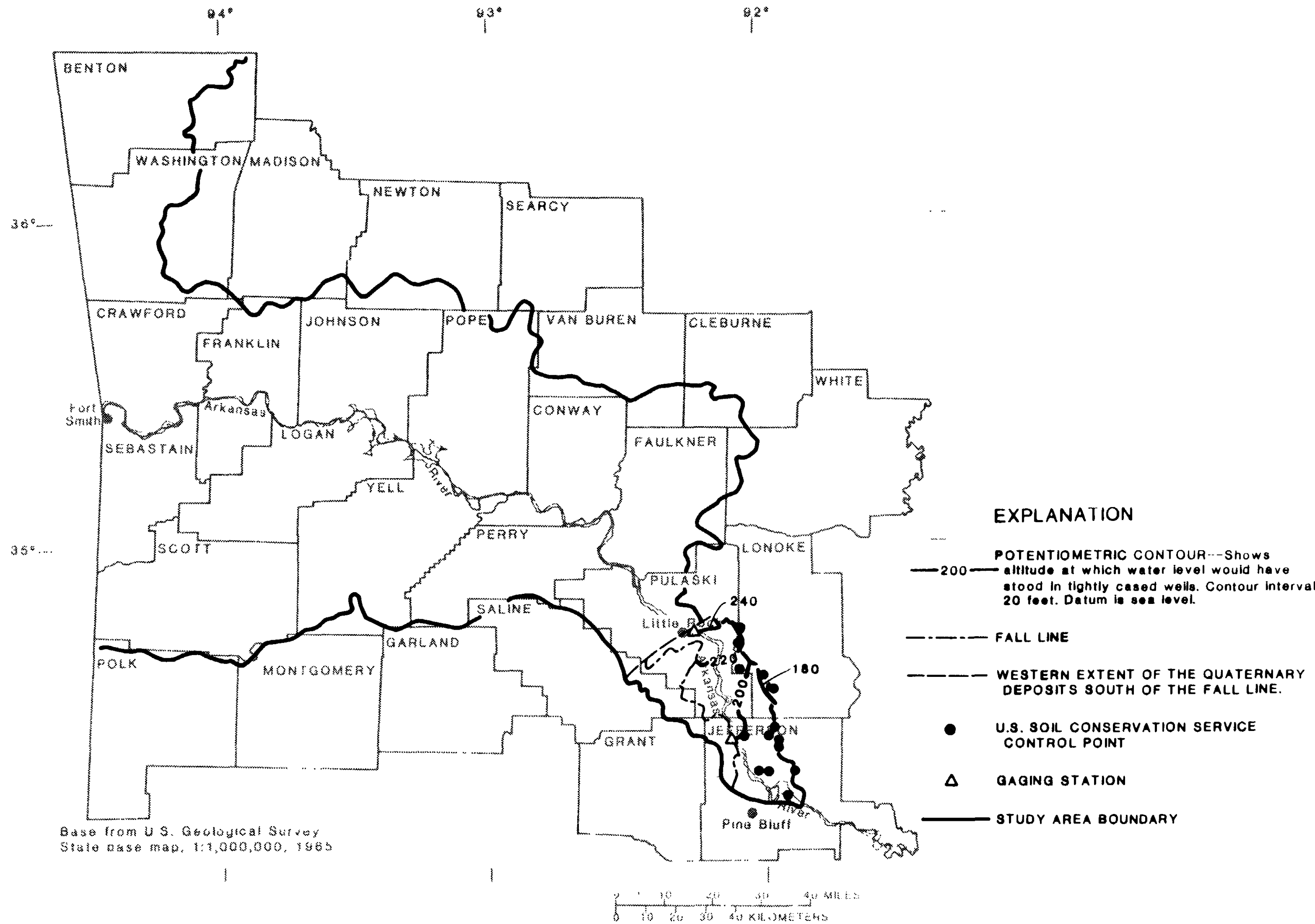

Figure 11.--Potentiometric surface in the Quaternary deposits south of the Fall Line in 1985 (modified from Plafcan and Fugitt, 1987).

Water Quality

Water from Quaternary deposits is of suitable quality for irrigation and some industrial uses. It is used for domestic supply when no public supply is available. Hardness and iron are the most pervasive problems, while locally concentrations of nitrate, iron, chloride, sulfate, and dissolved solids can exceed allowable limits. Water-quality data for wells in Quaternary deposits are summarized in table 13.

GROUND-WATER PROBLEMS

Quantity

In a large part of the study area, the only sources of ground water are the outcrops of Paleozoic rocks, which yield less than 10 gal/min. Such low yields are due to the nature of the occurrence of ground water in secondary openings with low storage capacities. Quaternary deposits yield substantially more water, particularly south of the Fall Line but their area of use is somewhat smaller. Subsurface rocks and the Sparta Sand also yield large amounts of water, but only in relatively small areas within the study area.

Quality

The quality of ground water in the study area is highly variable from aquifer to aquifer and from one area to another. Hardness and high iron concentrations are the most common problems, although in local areas nitrate, chloride, dissolved solids and sulfate concentrations can exceed U.S. Environmental Protection Agency primary and secondary drinking water standards.

The occurrence of bacterial contamination in shallow wells and springs in the Interior Highlands has increased as human and animal populations have increased in the study area. Fractures and solution channels in outcrops of Paleozoic rocks, particularly limestones and dolomites, are highly susceptible to contamination because the fractures allow rapid infiltration of fecal matter from a variety of sources including septic tanks, landfills, poultry and cattle operations, and runoff from pastures. Wells also can be contaminated because of deteriorated well bore seals and perforated casings that allow contaminants to enter the well.

Studies by Steele and others (1975), MacDonald and others (1976), and Wagner and others (1976) documented bacterial contamination of both wells and springs in the northern part of the study area. Chesney (1979) reported the contamination of spring water at two trout hatcheries near Springdale by wastewater from a city lagoon and an industrial waste lagoon.

Several other water-quality problems also are related to man's activities. In the coal region of the Arkansas Valley, acid water flows from at least two abandoned underground coal mines (Potts, 1987). One mine is near Huntington, and the other is near Hartford. Water from both these mines is flowing into tributaries of the James Fork River.

Table 13.--Ground-water quality in Quaternary deposits

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Conway	No. samples	133	13	177	128	86	86	53	84	13	13
	Minimum	13.5	0	157	0.0	11	0	9	30	22	7.1
	Maximum	21.0	27	2,150	8.8	700	19	572	690	180	48.0
	Mean	17.2	7	576	7.8	328	1	243	311	90	22.5
Crawford	No. samples	80	15	187	147	92	93	11	145	28	25
	Minimum	15.0	2	245	6.8	0	0	126	49	13	4.0
	Maximum	28.5	10	1,230	9.5	590	430	378	540	430	70.0
	Mean	17.2	5	541	8.0	317	10	285	296	113	20.9
Faulkner	No. samples	22	5	32	22	15	15	5	15	5	5
	Minimum	14.5	4	227	7.0	44	0	36	74	54	9.0
	Maximum	21.5	5	937	8.5	560	8	264	450	130	32.0
	Mean	16.9	4	551	7.8	317	1	172	291	80	18.0
Franklin	No. samples	294	51	333	72	68	67	0	71	63	63
	Minimum	0.0	0	102	6.0	19	0	--	26	4	3.0
	Maximum	26.5	11	44,100	8.2	390	26	--	1,300	170	23.0
	Mean	17.1	3	800	7.2	168	0	--	192	49	12.2
Jefferson	No. samples	33	6	35	35	35	34	31	35	8	8
	Minimum	16.0	5	280	5.7	4	0	3	14	8	2.3
	Maximum	19.0	10	1,150	8.5	560	26	462	570	160	39.0
	Mean	18.0	7	570	7.7	267	2	211	236	74	20.3
Johnson	No. samples	11	0	31	21	10	6	4	21	3	3
	Minimum	15.0	--	311	6.7	0	0	112	140	82	19.0
	Maximum	21.0	--	1,420	8.6	430	480	349	840	130	30.0
	Mean	17.1	--	679	8.0	249	135	231	326	104	25.0
Logan	No. samples	69	9	111	88	51	50	3	54	15	15
	Minimum	11.5	2	133	6.2	20	0	117	42	19	4.3
	Maximum	20.0	8	1,750	8.5	770	18	362	730	180	92.0
	Mean	16.9	5	556	7.8	354	0	209	315	89	24.3
Lonoke	No. samples	31	2	32	32	32	32	31	32	2	2
	Minimum	17.0	5	124	6.6	80	0	75	13	31	9.0
	Maximum	19.0	5	767	8.5	450	16	371	400	48	17.0
	Mean	18.0	5	429	7.4	232	2	197	191	40	13.0
Perry	No. samples	2	1	8	8	2	2	1	2	2	1
	Minimum	16.0	4	267	7.4	0	0	363	220	22	26.0
	Maximum	16.5	4	939	8.3	440	190	363	370	100	26.0
	Mean	16.3	4	560	8.0	220	95	363	295	61	26.0

Table 13.--Ground-water quality in Quaternary deposits -- Continued

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicar-bonate (mg/L as HCO_3) (00440)	Carbo-nate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hard-ness (mg/L as $CaCO_3$) (00900)	Dis-solved calcium (mg/L as Ca) (00915)	Dis-solved magnesium (mg/L as Mg) (00925)
Pope	No. samples	43	6	95	75	63	63	47	63	7	7
	Minimum	14.0	4	108	6.6	31	0	25	42	47	8.8
	Maximum	20.0	22	1,450	8.9	510	25	417	510	99	31.0
	Mean	17.1	8	395	7.7	195	1	174	187	66	17.8
Pulaski	No. samples	65	9	106	102	84	83	80	84	11	11
	Minimum	14.0	3	142	6.7	14	0	15	6	36	8.6
	Maximum	30.5	12	1,200	8.9	600	38	495	510	140	29.0
	Mean	18.9	6	552	7.8	267	3	227	241	89	18.8
Sebastian	No. ssmples	0	0	21	21	8	8	8	17	7	7
	Minimum	--	--	362	7.0	340	0	278	180	80	23.0
	Maximum	--	--	2,360	8.8	1,050	84	1,000	630	150	40.0
	Mean	--	--	796	8.0	491	13	424	346	101	28.4
Yell	No. samples	20	8	195	185	185	184	170	186	32	32
	Minimum	16.0	2	101	6.3	8	0	6	20	1	3.0
	Maximum	20.5	7	1,580	8.8	560	100	463	550	99	40.0
	Mean	17.8	6	490	7.9	193	3	165	193	45	14.7

County		Dis-solved iron (µg/L as Fe) (01046)	Dis-solved sodium (mg/L as Na) (00930)	Sodium absorp-tion ratio (00931)	Dis-solved potassium (mg/L as K) (00935)	Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L as F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Conway	No. samples	60	29	24	29	176	97	4	4	13	30
	Minimum	0	3.7	0.1	0.8	1.5	0.0	0.0	0.0	138	0.02
	Maximum	1,000	200.0	3.0	6.0	430.0	120.0	.40	22.0	971	64.00
	Mean	105	27.8	.5	2.4	26.5	21.9	.13	15.5	420	4.29
Crawford	No. samples	76	20	20	7	185	102	5	5	20	5
	Minimum	0	5.5	0.2	0.6	2.0	0.2	0.00	17.0	199	0.11
	Maximum	200	150.0	10.0	14.0	980.0	95.0	.10	22.0	634	6.80
	Mean	10	19.7	.8	5.0	21.0	26.5	.06	19.4	376	2.73
Faulkner	No. samples	10	7	7	7	31	16	0	0	5	3
	Minimum	0	5.4	0.2	0.6	1.5	0.4	--	--	214	0.07
	Maximum	80	13.0	.6	10.0	53.0	64.0	--	--	491	2.30
	Mean	33	9.4	.3	2.4	8.7	16.9	--	--	319	.90

Table 13.--Ground-water quality in Quaternary deposits -- Continued

County		Dis-solved iron (µg/L as Fe) (01046)	Dis-solved sodium (mg/L as Na) (00930)	Sodium absorp-tion ratio (00931)	Dis-solved potassium (mg/L as K) (00935)	Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L ss F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Franklin	No. samples	5	51	51	55	332	67	57	55	50	0
	Minimum	0	8.0	0.5	0.0	2.2	7.8	0.00	0.0	98	--
	Maximum	60	110.0	3.0	3.4	18,000.0	58.0	.60	34.0	743	--
	Mean	16	49.4	1.6	1.7	135.3	22.4	.25	23.7	372	--
Jefferson	No. samples	1	33	31	34	34	30	4	8	8	7
	Minimum	230	9.5	0.2	0.2	3.8	0.0	0.00	8.3	214	0.00
	Maximum	230	97.0	3.0	4.7	130.0	240.0	.40	43.0	748	.63
	Mean	230	35.0	1.1	2.1	38.6	39.0	.13	21.4	387	.22
Johnson	No. samples	1	1	1	2	31	12	1	1	1	4
	Minimum	20	20.0	0.5	4.1	4.0	1.0	0.10	20.0	441	0.43
	Maximum	20	20.0	.5	8.2	32.0	240.0	.10	20.0	441	1.40
	Mean	20	20.0	.5	6.2	15.0	76.5	.10	20.0	441	.78
Logan	No. samples	39	15	15	15	111	58	14	14	13	0
	Minimum	0	8.5	0.2	0.8	1.5	0.2	0.00	5.8	179	--
	Maximum	8,600	160.0	5.0	2.9	56.0	790.0	.60	30.0	1,290	--
	Mean	299	32.4	.9	1.5	11.7	30.1	.16	16.8	480	--
Lonoke	No. samples	2	25	27	27	32	10	0	0	2	6
	Minimum	80	5.3	0.2	0.8	4.0	0.0	--	--	220	0.11
	Maximum	100	34.0	2.0	2.8	74.0	26.0	--	--	260	5.20
	Mean	90	18.2	.6	1.7	22.7	11.3	--	--	240	1.80
Perry	No. ssmples	4	2	1	1	8	2	0	0	1	1
	Minimum	0	0.9	0.4	0.8	10.0	18.0	--	--	445	0.23
	Maximum	8,100	19.0	.4	.8	130.0	25.0	--	--	445	.23
	Mean	2,205	10.0	.4	.8	32.9	21.5	--	--	445	.23
Pope	No. samples	54	7	7	7	95	67	0	1	6	46
	Minimum	0	7.1	0.3	1.0	2.2	0.2	--	34.0	199	0.00
	Maximum	6,200	34.0	1.0	3.3	190.0	150.0	--	34.0	420	33.00
	Mean	228	17.7	.5	1.5	14.1	16.4	--	34.0	335	4.55
Pulaski	No. samples	56	34	32	33	105	85	6	6	10	50
	Minimum	0	6.8	0.2	0.0	1.7	0.0	0.00	14.0	242	0.02
	Maximum	5,500	170.0	5.0	6.2	150.0	140.0	.30	26.0	584	9.00
	Mean	382	25.4	.7	1.6	30.0	24.7	.15	18.2	419	.78
Sebastian	No. samples	1	2	2	2	21	8	2	2	2	8
	Minimum	10	7.1	0.2	2.9	5.5	10.0	0.10	16.0	414	0.00
	Maximum	10	17.0	.4	4.1	210.0	240.0	.10	18.0	597	.45
	Mean	10	12.1	.3	3.5	41.8	73.3	.10	17.0	506	.18
Yell	No. samples	152	12	11	12	195	185	6	7	10	167
	Minimum	0	5.5	0.4	0.9	1.0	1.0	0.10	4.1	88	0.00
	Maximum	3,800	240.0	12.0	48.0	270.0	250.0	1.20	35.0	733	67.00
	Mean	213	50.5	2.4	7.4	32.3	23.2	.30	22.7	330	5.34

Critical-Use Areas

Critical ground-water use areas have been defined by the ASWCC for both water-table and artesian aquifers using the following criteria:

Water-table aquifers

1. Less than 50 percent of the thickness of the aquifer is saturated
2. Average annual declines of 1 ft or more have occurred for the preceding 5-year period
3. Ground-water quality has been degraded or trends indicate probable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer

Artesian aquifers

1. The potentiometric surface is below the top of the aquifer
2. Average annual declines of 1 ft or more have occurred for the preceding 5 years
3. Ground-water quality has been degraded or trends indicate probable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer

If even one of these criteria is met by an aquifer in part of the study area, then that part of the study area is considered to be a critical-use area for that aquifer.

Subsurface rocks are considered to be artesian aquifers throughout the study area. Water levels in wells penetrating these rocks indicate no long-term declines and most water-quality problems appear to be of a local nature. The quality and quantity problems of available ground water primarily are due to natural constraints such as the number, size, openness, and degree of interconnectivity of the water-yielding openings and the mineralogic composition of the rocks penetrated by wells. On the basis of available data, no areas in these subsurface rocks are critical-use areas.

Ground water occurs in outcrops of Paleozoic rocks under water-table conditions. Well yields in these rocks are low because of the natural constraints mentioned previously, and water levels indicate no long-term declines. Water-quality problems generally are of a local nature and are unrelated to pumping rates. Therefore, no critical areas exist in these rocks.

Water in the Sparta Sand exists under artesian conditions downdip from its outcrop area. Water levels rose in most areas between 1982 and 1987 (Freiwald and Plafcan, 1987), but many wells had more than 5 ft of decline in the last year of that 5-year period. Although no critical-use areas exist in the Sparta Sand because of the net rise in water levels in the past 5 years, the 5- to 10-ft decline in water levels in the past year is reason for concern.

Water in Quaternary deposits exists under water-table conditions in the study area. Available data indicate that water levels in most areas have shown a net increase between 1982 and 1987 (Freiwald and Plafcan, 1987). Water-quality problems in the Quaternary deposits are of local concern only.

In summary, the problem of declining water levels is not severe enough to meet the criteria for a critical-use area. Water-quality problems are either isolated to individual wells or are naturally occurring. Water use from the

Sparta Sand and the Quaternary deposits, although significant, does not at this time appear to be causing water levels to decline at a rate high enough to meet critical-use criteria. Therefore, no areas in the study area are critical-use areas.

POTENTIAL GROUND-WATER PROBLEMS

The potential for ground-water contamination exists throughout the study area. Potential sources of contamination include landfills, surface waste impoundments, hazardous waste operations, storage tanks, septic tanks, and saline water intrusion. The probability of contamination of ground water varies from area to area depending largely on the permeability of the surface materials. Permeable materials that allow water to recharge aquifers will also allow contaminants to enter the ground-water system. Figure 12 shows the recharge potential of the basin in different areas. Zones shown on figure 12 as having high recharge potential include the outcrop areas of Paleozoic limestones, Arkansas Novaculite, Big Fork Chert, and Cockfield Formation. Zones with medium recharge potential are outcrops of Paleozoic rocks and stones and shales and low interstream terraces of Quaternary deposits. Zones with low recharge potential are the outcrops of the Jackson Group and the Cook Mountain Formation. The greatest potential for contamination is in zones with high recharge potentials.

At least 41 open landfills and dumps exist in the study area (fig. 12). The contents of the majority of these landfills and dumps are virtually unknown. Hazardous materials may be stored in these areas and could be leaking into the shallowest aquifer. One Resource Conservation and Recovery Act (RCRA) site and two Superfund sites exist in the study area. More than 2.3 million tons of hazardous waste were generated or stored in the study area in 1982 (C.T. Bryant, U.S. Geological Survey, written commun., 1984).

Surface waste impoundments also may be considered potential hazards to ground water. Chesney (1979) inventoried 7,640 impoundments at 872 sites. A small number of these impoundments (518) were selected for assessment of contamination potential. The assessment conducted by Chesney included a complete description of the impoundments including size in acres, age, amount, and type of wastes present and type of liner, and the presence of monitoring wells. In addition, the geologic formations underlying the impoundments were rated according to the ease with which contaminants could penetrate surface layers. By using these data, the impoundments were then assessed for ground-water contamination potential, which is expressed as a numerical rating with a low of 1 and a high of 29. Surface waste impoundments with a hazard rating of 16 or above are shown in figure 12.

Additional sources of potential ground-water contamination include storage tanks, septic tanks, waste-injection wells, mining activities, pipelines, and wastes spilled in transport.

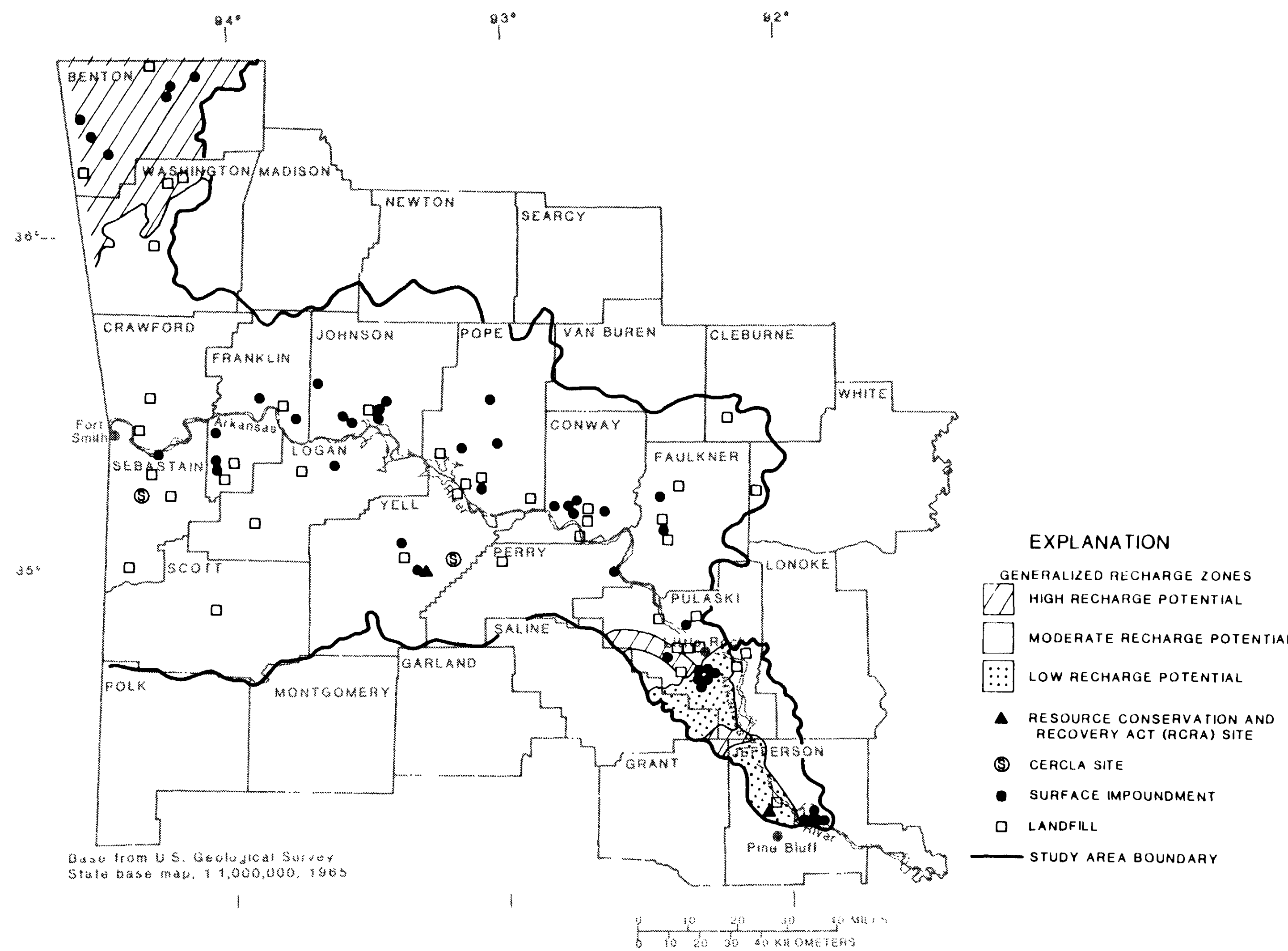

Figure 12.--Generalized recharge zones and potential ground-water contamination sources (modified from Bryant and others, 1985).

SUMMARY AND CONCLUSIONS

Ground water is available from nearly all the geologic units in the study area. Most of these units, such as the outcrops of Paleozoic rocks, are important only because they are accessible. However, several of the units are important regional sources of water. These include rocks in the subsurface and in outcrops in the Ozark Plateaus and Ouachita province. Important subsurface units include the Eminence and Potosi Dolomites, the Gasconade Dolomite and Van Buren Formation, and the Roubidoux Formation. In the Coastal Plain, both the Sparta Sand and Quaternary deposits are considered regionally important sources of water.

Although more than 90 percent of the water withdrawn in the 15-county area, which approximates the study area, was from Tertiary and Quaternary deposits, the outcrops of Paleozoic rocks are far more important areally. In most of the study area outcrops of Paleozoic rocks provide the only source of ground water.

Yields from the different water-yielding units are highly variable. In the Ozark Plateaus and Ouachita province, the subsurface Paleozoic rocks can yield as much as 500 gal/min, whereas the outcrops of Paleozoic rocks commonly yield less than 10 gal/min. The Quaternary deposits along the Arkansas River yield between 300 and 700 gal/min in these physiographic provinces. In the Coastal Plain, the Sparta Sand can yield as much as 2,000 gal/min, whereas Quaternary deposits can yield as much as 2,500 gal/min.

Ground water in the Ozark Plateaus and Ouachita provinces generally is usable without treatment for rural, domestic, and some industrial purposes; but may require softening and removal of iron to be made acceptable for municipal supplies and most industrial uses. In the Coastal Plain, the Sparta Sand yields a soft bicarbonate water, whereas the Quaternary deposits yield a very hard water. In most cases, ground water from the Quaternary deposits is much more highly mineralized than that from the Sparta Sand, which is widely used for public supply with little or no treatment.

In a large part of the study area, the only sources of ground water are the outcrops of Paleozoic rocks, which yield less than 10 gal/min. High iron concentrations in ground water are a common problem in much of the study area. Local ground-water quality problems include fecal bacterial contamination from poultry and cattle operations, septic tanks and other sources, and acid mine drainage near Huntington and Hartford, Arkansas.

Water use from the Sparta Sand and the Quaternary deposits, although substantial, does not at this time appear to be causing water levels to decline at a rate high enough to meet critical-use criteria. Therefore, no areas in the Arkansas River basin were designated as critical-use areas.

The potential for ground-water contamination exists throughout the study area. Potential hazards include landfills, surface waste impound-ments, hazardous waste operations, and storage tanks.

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