ARKANSAS STATE WATER PLAN

EASTERN ARKANSAS BASIN

ARKANSAS SOIL AND WATER CONSERVATION COMMISSION

JUNE, 1988

STATE OF ARKANSAS

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PREFACE

The Arkansas Soil and Water Conservation Commission received statutory authority to begin work on the first Arkansas State Water Plan in 1969. Act 217 gave specific authority to the Commission to be the designated agency responsible for water resources planning at the state level. The act mandated the preparation of a comprehensive state water plan of sufficient detail to serve as the basic water policy document for the protection, development, and management of water resources in the State of Arkansas.

The first State Water Plan was published in 1975 with five appendices that addressed specific problems and needs in the state. As more data have become available, it is apparent that the ever-changing nature of water-resource problems and potential solutions requires the planning process to be dynamic. Therefore, periodic revisions to the State Water Plan are necessary for the document to remain valid.

In 1985, the Arkansas Legislature passed Act 1051 which was established to determine the present and future requirements of the water users of the State. As a result of this Act, the Arkansas Soil and Water Conservation Commission was mandated to: (1) inventory the surface water and ground water resources within the state; (2) determine water needs for fish and wildlife, navigation, public water supply, industry, agriculture, and all other users; (3) delineate critical water areas; (4) determine the safe yield of streams and aquifers; (5) establish minimum streamflows; and (6) determine excess surface water. The requirements of Act 1051 will be addressed in each of the basin reports of the revised State Water Plan.

This report is the last of eight river basin reports to be published as a component of the revised Arkansas State Water Plan. The objectives of this plan are to incorporate data available from recent research, re-evaluate new and existing problems, present specific solutions and recommendations, and satisfy the requirements of Act 1051 of 1985.

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CHAPTER I

GENERAL DESCRIPTION

The Eastern Arkansas Basin is bounded on the north by the Missouri state line, on the east by the Mississippi River, on the south by the Arkansas River, and on the west generally by the Fall Line. The watershed consists of about 11,210 square miles or approximately 7,172,000 acres. <50> (Numbers in angle brackets refer to the references found in the bibliography.)

The Eastern Arkansas Basin is comprised of three major sub-basins: the St. Francis River, the Lower White River, and Bayou Meto, as shown in Figure 1-1. Principal streams in the area include: the St. Francis, L'Anguille, Cache, White, and Arkansas River, and Bayou Meto and Bayou DeView.

STUDY AREA

Sixteen counties comprise the study area of the Eastern Arkansas Basin. The counties that are included in the study area, as shown in Figure 1-1, are: Arkansas, Clay, Craighead, Crittenden, Cross, Greene, Jackson, Lee, Lonoke, Mississippi, Monroe, Phillips, Poinsett, Prairie, St. Francis, and Woodruff. The establishment of a study area based on county boundaries is necessary because some data that are included in the report, such as land and water use data, are available only by county. The study area for this report was established by selecting the counties which would most closely represent the conditions of the Eastern Arkansas Basin. Data in subsequent sections of the report that pertain to this 16-county study area will be so designated.

PHYSIOGRAPHY

The Eastern Arkansas Basin lies mainly in the Mississippi Alluvial Plain section of the Coastal Plain Physiographic Province. (Figure 1-2) A small segment along the western margin of the basin lies in the Interior Highlands Province. The surface of the alluvial valley is basically a flat, uniformly sloping plain. The principal topographic features include abandoned stream channels, natural levees, backswamp areas. Land surface altitudes range from about 300 feet in Clay County to about 150 feet near the confluence of the White and Mississippi Rivers.

The greatest relief on the plain is Crowley's Ridge which stands as much as 300 feet above the adjacent plain. The ridge trends north-south across the plain from Clay County to Helena in Phillips County and, except for a breach along the course of the L'Anguille River in Lee County, is continuous the entire distance. The width of the ridge ranges from 1 to 12 miles.

The Grand Prairie ridge forms a slightly elevated plain in the southwestern part of the basin. (Figure 1-2) The plain trends northwest-southeast for about 70 miles from near Little Rock to southern Arkansas County and averages 15 miles in width. Land surface on the plain is 30 to 60 feet above the flood plain of the White River and 10 to 30 feet above that of the Arkansas River and Bayou Meto.

The alluvial plain east of Crowley's Ridge is drained by the St. Francis River. Part of the plain west of the ridge drains to the St. Francis by way of the L'Anguille River through the breach in Crowley's Ridge. The rest of the alluvial plain west of the ridge is drained by the White River and its tributaries including the Cache River, Bayou DeView, Big Creek, and LaGrue Bayou, and by Bayou Meto.

FIGURE 1-1
EASTERN ARKANSAS BASIN AND STUDY AREA

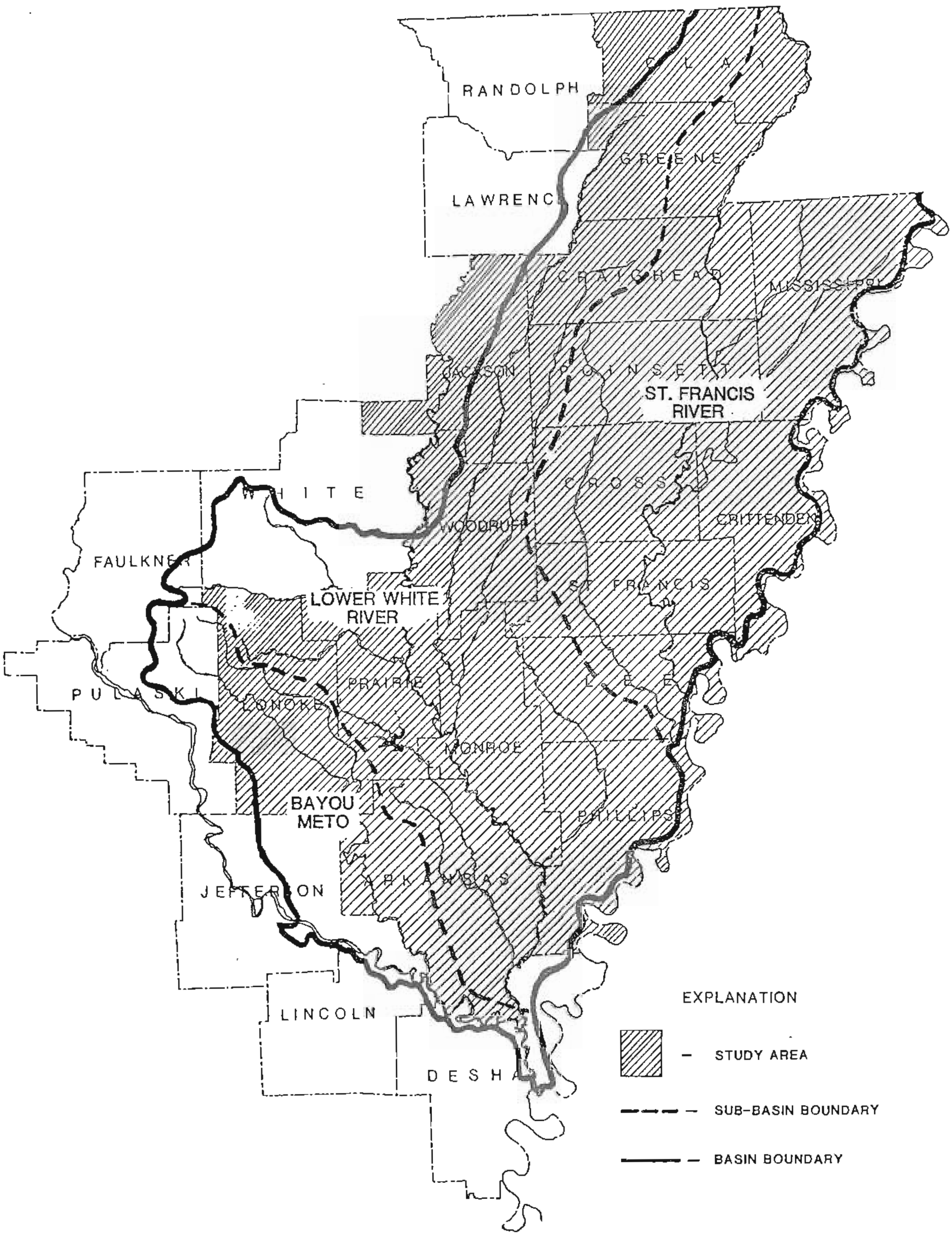
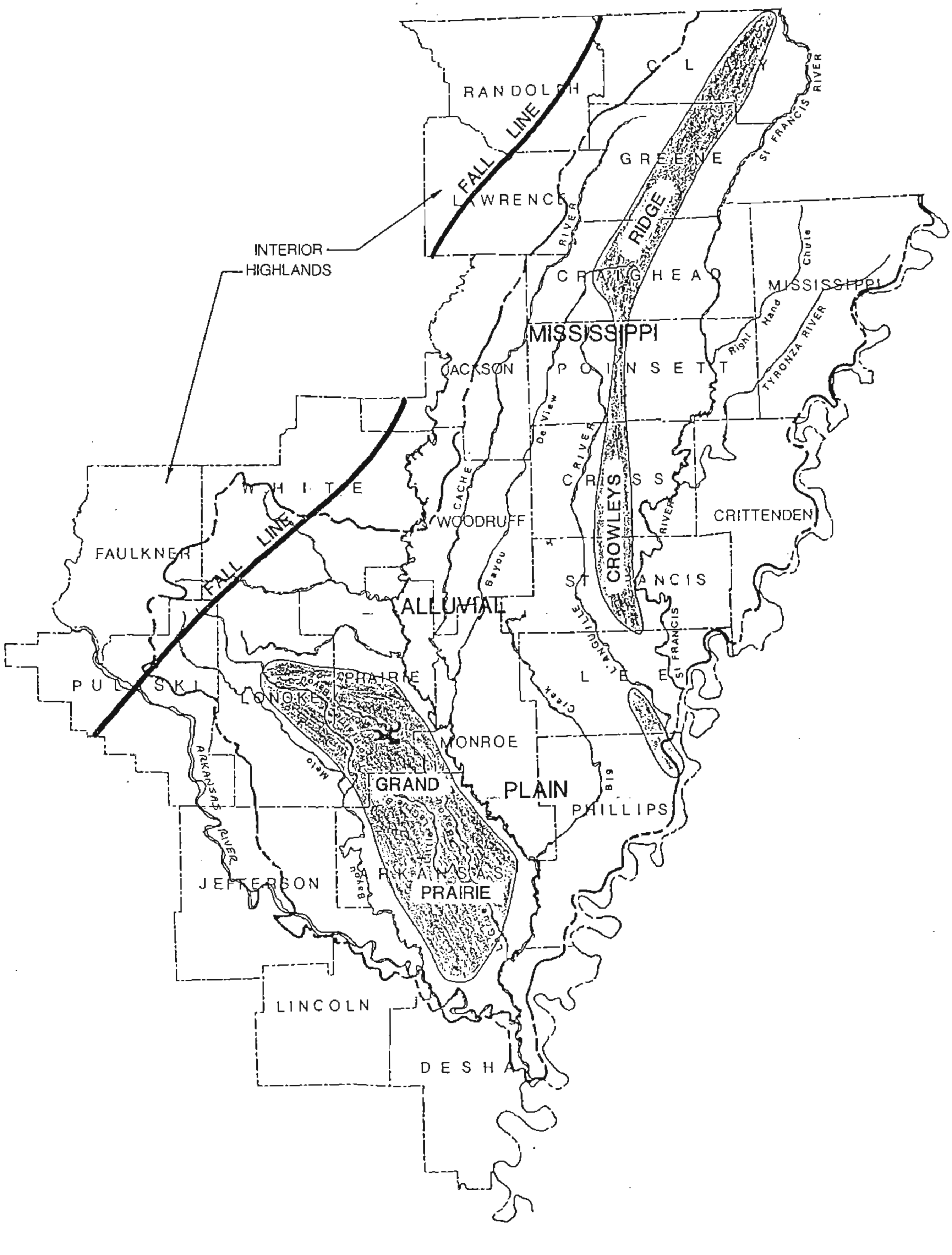


FIGURE 1-2
PHYSIOGRAPHIC DIVISIONS OF THE EASTERN ARKANSAS BASIN



SOURCE: FENNEMAN ⟨15⟩

CLIMATE

Climate of the Eastern Arkansas Basin is characterized by generally mild, humid conditions with an abundance of precipitation. Average annual precipitation ranges from approximately 47 inches in the northern part of the basin to approximately 50 inches in the central and southern parts of the basin. <18> Annual precipitation (since 1944) in the basin has been as high as 70.9 inches in 1978 and as low as 38.7 inches in 1963. The months of March, April, and May generally have the highest rainfall while August, September, and October are generally the driest months.

Evaporation data that have been collected at the Rice Experiment Station near Stuttgart since 1929 indicate that the average annual evaporation from reservoirs and other water surfaces in the area is about 37.4 inches, with approximately 23.3 inches occurring from May through September. The average evaporation for the months of May through September exceeds the average rainfall by about 5.4 inches. <49>

The average annual temperature for the basin is about 60o F. December, January, and February are the coldest months with an average temperature of about 42o F. The average temperature during the growing season of May through September is 76o F.

The growing season (frost-free period) in the Eastern Arkansas Basin generally ranges from about 200 days in northern Clay County to about 220 days in the eastern and southern parts of the basin. A small area around West Memphis in Crittenden County has a slightly longer growing season than the rest of the basin, at approximately 230 days. <58>

POPULATION AND ECONOMY

The population of the 16-county study area totaled approximately 437,000 in 1980. The majority of the population (71 percent) was centered in urban areas of the basin, while rural areas contained about 128,000 people, or 29 percent of the population. The percentage of people living in rural areas varied from 84 percent in Greene County to only 8 percent in Poinsett County. The population in the study area is projected to increase to about 626,000 people by the year 2030. <50>

The primary economic activity in the eastern Arkansas area is agriculture, with rice and soybeans the predominant crops at the present time. Less than 5 percent of the adult population is engaged in farming, however, many businesses and industries serve the agricultural community in the basin. Manufacturing, wholesale and retail trade, and service industries have increased significantly in the past fifteen years, however, unemployment in the area remains high relative to other areas of the state.

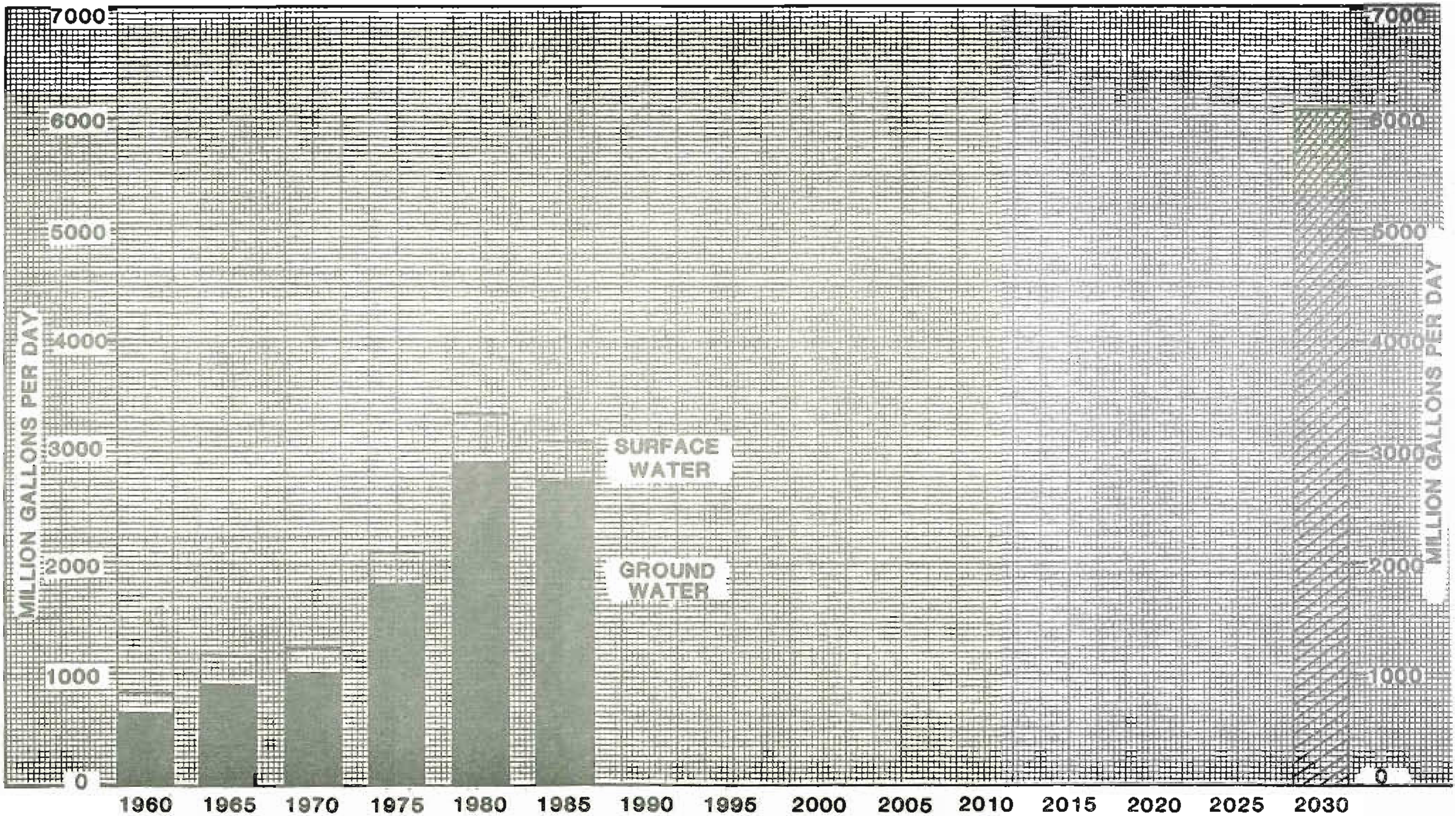
WATER USE

Water withdrawn from surface water and ground water sources in the 16-county study area in eastern Arkansas totaled 3090 million gallons per day (MGD) in 1985. <27> The water was used to satisfy public supply, rural domestic, self-supplied industry, and agriculture needs in the study area. Of the total amount of water withdrawn in the area, about 2800 MGD or 91 percent of the water was used for the irrigation of crops.

Water use in the eastern Arkansas region has generally increased since 1960 (as shown in Figure 1-3) when water withdrawals totaled only about 780 MGD. <44> Historically, ground water has been the predominant source of water for use in the study area. In fact, approximately 88 percent of the total amount of water used in 1985 was obtained from ground water sources.

Water use is projected to increase to about 6100 MGD by the year 2030 <50>, nearly twice the amount of water used in 1985. The majority of this increase will be necessary for the irrigation of additional cropland in the area. Due to the significant ground water declines that have occurred in some parts of eastern Arkansas, surface water sources will need to be developed to satisfy the projected increased demands for water in the area.

FIGURE 1-3
HISTORIC AND PROJECTED WATER USE IN THE STUDY AREA



SOURCES: WATER USE REPORTS <19, 20, 21, 26, 28, 42>
PROJECTED USE - CORPS OF ENGINEERS

CHAPTER II

LAND RESOURCES INVENTORY

LAND USE

The majority of land in the Eastern Arkansas Basin is devoted to agricultural operations. There are about 7,172,000 acres of land in the basin, of which approximately 5,346,000 acres (74%) are used for agriculture. About 880,000 acres (12%) of forest land and about 139,000 acres (2%) of urban and built-up areas are also present in the basin. The remaining land in eastern Arkansas consists of about 557,000 acres (8%) of wetlands, primarily in the White River National Refuge area; 244,000 acres (3%) of water; and 6,400 acres (<1%) of barren or rangeland. <50> Land use data for each category are compiled in Table 2-1 for each of the 16 counties in the study area.

The major crops in the basin are rice and soybeans, but winter wheat, milo, cotton, sorghum, and corn are also grown in some areas. Nearly half of the land devoted to crops in the basin in 1982 was irrigated (2,396,000 acres), according to the eastern Arkansas region comprehensive study. <50> It has been estimated that by the year 2030, the amount of irrigated cropland in the basin could nearly double, to as much as 4,702,000 acres. <67>

SOIL RESOURCES

Major Land Resource Areas

There are four major land resource areas in the Eastern Arkansas Basin, as shown in Figure 2-1. A general description of the four areas (Arkansas Valley and Ridges, Bottomlands and Terraces, Coastal Plain, and Loessial Plains and Hills) is presented in the following paragraphs.

Arkansas Valley and Ridges

The Arkansas Valley and Ridge area is comprised of broad valleys, narrow ridges, and high flat-topped mountains. The soils in this area which developed from sandstone and shale have surface textures that are mainly sandy loam, gravelly sandy loam, or stony sandy loam. The depth of soils ranges from deep to shallow and permeabilities range from rapidly permeable to very slowly permeable. Slope of the land surface is nearly level to gently sloping in the valleys and on ridge tops and moderately sloping to steep on hillsides and mountainsides. The valleys are mainly used for pasture production while the steeper areas remain in woodland. <58>

Bottomlands and Terraces

The Bottomlands and Terraces area consists of broad alluvial plains and low terraces. Soils developed from deep alluvial sediments. The soils are typically deep and are rapidly permeable to very slowly permeable. Surface textures are usually sandy loam, silt loam, or clay. Slopes are generally level to nearly level, with some areas undulating. Most of this area is cleared and used for production of cultivated crops. <56>

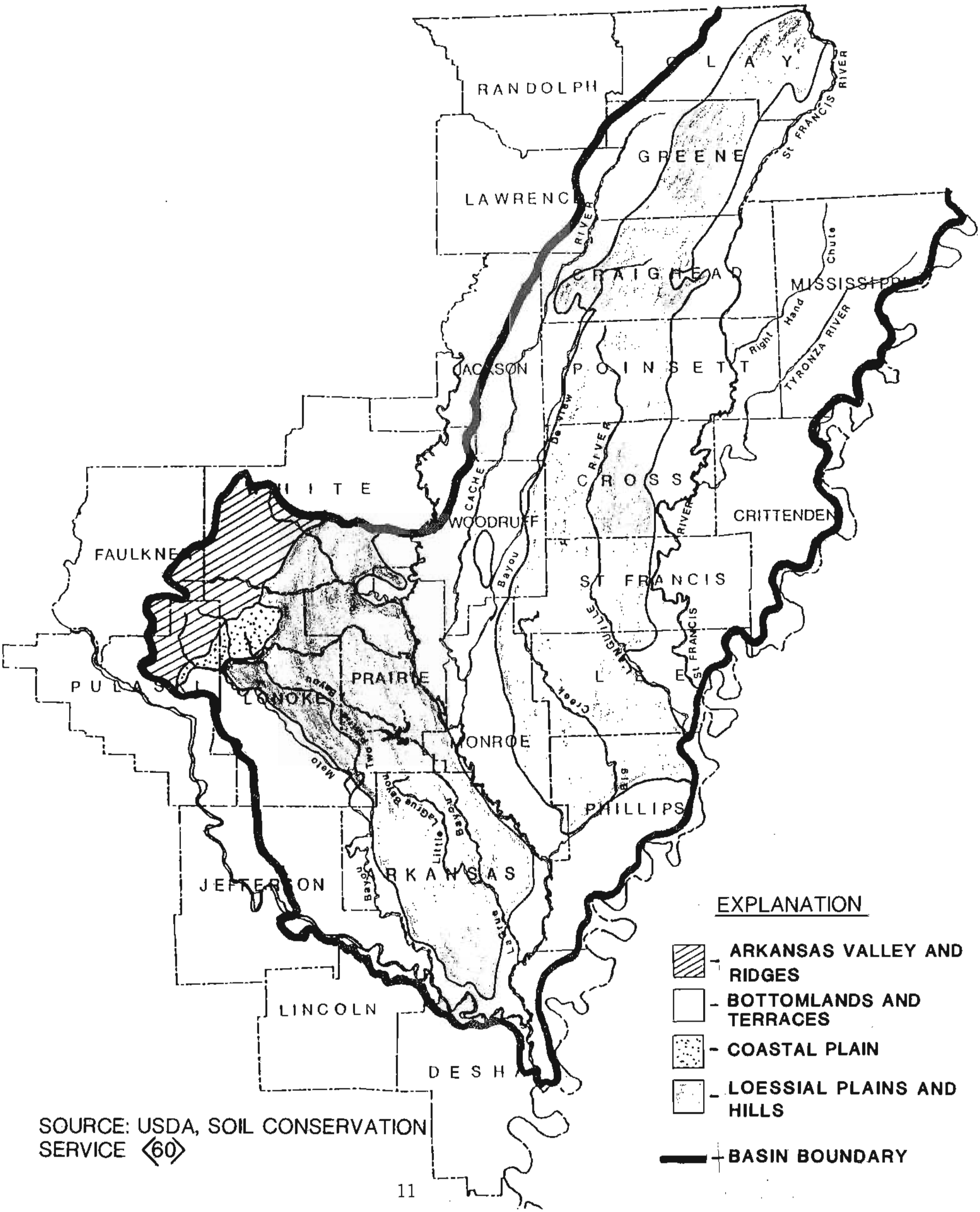
TABLE 2-1

LAND USE (IN ACRES) IN THE EASTERN ARKANSAS BASIN

COUNTY	AGRICULTURAL	FOREST LAND	URBAN and BUILTUP	BARREN or RANGELAND	WATER	WETLANDS	TOTAL
ARKANSAS	372,388	73,885	7,660	0	43,490	164,820	662,243
CLAY	300,480	82,532	12,107	0	988	1,235	397,342
CRAIGHEAD	383,260	47,938	15,319	3,954	1,730	17,287	469,488
CRITTENDEN	335,569	29,158	16,803	741	19,769	3,954	405,994
CROSS	331,367	45,220	6,177	0	5,930	21,745	410,439
GREENE	285,654	85,746	9,884	0	1,730	4,448	387,462
JACKSON	332,655	31,966	6,226	0	3,558	5,000	379,405
LEE	266,380	81,791	2,471	0	28,170	30,147	408,959
LONOKE	399,556	23,262	5,289	0	26,445	26,261	480,813
MISSISSIPPI	547,832	22,981	16,802	1,483	14,086	15,568	618,752
MONROE	213,993	61,035	2,965	0	21,993	99,089	399,075
PHILLIPS	317,284	66,471	11,366	247	28,912	38,301	462,581
POINSETT	406,241	42,255	8,154	0	2,965	21,746	481,361
PRAIRIE	300,480	77,591	4,694	0	21,251	34,101	438,117
ST. FRANCIS	283,925	63,259	8,649	0	14,580	27,676	398,089
WOODRUFF	269,098	44,726	4,448	0	8,402	45,220	371,894
TOTAL	5,346,162	879,816	139,014	6,425	243,999	556,598	7,172,014

SOURCE: U.S ARMY CORPS OF ENGINEERS (50)

FIGURE 2-1
MAJOR LAND RESOURCE AREAS



SOURCE: USDA, SOIL CONSERVATION SERVICE ⟨60⟩

Coastal Plain

The Coastal Plain area consists of rolling terrain broken by stream valleys. Soils in this area developed from deep marine sediments. Slopes range from level to moderately steep and permeabilities range from rapid to slow. This area is used mainly for timber production and pastureland. <58, 60>

Loessial Plains and Hills

The Loessial Plains comprise broad, level to nearly level areas in the Eastern Arkansas Basin. The Loessial Hills soils occur mainly on Crowley's Ridge. The loessial soils, which developed from deep loess deposits, have surface textures that are mainly silt loam. The Loessial Plains area is level to nearly level and is used extensively for cultivated crops. The Loessial Hills area is gently sloping to steep and is used mainly for pasture and timber production. <58>

General Soil Units

There are 20 general soil units covering the four resource areas in the basin. These soil units are listed by resource area in Table 2-2, and their locations are shown in Figure 2-2. Specific information for individual soil units is available in published Soil Surveys.

TABLE 2-2
GENERAL SOIL UNITS BY MAJOR LAND RESOURCE AREAS

ARKANSAS VALLEY AND RIDGES

12. Leadvale - Taft
13. Enders - Mountainburg - Nella - Steprock
15. Linker - Mountainburg

BOTTOMLANDS AND TERRACES

22. Foley - Jackport - Crowley
23. Kobel
24. Sharkey - Alligator - Tunica
25. Dundee - Bosket - Dubbs
26. Amagon - Dundee
27. Sharkey - Steele
28. Commerce - Sharkey - Crevasse - Robinsonville
29. Perry - Portland
31. Roxana - Dardanelle - Bruno - Roellen
32. Rilla - Hebert

COASTAL PLAIN

38. Amy - Smithton - Pheba
42. Sacul - Smithdale - Sawyer

LOESSIAL PLAINS AND HILLS

Loessial Plains

44. Calloway - Henry - Grenada - Calhoun
45. Crowley - Stuttgart

Loessial Hills

46. Loring
47. Loring - Memphis
48. Brandon

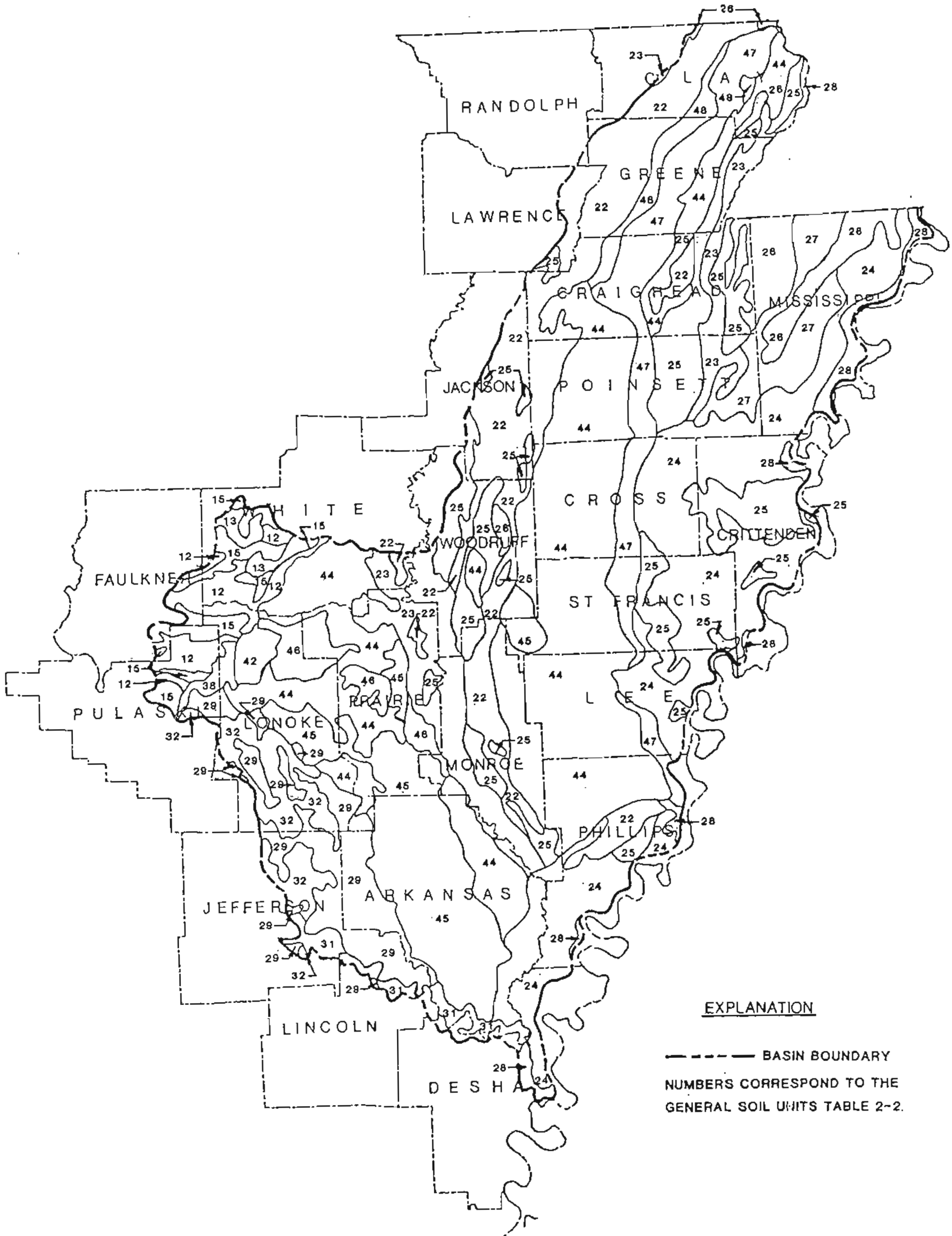
Source: USDA, Soil Conservation Service <60>

Erosion

Sources of the erosion that occurs in the Eastern Arkansas Basin include road surface, road bank, gully, streambank, and sheet and rill. The major source of erosion in the basin is sheet and rill erosion which amounts to 26,100,000 tons per year over 6,834,000 acres of land, according to the Soil Conservation Service's NRI-82 data <59>. The average erosion rate occurring on all non-federal rural land is 3.8 tons per acre. The sheet and rill erosion on cropland of 24,700,000 tons per year accounts for nearly 95 percent of the total sheet and rill erosion in the basin. The average rate of erosion on cropland is 4.8 tons per acre. <59>

It should be noted that the NRI erosion data do not estimate the amount of erosion that actually occurred during 1982. The erosion rates computed from the NRI data are estimated average annual (or expected) rates based upon the cropping practices, management practices, and resource conditions over a period of at least four years. The climatic factors included in the erosion equations are based upon long-term average conditions and not upon one year's actual climatic events. <64>

FIGURE 2-2
GENERAL SOIL UNITS



SOURCE: USDA, SOIL CONSERVATION SERVICE ⟨60⟩

INTRODUCTION

The principal streams in the Eastern Arkansas Basin are the St. Francis, White, and Arkansas Rivers. The St. Francis River and its tributaries which include the Tyronza River, Right Hand Chute of Little River, and the L'Anguille River drain the northeast and east-central parts of the Eastern Arkansas Basin. The Tyronza River and the Right Hand Chute of Little River lie to the east of Crowley's Ridge which extends lengthwise through and mainly in the middle of the St. Francis sub-basin. The L'Anguille River lies west of Crowley's Ridge but cuts through the ridge near its southern end. The White River and its tributaries including the Cache River, Bayou DeView, Big Creek,and Cypress Bayou drain the central and northwestern parts of the Eastern Arkansas Basin. The southwestern part of the Eastern Arkansas Basin is drained by the Arkansas River and tributaries which include Bayou Meto and Two Prairie Bayou.

Streamflow in the basin is generally sluggish due to the flat topography of the area. The majority of the drainage system in the Eastern Arkansas Basin has been significantly affected by man-made changes that have occurred during the past 50 years or more. These changes have included drainage improvement projects for flood control and conversion of forested wetlands to highly productive farmlands for cotton, soybeans, and rice.

The average annual runoff in the Eastern Arkansas Basin ranges from approximately 16 inches in the northwestern part of the basin to approximately 22 inches in the central and east-central parts of the basin <18>. Runoff varies seasonally as well as annually, with the area subject to extremes of both flood and drought. The seasonal variability is characterized by low flows which usually occur during August through October each year. It is important to note that this period of lowest streamflow occurs during the agricultural growing season which is a period of significant water use from many streams in the basin. Therefore, optimum development of surface-water resources in the Eastern Arkansas Basin requires storage of high winter and spring flows to meet the summer and fall water-use demands.

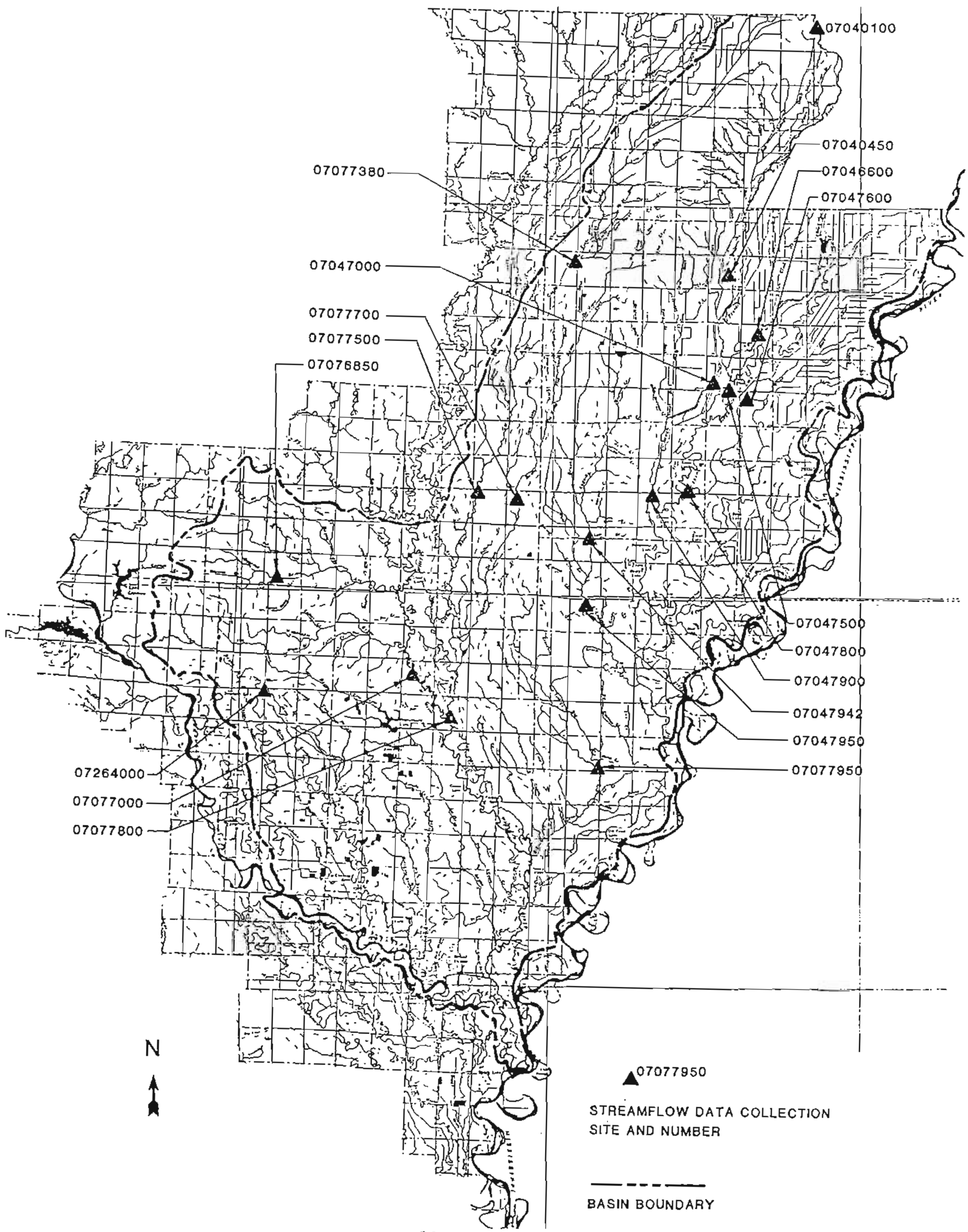
The suitability of streamflow for most uses depends on the flow characteristics of a stream and the chemical, physical, and biological properties of the water. These streamflow characteristics vary with time, with location, and with manmade changes and exert a major influence on the economics of water development.

The following sections in Chapter III of the report present an inventory of the surface-water resources of the Eastern Arkansas Basin. Present water use and estimated future water needs are quantified. In addition, problems affecting existing water resources are outlined and solutions and recommendations to solve existing problems are suggested. This information will provide a guide for the future use, management, and development of the water resources of the Eastern Arkansas Basin.

CHAPTER III

SURFACE WATER

FIGURE 3-1
STREAMFLOW DATA COLLECTION SITES



SURFACE-WATER INVENTORY

Streamflow Data Collection Network

Streamflow data are collected in the Eastern Arkansas Basin primarily by the U.S. Army Corps of Engineers and the U.S. Geological Survey. Locations of 18 streamflow data collection sites are shown in Figure 3-1. There are many additional sites in the basin where streamflow data have been collected, however, the sites selected have relatively long-term records available for study. Additional information on the streamflow sites is summarized in Table 3-1.

TABLE 3-1
SUMMARY OF SELECTED STREAMFLOW DATA-COLLECTION SITES
(Data collected by U.S. Army Corps of Engineers unless otherwise noted)

STATION NUMBER	NAME	DRAINAGE AREA (MI)	PERIOD OF RECORD	EXTREMES FOR PERIOD OF RECORD MAXIMUM DISCHARGE (CFS) AND DATE	MINIMUM DISCHARGE (CFS) AND DATE	AND YEARS OF RECORD USED TO COMPUTE DISCHARGE
07047900	ST. FRANCIS BAY AT RIVERFRONT	Indeterminate	Jan. 1935 - 81	54,100 2-2-37	No flow No. 17-26 1941. because of backwater from Mississippi River	5203 (1936-75)
07047942	L'ANGUILLE RIVER NEAR COLT	535	1971 - 86	12,000 12-9-78	0.99 7-20-78	747 (1971-86)
07047950	L'ANGUILLE RIVER AT PALESTINE	786	Jan. 1949 - 77	15,600 5-20-53	No flow at most times during most years	1161 (1950-77)
07076850	CYPRESS BAYOU NEAR BEEBE	166	1962 - 76	21,000 1-30-69	No flow at times	213 (1962-76)
07077000	WHITE RIVER AT DEVALLS BLUFF	23,431	1950 - 70	154,000	3230 9-29 to 10-1-54 10-29-54	25,700 (1950-70)
07077380	CACHE RIVER AT EGYPT	701	1965 - 86	8940 1-6-66	No flow 11-6 to 11-11-82 11-16, 17-82	847 (1965-86)
07077500	CACHE RIVER AT PATTERSON	1037	1928-31; Aug. 1937-77	13,200 1-24-37	No flow 10-27 to 10-30-56	259 (1928-31; 1938-77)

7 Part of the flow at this station is diverted from the St. Francis River at lock and dam about 4.0 mi northwest of Marked Tree. Some regulation by Wappapello Lake (Missouri) since April 1. 1941, Stage-dsicharge relation affected by backwater during high stages of Mississippi River.

8 Data collected by U.S. Geological Survey

9 Stage-discharge relation affected by backwater during high stages of Mississippi River.

10 Some regulation by Norfork Lake since 1943, by Clearwater Lake (Missouri) since sept. 9, 1943, Bull Shoals Lake since July 24, 1951, by Table Rock Lake Missouri since Sept. 9, 1956, by Greers Ferry Lake since Mar. 30, 1962, and by Beaver Lake since Dec. 26, 1963.
Rock Lake (Missouri) since Set. 9, 1956, by Greers Ferry Lake since Mar. 30, 1962, and Beaver Lake since Dec. 26, 1963.

TABLE 3-1

SUMMARY OF SELECTED STREAMFLOW DATA-COLLECTION SITES

(Data collected by U.S. Army Corps of Engineers unless otherwise noted)

STATION NUMBER	NAME	DRAINAGE AREA (MI)	PERIOD OF RECORD	EXTREMES FOR PERIOD OF RECORD MAXIMUM DISCHARGE (CFS) AND DATE	MINIMUM DISCHARGE (CFS) AND DATE	AVERAGE DISCHARGE (CFS) AND YEARS OF RECORD USED TO COMPUTE DISCHARGE
07040100	ST. FRANCIS RIVER AT ST. FRANCIS	1772	Jan. 1930 - 77	39,200 3-15-35	55 9-20-54	2223 (1942-77)
07040450	ST. FRANCIS RIVER AT LAKE CITY	2374	Jan. 1931 - 77	1-22 to 1-24-37	60 8-29,9-1-35	3139 (1942-77)
07046600	RIGHT HAND CHUTE OF LITTLE RIVER AT RIVERVALE	2106	Jan. 1947 - 77	31,400 11-23-57	77 11-5-71	2896 (1948-76)
07047000	ST. FRANCIS RIVER FLOODWAY NEAR MARKED TREE	--	Sept. 1927 - Sept. 1931; July 1934 - Sept. 1970	48,300 1-26 to 1-28-37	No flow at time in most years prior to 1965.	4216 (1935-73)
0704750	ST. FRANCIS RIVER AT MARKED TREE	5148 (includes that of floodway)	July 1934 - Sept. 1973	Combined flow of river and floodway 1934-70: 58,000 (maximum daily) 1-27-37	63 10-13-41	1590 (1935-73)
07047600	TYRONZA RIVER NEAR TYRONZA	290	Jan. 1949 - 74	6700 4-5-68	No flow 4-20-74	426 (1950-74)
07047800	ST. FRANCIS RIVER AT PARKIN	Indeterminate	Jan. 1930 - 81	25,300 1-31-30	174 11-12-54	2749 (1931-81)

1 Some regulation by Wappello Lake (Missouri) since April 1, 1941.

2 Flow diverted from St. Francis River bypasses Marked Tree and returns to St. Francis River below Marianna. Some Regulation by Wappapello Lake (Missour) sine April 1, 1941.

3 Data collected by U.S. Geological Survey.

4 Floodflow is diverted through St. Francis River floodway at dam of Poinsett County Drainage District 7 and returns to St. Francis River below Marianna. Flow regulated by Wappapello Lake (Missouri) since April 1, 1941, and by siphons at dam of Poinsett Co. Drainage District 7.

5 Stage-discharge relation affected by backwater during high stages of St. Francis River.

6 The greater part of St. Francis River floodflow is diverted through St. Francis River floodway at lock and dam about 4.0 mi northwest of Marked Tree, and is not included in records for this station. Diverted flow is included in records for St. Francis Bay at Riverfront (station 07047900) and returns to the St. Francis River downstream from Marianna. Some regulation since Apr. 1, 1941 by Wappello Lake (Missouri). Stage-discharge relation affected by backwater during high stages of Mississippi River.

TABLE 3-1
SUMMARY OF SELECTED STREAMFLOW DATA-COLLECTION SITES
(Data collected by U.S. Army Corps of Engineers unless otherwise noted)

USGS STATION NUMBER	NAME	DRAINAGE AREA (MI)	PERIOD OF RECORD	EXTREMES FOR PERIOD OF RECORD: MAXIMUM DISCHARGE (CFS) AND DATE	EXTREMES FOR PERIOD OF RECORD: MINIMUM DISCHARGE (CFS) AND DATE	AVERAGE DISCHARGE (CFS) AND YEARS OF RECORD USED: TO COMPUTE DISCHARGE
07077700	BAYOU DEVIEW AT MORTON	421	Feb. 1939-77	6700 11-23-57	No flow at times in most years.	515 (1940-77)
07077800	WHITE RIVER AT CLARENDON	25,555	Jan. 1928-81	299,000 4-23-45	2900 9-4-36	28,140 (1951-81)
07077950	BIG CREEK AT POPLAR GROVE	448 (includes that of: Crooked Creek)	1971-86	5910 4-23-73	No flow at times.	669 (1973-86)
07264000	BAYOU METO NEAR LONOKE	207	1955-86	4700 5-18-68	No flow at times.	294 (1955-86)

11 Some regulation since 1943 by Norfork Lake, since 1948 by Clearwater Lake (Missour), since July 24, 1951 by Bull Shoals Lake, since Sept. 9, 1956 by Table Rock Lake (Missouri), and since Dec. 26, 1963 by Beaver Lake.

12 Data collected by U.S. Geological Survey

13 Part of low flow is drainage from areas irrigated with groundwater and from large minnow farm supplied with groundwater.

Streamflow Characteristics

The Eastern Arkansas Basin is generally characterized by sluggish, meandering streams. Most stream channels have low hydraulic gradients due to the flat topography, therefore, runoff is slow. Numerous man-made changes to facilitate drainage of the land for cultivation and to improve the hydraulics of the channels have significantly altered the watersheds in the basin. Drainage projects such as dredging of channels, construction of levees, and construction of drainage ditches have altered the channels and watersheds to such an extent that they no longer resemble their natural state. In addition to the effects of drainage improvements on streamflow characteristics in the basin, diversions of water to and from the streams during the irrigation season affect base flow conditions in many eastern Arkansas streams.

Streamflows of the three major rivers in the Eastern Arkansas Basin (St. Francis, White, and Arkansas) are affected by reservoirs which are located outside the basin. The Corps of Engineers owns and operates Wappapello Lake in Missouri which regulates flow of the St. Francis River. Greer's Ferry, Bull Shoals, and Norfork Lakes, which are also owned and operated by the Corps of Engineers, affect the flow of the White River. The Arkansas River is regulated for flood control and navigation purposes by several reservoirs in Oklahoma and 17 locks and dams in Arkansas and Oklahoma.

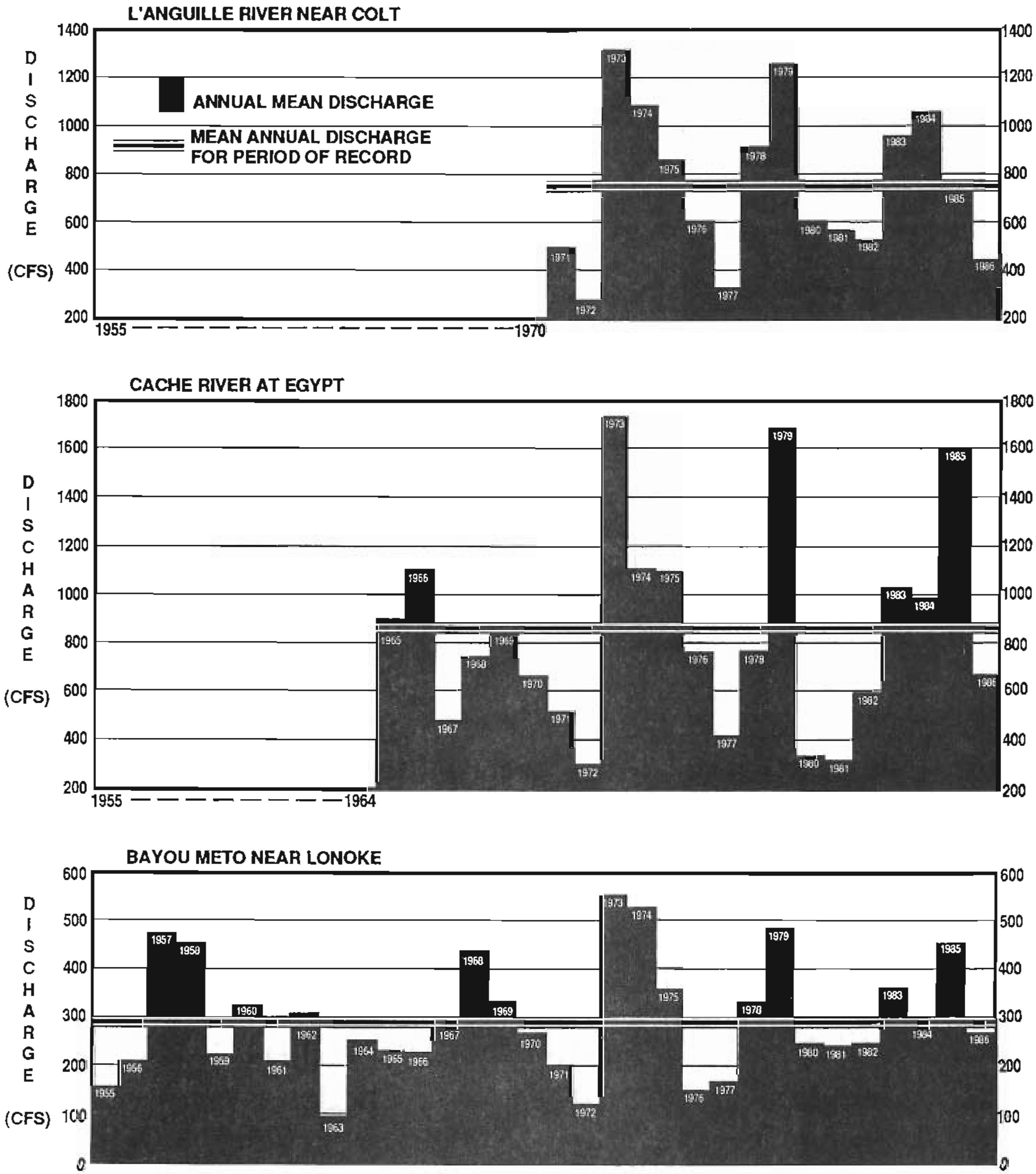
Streamflow Variability

Distribution of streamflow is dependent upon climate, physiography, geology, land use, and regulation in the basin. Generally, the distribution of high flows is governed largely by the climate, the physiography, and the plant cover of the basin. The distribution of low flows is controlled mainly by the basin geology. Streamflow variability is the result of variability in precipitation as modified by the basin characteristics previously mentioned. The variability is reduced by storage, either on the surface or in the ground <41>.

Streamflow in the Eastern Arkansas Basin is extremely variable, as illustrated by the annual streamflow data for three stations in the basin (Figure 3-2). Significant variation in annual streamflow has occurred at these three sites during the period for which records are available. For example, the annual mean discharge for the Cache River at Egypt ranged from 299 cfs in 1972 to 1762 cfs in 1973, based on data for the period of 1965-86. The mean annual discharge for the period of record is also shown in Figure 3-2 for each of the three sites. Comparison of the mean annual discharge with the annual discharge for each year during the period of record shows that the mean discharge for a particular year may be significantly different than the mean annual discharge computed for the period of record.

In the Eastern Arkansas Basin, streamflow is generally highest during January through May because of the large amount of precipitation during this period. Similarly, streamflow is generally lowest during June through December due to a decrease in precipitation and increases in agricultural water use and evapotranspiration that occur during the growing season. Mean monthly discharges at selected gaging stations are summarized in Table 3-2.

FIGURE 3-2
ANNUAL MEAN DISCHARGE FOR SELECTED SITES IN THE BASIN



SOURCE: U.S. GEOLOGICAL SURVEY STREAMFLOW DATA

TABLE 3-2
MEAN MONTHLY DISCHARGES AT SELECTED GAGING STATIONS

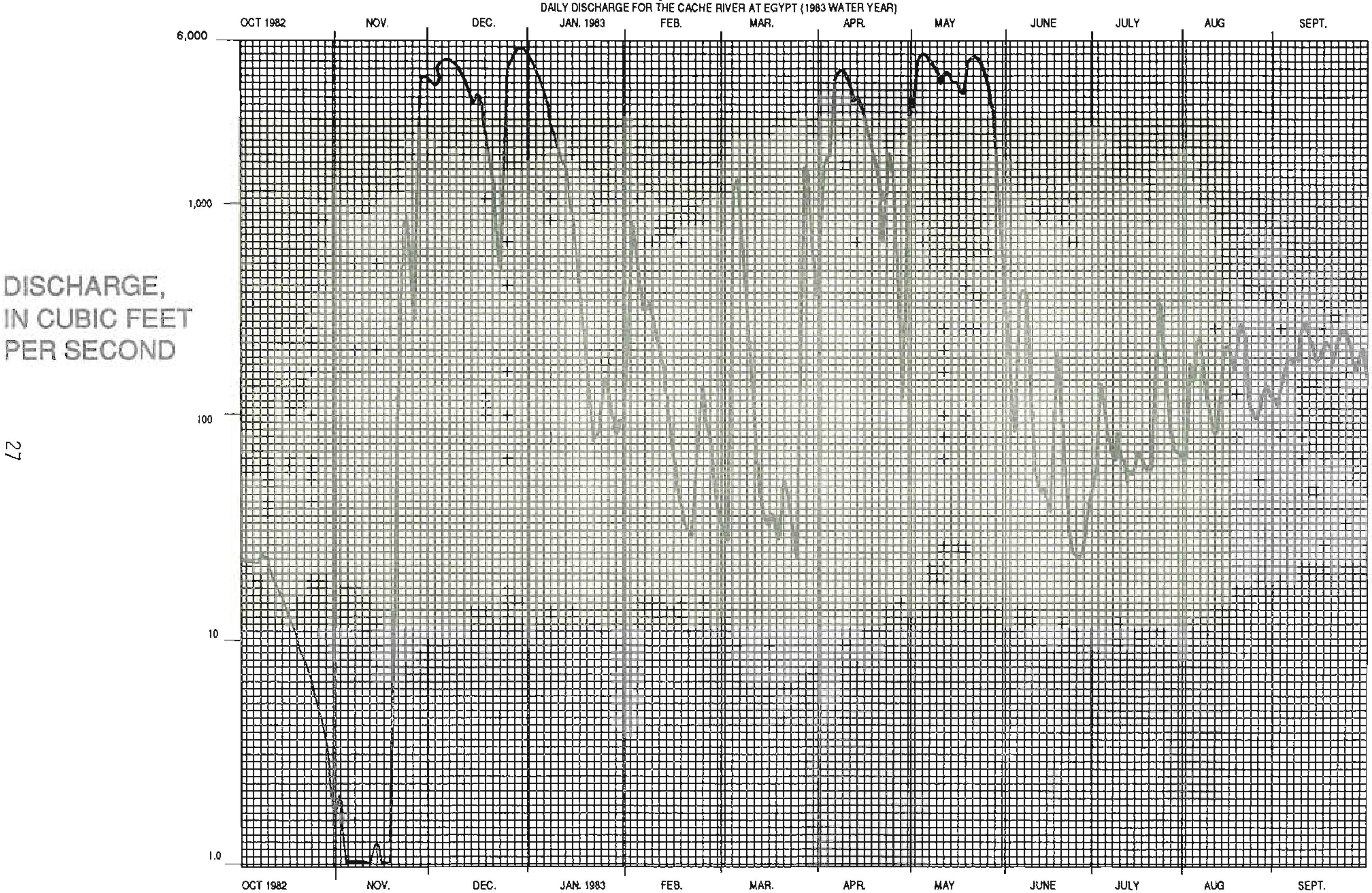
	YEARS USED FOR COMPUTATION	MEAN MONTHLY DISCHARGE (CUBIC FEET PER SECOND)											
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
07356000 - OUACHITA	1942 - 85	348	622	965	861	1149	1412	1156	1142	503	251	98.5	215
RIVER NR. MOUNT IDA													
07356500 - SOUTH	1950 - 70	28.3	69.6	90.6	129	156	183	161	167	38.1	38.1	14.2	29.8
FORK OUACHITA RIVER AT MOUNT IDA													
07357501 - OUACHITA	1956 - 77	1477	1453	1801	1814	1732	1445	1842	1911	1653	1192	1421	1378
RIVER AT BLAKELY													
MOUNTAIN DAM NEAR HOT SPRINGS													
07359500 - OUACHITA	1955 - 85	1815	2591	3243	2779	2826	2854	3402	3294	2051	1404	1395	1441
RIVER NR. MALVERN													
07359800 - CADDO	1939 - 41;	146	401	590	731	911	884	931	933	225	159	92.5	127
RIVER NR. ALPINE	1947 - 70												
07359910 - CADDO	1973 - 78;	488	1203	1696	806	787	1401	1091	1386	1225	630	416	428
RIVER AT DEGRAY	1981 - 84												
REGULATING DAM NEAR ARKADELPHIA													
07360000 - OUACHITA	1973 - 78;	2221	5224	6612	4301	4148	5587	5973	5795	4629	2122	1367	1548
RIVER AT ARKADELPHIA	1981 - 84												
07360501 - LITTLE	1958 - 77	259	349	451	367	382	456	438	641	443	439	406	322
MISSOURI RIVER AT													
NARROWS DAM NEAR MURFREESBORO													
07360800 - MUDDY	1947 - 59	66.8	125	135	263	314	314	378	415	85.1	50.8	12.0	70.9
FORK CREEK NEAR MURFREESBORO													
07361000 - LITTLE	1951 - 77	303	473	595	557	672	812	919	1025	603	494	460	392
MISSOURI RIVER NEAR MURFREESBORO													
07361500 - ANTOINE	1955 - 85	108	269	369	301	422	514	489	458	208	96.3	45.3	49.3
RIVER AT ANTOINE													
07361600 - LITTLE	1951 - 77	463	1214	1506	1635	2182	2431	2756	2601	1281	664	492	528
MISSOURI RIVER NEAR BOUGHTON													
07362000 - OUACHITA	1955 - 85	3383	6246	9568	8377	10680	11510	12500	12990	6091	3181	2671	2996
RIVER AT CAMDEN													

MONTHLY DISCHARGES FOR THE PERIOD OF 1982 - 84 ARE FROM UNPUBLISHED CORPS' RECORDS AND ARE SUBJECT TO REVISION

SOURCE: U.S. GEOLOGICAL SURVEY AND U.S. ARMY CORPS OF ENGINEERS STREAMFLOW RECORDS.

The computation of mean monthly discharges at selected locations indicates the seasonal variability of streamflow in the basin. There is also significant variability of streamflow on a daily basis, as shown by the hydrograph of daily discharge of the Cache River at Egypt for the 1983 water year (Figure 3-3). Daily mean discharge ranged from no flow at times in November to 5250 cfs in December at this station during the 1983 water year. The no-flow conditions of the Cache River at Egypt in November are mainly a result of significant withdrawals of water from the river.

Figure 3-3



DAILY DISCHARGE FOR THE CACHE RIVER AT EGYPT (1983 WATER YEAR)
OCT 1982
NOV.
DEC.
JAN. 1983
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG
SEPT.
6,000
1,000
100
10
1.0
DISCHARGE, IN CUBIC FEET PER SECOND

Flow Duration

Annual and seasonal variability of streamflow in the Eastern Arkansas Basin affect the water-supply potential of streams on a year-round basis. The percent of time specified stream discharges are available is one factor that determines the water-supply potential of a stream without storage. Flow-duration curves (cumulative frequency curves of daily mean flows that show the percent of time specified discharges were equaled or exceeded) were developed for streams in the Eastern Arkansas Basin to analyze the water-supply potential of streams at selected locations. Selected points from the seasonal and period-of-record flow-duration curves are summarized in Table 3-3. The period-of-record duration curve was developed using all daily mean discharge data for the period of record, whereas the seasonal flow-duration curve was determined by using only daily mean discharge for the normal irrigation season, May through September. It should be noted that the flow-duration curve applies only to the period for which data were used to develop the curve. However, these data may be used to estimate the probability of occurrence of future streamflow if the period used is representative of the long-term flow of the stream. Analysis of the data presented in Table 3-3, first of all, indicates that Cypress Bayou and Bayou DeView would not provide a sustained water supply without storage. These two streams have had no flow at least 10 percent of the time in the past, therefore, storage would be necessary to provide a sustained water supply at these locations. The data in Table 3-3 also indicate that streamflow in the basin is generally lower during the irrigation season than at other times of the year except during base flow conditions. The base flow during the irrigation season (May-September) is slightly higher than the annual base flow which is probably because the lowest streamflows of the year often occur during October and are not included in the irrigation season flow-duration curve.

The flow-duration curve is also a valuable medium for comparing drainage basin characteristics. Flow-duration curves for St. Francis River at Lake City and Cypress Bayou near Beebe were plotted in Figure 3-4 to illustrate the significant difference between the streamflow characteristics at the two sites. The flow-duration curve for Cypress Bayou near Beebe has a relatively steep slope throughout which denotes highly variable streamflow that is mainly from direct surface runoff. The curve for the St. Francis River has a flat slope which indicates streamflow that is from delayed surface runoff and ground-water storage. The flat slope at the lower end of the curve for the St. Francis River indicates sustained base flow, whereas the steep slope for the Cypress Bayou curve indicates a negligible base flow.

TABLE 3-3
FLOW DURATION OF STREAMS AT SELECTED CONTINUOUS RECORD GAGING STATIONS
[FLOW: UPPER FIGURE IS SEASONAL, MAY 1 TO SEPTEMBER 30, DURATION VALUE;
LOWER FIGURE IS PERIOD OF RECORD DURATION VALUE]

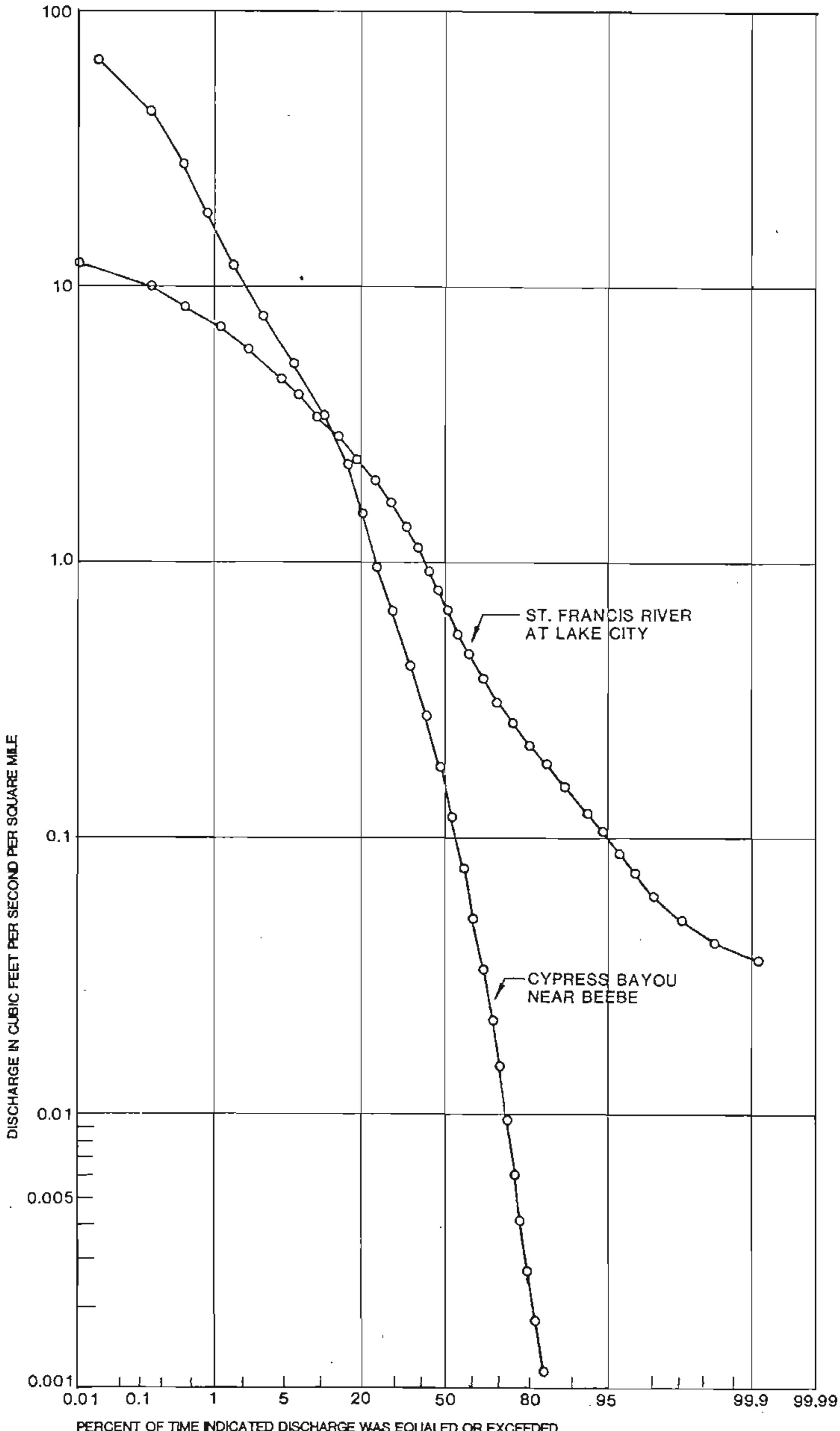
STATION NUMBER NAME	RECORDS USED (WATER YEARS)	FLOW, IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR PERCENTAGE OF TIME INDICATED IN COLUMN SUBHEADS 99	95	90	80	70	60	50	40	30	20	10	5	1	0.5
07040100-ST. FRANCIS RIVER	1942-77	97	130	170	230	310	420	580	830	1,300	2,500	5,000	7,300	11,700	12,900
AT ST. FRANCIS		84	120	170	270	410	630	980	1,500	2,500	3,900	5,900	8,400	13,000	14,500
07040450-ST. FRANCIS RIVER	1942-77	150	280	350	500	650	810	1,000	1,500	2,300	3,700	6,000	9,500	16,000	18,200
AT LAKE CITY		130	240	340	530	740	1,100	1,600	2,600	3,700	5,200	8,000	11,000	17,200	19,700
07046600-RIGHT HAND CHUTE OF LITTLE	1948-76	170	370	520	750	960	1,200	1,400	1,600	2,000	2,600	4,000	6,600	14,000	16,700
RIVER AT RIVERVALE		160	280	420	720	1,000	1,300	1,700	2,100	2,800	4,400	7,000	9,800	18,000	22,000
07047000-ST FRANCIS RIVER FLOODWAY	1935-65	0	0	0	0	150	500	960	1,500	2,400	4,000	7,400	11,000	23,400	27,800
NEAR MARKED TREE		0	0	0	46	420	840	1,600	2,600	4,000	6,800	12,400	18,000	30,000	35,000
07047500-ST FRANCIS RIVER	1935-73	110	220	440	860	1,200	1,400	1,500	1,700	2,000	2,300	2,700	2,900	3,300	3,600
AT MARKED TREE		90	140	230	610	1,000	1,300	1,500	1,800	2,100	2,500	2,900	3,300	4,100	4,300
07047600-TYRONZA RIVER	1950-74	33	47	56	59	82	97	110	140	170	250	640	1,400	3,400	4,000
NEAR TYRONZA		28	41	51	64	80	98	120	160	220	420	1,200	2,400	4,200	4,600
07047800-ST FRANCIS RIVER	1931-81	340	550	810	1,200	1,500	1,700	1,900	2,200	2,700	3,200	4,000	5,200	10,200	11,700
AT PARKIN		280	400	570	1,000	1,400	1,700	2,000	2,500	3,000	3,900	5,600	7,800	12,700	15,000
07047900-ST FRANCIS BAY	1936-75	56	91	140	330	730	1,200	1,800	2,500	3,400	5,100	9,600	15,800	27,000	32,400
AT RIVERFRONT		49	86	150	470	950	1,600	2,400	3,500	5,400	8,900	14,800	19,700	33,000	38,000
07047942-L'ANGUILLE RIVER	1971-86	15	27	40	80	130	180	260	360	500	700	1,200	2,100	4,600	5,700
NEAR COLT		4.7	18	32	81	160	270	400	560	750	1,100	1,900	2,700	5,200	6,400
07047950-L'ANGUILLE RIVER	1950-77	0	33	61	100	150	210	290	420	660	1,000	1,700	2,600	7,700	9,800
AT PALESTINE		0	7.5	35	88	160	270	470	790	1,200	1,800	3,100	4,400	9,200	10,800
07076850-CYPRESS BAYOU	1962-76	0	0	0	0.08	0.3	1.0	2.9	7.0	16	40	190	460	1,500	2,700
NEAR BEEBE		0	0	0	0.4	2.8	9.7	25	55	100	240	620	960	2,600	4,100

TABLE 3-3 (continued)

FLOW DURATION OF STREAMS AT SELECTED CONTINUOUS RECORD GAGING STATIONS
[FLOW: UPPER FIGURE IS SEASONAL, MAY 1 TO SEPTEMBER 30, DURATION VALUE;
LOWER FIGURE IS PERIOD OF RECORD DURATION VALUE]

STATION NUMBER NAME	RECORDS USED (WATER YEARS)	FLOW, IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR PERCENTAGE OF TIME INDICATED IN COLUMN SUBHEADS													
		99	95	90	80	70	60	50	40	30	20	10	5	1	0.5
07077000-WHITE RIVER	1950-70	5,800	7,200	8,100	9,600	11,300	13,400	16,000	20,000	26,000	35,000	50,000	65,500	105,000	115,000
AT DEVALLS BLUFF		4,200	6,800	7,600	9,100	11,100	13,900	17,800	23,600	31,000	40,500	54,500	67,000	103,000	120,000
07077380-CACHE RIVER	1965-86	27	58	74	96	130	160	210	280	420	790	1,700	2,700	4,500	5,000
AT EGYPT		10	27	45	83	120	180	280	480	890	1,500	2,500	3,300	5,100	5,800
07077500-CACHE RIVER	1928-31;	42	56	74	120	160	200	250	350	530	950	2,200	3,400	6,500	7,700
AT PATTERSON	1938-77	28	51	68	110	170	250	390	660	1,300	2,300	3,700	5,000	8,100	9,200
07077700-BAYOU DEVIEW	1940-77	0	0	0	11	27	46	71	110	170	340	810	1,500	3,100	3,400
AT MORTON		0	0	0	11	35	65	110	190	430	910	1,800	2,400	3,700	4,200
07077800-WHITE RIVER	1951-81	6,200	8,000	8,900	10,700	12,600	14,700	17,200	21,000	26,500	34,500	51,000	72,000	112,000	124,000
AT CLARENDON		5,200	7,400	8,400	10,500	13,000	16,000	19,500	25,000	33,000	44,000	60,000	76,000	115,000	132,000
07077950-BIG CREEK	1973-86	4.2	14	22	43	74	120	180	270	380	580	1,300	2,200	3,600	4,100
AT POPLAR GROVE		1.7	10	23	55	110	200	330	510	770	1,200	1,800	2,500	3,800	4,300
07264000-BAYOU METO	1955-86	0.6	2.9	6.2	12	18	25	35	52	85	180	510	970	2,200	2,700
NEAR LONOKE		0.7	4.0	7.9	16	27	47	85	150	280	490	880	1,300	2,400	2,800

FIGURE-3-4
DURATION OF DAILY MEAN DISCHARGE FOR ST. FRANCIS RIVER
AT LAKE CITY AND CYPRESS BAYOU NEAR BEEBE



Flood Frequency

Maximum streamflows generally occur during January through May in the Eastern Arkansas Basin. Although floods provide an opportunity to replenish depleted stores of water, flooding can cause considerable local damage. Because this basin is characterized by wide, flat flood plains, floods in the area usually inundate large areas of land. Storage of floodwaters is generally impractical in this part of the State because of the lack of suitable reservoir sites. Therefore, in order to alleviate flooding problems during the past several decades, drainage-improvement projects which have considerably altered the majority of streams and rivers in the Eastern Arkansas Basin have been implemented to facilitate drainage. Drainage improvements include deepening and straightening of sluggish and meandering streams, and construction of levees and ditches. The effects of many of these manmade changes on the magnitude and frequency of flooding in streams in the basin have been significant. For instance, prior to 1948, White River floodwaters sometimes topped the old levees in the vicinity of Augusta and flowed through the Cache River bottoms. <43> Levees and tributary-channel improvements from Clarendon to Newport have alleviated some of these flooding problems. Drainage improvements that have been made in the Eastern Arkansas Basin are not necessarily permanent. Dredged channels may become partially filled with sediment and channel clearing and snagging may provide only temporary improvements because of the regrowth of vegetation and reaccumulation of debris.

Information pertaining to the magnitude and frequency of floods in an area is essential for determining design characteristics of structures that control floodflows or that are subject to possible flooding, for establishing flood-insurance rates, and for determining the best land use that can be made of flood-plain areas. The magnitude and frequency of floods for some of the major streams in the Eastern Arkansas Basin have been determined by Neely <34>. Peak discharges for selected recurrence intervals are compiled in Table 3-4 for selected gaging stations in the basin. The recurrence interval is the average length of time between floods of a given magnitude that will probably occur at a specified location over an extended period of time. The recurrence interval does not imply any regularity of occurrence. For instance, statistically the flow of Bayou Meto near Lonoke will be as high as 5580 cfs (100-year flood from Table 3-4) only once every hundred years. However, two 100-year floods of 5580 cfs for Bayou Meto could conceivably occur in consecutive years, or even in the same year.

The information in Table 3-4 indicates the flood peak discharges that are expected to occur at gaging stations in the basin based on the analysis of historic streamflow records. To evaluate the frequency of flooding that has actually occurred in the past, ranges in annual peak stages and discharges at selected gaging stations in the basin were summarized and are presented in Table 3-5. A comparison of the bankfull stage with maximum and minimum peak gage heights provides an idea of the frequency of flooding that has occurred at a particular station in the past. For example, flooding has occurred every year throughout the period of record at Cypress Bayou near Beebe and Bayou Meto near Lonoke. But according to the data in Table 3-5, only intermittent flooding has occurred during the indicated period of record at the other gaging stations in the basin.

TABLE 3-4

FLOOD PEAK DISCHARGES, FOR SELECTED RECURRENCE INTERVALS,
AT GAGING STATIONS IN THE EASTERN ARKANSAS BASIN

STATION NUMBER	STATION NAME	PEAK DISCHARGE (CUBIC FEET PER SECOND), FOR RECURRENCE INTERVAL (YEARS) 2	5	10	50	100
07040100	- ST. FRANCIS RIVER AT ST. FRANCIS	10,600	15,300	18,600	26,000	29,300
07040450	- ST. FRANCIS RIVER AT LAKE CITY	14,100	20,500	24,900	35,100	39,700
07046600	- RIGHT HAND CHUTE OF LITTLE RIVER AT RIVERVALE	14,900	24,500	30,900	44,600	50,100
07047000	- ST. FRANCIS RIVER FLOODWAY NEAR MARKED TREE	19,200	32,000	40,500	58,500	65,700
07047500	- ST. FRANCIS RIVER AT MARKED TREE	3530	4320	4820	5850	6270
07047600	- TYRONZA RIVER NEAR TYRONZA	4170	4910	5420	6440	6830
07047800	- ST. FRANCIS RIVER AT PARKIN	10,000	13,500	15,700	20,400	22,200
07047900	- ST. FRANCIS BAY AT RIVERFRONT	21,100	33,000	40,900	57,400	64,100
07047942	- L'ANGUILLE RIVER NEAR COLT	5730	8800	10,800	15,200	16,900
07047950	- L'ANGUILLE RIVER AT PALESTINE	8570	12,700	15,100	20,000	21,800
07076850	- CYPRESS BAYOU NEAR BEEBE	5760	9540	12,100	17,975	21,600
07077000	- WHITE RIVER AT DEVALLS BLUFF	87,500	125,000	149,000	198,000	217,000
07077380	- CACHE RIVER AT EGYPT	4510	6130	7300	9770	10,800
07077500	- CACHE RIVER AT PATTERSON	6530	9460	11,500	16,300	18,400
07077700	- BAYOU DEVIEW AT MORTON	3330	4550	5400	6990	7630
07077800	- WHITE RIVER AT CLARENDON	81,600	118,000	143,000	197,000	221,000
07077950	- BIG CREEK AT POPLAR GROVE	3160	4830	5910	8030	8830
07264000	- BAYOU METO NEAR LONOKE	2180	3080	3690	5020	5580

SOURCE: Neely, 1987 <34>

TABLE 3-5

RANGES IN ANNUAL PEAK STAGES AND DISCHARGES AT SELECED GAGING STATIONS

STATION NUMBER AND NAME	PERIOD OF RECORD (WATER YEARS)	BANKFULL STAGE (feet)	MAXIMUM ANNUAL PEAK GAGE HEIGHT (feet)	MAXIMUM ANNUAL PEAK DISCHARGE (feet)	MINIMUM ANNUAL PEAK GAGE HEIGHT (feet)	MINIMUM ANNUAL PEAK DISCHARGE (cfs)
07040100-ST. FRANCIS RIVER	1942-80	19	24.83	27,400	17.25	--
AT ST. FRANCIS					--	4,940
07040450-ST. FRANCIS RIVER	1942-80	9	14.37	42,700	6.92	--
AT LAKE CITY					--	5,730
07046600-RIGHT HAND CHUTE OF LITTE	1939-80	8	13.55	--	4.85	--
RIVER AT RIVERVALE			--	35,600		
07046600-RIGHT HAND CHUTE OF LITTE	1935-80	--	--	53,000	--	2,190
RIVER AT RIVERVALE						
07047000-ST. FRANCIS RIVER FLOODWAY	1935-73	17	18.88	7,120	4.70	1,580
NEAR MARKED TREE						
07047500-ST. FRANCIS RIVER	1939-74	27	--	6,700	13.70	--
AT MARKED TREE*			31.61	--		
07047600-TYRONZA RIVER	1930-81	30	--	25,300	--	2,990
NEAR TYRONZA			34.20	--	7.92	--
07047900-ST. FRANCIS RIVER	1935-81	30	--	54,700	9.51	2,100
AT PARKIN*			39.03	--		
07047942-L'ANGUILLE RIVER	1971-84	--	15.81	12,000	12.54	1,730
NEAR COLT						

TABLE 3-5 (continued)
RANGES IN ANNUAL PEAK STAGES AND DISCHARGES AT SELECTED GAGING STATIONS

	PERIOD OF RECORD (WATER YEARS)	BANKFULL STAGE (Feet)	MAXIMUM ANNUAL PEAK Gage Height (feet)	MAXIMUM ANNUAL PEAK Discharge (cfs)	MINIMUM ANNUAL PEAK Gage Height (feet)	MINIMUM ANNUAL PEAK Discharge (cfs)
07047950-L'ANGUILLE RIVER AT PALESTINE	1933,1935-37, 1939,1943-80	22	39.70	--	21.58	2,700
07076850-CYPRESS BAYOU NEAR BEEBE	1962-76	10	16.09	21,000	11.46	1,270
07077000-WHITE RIVER AT DEVALLS BLUFF	1949-70	20	31.35	220,000	17.83	31,200
07077380-CACHE RIVER AT EGYPT	1938-40, 1953-84	--	21.88	8,940	-- / 15.00	2,620 / --
07077500-CACHE RIVER AT PATTERSON	1921-31, 1937-80	9	16.10	24,500**	8.70	2,400
07077700-BAYOU DEVIEW AT MORTON	1933,1935,1937, 1939-77,1980	16	-- / 18.75	6,700 / --	15.88	--
07077800-WHITE RIVER AT CLARENDON	1949-81	23	35.32	211,000	22.80 / --	-- / 31,500
07077950-BIG CREEK AT POPLAR GROVE	1971-84	--	31.74	5,910	17.90	808
07264000-BAYOU METO NEAR LONOKE	1955-84	16	26.55	4,700	16.50	966

* The greater part of St. Francis River floodflow is diverted through St. Francis River floodway and is not included in records for this station

** Peak flow affected by White River overflow

SOURCE: Neely, 1987 <34>

Low-Flow Frequency

Minimum streamflows typically occur during August through October of each year in the Eastern Arkansas Basin. Management and development of surface-water supplies depend on the rate of sustained streamflow during these dry periods. The flow of "natural" streams during dry periods is governed by the volume of water in ground storage and by the rate at which the ground water discharges into the streams. The character and distribution of the geologic formations of the drainage basins exert a major influence on the quantity of the low flows of "natural" streams <42>. However, in the Eastern Arkansas Basin, the effects of the geologic formations on low flows of streams are difficult to discern because diversions of water to and from streams during the irrigation season significantly affect baseflow conditions. For instance, ricefields are alternately flooded and drained during the growing season and, in many cases, irrigation water that is derived from ground water is diverted to streams when fields are drained. Accurate surface water and ground water withdrawal data and return-flow data are not currently available for the Eastern Arkansas Basin. Therefore, it is not possible to differentiate between "natural" low-flow conditions governed by the rate of ground water discharge and low-flow conditions that are a result of irrigation practices in the basin.
Indices generally used to define the low-flow characteristics of streams are the lowest mean discharges for seven consecutive days having recurrence intervals of 2 and 10 years. For simplicity, these indices are referred to as the 7-day 2-year (7Q2) and 7-day 10-year (7Q10) discharges, respectively. These discharges are taken from a frequency curve of annual values of the lowest mean discharge for seven consecutive days. Low-flow characteristics at gaging stations on streams in the Eastern Arkansas Basin are summarized in Table 3-6. The 7Q2 and 7Q10 values were determined using U.S. Geological Survey and U.S. Army Corps of Engineers streamflow data and the log Pearson Type III probability distribution program <40>. This program mathematically fits a frequency curve to the discharge data, and the 7Q2 and 7Q10 values are then taken from the curve generated by the program. If a stream is dry during any part of the year, however, this procedure is not directly applicable and a graphical solution for determining the low-flow characteristics must be used. To eliminate the effect of variation in drainage area size between sites, the 7Q2 and 7Q10 discharges per square mile were computed and were included in Table 3-6 for comparison purposes.

Low-flow characteristics at partial-record stations on streams in the Eastern Arkansas Basin have been estimated by Hines <25> and are summarized in Table 3-7. These estimates were made based on the correlation of several low-flow discharge measurements at the partial-record station with concurrent daily mean discharges at two or more continuous-record gaging stations.

Low-flow characteristics of streams in the Eastern Arkansas Basin are extremely variable, as indicated by the data compiled in Tables 3-6 and 3-7. The White River has the highest low-flow yield of streams in the basin for which low-flow data are available. The 7Q2 low-flow index is 0.31 cfs/square mile at DeValls Bluff and at Clarendon. In contrast, data compiled in Tables 3-6 and 3-7 show that many streams in the basin have no flow during dry-weather conditions. Streamflow yield may be significantly different at different locations on the same stream. For example, the Cache River near Stonewall has an estimated 7Q2 index of only 0.0003 cfs/square mile. However, at the downstream station at Patterson, the low-flow yield is considerably higher with a low-flow index of 0.06 cfs/square mile.

TABLE 3-6

LOW FLOW FREQUENCY AT SELECTED GAGING STATIONS

STATION NUMBER		STATION NAME	PERIOD OF RECORD	7Q (CFS)	7Q /mi (CFSM)	7Q (CFS)	7Q /mi (CFSM)
07040100	-	St. Francis River at St. Francis	1943-77	122	0.07	76	0.04
07040450	-	St. Francis River at Lake City	1943-77	284	0.12	127	0.05
07046600	-	Right Hand Chute of Little River at Rivervale	1949-76	386	0.18	155	0.07
07047000	-	St. Francis River Floodway near Marked Tree	1936-65	0	0	0	0
07047500	-	St. Francis River at Marked Tree	1936-73	197	0.04	98	0.02
07047600	-	Tyronza River near Tyronza	1951-74	47	0.16	29	0.10
07047800	-	St. Francis River at Parkin	1932-81	482	--	277	--
07047900	-	St. Francis Bay at Riverfront	1937-75	210	--	45	--
07047942	-	L'Anguille River near Colt	1972-86	8.3	0.02	2.5	0.005
07047950	-	L'Anguille River at Palestine	1951-77	2.6	0.003	0	0
07076850	-	Cypress Bayou near Beebe	1963-76	0	0	0	0
07077000	-	White River at DeValls Bluff	1951-70	7220	0.31	4830	0.21
07077380	-	Cache River at Egypt	1966-86	30	0.04	6.3	0.009
07077500	-	Cache River at Patterson	1929-31; 1939-77	64	0.06	15	0.01
07077700	-	Bayou DeView at Morton	1941-77	0	0	0	0
07077800	-	White River at Clarendon	1952-81	8040	0.31	5250	0.20
07077950	-	Big Creek at Poplar Grove	1974-86	5.4	0.01	0.5	0.001
07264000	-	Bayou Meto near Lonoke	1956-86	5.1	0.02	0.2	0.001

TABLE 3-7
ESTIMATES OF LOW-FLOW FREQUENCY AT PARTIAL-RECORD STATIONS
ON STREAMS IN EASTERN ARKANSAS
(modified from Hines <25>)

STATION NUMBER - NAME	DRAINAGE AREA (sq. mi)	7Q2 (cfs)	7Q2/(sq.mi) (CFSM)	7Q10 (CFS)
07040300 - BIG SLOUGH DITCH NEAR MARMADUKE	247	66	0.27	31
07040400 - LOCUST CREEK DITCH NEAR PARAGOULD	78.3	1.0	0.01	0.1
07046532 - CROOKED LAKE BAYOU AT NUMBER NINE	34.5	0.2	0.006	<0.1
07047550 - TYRONZA RIVER DITCH 31 AT VICTORIA	63.5	14	0.22	10
07047700 - TYRONZA RIVER AT TWIST	533	57	0.11	33
07047850 - LITTLE BAY DITCH NEAR JONESBORO	27.1	0	0	0
07047910 - BLACKFISH BAYOU NEAR FORREST CITY	227	2.4	0.01	0.7
07047920 - FIFTEEN MILE BAYOU NEAR WEST MEMPHIS	66.1	1.7	0.02	0.6
07076800 - BAYOU DES ARC NEAR GARNER	96.7	<0.1	--	--
07076880 - BULL CREEK NEAR MCRAE	95.8	0	0	0
07076940 - WATTENSAW BAYOU NEAR LONOKE	31.6	<0.1	--	<0.1
07076950 - WATTENSAW BAYOU NEAR HAZEN	192	0.2	0.001	<0.1
07077100 - BIG CREEK NEAR BOYDSVILLE	12.8	0	0	0
07077300 - CACHE RIVER NEAR STONEWALL	284	0.9	0.0003	0.3
07077450 - CACHE RIVER NEAR NEWPORT	871	21	0.02	11
07077650 - BIG CREEK NEAR JONESBORO	50.6	0.3	0.006	<0.1
07077920 - BIG CREEK AT GOODWIN	31.1	<0.1	--	--
07077940 - SPRING CREEK NEAR AUBREY	38	<0.1	--	--
07077970 - BIG CYPRESS CREEK AT TURNER	106	<0.1	--	--
07078180 - LITTLE LAGRUE BAYOU NEAR DEWITT	123	<0.1	--	--
07263890 - LITTLE BAYOU METO AT REYDEL	425	0	0	0
07264200 - BAYOU TWO PRAIRIE AT CARLISLE	151	0.4	0.003	0.2

Because of the wide variation in the yield of streams in the basin and variation in yield between reaches on the same stream, it is not possible to generalize that in an area where one stream shows an index of a given yield, all streams in the area have the same index. Interpolation of low-flow data should not be made to estimate the low flow at ungaged sites on the basis of drainage area without sufficient knowledge of the geohydrology, surface water and ground water withdrawals and return flows, and other factors affecting the low-flow conditions.

Instream Flow Requirements

Instream flow requirements are generally defined as "the quantity of water needed to maintain the existing and planned in-place uses of water in or along a stream channel or other water body and to maintain the natural character of the aquatic system and its dependent systems". <54> Instream flow requirements are established at a level at which the flow regime best meets the individual and collective instream uses. Instream uses of water include uses of water in the stream channel for navigation, recreation, fisheries, riparian vegetation, aesthetics, and hydropower. Off-stream water withdrawals include uses such as irrigation, municipal and industrial water supplies, and cooling water.

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to determine instream flow requirements for: (1) water quality, (2) fish and wildlife, (3) navigation, (4) interstate compacts, (5) aquifer recharge, and (6) needs of all other users in the basin such as industry, agriculture, and public water supply. Determination of the amount of water required to satisfy instream needs in the Eastern Arkansas Basin is necessary so that streamflow available for use within the basin for riparian needs and intrabasin transfer as well as the amount of excess water available for interbasin transfer can be quantified.

In order to determine instream flow requirements for the categories mentioned above, information was obtained from other agencies such as the Arkansas Department of Pollution Control and Ecology, the Arkansas Game and Fish Commission, the Corps of Engineers, and the U.S. Geological Survey. The flows recommended for the different categories (as provided by the appropriate agencies) were then evaluated with respect to all other instream needs in order to determine the flow regime which best meets the collective instream uses and off-stream withdrawals. This resulted in a two-part solution for the process of determining instream flow requirements. The first approach was to determine the amount of water necessary to maintain desirable instream flow conditions in the basin based on the flows recommended by other agencies before interbasin transfer of water could take place. The information compiled in the following sections on instream flow requirements pertains to this first approach. The second approach was to determine the amount of water necessary to satisfy minimum instream flow requirements in order to determine the streamflow available for use by riparian landowners and other water users within the basin. This second approach is described in more detail in the minimum streamflow section of the report.

Computations of instream flow requirements at selected locations in the basin are based on streamflow data that represent the current streamflow conditions. As previously stated in the streamflow characteristics section of the report, flows of the St. Francis, White, and Arkansas Rivers are affected by regulation. If the pattern of reservoir regulation changes in the future, the streamflow available to satisfy the instream flow requirements may be significantly different from the streamflow that has been historically available downstream of the reservoirs.

Water-Quality Requirements

The 7Q10 low-flow characteristic is a common criterion used by State and Federal agencies to determine the permissible rate of waste disposal into a given stream because one of the most important factors influencing the concentration of dissolved solids in streamflow is the volume of water available for dilution. The Arkansas Department of Pollution Control and Ecology (ADPC&E) is responsible for the management of water-quality conditions in the Eastern Arkansas Basin. The 7Q10 discharge for streams and rivers in the basin is the minimum flow at which the ADPC&E is responsible for maintaining streamflow contaminant concentrations at acceptable levels. The ADPC&E continues to monitor point-source discharges below the 7Q10 discharge and requires concentrations of certain pollutants to be maintained below critical levels. However, due to a lack of sufficient water at times during the year to dilute the effluent discharges, streamflow water quality may not meet the quality standards during all times of the year.
Streams that are regulated are addressed by ADPC&E on a case-by-case basis to determine the minimum flow required to maintain streamflow contaminant concentrations at acceptable levels. The St. Francis, White, and Arkansas Rivers in the Eastern Arkansas Basin are affected by reservoirs which are located outside the basin. To determine the 7Q10 low-flow characteristics for these regulated rivers, only those streamflow records which are representative of the existing pattern of regulation are used in the computations. If significant changes are made in the methods of reservoir regulation upstream, the 7Q10 values determined for regulated reaches of the St. Francis, White, and Arkansas Rivers must be recomputed.

The 7Q10 discharges were determined at 18 gaging station locations in the Eastern Arkansas Basin. The discharges required to meet water-quality standards at gaging station locations in the basin are as follows:

St. Francis River:
76 cfs at St. Francis
127 cfs at Lake City
98 cfs at Marked Tree
277 cfs at Parkin

Right Hand Chute of Little River:
155 cfs at Rivervale

St. Francis River Floodway:
no flow near Marked Tree

St. Francis Bay:
45 cfs at Riverfront

Tyronza River:
29 cfs near Tyronza
L'Anguille River:
2.5 cfs near Colt
no flow at Palestine

Cypress Bayou:
no flow near Beebe

White River:
4830 cfs at DeValls Bluff
5250 cfs at Clarendon

Cache River:
6.3 cfs at Egypt
15 cfs at Patterson

Bayou DeView:
no flow at Morton

Big Creek:
0.5 cfs at Poplar Grove

Bayou Meto:
0.2 cfs near Lonoke

The 7Q10 discharges at ungaged locations on streams in the Eastern Arkansas Basin can not be statistically quantified. As previously stated, extrapolation of the 7Q10 indices should not be attempted without knowledge of the basin characteristics and without knowledge of the effects of man-made practices. However, a range for the low-flow characteristics at ungaged locations can be estimated by using available low-flow information from other gaged locations. For example, to estimate a range in the 7Q10 discharge for the Arkansas River at the mouth, discharge records for the Arkansas River at Murray Dam (the most downstream gaging station on the Arkansas River) were analyzed. The 7Q10 discharge for the Arkansas River at Murray Dam is 624 cfs, based on discharge records for the period of 1972-86. It is assumed that the minimum 7Q10 discharge at the mouth is at least equal to the 7Q10 discharge at Murray Dam, or 624 cfs. The maximum 7Q10 discharge at the mouth is estimated by adjusting the 7Q10 discharge at Murray Dam based on a ratio of the drainage areas. This results in an estimate of 634 cfs for the maximum 7Q10 discharge for the Arkansas River at the mouth. This method was used to estimate the 7Q10 discharges for two other locations in the basin with the following results:

L'Anguille River at the mouth
estimated 7Q10 discharge = 0

White River at the mouth
estimated 7Q10 discharge range = 5250 - 5720 cfs.

It should be emphasized that these low-flow discharges are only estimates. However, the results do provide a general range in 7Q10 discharges for selected locations and can be compared with other instream flow requirements at these locations.

Fish and Wildlife Requirements

Several methods are currently available for determining instream flow requirements for fisheries. Some of these methods, such as the Instream Flow Incremental Method (IFIM) <10>, require considerable site-specific field work to characterize fishery habitat needs at selected locations. However, Tennant <45> has developed a method, often referred to as the "Montana Method", that requires limited field work. The Montana Method utilizes historic hydrologic records to estimate instream flow requirements for fish and other aquatic life by correlating the condition of the aquatic habitat with the percent of the average flow present in the stream. The Montana Method was tested by field studies which involved physical, chemical, and biological analyses conducted on 11 streams in three states. Additional analyses of hundreds of additional flow regimens in 21 different states substantiated the correlation between the condition of the aquatic habitat and the percent of the average flow present in the stream. Tennant's comprehensive study resulted in the following conclusions:

(A) "Ten percent (10%) of the average flow: This is a minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms. Channel widths, depths, and velocities will all be significantly reduced and the aquatic habitat degraded. The stream substrate may be about one-half exposed, except in wide, shallow riffle or shoal areas where exposure could be higher. Most side channels will be severely or totally dewatered. Most gravel bars will be substantially dewatered, and islands will usually no longer function as wildlife nesting, denning, nursery, and refuge habitat. Steambank cover for fish and fur animal denning habitat will be severely diminished. Many wetted areas will be so shallow they no longer will serve as cover, and fish will generally be crowded into the deepest pools. Riparian vegetation may suffer from lack of water. Large fish may have difficulty migrating upstream over many riffle areas. Water temperature may become a limiting factor, especially in the lower reaches of the stream in July and August. Invertebrate life will be severely reduced."

(B) "Thirty percent (30%) of the average flow: This is a base flow recommended to sustain good survival habitat for most aquatic life forms. Widths, depths, and velocities will generally be satisfactory. The majority of the substrate will be covered with water, except for very wide, shallow riffle or shoal areas. Most side channels will carry some water. Most gravel bars will be partially covered with water and many islands will provide wildlife nesting, denning, nursery, and refuge habitat. Streambanks will provide cover for fish and wildlife denning habitat in many reaches. Many runs and most pools will be deep enough to serve as cover for fishes. Riparian vegetation should not suffer from lack of water. Large fish should have no trouble moving over most riffle areas. Water temperatures are not expected to become limiting in most stream segments. Invertebrate life is reduced but not expected to become a limiting factor in fish production."

(C) "Sixty percent (60%) of the average flow: This is a base flow recommended to provide <u>excellent to outstanding</u> habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses. Channel widths, depths, and velocities will provide excellent aquatic habitat. Most of the normal channel substrate will be covered with water, including many shallow riffle and shoal areas. Side channels that normally carry water will have adequate flows. Few gravel bars will be exposed, and the majority of islands will serve as wildlife nesting, denning, nursery, and refuge habitat. The majority of streambanks will provide cover for fish and safe denning areas for wildlife. Most pools, runs, and riffles will be adequately covered with water and provide excellent feeding and nursery habitat for fishes. Riparian vegetation will have plenty of water. Fish migration is no problem in any riffle areas. Water temperatures are not expected to become limiting in any reach of the stream. Invertebrate life forms should be varied and abundant."

Tennant's recommended flows are generally applicable for both cold and warm water streams. However, it is suggested that the recommended flow regimens be altered to fit different hydrologic cycles or to coincide with vital periods of the life cycle of fishes.

Filipek and others <16> have developed a new method, termed the "Arkansas Method", which utilizes some of Tennant's basic principles. This new method was developed due to limitations in the application of the Montana method to Arkansas streams. The Arkansas method divides the water year into three seasons based on the physical and biological processes that occur in the stream. The three physical/biological seasons as well as the flow recommended for fisheries during each season are described in Table 3-8. The instream flow requirements, as determined by the Arkansas method, are those that apply to fish populations only and represent the point at which fisheries begin to be impacted. The method assumes that when instream flows meet the needs for fisheries, instream requirements for other wildlife forms are probably also satisfied.

The Arkansas method was applied to mean monthly discharge data (previously summarized in Table 3-2) to determine the instream flow requirements for fish and wildlife at selected streamflow gaging stations in the Eastern Arkansas Basin with the results compiled in Table 3-9. The flows required to satisfy instream needs for fish and wildlife on an annual basis were also determined for the gaging stations in the basin and are shown in Table 3-9. The annual instream flow requirements for fish and wildlife were computed by averaging the monthly instream flow requirements for the year.

Instream flow requirements for fish and wildlife are not available for many locations in the Eastern Arkansas Basin due to the limited number of gaging stations in the basin. If instream flow requirements for fish and wildlife are needed at ungaged locations on streams, streamflow data should be collected at the ungaged locations prior to determination of fish and wildlife instream needs. The procedure of adjusting mean monthly discharges based on a ratio of the drainage areas (as described in the Lower Ouachita Basin report of the State Water Plan <8>) is not applicable for streams in the Eastern Arkansas Basin. One assumption of the drainage area ratio method is that streamflow yield (discharge per square mile) is uniform between different reaches of a stream. However, in

TABLE 3-8

DESCRIPTION OF PHYSICAL/BIOLOGICAL SEASONS IN THE ARKANSAS METHOD

TIME OF YEAR	NOVEMBER THRU MARCH	APRIL THRU JUNE	JULY THRU OCTOBER
FLOW RECOMMENDED	60% OF THE MEAN MONTHLY FLOW	70% OF THE MEAN MONTHLY FLOW	50% OF THE MEAN MONTHLY FLOW OR THE MEDIAN MONTHLY FLOW, WHICHEVER IS GREATER
PHYSICAL/BIOLOGICAL PROCESSES INVOLVED	CLEAN AND RECHARGE	SPAWNING	PRODUCTION
NORMAL CONDITIONS	-HIGH AVERAGE MONTHLY FLOWS. -LOW WATER TEMPERATURES. -HIGH DISSOLVED OXYGEN CONTENT. FLUSHING OF ACCUMULATED SEDIMENT AND CLEANING OUT OF SEPTIC WASTES. SPRAWNING AREAS CLEANED AND REBUILT BY GRAVEL AND OTHER SUBSTRATE BROUGHT DOWNRIVER BY HIGH FLOWS. RECHARGE OF GROUNDWATER (AQUIFERS).	-HIGH AVERAGE MONTHLY FLOWS. -INCREASING (PREFERRED) WATER TEMPERATURES. -HIGH DISSOLVED OXYGEN CONTENT. HIGH FLOWS AND INCREASING WATER TEMPERATURES SPUR SPAWNING RESPONSE IN FISH TO SPAWN: 1) IN CHANNEL 2) IN OVERBANK AREA OR 3) UPRIVER AFTER MIGRATION. FEEDING ALSO ACTIVATED BY HIGH SPRING FLOWS.	-LOW AVERAGE MONTHLY FLOWS. -HIGH WATER TEMPERATURES. -LOW DISSOLVED OXYGEN CONTENT COMMON. HIGH WATER TEMPERATURES INCREASE PRIMARY, SECONDARY AND TERTIARY PRODUCTION. LOW FLOWS CONCENTRATE PREDATORS (FISH) WITH PREY (INVERTEBRATES, FORAGE FISH).
LIMITING FACTORS	REDUCED FLOWS AT THIS TIME OF YEAR CAUSE: DECREASE IN BENTHIC PRODUCTION DUE TO ACCUMULATED SEDIMENT ON SUBSTRATE. DECREASE IN FISH SPAWNING HABITAT DUE TO REDUCED FLUSHING. DECREASE IN AQUIFER RECHARGE.	REDUCED FLOWS AT THIS TIME OF YEAR CAUSE: DECREASE IN SPAWNING EGGS AND FRY SURVIVAL AND OVERALL REPRODUCTIVE SUCCESS OF IMPORTANT SPORT AND NON-GAME FISH. WEAK YEAR CLASSES OF IMPORTANT SPORT, COMMERCIAL, NON-GAME AND THREATENED FISH SPECIES.	REDUCED FLOWS AT THIS TIME OF YEAR CAUSE: WATER TEMPERATURES TO INCREASE, DECREASING SURVIVAL OF CERTAIN FISH SPECIES. DECREASE IN WETTED SUBSTRATE AND THEREFORE DECREASE IN ALGAE, MACROINVERTEBRATES. DECREASE IN DISSOLVED OXYGEN DUE TO HIGHER WATER TEMPERATURES; FISHKILLS. INCREASE CONCENTRATION OF POLLUTANTS AND SEDIMENT IN WATER. ADDITIONAL DECREASE IN GROUNDWATER TABLE.

SOURCE: FILIPEK AND OTHERS, 1985 <16>

TABLE 3-9

MONTHLY AND ANNUAL INSTREAM REQUIREMENTS FOR FISH AND WILDLIFE (ARKANAS METHOD) AT SELECTED GAGING STATIONS

MONTHLY AND ANNUAL INSTREAM FLOW REQUIREMENTS FOR FISH AND WILDLIFE (cfs)

07040100 - ST. FRANCIS RIVER AT ST. FRANCIS	288	709	1245	1757	1961	2409	3120	2650	1492	587	303	279	1400
07040450 - ST. FRANCIS RIVER AT LAKE CITY	414	1010	1606	2581	2812	3320	4283	3644	2174	896	511	412	1972
07046600 - RIGHT HAND CHUTE OF LITTLE RIVER AT RIVERVALE	452	1007	1706	2615	2906	3013	3399	2745	1821	874	580	468	1799
07047000 - ST. FRANCIS RIVER FLOODWAY NEAR MARKED TREE	282	1009	1916	3543	4710	5302	6551	4195	2888	1058	380	253	2674
07047500 - ST. FRANCIS RIVER AT MARKED TREE	448	607	685	1062	1284	1331	1520	1506	1303	800	615	466	969
07047600 - TYRONZA RIVER NEAR TYRONZA	74.0	221	336	362	433	358	435	428	214	124	87.5	84.5	263
07047800 - ST. FRANCIS RIVER AT PARKIN	608	974	1394	2082	2581	2546	3027	2577	1940	1057	815	702	1692
07047900 - ST. FRANCIS BAY AT RIVERFRONT	482	1217	2575	4263	5536	6006	7434	6043	3532	1270	640	497	3291
07047942 - L'ANGUILLE RIVER NEAR COLT	147	386	766	524	586	624	860	638	449	99.0	148	305	461
07047950 - L'ANGUILLE RIVER AT PALESTINE	163	426	735	982	1462	1303	1269	1127	419	213	208	326	719
07076850 - CYPRESS BAYOU NEAR BEEBE	6.70	95.4	191	243	210	280	260	176	84.7	5.95	16.2	28.6	133
07077000 - WHITE RIVER AT DEVALLS BLUFF	5740	8538	12,560	17,730	20,930	23,030	28,830	31,120	18,36	9430	7925	6460	15,890
07077380 - CACHE RIVER AT EGYPT	162	391	797	713	719	668	1021	918	335	168	168	230	524
07077500 - CACHE RIVER AT PATTERSON	159	433	784	1235	1427	1457	1516	1116	650	245	182	194	783
07077700 - BAYOU DEVIEW AT MORTON	63.0	226	372	544	622	608	570	405	226	77.0	101	113	327
07077800 - WHITE RIVER AT CLARENDON	6355	10,150	16,160	18,010	20,860	25,360	33,940	33,660	19,500	9800	8350	6910	17,420
07077950 - BIG CREEK AT POPLAR GROVE	114	304	662	501	544	621	790	792	406	68.5	103	122	419
07264000 - BAYOU METO NEAR LONOKE	32.6	139	265	222	307	309	368	352	132	27.4	28.9	41.1	185
	J	F	M	A	M	J	J	A	S	O	N	D	Σ/12

the Eastern Arkansas Basin streamflow yield may be significantly different between stream reaches due to the interchange of flow between watersheds and to the withdrawal of streamflow for irrigation use. Therefore, estimates of discharge at ungaged locations may be significantly different than actual stream discharge.

According to a report submitted to the Arkansas Soil and Water Conservation Commission by Filipek and others <17>, the recommended instream requirements as determined by the Arkansas method are designed "to maintain existing fisheries, many of which are at optimal levels." Therefore, to protect stream fisheries and to satisfy water needs for fish and wildlife in the Eastern Arkansas Basin, the instream flow requirements (as previously described for streams in this basin) represent an amount of water that is unavailable for interbasin transfer.

Navigation Requirements

The U.S. Army Corps of Engineers operates and maintains the Arkansas River and White River navigation projects. The lower reaches of the Arkansas and White Rivers in the Eastern Arkansas Basin are included in these two navigation projects which are quite different. The Arkansas River navigation system consists of a series of locks and dams which provide a nine-foot navigation channel. Navigability of the river is maintained through flow management of dam releases and also by dredging. On the other hand, maintenance dredging and bank stabilization measures provide "open-river" navigation on the White River in the Eastern Arkansas Basin.

According to the Little Rock District of the Corps of Engineers <53>, 3000 cfs is needed to maintain navigation in the lower reaches of the Arkansas River. This instream flow requirement takes into account lockage, leakage, evaporation, and operation inflexibility. Therefore, to enable navigation of the Arkansas River in eastern Arkansas, 3000 cfs of water should be maintained in the Arkansas River. However, this figure is preliminary and subject to revision by the Corps of Engineers.

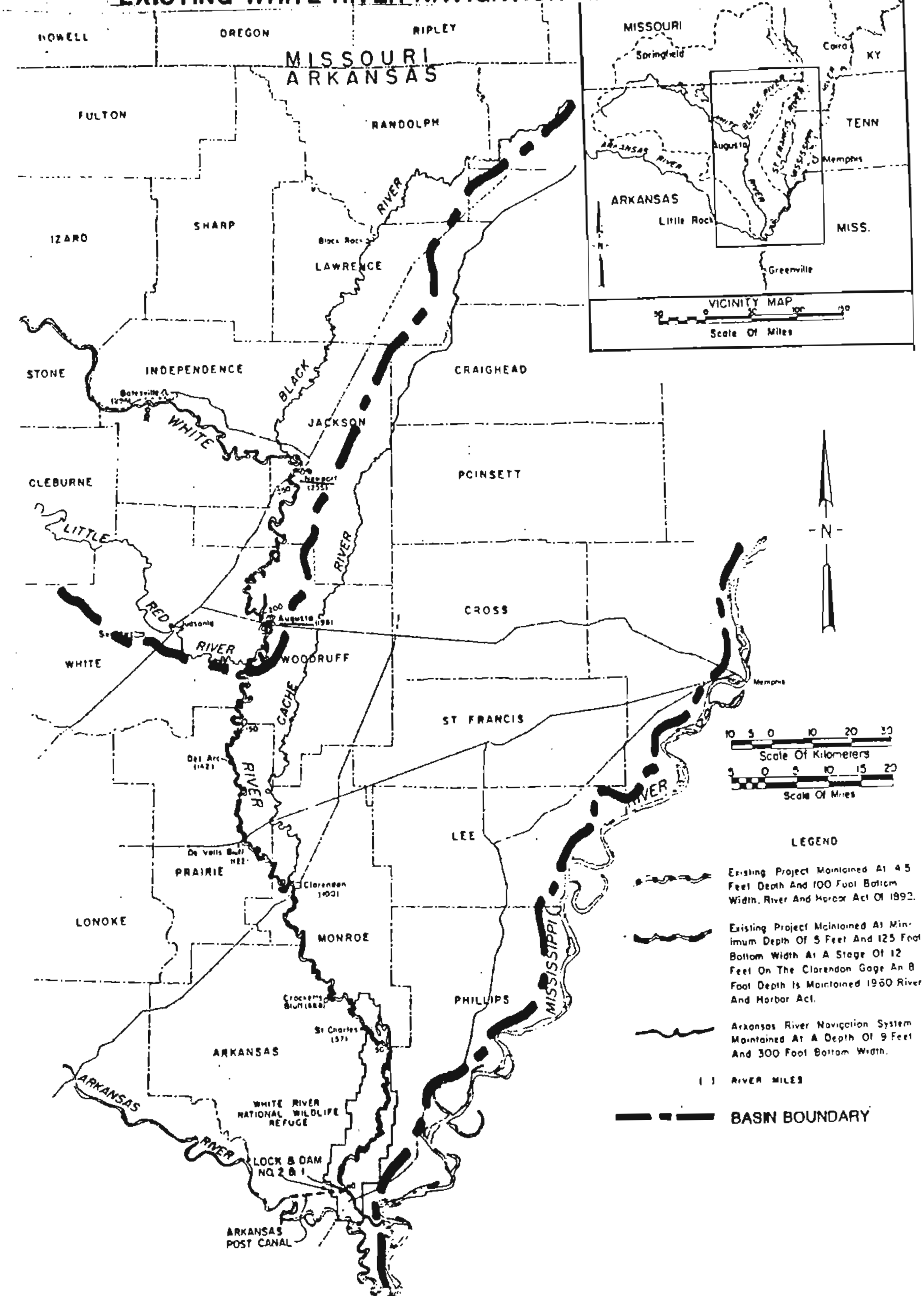
To facilitate navigation on the White River in eastern Arkansas, the White River channel from the Arkansas Post Canal (mile 10) upstream to Augusta (mile 198) (See Figure 3-5) is maintained at a minimum depth of 5 feet and bottom width of 125 feet. An 8-foot deep channel is maintained in this reach when the river stage at Clarendon exceeds 12.0 feet. From the mouth of the White River to the Arkansas Post Canal (See Figure 3-5), a channel 300 feet wide and 9 feet deep is maintained as part of the Arkansas River navigation project. Channel conditions suitable for navigation on the White River are sustained through annual dredging and snagging <47>.

According to information from the Memphis District of the Corps of Engineers (personal communication, 1988), streamflow at selected gaging stations in the basin that is required to maintain the previously described White River channel conditions is as follows:

Channel 5-feet deep and 125 feet wide

White River at DeValls Bluff - 2570 cfs
White River at Clarendon - 2800 cfs

FIGURE 3-5
EXISTING WHITE RIVER NAVIGATION IMPROVEMENTS



SOURCE: MODIFIED FROM U.S. ARMY CORPS OF ENGINEERS ⟨47⟩

Channel 8-feet deep
(when stage at Clarendon exceeds 12.0 feet)
White River at DeValls Bluff - 6890 cfs
White River at Clarendon - 7500 cfs

Additional navigation improvements on the White River have been authorized for construction by the Water Resources Development Act of 1986. These improvements would provide a channel 200 feet wide and 9 feet deep from the Arkansas Post Canal upstream to Newport <47>. Annual maintenance dredging would ensure that these channel conditions in this reach of the White River would be available 95 percent of the time. Implementation of these improvements would require an increase in the instream flow requirements for navigation to: 8850 cfs at DeValls Bluff and 9650 cfs at Clarendon.

There are no instream flow requirements for navigation on other streams in the Eastern Arkansas Basin.

Interstate Compact Requirements

Arkansas is a participating state in the Red River Compact and the Arkansas River Compact. The Eastern Arkansas Basin is not included in the areas which are specifically governed by these two interstate compacts, however, provisions of the Arkansas River Compact could have an effect on the quantity of streamflow in downstream reaches of the Arkansas River in the Eastern Arkansas Basin. The Arkansas River Compact between the states of Oklahoma and Arkansas includes the area defined as: "... the drainage basin of the Arkansas River and its tributaries from a point immediately below the confluence of the Grand-Neosho River with the Arkansas River near Muskogee, Oklahoma, to a point immediately below the confluence of Lee Creek with the Arkansas River near Van Buren, Arkansas, together with the drainage basin of Spavinaw Creek in Arkansas, but excluding that portion of the drainage basin of the Canadian River above Eufaula Dam." <6> The area encompassed by the Arkansas River Compact is divided into the following five sub-basins: Spavinaw Creek, Illinois River, Lee Creek, Poteau River, and Arkansas River. The Arkansas River sub-basin represents approximately 70 percent of the total compact area and according to Article IV of the Arkansas River Compact defined in "Arkansas Water Law", <6> "The State of Oklahoma shall have the right to develop and use the waters of the Arkansas River sub-basin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%)." In past years, Oklahoma has generally used considerably less water than the 60 percent of the annual yield of the Arkansas River sub-basin which has been apportioned to the state since the ratification of the Arkansas River Compact. However, depletion of the annual yield of the Arkansas River sub-basin by 60 percent in Oklahoma could significantly reduce the streamflow of the Arkansas River downstream in the Eastern Arkansas Basin. In addition, Oklahoma is most likely to use a greater amount of their apportionment of water during dry years which would correspond with the time when a greater amount of water would be required by downstream Arkansas water users.

Aquifer Recharge Requirements

Recharge to the major aquifers in the Eastern Arkansas Basin is primarily by the infiltration of water from precipitation, irrigation, and impoundments. The rate of recharge to the alluvial aquifer in the basin is significantly reduced by the presence of a subsurface clay layer. The low permeability of the clay cap in the basin reduces the amount of water that recharges the alluvial aquifer, thereby reducing the amount of water available to wells in the area. However, the clay cap also minimizes infiltration losses from irrigated cropland and manmade ponds which is one of the main reasons that rice production and aquaculture are successful activities in the Eastern Arkansas Basin.

Aquifer recharge occurs locally along streams in the basin that penetrate the clay cap and incise the alluvial aquifer. Flow may alternate from the stream to the aquifer or from the aquifer to the stream depending on the head distribution in the aquifer and the stage of the stream. Generally, the streams recharge the aquifer during periods of high stage and drain the aquifer during periods of low stage. However, streams may function as year-round sources of aquifer recharge in areas of extensive ground water pumping.

Broom and Lyford <11> have estimated the amount of flow that is exchanged between the streams and the alluvial aquifer in the Cache and St. Francis River Basins. Determination of the stream-aquifer interflow has indicated that, at times, streams in the basin are sources for recharge to the aquifer. However, streams in the basin that exhibit sustained baseflow are evidence that formations in these drainage basins are not accepting recharge from streams during dry-weather conditions. The baseflow of these streams is sustained by water that is discharged from the formations. Therefore, in these basins, there would be no aquifer recharge requirements. However, if ground water levels were drawn down below the level of the streambed, the aquifer recharge requirements would then need to be considered.

A ground water model of the alluvial aquifer is currently being developed by the U.S. Geological Survey. This investigation will provide information on ground water-surface water relationships, which will contribute to quantification of the aquifer recharge requirements where applicable.

Riparian Use Requirements

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to determine surface water needs of public water supplies, industry, and agriculture. In 1985, surface water use for agriculture and industry totaled approximately 390 MGD (437,200 acre-feet/yr) of water in the Eastern Arkansas Basin, as determined from U.S. Geological Survey file data. There was no surface water use for public water supplies in the basin in 1985. Of the total amount of surface water diverted for agriculture and industry, 57.2 MGD (64,100 acre-feet/yr) were used for livestock and fish and minnow farms, 332 MGD (372,200 acre-feet/yr) were used for irrigation, and 1.12 MGD (1260 acre-feet/yr) were used for industry. These figures represent current riparian needs in the Eastern Arkansas Basin.

The amount of water diverted from each of the major streams in the Eastern Arkansas Basin was not determined for this report. The purpose of defining and quantifying instream flow requirements for streams in the basin was to determine the amount of water available for other uses, such as interbasin transfer. Since the water diverted for the uses mentioned above has already been removed from the streams and is not available, it was not included in the computations for total surface-water yield and excess streamflow of the basin.

Riparian water use requirements may vary considerably from year to year based on changing needs. Projected riparian water needs are accounted for in the water-use projections for agriculture and industry.

Aesthetic Requirements

Instream flow requirements, as previously defined, include water that is necessary to maintain the existing in-place uses of water in or along a stream channel. Recreational activities, such as fishing and hunting, in the Eastern Arkansas Basin represent another use of water in the streams in addition to those uses previously addressed. Instream flow requirements established for fish and wildlife (50,60, or 70 percent of the appropriate mean monthly discharge) should be adequate to maintain fishing and hunting activities in the basin.

Current Available Streamflow

Determination of the current available streamflow in the Eastern Arkansas Basin is necessary so that excess streamflow (that amount of water available for interbasin transfer) can be quantified. The flows required to satisfy the instream needs previously identified were compared with average annual discharges to determine the amount of streamflow that is currently available from streams and rivers in the basin. The information in Table 3-10 was compiled by stream to provide a generalized summary of the current water available on an average annual basis for selected streams in the basin.

The instream flow requirements for the different categories are not additive. The highest instream need represents the amount of water required to satisfy all the existing instream needs at the selected locations. The instream needs for fish and wildlife were the governing instream flow requirements for all streams listed in Table 3-10. Therefore, to determine the amount of water that is currently available at these locations, the flows required for fish and wildlife were subtracted from the average annual discharges. The water currently available for other uses, on an average annual basis, ranged from 109 cfs for Bayou Meto near Lonoke to 17,310 cfs for the Arkansas River at the mouth. These results may, however, be somewhat misleading. Due to seasonal streamflow variability, most of the water is available during the winter and spring months with considerably less water available during the low-flow months of the year.

To illustrate the effect that streamflow variability can have on the determination of available streamflow, the streamflow that is currently available on a monthly basis was determined for the White River at the mouth (Table 3-11). The governing instream flow requirements for each month (as noted in Table 3-11) were subtracted from the estimated mean monthly discharges to determine the streamflow available on a monthly basis. As previously determined, the White River at the mouth has 11,670 cfs of water available for other uses on an average annual basis. However, on a mean monthly basis, the available water ranges from 4,190 cfs in October to 18,400 cfs in March. The data in Table 3-11 show that the majority of the current available streamflow of the White River near the mouth occurs during the period of December through May.

The current available streamflows computed in Tables 3-10 and 3-11 do not represent the amount of water that is available for interbasin transfer. Before interbasin transfer of water can be considered, the projected water needs of the basin must be addressed. The previous determinations of current available streamflow do not account for the projected water needs of the basin because data identifying the projected water needs for individual streams in the basin are not currently available. However, the projected water needs of the entire basin have been estimated and are accounted for in the excess streamflow section of the report for the determination of the total amount of water in the Eastern Arkansas Basin that is available for interbasin transfer.

Table 3-10

Streamflow at selected locations in the Eastern Arkasnas Basin that is currently available for other uses

STATION NAME	Average Annual Discharge (cfs)	INSTREAM FLOW REQUIREMENTS (CFS) Water Quality	*Fish and Wildlife	Navigation	Current Available Streamflow (cfs)
Tyronza River near Tyronza	426	29	263	--	163
St. Francis River at Parkin	2,749	277	1,692	--	1,057
St. Francis Bay at Riverfront	5,203	45	3,291	--	1,912
L'Anguille River at the mouth	1,386**	no flow	858	--	528
Cache River at Patterson	1,259	15	783	--	476
Bayou DeView at Morton	515	no flow	327	--	188
Big Creek at Poplar Grove	669	0.5	419	--	250
White River at the mouth	30,630**	5250-5720	18,960	9,650	11,670
Bayou Meto near Lonoke	294	0.2	185	--	109
Arkansas River at the mouth	46,430**	624-634	29,120	3,000***	17,310

*** Preliminary and subject to revision

** Estimated

* Governing instream flow requirement which represents the amount of water required to satisfy existing needs at selected locations.

Table 3-11

Streamflow from the White River (at the mouth) that is currently available on a monthly basis for other uses

	Estimated Mean Monthly Discharge (cfs)	Water Quality	Fish and Wildlife	Navigation	Current Available Streamflow (cfs)
October	13,840	5250-5720	6,920	9650*	4,190
November	18,420	5250-5720	11,050*	9650	7,370
December	29,310	5250-5720	17,590*	9650	11,720
January	32,680	5250-5720	19,610*	9650	13,070
February	37,840	5250-5720	22,700*	9650	15,140
March	46,010	5250-5720	27,610	9650	18,400
April	52,770	5250-5720	36,940*	9650	15,830
May	52,340	5250-5720	36,640*	9650	15,700
June	30,320	5250-5720	21,220*	9650	9,100
July	21,340	5250-5720	10,670*	9650	10,670
August	18,180	5250-5720	9,090	9650*	8,530
September	15,040	5250-5720	7,520	9650*	5,390

*Governing instream flow requirement which represents the amount of water required to satisfy existing needs

Minimum Streamflow

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to establish minimum streamflows. Minimum streamflow is defined as the lowest daily mean discharge that will satisfy minimum instream flow requirements. A minimum streamflow is established to protect instream needs, particularly during low-flow conditions which may occur naturally or of significant water withdrawals from the stream. The minimum streamflow also represents a critical low flow condition below which some minimum instream need will not be met. The minimum streamflow is not a target level or a flow that can be maintained for an extended period of time without serious environmental consequences. Therefore, the minimum streamflow also represents the discharge at which all withdrawals from the stream will cease. Because of the critical low flow conditions which may exist at the minimum streamflow level, allocation of water based on the establishment of water-use priorities should be in effect long before this point is reached. Allocation of water should help to maintain streamflow above the established minimum discharge.

Minimum streamflows were not determined for streams in the Eastern Arkansas Basin because natural streamflow variability as well as surface water and ground ~~with~~ withdrawals and irrigation return flows in most of the watersheds make it extremely difficult to develop a procedure that is applicable for determining minimum streamflow for all streams. Therefore, minimum streamflows in the Eastern Arkansas Basis will be determined on a site-specific basis as necessary and will be based upon the appropriate streamflow characteristic, historic use, riparian rights, instream needs, and any other factors that might be applicable.

For illustration purposes, theoretical minimum streamflows for streams in the Eastern Arkansas Basin have been estimated to assess the levels at which minimum streamflows might be established in the future. The instream flow requirements as previously described in the report were used in the computations with the exception of fish and wildlife requirements. The instream flow requirements for fish and wildlife were re-evaluated to determine instream needs that represent minimum conditions. This was necessary recommended instream flow requirements for fish and wildlife using the Arkansas Method (Arkansas Game and Fish Commission) would maintain existing fisheries. These recommended flows are viewed as representing desirable conditions and not minimum instream flow needs.

To determine minimum instream flow requirements for fish and wildlife, the following procedure was used. Tennant <45> concluded from his study that 10 percent of the average annual streamflow is the minimum flow required for short-term survival of most aquatic life forms. However, analysis of streamflow records for unregulated streams in the Eastern Arkansas Basin showed that 10 percent of the average annual discharge was frequently higher than the daily mean discharge during the summer months. High streamflows that generally occur during January through May increase the average annual discharge which causes the flow recommended by Tennant for short-term survival (10 percent of the average annual discharge) to frequently exceed streamflow during the low-flow season. Therefore account for the seasonal variability of streamflow in the basin, the year was divided into three seasons as identified in the Arkansas Method <16>. The minimum instream flow requirements for fish and wildlife were then established by for each of the threee season as the discharge that if equal to taking 10 percent of the average seasonal flow.

In addition to requirements for fish and wildlife, instream flow requirements for water quality, navigation, aquifer recharge, interstate compacts, and aesthetics were also considered in the estimation of minimum streamflows. Since the instream flow requirements are not additive, the highest instream need for each season was used to establish the minimum streamflow for each season. Theoretical minimum streamflows at gaging station locations in the basin are presented in Table 3-12.

Minimum streamflows established for two gaging stations in the basin (White River at DeValls Bluff and Bayou Meto near Lonoke) were compared with historic streamflow data to analyze the frequency that streamflow at the two locations has been less than the minimum streamflows. As shown in Figure 3-6, the relatively uniform flow of the White River at DeValls Bluff for the period of record (1950-70) was generally higher than the minimum flow during the irrigation season (May-September). In contrast, the extremely variable flow of Bayou Meto near Lonoke for the period of record (1955-86) has often been less than the minimum flow during the irrigation season, as shown in Figure 3-7. The minimum streamflow for Bayou Meto near Lonoke during the irrigation season generally occurs between the median daily discharge and the minimum daily discharge. The percent of time that the minimum streamflows at these 2 locations and at other gaging stations in the basin have been exceeded during the period of record are shown in Table 3-13.

The establishment of minimum streamflows may have significant effects on the different water users in the basin. Agricultural riparian users will be affected by the establishment of minimum streamflows if streamflow levels are below the minimum streamflows for extended periods of time. In such cases, water must either be conserved or storage reservoirs must be constructed in anticipation of the times when the flow of a stream falls below the minimum level. Instream water uses will also be affected by the establishment of minimum streamflows. Although some level of flow protection will be beneficial to fish and wildlife, minimum streamflows are clearly not desirable conditions.

TABLE 3-12

THEORETICAL MINIMUM STREAMFLOWS BY SEASON

IN THE EASTERN ARKANSAS BASIN 1

STATION NUMBER	NAME	NOV-MAR	APR-JUN	JUL-OCT
07040100	- ST. FRANCIS RIVER AT ST. FRANCIS	269	346	76
07040450	- ST. FRANCIS RIVER AT LAKE CITY	378	481	127
07046600	- RIGHT HAND CHUTE OF LITTLE RIVER AT RIVERVALE	375	379	155
07047000	- ST. FRANCIS RIVER FLOODWAY NEAR MARKED TREE	549	649	98.6
07047500	- ST. FRANCIS RIVER AT MARKED TREE	166	206	116
07047600	- TYRONZA RIVER NEAR TYRONZA	57.0	51.3	29
07047800	- ST. FRANCIS AT PARKIN	319	359	277
07047900	- ST. FRANCIS BAY AT RIVERFRONT	653	810	144
07047942	- L'ANGUILLE RIVER NEAR COLT	96.2	92.7	35.0
07047950	- L'ANGUILLE RIVER AT PALESTINE	164	134	45.5
07076850	- CYPRESS BAYOU NEAR BEEBE	34.0	24.8	2.9
07077000	- WHITE RIVER AT DEVALLS BLUFF	6890	6890	4830
07077380	- CACHE RIVER AT EGYPT	110	108	36.4
07077500	- CACHE RIVER AT PATTERSON	178	156	39.0
07077700	- BAYOU DEVIEW AT MORTON	79.1	57.2	17.7
07077800	- WHITE RIVER AT CLARENDON	7500	7500	5250
07077950	- BIG CREEK AT POPLAR GROVE	87.7	94.7	20.4
07264000	- BAYOU METO NEAR LONOKE	41.4	40.6	6.5

1 Fish and wildlife is the governing instream requirement unless otherwise noted.

2 Water quality (7Q) is the governing instream requirement.

3 Navigation is the governing instream requirement.

FIGURE 3-6

COMPARISON OF SEASONAL MINIMUM STREAMFLOW WITH MINIMUM AND MEDIAN DAILY DISCHARGE OF WHITE RIVER AT DEVALLS BLUFF FOR THE PERIOD OF RECORD. (1950-70)

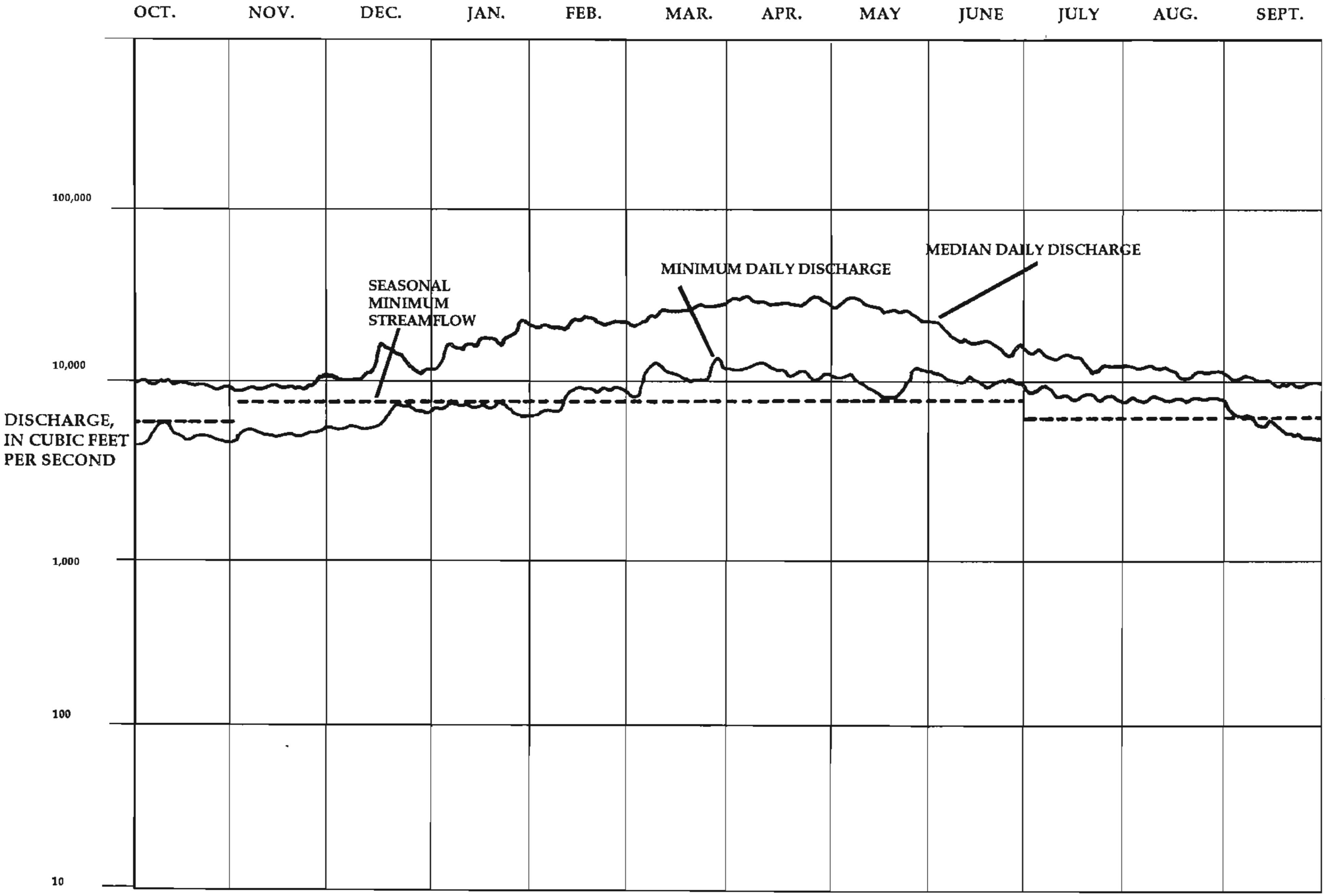


FIGURE 3-7
COMPARISON OF SEASONAL MINIMUM STREAMFLOW WITH MINIMUM AND MEDIAN DAILY DISCHARGE OF BAYOU METO NEAR LONOKE FOR THE PERIOD OF RECORD(1955-86)

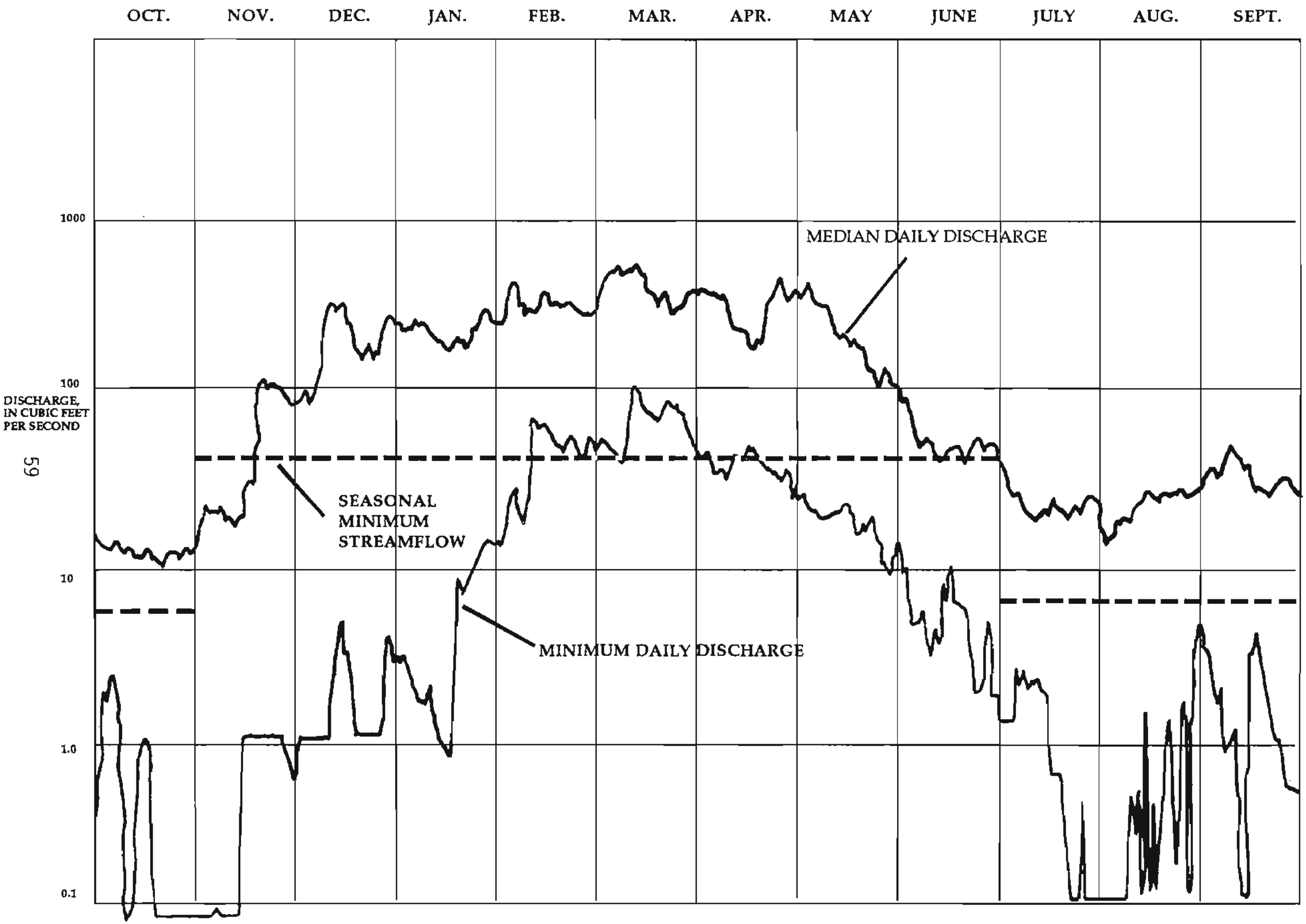


TABLE 3-13

PERCENT OF TIME SEASONAL MINIMUM STREAMFLOW HAS BEEN EXCEEDED DURING THE PERIOD OF RECORD FOR SELECTED GAGING STATIONS IN THE EASTERN ARKANSAS BASIN

STATION NAME	STATION NUMBER	PERCENT OF TIME SEASONAL MINIMUM STREAMFLOW HAS BEEN EXCEEDED DURING THE PERIOD OF RECORD		
		NOV-MAR	APR-JUN	JUL-OCT
St. Francis River at St. Francis	07040100	89	95	>99
St. Francis River at Lake City	07040450	92	>99	98
Right hand chute of Little River at Riverv	07046600	92	100	98
St. Francis River Floodway near Marked	07047000	79	91	53
St. Francis River at Marked Tree	07047500	90	100	96
Tyronza River near Tyronza	07047600	82	99	98
St. Francis River at Parkin	07047800	97	100	99
St. Francis Bay at Riverfront	07047900	82	94	80
L'Anguille River near Colt	07047942	84	84	84
L'Anguille River at Palestine	07047950	77	77	86
Cypress Bayou near Beebe	07076850	76	53	36
White River at DeValls Bluff	07077000	93	>99	98
Cache River at Egypt	07077380	76	81	92
Cache River at Patterson	07077500	77	89	98
Bayou DeView at Morton	07077700	70	66	66
White River at Clarendon	07077800	92	>99	98
Big Creek at Poplar Grove	07077950	85	80	86
Bayou Meto near Lonoke	07264000	81	80	83

Safe Yield

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to define the safe yield of streams and rivers in Arkansas. The safe yield of a stream or river is defined as the amount of water that is available on a dependable basis which could be used as a surface-water supply.

Seasonal and annual variability of streamflow affect the dependability of water available for development. Flow-duration curves, which show the percentage of time that specified discharges have been equaled or exceeded indicate the dependability of streamflow available at a particular location based on the period of record. As previously discussed, flow-duration curves for streams in the Eastern Arkansas Basin were developed at gaging station locations with the data summarized in Table 3-3. To quantify the safe yield of streams in the basin, the amount of water available on a dependable basis has been designated as the discharge which has been equaled or exceeded 95 percent of the time for the available period of record. This flow represents the discharge which can be expected at selected stream locations on a dependable basis, however, not all of this flow is actually available for use. Minimum streamflows represent discharge that is not available for use. Therefore, the safe yield of a stream or river is defined as the discharge which can be expected 95 percent of the time minus the discharge necessary to maintain the minimum flow in the stream during the low-flow season (July-October).

The safe yield of streams at selected gaging stations is summarized in Table 3-14. The designation of safe yield for some streams such as the L'Anguille River, Bayou DeView, and Bayou Meto is not applicable since the minimum streamflow is greater than the 95 percent flow. This indicates that, at times during the year, water is not available in these streams for other uses and some type of streamflow storage would be required at these locations to provide a sustained yield.

Potential For Development

Although most streams in the Eastern Arkansas Basin have relatively small safe yields, development of surface water storage impoundments could significantly increase dependable yields from streams in the basin. The seasonal variability in streamflow could be compensated for by storing water during high-flow periods and releasing it during low-flow periods.

The amount of water that is potentially available for future development at selected locations in the Eastern Arkansas Basin is presented in Table 3-15. In order to estimate the seasonal potential development for streams in the basin, the quantity of water necessary to satisfy minimum seasonal instream flow requirements was subtracted from the mean seasonal discharge. The remainder of the water is potentially available for development at the specified locations. The annual potential development in Table 3-15 was computed by totaling the flow available during the three seasons.

TABLE 3-14

SAFE YIELD OF STREAMS AT SELECTED GAGING STATIONS

LOCATION NUMBER	LOCATION NAME	FLOW (CFS) WHICH WAS EQUALLED OR EXCEEDED 95% OF THE TIME	MINIMUM STREAMFLOW JUL - OCT (CFS)	SAFE YIELD (CFS)
07356000	OUACHITA RIVER NR. MOUNT IDA	20	22.8	N/A
07356500	SOUTH FORK OUACHITA RIVER AT MOUNT IDA	2.9	2.8	0.1
07357501	OUACHITA RIVER AT BLAKELY MOUNTAIN DAM	20	126	N/A
07359500	OUACHITA RIVER NR. MALVERN	308	256	52
07359800	CADDO RIVER NR. ALPINE	29	13.1	15.9
07359910	CADDO RIVER AT DEGRAY REGULATING DAM	141	130	11.0
07360000	OUACHITA RIVER AT ARKADELPHIA	500	181	319
07360501	LITTLE MISSOURI RIVER AT NARROWS DAM	10	35.6	N/A
07360800	MUDDY FORK CREEK NR. MURFREESBORO	0.0	5.0	N/A
07361000	LITTLE MISSOURI RIVER NR. MURFREESBORO	18	41.2	N/A
07361500	ANTOINE RIVER AT ANTOINE	0.5	7.5	N/A
07361600	LITTLE MISSOURI RIVER NR. BOUGHTON	63	53.7	9.3
07362000	OUACHITA RIVER AT CAMDEN	875	576	299

TABLE 3-15

SEASONAL AND ANNUAL POTENTIAL DEVELOPMENT FOR STREAMS AT SELECTED LOCATIONS IN THE EASTERN ARKANSAS BASIN

STATION NAME	MEAN SEASONAL DISCHARGE (cfs) NOV-MAR	SEASONAL POTENTIAL (cfs)	SEASONAL DEVELOPMENT (mgd)	MEAN SEASONAL DISCHARGE (CFS) APR-JUN	SEASONAL POTENTIAL (cfs)	SEASONAL DEVELOPMENT (mgd)	MEAN SEASONAL DISCHARGE (cfs) JUL-OCT	SEASONAL POTENTIAL (cfs)	SEASONAL DEVELOPMENT (mgd)	ANNUAL POTENTIAL (cfs)	ANNUAL DEVELOPMEN (mgd)
TYRONZA RIVER NEAR TYRONZA	570	513	332	513	462	299	185	156	101	1131	732
ST. FRANCIS RIVER AT PARKIN	3192	2873	1857	3592	3233	2089	1591	1314	849	7420	4795
ST. FRANCIS BAY AT RIVERFRONT	6532	5879	3800	8100	7290	4712	1445	1301	841	14470	9353
L'ANGUILLE RIVER AT THE MOUTH	1952	1757	1136	1600	1440	931	542	488	315	3685	2382
CACHE RIVER AT PATTERSON	1778	1600	1034	1563	1407	909	390	351	227	3358	2170
BAYOU DEVIEW AT MORTON	791	712	460	572	515	333	177	159	103	1386	896
BIG CREEK AT POPLAR GROVE	877	789	510	947	852	551	204	184	119	1825	1180
WHITE RIVER AT THE MOUTH	32850	23200	14990	45140	35490	22940	17100	7450	4815	66140	42740
BAYOU METO NEAR LONOKE	414	373	241	406	365	236	65.0	58.5	37.8	796	515
ARKANSAS RIVER AT THE MOUTH	51420	46280	29910	73970	66570	43020	19910	16910	10930	129800	83880

(1) Seasonal potential development = mean seasonal discharge - minimum seasonal instream flow requirements.

(2) Estimated

Approximately 143,000 MGD of water is available annually for development in the Eastern Arkansas Basin as estimated by totaling the potential flow available at the following locations: St. Francis River at Parkin, St. Francis Bay at Riverfront, L'Anguille River at the mouth, White River at the mouth, and Arkansas River at the mouth. Of the total amount of flow available for development in the basin, about 88 percent is available from the Arkansas and White Rivers. Due to the seasonal variability of streamflow in the basin as shown in Table 3-15, the water available for use must be stored during the high-flow winter months for later use during the irrigation season.

Potential Site Locations

The previous computations indicate that a large volume of water is available for development in the Eastern Arkansas Basin. Due to the topography of the basin, however, there are no suitable sites for construction of large-scale impoundments to store the available water. There is the potential for development of some small surface-water reservoirs at locations on Crowleys Ridge in the northern part of the basin. Hines and others <26> identified 19 potential reservoir sites on Crowleys Ridge. Information regarding the location, storage capacity, and draft for these potential sites is summarized in Table 3-16. The total storage capacity for all the reservoir sites is only about 14,000 acre-feet, but these reservoirs have the potential to provide a year-round water supply on streams that would not otherwise provide sufficient water during low-flow conditions.

TABLE 3-16

POTENTIAL RESERVOIR SITES ON CROWLEYS RIDGE FOR SURFACE-WATER SUPPLY.

(Reservoir sites, storage capacity, and drainage area furnished by Soil Conservation Service, U.S. Dept. of Agriculture.)

STREAM NAME	DAMSITE		STORAGE CAPACITY, acre-ft	DRAINAGE AREA square miles	ESTIMATED AVERAGE ANNUAL RUNOFF acre-ft	DRAFT cubic feet per second
POLLARD (HORSE) CREEK TRIBUTARY	21N-8E-NW	sec. 29	449	1.53	1470	0.89
POLLARD CREEK (HORSE CREEK)	21N-8E-NW	sec. 32	846	2.56	2460	1.66
HOUSMAN CREEK	21N-7E-NE	sec. 36	399	1.80	1730	0.88
SALES CREEK	21N-7E-SE	sec. 27	784	2.58	2480	1.64
SOUTH FORK BIG CREEK TRIBUTARY	20N-7E-NW	sec. 11	651	2.18	2090	1.30
SOUTH FORK BIG CREEK TRIBUTARY	20N-7E-NW	sec. 14	419	1.43	1370	0.83
SOUTH FORK BIG CREEK	20N-7E-SW	sec. 23	378	1.29	1240	0.75
BIG CREEK TRIBUTARY	20N-6E-SW	sec. 35	375	1.28	1230	0.75
BIG CREEK TRIBUTARY	19N-6E-SE	sec. 1	730	2.40	2300	1.52
BIG CREEK TRIBUTARY	19N-7E-NE	sec. 7	609	2.04	1960	1.22
JOHNSON CREEK	19N-6E-NW	sec. 15	639	2.14	2050	1.27
DART CREEK	19N-6E-NW	sec. 21	452	1.54	1480	0.90
MILL CREEK TRIBUTARY	19N-6E-N	sec. 29	346	1.18	1130	0.69
MILL CREEK	19N-6E-SW	sec. 29	475	1.62	1560	0.94
MILL CREEK TRIBUTARY	19N-6E-SW	sec. 30	311	1.06	1020	0.62
BIG CREEK	18N-5E-NE	sec. 12	609	2.04	1960	1.22
SUGAR CREEK TRIBUTARY	17N-4E-SW	sec. 12	888	6.31	6060	2.18
SUGAR CREEK	17N-4E-SW	sec. 14	2014	10.36	9950	4.67
POPLAR CREEK	16N-4E-SW	sec. 17	2362	7.03	6750	4.57
TOTAL			13736	52.37	50290	28.50

(1) Permissible rate of withdrawal on a day to day basis, 20 yr frequency (supply will be deficient on the average of once in 20 yrs.)

NOTE - 1 cubic foot per second = 0.646 million gallons per day, 448.8 gallons per minute or 1.98 acre-ft per day.

SOURCE: Modified from Hines and others, 1972 <26>

Surface Water Use

Water withdrawn from surface water sources such as streams, rivers, and ponds in the 16-county study area in eastern Arkansas totaled 362 million gallons per day (MGD) in 1985. Approximately 60 percent of the total surface water use in the study area occurred in 2 counties. Surface water withdrawals were highest in Arkansas County totaling approximately 157 MGD, while about 63 MGD of surface water was withdrawn for use in Prairie County. <27>

Surface waters in the eastern Arkansas area were used for two primary purposes in 1985. About 85 percent (307 MGD) of the surface water withdrawn was used for the irrigation of crops in the basin. Fifteen percent (55 MGD) was used for non-irrigation agricultural purposes such as fish farming and livestock. <27> Some surface water in the study area was also withdrawn for power generation. However, water used in the production of thermoelectric and hydroelectric power is a nonconsumptive use because the majority of the water is not permanently removed from the watercourse. Therefore, water use for power generation is not included in the current (1985) consumptive water use figures.

Excess Streamflow

Excess streamflow (defined in Section 5 of Act 1051 of 1985) is twenty-five percent of that amount of water available on an average annual basis above the amount required to satisfy the existing and projected water needs of the basin. In order to determine the excess streamflow in the Eastern Arkansas Basin, the amount of water in the streams and rivers on an average annual basis was first calculated for the three major sub-basins in the study area (Arkansas, White, and St. Francis), based on U. S. Geological Survey streamflow data. The mean monthly discharges at the mouth of the Arkansas River and at the mouth of the White River were estimated based on streamflow data for the gaging stations which are closest to the mouth. An estimate for the mean annual discharge at the mouth of the St. Francis River was not calculated because streamflow data for the most downstream gaging stations (Parkin and Riverfront) could not be extrapolated to the mouth. The drainage areas at these two sites are indeterminate, therefore, the method of adjusting streamflow data based on a ratio of the drainage areas could not be used. A conservative estimate of the surface-water yield from the St. Francis River sub-basin was calculated by summing the mean annual discharges for the L'Anguille River at the mouth, the St. Francis River at Parkin, and St. Francis Bay at Riverfront. The sum of the estimated mean annual discharges for the three major sub-basins indicated a surface-water yield of approximately 62.6 million acre-feet of water from the streams and rivers of the Eastern Arkansas Basin on an average annual basis.

To determine the excess streamflow in the basin, the surface-water yield of 62.6 million acre-feet must be adjusted to account for the water needed to satisfy existing water needs for instream flow requirements. Since the instream flow requirements are not additive, the highest instream need represents the amount of water required to satisfy all existing instream needs. The annual instream flow requirements for fish and wildlife were previously identified in the Current Available Streamflow section of the report as the governing instream need for the streams in the basin that were investigated. Therefore, to determine the amount of water required to satisfy instream flow requirements in the basin, the annual instream flow requirements for fish and wildlife for the following locations from Table 3-10 were totaled: St. Francis River at Parkin, St. Francis Bay at Riverfront, L'Anguille River at the mouth, White River at the mouth, and Arkansas River at the mouth. On an average annual basis, 53,900 cfs or approximately 39.1 million acre-feet of water is necessary to satisfy instream flow requirements in the basin.

Projected surface-water needs of the basin must also be satisfied prior to determination of the amount of water that is available for other uses. In 1982, the total water use of the basin (ground water and surface water) amounted to approximately 4.5 million acre-feet <67>. It has been estimated that by the year 2030 approximately 5.5 million acre-feet of water will be required to meet the needs of water users in the basin <67>. It has been assumed that surface water sources will have to supply the additional 1.0 million acre-feet of water necessary to satisfy the increased demand for water in the future because of the ground water supply problems that currently exist in the Eastern Arkansas Basin. In fact, ground water withdrawals in the basin should be reduced by approximately 0.5 million acre-feet to alleviate ground water overdraft which is a serious problem at the present time in this basin. Therefore, it was estimated that approximately 1.5 million acre-feet of water will be necessary for future surface-water needs in the basin.

In addition to accounting for the projected surface water needs of users in the Eastern Arkansas Basin, it has been assumed that the projected surface water use and the computed excess streamflow for the Arkansas River Basin and the Upper White River Basin represent water that will be unavailable for downstream water users in the Eastern Arkansas Basin. Therefore, the projected water needs and computed excess streamflow for the Arkansas River Basin (0.6 and 2.7 million acre-feet, respectively <54>) and the projected water needs and computed excess streamflow for the Upper White River Basin (0.3 and 1.7 million acre-feet, respectively <55>) must be subtracted from the surface-water yield for the Eastern Arkansas Basin.

The available surface water in the Eastern Arkansas Basin was calculated by subtracting the flow necessary to satisfy instream flow requirements (39.1 million acre-feet); projected surface-water needs of the basin (1.5 million acre-feet); and projected surface-water needs and computed excess streamflow of the upstream Arkansas and White River Basins (0.9 and 4.4 million acre-feet, respectively) from the 62.6 million acre-feet of water in the basin resulting in 16.7 million acre-feet of available water. According to Act 1051 of 1985, twenty-five percent of the 16.7 million acre-feet of available water, or 4.2 million acre-feet, is excess surface water in the Eastern Arkansas Basin which is available on an average annual basis for other uses, such as interbasin transfer. Due to streamflow variability in the basin, the majority of the excess surface water is available from the Arkansas and White Rivers during the high-flow period of January through May.

Streamflow Water Quality

Water-quality data are collected in the Eastern Arkansas Basin primarily by the U. S. Geological Survey and the Arkansas Department of Pollution Control and Ecology. Locations of 20 water-quality data collection sites are shown in Figure 3-8 and include: 4 sites on the St. Francis River; 3 sites on the Cache River, Bayou DeView, and White River; 2 sites on the L'Anguille River, Bayou Meto, and the Arkansas River; and 1 site on the Tyronza River. There are many additional sites in the basin where water-quality data have been collected, however, the sites selected are located on the major rivers in the basin and have relatively long-term records available for analysis.

Water-Quality Summary

Water-quality data that have been collected for several common constituents such as turbidity, dissolved oxygen, hardness, chloride, sulfate, and total dissolved solids were statistically summarized for the 20 sites in Figure 3-8 with the results compiled in Table 3-17. In order to characterize the streamflow water-quality conditions in the basin, these data were compared with the water-quality standards for eastern Arkansas streams, as recommended by the ADPC&E in Regulation #2 <2>. Analysis of these data indicates that streamflow in the Eastern Arkansas Basin is often very turbid, moderately mineralized, and oxygen deficient.

Turbidity concentrations, which indicate the amount of suspended particulate matter in streamflow, were often extremely high in eastern Arkansas streams. For example, the turbidity standard recommended by the ADPC&E for Bayou Meto and the Tyronza River is 75 NTU <2>, however, concentrations as high as 2000 NTU and 2700 NTU have been measured at Bayou Meto near Bayou Meto and Tyronza River near Twist, respectively. Comparison of the turbidity data in Table 3-17 with the recommended standards indicates that turbidity concentrations have frequently exceeded standards at all sampling stations in the basin.

Dissolved oxygen concentrations of streamflow in the Eastern Arkansas Basin are extremely variable. For instance, dissolved oxygen at Bayou DeView near Gibson has ranged from 0.0 to 14.5 mg/L for measurements made during the period of record.. The variability in dissolved oxygen concentrations at several other locations in the basin is shown graphically in Figure 3-9. Comparison of the data in Figure 3-9 and Table 3-17 with the recommended minimum dissolved oxygen concentration of 5.0 mg/L <2> shows that all samples at all stations on the White and Arkansas Rivers contained dissolved oxygen concentrations higher than the 5.0 mg/L standard. However, concentrations at all other stations in the basin were less than the standard at times. In fact, approximately half of the dissolved oxygen measurements at Bayou Meto near Lonoke did not meet the state standard, and measurements made at the Cache River at Patterson and at Bayou DeView near Gibson indicated that dissolved oxygen at these locations had been totally depleted at times.

Nitrogen and phosphorus concentrations in streamflow have, at times, been extremely high in the Eastern Arkansas Basin. These high nutrient concentrations contribute to accelerated growth of nuisance aquatic vegetation and to eutrophication problems in streams and impoundments. The ADPC&E has not established standards for nutrients in streamflow, however, a

FIGURE 3-8
WATER-QUALITY DATA COLLECTION SITES

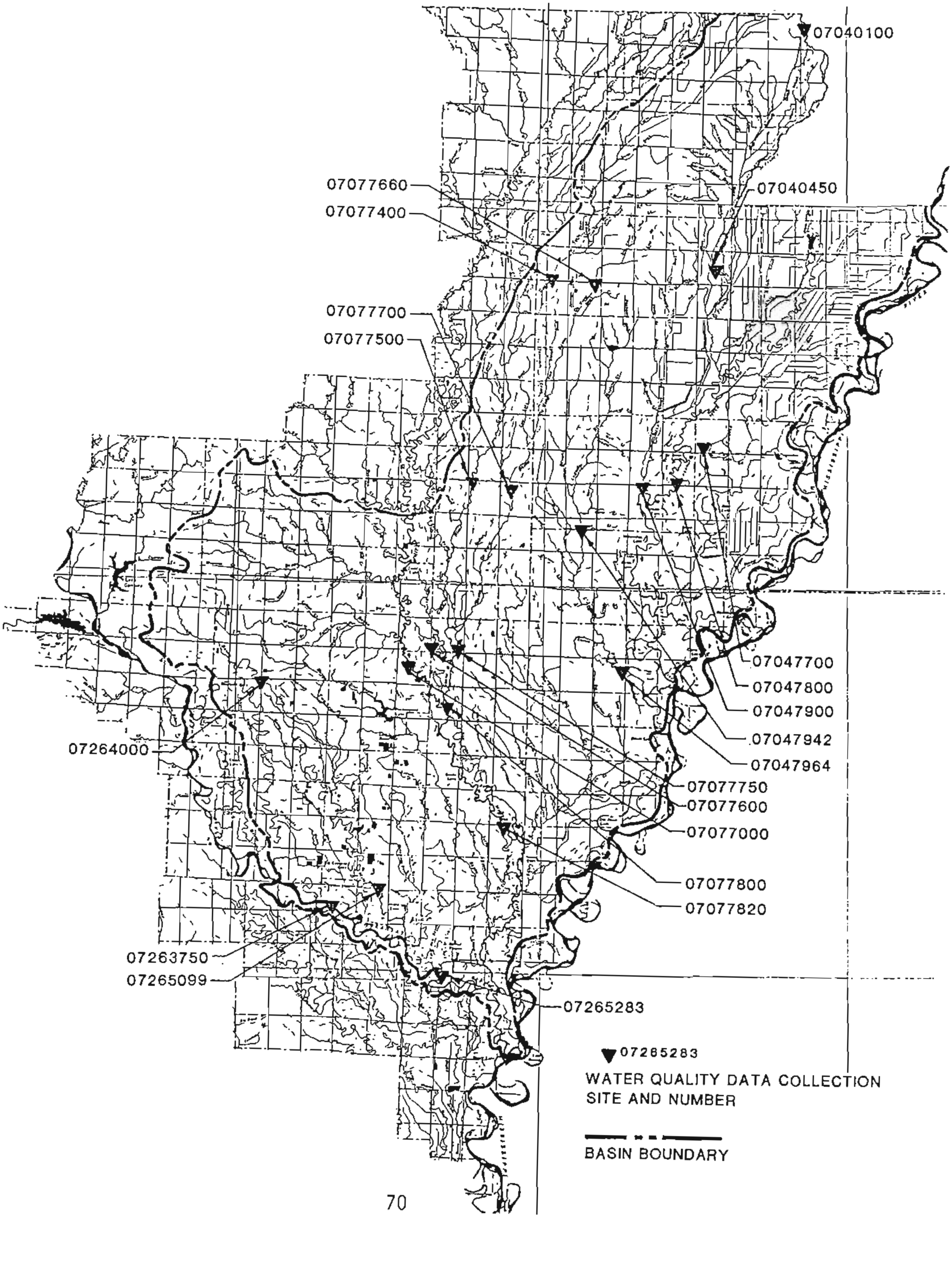


TABLE 3-17

Statistical summary of common constituents at selected sites in the Eastern Arkansas Basin
{mg/L =milligrams per liter' NTU-nephelometric turbidity; uS/cm=microsiemens per centimeter; five digit numbers in parentheses are STORET codes used for computer starage of data; < = constituent concentration less than detection limit; > = constituent concentration greater than indicated value.}

STATION NUMBER AND NAME		Turbidity (NTU) (00076)	Specific Conductance (uS/cm) (00095)	Dissolved oxygen (mg/L) (00300)	Alkalinity (mg/L as CaCO3) (00410)	Nitrogen NO2+NO3 (mg/L as N) (00630)	Phosphorus (mg/L as P) (00665)	Hardness (mg/L as CaCo3) (00900)	Chloride dissolved (mg/L as Cl) (00940)	Sulfate dissolved (mg/L as Cl) (00940)	Dissolved Solid (mg/L) (70300)
07040100 - ST. FRANCIS RIVER AT ST. FRANCIS	No. of Samples	33	160	193	52	54	116	80	126	124	89
(Period of record: 1970-83)	Max	340	363	13.2	180	0.49	1.9	180	31	27	468
	Min	7.5	65	4.5	34	<0.10	0.01	38	1.4	<1.0	55
	Median	30	192	8.8	73	0.10	0.13	89	5.5	9.6	120
07040450 - ST. FRANCIS RIVER AT LAKE CITY	No. of Samples	36	170	170	23	44	100	52	99	101	57
(Period of record: 1974-83)	Max	340	388	388	180	1.00	0.60	210	24	46	960
	Min	20	24	24	32	<0.10	<0.01	6	3.0	<1.0	106
	Median	40	210	210	107	0.10	0.18	94	6.5	10	164
07047700 - TYRONZA RIVER NEAR TWIST	No. of Samples	32	64	98	21	42	90	46	89	92	54
(Period of record: 1974-83)	Max	2700	739	14.0	280	2.3	1.85	360	150	110	502
	Min	9.5	43	3.5	28	<0.01	0.06	36	2.0	<1.0	134
	Median	50	462	7.8	210	0.08	0.26	210	7.5	32	306
07047800 - ST. FRANCIS RIVER AT PARKIN	No. of Samples	62	124	108	97	99	124	124	124	124	122
(Period of record: 1973-86)	Max	800	516	12.6	250	4.3	5.3	250	13	33	302
	Min	1.2	65	3.8	17	0.0	0.09	27	1.8	<5.0	43
	Median	78	310	7.2	139	0.40	0.32	140	6.1	18	189
07047900 - ST. FRANCIS BAY AT RIVERFRONT	No. of Samples	70	238	220	101	98	131	130	131	131	131
(Period of record: 1974-86)	Max	310	474	13.8	210	1.1	0.68	230	13	30	314
	Min	1.5	68	4.5	25	<0.10	0.04	27	<0.10	<1.0	55
	Median	58	244	8.4	93	0.17	0.21	100	5.9	14	147
07047942 - L'ANGUILLE RIVER NEAR COLT	No. of Samples	19	240	216	76	114	147	65	66	66	33
(Period of record: 1974-86)	Max	190	638	13.1	260	3.6	1.1	260	47	29	368
	Min	8.2	51	2.1	15	<0.10	0.03	17	1.9	<5.0	46
	Median	84	168	6.0	62	0.30	0.23	73	9.6	14	125
07047964 - L'ANGUILLE RIVER AT MARIANNA	No. of Samples	64	68	141	24	78	127	73	133	134	94
(Period of record: 1974-86)	Max	260	654	12.8	230	1.3	3.5	310	46	100	391
	Min	15	59	2.4	23	<0.01	0.07	25	2.5	2.0	102
	Median	70	175	6.8	95	0.28	0.27	74	11	12	188

TABLE 3-17

(continued)

Statistical summary of common constituents at selected sites in the Eastern Arkansas Basin

[mg/L=milligrams per liter; NTU=nephelometric turbidity units; uS/cm=microsiemens per centimeter; five digit numbers in parentheses are STORET codes used for computer storage of data; < = constituent concentration less than detection limit; > = constituent concentration greater than indicated value.]

Site	Statistic	Turbidity (NTU) (00076)	Specific Conductance (uS/cm) (00095)	Dissolved oxygen (mg/L) (00300)	Alkalinity (mg/L as CaCO3) (00410)	Nitrogen NO2+NO3 (mg/L as N) (00630)	Phosphorus (mg/L as P) (00665)	Hardness (mg/L as CaCO3) (00900)	Chloride dissolved (mg/L as Cl) (00940)	Sulfate dissolved (mg/L as SO4) (00945)	Dissolved Solids (mg/L) (70300)
07077000-White River at DeValls Bluff	No. of Samples	65	70	144	24	82	127	73	133	133	98
(Period of record: 1974-86)	Max	130	314	13.1	160	0.71	1.1	330	57	16	225
	Min	3.0	134	5.2	63	0.01	<0.01	11	2.5	<1.0	106
	Median	25	244	9.3	120	0.20	0.07	130	5.5	5.0	147
07077400-Cache River near Cash	No. of Samples	34	79	104	23	43	94	52	92	95	56
(Period of record: 1974-83)	Max	>1000	436	12.8	200	2.5	2.0	210	30	51	472
	Min	25	29	2.7	16	<0.05	0.01	8	3.0	<1.0	3
	Median	100	159	7.8	62	0.20	0.30	61	9.0	9.0	212
07077500-Cache River at Patterson	No. of Samples	28	116	105	92	110	116	115	116	116	81
(Period of record: 1974-86)	Max	330	449	13.6	200	1.1	0.59	180	20	26	242
	Min	17	44	0.0	7	<0.10	0.12	15	1.7	<5.0	41
	Median	94	128	6.9	40	0.32	0.22	43	6.6	9.6	104
07077600-Cache River at Brasfield	No. of Samples	32	82	112	26	48	100	51	99	99	65
(Period of record: 1974-83)	Max	200	435	12.7	164	1.2	0.45	190	55	22	302
	Min	10	51	3.2	5	0.04	0.02	16	3.5	<1.0	97
	Median	75	140	6.8	52	0.22	0.20	59	12	6.0	182
07077660-Bayou DeView near Gibson	No. of Samples	66	63	128	21	71	120	74	123	121	86
(Period of record: 1974-86)	Max	550	578	14.5	150	4.2	10.0	580	71	230	375
	Min	6.4	51	0.0	15	<0.05	0.08	13	2.5	<1.0	81
	Median	45	190	8.2	68	0.68	0.97	55	17	16	204
07077700-Bayou DeView at Morton	No. of Samples	28	116	105	91	110	116	116	116	116	77
(Period of record: 1974-86)	Max	430	463	11.9	196	1.0	0.94	200	28	34	275
	Min	17	49	1.6	7	<0.10	0.03	15	2.0	<5.0	49
	Median	93	147	6.2	42	0.27	0.24	44	8.6	13	120
07077750-Bayou DeView near Brasfield	No. of Samples	33	66	106	20	43	94	46	93	94	60
(Period of record: 1974-83)	Max	180	347	13.1	139	0.52	0.46	160	22	29	286
	Min	8.4	54	1.8	19	0.01	0.03	21	4.0	<1.0	109
	Median	50	130	6.0	43	0.09	0.21	50	10	7.0	154

TABLE 3-17

(continued)

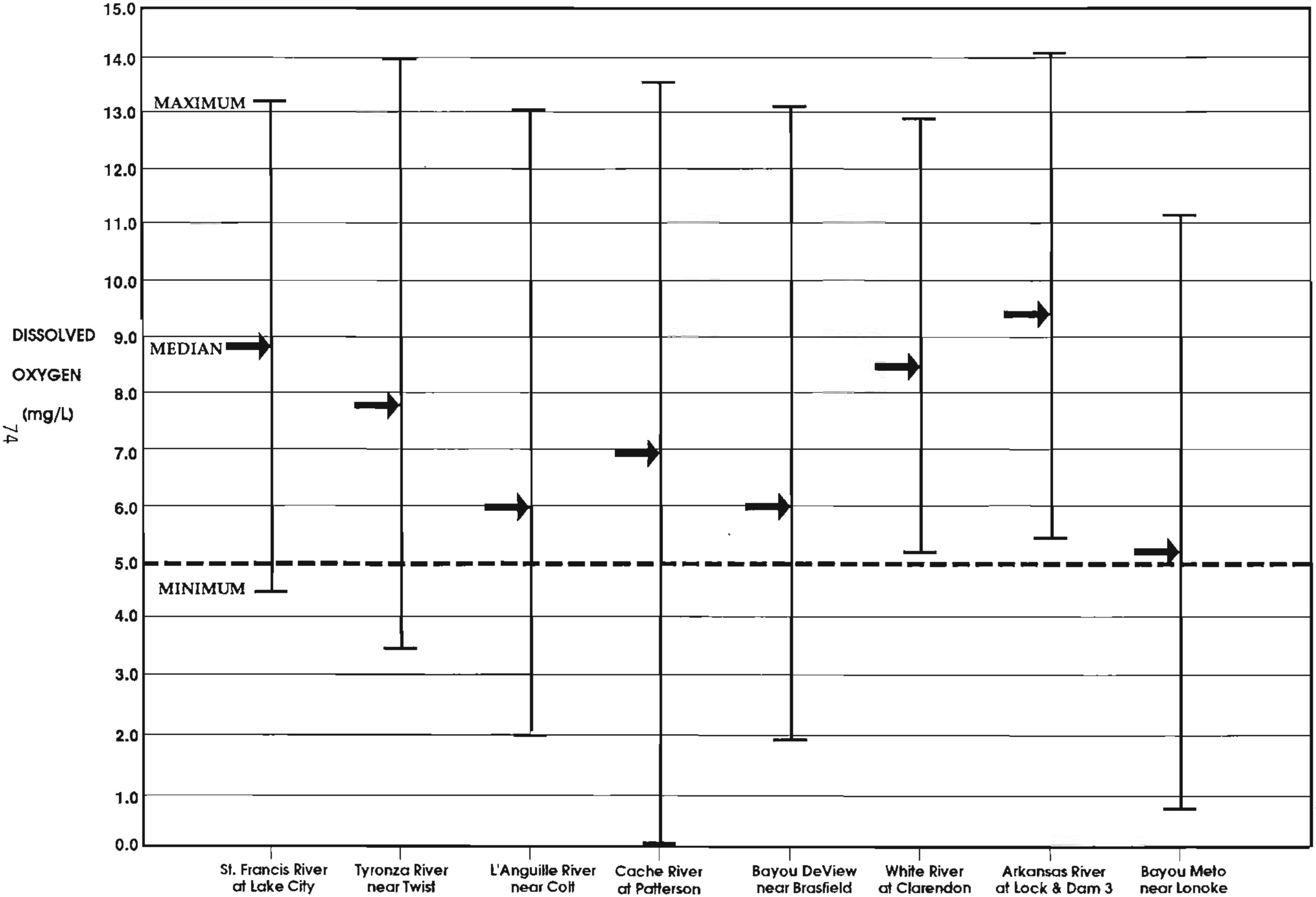
Statistical summary of common constituents at selected sites in the Eastern Arkansas Basin

[mg/L=milligrams per liter; NTU=nephelometric turbidity units; uS/cm=microsiemens per centimeter; five digit numbers in parentheses are STORET codes used for computer storage of data; < = constituent concentration less than detection limit; > = constituent concentration greater than indicated value.]

Site		Turbidity (NTU) (00076)	Specific Conductance (uS/cm) (00095)	Dissolved oxygen (mg/L) (00300)	Alkalinity (mg/L as CaCO3) (00410)	Nitrogen NO2+NO3 (mg/L as N) (00630)	Phosphorus (mg/L as P) (00665)	Hardness (mg/L as CaCO3) (00900)	Chloride dissolved (mg/L as Cl) (00940)	Sulfate dissolved (mg/L as SO4) (00945)	Dissolved Solids (mg/L) (70300)
07077800-White River at Clarendon	No. of Samples	59	159	138	107	93	142	112	111	111	107
(Period of record: 1971-86)	Max	100	365	12.8	164	5.1	1.8	170	28	24	192
	Min	1.0	86	5.3	30	<0.10	<0.01	48	2.4	<5.0	68
	Median	26	244	8.4	110	0.20	0.08	120	4.7	7.0	134
07077820-White River at St. Charles	No. of Samples	68	73	148	27	86	136	81	131	137	98
(Period of record: 1974-86)	Max	110	333	13.6	170	0.85	0.33	270	25	12	185
	Min	2.0	120	5.5	58	<0.01	0.02	36	2.5	<1.0	61
	Median	30	235	8.7	110	0.20	0.09	120	6.0	6.0	144
07263750-Arkansas River at Lock & Dam 3	No. of Samples	35	81	108	22	49	105	52	96	101	58
(Period of record: 1974-83)	Max	150	1150	14.1	107	0.79	0.76	250	280	87	598
	Min	2.8	167	5.5	31	<0.01	0.02	24	0.5	7.0	67
	Median	20	493	9.3	74	0.33	0.12	100	86	39	316
07264000-Bayou Meto near Lonoke	No. of Samples	33	78	103	18	44	100	47	91	97	56
(Period of record: 1974-83)	Max	100	1530	11.2	123	0.98	0.85	250	550	130	1120
	Min	3.0	39	0.8	18	0.19	0.08	11	9.0	<1.0	77
	Median	35	276	5.2	62	0.50	0.25	60	38	12	163
07265099-Bayou Meto near Bayou Meto	No. of Samples	61	68	134	22	73	125	77	121	126	86
(Period of record: 1974-86)	Max	2000	618	11.4	110	0.58	0.95	220	160	43	390
	Min	8.0	69	2.5	19	<0.01	0.03	12	4.5	<1.0	56
	Median	50	164	6.0	41	0.23	0.22	49	16	10	155
07265283-Arkansas River at Dam No. 2	No. of Samples	54	118	113	55	38	110	74	105	102	67
near Gillett	Max	80	1260	13.9	115	2.7	1.3	170	310	100	540
(Period of record: 1974-86)	Min	<1.0	157	5.8	36	0.0	0.02	23	21	10	139
	Median	22	496	8.8	78	0.42	0.11	120	78	39	287

SOURCE: U. S. Geological Survey File Data

FIGURE 3-9


DISSOLVED
OXYGEN
(mg/L)
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
MAXIMUM
MEDIAN
MINIMUM
St. Francis River at Lake City
Tyronza River near Twist
L'Anguille River near Colt
Cache River at Patterson
Bayou DeView near Brasfield
White River at Clarendon
Arkansas River at Lock & Dam 3
Bayou Meto near Lonoke

concentration of 0.1 mg/L of total phosphorus in streams has been suggested as a guideline to minimize eutrophication problems. <2> Data compiled in Table 3-17 show that samples collected at all stations often contained phosphorus concentrations higher than 0.1 mg/L.

The ADPC&E has recommended water-quality standards for chloride, sulfate, and total dissolved solids concentrations on a stream-specific basis. <2> Comparison of the data in Table 3-17 with the appropriate state standards for each of the streams indicates that water samples collected at all stations have, at times, exceeded at least one or more of these standards.

In addition to the water-quality violations previously noted, the ADPC&E has documented high fecal coliform bacteria concentrations in many areas of the basin which often exceed state-recommended standards. <1> Due to the frequent violations of state water-quality standards in the basin, degraded water-quality conditions of streams in the Eastern Arkansas Basin often restrict the use of streamflow for some purposes.

Suitability of Surface Water for Irrigation Use

The major use of surface water in the Eastern Arkansas Basin is for agricultural purposes, particularly irrigation. Streamflow water quality data were analyzed to ascertain the suitability of the surface waters in the basin for irrigation use. Data for several common constituents and 10 trace metals were summarized for the 20 sites in Figure 3-8 with the results compiled in Table 3-18. Constituent limits for irrigation water, as recommended by the National Academy of Engineering Committee <33>, are also included in Table 3-18 for comparison purposes.

Generally, the streams and rivers in the Eastern Arkansas Basin are satisfactory sources of irrigation water for use on most crops in the area. However, comparison of the data in Table 3-18 with the standards for irrigation water shows that some constituents (particularly trace metals) have periodically exceeded the recommended limits. Concentrations of cadmium, copper, and selenium have, at times, exceeded recommended limits at several locations in the basin while iron and manganese concentrations have frequently exceeded the standards at all sampling locations. The other trace metals summarized in Table 3-18 (arsenic, chromium, cobalt, lead, and zinc) did not exceed the recommended concentrations in any of the samples collected at the 20 stations. In fact, concentrations of these trace elements were often less than the detection limits.

The pH of streamflow in the Eastern Arkansas Basin was within the recommended range of 4.5 to 9.0 at all sampling locations. Median pH values for all stations in the basin ranged from 7.2 to 8.0 indicating that slightly alkaline streamflow conditions often exist.

Concentrations of fecal coliform bacteria in streamflow in the Eastern Arkansas Basin are extremely variable. For example, fecal coliform concentrations at Bayou DeView near Gibson have ranged from less than 100 colonies/100 ml to 870,000 colonies/100 ml for samples collected during the period of record. Comparison of the fecal coliform data in Table 3-18 with the recommended standard of 1000 colonies/100 ml shows that water at all sampling stations except the White River at St. Charles has exceeded the recommended limit at

TABLE 3-18

Analyses of surface water and recommended limits for constituents in irrigation water at selected sites in the Eastern Arkansas Basin
[ug/L=micrograms per liter; mg/L=milligrams per liter; five digit numbers in parentheses are STORET parameter codes used for computer storage of data; < = constituent concentration less than detection limit.]

Station		Arsenic, total (ug/L as As) (01002)	Cadmium total (ug/L as Cd) (01027)	Chromium, total (ug/L as Cr) (01034)	Cobalt, total (ug/L as Co) (01037)	Copper, total (ug/L as Cu) (01042)	Iron, total (ug/L as Fe) (01045)	Lead, total (ug/L as Pb) (01051)	Manganese, total (ug/L as Mn) (01055)	Zinc, total (ug/L as Zn) (01092)	Selenium, total (ug/L as Se) (01147)	pH (standard units) (00400)	Fluoride, dissolved (mg/L as F) (00950)	Coliform, fecal (cols./100ml) (31616)	Dissolved Solids (mg/L) (70300)
07040100-St. Francis River at St. Francis (Period of record: 1970-83)	No. of Samples	39	16	50	---	93	52	43	51	81	22	191	34	124	89
	MAX	10	<20	11	---	520	27,000	300	1,800	650	<10	8.5	0.7	11,000	468
	MIN	<10	<20	<5	---	<20	140	<20	93	<20	<10	5.9	<0.1	<200	55
	MEDIAN	<10	<20	<5	---	<20	2,300	<20	340	30	<10	7.7	0.1	<200	120
07040450-St. Francis River at Lake City (Period of record: 1974-83)	No. of Samples	54	84	60	---	102	60	45	64	90	25	194	---	100	57
	MAX	10	<20	11	---	170	15,000	<20	910	110	14	8.8	---	7,200	560
	MIN	<10	<20	<5	---	<20	400	<20	32	<20	<10	6.1	---	<13	106
	MEDIAN	<10	<20	<5	---	<20	3,600	<20	340	20	<10	7.7	---	82	164
07047700-Tyronza River near Twist (Period of record: 1974-83)	No. of Samples	52	81	57	---	180	63	53	66	89	21	95	---	83	54
	MAX	16	<20	48	---	340	30,000	960	1,000	350	<10	8.3	---	4,200	502
	MIN	<10	<20	<20	---	<20	30	<20	22	<20	<10	6.7	---	<13	134
	MEDIAN	<10	<20	<20	---	<20	4,400	<20	300	40	<10	7.9	---	120	306
07047800-St. Francis River at Parkin (Period of record: 1973-86)	No. of Samples	35	37	37	37	37	37	37	37	37	37	123	124	31	122
	MAX	10	<20	40	<100	120	20,000	<200	670	300	9	8.4	1.6	3,000	302
	MIN	2	<20	<20	<100	<20	1,100	<200	120	10	<1	5.9	<0.1	20	43
	MEDIAN	5	<20	<20	<100	20	7,600	<200	320	60	<1	7.8	0.2	210	189
07047900-St. Francis Bay at Riverfront (Period of record: 1973-86)	No. of Samples	36	37	37	37	37	37	37	36	36	35	239	131	34	131
	MAX	20	<20	30	<100	110	19,000	<200	610	170	7	8.6	0.6	4,600	314
	MIN	<1	<20	<20	<100	<20	780	<200	70	<20	<1	5.6	<0.1	<33	55
	MEDIAN	3	<20	<20	<100	<20	3,500	<200	220	50	<1	7.8	0.2	50	147
RECOMMENDED LIMITS FOR CONSTITUENTS IN IRRIGATION WATER <32>	For waters used continuously on all soils	100	10	100	50	200	5,000	5,000	200	2,000	20		1.0		
												4.5-9.0		1,000	500
	For use up to 20 years on fine textured soils of pH 6.0 to 8.5	2,000	50	1,000	5,000	5,000	20,000	10,000	10,000	10,000	20		15.0		

TABLE 3-18

(continued)

Analyses of surface water and recommended limits for constituents in irrigation water at selected sites in the Eastern Arkansas Basin (ug/L=micrograms per liter; mg/L=milligrams per liter; five digit numbers in parentheses are STORET parameter codes used for computer storage of data; < = constituent concentration less than detection limit.)

Site		Arsenic, total (ug/L as As) (01002)	Cadmium, total (ug/L as Cd) (01027)	Chromium, total (ug/L as Cr) (01034)	Cobalt, total (ug/L as Co) (01037)	Copper, total (ug/L as Cu) (01042)	Iron, total (ug/L as Fe) (01045)	Lead, total (ug/L as Pb) (01051)	Manganese, total (ug/L as Mn) (01055)	Zinc, total (ug/L as Zn) (01092)	Selenium, total (ug/L as Se) (01147)	pH (standard units) (00400)	Fluoride, dissolved (mg/L as F) (00950)	Coliform, fecal (cols./100ml) (31616)	Dissolved Solids (mg/L) (70300)
07047942-L'Anguille River near Colt (Period of record: 1971-86)	No. of Samples	14	15	15	13	15	15	15	15	15	15	238	66	57	33
	MAX	7	<20	20	<100	33	23,000	<200	1,200	80	9	8.4	1.9	31,000	368
	MIN	1	<20	<20	<100	<20	1,100	<200	130	<20	<1	6.2	<0.1	<7	65
	MEDIAN	3	<20	<20	<100	<20	2,000	<200	450	30	<1	7.4	0.2	230	125
07047964-L'Anguille River at Marianna (Period of record: 1974-86)	No. of Samples	66	127	91	---	134	64	76	68	121	38	143	---	128	94
	MAX	56	<20	30	---	91	20,000	66	4,900	510	34	8.4	---	42,000	391
	MIN	<10	<20	<5	---	<20	80	<10	<10	<20	<10	6.4	---	<10	182
	MEDIAN	<10	<20	<5	---	<20	4,800	<10	280	20	<10	7.3	---	130	188
07077000-White River at DeValls Bluff (Period of record: 1974-86)	No. of Samples	53	113	94	5	110	39	76	42	95	28	144	5	133	98
	MAX	16	20	30	<100	120	9,000	<200	1,100	180	16	8.6	0.1	1,600	225
	MIN	<6	<20	<20	<100	<20	190	<200	<27	<20	<10	7.2	0.1	<7	106
	MEDIAN	<6	<20	<20	<100	<20	1,200	<200	110	<20	<10	8.0	0.1	40	147
07077400-Cache River near Cash (Period of record: 1974-83)	No. of Samples	56	84	63	---	99	59	55	62	87	26	101	---	91	56
	MAX	24	20	30	---	230	39,000	280	1,800	460	<10	8.7	---	4,600	472
	MIN	<6	<20	<5	---	<20	280	<20	31	<20	<10	6.5	---	<50	3
	MEDIAN	<6	<20	<5	---	<20	4,100	<20	320	40	<10	7.5	---	97	212
07077500-Cache River at Patterson (Period of record: 1974-86)	No. of Samples	15	15	15	15	15	15	15	15	15	15	116	116	34	83
	MAX	7	<20	30	<100	27	10,000	<200	1,300	360	1	8.2	0.5	1,200	282
	MIN	1	<20	<1	<100	<20	700	<200	70	<20	<1	6.4	<0.1	5	41
	MEDIAN	2	<20	<1	<100	<20	2,200	<200	310	30	<1	7.3	0.1	140	184
RECOMMENDED LIMITS FOR CONSTITUENTS IN IRRIGATION WATER <32>	For waters used continuously on all soils	100	10	100	50	200	5,000	5,000	200	2,000	20	4.5-9.0	1.0	1,000	500
	For use up to 20 years on fine textured soils of pH 6.0 to 8.5	2,000	50	1,000	5,000	5,000	20,000	10,000	10,000	10,000	20		15.0		

TABLE 3-18

(continued)

Analyses of surface water and recommended limits for constituents in irrigation water at selected sites in the Eastern Arkansas Basin
[ug/L=micrograms per liter; mg/L=milligrams per liter; five digit numbers in parentheses are STORET parameter codes used for computer storage of data; < = constituent concentration less than detection limit.]

Site		Arsenic, total (ug/L as As) (01002)	Cadmium, total (ug/L as Cd) (01027)	Chromium, total (ug/L as Cr) (01034)	Cobalt, total (ug/L as Co) (01037)	Copper, total (ug/L as Cu) (01042)	Iron, total (ug/L as Fe) (01045)	Lead, total (ug/L as Pb) (01051)	Manganese, total (ug/L as Mn) (01055)	Zinc, total (ug/L as Zn) (01092)	Selenium, total (ug/L as Se) (01147)	pH (standard units) (00400)	Fluoride, dissolved (mg/L as F) (00950)	Coliform, fecal (cols./100ml) (31616)	Dissolved Solids (mg/L) (70300)
07077600-Cache River at Brasfield (Period of record: 1974-83)	No. of Samples	58	89	65	5	97	61	47	65	93	32	112	5	95	65
	MAX	15	<20	50	<100	280	9,300	<200	980	330	170	8.1	0.2	2,500	302
	MIN	<6	<20	<20	<100	<20	290	<200	22	<20	<10	6.6	0.1	<10	37
	MEDIAN	<6	<20	<20	<100	<20	3,400	<200	210	20	<10	7.3	0.1	60	182
07077660-Bayou DeView near Gibson (Period of record: 1974-86)	No. of Samples	49	119	89	---	135	61	71	64	115	24	130	---	119	85
	MAX	36	30	18	---	250	20,000	170	1,600	420	<10	9.0	---	870,000	375
	MIN	<6	<20	<5	---	<20	650	<10	<10	<20	<10	6.4	---	<100	81
	MEDIAN	<6	<20	<5	---	<20	3,600	<10	370	30	<10	7.4	---	400	284
07077700-Bayou DeView at Morton (Period of record: 1974-86)	No. of Samples	14	15	14	15	15	15	15	15	15	15	115	116	31	77
	MAX	5	<20	20	<100	21	7,400	<200	1,200	50	1	8.2	0.5	10,000	275
	MIN	2	<20	<1	<100	<20	850	<200	160	<20	<1	6.2	<0.1	50	49
	MEDIAN	2	<20	1	<100	<20	1,800	<200	440	30	<1	7.3	0.2	200	129
07077750-Bayou DeView near Brasfield (Period of record: 1974-83)	No. of Samples	49	89	61	---	96	61	52	64	93	23	106	---	59	60
	MAX	33	<20	30	---	230	9,600	880	8,000	290	19	8.2	---	1,800	225
	MIN	<6	<20	<20	---	<20	550	<10	23	<20	<10	6.6	---	<10	103
	MEDIAN	<6	<20	<20	---	<20	3,500	12	180	30	<10	7.2	---	60	154
07077800-White River at Clarendon (Period of record: 1971-86)	No. of Samples	38	38	38	38	38	38	38	38	36	39	155	111	54	107
	MAX	3	<20	40	<100	100	6,500	<200	370	150	1	8.8	0.3	12,000	182
	MIN	<1	<20	<20	<100	<20	440	<200	60	<20	<1	6.9	<0.1	<11	68
	MEDIAN	1	<20	<20	<100	<20	1,600	<200	140	30	<1	7.9	0.1	70	134
RECOMMENDED LIMITS FOR CONSTITUENTS IN IRRIGATION WATER <32>	For waters used continuously on all soils	100	10	100	50	200	5,000	5,000	200	2,000	20	4.5-9.0	1.0	1,000	500
	For use up to 20 years on fine textured soils of pH 6.0 to 8.5	2,000	50	1,000	5,000	5,000	20,000	10,000	10,000	10,000	20		15.0		

TABLE 3-18

(continued)

Analyses of surface water and recommended limits for constituents in irrigation water at selected sites in the Eastern Arkansas Basin
[ug/L=micrograms per liter; mg/L=milligrams per liter; five digit numbers in parentheses are STORET parameter codes used for computer storage of data; < = constituent concentration less than detection limit.]

Site		Arsenic, total (ug/L as As) (01002)	Cadmium, total (ug/L as Cd) (01027)	Chromium, total (ug/L as Cr) (01034)	Cobalt, total (ug/L as Co) (01037)	Copper, total (ug/L as Cu) (01042)	Iron, total (ug/L as Fe) (01045)	Lead, total (ug/L as Pb) (01051)	Manganese, total (ug/L as Mn) (01055)	Zinc, total (ug/L as Zn) (01092)	Selenium, total (ug/L as Se) (01147)	pH (standard units) (00400)	Fluoride, dissolved (mg/L as F) (00950)	Coliform, fecal (cols./100ml) (31616)	Dissolved Solids (mg/L) (70300)
07077820-White River at St. Charles (Period of record: 1974-86)	No. of Samples	66	96	92	5	100	33	74	34	90	38	143	5	137	38
	MAX	12	<20	30	<100	70	7,800	<200	340	40	<10	8.5	0.2	550	185
	MIN	<6	<20	<20	<100	<20	180	<200	27	<20	<10	7.2	0.1	<20	67
	MEDIAN	<6	<20	<20	<100	<20	1,400	<200	120	<20	<10	7.9	0.1	25	144
07263750-Arkansas River at Lock & Dam 3 (Period of record 1974-83)	No. of Samples	52	70	59	---	78	45	56	47	83	21	105	---	104	53
	MAX	28	<20	20	---	350	5,200	340	1,100	1,100	11	8.6	—	4,000	538
	MIN	<6	<20	<20	---	<20	130	<20	<27	<20	<10	7.0	---	<17	67
	MEDIAN	<6	<20	<20	---	<20	1,400	<20	120	30	<10	7.9	—	82	315
07264000-Bayou Meto near Lonoke (Period of record: 1974-83)	No. of Samples	49	75	54	---	98	56	40	58	88	21	104	---	32	55
	MAX	24	<20	20	---	140	6,300	70	1,500	320	<10	8.1	—	7,400	1,120
	MIN	<6	<20	<5	---	<20	260	<10	<10	<20	<10	6.2	---	<7	77
	MEDIAN	<6	<20	<5	---	<20	1,800	20	270	30	<10	7.2	---	140	163
07265099-Bayou Meto near Bayou Meto (Period of record: 1974-86)	No. of Samples	50	108	84	---	122	59	70	62	115	21	132	---	127	86
	MAX	19	<20	28	---	180	14,000	56	1,400	240	<10	8.3	---	4,200	398
	MIN	<6	<20	<5	---	<20	460	<10	<10	<20	<10	6.3	---	<13	56
	MEDIAN	<6	<20	<5	---	<20	2,900	<10	180	20	<10	7.2	---	64	155
07265283-Arkansas River at Dam No. 2 near Gillett (Period of record: 1974-86)	No. of Samples	40	45	40	13	56	56	42	58	57	13	116	55	50	67
	MAX	15	<20	20	<3	320	5,200	120	260	300	2	8.6	0.3	7,500	540
	MIN	<5	<20	<5	<3	<20	200	<10	53	<20	<1	7.0	0.1	<1	133
	MEDIAN	<5	<20	<5	<3	<20	1,100	<10	110	20	<1	7.9	0.2	45	287
RECOMMENDED LIMITS FOR CONSTITUENTS IN IRRIGATION WATER <327>	For Waters used continuously on all soils	100	10	100	50	200	5,000	5,000	200	2,000	20	4.5-9.0	1.0	1,000	500
	For use up to 20 years on fine textured soils of pH 6.0 to 8.5	2,000	50	1,000	5,000	5,000	20,000	10,000	10,000	10,000	20		15.0		

times. However, median fecal coliform concentrations at all sites were significantly lower than the recommended standard.Total dissolved solids concentrations at several locations in the basin have exceeded the 500 mg/L standard at times, but the majority of water samples at all sites contained dissolved solids concentrations well below 500 mg/L. The recommended 500 mg/L concentration for total dissolved solids represents the level at which no detrimental effects on crops and (or) soils are usually noticed. Waters containing dissolved solids concentrations greater than 500 mg/L can be used for irrigation but careful management practices should be followed <33>.

Comparison of the surface water quality data with the recommended standards for irrigation water provides some indication of the suitability of surface water in the Eastern Arkansas Basin for irrigation use. However, due to the interaction of chemical and physical processes between the irrigation water, the soils, and the crops, other factors in conjunction with the chemical composition of the water should also be investigated to determine the suitability of water for irrigation use. Some of these factors include: soil composition, soil-water interactions, climatological factors (rainfall distribution, temperature, radiation, humidity), irrigation methods (frequency and quantity of water applied), crop types, and ground water and surface water drainage systems. The composite effects of these and other factors govern the suitability and effectiveness of using available surface water in the Eastern Arkansas Basin for irrigation.

Pesticides

Water-quality samples collected in the Eastern Arkansas Basin by the USGS and the ADPC&E have been analyzed for the presence of pesticides at all locations shown in Figure 3-8 except for the data-collection site at St. Francis Bay at Riverfront. Water samples collected at these 19 sites during the past 10 to 15 years have been analyzed for many different pesticides including: aldrin; chlordane; DDT (and its metabolites DDE and DDD); dieldrin; endrin; heptachlor; heptachlor epoxide; lindane; methoxychlor; toxaphene; 2,4-D; silvex; 2,4,5-T; and endosulfan. Concentrations of these pesticides were compared with the ADPC&E's acute toxicity levels as specified in Regulation #2 <2> and with the National Academy of Science's recommended limits for pesticide concentrations for farm animal supplies <33> to determine if any areas of pesticide contamination exist in the basin. In the majority of samples analyzed, pesticide concentrations were less than the acute toxicity levels and the recommended limits, with many samples containing pesticide concentrations less than detection limits. However, water samples collected at Tyronza River near Twist, Cache River near Cash, Arkansas River at Lock & Dam 3, and Bayou Meto near Bayou Meto contained toxaphene concentrations that, at times, exceeded ADPC&E's acute toxicity level of 0.73 ug/L. Water samples collected at L'Anguille River near Colt have, at times, exceeded the National Academy of Science's recommended limit of 2 ug/L of 2,4,5-T.

In addition to analyzing water samples for the presence of pesticides, the ADPC&E also collects and analyzes fish samples in order to determine if any bioaccumulation of pesticides is occurring. Based on analyses of fish samples collected in the Eastern Arkansas Basin, the ADPC&E has documented the contamination of fish in Bayou Meto by 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), a by-product resulting from production of the herbicide 2,4,5-T. <1> Since the discovery of dioxin contamination in 1979, the ADPC&E has been collecting additional fish samples from Bayou Meto and its tributaries to ascertain the extent of pesticide contamination in the Bayou Meto sub-basin.<1>

Impoundments

The flat topography of the Eastern Arkansas Basin is not suitable for the construction of large-scale reservoirs in this part of the state. However, many small man-made and natural lakes are present in the basin, as shown by data compiled in Table 3-19. There are approximately 7900 lakes within the 16-county study area with a total capacity of about 524,000 acre-feet <7>. A summary of impoundment data for the study area by county (Table 3-20) shows that the majority of water impounded in the study area is in Arkansas, Crittenden, Lonoke, and Prairie counties.

Impoundment Water Use

Reported withdrawals from impoundments in 1984 totalled approximately 36,000 acre-feet. This use represents only about 7 percent of the total storage in the study area and is about 6 percent of the total surface-water use that was reported for the area in 1984. The majority of water withdrawn from impoundments was used for irrigation purposes.

Impoundment Water Quality

Extremely limited data are available to assess impoundment water quality in the Eastern Arkansas Basin. The water-quality conditions of impoundments in the basin are directly affected by the water-quality conditions of tributary streams that provide inflow to the impoundments. As previously described in the streamflow water quality section of the report, streamflow in this basin often contains high concentrations of suspended sediment, chloride, fecal coliform bacteria, and dissolved solids. These streamflow water-quality problems could cause water-quality problems in impoundments in the basin. For instance, high concentrations of suspended sediment in tributary streams providing inflow to impoundments will increase the sedimentation rate in the reservoir, thereby reducing the storage and the efficiency of the impoundment.

One specific impoundment water-quality problem in the Eastern Arkansas Basin that has been identified is in Lake Dupree, an impoundment in Pulaski County near Jacksonville. The Arkansas Department of Pollution Control and Ecology has documented dioxin contamination of fish populations in the lake as a result of nonpoint pollution from the Vertac chemical plant in Jacksonville <1>. According to the ADPC&E, the actions that have been taken by the Vertac Chemical Corporation to significantly reduce or eliminate the dioxin contamination should prevent further contamination of the aquatic system in this area.

TABLE 3-19
SUMMARY OF LAKES IN THE 16-COUNTY STUDY AREA FOR THE EASTERN ARKANSAS BASIN

OWNER / OPERATOR	NUMBER	AREA (acres)	CAPACITY (acre-ft)
U.S. Forest Service	2	1045	11000
Arkansas Parks and Tourism	4	181	2528
Arkansas Game and Fish Commission	17	4313	37458
All others:			
over 5 acres	1129	86899	450678
under 5 acres	6754	6779	22376
TOTAL	7906	99217	524040

(1) Data from study area totals in Table D.

(2) Data estimated by USDA - Soil Conservation Service.

Source: Arkansas Soil and Water Conservation Commission. (w)

TABLE 3-20

SUMMARY OF LAKES BY COUNTY IN THE STUDY AREA

COUNTY	LAKES OVER 5 ACRES NUMBER	LAKES OVER 5 ACRES AREA (acres)	LAKES OVER 5 ACRES CAPACITY (acre-ft)	LAKES UNDER 5 ACRES NUMBER	LAKES UNDER 5 ACRES AREA (acres)	LAKES UNDER 5 ACRES CAPACITY (acre-ft)	TOTAL NUMBER	TOTAL AREA (acres)	TOTAL CAPACITY (acre-ft)
ARKANSAS	374	20730	111781	171	477	1502	545	21207	113283
CLAY	26	487	3212	814	804	1943	840	1291	5155
CRAIGHEAD	24	618	3103	610	305	1220	634	923	4323
CRITTENDEN	40	7550	96135	49	147	882	89	7697	97017
CROSS	25	717	4768	340	170	850	365	887	5618
GREENE	14	423	3205	1279	1971	3940	1293	2394	7145
JACKSON	25	917	5957	346	173	692	371	1090	6649
LEE	32	1202	3941	224	90	900	256	1292	4841
LONOKE	183	20506	73967	1577	946	3784	1760	21452	77751
MISSISSIPPI	24	6880	12071	35	70	280	59	6950	12351
MONROE	92	4385	26301	75	152	760	167	4537	27061
PHILLIPS	8	3700	16100	49	82	328	57	3782	16428
POINSETT	46	2260	7704	345	352	2730	391	2612	10434
PRAIRIE	112	11350	56744	482	482	723	594	11832	57467
ST. FRANCIS	61	3206	16048	316	474	1422	377	3680	17470
WOODRUFF	43	1968	9641	42	84	420	85	2052	10061
TOTAL	1129	86899	450678	6754	6779	22376	7883	93678	473054

(1) Does not include U.S. Forest Service lakes, Arkansas Game and Fish Commission lakes, and Arkansas Department of Parks and Tourism lakes.
(2) Data estimated by USDA - Soil Conservation Service.
SOURCE: Arkansas Soil and Water Conservation Commission <W>

Federal Projects

USDA - Soil Conservation Service

P.L. 88-566 program: The Watershed Protection and Flood Prevention Act (Public Law 83-566) of 1954 authorized the Secretary of Agriculture to cooperate with states and local agencies in the planning and carrying out of works of improvement for soil and water conservation. Both technical and financial assistance is provided under the P.L. 83-566 program to local organizations representing people living in small watersheds. Eligible purposes are projects that (1) prevent damage from erosion, floodwater, and sediment; (2) further the conservation, development, utilization, and disposal of water; or (3) conserve and properly use land. <61>

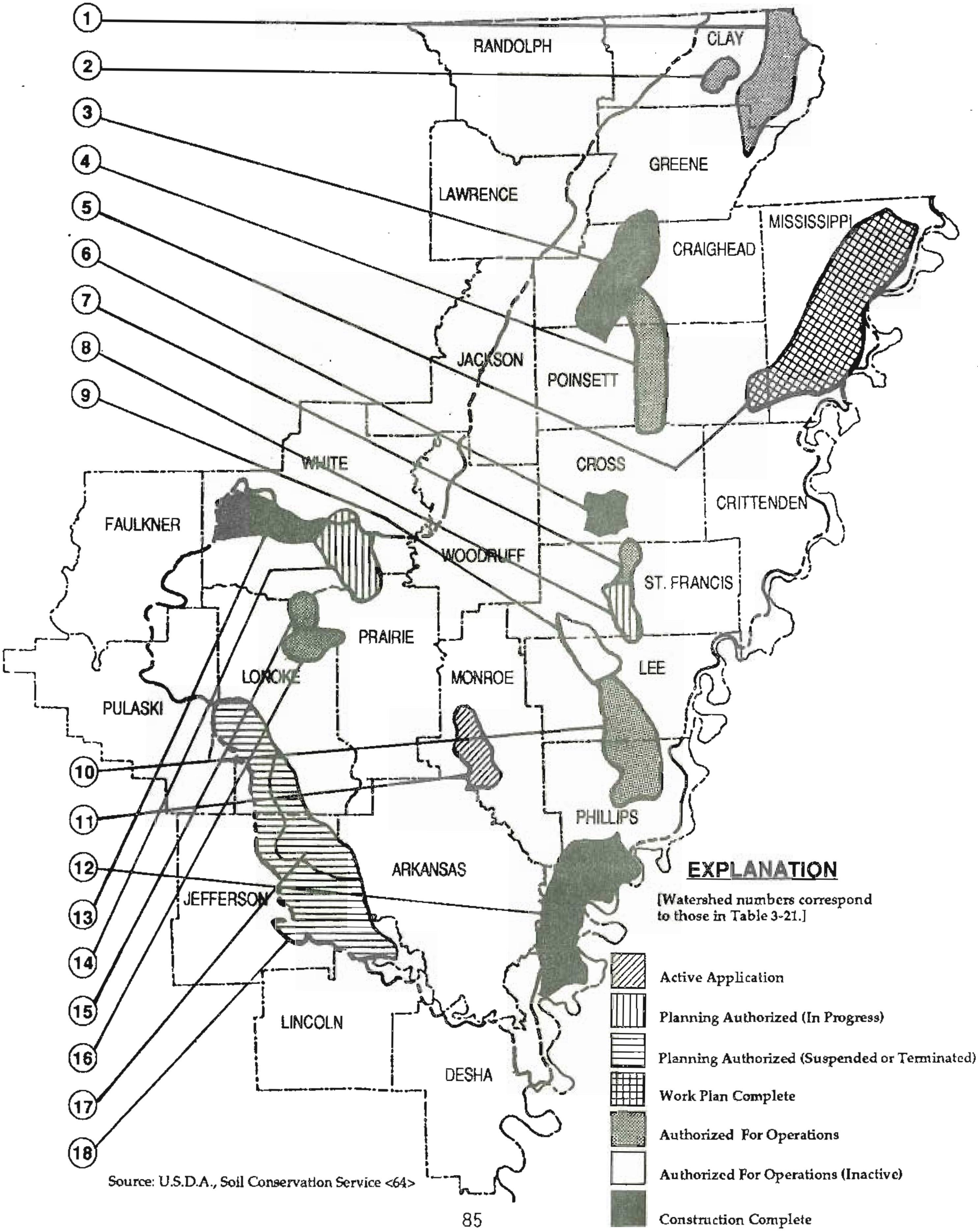
There are 18 Public Law 566 watersheds located in the Eastern Arkansas Basin as shown in Figure 3-10. Construction has been completed in four of these watersheds and seven watersheds have been authorized for operations. Additional information on the status of all P.L. 83-566 watersheds in the basin is summarized in Table 3-21.

The Crow Creek land treatment project in St. Francis County was authorized in 1986. The project area encompasses 17,324 acres in the north-central part of the county. The principal problem in the project area is the loss of agricultural productivity due to excessive cropland erosion on 4,056 acres. At the present time, six contracts for establishing land treatment conservation practices on 559.3 acres in the project area have been negotiated. <68>

The Duck Creek and Dunn Creek land treatment projects in northeastern Lonoke County and northwestern Prairie County were authorized in 1987. The Duck Creek project area encompasses 10,831 acres and the Dunn Creek project area encompasses 23,540 acres. Ninety-eight percent of both project areas are privately owned. The principal problem in the two project areas is the loss of agricultural productivity resulting from excessive cropland erosion. Erosion is a problem on 2,519 acres of cropland in the Duck Creek area and 7,263 acres of cropland in the Dunn Creek project area. No contracts for establishing land treatment conservation practices in either of the project areas have been negotiated. <68>

The Lee-Phillips project was authorized in 1964 to address floodwater and sediment damage and inadequate drainage on agricultural land in south-central Lee County and north-central Phillips County. The Lee-Phillips project area encompasses 83,504 acres. Specific purposes of the project are to: (1) provide an approximate two-year frequency level of protection against flood damages in low areas; (2) provide drainage outlets within one-half mile of each farm unit; (3) provide increased land-use efficiency through crop rotation and land-use planning; and (4) stimulate economic growth and development in the watershed area. Land treatment and structural measures are being employed in the project to alleviate flooding and drainage problems in the project area. At the present time, 515 of the 597 farmers in the watershed have signed cooperative land treatment agreements. In addition, all planned structural measures, including channel work on 94 miles of main and lateral ditches and installation of approximately 550 grade stabilization structures, have been installed. Numerous problems have been encountered during the past few years from damage of the completed structural measures by excessive rainfall and unstable soil conditions,

FIGURE 3-10
STATUS OF U.S.D.A. (SCS) WATERSHED PROJECTS



Source: U.S.D.A., Soil Conservation Service <64>

however, the project has alleviated flooding and drainage problems in the watershed. <68>

The Poinsett project was authorized in 1969 to address floodwater and sediment damage to agricultural land in south-central Craighead County and central Poinsett County. Land treatment and structural measures are being used to alleviate flooding problems in the 51,326-acre Poinsett project area. Currently, land treatment agreements have been negotiated for about 90 percent of the land in the project area. Structural measures planned for the project consist of 47 floodwater-retarding structures, 22 miles of channel work, and 200 acres of land stabilization. Construction has been completed on 26 of the planned structures, however, flooding and sediment damage in the area continue to be a problem. <68>

Eastern Arkansas Water Conservation Project <65>: Serious water-shortage problems that occurred during the drought of 1980 prompted the farmers in the Jackson, Arkansas, Prairie, and Woodruff County Conservation Districts to request assistance from local, state, and federal agencies to alleviate the water supply problems in the eastern Arkansas area. In order to address these problems, the Eastern Arkansas Water Conservation Project was designed and implemented to conduct an indepth study on agricultural water use and ground water resources in eastern Arkansas. Funding for the Eastern Arkansas Water Conservation Project was made through the USDA - Soil Conservation Service, however, several local, state, and federal agencies including: the Arkansas Association of Conservation Districts, the 26 conservation districts of eastern Arkansas, the Arkansas Soil and Water Conservation Commission, the University of Arkansas at Fayetteville, the University of Arkansas at Pine Bluff, and the U. S. Geological Survey are also involved in the study.

The study area encompasses 26 counties totalling about 12 million acres in eastern Arkansas. The 26 counties included in the project area are: Clay, Randolph, Lawrence, Greene, Mississippi, Craighead, Independence, Jackson, Poinsett, Crittenden, Cross, Woodruff, White, St. Francis, Lee, Monroe, Prairie, Lonoke, Jefferson, Arkansas, Phillips, Lincoln, Desha, Drew, Ashley, and Chicot.

The two major purposes of the Eastern Arkansas Water Conservation Project are: (1) to increase irrigation efficiencies to reduce the amount of water pumped and energy consumed through water management practices and techniques, and (2) to develop a series of calibrated digital models of the alluvial aquifer to be used by state and federal agencies for assessing the impact of projected irrigation demands and for evaluating alternative pumping schemes that could involve the conjunctive use of surface water and ground water. Studies that are currently underway to address the major purposes of the project include: evaluation of the efficiency of different irrigation methods (continuous flood, intermittent flood, furrow, and sprinkler), evaluation of application efficiencies, pumping plant evaluations, canal delivery systems studies, soil moisture and soil-irrigation characteristics studies, soil/water salinity studies, and water-level monitoring and determination of aquifer characteristics.

Data that have been collected are currently being evaluated and results are being provided to farmers in the area for use in increasing the efficiency of irrigation practices. The Eastern Arkansas Water Conservation study is projected to continue through 1989.

U. S. Army Corps of Engineers

Authorized projects: The U. S. Army Corps of Engineers is currently investigating several projects in the Eastern Arkansas Basin to improve flood control, drainage, and navigation in the area. The major Corps of Engineers projects which have been authorized for construction in the basin are summarized below, based on information from the reconnaissance summary for the Eastern Arkansas Region Comprehensive Study <50>.

1.) The St. Francis Basin project, which was authorized by the Flood Control Act of 1928 (as amended by Flood Control Acts of 1936, 1941, 1946, 1950, 1965, and 1968), provides flood control for the St. Francis River Basin. Authorized features of the project include a reservoir and dam at Wappapello Lake in Missouri, 438 miles of levees, 922 miles of channel improvements, 3 pumping plants, 8 flood control and diversion structures, and the purchase of 13,500 acres of mitigation lands. Completed works (as of 1985) include Wappapello dam and reservoir, 433 miles of levees, 639 miles of channel improvements, 2 pumping plants, 6 flood control and diversion structures, and the acquisition of 9,851 acres of mitigation land.

2.) The L'Anguille River Basin project was authorized for construction by Section 203 of the Flood Control Act of 1948 to provide flood control and improved drainage in the L'Anguille River Basin. Project features which have been authorized include 97.6 miles of channel improvement on the main stem and 8.0 miles and 6.4 miles of channel improvement on First Creek and Brushy Creek, respectively. The project has not been constructed, however, due to the absence of a non-Federal sponsor. Because flooding continues to be a significant problem in the basin, the L'Anguille Improvement District No. 1 provided funds for initiation of a re-evaluation study of this project in 1980. The purpose of the re-evaluation was to reaffirm the features of the original plan or to reformulate the project under current planning criteria. The re-evaluation report, published by the Corps of Engineers in 1985 <50>, recommends a revised plan consisting of 95.0 miles of vegetative clearing on the L'Anguille River with selective cleanout to alleviate some of the flooding in the basin.

3.) The Cache River-Bayou DeView Basin project was authorized by the Flood Control Act of 1950 and the Water Resources Development Act of 1974. The project will provide for flood control and improved drainage for approximately 2,020 square miles in the basin. Authorized features of the project include 154.6 miles of channel improvements on the Cache River and its upper tributaries, and 76.9 miles of channel improvements on Bayou DeView. Implementation of the project will provide for enlarged and new channels throughout reaches of both the Cache River and Bayou DeView. At the present time, only 7 miles of channel improvement on the lower end of the Cache River have been completed. Progress of the project has been delayed in recent years due to EPA objections and a lack of unified Congressional support.

4.) A study of the Graham Burke pumping plant wasauthorized by a resolution adopted by the U. S. Senate Committee in 1975. The existing pumping plant is located on the left bank of the White River in Phillips

County, about 47 miles southwest of Helena and approximately 35 miles upstream from the confluence of the white and Mississippi Rivers. Flooding in the White River backwater area, at times, causes delays in crop planting or damages crops already planted even with the operation of the existing pumping plant. Therefore, the major purpose of this study is to determine the need and justification of enlarging the Graham Burke pumping plant. To date (1985), this study has not been funded.

5.) The Lower White River project was authorized by theFlood Control Act of 1965. The latest recommended plan of improvement includes enlarging, cleaning, and minor straightening of the channels on Big Creek, Crooked Creek, Spring Creek, Hog Tusk Creek, Big Piney Creek, Flat Fork, and Little River in the lower White River Basin. This plan differs from the original authorized plan which included substantial realignment of the Big Creek channel downstream from Poplar Grove. The latest recommended plan provides for a meandering channel along this reach to follow the existing channel wherever practicable. Comments regarding the acquisition of woodlands to mitigate fish and wildlife losses resulting from the project have not yet been resolved.

6.) White River navigation to Batesville was authorized bythe adoption of a resolution of the Senate Committee on Public Works in 1967. The study area includes the lower 300 miles of the White River. The feasibility report recommended construction and maintenance of a 200-foot wide, 9-foot deep navigation channel available 95 percent of the time from mile 10 (Arkansas Post Canal) to mile 254 (Newport). Other project features include two scenic overlooks, a primitive camping area, and acquisition of as much as 1,865 acres of woodlands for mitigation. Construction of the project was authorized by the Water Resources Development Act of 1986.

Eastern Arkansas Region Comprehensive Study <48>: Due to the severe water shortages in the eastern Arkansas area, the Eastern Arkansas Region Comprehensive Study was designed and implemented to investigate water conservation and water supply practices in eastern Arkansas. The study was authorized by a resolution adopted by the U. S. House of Representatives Committee on Public Works and Transportation in 1982. The Memphis District of the Corps of Engineers has responsibility for the overall management of the study, however, many Federal, State, and local agencies are also contributing to the study effort. Agencies that are providing input include: Vicksburg and Little Rock Districts of the Corps of Engineers; U. S. Geological Survey; USDA-Soil Conservation Service; U. S. Fish and Wildlife Service; Federal Energy Regulatory Commission; Arkansas Soil and Water Conservation Commission; Arkansas Department of Health; Arkansas Department of Pollution Control and Ecology; Arkansas Game and Fish Commission; Arkansas Geological Commission; University of Arkansas at Fayetteville; Arkansas Waterways Commission; Conservation Districts; and numerous planning and management districts, water distribution districts, and municipalities.

The study area, which includes approximately 13,400 square miles in eastern Arkansas, is bounded on the north by the Missouri state line, on the east by the Mississippi River, on the west by the Ozark Escarpment, and on the south by the Arkansas River. All or parts of the following 24 counties are included in the project area: Arkansas, Clay, Craighead, Crittenden, Cross, Desha, Faulkner, Greene, Independence, Jackson, Jefferson, Lawrence, Lee, Lonoke, Mississippi, Monroe, Phillips, Poinsett, Prairie, Pulaski, Randolph, St. Francis, White, and Woodruff.

The Eastern Arkansas Region Comprehensive Study is being conducted in two phases-the reconnaissance phase and the feasibility phase. Objectives of the first stage of the study (the reconnaissance phase) include: developing a water balance for the region which describes the current and future use of the water resources; identifying problems and needs in each of the sub-basins; formulating solutions to address the identified needs; and determining project feasibility and need for additional detailed studies. Objectives of the second stage of the study (the feasibility phase) include: conducting detailed area-wide studies where necessary; defining problems and needs at specific locations; formulating a broad range of alternative solutions; selecting plans of improvement; and developing recommendations for authorization of implementable projects.

The reconnaissance phase of the study has been completed. A summary of the results of this first part of the study was published in 1985 by the Memphis District of the Corps of Engineers. <50> Problem areas identified in the reconnaissance phase of the study are the Eastern Grand Prairie, Western Grand Prairie, Cache River-Bayou DeView Basin, and the L'Anguille River Basin. Multipurpose plans for improving the irrigation water supply in the region through the diversion and transfer of surface water from major rivers appear to be feasible. Detailed design and cost analyses addressing flood control and water supply problems in the previously mentioned areas are being conducted in the feasibility phase of the project, which is currently underway. Results of the Eastern Arkansas Region Comprehensive Study will provide information which will be used to determine the direction and scope of future water resource management and development in the region.

TABLE 3-21
STATUS OF USDA (SCS) WATERSHED PROJECTS
[Watershed numbers correspond to those in Figure 3-10]

No.	Name	Status
1	Big Slough	Authorized for operations
2	Boydsville	Authorized for operations
3	Big Creek	Construction complete
4	Poinsett	Authorized for operations
5	Tyronza River	Work plan complete
6.	Caney Creek	Construction complete
7.	Crow Creek	Authorized for operations
8.	Yocona-Spybuck	Planning Authorized (in progress)
9.	Larkin Creek	Authorized for operations inactive
10.	Lee-Phillips	Authorized for operations
11.	Dials Creek	Active application
12.	White River Backwater	Construction complete
13.	Des Arc Bayou	Construction complete
14.	Little Red River	Planning authorized (in progress)
15.	Duck Creek	Authorized for operations
16.	Dunn Creek	Authorized for operations
17.	Upper Little Bayou Meto	Planning authorized (suspended or terminated)
18.	Lower Little Bayou Meto	Planning authorized (suspended or terminated)

Source: USDA, Soil Conservation Service, 1987 <66>

SURFACE-WATER RESOURCE PROBLEMS

Future productivity and economic growth in the Eastern Arkansas Basin are dependent upon the availability of adequate water supplies in the region. This basin is currently a highly productive agricultural region of the state and the potential exists for a significant increase in agricultural activities in the next few decades. At the present time, surface water in the basin supplies only about 10 percent of the water needed for irrigation. However, due to a significant decline in ground water levels recently in many parts of the Eastern Arkansas Basin, farmers in the basin will probably be more dependent upon surface water sources to satisfy irrigation needs in the future. Without the availability of adequate quantities of suitable water, production from economic activities in the basin could be significantly impacted in the years to come.

Several surface-water resource problems currently exist in the Eastern Arkansas Basin. Analysis of available data for this area identified several major surface-water problems in the basin, including the following: (1) shortage of surface water available for use, particularly during the irrigation season, (2) flooding and drainage problems that impair the uses of land in the basin, and (3) degraded water-quality conditions due to excessive soil erosion and high nutrient and pesticide concentrations in surface waters resulting from agricultural activities in the basin. These problems are addressed in more detail in subsequent sections of the report along with an explanation of the problems that have been encountered in the determination of instream flow requirements for the Eastern Arkansas Basin.

Surface-Water Quantity Problems

Availability

Streamflow in the Eastern Arkansas Basin is adequate, on an average annual basis, to satisfy existing water needs in the basin. In fact, as previously determined in the excess streamflow section of the report, 4.2 million acre-feet of water in the basin, which is approximately equal to one and a half times the total storage capacity of Lake Ouachita, is excess surface water which is available on an average annual basis for other uses. However, the determination of streamflow availability based on average annual streamflow can be very misleading. This is illustrated by an example of the streamflow variability for the White River at the mouth. Computations of current available streamflow for the White River at the mouth (current available streamflow section) show that 11,670 cfs of water is available for other uses on an average annual basis. However, on a mean monthly basis, the available water ranges from 4,190 cfs in October to 18,400 cfs in March. Due to the variability of flow of the White River and of other streams in the basin, the majority of streamflow is available during the winter and spring months of the year with considerably less water available during the summer and fall months. The lowest streamflow levels in the basin usually occur during August through October. This period of lowest streamflow occurs during the agricultural growing season when water use demands are generally highest. Therefore, planning efforts for the Eastern Arkansas Basin should primarily focus on the low-flow periods when streamflow availability is often a problem.

A large volume of water from streams and rivers in the Eastern Arkansas Basin is available on an annual basis for development, however, due to streamflow variability in the basin, water is often not available during the times when it is most needed. This seasonal variability in streamflow could be compensated for by storing water during high-flow periods in the winter and spring and releasing it during low-flow periods to meet the summer and fall water-use demands. This development of surface water storage impoundments could significantly increase the dependable yield from streams in the basin. However, since most of the land in the Eastern Arkansas Basin is relatively flat, there are no suitable sites for construction of large-scale impoundments to store the available water in the basin. Reservoirs constructed in the basin would have large surface areas and relatively shallow depths. The impounded water would inundate a large area of land thereby eliminating the use of many acres of cropland in the basin, and a considerable amount of the stored water would be lost to evaporation due to the large surface area of the impoundment. Therefore, due to the topography of the basin, storage of the available water for future use in the Eastern Arkansas Basin is currently a problem.

Another surface-water quantity problem that often occurs in the basin is a reduction in the amount of streamflow that is available to satisfy the flow requirements for instream needs. Diversion of water from streams for uses such as the irrigation of cropland in the summer and the flooding of greentree reservoirs for hunting purposes in the fall contribute to this reduction in streamflow. For example, the 1983 water year hydrograph of daily discharge of the Cache River at Egypt (Figure 3-3 in the streamflow characteristics section) showed that, at times in November, there was no flow in the Cache River at Egypt. This no-flow condition, which resulted from significant withdrawals of water for flooding of greentree reservoirs in the area, reduced the available habitat for fisheries and also reduced the amount of water available in the stream for the maintenance of suitable water-quality conditions.

Flooding

Flooding and impaired drainage are significant and persistent problems in the Eastern Arkansas Basin. In the past, many areas of the basin have been subjected to devastating floods. Therefore, considerable attention has been focused on flood control and many changes have been made in the watersheds of the basin during the past 50 years or more. Implementation of drainage improvement projects such as dredging of channels, construction of levees, and construction of drainage ditches has improved flood control in the area. However, some of these improvements have resulted in only a temporary reduction in flooding because, with time, drainage ditches become overgrown with vegetation and streams and ditches become partially filled with sediment. This reduces the efficiency of the streams and ditches to remove storm runoff. As a result, significant flooding and drainage problems still exist in the basin.

Maximum streamflows in the Eastern Arkansas Basin generally occur during the months of January through May. Because of the wide, flat floodplains in the basin, large areas are often inundated by floods and the water recedes slowly. Destruction from the force of the water is generally minimized because of the low floodflow velocities, however, significant agricultural losses including reduced crop yield, delays in crop planting, and total crop failure result from the frequent flooding in the basin. Storage of floodwaters in the basin is generally impractical because of the lack of suitable reservoir sites.

The most severe flooding problems in the Eastern Arkansas Basin occur in the Lower White River sub-basin, particularly along the Cache River and Big Creek. <48> Flooding in the St. Francis River sub-basin, which includes the L'Anguille River, has also been a significant problem in the past.

There are approximately 2,768,000 acres of land located in flood-prone areas in the Eastern Arkansas Basin. Land use within the floodplain consists of an estimated 1,922,000 acres of cropland, 96,000 acres of pastureland, 722,000 acres of forestland, and 28,000 acres of other land uses. <57>

An estimated 83 million dollars (1977 Price Base) in damages occur annually to crop, pasture, and forest lands within the floodplain. Total damages, which include damages to roads and bridges, urban areas, and agricultural areas, are estimated to be approximately 133 million dollars (1977 Price Base) annually. <56>

<u>Potential problems</u>

Flow in some streams and rivers in the Eastern Arkansas Basin is currently inadequate at times to satisfy water use demands, particularly during the irrigation season. This will most likely become even more of a problem in the future since a significant increase in the amount of cropland in the basin is likely to occur. The use of surface water for irrigation of these additional acres of cropland combined with a reduction in the amount of ground water withdrawn for irrigation will contribute to additional demands on the surface water system to satisfy the water needs of the basin.

In addition to an increase in the demand for surface water in the future, the supply of surface water in the basin could potentially be reduced as a result of an increase in the use of water in upstream basins. For instance, according to the Arkansas River Compact <6>, the state of Oklahoma has the right to develop and use 60 percent of the annual yield of the Arkansas River sub-basin. In past years, Oklahoma has generally used considerably less water than the amount that has been apportioned to the state. However, an increase in water use by Oklahoma could significantly reduce the flow of the Arkansas River downstream in the Eastern Arkansas Basin. To compound this problem, Oklahoma is most likely to use a greater amount of their apportionment of water during dry years which would correspond with the time when a greater amount of water would be required by downstream Arkansas water users. In addition to the potential reduction of flow resulting from Oklahoma's use of water, the flow of the Arkansas River in Arkansas could also be significantly reduced by the use of water upstream of the interstate compact area by the states of Colorado, Kansas, and Oklahoma.

Surface-Water Quality Problems

Water-quality of the streams and rivers in the Eastern Arkansas Basin is significantly impacted by man's activities. Water-quality problems that currently exist in many streams in the basin include: excessive turbidity; low dissolved oxygen concentrations; and increased concentrations of nitrogen, phosphorus, pesticides, and fecal coliform bacteria which often preclude the use of streamflow to satisfy water needs in the basin. In fact, the Arkansas Department of Health discourages the use of surface waters in this basin for public water supplies because of the significant risk of contamination from nonpoint pollution sources resulting from land use practices associated with agricultural operations. <1> Excessive erosion rates in conjunction with periodic applications of pesticides and fertilizers on cropland in the basin contribute to the water quality degradation of streams and rivers in eastern Arkansas. In addition to the effects of agricultural activities on the water quality of streams, sewage treatment plants and industrial activities also adversely impact surface water quality conditions in some areas of the basin.

Excessive Soil Erosion

Excessive soil erosion in a watershed increases the suspended sediment concentrations in streamflow which often results in extremely turbid streamflow conditions that impair recreational and aesthetic qualities of streams. The increased streamflow sediment loads also: reduce storage and efficiency of impoundments, adversely affect irrigation delivery canals and other water distribution equipment, increase flooding as a result of channel aggradation, increase water treatment costs, and reduce the available habitat for aquatic life in the streams. Excessive soil erosion also increases the quantity of nutrients, pesticides, and toxic metals that are transported to streams and rivers in the basin since these constituents are often adsorbed on suspended sediment particles. However, one partially offsetting benefit of suspended material in streamflow is that subsequent sedimentation of these materials in streams and rivers may remove constituents such as nutrients and pesticides from the water column.

Approximately three-fourths of the land in the Eastern Arkansas Basin is cropland <59>, with many areas of the basin characterized by excessive soil erosion rates. Average annual erosion for the basin is approximately 26 million tons, as estimated by the Soil Conservation Service. <57> Of the total amount of erosion that occurs in the basin, about 95 percent is from cropland. A certain amount of erosion is unavoidable, however, inadequate land treatment measures and limited watershed protection on many agricultural lands in the basin contribute to the excessive soil erosion rates.

To identify the amount of excess erosion in eastern Arkansas, the soil loss tolerance value (T-value) was computed for different land uses in the basin. The soil loss tolerance value indicates the rate of soil loss in tons per acre per year that can exist while still allowing a high level of production to be economically sustained for an indefinite period of time. Any combination of cropping and management practices that will keep soil losses at or below the T-value for a specific soil will provide satisfactory erosion control for that soil. T-values generally range from 1.0 to 5.0 tons per acre per year. <61> The erosion that is occurring on non-federal rural land in the Eastern Arkansas Basin is shown in relation to T in Table 3-22. Approximately 4,700,000 acres of land in the basin are

TABLE 3-22.

EROSION IN RELATION TO T VALUE ON NON-FEDERAL RURAL LAND

LAND USE	<T 1000 TONS	<T 1000 ACRES	<T TONS/ACRE	T-2T 1000 TONS	T-2T 1000 ACRES	T-2T TONS/ACRE	>2T 1000 TONS	>2T 1000 ACRES	>2T TONS/ACRE
CROPLAND	9401.8	3050.9	3.1	8034.7	1491.7	5.4	7598.9	610.8	12.4
PASTURELAND	193.6	447.8	0.4	75.6	10.7	7.1	127.7	11.9	10.7
FORESTLAND	66.3	1135.0	0.1	---	---	---	---	---	---
OTHER	26.3	60.1	0.4	16.4	2.3	7.1	866.7	12.8	67.7
TOTAL	9688.0	4693.8	2.1	8126.7	1504.7	5.4	8593.3	635.5	13.5

SOURCE: USDA, Soil Conservation Service (57) in the "less than T" category, meaning that there is not a significant erosion problem on these lands. However, approximately 2,100,000 acres of cropland in the basin are eroding above tolerable levels (T-2T and >2T categories in Table 322). Watershed protection and land treatment measures are necessary to reduce the excessive erosion rates in the Eastern Arkansas Basin.

Pesticide Contamination

The application of pesticides to cropland, forestland, and grassland in the Eastern Arkansas Basin is a common practice. In 1977, an estimated 15,000 tons of herbicides, insecticides, and fungicides were applied to lands in eastern Arkansas. <3, 4, 5> In the past, significant concentrations of these pesticides have been commonly found in the water and sediment of streams and rivers in the basin which has limited the use of surface waters for some purposes such as drinking water supplies. However, recently the ADPC&E has documented a drastic decline in pesticide concentrations in surface waters. <1> In fact, the majority of water samples that have been collected in the past several years at most locations in the basin have contained very low pesticide concentrations, with many samples containing concentrations less than detection limits.

Pesticide contamination of surface waters in the basin can also result from production and(or) transportation of these toxic chemicals. For example, in 1979 the ADPC&E discovered that fish in Bayou Meto had been contaminated by dioxin. <1> Dioxin is a by-product resulting from production of the herbicide 2,4,5-T which was being produced at the Vertac Chemical Corporation in Jacksonville at the time of the contamination. Runoff from the Vertac plant entered Bayou Meto and Lake Dupree from Rocky Branch Creek. As a result of the dioxin contamination, commercial fishing was banned on Bayou Meto in 1980 by an emergency order of the Arkansas Game and Fish Commission. Production of 2,4,5-T at the Vertac plant has recently been discontinued, however, the ban on fishing remains in effect due to the persistence of dioxin in the aquatic system. <1>

Excessive nutrient concentrations

Approximately 600,000 tons of nitrogen- and phosphorus-based fertilizers were applied to cropland in the Eastern Arkansas Basin in 1977 to facilitate crop growth and to increase crop yield. <3, 4, 5> However, when nitrogen and phosphorus are transported to streams in the basin, these nutrients also facilitate and accelerate the growth of nuisance aquatic vegetation. Streamflow in eastern Arkansas often contains excessively high nitrogen and phosphorus concentrations which, at times, may cause algal blooms. Initially, this increase in algae increases the dissolved oxygen in streams. But when the nutrient concentrations become limiting again, die-off of the algae occurs causing oxygen-deficient conditions to prevail, which are detrimental to the aquatic life in the stream. Excessive nutrient concentrations also contribute to eutrophication problems in impoundments in the basin.

Fecal Coliform Contamination

The ADPC&E has documented excessively high fecal coliform bacteria concentrations in streamflow in most areas of the Eastern Arkansas Basin. <1> Some of this bacterial contamination is a result of nonpoint source runoff from agricultural lands, while point sources such as sewage treatment plants also contribute to the problem. High concentrations of fecal coliform bacteria in streamflow in the basin restrict the use of surface water for purposes such as drinking water supplies and recreation (swimming) because of the risk of health-related problems.

Potential water-quality problems

Most of the current surface water quality problems in the Eastern Arkansas Basin are a result of land use practices associated with agricultural operations. In the next several decades, there is the potential for the amount of cropland in the basin to double. A significant increase in the amount of acreage devoted to cropland could contribute to additional soil erosion and increased concentrations of pesticides, nutrients, and fecal coliform bacteria in the surface waters of the basin. These increases could degrade surface water quality to the point where it would not be suitable for irrigation use or any other use in the basin.

Determination of Instream Flow Requirements

The Arkansas Soil and Water Conservation Commission has been mandated by Act 1051 of 1985 to determine the instream flow requirements for water quality, fish and wildlife, navigation, interstate compacts, aquifer recharge, and other uses in the State of Arkansas. When these needs are determined and future water needs are projected for the Eastern Arkansas Basin, the water that is available for other uses can be determined. Two major problems that have been encountered in the process of determining instream flow requirements for streams in the Eastern Arkansas Basin for the categories previously mentioned are: (1) lack of sufficient and(or) appropriate data, and (2) inflexible methodologies.

(1) Lack of sufficient and(or) appropriate data

Streamflow data in the Eastern Arkansas Basin are necessary in the determination of instream flow requirements for water quality, fish and wildlife, and navigation. However, information for only eighteen continuous streamflow gaging stations in the basin is currently available. Extrapolation of the gaging station data to other reaches on gaged streams such as Bayou Meto and to other ungaged streams such as LaGrue Bayou may produce erroneous results because of the effects of man's activities on streamflow characteristics in many of the watersheds. For instance, the existence of numerous diversions of water to and from streams in the basin during the irrigation season makes it extremely difficult to ascertain current streamflow conditions for determination of the instream flow requirements.

Appropriate data are not available to determine instream flow requirements for fish and wildlife. Limited data have been collected to characterize fish and wildlife habitat conditions in conjunction with streamflow conditions. This information must be available in order to determine the streamflow necessary for protection of fish and wildlife populations, and is particularly important if the habitat of an endangered species must be protected. According to results of the environmental analysis for the Eastern Arkansas Region Comprehensive Study <49>, the fat pocketbook mussel (Proptera capax) and the Curtis pearly mussel (Epioblasma florentina curtisi), which are listed by the U. S. Fish and Wildlife Service as endangered species, are found in the St. Francis River in the Eastern Arkansas Basin. Data identifying instream flow requirements for these endangered species should be collected as well as information on the instream needs for fish and wildlife in the basin so that flows necessary to protect these populations will be available in the streams.

(2) Inflexible methodologies

The second major problem in the process of determining instream flow requirements is that the methods currently used are not flexible and do not address the diversity of the aquatic systems or the historic instream and off-stream uses of water from the streams. For example, the White and Arkansas Rivers in the

Eastern Arkansas Basin are maintained for navigation purposes, but the two projects are quite different. The White River project provides "open-river" navigation while locks and dams provide a series of pools to facilitate navigation on the Arkansas River. The Arkansas River navigation project is maintained so that the series of pools provide adequate depths for navigation, even when the flow of the river is extremely low. On the other hand, navigation on the White River is dependent on flow conditions since there are no locks and dams on the river in eastern Arkansas to provide navigable pools. The recommended navigation requirements for the Arkansas and White Rivers, however, are both based on the amount of flow in the river, regardless of the river depth.

Another example of the inflexible methods used to determine instream flow requirements is the use of the Arkansas Method for identifying the flows necessary to satisfy instream needs for fish and wildlife. According to the Arkansas Method, instream flow requirements for fish and wildlife are computed as a percent of the mean monthly discharge at each of the gaging station locations in the basin. At the present time, however, there is no flexibility in the method so that the unique streamflow needs of the different fisheries in the basin can be taken into account.

In addition to the problems with the methodologies previously described, the current methods used to determine instream flow requirements do not take into consideration the variation in historic instream and off-stream uses of surface water in the basin. For example, water needs for agricultural purposes are important in most reaches of Bayou Meto and should be considered in the establishment of instream flow requirements for all categories for Bayou Meto. Similarly, the lower St. Francis River has been designated as an ecologically sensitive waterbody due to the presence of endangered mussels. A high level of protection for the aquatic habitat of the endangered species in this area should be considered.

Critical Surface Water Areas

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to define critical water areas and to delineate areas which are now critical or which will be critical within the next thirty years. A critical surface water area is defined as any area where current water use, projected water use, and(or) quality degradation have caused, or will cause, a shortage of useful water for a period of time so as to cause prolonged social, economic, or environmental problems.

Bayou DeView in the Lower White River sub-basin and Bayou Meto in the Bayou Meto sub-basin have been designated as critical surface water areas based on quantity problems. Withdrawals for irrigation have, at times in the past, contributed to no-flow conditions in the two streams. In fact, during the 37 years of streamflow data collection at a gaging station on Bayou DeView, the stream has had no flow at least 10 percent of the time. Due to the frequency of no-flow conditions in Bayou DeView as well as in Bayou Meto, the two streams have been designated as critical surface water areas in the basin. Flows of these two streams are not adequate to satisfy the instream needs and the offstream water needs for irrigation.

Current streamflow conditions along with surface water and ground water withdrawals, and irrigation return flows are not well defined in the Eastern Arkansas Basin. Therefore, other streams in the basin may also need to be designated as critical surface water areas, but a lack of information defining the surface water-ground water system precludes the identification of additional streams as critical surface water areas.

Many streams in the Eastern Arkansas Basin could be critical areas in the next thirty years, since a significant increase in the amount of cropland in the basin is likely to occur. The use of surface water for irrigation of the additional acres of cropland, combined with a reduction in the amount of ground water withdrawn for irrigation,, will contribute to additional demands on the surface water system to satisfy the water needs of the basin.

The water quality of streams and rivers in the Eastern Arkansas Basin is significantly impacted by man's activities, but is generally satisfactory for irrigation purposes in the area. Nonpoint pollution from land use practices associated with agricultural operations contributes to water quality problems such as excessive turbidity and increased concentrations of nitrogen, phosphorus, pesticides, and fecal coliform bacteria. These water quality problems, at times, limit the beneficial uses of water in the basin. However, no streams in the basin have been designated as critical surface water areas based on water-quality problems since the use of streamflow for irrigation (its primary use) in the basin is usually not limited as a result of water-quality problems.

Water quality of streams and rivers in the basin may be significantly degraded within the next thirty years. The amount of cropland in the basin could potentially double in the next several decades which would contribute to additional soil erosion and increased concentrations of pesticides, nutrients, and fecal coliform bacteria in the surface waters of the basin. These increases could degrade surface water quality to the point where it would not be suitable for irrigation use or any other use in the basin. Therefore, it is projected that streams draining watersheds where cropland is significantly increased in the future will be critical surface water areas within the next thirty years.

SURFACE WATER SOLUTIONS AND RECOMMENDATIONS

The Eastern Arkansas Basin has a relatively abundant supply of surface water that is suitable for many uses. However, at times, the quantity and(or) quality of water necessary to satisfy water users in the basin may not be available. Additional demands for irrigation water in the future will intensify the water problems that already exist in the Eastern Arkansas Basin. It is imperative that the surface water supplies be managed and protected so that adequate water is available for all future water users in the basin.

State and Federal government programs exist which could provide assistance in solving some of the surface water resource problems that have been identified in the Eastern Arkansas Basin. Information regarding several of these programs is summarized in Table 3-23. Purposes of the programs include flood control, water supply, wastewater treatment, and land use planning. The appropriate State and(or) Federal agencies provide assistance in these programs, ranging from technical assistance to loans and grants. The administrating agencies listed in Table 3-23 can be contacted for an update of current program objectives and program guidelines.

Additional solutions and recommendations addressing problems that have been identified in the basin include: (1) diversion and transfer of surface water from major rivers to alleviate water availability problems; (2) channel improvements and floodplain management to reduce flooding and drainage problems; (3) implementation of best management practices in agricultural areas to reduce water quality problems; (4) conservation of water through improved irrigation water management; and (5) prioritization of streams to identify areas with current or potential instream use problems. Additional information pertaining to these and other solutions for addressing the surface water problems in the basin is provided in subsequent sections of the report.

TABLE 3-23

SELECTED GOVERNMENT PROGRAMS TO AID IN SOLVING WATER RESOURCES PROBLEMS

NAME OF PROGRAM	PROGRAM OBJECTIVE	ADMINISTRATING AGENCY	TYPE OF ASSISTANCE
	(STATE)		
WATER RESOURCE CONSERVATION AND DEVELOPMENT INCENTIVES ACT OF 1985	TO ENCOURAGE CONSTRUCTION OF SOIL AND WATER CONSERVING STRUCTURES TO REDUCE THE USE OF GROUNDWATER AND POTENTIAL FURTHER DEPLETION	AR SOIL AND WATER CONS. COMMISSION	TAX CREDIT
WATER DEVELOPMENT FUND	TO ASSIST LOCAL AND REGIONAL ENTITIES IN THE DEVELOPMENT OF URGENTLY NEEDED WATER DEVELOPMENT PROJECTS	ASWCC	LOANS AND GRANTS
WATER, SEWER, AND SOLID WASTE REVOLVING FUND	TO ASSIST CITIES, TOWNS, AND COUNTIES IN FINANCING THE CONSTRUCTION OF FACILITIES FOR WATER, SEWER, AND SOLID WASTE MANAGEMENT SYSTEMS	ASWCC	LOANS AND GRANTS
WATER RESOURCES DEVELOPMENT GENERAL OBLIGATION BOND PROGRAM	TO LOAN MONEY RAISED BY THE ISSUANCE OF GENERAL OBLIGATION BONDS FOR WATER RESOURCES DEVELOPMENT PROJECTS TO LOCAL ENTITIES FOR CONSTRUCTION OF PROJECTS	ASWCC	LOANS
ACT 81 OF 1957 AS AMENDED	TO MAKE ALLOCATION AMONG PERSONS TAKING WATER FROM STREAMS DURING PERIODS OF WATER SHORTAGE	ASWCC	TECHNICAL ASSISTANCE
	(FEDERAL)		
COMMUNITY FACILITIES LOANS	TO CONSTRUCT, ENLARGE, EXTEND, OR OTHERWISE IMPROVE COMMUNITY FACILITIES PROVIDING ESSENTIAL SERVICES TO RURAL AREAS	USDA,FHA	LOANS
COMMUNITY DEVELOPMENT BLOCK GRANTS	TO DEVELOP VIABLE URBAN COMMUNITIES, INCLUDING DECENT HOUSING, AND SUITABLE LIVING ENVIRONMENT AND EXPAND ECONOMIC OPPORTUNITIES, PRINCIPALLY FOR LOW AND MODERATE INCOME PERSONS	HUD-AIDC	GRANTS
NATIONAL FLOOD INSURANCE PROGRAM	TO ENABLE PERSONS TO PURCHASE INSURANCE ON REAL AND PERSONAL PROPERTY WHERE FLOOD PLAIN MANAGEMENT MEASURES HAVE BEEN ADOPTED AND ARE ENFORCED	FEMA-ASWCC	INSURANCE
WATERSHED PROTECTION AND FLOOD PREVENTION ACT (PL-566)	ASSIST LOCAL ORGANIZATIONS IN PLANNING AND CARRYING OUT A PROGRAM FOR THE DEVELOPMENT, USE, AND CONSERVATION OF SOIL AND WATER RESOURCES	USDA,SCS	TECHNICAL AND FINANCIAL
RESOURCE CONSERVATION AND DEVELOPMENT	TO CARRY OUT A PROGRAM OF LAND CONSERVATION AND LAND UTILIZATION	USDA,SCS	TECHNICAL AND FINANCIAL
FLOOD CONTROL ACT OF 1948 AS AMENDED; SECTION 205	TO ASSIST LOCAL SPONSORS IN PLANNING, DESIGNING, AND CONSTRUCTING LOCAL FLOOD PROTECTION PROJECTS, INCLUDING DAMS, LEVEES, RESERVOIRS, AND CHANNELS	CORPS OF ENGINEERS, DEPT. OF THE ARMY	TECHNICAL, FINANCIAL AND CONSTRUCTION
WATER SUPPLY ACT OF 1958 AS AMENDED	TO INSURE A CONTINUING SUPPLY OF FRESH WATER, ADEQUATE FOR URBAN AND RURAL NEEDS, BY COOPERATING WITH STATE AND LOCAL INTEREST IN THE DEVELOPMENT OF WATER SUPPLIES FOR DOMESTIC, MUNICIPAL, AND INDUSTRIAL WATER STORAGE IN RESERVOIR PROJECTS. COST IS 100% NON-FEDERALLY FUNDED	CORPS OF ENGINEERS, DEPT. OF THE ARMY	TECHNICAL AND CONSTRUCTION

Surface Water Quantity Solutions and Recommendations

Availability

Adequate amounts of streamflow are often not available during the low-flow season to satisfy irrigation needs in the Eastern Arkansas Basin. The limited availability of surface water is a result of the natural variability of streamflow in the basin combined with significant water withdrawals during the summer for irrigation of crops and during the fall for flooding of greentree reservoirs. Due to the topography of the area, construction of large-scale impoundments is not a feasible solution to the water supply problems that exist in the basin. However, seasonal low-flow problems could be alleviated by construction of off-stream storage reservoirs to capture the high winter and spring flows for use during the summer and fall periods. For example, a portion of least-productive cropland could be converted into a reservoir for storing precipitation runoff and irrigation return flows for use during low-flow periods, thus providing an on-farm water supply system.

The Water Resource Conservation and Development Incentives Act (Act 417 of 1985) allows a tax credit for the construction and(or) restoration of surface water impoundments. The impoundment or water control structure must store a minimum of 20 acre-feet of water and be used for the production of food and fiber as a business (excluding aquaculture) or be used for domestic or industrial purposes. Impoundment tax credits are limited to fifty percent of the actual construction costs of $3,000 annually for a period of eleven years. To qualify for the tax credit, a construction permit must be obtained from the ASWCC, or proof of exemption from the permit must be provided as per the requirements of Act 81 of 1957 (as amended). It is recommended that special projects providing technical and financial assistance to farmers for the installation of on-farm water supply systems be implemented in all areas of the Eastern Arkansas Basin.

Solutions to some of the most serious water availability problems in the basin are being formulated as part of the Eastern Arkansas Region Comprehensive Study (EARCS) <50>. Problem areas which have been identified in the reconnaissance phase of the study are the Eastern Grand Prairie, Western Grand Prairie, Cache River-Bayou DeView Basin, and the L'Anguille River Basin. Multipurpose plans for improving the irrigation water supply in these regions through diversion and transfer of surface water from major rivers are currently being developed. The primary diversion plans that are being considered for the three problem areas in the basin are as follows <50>:

(1.) Eastern Grand Prairie - plans involve a pumped diversion ofwater from the White River at DeValls Bluff into a main canal. Water would flow by gravity to lateral canals to supplement water supply needs in parts of Arkansas and Prairie Counties.

(2.) Western Grand Prairie - Plans consist of diverting water from the Arkansas River at Pool 6 above David D. Terry Lock and Dam (mile 110). A gravity flow main canal would be utilized to transport water from the Arkansas River to Bayou Meto. An additional option that is being considered includes utilization of a canal and pump station to lift water out of Bayou Meto and convey it to Skinners Branch of Bayou Two Prairie. Conveyance of water to Plum Bayou is also being evaluated.

(3.) Cache River-Bayou DeView-L'Anguille River Basins -All plans currently being consideredinvolve a diversion and transfer of water from the Black River to the Cache and L'Anguille Rivers.

The Little Rock and Vicksburg Districts of the Corps of Engineers have investigated the economic and engineering feasibility of the two proposed diversion projects for the Grand Prairie region. According to the Corps' studies <48, 49>, both projects are economically and engineeringly feasible, and it is recommended that further studies be conducted to determine whether or not the projects can be successfully implemented.

In addition to the investigations by the Corps of Engineers, Peralta and Dixon <35> conducted a study to assess the viability of the Arkansas and White Rivers as sources of supplemental water for the problem areas in the Eastern Arkansas Basin. Results from this study indicate that surface water is available for diversion from the Arkansas and White Rivers during average streamflow conditions. There is the potential for problems during low-flow periods, particularly on the White River, when streamflow may not be adequate to satisfy off-stream withdrawals for irrigation and instream needs for navigation.

Diversion of water from the Arkansas and White Rivers to the Grand Prairie and diversion of water from the Black River to the Cache-Bayou DeView-L'Anguille Basins will alleviate surface water availability problems that currently exist in these areas. Feasibility studies, which are currently underway as part of the Eastern Arkansas Region Comprehensive Study, involve area-wide investigations to provide site-specific detailed design and cost analyses for the proposed diversion projects. Due to the serious water supply problems that currently exist in some areas of the basin, it is recommended that these diversion projects be implemented as soon as possible so that adequate water supplies will be available for irrigation purposes in the Eastern Arkansas Basin.

Flooding

Flooding and drainage problems in the Eastern Arkansas Basin can be solved by structural and(or) non-structural alternatives. Structural alternatives include measures such as channel improvement and floodwater detention dams, while non-structural measures relate to land treatment and floodplain management.

Several Corps of Engineers' projects that employ structural measures for flood control and improved drainage have been authorized for construction in the basin. Channel improvements have been proposed for the L'Anguille River Basin, the Cache River-Bayou DeView Basin, and the Lower White River Basin to alleviate flooding and drainage problems in the watersheds. The St. Francis Basin project includes authorized features such as a reservoir and dam at Wappapello Lake, levees, channel improvements, pumping plants, and flood control and diversion structures to provide flood control for the St. Francis River Basin. <48>

The Soil Conservation Service currently has two Public Law 83-566 watersheds in the Eastern Arkansas Basin which employ structural and non-structural (land treatment) measures to alleviate flooding and drainage problems in the area. The Lee-Phillips project has been authorized to address floodwater and sediment damage and inadequate drainage on 83,504 acres of agricultural land in south-central Lee County and north-central Phillips County. Land treatment and structural measures are also being employed to alleviate flooding problems on 51,326 acres of land in south-central Craighead County and central Poinsett County in the Poinsett project. <68>

Continued implementation of Soil Conservation Service programs, such as the PL 83-566 small watershed program, should reduce damages from flooding and impaired drainage in the Eastern Arkansas Basin. Identification of additional feasible flood control projects in the basin should be considered in the Arkansas Highlands River Basin Study conducted by the Soil Conservation Service.

The United States Congress established the National Flood Insurance Program with the "National Flood Insurance Act of 1968". The program is administered by the Federal Insurance Administration (FIA) of the Federal Emergency Management Agency (FEMA). The Arkansas Soil and Water Conservation Commission is the state agency responsible for coordination of the program in Arkansas. Act 629 of 1969, enacted by the Arkansas General Assembly, authorized the cities, towns, and counties, where necessary, to enact and enforce floodplain management to curtail losses in flood prone areas.

Surface-Water Quality Solutions and Recommendations

Surface water quality in the Eastern Arkansas Basin is generally satisfactory for irrigation, its primary use. However, excessive erosion from cropland increases the concentrations of sediment, nitrogen, phosphorus, pesticides, and fecal coliform bacteria in streamflow which often renders surface waters in the basin unsuitable for other beneficial uses without extensive treatment. Watershed protection measures such as the implementation of best management practices, particularly for agricultural activities, would be the most effective and practical action to improve water quality conditions in the Eastern Arkansas Basin. Regulation of point source discharges and enforcement of effluent guidelines would also contribute to an improvement of streamflow water quality in the basin.

Watershed Protection

Best Management Practices (BMP's), which have been recommended by the local conservation districts in the Eastern Arkansas Basin and compiled in Table 3-24, can be used effectively to reduce the majority of water quality problems that are a result of land use practices in the basin. Implementation of these BMP's, particularly the agricultural BMP's, would significantly reduce the problems of excessive erosion and increased concentrations of nutrients, pesticides, and fecal coliform bacteria.

TABLE 3-24

BEST MANAGEMENT PRACTICES RECOMMENDED BY LOCAL CONSERVATION DISTRICTS

AGRICULTURAL BMP'S

1. Irrigation water management
2. Grade stabilization structures
3. Minimum tillage or no-till (conservation cropping system)
4. Crop residue management
5. Rotation cropping systems
6. Land levelling
7. Underground irrigation
8. Critical area planting
9. Establishment and management of permanent pasture and hayland
10. Ponds
11. Rotation grazing
12. Contour farming
13. Terraces
14. Diversions
15. Grassed waterways
16. Field borders
17. Debris and sediment basins
18. Soil testing and plant analysis
19. Correct pesticide use
20. Correct pesticide container disposal
21. Resistant crop varieties
22. Pipe drops
23. Pipelines
24. Winter cover crops
25. Filter strips
26. Streambank protection plus stream channel stabilization
27. Irrigation return flow systems
28. Educational program directed toward use of BMP's
29. Irrigation conveyance systems
30. Tree planting and strip cropping
31. Cross slope farming
32. Stand improvement
33. Close growing of grasses and legumes on steeper slopes
34. Land grading or smoothing
35. Integrated pest control
36. Waste management systems
37. Field drains
38. Broadcast planting
39. Mulching
40. Brush control
41. Field windbreaks
42. Water control structures
43. Critical area treatment
44. Cross fencing
45. Row arrangement

FORESTRY BMP'S

1. Improvement of fire control
2. Stand improvement
3. Critical area planting
4. Less clearing for cropland
5. Critical area treatment
6. Debris basins

CONSTRUCTION BMP'S

1. Critical area planting
2. Debris and sediment basins
3. Diversions
4. Grass waterways
5. Revegetating disturbed areas
6. Mulching
7. Temporary vegetative cover
8. Topsoiling
9. Critical area shaping
10. Water control structures
11. Grade stabilization structures
12. Lined waterways
13. Terraces
14. Vegetation filter strips
15. Site planning and proper timing of operations
16. Conservation of natural vegetation
17. Desilting basins
18. Erosion and sediment control plans for construction sites
19. Establishment and maintenance of permanent vegetative over to include trees
20. Collection of solid waste at site
21. Land grading
22. Traffic barriers
23. Access road design
24. Limited soil disturbance
25. Roadside stabilization on existing roads

SUBSURFACE DISPOSAL BMP'S

1. Septic tanks and filter fields properly installed
2. Provide municipal sewer service to rural areas
3. Sanitary landfills
4. Recycling
5. Alternate systems for sewage disposal
6. Limit housing density
7. Anaerobic and aerobic lagoons for animal wastes
8. Lagoons with impermeable membranes
9. Permit system for septic tanks and filter fields with stricter regulations

SALTWATER INTRUSION AND URBAN RUNOFF BMP'S

1. Grade stabilization structures
2. Critical area treatment
3. Grass waterways
4. Structures for water control
5. Debris and sediment basins
6. Crop rotation
7. Permanent vegetative cover
8. Flood control structures
9. Mulching
10. Water management
11. Diversions
12. Proper application of chemicals
13. Ponds
14. Hard surface all heavy use areas
15. Critical area planting
16. Holding ponds or pits
17. Lined waterways
18. Plug salt-producing wells
19. Terraces

MINING BMP'S

1. Reshaping strip mines
2. Sediment retention basins
3. Revegetation
4. Desilting basins
5. Diversions
6. Collection of funds for abandoned mine reclamation
7. Mulching
8. Mine land reclamation
9. Mandatory reclamation plans for new mines
10. Control measures to collect sediment during mining operations
11. Temporary vegetative cover

HYDROLOGICAL MODIFICATION BMP'S

1. Grade stabilization structures
2. Dikes
3. Streambank protection
4. Construction of irrigation reservoirs
5. Water return system in conjunction with reservoirs
6. Properly designed channels
7. Stream channel stabilization
8. Revegetation at time of construction
9. Spoil spreading
10. Water control structures
11. Designing of side slopes to facilitate revegetation and maintenance
12. Clearing and snagging
13. Channel excavations
14. Construction of retarding basins
15. Deepen existing ditches

16. Low water weirs
17. Critical area planting
18. Floodways

HYDROLOGICAL MODIFICATION BMP'S (CONTINUED)

19. Surface drainage
20. Rock-lined waterways
21. Mulching

RESIDUAL AND LAND DISPOSAL SITES BMP'S

1. Critical area planting
2. Diversions
3. Filter strips
4. Fencing
5. Sanitary landfills
6. Sites for disposal of pesticide containers
7. Solid waste collection systems
8. Disposal sites for removal of residual wastes
9. County-wide refuse disposal plan
10. Roadside stabilization
11. Traffic barriers
12. Process waste daily
13. Site selection plan

ROAD BMP'S

1. Topsoiling ditch banks
2. Paving
3. Grade stabilization structures
4. Diversions
5. Critical area planting
6. Mulching
7. Lined waterways
8. Design site selection to avoid steep areas
9. Water conveyance structures
10. Establishing and maintaining permanent vegetation
11. Planning and proper timing of operations
12. Use material with low content of erosive particles for surface of unpaved roads
13. Elimination of regular use of road grader for maintenance work
14. Pave county roads
15. Roadside stabilization practices
16. Water control structures

STREAMBANK BMP'S

1. Critical area planting
2. Floodwater retarding structures
3. Lined waterways
4. Sediment basins
5. Revetments and jetties
6. Fencing
7. Grade stabilization structures
8. Streambank protection
9. Water control structures
10. Establishing and maintaining vegetative cover

11. Stream zone management
12. Rock rip-rap
13. Streambank vegetation including trees

STREAMBANK BMP'S (CONTINUED)

14. Stream channel stabilization
15. Reshaping banks
16. Concrete mats

GULLY BMP'S

1. Grade stabilization structures
2. Critical area planting
3. Sediment basins
4. Terraces
5. Diversions
6. Grassed waterways
7. Critical area shaping
8. Water control structures
9. Mulching
10. Fencing
11. Floodwater retarding structures

Sources: Arkansas Soil and Water Conservation Commission, 1979
<3, 4, 5>

Anticipated reductions in nonpoint pollution sources will enhance the environment by improving water quality conditions throughout the region. It is expected that fisheries habitat and the opportunity for water-based recreation will be improved significantly. Wildlife habitat will also be enhanced because of improved cover and diversity throughout the region.

In addition to enhancement of the environment, implementation of the BMP's is expected to result in economic and social benefits including protection of the land and water resource base, availability of additional recreational activities in the basin, and improvements related to a reduction in hazards to human health. It is also anticipated that agricultural income will be increased. Crop production practices such as optimized fertilizer and pesticide applications will result in significant cost savings to growers with no significant effects on crop yield. Optimized crop production practices which have been utilized for cotton production in some areas of the state have resulted in cost savings of $55 to $65 per acre for the grower. <5>

The financial cost of implementing agricultural BMP's can be quite high. However, the Watershed Protection and Flood Prevention Act, PL 83-566, provides for the technical, financial, and credit assistance by the Department of Agriculture to local organizations representing the people living in small watersheds. A watershed protection plan includes only on-farm land treatment practices for sustaining productivity, conserving water, improving water quality, and reducing off-site sediment damages. <63> Practices might include such BMP's as conservation tillage, terraces, or even land use conversion. Participation within the watershed is voluntary and federal funds may be available. For practices sustaining agricultural productivity and reducing erosion and sediment damages, cost share rates may be up to 65 percent of the cost of the enduring practices installed, or the existing rate of ongoing conservation programs, whichever is less. Payments for management practices such as conservation tillage, based on 50 percent of the cost of adoption are limited to a one-time payment not to exceed $10,000 per landowner. No more than $100,000 of cost-shared PL 83-566 funds may be paid to any one individual. <61>

Regulation and Enforcement

Some of the water quality problems in the Eastern Arkansas Basin result from municipal and industrial discharges. Effluent from sewage treatment plants in the area often contributes to high fecal coliform concentrations which exceed the state water-quality standards in many streams. These high bacterial levels in streams could be reduced by chlorination of all municipal wastes discharged within the basin. The ADPC&E, which has powers of regulation and enforcement over municipal and industrial discharges, has been successful in correcting some of the most serious violations of the water-quality standards. For instance, the problem of dioxin contamination of the fisheries in the Bayou Meto sub-basin is currently being addressed. The Vertac Chemical Corporation has removed the contaminated soil from their industrial site and has covered areas with clay and asphalt to prevent further contamination. These actions have significantly reduced or eliminated this nonpoint dioxin contamination of Rocky Branch Creek, Lake Dupree, and Bayou Meto.

CONSERVATION

Water conservation efforts in the past have been somewhat limited since water supplies in the Eastern Arkansas Basin have usually been adequate to satisfy water needs. However, serious water-shortage problems that occurred during the drought of 1980 emphasized the need for efficient use of the available water in the basin and prompted initiation of the Eastern Arkansas Water Conservation Project <63>. This study was undertaken to investigate irrigation water management in the Eastern Arkansas Basin. Irrigation water management includes maintaining high infiltration rates, using efficient delivery systems, choosing proper application methods, achieving high application efficiencies, employing irrigation scheduling, and obtaining sound engineering planning. These elements are being investigated in the Eastern Arkansas Water Conservation Project which will help farmers in the area to improve the efficiency of current irrigation water management practices and techniques.

Infiltration Rates

Water is conserved for agricultural use when rainfall infiltrates the soil and is stored for use when needed by plants. High infiltration rates increase the amount of water that is stored in the soil. Infiltration of water into the soil may be increased by two methods: (1) practices that maximize soil pore space, and (2) practices that alter the soil surface to allow more time for infiltration. Vegetative cover on the soil surface absorbs raindrop impact to keep soil pores open. Stubble mulch tillage and no-till planting keep plant residues on the soil surface to increase infiltration and to decrease evaporation. Cover crops, when planted, are also effective in maintaining high infiltration rates. The second method for increasing infiltration rates involves alteration of the soil surface to allow more time for infiltration of water. With proper management, runoff can be minimized and more infiltration will occur. The construction of terraces and the practice of farming on the contour are two methods of surface alteration that allow more time for infiltration.

Delivery Systems

Delivery systems vary from high efficiency pipelines to significantly less efficient earthen canals or temporary ditches. Water losses for the different types of delivery systems, as estimated by the Soil Conservation Service <57>, are shown in the following table:

Component	Estimated Range Of Water Loss ----percent----
Delivery Systems	
Main Canal (earth)	10-40
Field Canal (earth)	10-40
Portable Pipeline	0-10
Main Pipeline	0-5
Underground Pipeline	0

Delivery systems used in the Eastern Arkansas Basin consist of about 1,200 miles of earthen irrigation canals, 1,300 miles of underground pipelines, 300 miles of above-ground pipes (gated pipe), and about 100 miles of temporary ditches. <60> Replacement of earthen canals, which typically lose from 10 to 40 percent of the total volume of water pumped through the canal, with underground pipeline which has virtually no water loss could significantly increase the efficiency of the delivery system. Replacing canals with pipelines will eliminate seepage and evaporation losses, while also reducing system maintenance. Pipelines also require less land area than canals and allow more positive control in water management. Irrigation water supplied through pipelines is available for use at the precise time and location it is needed.

As previously noted, water loss in the delivery system can be significantly reduced by increasing the amount of pipelines in the delivery system, however, this would also be an expensive modification. Therefore, one aspect of the Eastern Arkansas Water Conservation Project <63> involves a study of canal delivery systems. The objectives of this part of the study are: (1) to determine typical water loss in canal delivery systems; (2) to determine variables that affect canal water loss and the relative importance of each (soil types, canal length, canal shape and condition); and (3) to develop guides for estimating delivery system water loss. This information will be used to develop a cost benefit analysis procedure to be used for system modification by the farmers in eastern Arkansas.

Application Methods

Contour levee irrigation is the most common method of applying water to crops in the Eastern Arkansas Basin. In 1980, about 86 percent of irrigated acreage in the basin was irrigated by contour levee methods. Other methods of irrigation in eastern Arkansas include: furrow irrigation (7%), sprinkler methods (3%), level border (3%), and other methods (1%). <60>

The greatest single on-farm conservation of water can be accomplished by selection of the most suitable irrigation method. Factors to be considered in the choice of an application method include slope, soil type (infiltration and permeability), crop type, water availability, and availability of labor. Choosing the proper application method is the first step in obtaining high application efficiencies.

Application Efficiency

Application efficiency depends on the uniform application of water at the appropriate rate and at the proper time. The application efficiency can be increased if water is applied at a uniform depth over the entire field. Over-application to the upper end of the field causes water loss by deep percolation which is a common problem with furrow irrigation. However, methods such as furrow diking and surge irrigation help to obtain uniform application. Precision land leveling and land smoothing are practices that modify the soil surface to allow for a more uniform application of water, thereby increasing application efficiency. Water can be conserved on contour levee irrigation of rice by shallow flooding. Shallow flooding of rice is practical on a relatively flat, precision-leveled field where a minimum depth of water will cover the entire field.

Application efficiencies for gravity methods of irrigation can be increased significantly by installing tailwater recovery systems (return systems). For example, data in the following table show that the estimated water loss for contour levee irrigation without return systems ranges from 20 to 60 percent. The installation of a tailwater recovery system could reduce water loss for contour levee irrigation to about 5 to 20 percent. Furrow irrigation is also much more efficient with return systems.

	Estimated Range of Water Loss --percent--
Application Method	
Levee (without return)	20-60
Levee (with return)	5-20
Furrow (without return)	15-70
Furrow (with return)	5-20
Center Pivot Sprinkler	10-25
Solid Set or Portable Sprinkler	10-25
Traveling Sprinkler	10-25

(Source: Soil Conservation Service <57>)

Sprinkler methods of irrigation are more efficient than gravity methods (without return systems), with water losses for sprinkler methods ranging from 10-25 percent. <55> High efficiencies are dependent upon climatic factors such as wind and temperature, with evaporation losses normally 5 to 10 percent of the total discharge. Only about 3 percent of the irrigated acreage in the basin is irrigated by sprinkler methods. Significant water conservation could result if gravity methods of irrigation were replaced with sprinkler methods, however, the high cost of conversion must be considered.

Data are currently being collected in the basin as part of the Eastern Arkansas Water Conservation Project <65> to determine typical application efficiencies as related to : application method (continuous flood, intermittent flood, furrow, and sprinkler irrigation), crop type, and soil type. These data will provide information necessary to determine the potential for water and energy conservation through improved water management practices and techniques.

Irrigation Scheduling

Regardless of the method of application, irrigation water must be applied in the appropriate amount and at the proper time for maximum irrigation efficiency. Irrigation scheduling allows the farmer to apply water in sufficient quantity to satisfy crop requirements at the appropriate times during the growing season. Factors that are considered in the determination of irrigation scheduling are soil properties, plant characteristics, climatic conditions, and management practices. Important soil properties include texture, depth to restricting layer, available water holding capacity, infiltration, and permeability. Plant characteristics that govern irrigation scheduling are crop type, drought tolerance, and root depth. Climatic conditions that are considered include temperature, wind, relative humidity, and rainfall. These factors, along with management practices including row spacing, short or long season crop varieties, and planting dates, are considered in the development of an efficient irrigation schedule.

Irrigation scheduling also involves the use of some specialized equipment. Moisture monitoring equipment is used to determine the quantity and time of water application. Tensiometers, gypsum blocks, feel methods, speedy moisture testers, and nuclear moisture gages are the most popular moisture monitoring equipment and techniques. In addition, flow meters, flumes, and weirs are installed to determine the amount of water that can be applied to the field. This equipment is used to implement the irrigation schedule for maximum application efficiency.

Irrigation scheduling is currently being investigated in the Eastern Arkansas Water Conservation Project <63> to determine the most efficient methods to be used based on existing conditions in the basin. Studies are underway to determine consumptive water use by crops and to develop methods so that water application coincides with plant needs. Information compiled on irrigation characteristics of soils including: intake rates, water holding capacities, root zone depths and densities, seasonal percolation rates, and runoff rates for different application methods will also contribute to better irrigation scheduling in the basin.

Engineering Planning

An engineering plan can contribute to maximum use of available water. Irrigation and drainage of individual fields should be carefully planned to utilize the complete irrigation and drainage system. Engineering planning can help determine the size of fields, slopes needed on precision-leveled fields, location of drainage ditches, location of underground pipelines and outlets, location and size of pipes for water control, and location of wells.

Some of the water-supply problems in the Eastern Arkansas Basin could be alleviated by implementation of conservation measures. An increase in the efficiency of current irrigation systems could be achieved with the use of proper application methods along with equipment maintenance. Leaks in pipelines and canals, vegetation along canals, inefficient pump and power unit maintenance, improper irrigation scheduling, and excessive runoff from irrigated land contribute to losses in irrigation water use efficiency.

Water conservation will be even more important in the future since water use for agricultural needs in the basin is projected to increase significantly. An aggressive educational effort informing irrigators of efficient, cost-effective irrigation water use methods would promote improved irrigation water management in the Eastern Arkansas Basin.

Determination of Instream Flow Requirements

Determination of instream flow requirements for streams in the basin is an important first step in ensuring the maintenance of suitable flows to support these important uses. However, two major problems that have been encountered in the determination of instream flow requirements for streams in the basin are the lack of sufficient data and the inflexible methodologies. These problems make it very difficult at the present time to determine instream flow requirements for all streams in the Eastern Arkansas Basin.

A solution to the problem of determining instream flow requirements for streams in the basin is to first prioritize the streams to determine those which currently have instream use problems or have the highest potential for instream problems. Once these streams in the basin are identified, determination of instream flow requirements for these priority streams is a much more realistic and manageable task than determining instream uses for all streams in the basin.

The South Carolina Water Resources Commission has taken this approach in their Instream Flow Study <13>. The South Carolina Instream Flow Study is divided into two phases. Phase I includes the identification and listing of streams for which instream flow requirements need to be established. Phase II entails the determination of instream flow needs to protect instream uses in the priority streams identified in Phase I. In the following paragraphs, a summary of their methodology is presented as a recommendation for determining instream flow requirements for streams in the Eastern Arkansas Basin.

In Phase I of the South Carolina Instream Flow Study, stream segments in need of streamflow protection were identified and ranked in priority order using the following methods and procedures:

(1.) Stream segment delineation - All permanent streams in the study area were divided into discrete segments. Most of the smaller streams were represented by a single segment, however, larger streams were subdivided into two or more segments based on segment length and significant tributary inflow.

(2.) Data management - Streamflow and water use data for each segment were assimilated and several values were calculated for the stream ranking process (use impact, dam impact, flow variability, protection need, significance value, and overall rating value).

(3.) Stream ranking procedure - A mathematical procedure was developed to rank streams in need of flow protection. For each stream segment in the study area, two numerical values were determined: the protection need value and the significance value. The protection need value is an indicator of the relative need for low-flow protection based on natural streamflow conditions and man's activities within the segment. The significance value indicates the relative importance of each segment based on instream and offstream use activities occurring on the segment. The product of multiplying these two values together equals the overall rating value of a stream. The potential for a stream to experience instream flow problems is proportional to the magnitude of its overall rating value. Therefore, the higher the overall rating value, the greater the need for streamflow protection. The highest priority streams were selected by identifying a significant break point in the ranking of overall rating values.

Water use activities, flow characteristics, and existing water use problems of each segment were also considered in selecting the highest priority streams.

(4.) Determination of protection need values - The natural variability of the streamflow and the potential impacts from man's activities in and along the stream were incorporated in the evaluation of streams for need of flow protection. Streams with poorly sustained baseflow and(or) relatively extensive offstream water use compared to flow, are at a high risk of having instream use problems. Based on this premise, the following empirically derived equation was used to evaluate the need for flow protection:

$P = A\ (1+B+C)$ where:
P = Protection need value
A = Average Flow/7Q10
B = Total water withdrawal/7Q10 (100)
C = Reservoir storage/7Q10

The higher the protection need value the greater the need for streamflow protection.

(5.) Determination of significance values - Significance was defined as relative importance based on the extent of instream and offstream use occurring within each stream segment. Each stream segment was assessed for the occurrence and extent of use for each of the following water use categories:

(1) Industrial water withdrawals
(2) Municipal water withdrawals
(3) Agricultural water withdrawals
(4) Thermoelectric power water withdrawals
(5) Hydroelectric power water use
(6) Commercial fishery
(7) Recreational fishery
(8) Commercial navigation
(9) Recreational navigation
(10) Maintenance of endangered or threatened species
(11) Wastewater assimilation (water quality)
(12) Unique aesthetic and ecological characteristics

A separate water use value (see below) was determined for each use category for all stream segments. The significance value for a given stream segment was equal to the sum of all water use values determined for that segment.

(6.) Water use values - A common scale of water use values, ranging from 0 to 5, was applied to all use categories. A single water use value was determined for each of the 12 use categories occurring on each stream segment. The water use value for each use category indicates the relative importance of that use within a given stream segment to that same use in all other stream segments. The greater the relative degree of use, the higher the water use value.

Water use values were determined for a given use category by first determining the degree of that use for each stream segment. Then for each use category, stream segments were ranked from lowest to highest. If no use occurred, a value of zero was assigned to the segment. Use values of 1-5 were evenly assigned to the segments with use by assigning a value of one to the first 20 percent of segments with the lowest use for that category, then a value of two for the next highest 20 percent of segments, and so on. Segments with the same degree of use always received the same water use value.

(7.) Results - The result of the stream ranking procedure previously discussed was a priority list of streams that are in the greatest need of establishing instream flow requirements in the study area. The inclusion of a stream segment on the list does not necessarily indicate that instream use problems occur, but rather that the potential for such problems is greater for these streams than for most other streams in the study area.

In the second phase of the Instream Flow Study, the priority streams identified in Phase I are studied in more detail to determine instream flow levels that will adequately assure the "continued viability" of recognized uses within their channels. The two major problems previously identified for determining instream flow requirements in the Eastern Arkansas Basin (lack of sufficient data and inflexible methodologies) should be significantly easier to deal with since only the priority streams would be evaluated. For instance, the prioritization of streams would limit the areas necessary for evaluation, and additional data collection necessary to quantify instream flow requirements could be concentrated in the identified priority areas. In addition, the methods used to determine instream flow requirements could be more easily modified to address the priority streams rather than attempting to develop methods that are applicable for the entire basin or the entire state.

Identification of these priority segments is an important first step in addressing the maintenance of instream uses. However, protection measures can not be limited to these segments alone, as if they are isolated from the rest of the river and stream systems. By the very nature of flowing waters, actions which impact flows in any single segment will also impact flows downstream. Consumption of flows in small headwater streams may not greatly affect uses on each individual stream, but the cumulative loss of water from several small streams may severely affect streamflows in larger downstream segments. Therefore, to provide adequate long-term protection of instream uses, a statewide approach to manage flows in all streams, regardless of size, must be considered.

CHAPTER IV

GROUND WATER

INTRODUCTION

The East Arkansas Basin is located on the western flank of the Mississippi Embayment, a southward plunging syncline which has an axis that is roughly parallel to the Mississippi River. Geologic units from the Paleozoic, Mesozoic and Cenozoic eras are present at the surface or in the subsurface of the basin (See Table 4-1).

The Paleozoic strata consists chiefly of sandstone and shale which crop out in the extreme western part of the basin and dip to the southeast where they are covered by unconsolidated strata of the Mesozoic and Cenozoic eras. The Paleozoic strata forms an impermeable base which dips towards the axis of the embayment, where it reaches a depth of approximately 4600 feet below sea level. Strata of the Paleozoic Era are used as a source of groundwater where no other alternatives exist. <38>

Rocks of the Paleozoic era are overlain by clay, silt, lignite, sand, and gravel deposits of younger age. These sediments originate from both marine and continental environments. Succeeding transgressions and regressions of the sea formed alternating layers consisting chiefly of sand and clay. The continental deposits consist of coarser-grained sediments which have a high permeability and make up the aquifers of the basin. The marine deposits are composed mostly of marl and clay layers which form confining beds that greatly limit ground water flow into and out of aquifers.

The uppermost layer of the basin is an alluvial deposit of the Quaternary Period. This alluvium consists of clay, silt, sand, and gravel deposited by stream activity, and wind-blown deposits of silt and loess. Alluvial terraces were deposited during the Pleistocene Epoch where glacial runoff from the north reached the lower gradient of the Gulf Coastal Plain, and sediment aggradation occurred. Fluvial activities of erosion, transportation, and deposition further shaped the alluvium and continues to do so today. Wind-blown deposits of silt and loess accumulated over much of Northeast Arkansas during the Quaternary Period. Most of this sediment has been redistributed by erosional processes. Crowleys Ridge is an erosional remnant of these wind-blown sediments.<9, 11>

Several geological units of the Tertiary Period subcrop beneath the Quaternary deposits of Crowleys Ridge. The ridge is underlain by the Wilcox Group in Greene, and Craighead counties, and by the Memphis Sand in Poinsett and Cross counties.

The principal sources of groundwater in the East Arkansas Basin are the Quaternary alluvium, Sparta Sand, Memphis Sand, Wilcox Group, and Nacatoch Sand. Minor withdrawals from the Carrizo Sand, Cane River Formation, Cockfield Formation, and Paleozoic Erathem also occur. Figure 4-1 illustrates the general physiography and stratigraphy of the principal aquifers of East Arkansas.

Downdip from the outcrop or subcrop areas, some of these aquifers contain saline water of natural origin. Excessive pumping can induce migration of this saline water into freshwater areas. <29,37>

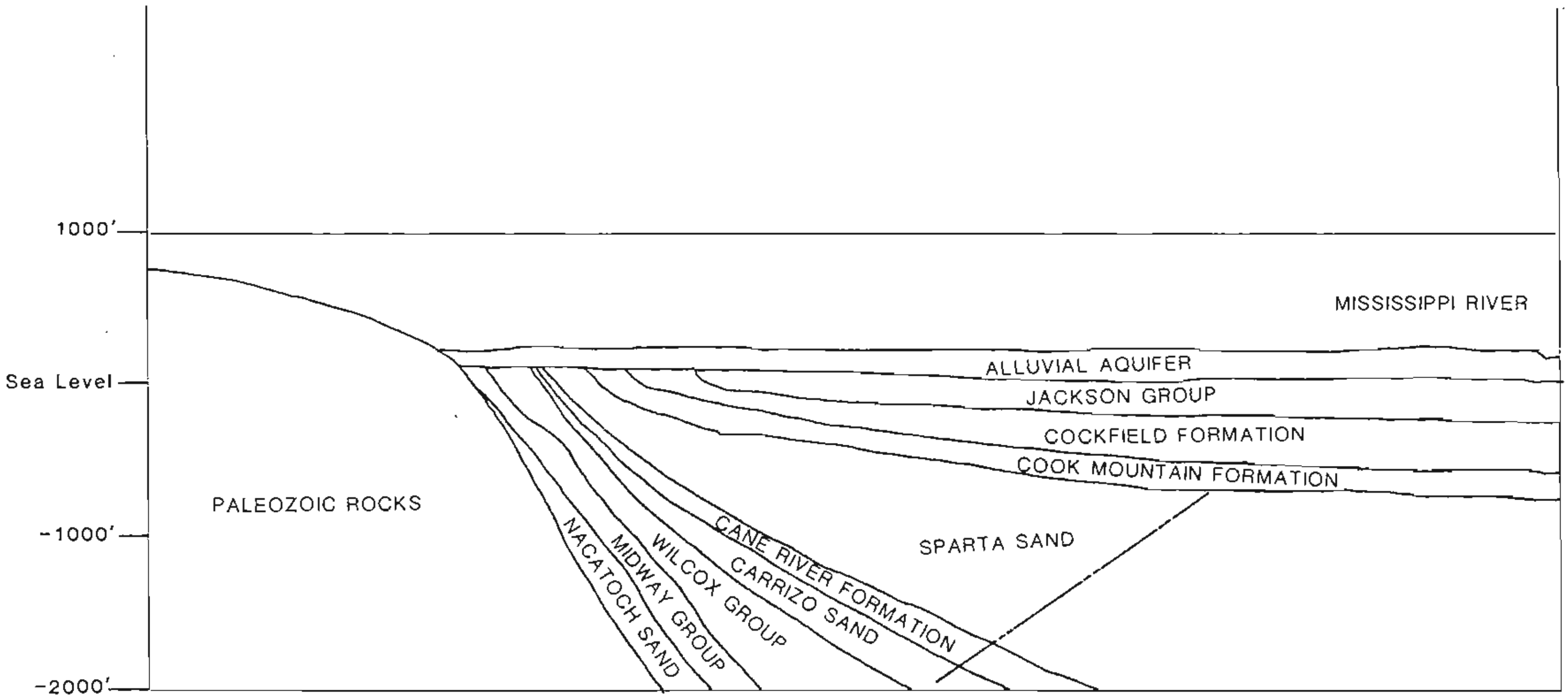
table 4-1

STRATIGRAPHIC COLUMN OF ARKANSAS

ERA	PERIOD	ARKANSAS		
	QUATERNARY	Alluvial deposits undifferentiated		
	QUATERNARY	Loess Terrace deposits undifferentiated		
CENOZOIC	TERTIARY	JACKSON GROUP	Undifferentiated	
		CLAIBORNE GROUP	Cockfield formation	
			Cook Mountain Formation	
			Sparta Sand	Memphis Sand
			Cane River Formation	Memphis Sand
			Carrizo Sand	Memphis Sand
		WILCOX GROUP	Undifferentiated	
		MIDWAY GROUP	Porters Creek Clay	
			Clayton Group	
MESOZOIC	CRETACEOUS	Nacatoch Sand		
PALEOZOIC		Undifferentiated		

figure 4-1

GENERALIZED CROSS SECTION OF EAST ARKANSAS



Source: Modified from Ludwig 29

NACATOCH SAND

Geology

The Nacatoch Sand is an unconsolidated formation of the Cretaceous Period which is composed chiefly of a fine-grained quartz sand with interbedded calcareous clay, and limestone layers. The formation occurs only in the subsurface of the East Arkansas Basin. Along the fall line, in Randolph, Lawrence and Independence counties, the formation subcrops beneath alluvial deposits of the Quaternary Period (See Figure 4-2). The strata dips to the southeast with a gradient of about 35 ft. per mile. In the southeast corner of the basin, the formation occurs at a depth of approximately 3,600 ft. below sea level (See Figure 4-3). Maximum thickness of the Nacatoch sand is about 600 feet. The formation is overlain by dense marine clays of the Midway Group, and underlain by carbonate rock of the Paleozoic Era. <37,50>

Hydrology

The Nacatoch Sand is the only aquifer of the Cretaceous Age present in the East Arkansas Basin. The aquifer commonly yields 150 to 300 gallons per minute to wells. Recharge to the aquifer occurs in the subcrop area where water percolates through the overlying alluvium into the formation: Ground water flow is downdip, in the southeastward direction. <30,37>

The potentiometric surface of the Nacatoch Sand aquifer varies from 9.69 to 71.2 feet below land surface. Average annual declines in water levels measured from 1982 to 1987 range from 1 to 9.56 feet. An increase of 6.42 feet was observed in the public supply well at Knobel. <29,37,50>

Water Use

In 1980, 1.71 mgd (1915.2 acre-ft.) was pumped from the Nacatoch Sand in eastern Arkansas. These withdrawals occurred in Clay and Greene counties where the aquifer is used for public supply at Knobel, Rector, Piggot, Greenway, McDougal, St. Francis and the Lafe Water District. <19,29>

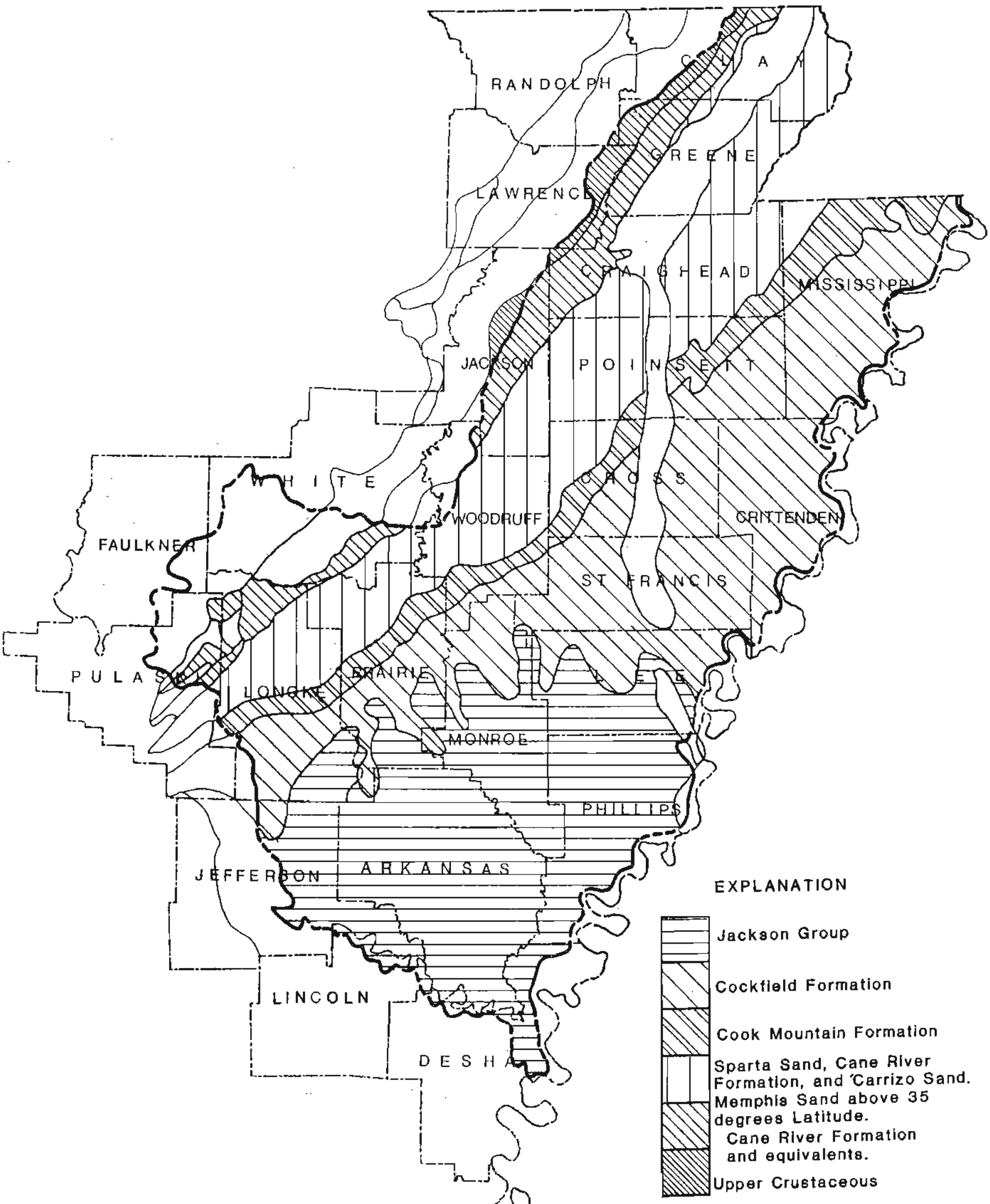
Water Quality

Water from the Nacatoch Sand is a soft, sodium bicarbonate type. Salinity of the aquifer becomes greater downdip from the subcrop area. <30>

Table 4-2 illustrates median values for some of the water quality samples taken from the Nacatoch Sand. These data indicate that the water quality is good in the area of use. The aquifer contains less iron than most aquifers in the basin. The sodium content exceeds the limit of 100 mg/l at which the Arkansas Department of Health issues a sodium alert to public supply systems. <72>

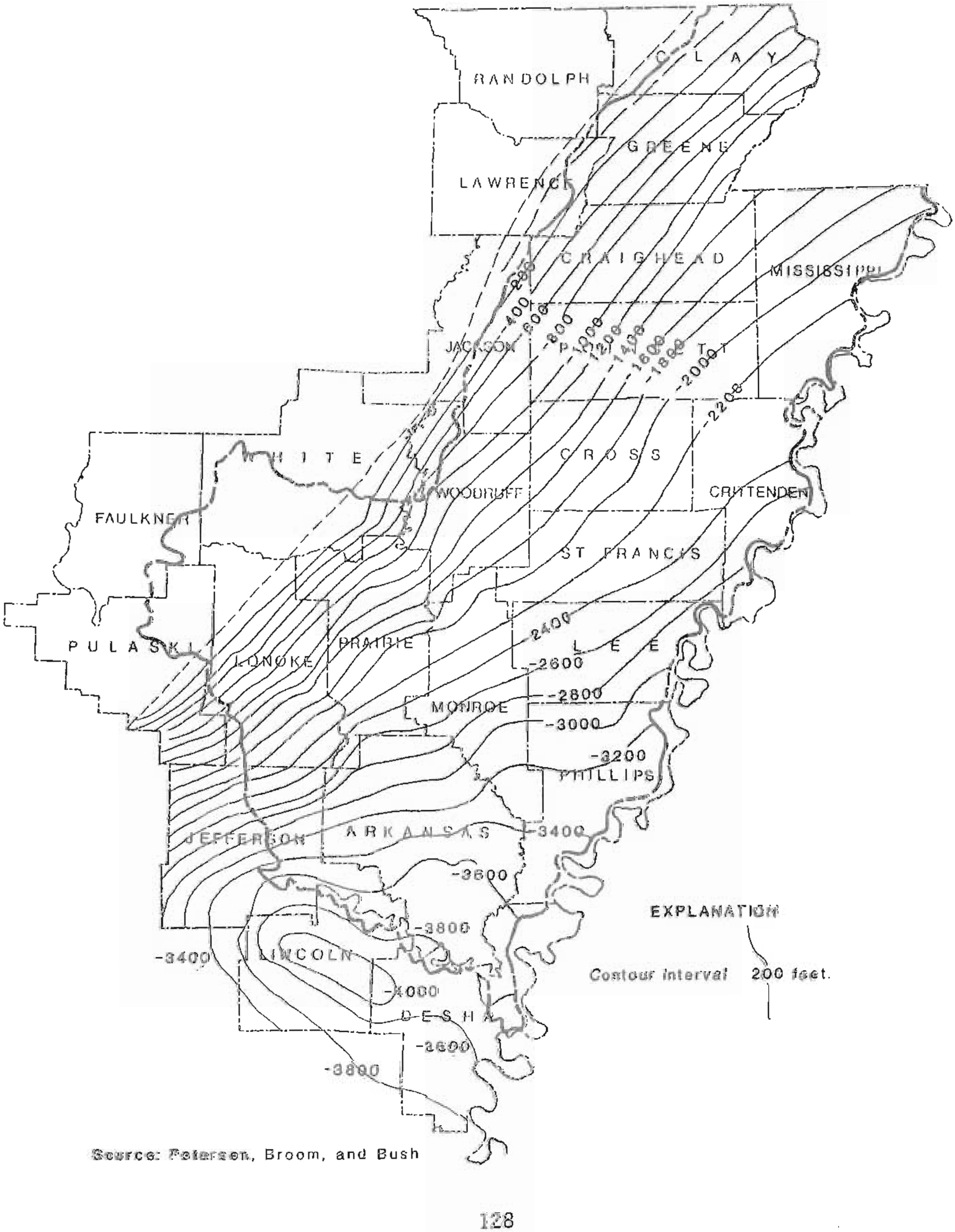
figure 4-2

DISTRIBUTION OF SEDIMENTS UNDERLYING THE ALLUVIAL AQUIFER



Source: U. S. Army Corps of Engineers, Eastern Arkansas Region comprehensive study

figure 4-3
STRUCTURE OF TOP OF THE NACATOCH SAND



Source: Petersen, Broom, and Bush

TABLE 4-2

Nacatoch Sand Water Quality

Median Values for Selected Constituents
(mg/L unless otherwise noted)

Temperature	22oC
pH	8.4
Hardness as CaCO3 (mg/L)	22
Calcium	6
Magnesium	1.3
Sodium	190
Potassium	3.2
Chloride	71
Sulfate	9
Flouride	.4
Silica	11
Dissolved Solids	472
Iron	.032
Manganese	<.01

Source: USGS file data <72>

WILCOX GROUP

Geology

The Wilcox Group is an unconsolidated strata of the Tertiary Period. The strata consists of a sequence of interbedded sand, clay, and lignite. The upper unit consists chiefly of clay while the lower unit is primarily a massively bedded fine-grained sand. This lower unit is known as the "lower Wilcox aquifer" or the "1400 ft. sand" because it is usually encountered at about this depth in the subsurface. West of Crowleys Ridge the sand beds are lensing and discontinuous. <37,46>

The Wilcox Group outcrops in northern Lonoke County, east of Cabot and along the western edge of Crowleys Ridge in Clay, Greene, and Craighead counties. The formation subcrops beneath the Quaternary alluvium as shown in Figure 4-2. Strata of the Wilcox Group dips to the southeast at approximately 40 feet per mile. The top of the formation is shown in Figure 4-4. Maximum depth to the top of the formation is about 1,800 feet below sea level, or 2,000. below land surface, which occurs in Arkansas County. Maximum thickness is about 1100 feet which occurs along the axis of the Mississippi River Embayment, roughly parallel to the Mississippi River. The Wilcox Group is confined by the overlying prominent sands of the Carrizo Sand and the underlying clays of the Midway Group. <11,37,46,50>

Hydrology

The Wilcox Group contains the lowermost ground water supply of the Tertiary Period. The "lower Wilcox aquifer" yields large quantities of water to wells in eastern Arkansas. East of Crowleys Ridge, the aquifer yields over 1,000 gallons per minute to wells. In the outcrop and subcrop areas, the aquifer yields 200 to 300 gallons per minute to wells. <30, 37>

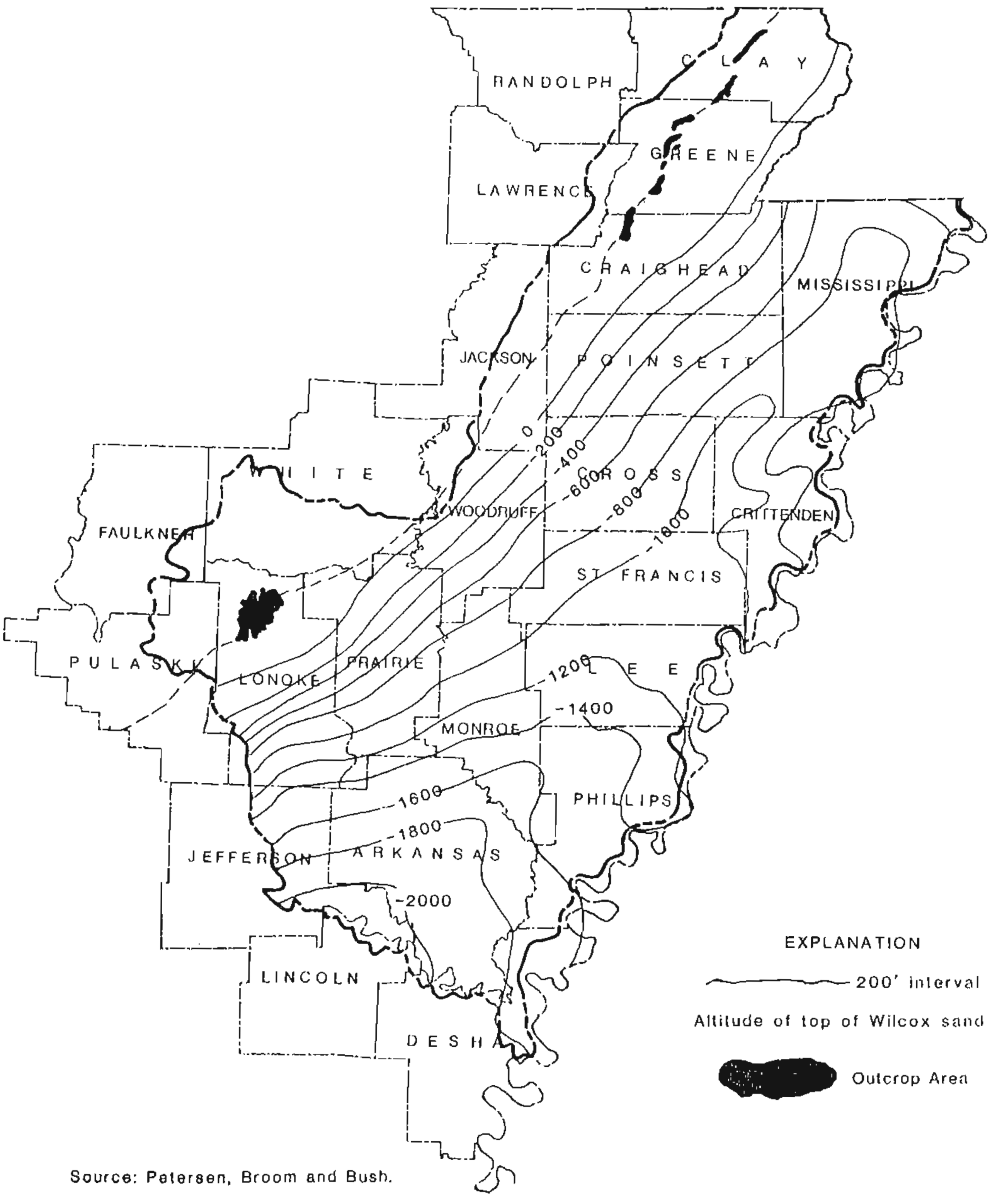
Recharge occurs from precipitation entering the outcrop zone or by percolating through the overlying alluvium. Groundwater flow is to the southeast toward the axis of the Mississippi Embayment. The potentiometric surface of the Wilcox aquifer varies from 8 to 150 feet below land surface. Water-level declines from 1982 to 1987 range from .07 to 10.6 ft. The most severe declines have occurred in Crittendon County. Increases in the water levels of up to 16 ft. have been observed in Poinsett County. <18, 36>

Water Use

Withdrawals from the Wilcox Group in the East Arkansas Basin during 1980 have been estimated to be 46.68 million gallons a day or 52,281.6 acre-feet per year. Withdrawals occur primarily in the area east of Crowleys Ridge where the "lower Wilcox aquifer" yields large quantities of water to wells, and in the outcrop and subcrop areas along the western boundary of the basin. Water pumped from the aquifer is used primarily for municipal and industrial supply. The aquifer is tapped for public supply by the communities of Caraway, Lake City, Black Oak, Snowden, Midway, West Memphis, Crawfordsville, Marion, Earle, Turrell, Paragould, Dyess, Bassett, Wilson and numerous other water associations.

figure 4-4

STRUCTURES OF THE WILCOX SAND



Source: Petersen, Broom and Bush.

Water Quality

Median values for wells monitored from the Wilcox aquifer indicate a good quality water except in the extreme southeast corner of the basin where total dissolved solids concentrations are above 10,000 mg/L. Water quality data is summarized in Table 4-3. The water is a soft, sodium bicarbonate type which becomes saline in the downdip areas. In it's area of use, the aquifer contains generally less than 1,000 mg/L of dissolved solids. The water is hard as $CaCO_3$ and also contains high concentrations of iron in some areas.

TABLE 4-3

Wilcox Aquifer Water Quality

Median Values for Selected Constituents
(mg/L unless otherwise noted)

Temperature	23.5oC
pH	7.5
Hardness as CaCO3	15
Calcium	4.2
Magnesium	1.1
Sodium	35
Potassium	2.5
Chloride	2.2
Sulfate	4.8
Flouride	.10
Silica	9.9
Dissolved Solids	116
Iron	.07
Manganese	.02
Nitrate (N)	.09
Nitrate (NO3)	.31

Source: USGS file data <72>

SPARTA SAND

Geology

The Sparta Sand is an unconsolidated formation of the Tertiary Period which occurs in the subsurface of the East Arkansas Basin. The formation consists of an upper unit of alternating sand and clay beds and a lower massively bedded sand. North of about 35 degrees, the Sparta Sand combines with the underlying Cane River Formation and Carrizo Sand to form the Memphis Sand.

The Sparta Sand is found only in the subsurface of the East Arkansas Basin. The outcrop area is located outside of the basin, further to the southwest. The formation subcrops beneath the Quaternary alluvium along a northeast to southwest line in parts of Pulaski, Prairie and Lonoke Counties (See Figure 4-2). From the subcrop area, the formation dips generally to the southeast except in southern Arkansas County where the dip is to the southwest. The gradient is approximately 30 feet per mile. The top of the formation reaches a maximum depth of about 450 feet below mean sea level (See Figure 4-5). Maximum thickness of the Sparta Sand is about 800 feet in southern Arkansas County. The formation is confined between the clays of the Cock Mountain Formation and the Cane River Formation. <37,46,50>

Hydrology

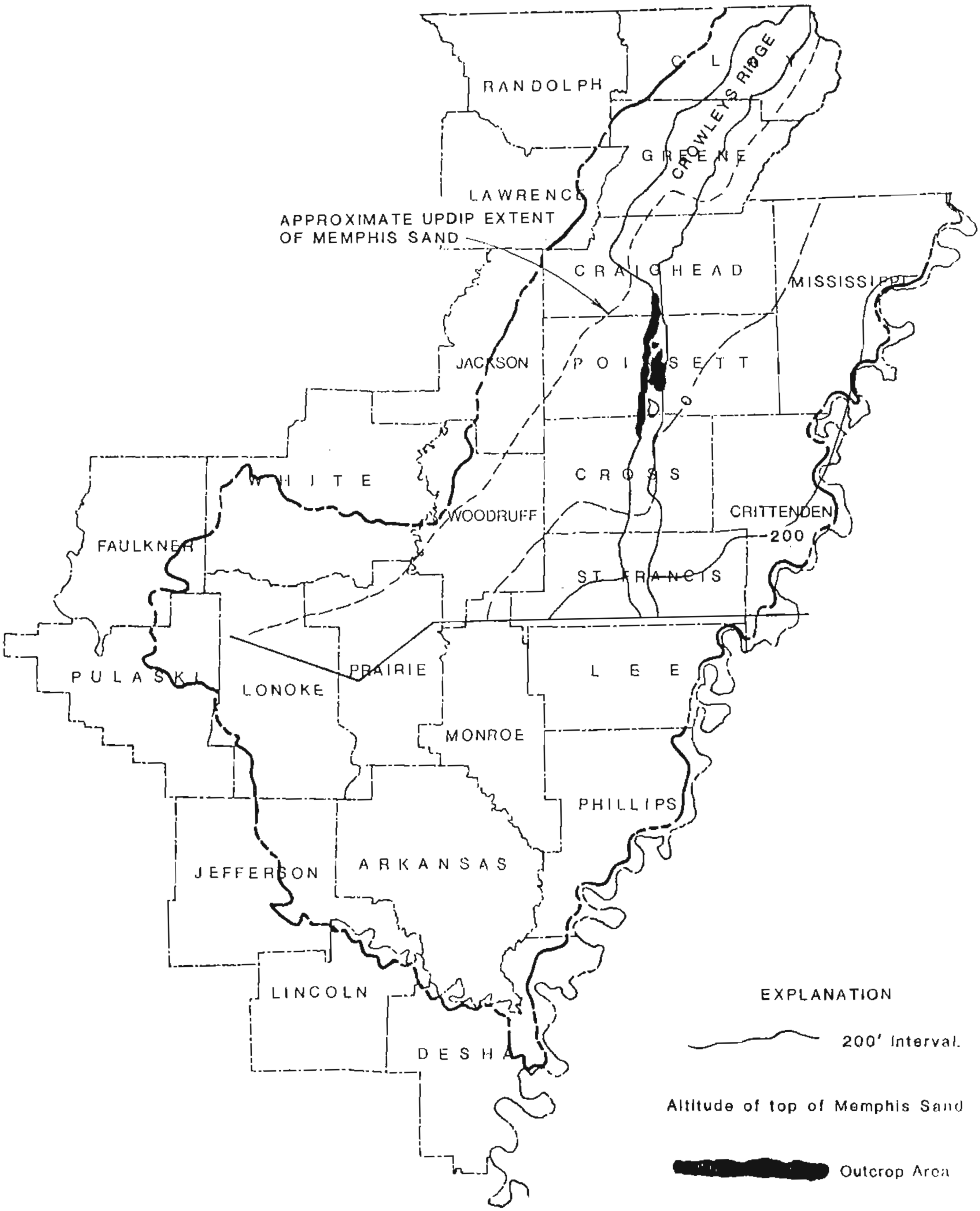
The Sparta Sand aquifer generally yields up to 1,000 gallons per minute of water to wells. Above about 35 degrees latitude, the Sparta Sand combines with the underlying Cane River and Carrizo Sand formations to form a massive sand unit known as the Memphis Sand aquifer.

Within the basin, recharge to the Sparta Sand occurs primarily in the subcrop area where water percolates through the overlying alluvium into the formation. Ground water flow is downdip, or toward areas of concentrated pumping where ground water flow patterns have been altered by cones of depression. Water levels for the aquifer range from -20 to 180 above mean sea level as shown in Figure 4-6. The greatest depth to the potentiometric surface is located in the vicinity of Pine Bluff where a cone of depression has developed as a result of overpumping from the aquifer. Water levels have declined throughout most of the basin, but are the most severe around the Pine Bluff area (See Figure 4-7). The immediate area around Pine Bluff and Wilkins shows a water level increase of 5 to greater than 10 feet. Another area where the potentiometric surface has risen is adjacent to the Mississippi River in Phillips County. <14,19,37>

Water Use

Primary use of the Sparta Sand aquifer is for municipal and industrial water supply. The aquifer is a source of public water supply in the communities of Almyra, Humphrey, DeWitt, Gillett, Marianna, Coy, Clarendon, Brinkley, Marvell, West Helena, Lakeview, Wabash, Elaine, Hensley and Woodson. Estimates show that in 1980, 68.33 million gallons a day, or 76,529.6 acre-ft. per year, was pumped from the aquifer within the East Arkansas Basin. Based on this amount, the Sparta Sand aquifer is second in significance only to the Quaternary alluvium. In 1985, estimated withdrawals of 68.86 million gallons per day, or 77,123.2 acre-ft. per year, occurred from the aquifer in the basin. This is an increase of less than one percent. <19,27,29>

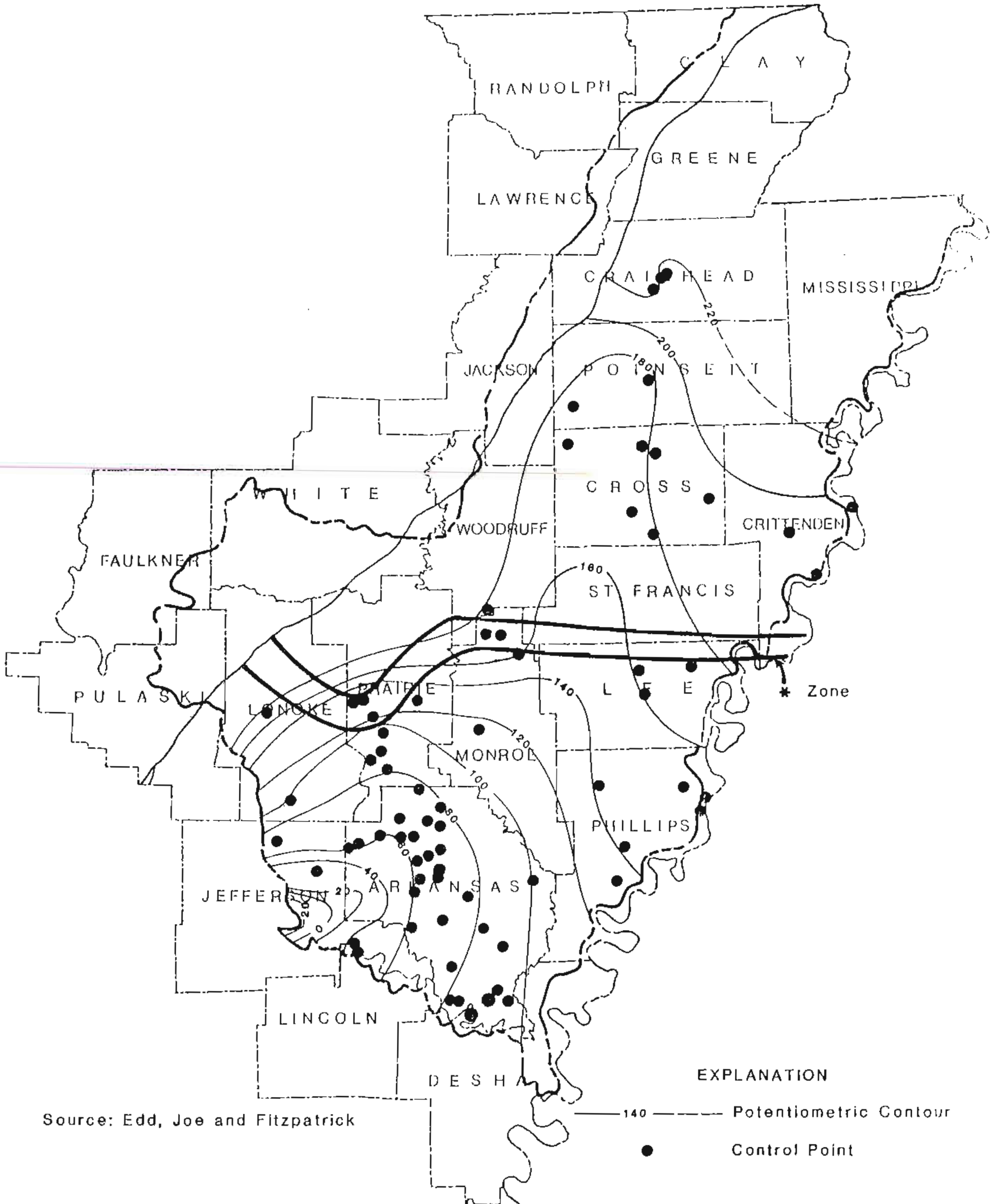
figure 4-5
STRUCTURE OF TOP OF MEMPHIS SAND



Source: Petersen and Broom.

figure 4-6

WATER-LEVEL MAP OF THE SPARTA-MEMPHIS SAND AQUIFER

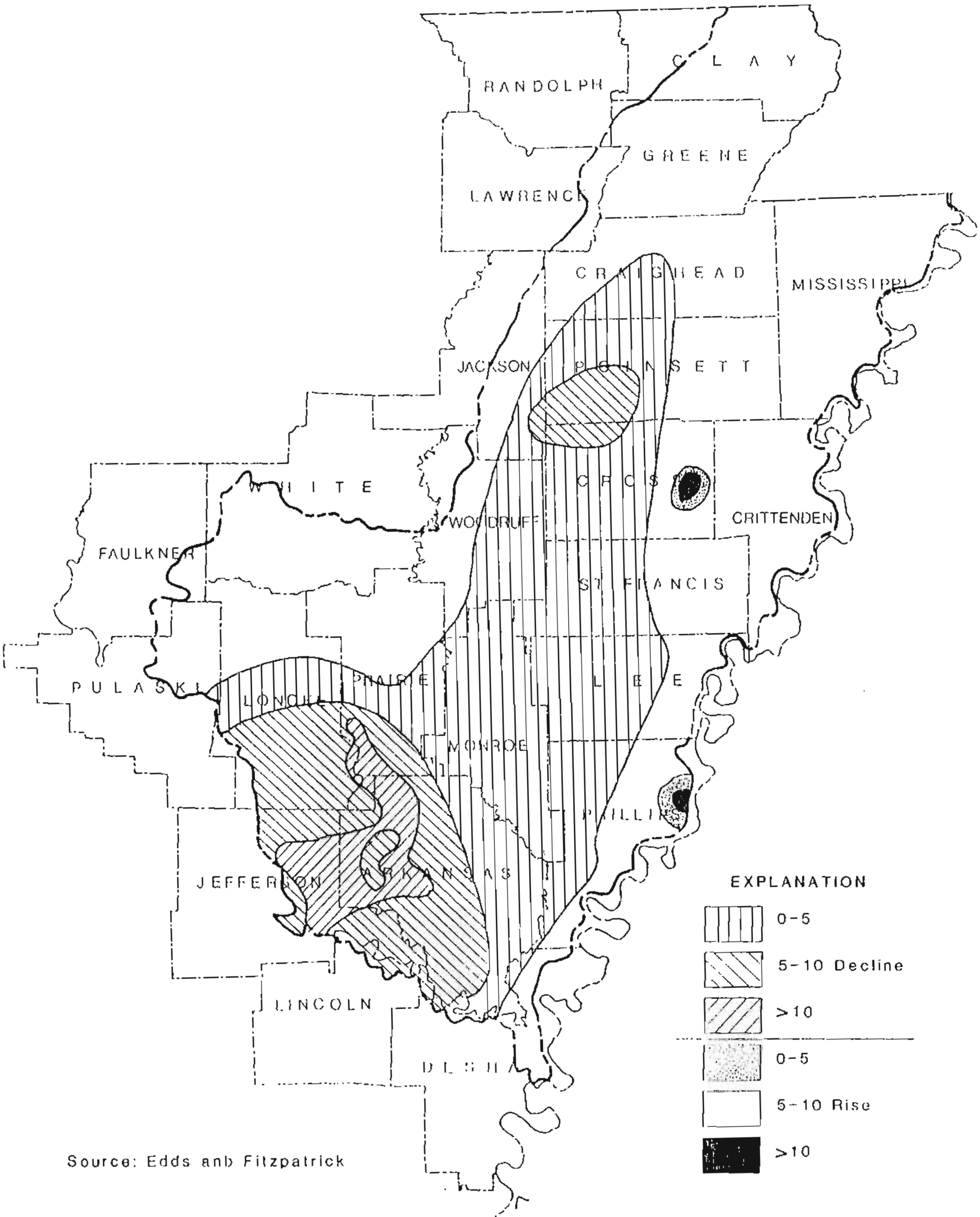


Source: Edd, Joe and Fitzpatrick

* Zone of transition where Cane River Formation or equivalents change facies from Clay to Sand- marks southern limit of Memphis Aquifer.

figure 4-7

SPARTA SAND-MEMPHIS SAND
WATER-LEVEL CHANGE MAP



Water Quality

Ground water in the Sparta Sand is locally hard to very hard and contains iron concentrations of up to 2.8 mg/L. Median values for the total dissolved solids range from 320 to 384 mg/L with maximum values of up to 1220 mg/L (See Table 4-4). Figure 4-8 illustrates the total dissolved solids concentration. This condition is a natural phenomenon, however, concentrated pumping can cause upconing and lateral encroachment of the contaminated water into freshwater zones. Chloride content is excessive in local areas such as near Brinkley where maximum concentrations are as high as 1100 mg/L. Sodium is strongly associated with the chloride concentration in this area. <24,37,39,72>

County by county water quality data for the Sparta Sand aquifer is shown in Table 4-5. Most constituent concentrations are less than the limits established for drinking water standards. However, maximum levels of chloride, iron, sodium, and dissolved solids indicate quality problems in local areas where concentrations exceed established standards as seen in Table 4-6. <72>

TABLE 4-4

Sparta Sand Water Quality

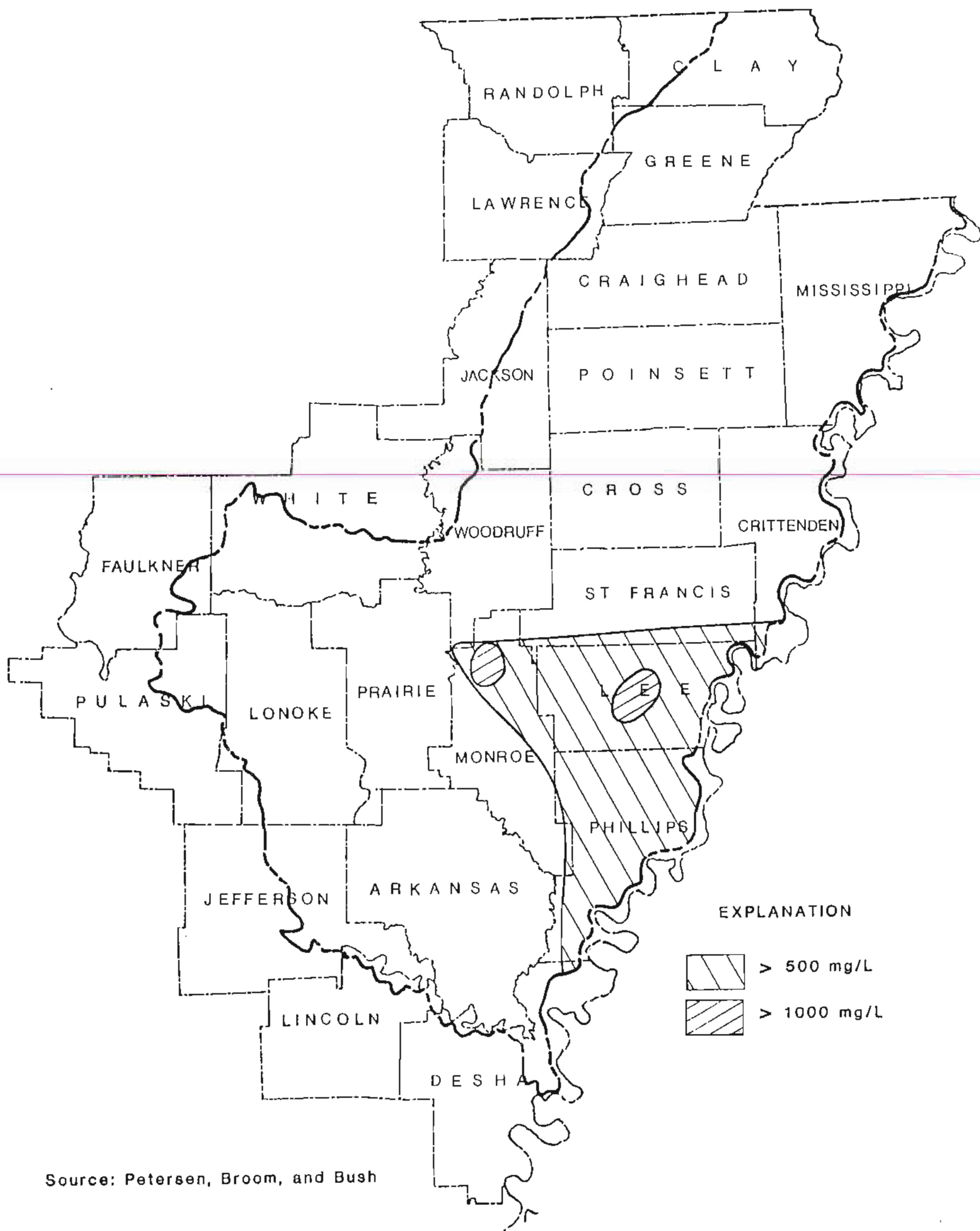
Median Values for Selected Constituents
(mg/L unless otherwise noted)

Temperature	19°C
pH	7.6
Hardness as $CaCO_3$	130
Calcium	33
Magnesium	9.8
Sodium	60
Potassium	5.8
Chloride	24
Sulfate	2.0
Flouride	.20
Silica	14
Dissolved Solids	320
Iron	.13
Manganese	30
Nitrate (N)	.18
Nitrate (NO_3)	--

Source: USGS file data <72>

figure 4-8

SPARTA SAND TOTAL DISSOLVED SOLIDS



Source: Petersen, Broom, and Bush

Table 4-5
Sparta Sand Water Quality

COUNTY		Temperature (°C)	Color (Platinum-cobalt units)	Specific Conductance (US/CM)	pH (Standard Units)	Alkalinity Field (mg/L as CaCO3)	Hardness as CaCO3 (mg/L)	Noncarbonate Hardness as CaCO3 (mg/L)	Calcium dissolved (mg/L as Ca)	Magnesium dissolved (mg/L as Mg)	Sodium dissolved (mg/L as Na)	Sodium Absorption Ratio	Potassium dissolved (mg/L as K)
ARKANSAS	No. of Samples	7	8	8	8	7	10	10	10	11	10	9	10
	Max	24.5	21	485	8.4	236	160	0	48	10	68	24	7.4
	Min	19.0	0	228	7.2	0	1	0	0.4	0.0	37	1	0.8
	Median	23.5	4	464	7.5	213	120	0	35	8.5	43	2	6.4
LEE	No. of Samples	5	6	8	7	5	7	7	7	7	6	6	6
	Max	20.5	10	2980	8.2	386	150	0	40	16	600	31	8.0
	Min	18.5	2	392	7.4	207	53	0	6.5	2.6	120	5	4.3
	Median	20.0	5	1390	7.7	331	110	0	28	10	260	12	7.6
MONROE	No. of Samples	11	---	11	6	---	6	6	6	6	6	6	6
	Max	20.5	---	3720	7.8	---	320	0	87	25	700	25	8.9
	Min	18.0	---	425	7.0	---	3	0	0.82	0.17	91	7	1.1
	Median	19.0	---	1920	7.4	---	160	0	42	12	310	12	6.5
Phillips	No. of Samples	5	8	9	9	9	9	9	9	9	9	9	9
	Max	20.0	7	841	8.1	451	270	0	67	28	190	14	10
	Min	16.5	5	705	6.9	292	37	0	6.9	4.9	61	2	2.0
	Median	17.5	5	805	7.6	400	130	0	33	12	130	6	5.8
Prairie	No. of Samples	8	6	8	8	7	7	9	7	7	7	7	7
	Max	23.0	9	671	8.1	276	260	0	73	21	55	2	7.6
	Min	17.0	5	340	6.7	146	130	0	30	9.7	23	0.8	1.4
	Median	20.5	5	520	7.6	258	170	0	44	15	36	1	4.5

Table 4-5 *(continued)*
Sparta Sand Water Quality

COUNTY		Chloride dissolved (mg/L as Cl)	Sulfate dissolved (mg/L as F)	Fluoride dissolved (mg/L as F)	Silica dissolved (mg/L as SiO2)	Solids residue at 180°C, dissolved (mg/L)	Nitrogen nitrate dissolved (mg/L as N)	Nitrogen nitrate (mg/L as NO3)	Iron, Total recoverable (ug/L as Fe)	Iron dissolved (ug/L as Fe)	Manganese dissolved (mg/L as Mn)
ARKANSAS	No. of Samples	11	11	10	8	10	---	7	---	7	8
	Max	27	20	0.3	17	298	---	1.5	---	920	60
	Min	3.0	0	0.1	10	146	---	0.0	---	250	0
	Median	14	3.8	0.2	14	258	---	0.0	---	620	32
LEE	No. of Samples	8	6	6	6	6	---	6	---	---	6
	Max	710	1.2	0.8	16	1620	---	3.3	---	---	50
	Min	1.0	0	0.1	14	481	---	0.2	---	---	0
	Median	240	0.4	0.2	15	767	---	0.41	---	---	20
MONROE	No. of Samples	11	6	6	6	6	---	---	---	6	---
	Max	1100	5.0	0.6	16	2250	---	---	---	2800	---
	Min	22	<0.2	0.2	4.3	265	---	---	---	0	---
	Median	410	1.0	0.4	9.3	1030	---	---	---	100	---
Phillips	No. of Samples	8	8	8	9	8	5	5	---	9	6
	Max	68	3.2	0.4	22	528	0.52	2.3	---	2100	500
	Min	5.5	0	0.0	3.9	421	0.02	0.09	---	0	0
	Median	25	0.7	0.1	16	481	0.18	0.80	---	40	180
Prairie	No. of Samples	8	7	5	5	7	7	7	---	5	5
	Max	42	17	0.40	23	374	0.32	1.4	---	1600	180
	Min	9.5	0.2	0.0	9.3	201	0.0	0.0	---	50	0
	Median	17	10	0.20	13	314	0.25	1.1	---	80	10

SOURCE: USGS FILE DATA (72)

TABLE 4-6

NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Arsenic	.05 mg/l
Barium	1.0 mg/l
Cadmium	.010 mg/l
Chromium	.05 mg/l
Lead	.05 mg/l
Mercury	.002 mg/l
Nitrate (as N)	10 mg/l
Selenium	0.01 mg/l
Silver	0.05 mg/l
Fluoride (Revised)	4 mg/l
Endrin	0.0002 mg/l
Lindane	0.004 mg/l
Methoxychlor	0.1 mg/l
Toxaphene	0.005 mg/l
2,4-D	0.1 mg/l
2,4,5-TP Silvex	0.01 mg/l
Coliform bacteria	< 1/100 ml
Radium-226 + Radium-228	5 pCi/l
Gross alpha particle activity	15 pCi/l
Beta particle and photon radioactivity	4 mrem (annual dose equivalent)
Turbidity	1 Tu (up to 5 Tu)

Trihalomethanes [the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)]	0.10 mg/l
Sodium Monitoring and Reporting	
Corrosion Monitoring and Distribution System Composition	

SOURCE: U.S. EPA <69>

NATIONAL SECONDARY DRINKING WATER REGULATIONS

Chloride	250 mg/l
Color	15 color units
Copper	1 mg/l
Corrosivity	Non-corrosive
Foaming Agents	0.5 mg/l
Iron	0.3 mg/l
Manganese	.05 mg/l
Odor	3 threshold odor number
pH	6.5 - 8.5
Sulfate	250 mg/l
TDS	500 mg/l
Zinc	5 mg/l
Fluoride	2 mg/l (plus notification)

SOURCE: U.S. EPA <70>

MEMPHIS SAND
Geology

The Memphis Sand is a massive sand unit of the Tertiary Period which exists in the subsurface of the northern half of the basin. At approximately 35 degrees latitude, the Carrizo Sand, Cane River Formation, and Sparta Sand combine to form the undifferentiated Memphis Sand. The formation is described as a massive fine to medium-grained sand with some interbeds of clay. <37, 50>

The Memphis Sand outcrops on Crowleys Ridge in Poinsett and Cross counties. The formation subcrops beneath the Quaternary alluvium in parts of Woodruff, Cross, Poinsett, Jackson, Craighead, Mississippi, Greene and Clay counties (See Figure 4-2). From the outcrop and subcrop areas, the formation dips to the southeast at about 10 to 20 feet per mile. A maximum depth of about 200 feet below mean sea level, or 400 feet below land surface, occurs along the eastern boundary of the basin as shown in Figure 4-5. Maximum thickness of the formation is about 900 feet which occurs east of Crowleys Ridge in Cross and St. Francis counties. <37, 50>

The Memphis Sand is confined between older and younger strata of the Tertiary Period. Downdip from the subcrop area, the formation is overlain by clay strata of the Cook Mountain Formation. The formation is underlain by sand and clay sequences of the Wilcox Group.

Hydrology

The Memphis Sand aquifer commonly yields up to 1,000 gallons per minute of water to wells. The aquifer is recharged in the outcrop area from precipitation on the formation, and in the subcrop area from percolation through the overlying alluvium. From the recharge area, ground water in the Memphis Sand flows downdip to the southeast. Where the Memphis Sand subcrops beneath the alluvium, intensive pumping from the alluvial aquifer can divert flow in the Memphis Sand toward the areas of concentrated pumping.

Water levels of the Memphis sand range from 160 to 220 feet above mean sea level as shown in Figure 4-6. West of Crowleys Ridge, water levels have decreased as much as 10 ft. from 1980 to 1985. <37>

Water Use

Withdrawal from the Memphis Sand aquifer in eastern Arkansas during 1985 occurred in Cross, Craighead, Poinsett and Mississippi counties. The largest withdrawal was .64 million gallons per day from municipal wells in Cross County. Total withdrawals from the Memphis Sand aquifer during 1980 have been estimated at 4.05 million gallons per day or 4536 acre-feet per year. The only significant withdrawals from the Memphis Sand aquifer in 1985 was .40 million gallons a day or 448 acre feet per year in Craighead County. Minor withdrawals also occurred in Poinsett County.

Ground Water Quality

Water from the Memphis Sand aquifer is generally hard to very hard and contains excessive levels of iron and manganese of iron in local areas. Table 4-7 illustrates the quality characteristics for selected constituents of the aquifer.

Hardness values range from 52 to 250 mg/L. The aquifer generally contains less than 500 mg/L of total dissolved solids. Most constituent concentrations are less than the limits established for drinking water standards.

TABLE 4-7

Memphis Sand Water Quality

Median Values for Selected Constituents
(mg/L unless otherwise noted)

Temperature	18.5°C
pH	7.4
Hardness as CaCO3	120
Calcium	30
Magnesium	12
Sodium	21
Potassium	2.4
Chloride	3.3
Sulfate	4.4
Flouride	.10
Silica	16
Dissolved Solids	154
Iron	1.1
Manganese	.07
Nitrate (N)	.20
Nitrate (NO3)	.89

Source: USGS File Data (72)

QUATERNARY ALLUVIUM

Geology

Deposits of Quaternary age cover most of the East Arkansas Basin with alluvium and terrace deposits. The alluvium is a result of recent stream deposition in the form of point bar sequences and floodplain deposits. The terrace deposits are a result of glacial outwash from the North during the Pleistocene Epoch. The Quaternary alluvium consists of an upper strata of silt and clay, and a lower strata of sand and gravel. The gravel deposits often make up over 50 percent of the thickness of the alluvium. Crowleys Ridge is an erosional remnant of Quaternary silt and loess overlying sand and clay units of the Tertiary Period. <E,N,B>

The Quaternary alluvium is the surface stratum of the basin except where Tertiary formations outcrop, and at Crowleys Ridge. Figure 4-9 illustrates the surface area of the alluvium in eastern Arkansas. The bottom of the Quaternary deposits rest on the erosional surface of older Cretaceous and Tertiary formations. This erosional surface determines the dip of the overlying alluvium. The alluvium is generally 100 to 150 feet thick. <E,N,B>

Hydrology

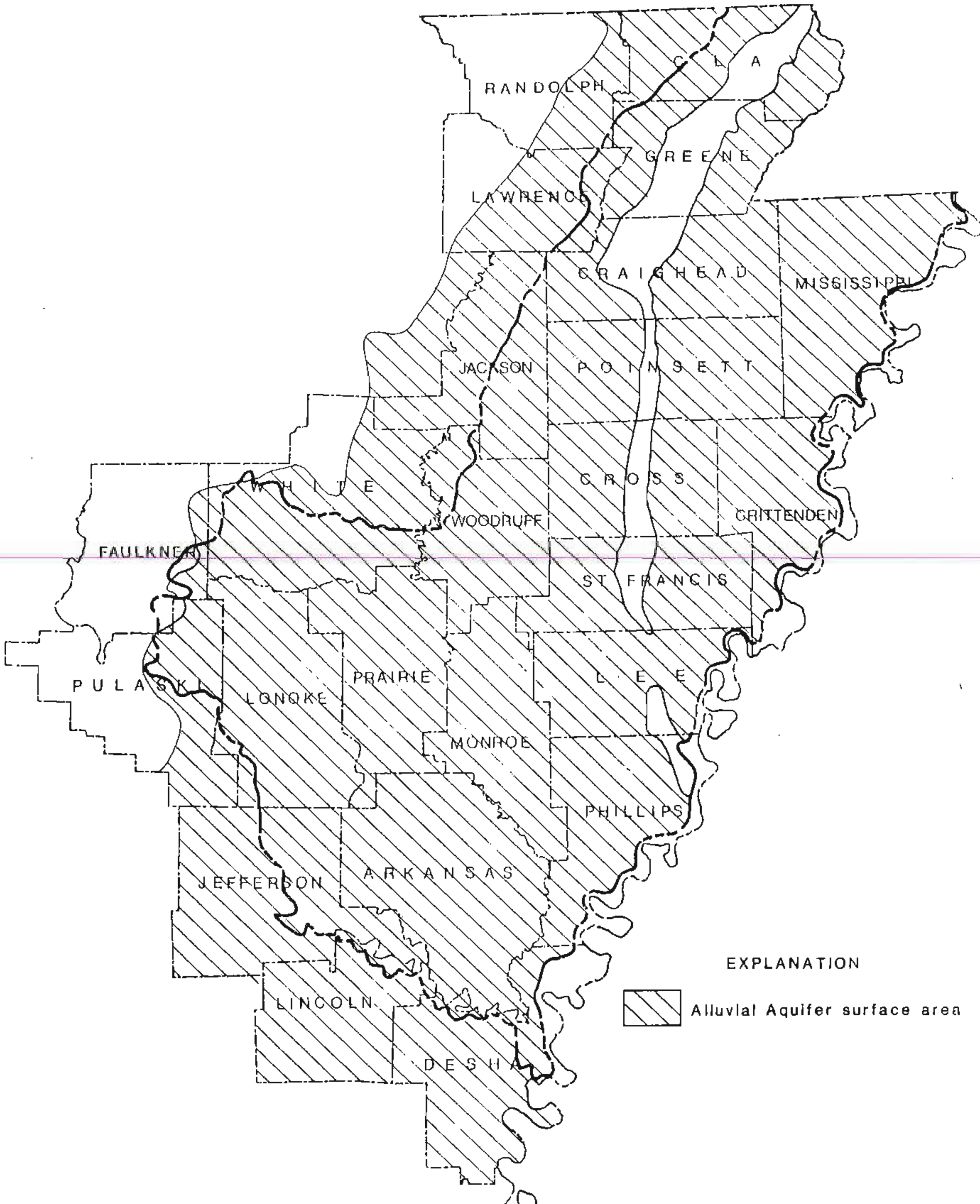
The Quaternary alluvium contains the uppermost aquifer in the basin. The alluvial aquifer commonly yields 1,000 to 2,000 gallons per minute of water to wells with occasional occurrences of up to 5,000 gallons per minute. Transmissivity of the aquifer varies from 10,000 to more than 40,000 feet squared per day (See Figure 4-10). The most productive wells are those which are developed in the sand and gravel deposits located at the base of the alluvium. <A,E,F>

Recharge to the alluvial aquifer occurs primarily from precipitation percolating into the formation. This recharge is limited in some areas where the upper stratum of clay is thick enough to function as a confining bed. Recharge also occurs where heavy withdrawals from the aquifer occur causing underflow from the Memphis Sand to enter the alluvium. <E,B>

Groundwater flow within the alluvial aquifer is in the direction of general land slope and toward streams which receive water from the aquifer. Locally, flow is from areas of recharge to areas of discharge. In areas of concentrated pumping, where withdrawals are greater than recharge to the aquifer, cones of depression develop. In these areas, ground water flow is toward the center of the cone, where the pumping is occurring. The streams of eastern Arkansas are hydraulically connected to the alluvial aquifer. Therefore, during the low flow season, ground water flow is toward streams which are sustained by the aquifer. This stream-aquifer interflow is reversed in the spring when water levels in streams are higher than water levels in the aquifer. <A,E,B,C,M>

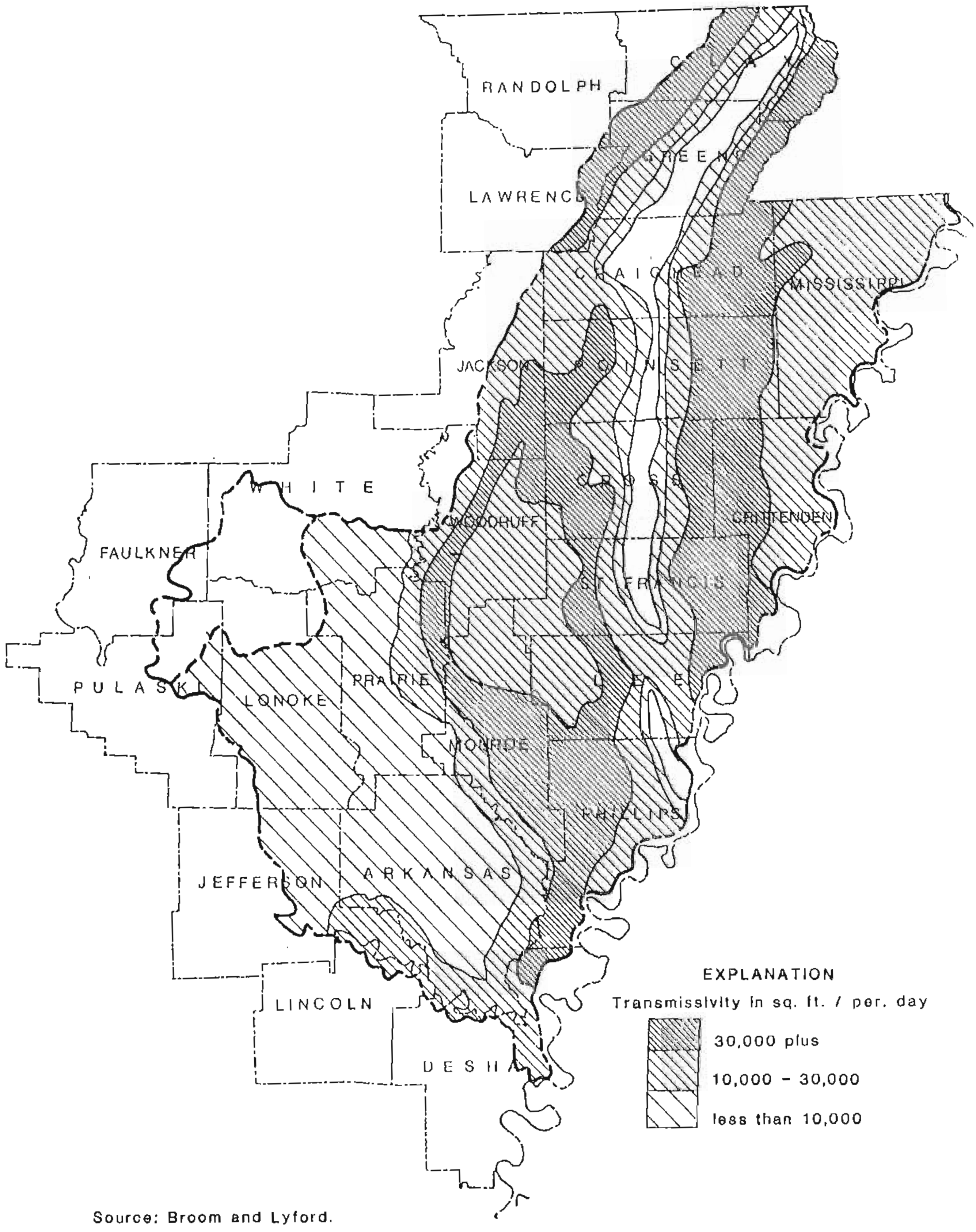
A potentiometric surface map for the alluvial aquifer of East Arkansas is shown in Figure 4-11. The potentiometric surface is less than 90 ft. in Arkansas County and as high as 290 feet in Clay County in the northern extreme of the basin. The potentiometric surface of the alluvial aquifer has been greatly influenced in the past few decades by concentrated pumping for the irrigation of rice and other crops. Cones of depression have developed in several areas of East Arkansas where concentrated pumping has greatly reduced water levels. This trend is further enhanced by the presence of a clay cap which is thick enough in some areas to greatly inhibit recharge to the alluvium from surface

figure 4-9
SURFACE AREA OF THE ALLUVIAL AQUIFER IN EAST ARKANSAS



Source: U. S. Army Corps of Engineers, Eastern Arkansas Region Comprehensive Study

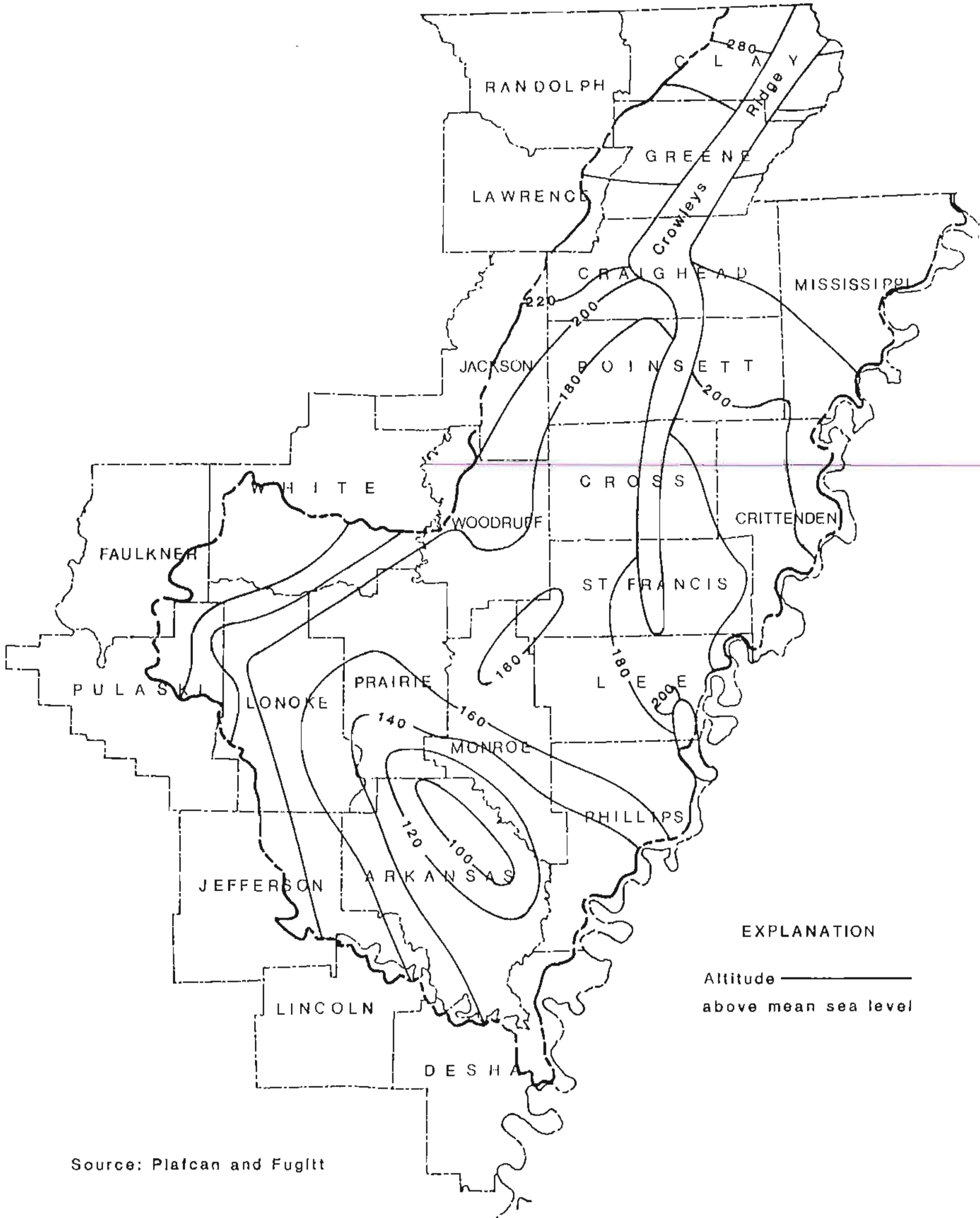
figure 4-10
DISTRIBUTION OF AQUIFER TRANSMISSIVITY



Source: Broom and Lyford.

figure 4-11

POTENTIOMETRIC SURFACE OF THE ALLUVIAL AQUIFER



Source: Plafcan and Fugitt

water sources. The most extensive cone of depression is found in Arkansas County where is water levels fall 70 ft. in 10 miles. These low water levels are attributed to overpumping of the alluvium for irrigation purposes and a clay cap thickness of 50 to 100 feet which inhibits recharge. Other cones of depression are developing in Poinsett County, west of Crowleys Ridge, and in the vicinity of northwest Monroe County and southwest St. Francis County.

Water-level changes from 1980 to 1985 in the alluvial aquifer are shown in Figure 4-12. In this time, water level increases are observed in the extreme northwestern part of the basin and along a line with a noticeable proximity to the White River. The water level rise in the northwestern area of the basin is probably a result of recharge to the alluvium through the exposed Quaternary sands. In this area, the clay cap is absent and the outcrop of sand allows a high rate of recharge. The alluvium and terrace deposits of the Lower White River are also areas of water level increase. This suggests that the White River is a losing stream which recharges the alluvium at a greater rate than withdrawals are occurring. <N,G,P>

Declines in the water table of the alluvial aquifer from 1980 to 1985 are found in areas of heavy withdrawals within the basin. The most noticeable areas of decline are found west of Crowleys Ridge, in the vicinity of Lonoke County and in northeast Lincoln County. <G,N,K>

The most significant water level declines are located along the western boundary of Crowleys Ridge in Craighead, Poinsett and Cross counties, and in the Grand Prairie in Arkansas, Lonoke and Prairie counties. Figure 4-13 illustrates the saturated thickness of the alluvial aquifer in eastern Arkansas. There are two major areas where the saturated thickness of the alluvial aquifer has been reduced to critical levels. There is only one small area east of Crowleys Ridge where the zone of saturation has been depleted to critical levels. This spot is located in Mississippi County where the alluvial aquifer is less than 100 feet thick. <B,Q>

Water Use

The alluvial aquifer is the principal source of water for irrigation in eastern Arkansas. The aquifer is also a source of public supply for the communities of Bay, Marianna, Weiner, Leachville, Biscoe, Jacksonville and McRae. The largest withdrawals from the alluvial aquifer in 1985 were from Poinsett and Lonoke counties. Table 4-8 shows withdrawals from the alluvium by county. <k,G>

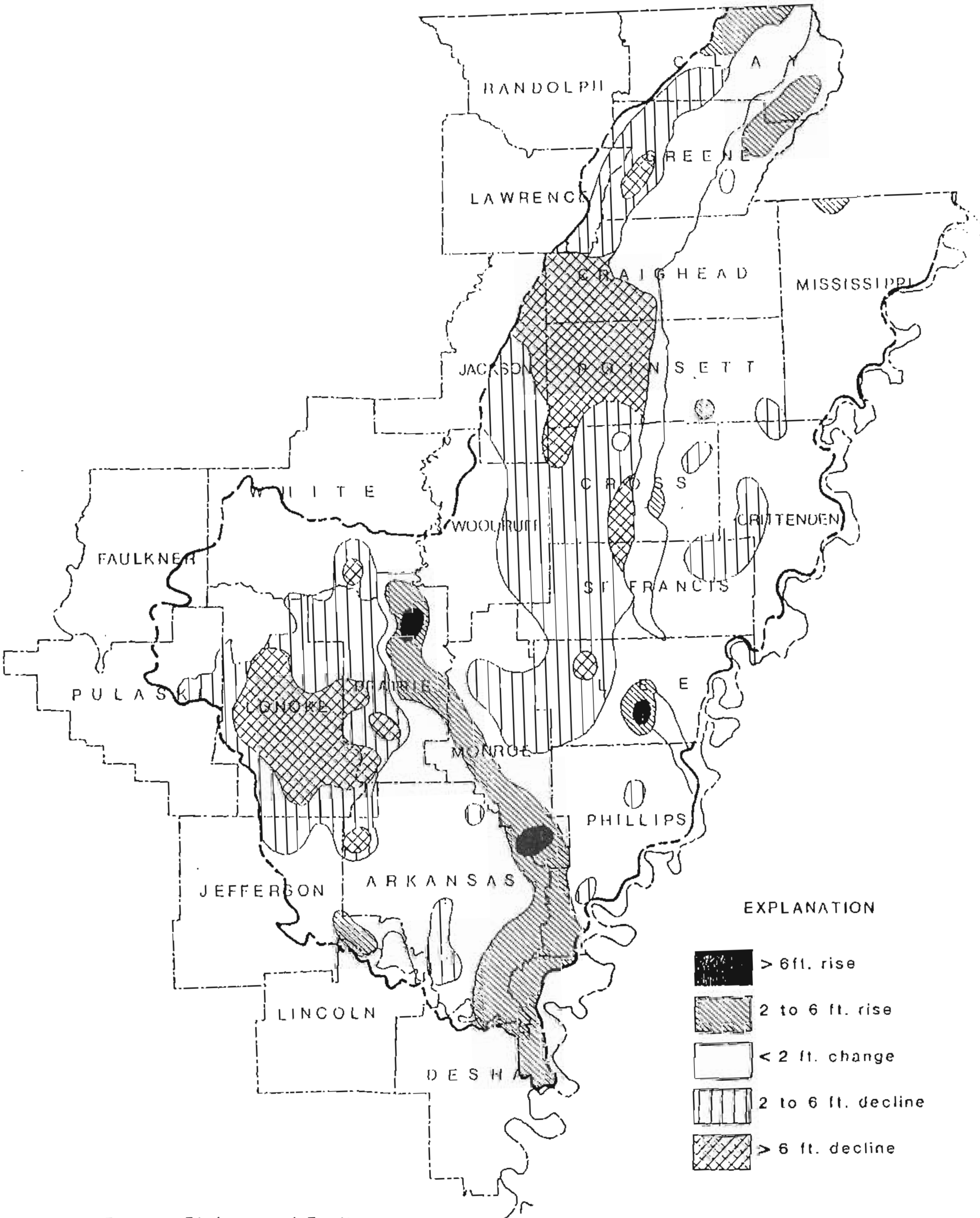
In the 20 year period from 1965 to 1985, withdrawals from the alluvial aquifer in east Arkansas increased from 957,600 to 2,948,960 acre-ft./yr. However, from 1980 to 1985, withdrawals decreased slightly. Some sources project a 60 percent increase in withdrawals from the alluvial aquifer by the year 2030. <K,G,O>

Ground Water Quality

Water in the alluvium in eastern Arkansas is generally hard and contains excessive concentrations of iron and manganese. Most constituent concentrations are within drinking water standards, however, local excesses of nitrate, chloride, and total dissolved solids exist in several areas (See Table 4-9). Nitrate (NO3) concentrations are as high as 220 mg/L which is above the 45 mg/L limit suggested by the U.S. Public Health Service. A median nitrate value

figure 4-12

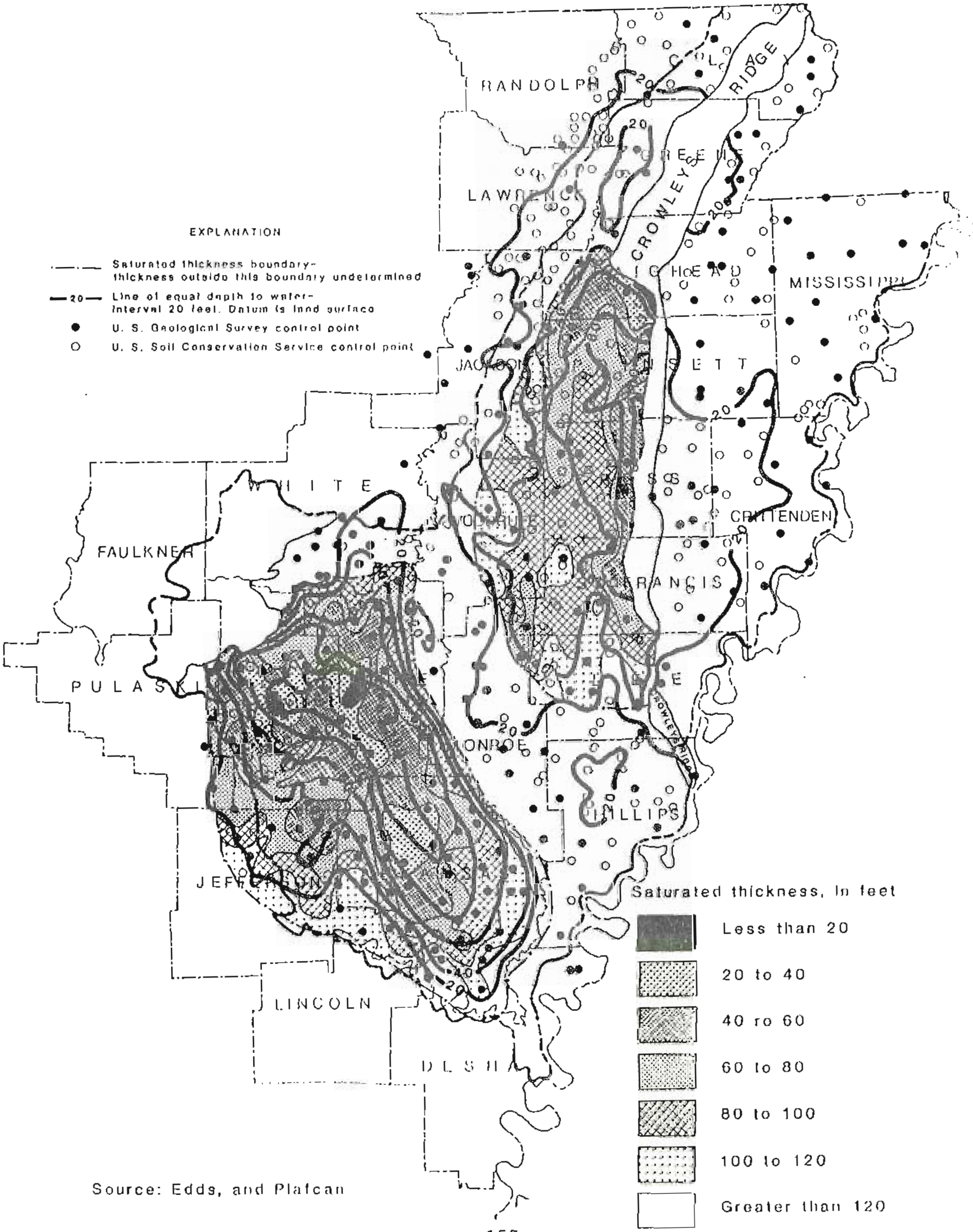
WATER-LEVEL CHANGE MAP OF THE ALLUVIAL AQUIFER



Source: Plafcan and Fugitt

figure 4-13

SATURATED THICKNESS OF THE ALLUVIAL AQUIFER



Source: Edds, and Plafcan

TABLE 4-8
ALLUVIAL AQUIFER WITHDRAWALS IN 1985
(IN ACRE-FEET PER YEAR)

COUNTY	
Arkansas	207,278.4
Clay	196,974.4
Craighead	227,180.8
Crittendon	127,321.6
Cross	292,320.0
Greene	147,604.8
Jackson	227,953.6
Lee	108,192.0
Lonoke	329,100.8
Mississippi	56,403.2
Monroe	139,003.2
Phillips	80,371.2
Poinsett	335,742.4
Prairie	189,907.2
St. Francis	124,208.0
Woodruff	159,454.4
	2,949.016.0

Source: Holland <27>

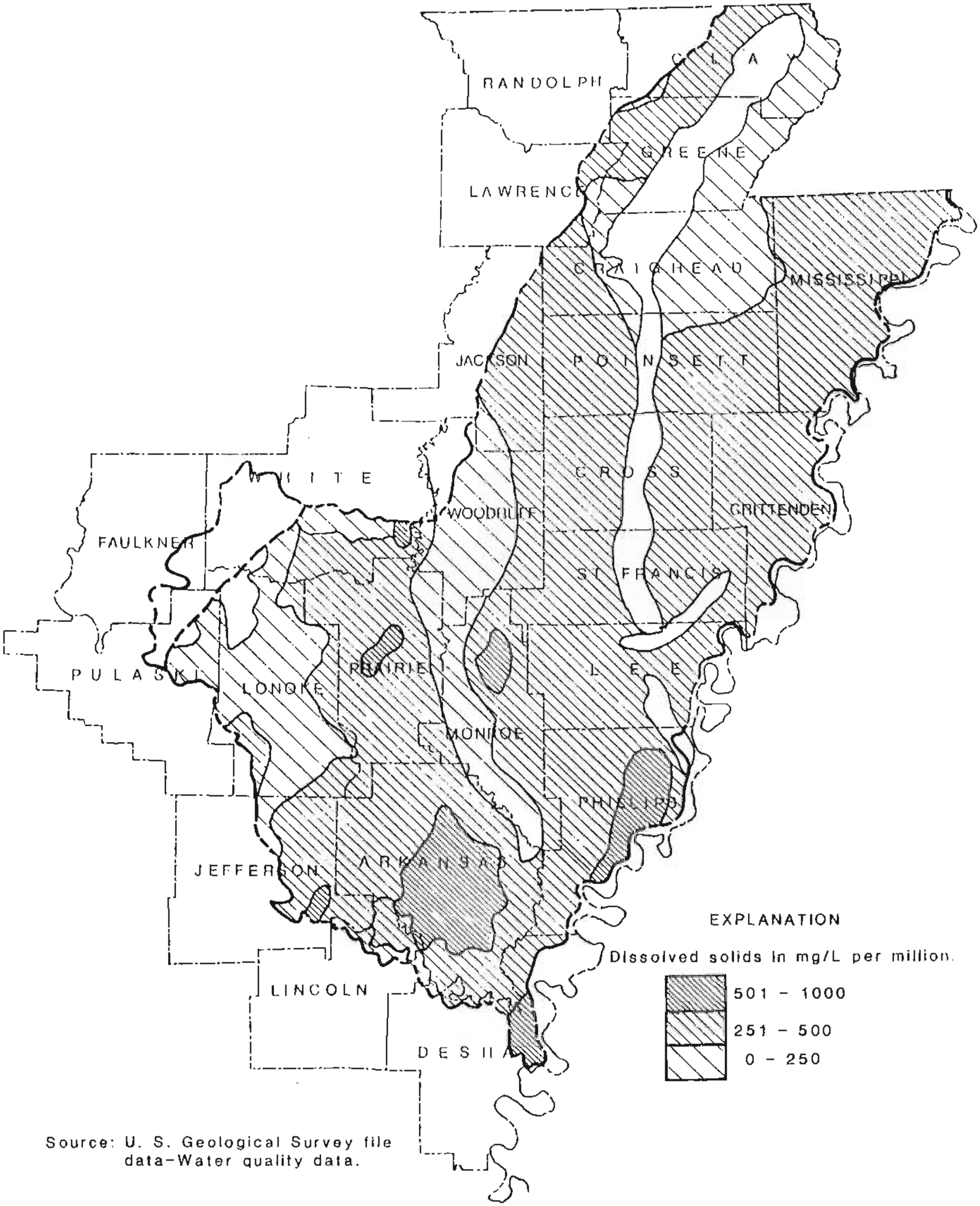
of .49 mg/L suggests that the higher concentrations are a localized problem. Chloride concentrations are as high as 960 mg/L with median values of about 20 mg/L. Total dissolved solids concentrations are as high as 2350 mg/L with median values of about 320 mg/L. Dissolved solids concentrations in the alluvial aquifer are illustrated in Figure 4-14. Median values for iron and manganese are above drinking water standards. This condition is a natural phenomenon which is uniformly dispersed throughout the alluvial aquifer. <H,B,I>

Table 4-9
Alluvial Aquifer Water Quality

	Temperature (°C)	Color (Platinum-cobalt units)	Specific Conductance (US/CM)	pH (Standard Units)	Alkalinity Field (mg/L as CaCO3)	Hardness as CaCO3 (mg/L)	Noncarbonate Hardness as CaCO3 (mg/L)	Calcium dissolved (mg/L as Ca)	Magnesium dissolved (mg/L as Mg)	Sodium dissolved (mg/L as Na)	Sodium Absorption Ratio	Potassium dissolved (mg/L as K)	Chloride dissolved (mg/L as Cl)
No. of Samples	1040	412	1184	882	654	829	680	487	487	595	534	448	982
Max	27.0	60	3720	8.7	551	640	320	190	52	550	21	50	960
Min	13.0	41	46	5.2	0	10	0	2.2	0.8	0.23	0.0	0.08	0.3
Median	17.0	5	588	7.5	240	250	0	71	19	21	0.6	2.0	20

	Sulfate dissolved (mg/L as F)	Fluoride dissolved (mg/L as F)	Silica dissolved (mg/L as SiO2)	Solids residue at 180°C, dissolved (mg/L)	Nitrogen nitrate dissolved (mg/L as N)	Nitrogen nitrate (mg/L as NO3)	Iron, Total recoverable (ug/L as Fe)	Iron dissolved (ug/L as Fe)	Manganese dissolved (mg/L as Ma)
No. of Samples	664	206	207	458	469	490	542	457	200
Max	250	10	50	2350	49	220	110,000	31,000	25,000
Min	0	0.0	3.8	0	0.0	0.0	0	<10	<10
Median	9.4	0.2	31	345	0.11	0.49	4400	230	300

figure 4-14
DISTRIBUTION OF DISSOLVED SOLIDS CONCENTRATION IN EAST ARKANSAS



Source: U. S. Geological Survey file data-Water quality data.

GROUNDWATER PROBLEMS

Declines

One of the most common groundwater problems in the East Arkansas Basin is water-level declines. Intensive pumping of groundwater has developed cones of depression in two of the five principal aquifers. Noticeable declines have occurred in all five of the major aquifers. Excessive declines can cause dewatering, which allows compaction of the sediments and destroys the porosity of the aquifer. Water level declines may also alter the direction of groundwater flow and cause saltwater to migrate into freshwater zones.

Quality

The most severe groundwater quality problem in eastern Arkansas is saltwater intrusion. This problem is reflected by the excessive levels of total dissolved solids in the downdip areas of several major aquifers. This condition is a natural phenomenon; however, intensive pumping is conducive to migration of the saltwater into freshwater zones. Upconing of saltwater beneath pumping wells is a more serious problem than lateral encroachment. This is because lateral encroachment requires a much larger displacement of freshwater. Excessive levels of saltwater occur near Brinkley, Bald Knob, and Marianna. It has been suggested that the most likely avenue for the intrusion is upward movement from deeper aquifers through deep wells, faults, or areas where confining beds are unusually thin or absent.

Iron concentrations are generally high in the alluvial aquifer, ranging from less than .01 to 31 mg/L. Manganese concentrations are also high, ranging from .01 to 25 mg/L. These constituents occur naturally in the alluvium of eastern Arkansas and make it necessary to treat the water for some uses.

Nitrate (NO3) concentrations in the alluvium of eastern Arkansas vary from about .02 to 220 mg/L. The highest concentrations occur in Craighead and Greene counties. The occurence of nitrate in the alluvium is generally attributed to leaky septic tanks, animal waste, decomposing plant debris, and some fertilizers. The established drinking water standard for nitrate (NO3) is 45 mg/L (10 mg/L as Nitrogen), because concentrations greater than this can have a toxic effect on infants that drink the water.

Median values by county for sodium content in the alluvial aquifer range from 11 to 49 mg/L. Maximum values by county range from 19 to 550 mg/L. Water from the Nacatoch Sand contains sodium concentrations which vary from 170 to 210 mg/L which is above the American Health Association's recommended guidance level of 20 mg/L.

Critical Use Areas

Critical groundwater use areas have been defined by the Arkansas Soil and Water Conservation Commission as an aquifer in which at least one of the following criteria applies: (Unconfined aquifer) (A) 50 percent of the thickness of the formation or less is saturated, and/or (B) average annual declines of one foot or more have occurred for the preceeding five year period, and/or (C) groundwater 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. (confined aquifer) (A) potentiometric surface is below the top of the formation, and (or) (B) average annual declines of one foot or more have occurred for the preceeding five years, and/or (C)groundwater 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.

Confined Systems

Declines in the water levels of the Sparta Sand and Memphis Sand aquifers from 1980 to 1985 are illustrated in Figure 4-15. Areas where declines have exceeded 5 feet are delineated as critical use areas. However the southern area of excessive declines has not been designated as critical because digital model simulation indicates that in this area the aquifer is under steady-state flow conditions. Any further increases in pumpage will be in excess of what the aquifer can safely yield. The largest area of excessive declines is located in the vicinity of Pine Bluff where a cone of depression has developed. A critical area has been designated west of Crowley's Ridge in Poinsett and Cross counties. Declines in this area are reflected in the potentiometric surface; however, a cone of depression has not yet developed.

Another significant problem in eastern Arkansas is saltwater intrusion. Figure 4-15 illustrates the total dissolved solids concentration for the Sparta Sand within the East Arkansas Basin. The occurence of saltwater is a natural phenomenon, however, intensive pumping can induce lateral migration into freshwater zones. Primary use of the Sparta Sand aquifer is for municipal and industrial supply; therefore, the secondary drinking water standard of 500 mg/L of chloride was chosen as the level for delineating the critical use area. The occurrence of saltwater is widespread in the downdip parts of the aquifer with concentrations of over 1,000 mg/L in the vicinity of Brinkley and Marianna.

Unconfined Systems

Critical use areas for the alluvial aquifer have been delineated based on the established criteria for an unconfined aquifer. Water level Declines in the alluvial aquifer have reduced the saturated thickness to critical levels in two general areas. The critical use criteria for declines and saturated thickness is exceeded in roughly the same areas within the alluvium. Therefore, these criteria are combined to delineate the critical use areas.
(See Figure 4-16).

Saltwater intrusion is also a problem in the alluvial aquifer. Total dissolved solids concentrations of greater than 1000 mg/L occur in local areas and usually are the result of improperly constructed or abandoned wells. However, concentrations are generally within tolerable limits for agricultural purposes which is the primary use of the aquifer. Therefore, no critical areas have been identified in the alluvial aquifer in eastern Arkansas based on water quality degradation criteria.

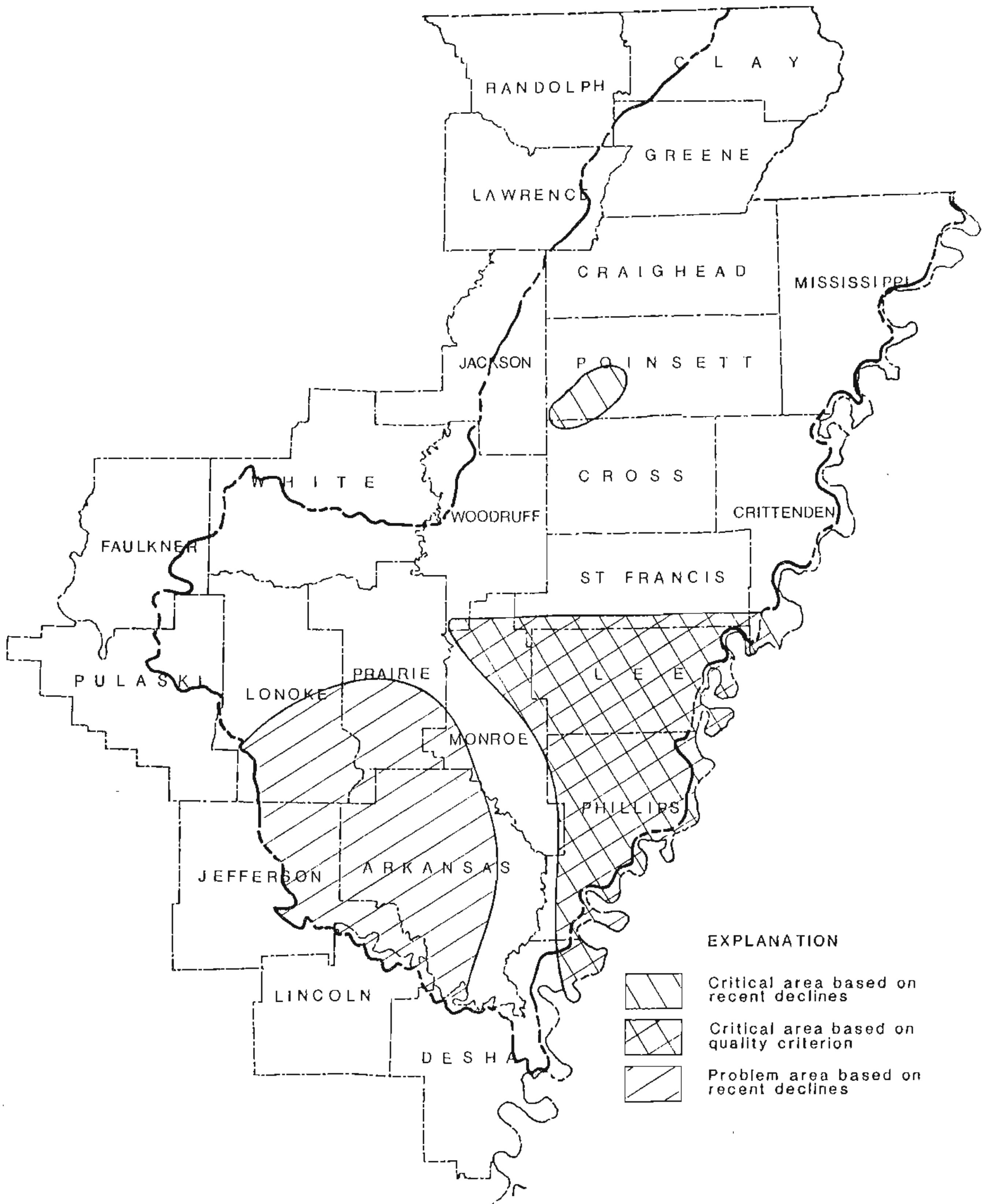
Potential Problems

Potential hazards to groundwater in the basin include landfills, impoundments, hazardous and non-hazardous waste sites, and improperly constructed and abandoned wells.

Many landfills and impoundments exist in East Arkansas Basin. Figure 4-17 shows the location 60 landfills and 22 impoundments. These sources of contamination are especially dangerous in the areas of high recharge potential where water percolates rapidly into the aquifer system. There are six (6) sites

figure 4-15

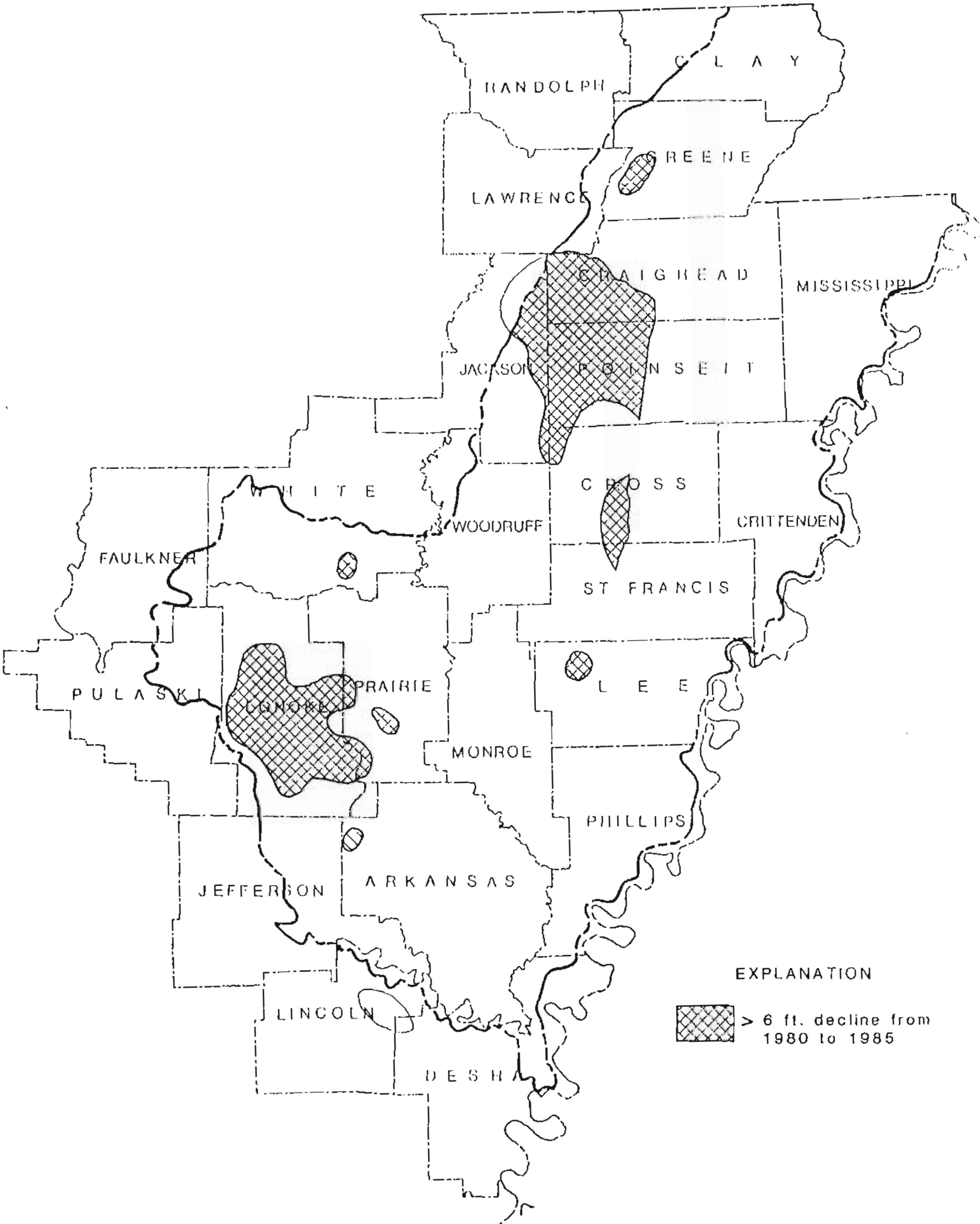
SPARTA-MEMPHIS SAND AQUIFER CRITICAL AREAS



Source: Edds, Fitzpatrick, Petersen, Broom, and Bush

figure 4-16

ALLUVAL AQUIFER CRITICAL AREAS



Source: Plafcan and Fugitt

Scott Henderson
Assistant Director

Arkansas Game & Fish Commission

September 7, 1988

RECEIVED
SEP 8 1988
SOIL AND WATER
CONSERVATION COMMISSION

Mr. Randy Young, Director
Arkansas Soil and Water Conservation Commission
#1 Capitol Mall, Suite 2D
Little Rock, AR 72201

Dear Randy:

We have received and reviewed the draft East Arkansas Basin report of the State Water Plan. The following are comments from our staff on this document.

As you know, Randy, this is the basin that is really the most affected by groundwater depletion and irrigation supply problems. It is also an area where surface water supplies have also been overutilized at times (i.e., Cache River, Bayou Meto) often to the detriment of the fish and wildlife resources in the basin. Our comments on this draft proposal are made then with these resources foremost in our thoughts but also with the historical uses of water in the basin in mind.

Under <u>Instream Flow Requirements</u> (page 51), it is our responsibility as caretakers of the fish and wildlife resources of the state to point out in answer to a statement made in the first paragraph that really instream flow requirements must be set to first protect the <u>instream</u> needs in question, then to consider <u>offstream</u> needs with that amount of water above and beyond the instream needs. Using navigation as an example, one does not set or consider the offstream quota or level of water withdrawal before the necessary water level for safe transport of a tug and barge is already reserved in that particular stream. The same holds true for other instream needs including fish and wildlife.

The AGFC is strongly against waiting until drought or crisis conditions and then determining minimum stream flows on a case-by-case basis as you propose. This type of crisis management is not long-term management of the state's water resource, is not conservation of an invaluable resource in Arkansas, and does not follow the mandate of Act 1051, which was to determine minimum flows for state streams. The draft's statement that flows recommended by the AGFC and sanctioned by most of the other natural resource agencies in the state are flows representing desirable conditions and not minimum flows is incorrect when the viability of fish and wildlfie populations are considered. The AGFC's recommendations are flows for maintenance of fish and wildlife populations. Maintenance is the bare minimum that a wildlife population must have to keep it going. Anything less is a decrease in the population. Desirable conditions, on the other hand, increase a fishery or wildlife population so that it is healthy, expanding and dynamic. This one point seems to be a major point of misunderstanding between the engineers in the ASWCC and the biologists with AGFC. We would be more than glad to explain the concept with examples if you so desire. The proposal's example of 10% of the seasonal average flow is a figure much too low to keep aquatic biota and dependent terrestrial wildlife going for any substantial period of time. Therefore, it is not acceptable as a minimum flow because it does not fulfill the definition of minimum flow in Act 1051, which is the water level where instream needs are protected. Decreasing populations are not protected populations since they cannot maintain themselves due to some limiting factor (in this case, lack of sufficient water flow).

The AGFC agrees with some of the statements made under the section on Determination of Instream Flow Requirements (page 147). More data on streams in the basin is a must and expansion of gagging network in East Arkansas (USGS, COE, ASWCC) appears to be a necessity. A specific study to determine the instream needs of endangered species in the basin, the fat pocketbook pearly mussel (*Proptera capax*) and the Curtis pearly mussel (*Epioblasma florentina curtisi*) would indeed seem justifiable. However, it should be noted that cooperative work between the AGFC and ASWCC on the L'Anguille River has not been utilized by ASWCC in the way originally planned. Analysis of the data from that study showed substantial agreement between the fisheries instream flow windows from the PHABSIM model and flows recommended by the AGFC computed using the Arkansas Method. Since these studies are expensive, we must use them to the fullest in assisting us with the determination of instream flow needs.

The second major problem with determination of instream flows in the draft basin report is "**inflexible methodologies.**" However, when you consider that: (1) percentages of flow reflect what has been occurring in a particular stream for the immediate past and aquatic organisms acclimate to these flows; (2) the Arkansas Method used percentages of existing flows instead of pre-irrigation flows which prorates an agricultural basin and in fact considers historical uses; and (3) a compromise plan recommending an adjustment for instream flows for the East Arkansas region was submitted to ASWCC without a response back, then it appears that if inflexibility exists in this process, it is not from the AGFC or fish and wildlife interests.

Under Conservation (page 174), the AGFC would like to commend the ASWCC for outlining a way to alleviate water shortage problems through better conservation and water management practices. We urge this type of philosophy be pushed instead of a purely pro-consumption type approach.

Randy, if there are any questions on our comments, or if you feel the need to get our staffs together to work out some issues, please feel free to contact me.

Cordially,

Steve N. Wilson
Director

SNW:SF:amcg

Arkansas **DEPARTMENT OF HEALTH**

4815 WEST MARKHAM STREET • LITTLE ROCK, ARKANSAS 72205
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M. JOYCELYN ELDERS, M.D.
DIRECTOR

BILL CLINTON
GOVERNOR

September 6, 1988

SEP 1988
SOIL AND WATER
CONSERVATION COMMISSION

Mr. Randy Young, P.E., Director
Soil & Water Conservation Commission
One Capitol Mall, Suite 2D
Little Rock, Arkansas 72201

RE: Arkansas State Water Plan
Eastern Arkansas Basin Draft

Dear Mr. Young:

A staff review of the above referenced draft report has been made. The following comments are presented for your attention:

1. On page 237 of the report reference is made to a "100 mg/l limit at which the U. S. Health Department issues a sodium alert to public water systems". This statement is in error. Any health alerts based upon the water quality of a public water system in Arkansas would be made by the Department of Health. The Department of Health has primacy from the USEPA to administer the State's Public Water Supply Supervision Program, rather than a nonexistent U. S. Health Department. Also, no health alerts are issued based upon a 100 mg/l sodium concentration. There is no primary maximum contaminant level established for sodium in drinking water. As a public service, however, we do recommend that the operator of a public water supply inform local physicians whenever a sodium level of 20 mg/l is exceeded for those special patients whose diet is sodium restricted for various medical reasons.

2. On page 237 the report states that the primary drinking water standard for nitrate is 45 mg/l (as nitrate). However, drinking water standards routinely reference the standard as 10 mg/l (as nitrogen). You might wish to make this change for consistency.

3. On page 240 the report states that there is a primary drinking water standard of 500 mg/l for total dissolved solids. This standard is a secondary maximum contaminant level which is based upon aesthetics (i.e.; taste, odor, appearance) and is not legally enforceable.

4. The report references plans under consideration to remedy surface water quantity problems through the diversion and transfer of one surface water supply to another. Two of the referenced sources of diversion are the Black and White Rivers which are currently being used as sources for public water supply. The implementation of any diversion plans must be made in a manner which will not compromise these drinking water sources.

If you have any questions please advise. Thanks for the opportunity to comment on this report.

Sincerely,

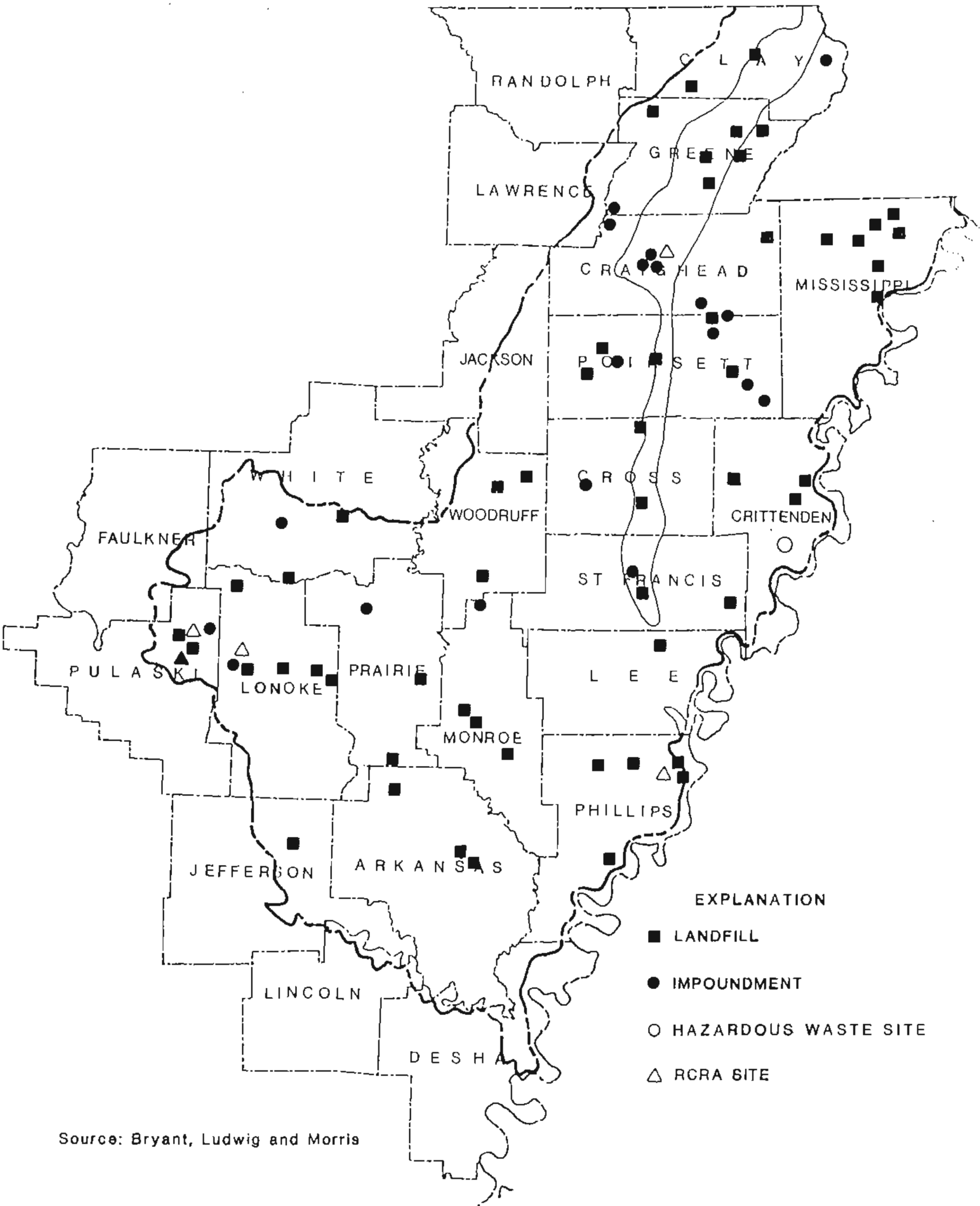
Bob Makin

Bob Makin, Assistant Director
Division of Engineering

BM/br

figure 4-17

POTENTIAL GROUND WATER PROBLEMS



Source: Bryant, Ludwig and Morris

known to contain hazardous waste. Four of these sites, which are located in Pulaski, Lonoke, Phillips and Craighead counties are covered by the Resource Conservation and Recovery Act (RCRA) which requires permits to operate and often require groundwater monitoring. Two other hazardous waste sites, located in Pulaski and Crittendon counties, are covered by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These sites are considered to be potential sources of significant harm to human health or the environment.

Another problem of growing concern is improperly constructed and abandoned wells. These wells provide an avenue for surface contamination to enter the groundwater, and also provide an avenue for the upward migration of saltwater into overlying freshwater aquifers.

Solutions and Recommendations

The most common groundwater problems in the East Arkansas Basin are water level declines and saltwater intrusion. These problems must be considered together because where the potentiometric surfaces of freshwater aquifers are lowered, saltwater migrates toward the area of declines until a new hydraulic balance is established. With groundwater resources in some areas being rapidly depleted, it is necessary to seek surface water alternatives to meet the needs of economic development in eastern Arkansas. Act 417 of 1985 assists groundwater users in converting to surface water withdrawal and delivery systems.

Long range planning will rely on regional irrigation districts as the most efficient mechanism for activating excess surface water diversions. This excess water will be diverted into an extensive delivery system of irrigation canals and existing streams by means of pumping stations and gravity flow.

Research efforts must be continued in establishing sustained yield pumping strategy for eastern Arkansas. This strategy will help determine the safe yield of the alluvial aquifer and suggest withdrawal rates which will not cause water-level declines. Irrigation needs above this amount will be met through surface water supplies.

Concentrations of iron and manganese occur naturally in the groundwater of Eastern Arkansas, however, this condition is treatable and the water can be used for most purposes.

Excessive nitrate concentrations can be reduced through proper well construction practices and by locating waste disposal sites away from wells. Following the Best Management Practices suggested by local Conservation Districts could also reduce nitrate contamination by selective use of nitrate fertilizers.

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APPENDIX A

COMMENTS ON THE DRAFT REPORT

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