ARKANSAS STATE WATER PLAN

RED RIVER BASIN BELOW FULTON

Prepared for

Arkansas Soil and Water Conservation Commission

by

U.S.D.A., Soil Conservation Service

FEBRUARY, 1987

ACKNOWLEDGEMENT

This report was prepared by the USDA, Soil Conservation Service for the Arkansas Soil and Water Conservation Commission. Assistance and cooperation extended by individuals from many state and federal agencies and from private and local organizations were instrumental in the development of this document.

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 document for defining water policy for the development of land and 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 has become available, it is apparent that the ever-changing nature and severity of water resource problems and potential solutions require the planning process to be dynamic. Periodic revisions to the State Water Plan are necessary for the document to remain valid.

This report covers the revision of Basin Number 12 (Red River Basin below Fulton) component of the Arkansas State Water Plan. The objectives are:

(1) to incorporate into the report newly developed and compiled data available;

(2) to address new and existing problems;

(3) to present current solutions and recommendations; and

(4) to satisfy the requirements of Act 1051 of 1985 for the Red River Basin below Fulton.

ABSTRACT

The Red River Basin below Fulton, Arkansas consists of nearly 1.5 million acres of level to gently rolling land located in the southwest part of the state. Forest land accounts for about 67 percent and cropland covers 11 percent of the total land use in the basin. Water is available from both surface-water and ground water sources. The Red River and Sulphur River are the principal streams, and the Quaternary and Sparta Sand Aquifers are sources of 80 percent of the ground water withdrawn in the basin.

Streams in the Red River Basin below Fulton have a combined yield of approximately 14 million acre-feet of water on an average annual basis. Runoff varies seasonally as well as annually, with the area subject to extremes of both flood and drought. Seasonal variability is characterized by low flows which usually occur from August through October. This period of lowest streamflow parallels the season of greatest agricultural water needs from some streams such as Posten and McKinney Bayous. In response to Act 1051 of 1985 the following actions were taken:

(1) instream flow requirements were identified for riparian needs, water quality, fish and wildlife, navigation, and interstate compacts;

(2) minimum streamflows were defined and established for selected streams for the purpose of protection of all instream flow needs during low-flow conditions; and

(3) safe yield of streams was quantified for selected streams.

Seasonal low flows have caused shortages for irrigation in some areas of the basin. Streamflow is normally low during the summer irrigation season and has at times caused riparian landowners to seek alternate water sources.

Water quality problems associated with the Red River originate principally outside the Red River Basin below Fulton and more specifically in the area above Denison Dam. The pollution problems consist mostly of high chloride concentration and turbidity. Also, non-point source pollution from agriculture, silviculture, and oil field activities often deteriorate the water quality in some of the basin streams.

Recommendations for surface water quantity problems include alternate water sources such as the construction of off-channel and on-farm water storage reservoirs and the transfer of Little River water to the Red River Basin below Fulton. Best Management Practices (BMP's) can be used to reduce the water quality problems, and watershed protection projects can help implement BMP's in agricultural areas. Water conservation, if practiced throughout the basin, will result in more water of higher quality.

Cretaceous, Tertiary, and Quaternary age deposits contain freshwater in the Red River Basin below Fulton. Ground water withdrawals in 1980 from the Quaternary Aquifer were 22.7 M.G.D. which represent 58 percent of the total ground water withdrawn in the basin and was used primarily for rice irrigation in Lafayette and Miller Counties.

Withdrawals from the Sparta Sand (8.5 MGD) and the Cane River Formation (4.8 MGD) represent 34 percent of the total ground water withdrawals in the basin and were used mainly for irrigation, public supplies, and self-supplied industry. The remaining 8 percent of ground water used in the basin was withdrawn as follows:

Nacatoch Sand (2.0 MGD);
Wilcox Group (0.4 MGD);
Cockfield (0.4 MGD); and
Carrizo Sand (0.3 MGD).

The major ground water problems in the basin are as follows:

(1) Quaternary Aquifer - quality degradation; and

(2) Sparta Sand Aquifer - relationship of the top of the Sparta formation and the potentiometric surface.

Quality degradation caused by chloride concentrations in the Quaternary alluvium is a local problem in a portion of Miller and Lafayette Counties. Chloride concentrations of as much as 46,250 mg/l have been found in the alluvium near Garland City, in Miller County. The high chloride content of the water in the alluvial aquifer has made ground water in this area unsuitable for irrigation. The contamination is associated with oil-field activity in the area and is related directly to effluent seepage from brine-storage pits, some of which have been in use for as long as 40 years.

A smaller area, also contaminated by salt water, is located a few miles east of Garland City in Lafayette County. This site includes an area about 7 miles long and 3 miles wide near Spirit Lake. Contamination of the alluvial aquifer at this site has been traced to an abandoned oil well in the Spirit Lake oil and gas field.

The potentiometric surface is below the top of the Sparta Sand formation in the southeastern part of the study area. Most of the problem is centered around Magnolia in Columbia County where water levels declined an average of 2 feet per year for 60 years. Pre-development levels were about 250 feet higher than today's level.

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CHAPTER I

GENERAL DESCRIPTION

LOCATION AND SIZE

The Red River Basin below Fulton, Arkansas (herein referred to as the Red River Basin below Fulton) consists of about 2,212 square miles, or 1,415,865 acres and is located in the extreme southwestern part of Arkansas. <38> (Numbers in angle brackets refer to the reference numbers cited in the bibliography). The basin is bounded on the west by Texas and on the south by Louisiana.

In order to comply with the requirements of Arkansas Act 1051 (1985), basic data in this report was compiled and presented according to surface drainage or watershed boundaries established on the Arkansas Hydrologic Unit Map (U. S. Water Resources Council) rather than on sub-surface divisions such as geologic formations or aquifers. Figure 1-1 shows the Red River Basin below Fulton boundary and contains information from the Arkansas Hydrologic Unit Map. <52> The three weights of solid lines on Figure 1-1, starting with the heaviest weighted line and descending to the lightest weighted line, correspond to Region, Accounting, and Cataloging Boundary Units, respectively, which are utilized by the U. S. Geological Survey in their management of the National Water Data Network. (See Figure 1-1 Legend) The Red River Basin below Fulton area is bounded by the Regional Boundary Line on the east and the Accounting Unit boundary line passing through Fulton, Arkansas on the northwest, as shown on Figure 1-1.

The basin has an overall length of about 45 miles in a north-south direction and averages about 50 miles in width. The main watercourse is a 90-mile reach of the Red River from immediately downstream of its confluence with the Little River near Fulton to the Louisiana state line. In addition to the Red River, other major streams located in the basin are the Sulphur River, McKinney Bayou, Bois d'Arc Creek, Bodcau Creek, and Bayou Dorcheat. <53>

All of one county and parts of five other counties lie within the basin. Each county in the basin with corresponding total acreage in the basin and percentage of each county in the basin are:

Columbia -	339,142 acres	(69.0 percent)
Hempstead -	229,323 acres	(48.3 percent)
Howard -	607 acres	(0.2 percent)
Lafayette -	343,680 acres	(100.0 percent)
Miller -	398,582 acres	(97.0 percent)
Nevada -	104,531 acres	(26.5 percent)
	1,415,865	

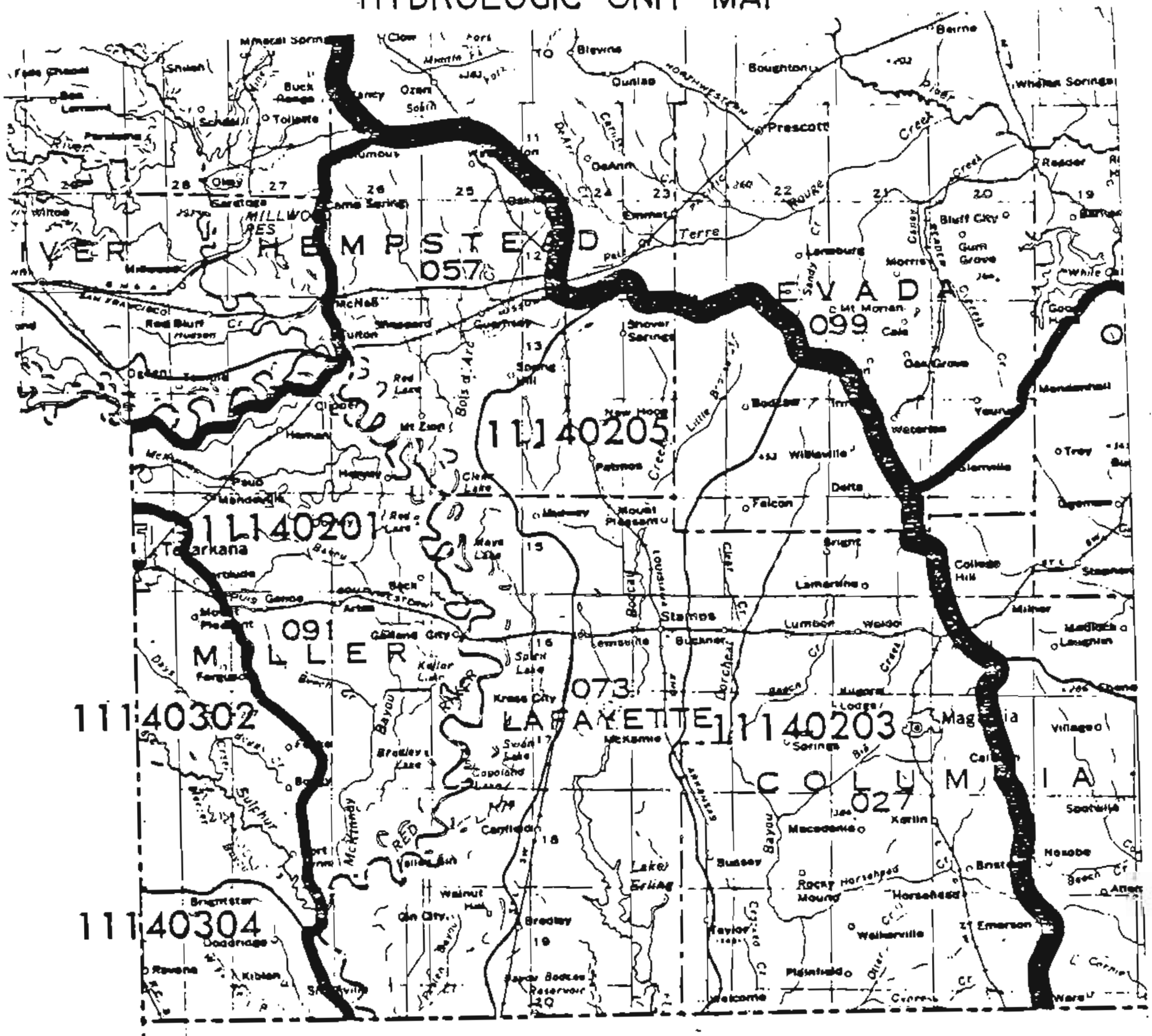
Lake Erling is the only major existing impoundment in the basin. This 7,000-acre lake is located in Bodcau Creek in Lafayette County and is owned by the International Paper Company.

Figure 1-1

RED RIVER BASIN BELOW FULTON

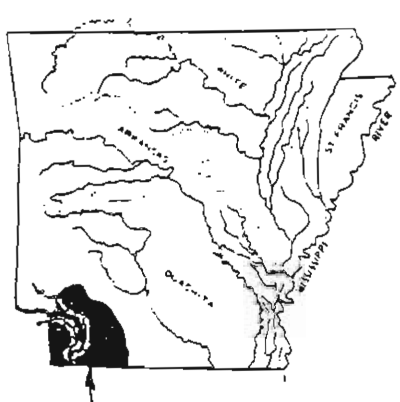
HYDROLOGIC UNIT MAP

TEXAS



LOUISIANA

SCALE : 1" = APPROX. 11 MILES



LEGEND

REGIONAL BOUNDARY

ACCOUNTING UNIT BOUNDARY

CATALOGING UNIT BOUNDARY

11140302 CATALOGING UNIT NUMBER

TOPOGRAPHY

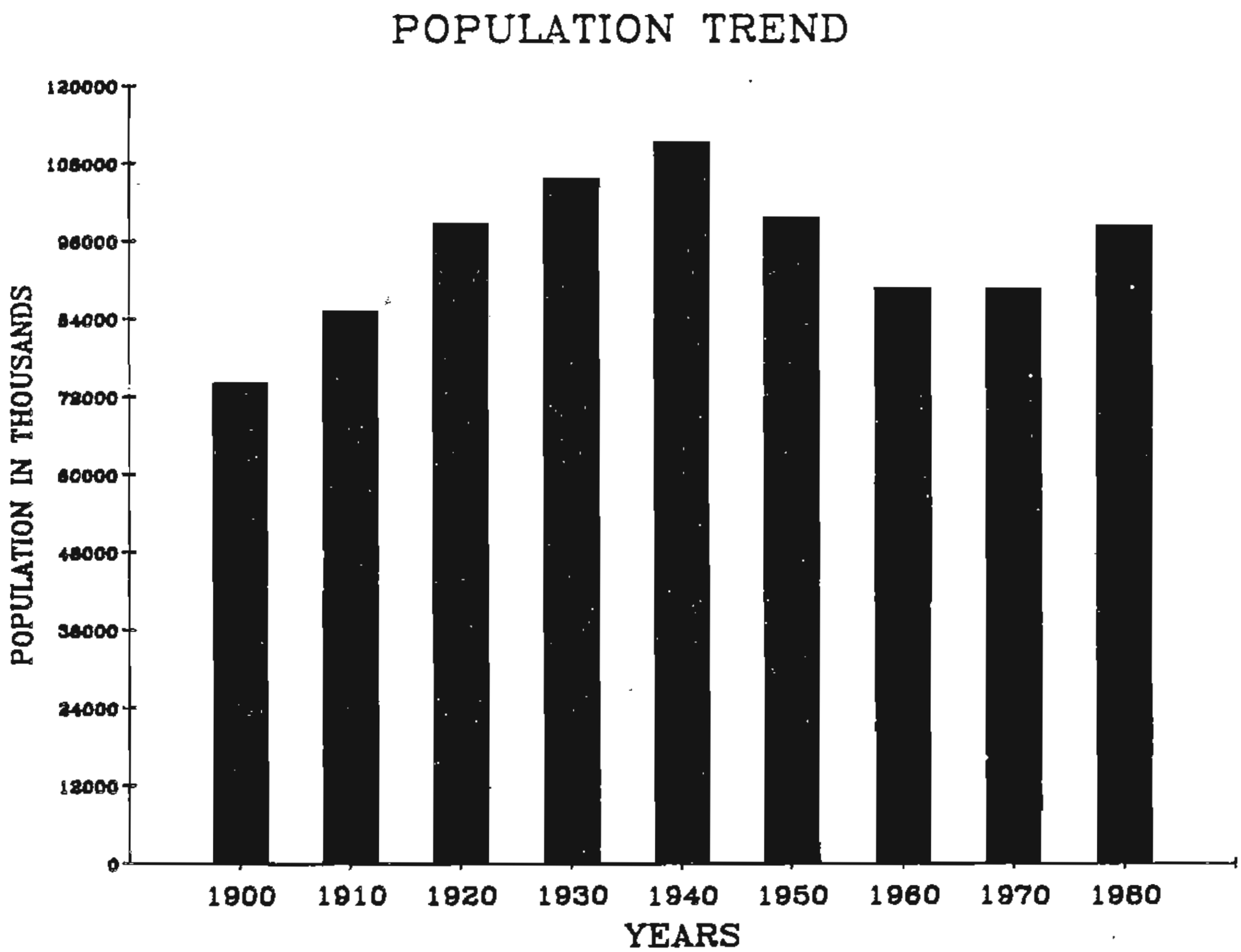
Relief of the basin ranges from level or undulating to moderately steep, with most of the area being gently rolling. Elevations range from about 500 feet above National Geodetic Vertical Datum (NGVD) in the northern part of the basin to about 100 feet above NGVD along the Red River at the southern boundary.

POPULATION

Census data for four of the six basin counties (Columbia, Hempstead, Lafayette, and Miller) were used to profile the basin's population. Howard and Nevada Counties account for only about 7 percent of the total basin area. It was determined that incorporation of census data from these two counties in the development of population trends and projections could cause the results to be misleading.

The total 1980 population of the four counties in the basin (including Texarkana, Arkansas) was 98,258, an increase of about 10,000 over the 1970 census. Each of these counties showed an increase in population from 1970 to 1980. Figure 1-2 and Table 1-1 show the population by county and the population trend in the four counties since 1900. <41> <66>

Figure 1-2



Source: UALR, Research and Public Services <66>.

TABLE 1-1: POPULATION BY COUNTY

COUNTY	1900	1910	1920	1930	1940	1950	1960	1970	1980
Columbia	22,077	23,820	27,670	27,320	29,822	28,770	26,400	25,952	26,644
Hempstead	24,101	28,285	31,602	30,847	32,770	25,080	19,661	19,308	23,635
Lafayette	10,594	13,741	15,522	16,934	16,851	13,203	11,030	10,018	10,213
Miller	17,558	19,555	24,021	30,586	31,874	32,614	31,686	33,385	37,766
TOTAL	74,330	85,401	98,815	105,687	111,317	99,667	88,777	88,663	98,258

Source: U. S. Department of Commerce <41>
Research and Public Services <66>

Arkansas Department of Pollution Control and Ecology projections (Table 1-2) show a population increase from 98,258 to 112,750 by the year 2000, an increase of about 15 percent. The Arkansas Soil and Water Conservation Commission extended a straight line projection to the year 2030 and projections indicate the population will be about 134,650, an increase over the year 2000 by about 19 percent. The above estimates amount to an overall increase from 1980 to the year 2030 of about 37 percent.

TABLE 1-2: POPULATION PROJECTIONS

COUNTY	YEARS 1980	2000 1/	2030 2/
Columbia	26,644	31,660	39,010
Hempstead	23,635	27,260	32,980
LaFayette	10,213	12,090	14,840
Miller	37,766	41,740	47,820
Total	98,258	112,750	134,650
Percent Change		+ 14.7 %	+ 19.4 %

1/ Prepared by the Arkansas Department of Pollution Control and Ecology.

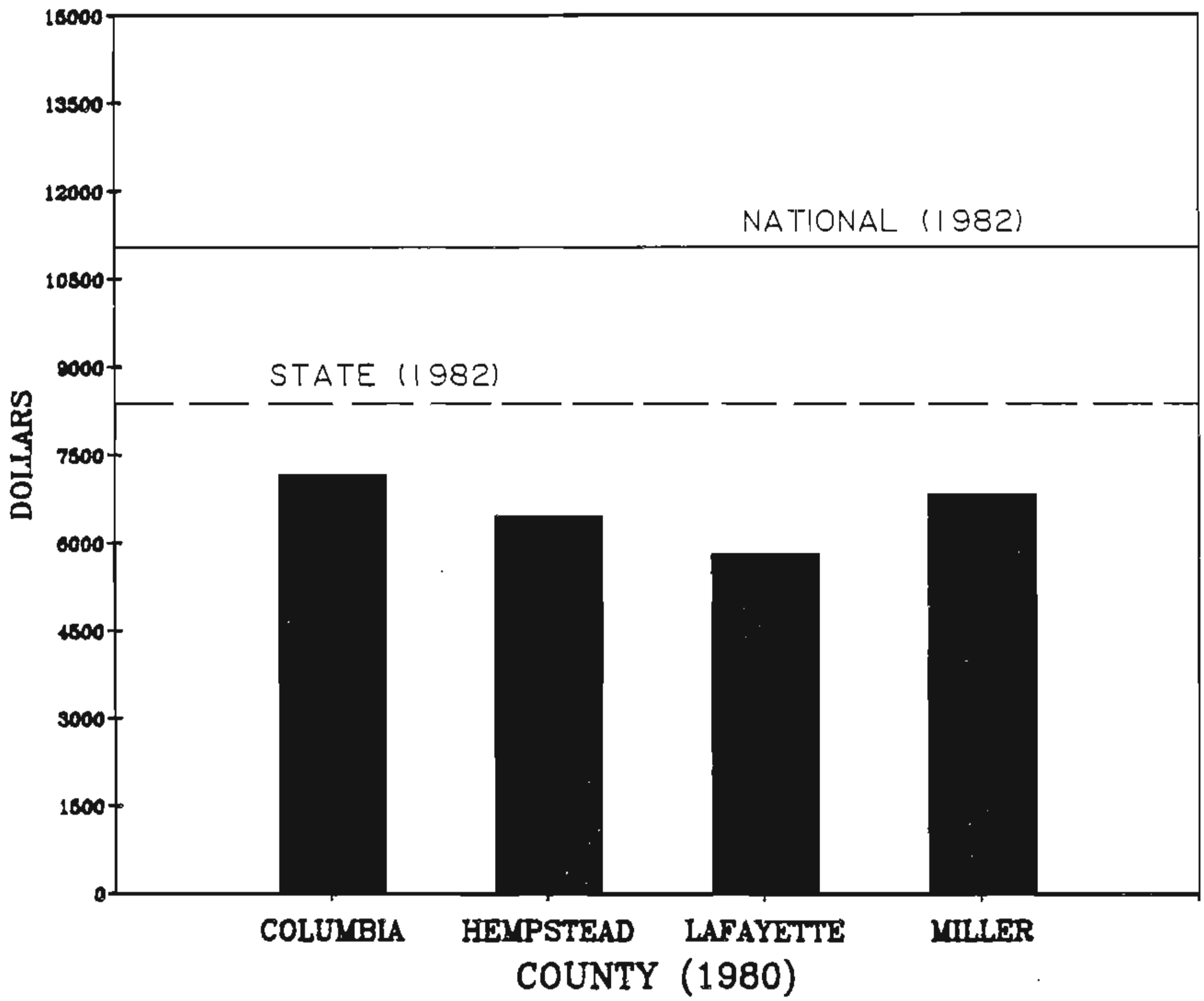
2/ Prepared by the Arkansas Soil and Water Conservation Commission.

Source: U. S. Department of Commerce <41>

The 1980 average per capita personal incomes for the four counties ranged from a low of $5,826 in Lafayette County to a high of $7,182 in Columbia County. Columbia County's reported per capita income ranked fourteenth in the state in per capita personal income. The 1980 per capita income for Arkansas was $7,185. <42> In 1982, per capita incomes of $8,332 and $11,056 were reported for Arkansas and the United States respectively. <6> (See Figure 1-3.)

Figure 1-3

PER CAPITA INCOME



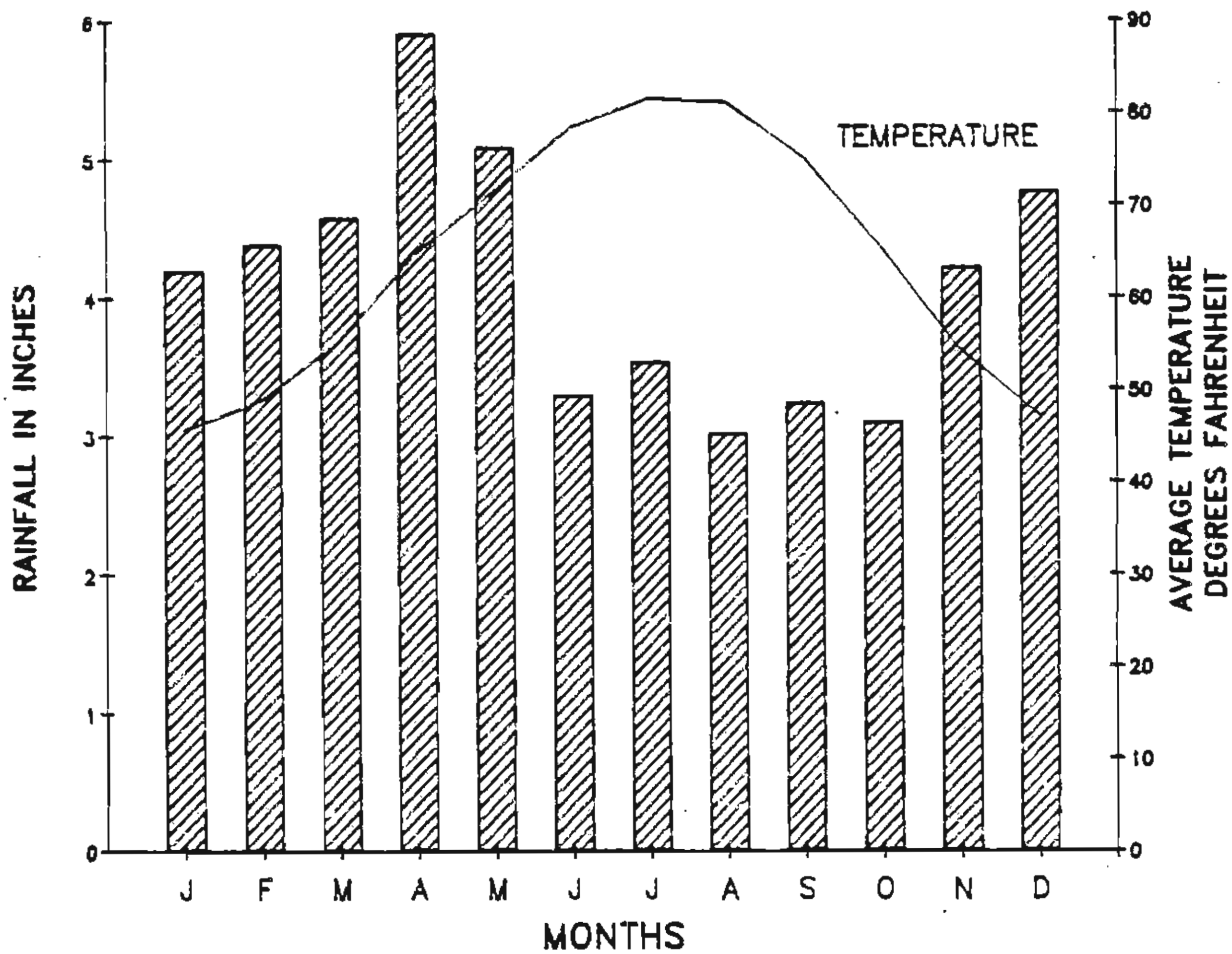
Source: Ark Employment Security Division & U.S. Department of Commerce. <6><42>

CLIMATE

The climate in the basin is humid with warm summers. Mean temperatures range from 81.6 degrees Fahrenheit in July to 45.7 degrees Fahrenheit in January. The average annual temperature in the basin is 64.1 degrees Fahrenheit. Recorded temperature extremes are 114.0 degrees Fahrenheit and minus 5.0 degrees Fahrenheit. The average annual rainfall in the basin is about 49 inches. (See Figure 1-4 for the average monthly rainfall and temperature from the Magnolia gage) <44> Climatic data were selected from a 30-year (1941-1970) Weather Bureau record at Magnolia, Arkansas, located in the east-central part of the basin. (See Figure 1-5) <43>

Figure 1-4

AVERAGE MONTHLY RAINFALL AND TEMPERATURE
MAGNOLIA GAGE



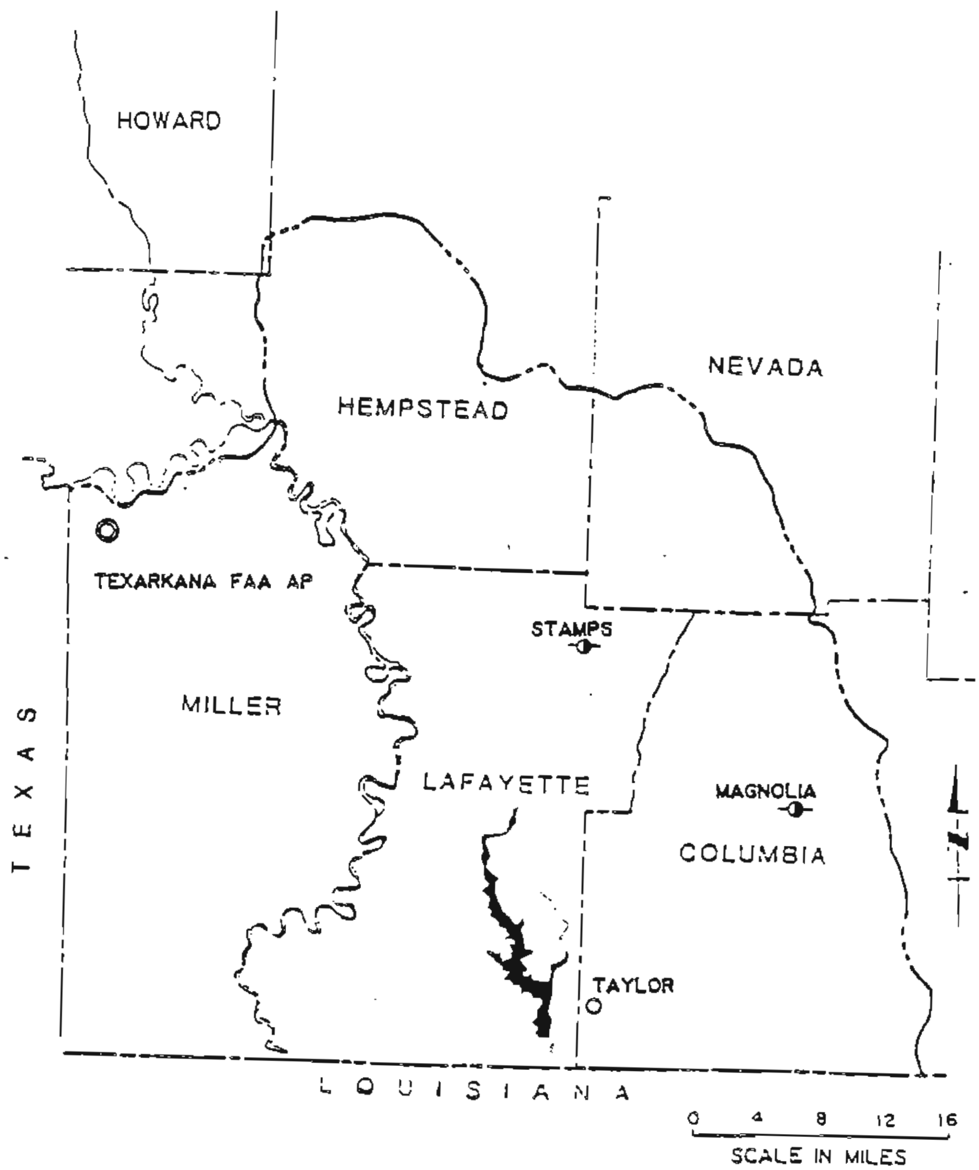
SOURCE: U.S. DEPARTMENT OF COMMERCE (44)

Figure 1-5

WEATHER STATION LOCATIONS

LEGEND

- ○ Precipitation, Non-Recording
- -◑- Precipitation and Temperature, Recording and Non-Recording
- ◎ Precipitation and Temperature, More Meteorological Data Available



SOURCE : U.S. DEPARTMENT OF COMMERCE <43>

CHAPTER II

LAND RESOURCES INVENTORY

LAND USE

Of the total 1,415,865 acres in the basin, forest land accounts for 944,721 acres (66.7 percent). Grassland occupies 267,964 acres in the basin (18.9 percent), and cropland covers 154,093 acres (10.9 percent). The remaining 49,087 acres (3.5 percent) are urban and builtup land and other land. (See Table 2-1 and Figure 2-1) <38> About 38 percent of the cropland is used for growing soybeans, 6 percent for cotton, 6 percent for rice, 12 percent for sorghum, and the remaining for a variety of other crops such as corn and vegetables. Figure 2-2 shows cropland trends. <26>

TABLE 2-1: LAND USE BY COUNTY
RED RIVER BASIN BELOW FULTON

County	Crop-land	Grass-land	Forest Land	Urban & Builtup	Other	Total Acres in Basin	Total Acres in County	Percent of County in Basin
Columbia	-	46,631	287,555	4,956	-	339,142	491,520	69.0
Hempstead	10,691	63,050	150,236	5,346	-	229,323	474,880	48.3
Howard	-	-	607	-	-	607	384,000	0.2
Lafayette	56,868	63,116	206,817	4,192	12,687	343,680	343,680	100.0
Miller	86,534	76,098	214,044	5,081	16,825	398,582	410,880	97.0
Nevada		19,069	85,462	-	-	104,531	394,240	26.5
TOTAL	154,093	267,964	944,721	19,575	29,512	1,415,865	-	-
PERCENT	10.9	18.9	66.7	1.4	2.1	-	-	-

Source: USDA, Soil Conservation Service <38>

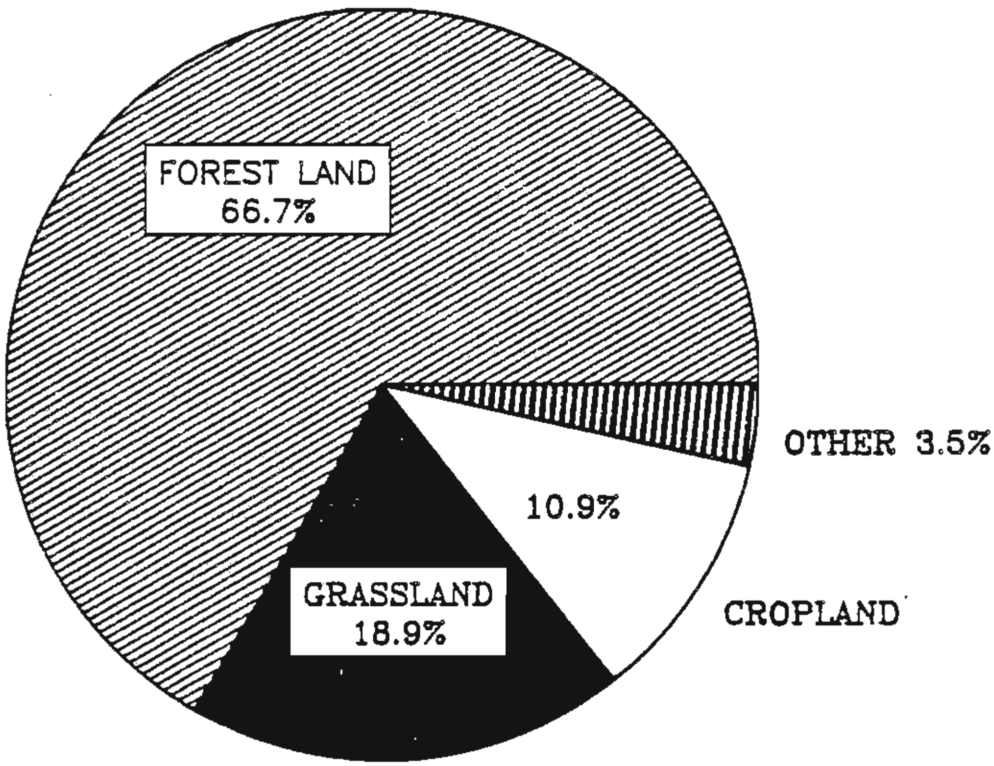
Forest Land

Forest land in the basin is defined as land with a 10 percent or more tree canopy cover of any size forest trees or land formerly having had such tree cover, and not currently developed for nonforest use.

The Red River Basin below Fulton has 944,721 acres of forest land which is 66.7 percent of the total land use. Table 2-2 shows forest land percentages by type and ownership. Much of the forest land in the study area is commercially managed.

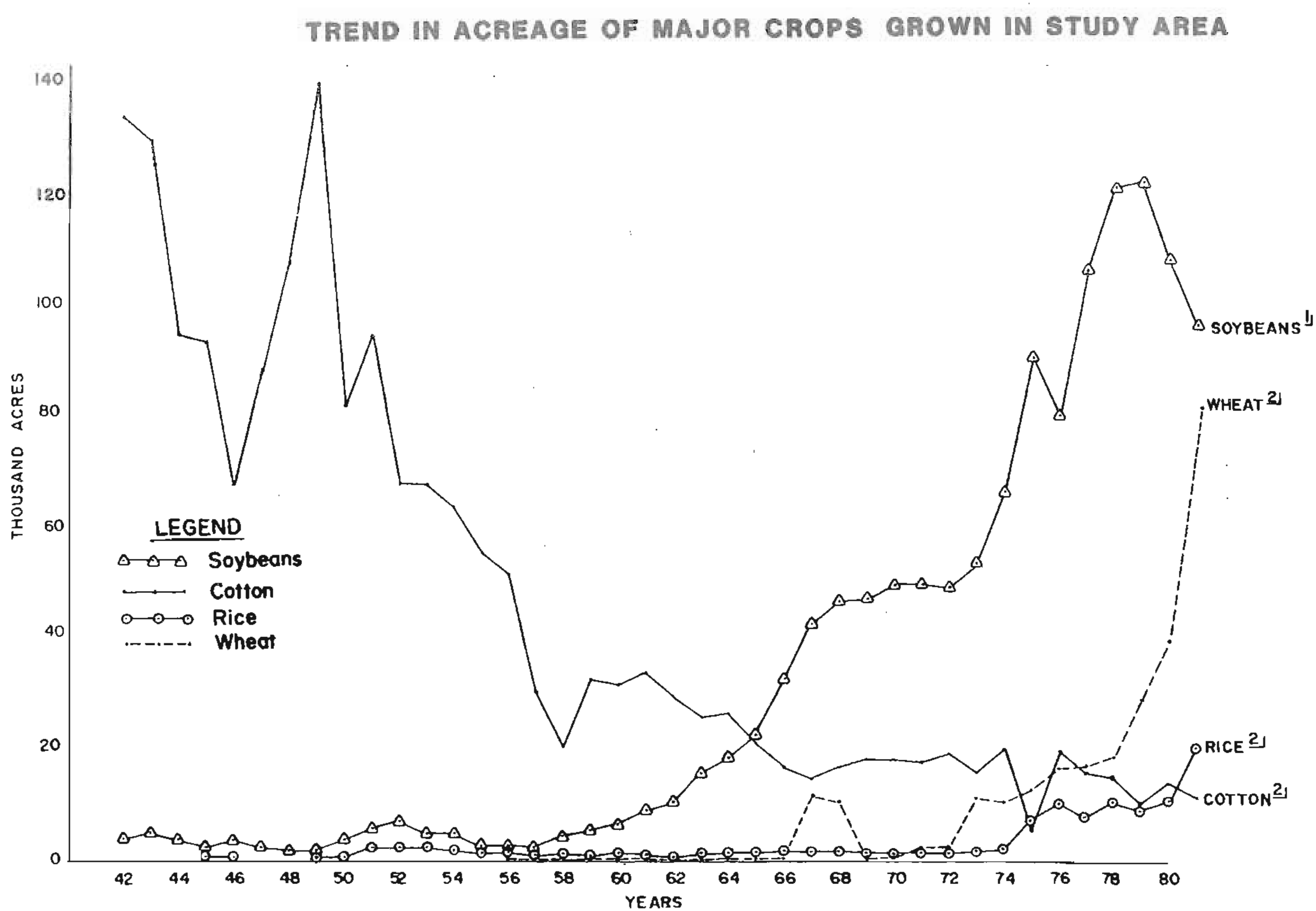
Figure 2-1

LAND USE IN THE BASIN



SOURCE: USDA, SOIL CONSERVATION SERVICE <38>.

Figure 2-2



SOURCE : USDA, Arkansas Agriculture Statistics Service <26>

1| Acres Harvested
2| Acres Planted

TABLE 2-2: FOREST LAND BY TYPE
(Percent)

Loblolly - Shortleaf Pine	53.3
Oak - Pine	29.6
Oak - Hickory	1.5
Oak - Gum - Cypress	10.5
Elm - Ash - Cottonwood	5.1
	100.0

FOREST LAND BY OWNERSHIP
(Percent)

State	2.6
City	0.6
Forest Industry	20.2
Private	76.6
	100.0

Source: USDA, Soil Conservation Service <38>

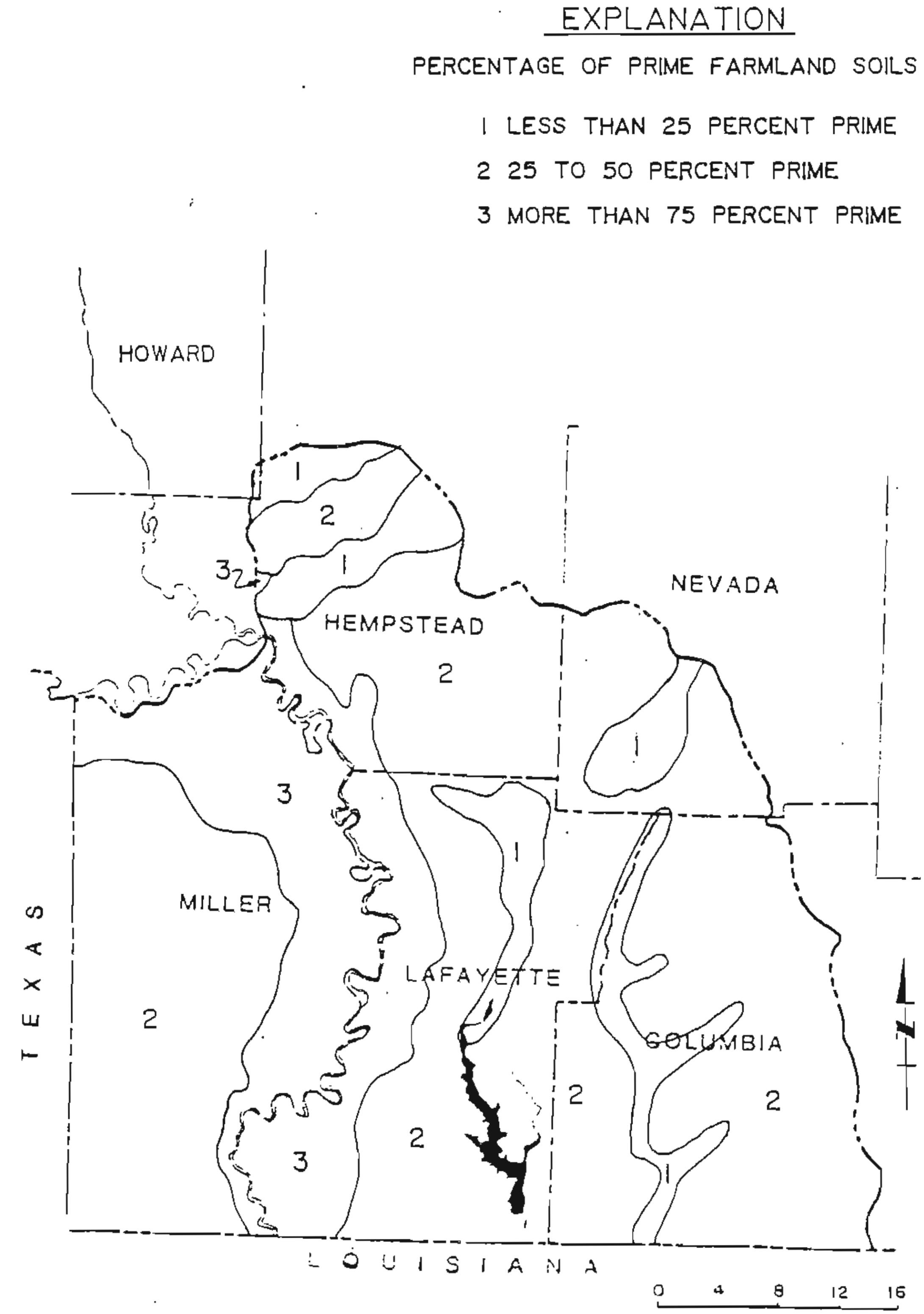
Prime Farmland

Prime farmland is land having the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. Figure 2-3 shows the range of percentages of prime farmland in the basin. Prime farmland use can be cropland, pastureland, rangeland, forest land, or other land, but not urban or built-up land or water.

Prime farmland soils meet all the following criteria: (1) have adequate and dependable water supply from precipitation or irrigation; (2) have a favorable temperature and growing season; (3) have acceptable acidity or alkalinity; (4) are not saturated with water during the growing season; (5) have low salt and sodium content; (6) are not flooded during the growing season; (7) are not highly erodible; (8) are permeable to air and water; and (9) contain few or no coarse fragments. More detailed criteria for prime farmland are given in the Federal Register, Vol. 43, No. 21, Tuesday, January 31, 1978.

The basin has 481,000 acres of prime farmland or about 4 percent of the total prime farmland in the state. <35> Of this total, 165,000 acres (34.3 percent) are cropland, 119,000 acres (24.7 percent) are pastureland, 189,100 acres (39.3 percent) are forest land, and 7,900 acres (1.7 percent) are minor land uses. The 165,000 prime farmland (cropland) acres were obtained from 1982 National Resource Inventory (NRI) data, whereas the 154,093 acres of cropland shown on Table 2-1 were obtained from 1977 Resource Inventory Data System (RIDS) data. <38><35>

Figure 2-3
PRIME FARMLAND



SOURCE : USDA, SOIL CONSERVATION SERVICE <37>

Irrigated Cropland

Data compiled for the United States Department of Agriculture (USDA), Agriculture Water Use Study shows a total of 16,072 irrigated acres in the basin in 1980. <31> Irrigated acres represents 10.4 percent of the total cropland in the basin. Rice is the major irrigated crop with 9,642 acres (60 percent) followed by soybeans with 4,095 acres (25.5 percent), and cotton with 2,135 acres (13.3 percent).

Potential for Irrigated Cropland

To preserve a sufficient amount of water for future agriculture uses in this basin and quantify the excess water for possible interbasin transfer, the determination of maximum agriculture water needs is essential. Projection techniques were used by the U.S.D.A. Economic Research Service to estimate the maximum potential acreage of irrigated cropland in the combined above Fulton and below Fulton Red River Basins. These projections were made in conjunction with the Arkansas Statewide Study, Phase V. <29> The projections were based on 1980 irrigated acreage data and expanded to the years 2000 and 2030 (see Table 2-3). A profit maximization linear programming model was used as an aid in estimating irrigated acres for the year 2030. Institutional and physical restraints were included but water availability and cost of converting prime farmland to cropland was not considered.

As previously stated, projections of maximum potential irrigated acreage were established for the entire Red River Basin area of Arkansas (above and below Fulton combined). To determine the projected acreage of maximum potential irrigated cropland in the Red River Basin above Fulton and below Fulton, the percentage of total cropland in each basin for 1977 was applied to the maximum potential acreage of each crop. For example, the combined basin had 221,010 acres of cropland in 1977. The Red River Basin below Fulton had 154,093 acres of cropland or about 70 percent of the total. (See Table 2-1) The result of 70 percent times the projected total basin irrigated acreage of each crop for the year 2030 is shown in Table 2-3. <29> The year 2000 was then determined from a straight line projection.

Table 2-3 projects a maximum 234,990 acres of irrigated cropland by the year 2030. Table 2-3 does not include acreage for orchards and vineyards, vegetables, surface water areas for recreation, and other miscellaneous uses. The total basin cropland (irrigated and nonirrigated) is 154,093 acres. (See Table 2-1). If the estimated 234,990 acres are actually irrigated by 2030, an additional 80,897 acres must be converted from some other land use, assuming all the current 154,093 acres of irrigated and non-irrigated cropland is irrigated. The conversion would likely come from the 481,000 acres of prime farmland in the basin of which 119,000 acres are pastureland.

TABLE 2-3: IRRIGATED CROP ACREAGE PROJECTIONS
RED RIVER BASIN BELOW FULTON

Year	Soybeans	Sorghum	Rice	Corn	Cotton	Total
			(ACRES)			
1980 1/	4,095	200	9,642	0	2,135	16,072
2000 2/	75,033	400	19,729	168	8,309	103,639
2030 3/	181,440	700	34,860	420	17,570	234,990

Sources: 1/ USDA, Soil Conservation Service <31>
2/ Straight line projection
3/ USDA, Soil Conservation Service <29>

Wetlands

Wetlands are areas inundated or saturated by surface water or ground water at a frequency and duration sufficient to support a prevalence of plants which are adapted for life in saturated soil conditions. Such areas in Arkansas are commonly referred to as swamps, sloughs, shallow lakes, ponds, and river-overflow lands.As part of an inventory of the Nation's resources, the SCS collected information about wetlands in 1982. <35> Inventory sample areas were classified with respect to types of wetlands as described in Wetlands of the United States, Circular 39. <50> Within the Red River Basin below Fulton, a total of 100,800 acres of wetlands, including river-overflow lands and permanently flooded sloughs and swamps, are estimated to exist. <35>

SOIL RESOURCES

Major Land Resource Areas

The three major land resource areas (MLRA) in the basin are the Western Coastal Plain, Southern Mississippi Valley Alluvium, and Blackland Prairie. These major land resource areas are illustrated in Figure 2-4. A general description of each area is provided in the following paragraphs.

Western Coastal Plain (MLRA)

The Western Coastal Plain area consists of rolling terrain broken by stream valleys. Elevations range from about 100 to 500 feet NGVD. The soils developed from deep, clayey, loamy or sandy marine sediments. Slopes are level to nearly level on flood plains and terraces and nearly level to moderately steep on uplands. This area is used extensively for timber production and pasture. The Coastal Plain accounts for about 53 percent or 749,285 acres in the basin. <28> <33>

Southern Mississippi Valley Alluvium (MLRA)

The Southern Mississippi Valley Alluvium consists of broad alluvial plains in the western part of this basin. Elevations range from about 100 to 400 feet NGVD. Soils are developed in deep, clayey, loamy, or sandy alluvial sediments. Slopes are dominantly level to nearly level and some areas are undulating. Most of this area is used for production of cultivated crops. Some areas remain forested and are important for hardwood production and wildlife habitat. This MLRA makes up approximately 45 percent or 642,090 acres of the basin. <28><33>

Blackland Prairie (MLRA)

The Blackland Prairie consists of gently rolling areas in the southwestern part of the state. Elevations range from 300 to 700 feet NGVD. Soils were developed from clayey sediments overlying beds of marly clay or chalk; or from marly clay or chalk. Slopes range from nearly level to moderately steep. The soils are used mainly for pasture and hayland. Blackland Prairie accounts for about 2 percent or 24,490 acres in this basin. <28><33>

Soil Surveys

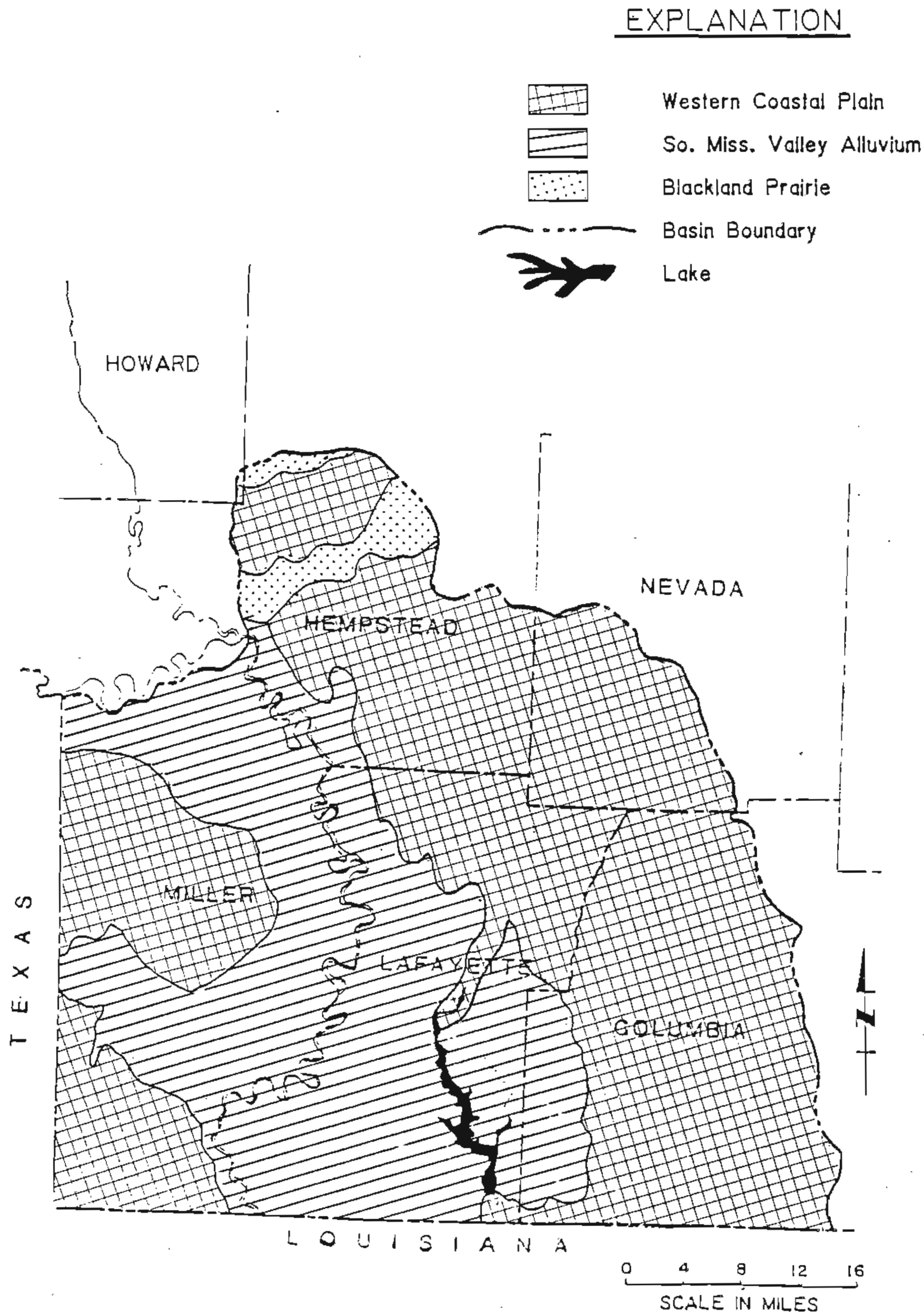
The Soil Conservation Service (SCS) is responsible for all soil survey activities of the U. S. Department of Agriculture. The soil surveys and interpretations are made cooperatively with the University of Arkansas Agricultural Experiment Station, Agriculture Extension Service, U. S. Forest Service, Arkansas Highway Department, the 76 soil and water conservation districts, and other state and federal agencies. Complete soil surveys for five of the six counties in the basin have been published. The counties and corresponding dates of publication are: Columbia (1985), Hempstead (1979), Miller (1984), Lafayette (1984), and Howard (1975). The Nevada County soil survey is in progress.

General Soil Units

In the Red River Basin below Fulton there are four soil units of the Western Coastal Plain MLRA, five soil units of the Southern Mississippi Valley Alluvium MLRA, and one of the Blackland Prairie MLRA. Additional information for these soil units can be found in published county soil surveys and the General Soil Map of Arkansas.

These soils units are shown by resource area in Table 2-4 and their locations are shown on Figure 2-5.

Figure 2-4
MAJOR LAND RESOURCE AREAS



SOURCE : USDA, SOIL CONSERVATION SERVICE <33>

TABLE 2-4: GENERAL SOIL UNITS BY MAJOR LAND RESOURCE AREA

Major Land Resource Area (MLRA)	General Soil Unit
Blackland Prairie	49 Oktibbeha - Sumter
Western Coastal Plain	39 Darco - Briley - Smithdale 41 Smithdale - Sacul - Savannah - Saffell 42 Sacul - Smithdale - Sawyer 43 Guyton - Ouachita - Sardis
Southern Mississippi Valley Alluvium	32 Rilla - Hebert 33 Billyhaw - Perry 34 Severn - Oklared 35 Adaton 36 Wrightsville - Louin - Acadia

Source: USDA, Soil Conservation Service, Arkansas General Soil Map (published) <33>

Figure 2-5

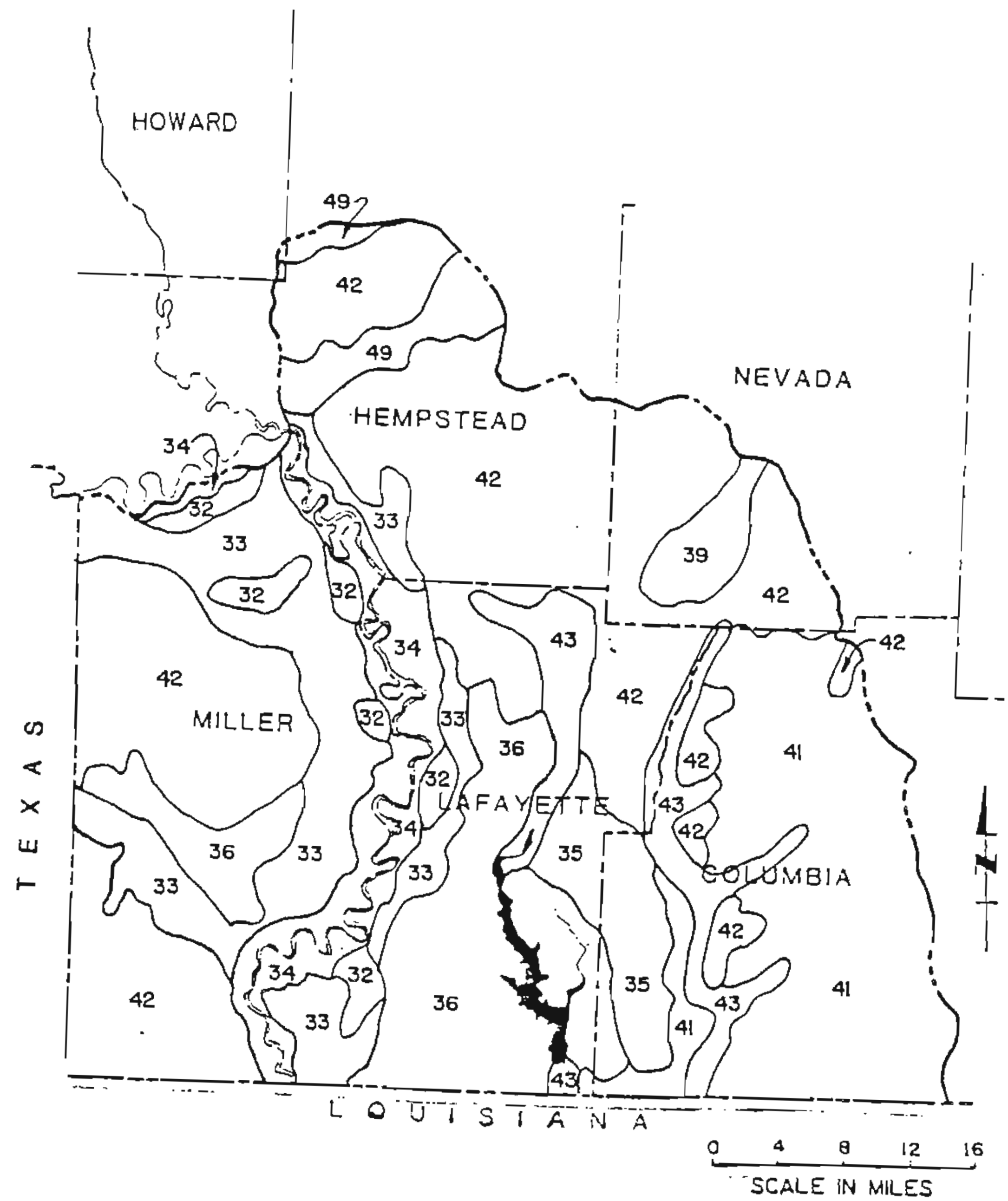
GENERAL SOILS MAP

EXPLANATION

36 Number Indicates General Soil Unit (See Table 2 - 4)

Basin Boundary

Lake



SOURCE : USDA, SOIL CONSERVATION SERVICE <33>

CHAPTER III

SURFACE WATER

INTRODUCTION

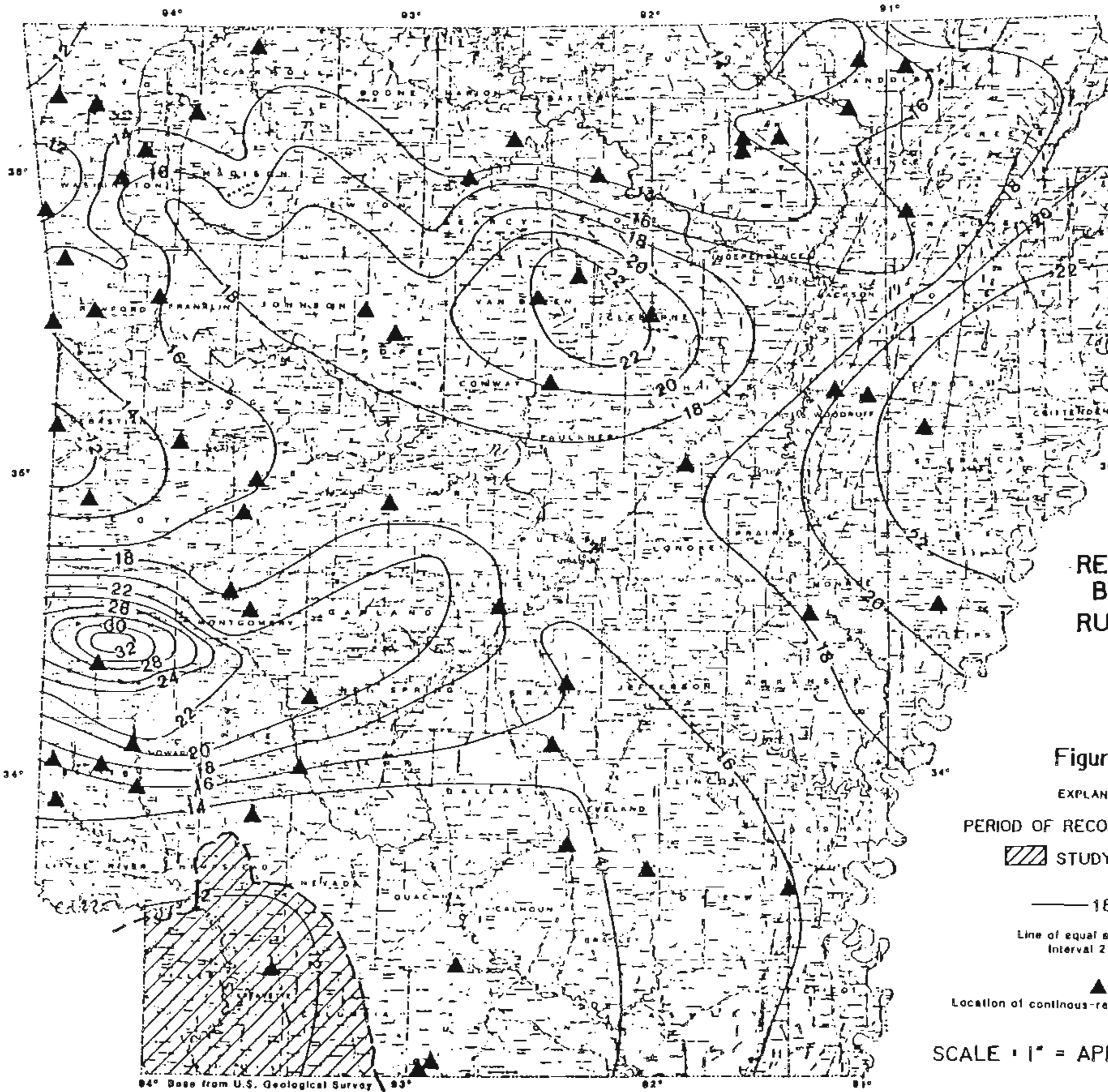
This section of the report presents an inventory of the surface water resources of the Red River Basin below Fulton. Present water use and estimated future water needs are quantified. Current water resource problems are identified and possible solutions are presented, if appropriate. The information in this section is intended to serve as a guide for the proper use, management, and development of basin water resources.

The Red River Basin below Fulton has 157 impoundments exceeding 5 acres in size. Impoundments smaller than 5 acres total 6,257 within the six county area. <17> The primary stream in the basin is the Red River which has a drainage area of 52,336 square miles at the Fulton, Arkansas stream gage. The 54-year average discharge is 17,190 cubic feet per second. The maximum discharge of 338,000 cubic feet per second occurred February 24, 1938, and the minimum of 390 cubic feet per second on October 26, 1956. <54> The Red River below Fulton, Arkansas meanders in a southerly direction to the Arkansas/Louisana state line and serves as the common boundary for Miller and Lafayette Counties in Arkansas until it enters Louisiana near Smithville, Arkansas. Flows in the Red River are regulated by Denison Dam (completed in 1943) on the main stem and by numerous other contributing land and water resource developments in Oklahoma, Texas, and Arkansas.

The second largest stream in the study area is the Sulphur River with a drainage area of 3,479 square miles at the Texas/Arkansas state line and 3,748 square miles at its confluence with the Red River. Other major streams in the basin include Bodcau Creek, Bayou Dorcheat, Days Creek, McKinney Bayou, and Bois D'Arc Creek.

The largest artificial impoundment in the basin is Lake Erling which is located in southeastern Lafayette county. Lake Erling is a 7,000 surface-acre impoundment owned by the International Paper Company. The primary uses of Lake Erling are recreation and flood control. Lake Columbia, a 2,600 surface acre municipal water supply reservoir for Magnolia, is currently under construction. Other small natural impoundments, most of which are ox-bow lakes, exist throughout the basin but primarily in the Red River vicinity.

The average annual runoff in the Red River Basin below Fulton, based on data for the record period 1951-1980, ranges from slightly above 12 inches in the extreme eastern and northern parts of the basin to slightly below 12 inches in the central and western parts. (See Figure 3-1) Runoff varies seasonally and annually. The seasonal variability is characterized by low flows usually occurring June through November each year. The period of lowest stream flow occurs during the peak agricultural growing season which parallels maximum water use from many streams in the basin. Optimum development of surface water resources in the basin would require storage of high winter and spring flows for use in the summer and fall. Existing surface water storage in the basin is minimal.



RED RIVER BASIN
BELOW FULTON
RUNOFF IN INCHES

Figure 3-1

EXPLANATION

PERIOD OF RECORD 1951-1980

STUDY AREA

——18——

Line of equal annual runoff.
Interval 2 inches.

Location of continous-record gaging station.

SCALE : 1" = APPROX. 34 MILES

MODIFIED FROM FREIWALD, 1985 <69>

SURFACE WATER INVENTORY

Surface Water Data Collection Network

Gage height, streamflow, and water quality data are collected in the Red River Basin below Fulton primarily by the U.S. Geological Survey, the Arkansas Department of Pollution Control and Ecology, and the U.S. Army Corps of Engineers. Locations of six streamflow data collection sites, used in computations for parts of this report, are shown in Figure 3-2. The six stations selected have relatively long-term records available for study. Information from the data collection sites is summarized in Table 3-1. Table 3-2 provides information for two additional gaging stations operated by the Corps of Engineers.

Streamflow Characteristics

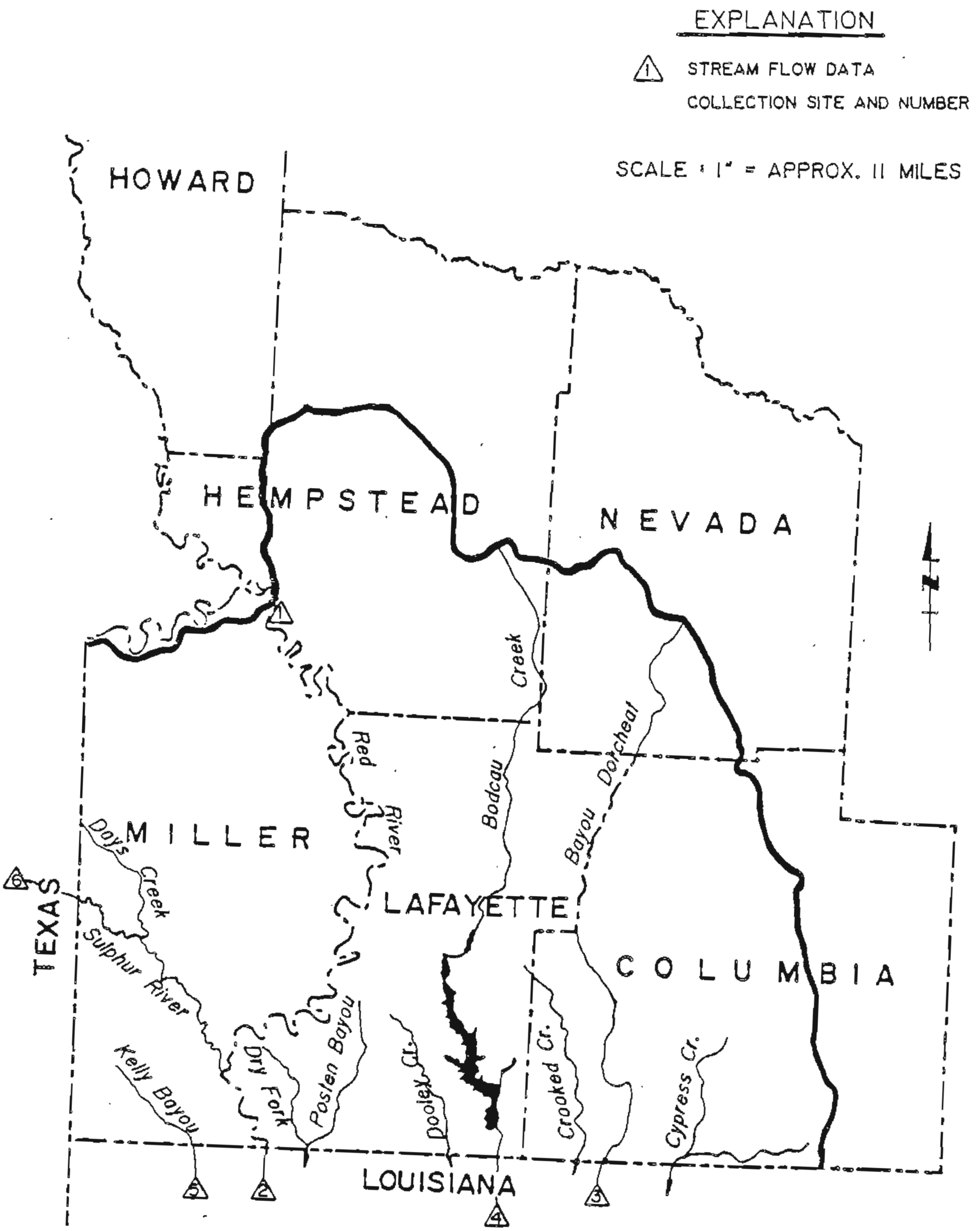
Distribution of streamflow is dependent upon climate, physiography, geology, and land use in the basin. Basins where these conditions are similar may have similar streamflow characteristics. Generally, the distribution of high flows is governed largely by the climate, the physiography, and the plant 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. <61>

In the Red River Basin below Fulton, streamflow is generally highest during December through May because of the large amount of precipitation during this period. Similarly, streamflow is generally lowest during June through November due to a decrease in precipitation and an increase in evapotranspiration that occurs during the growing season. Mean monthly discharges at selected gaging stations are shown in Table 3-3. Also, peak flow frequency analysis for three selected sites are shown on Figure 3-3, Figure 3-4, and Figure 3-5. The values in the Figures were determined according to guidelines found in WRC Bulletin 17-B. <67>

Management and development of surface water supplies depend on the rate of sustained streamflow during dry periods. The index generally used to define the low flow characteristics of a stream is defined as the lowest mean discharge for seven consecutive days at recurrence intervals of 2 and 10 years. It is referred to as the 7-day Q_2($7Q_2$) and 7-day Q_{10}($7Q_{10}$) discharge, respectively. Discharges are taken from a frequency curve of annual values of the lowest mean discharge for seven consecutive days. Low flow characteristics of selected streams are shown in Table 3-4. The $7Q_2$ and $7Q_{10}$ discharges per square mile are also shown in Table 3-4 for comparison purposes.

Figure 3-2

GENERAL LOCATIONS OF WATER RECORDING STATIONS AND STREAMS



SOURCE : U.S. GEOLOGICAL SURVEY <54>

TABLE 3-1: SUMMARY OF SELECTED STREAMFLOW COLLECTION SITES
(DATA COLLECTED BY U. S. GEOLOGICAL SURVEY UNLESS OTHERWISE NOTED
SITE NUMBERS CORRESPOND TO THOSE IN FIGURE 3-2)

Site No.	USGS Station No.	Name	Period and Type of Record	Drainage Area (Sq. Miles)	Maximum Discharge(CFS)	Minimum Discharge(CFS)	Average Discharge(CFS)
1.	07341500 1/	Red River at Fulton, AR	Streamflow 1928-1981	52,336 2/	338,000	390	17,190
2.	07344400 3/	Red River near Hosston, LA	Streamflow 1958-1968	57,041 2/	214,000	850 7/	17,920
3.	07348700 4/	Bayou Dorcheat near Springhill, LA	Streamflow 1958-1984	605	36,400	No Flow	543
4.	07349500 5/	Bodcau Bayou near Sarepta, LA	Streamflow 1939-1984	546	18,600	0.1	562
5.	07347000	Kelly Bayou near Hosston, LA	Streamflow 1945-1968	116	4,460	1.0	94.9
6.	07344210 6/	Sulphur River near Texarkana, TX	Streamflow 1939, 1945-1984	3,443	11,100	No Flow	2,889

1/ Regulation since 10/31/43 by Lake Texoma (TX) and since 8/16/66 by Millwood Lake (AR).
2/ 5,936 square miles probably non-contributing.
3/ Regulation by Lake Texoma (TX) since 1943, Texarkana Reservoir (TX) since 1956, and Millwood Lake (AR) since 1966.
4/ Gage is 1.7 miles D/S from AR-LA line.
5/ Some regulation from Lake Erling since 1956.
6/ Monitored by U.S. Army Corps of Engineers through 1979; 1979 to present by U.S.G.S. Regulation by Lake Texarkana (TX) since 1956.
7/ Minimum daily flow.

Source: Arkansas, Texas, and Louisiana Water Resources Data, U.S. Geological Survey

TABLE 3-2: SUMMARY OF SELECTED STREAM GAGING STATIONS OPERATED BY THE U. S. ARMY CORPS OF ENGINEERS

Number	Name	Years of Record	Drainage Area Square Miles	Maximum Stage Ft.	Minimum Stage Ft.	Remarks
35365	Sulphur River at Fort Lynn, AR	37	3,739	34.7	0	Prior to 2/16/72, gage zero was 174.52 ft. NGVD, present gage zero at NGVD.
35280	Red River at Spring Bank, AR	70	56,903	42.0	2.0	Gage zero at 172.39 ft. NGVD.

Source: Water Resources Data, Corps of Engineers

TABLE 3-3: MEAN MONTHLY DISCHARGE AT SELECTED GAGING STATIONS

Station Number	Station Name	Drainage Area (Sq. Mi.)	Years Used for Computations	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
07341500	Red River at Fulton, AR	52,336 1/	1946-1981 Regulated Period 2/	9,837	13,310	15,410	15,060	21,260	20,990	23,660	33,390	23,510	9,462	6,239	7,844
07344400	Red River near Hosston, LA	57,041	1958-1968	11,200	13,850	17,840	18,630	20,310	23,500	25,740	37,710	19,100	12,190	7,417	7,616
07348700	Bayou Dorcheat near Springhill, LA	605	1958-1984	77.1	242	681	830	1,012	1,024	1,175	815	345	140	67.8	141
07349500 3/	Bodcau Bayou near Sarepta, LA	546	1939-1984	105	355	663	916	1,158	980	986	1,019	313	159	41.3	82.8
07347000	Kelly Bayou near Hosston, LA	116	1945-1968	15.1	65.9	92.6	163	165	166	183	180	57	25.5	11.3	18
07344210 4/	Sulphur River near Texarkana, TX	3,443	1957-1977	1,846	2,609	3,487	3,453	3,727	3,783	3,286	4,152	3,962	2,799	777	792

1/ 5,936 square miles non contributing.
2/ Regulation from Lake Texoma since 1943.
3/ Some regulation from Lake Erling since April 1956.
4/ Regulation from Lake Texarkana (TX) since 1956.

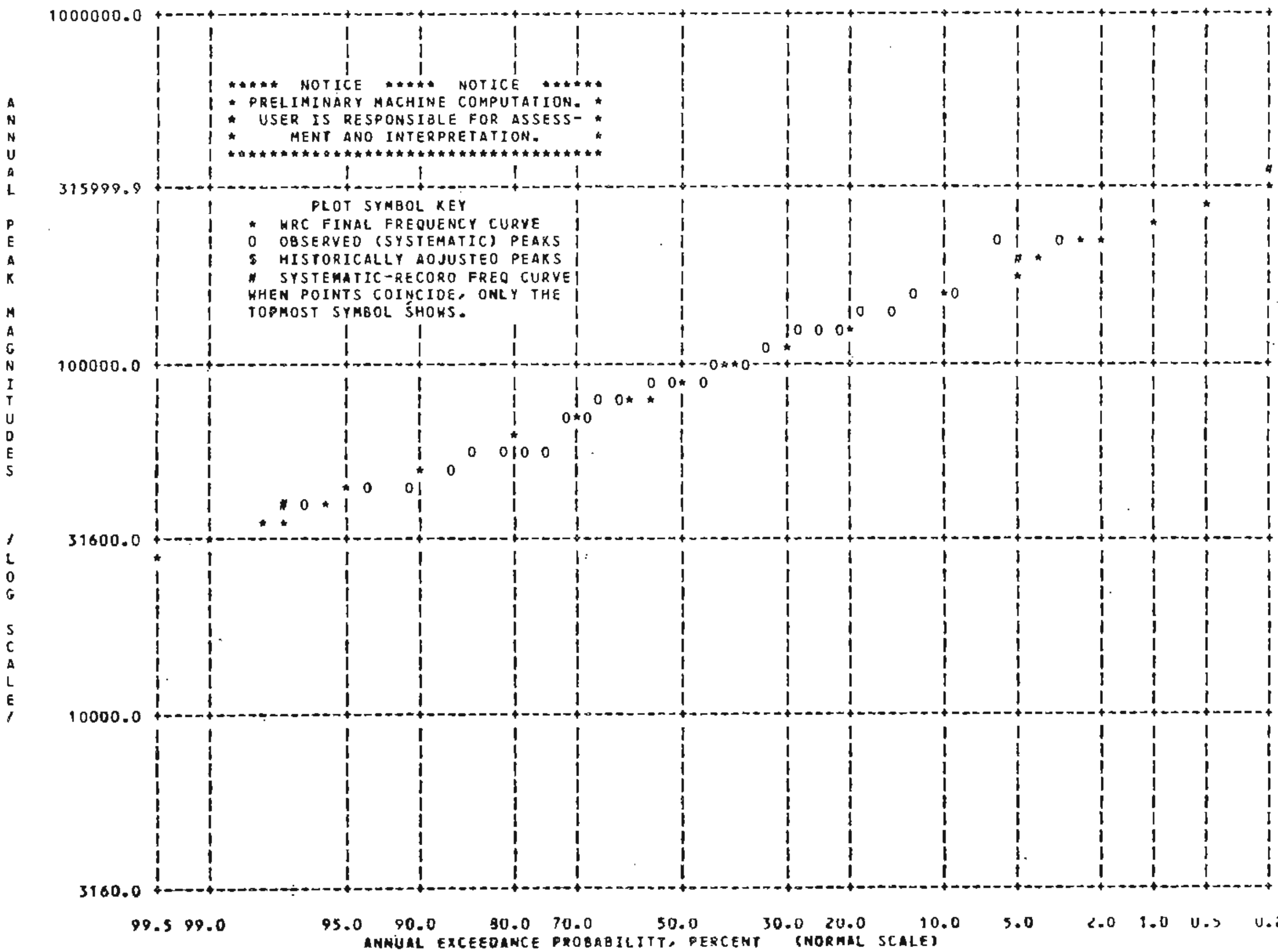
Source: U. S. Geological Survey <54>

Figure 3-3

PGM J407 VER 3.7
(REV 11/5/81)

ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.
RUN-DATE 4/23/86 AT 1558 SEQ 1.0001

STATION - 07341500 /USGS RED RIVER AT FULTON, ARK. 1950-1980 07341500 /USGS



SOURCE : U.S. GEOLOGICAL SURVEY

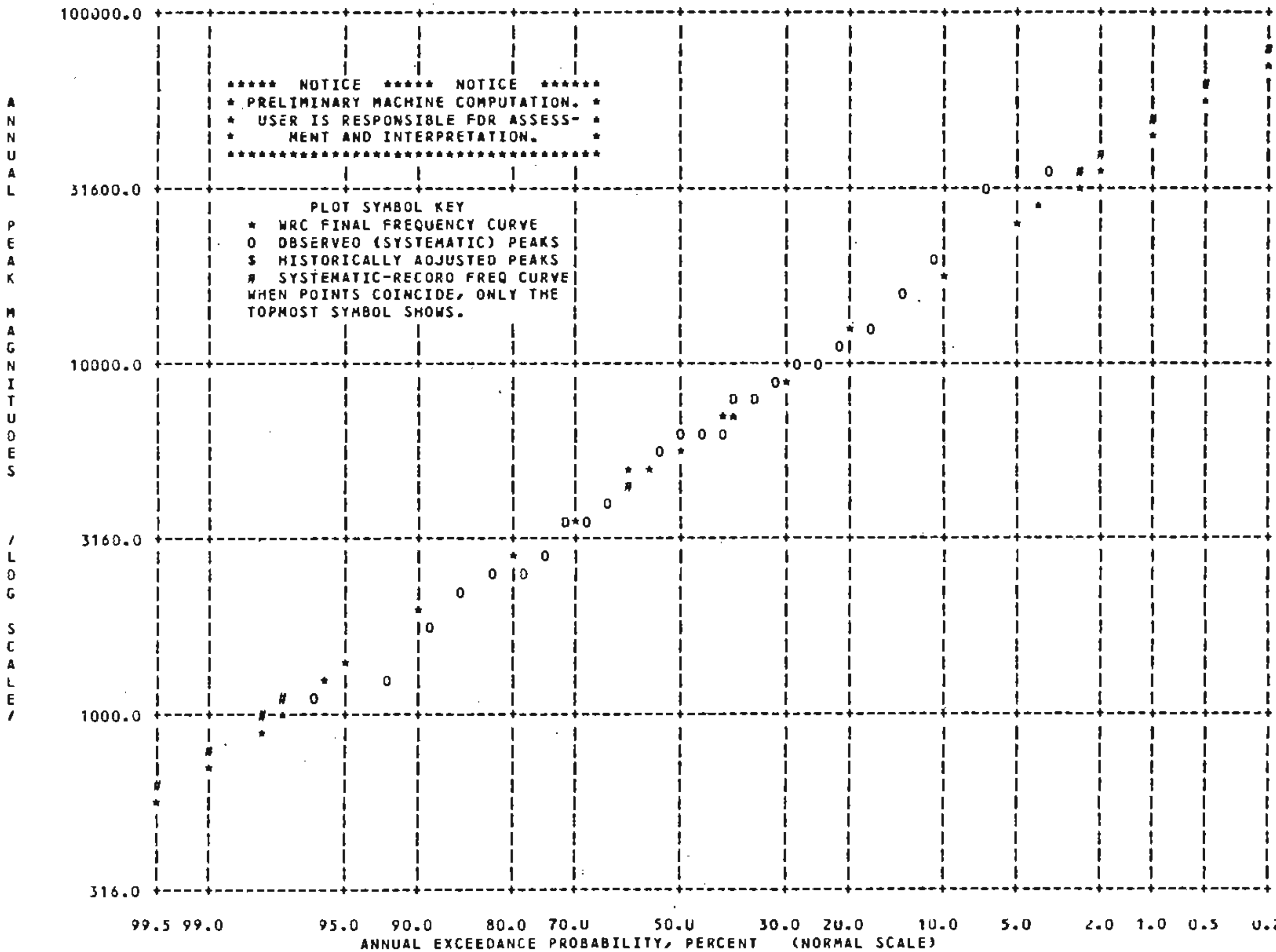
Figure 3-4

PGM J407 VER 3.7
(REV 11/5/81)

ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

RUN-DATE 4/23/86 AT 1558 SEQ 1.0003

STATION - 07348700 /USGS BYU DORCHEAT NR SPRINGHILL, LA 1958-1984 07348700 /USGS



SOURCE : U.S. GEOLOGICAL SURVEY

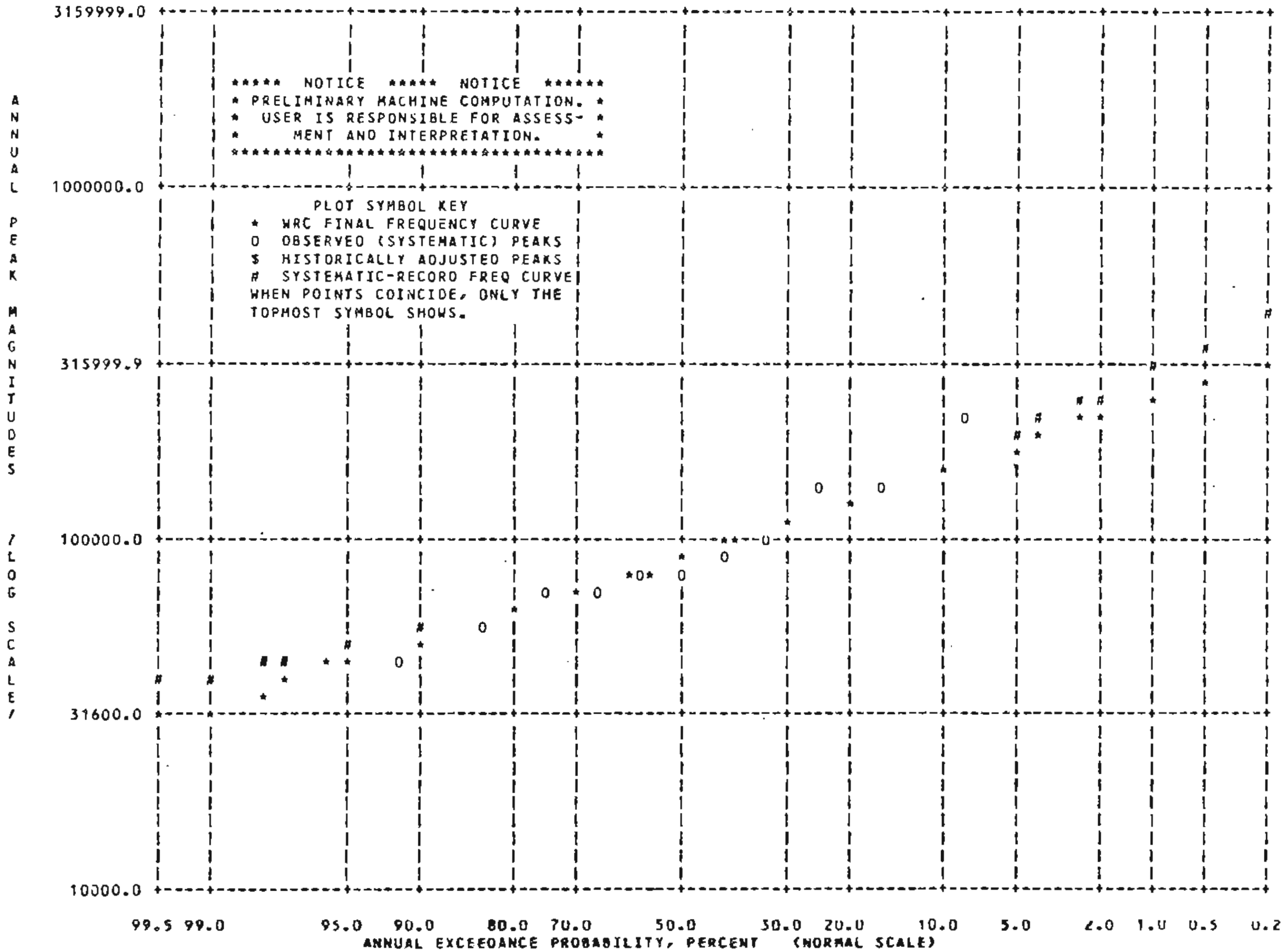
Figure 3-5

PGM J407 VER 3.7
(REV 11/5/81)

ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

RUN-DATE 4/23/86 AT 1558 SEQ 1.0002

STATION - 07344400 /USGS RED RIVER NEAR HOSSTON, LA. 1958-1984 07344400 /USGS



SOURCE : U.S. GEOLOGICAL SURVEY

TABLE 3-4: SUMMARY OF LOW FLOW CHARACTERISTICS FOR SELECTED STREAMS

Name	Period of Record used	$7Q_2$ (CFS)2/	$7Q_2/Mi^2$ (CFSM)3/	$7Q_{10}$ (CFS)2/	$7Q_{10}/Mi^2$ (CFSM)3/
Red River at Fulton, AR 1/	1946-1981	2,393	0.052	1,110	0.024
Red River near Hosston, LA 1/	1958-1968	3,130	0.061	1,650	0.032
Bayou Dorcheat near Springhill, LA	1958-1984	2.4	0.004	0.8	0.001
Kelley Bayou near Hosston, LA	1945-1968	3.01	0.026	1.39	0.012
Sulphur River near Texarkana, TX 1/	1939, 1945-1984	-	-	6.0	0.002

1/ Low-flow characteristics are applicable only as long as the existing pattern of regulation and/or diversion exists.

2/ CFS - Cubic feet per second.

3/ CFSM - Cubic feet per second per square mile of drainage area.

Source: U. S. Geological Survey and Lee <54><68>

The $7Q_2$ and $7Q_{10}$ values were determined using U. S. Geological Survey streamflow data and the Log Pearson Type III probability distribution program. <62> The program mathematically fits a frequency curve to the discharge data and $7Q_2$ and $7Q_{10}$ values are 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. Also, extrapolation of the $7Q_2$ and $7Q_{10}$ indices in Table 3-4 to other reaches on the streams or to other streams in the basin without knowledge of the basin characteristics and without knowledge of the effects of man-made practices can produce erroneous results.

Low flow characteristics of basin streams may be affected by such conditions as frequent irrigation diversions, municipal or industrial effluent discharged into the streams, heavy pumping of ground water near the streams <62> or stream channel work such as dredging. The only stream appreciably affected in the basin is the Red River which periodically undergoes bank stabilization, revetment and stream training.

Since seasonal and annual variability of streamflow affect the dependability of water available for development, flow duration curves were developed to analyze the variability of streamflow in the Red River Basin below Fulton. The flow duration curve is a cumulative frequency curve of daily mean flows that shows the percent of time which specified discharges were equaled or exceeded. The method outlined by Searcy <61> was used to develop the flow duration curves and selected points from the curves are summarized in Table 3-5. Figures 3-6 and 3-7 show the flow duration curves of the Red River at Fulton and Sulphur River south of Texarkana from which values shown in Table 3-5 were obtained.

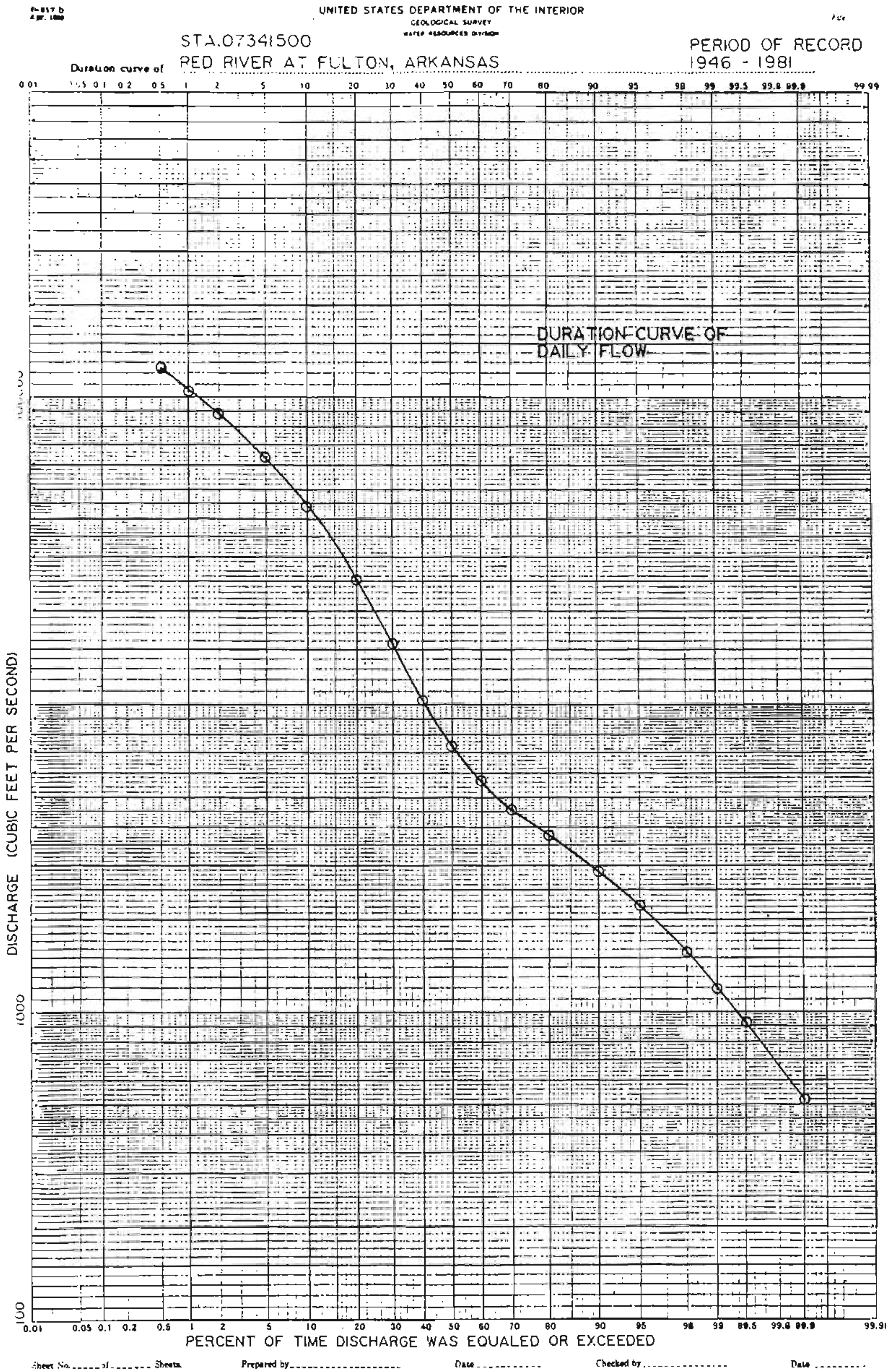
TABLE 3-5: FLOW DURATION OF STREAMS AT SELECTED CONTINUOUS - RECORD GAGING STATIONS

Station Number and Name	Drainage Area (sq. mi.)	Records Use (wtr. yrs.)	Flow in Cubic Feet Per Second, Which Was Equaled or Exceeded For Percentage of Time Indicated																	
			99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	0.5
07341500 - Red River near Fulton, AR	52,336 (5,936 is non-contributing)	1946-1981	510	920	1190	1550	2200	2860	3720	4560	5680	7380	10,200	15,700	25,300	44,000	63,500	88,000	105,000	126,000
07344400 - Red River near Hosston, LA	57,041 (5,936 is non-contributing)	1958-1968	975	1200	1430	1880	2900	3750	4900	6250	8100	10,700	14,300	18,900	26,300	41,000	58,000	81,500	103,000	124,000
07344210-Sulphur River near Texarkana, TX	3443	1958-1977	NV	NV	NV	NV	NV	NV	62	175	490	1050	1950	3400	7500	NV	NV	NV	NV	NV
07347000 -Kelly Bayou near Hosston, LA	166	1945-1968	1.1	1.4	1.6	1.8	2.5	3.3	5.0	7.7	14	21	37	65	110	235	430	800	1110	1420
07348700 -Bayou Dorcheat near Springhill, LA	605	1958-1984	0.42	0.95	1.2	1.5	2	3.2	12	28	60	113	212	410	770	1500	2330	3730	5350	7550
07349430 - Bodcau Creek at Stamps, AR	236	1959-1970	0	0	0	0	0.2	0.6	3	9.5	23	45	90	190	370	635	815	1370	2480	3700

NV - No Value Determined Due to Insufficient Flow Data in This Percentage Range.

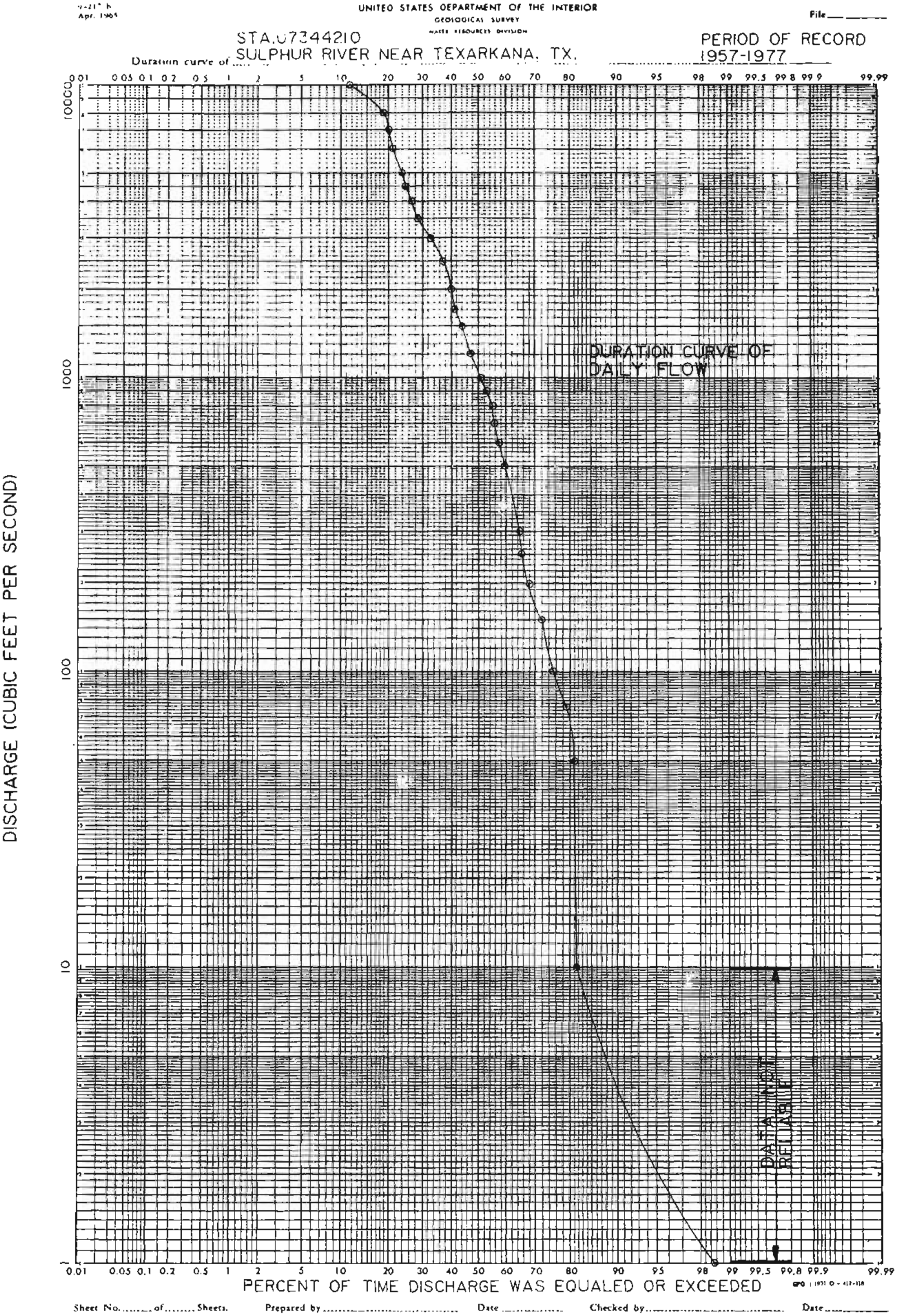
Source: U. S. Geological Survey

Figure 3-6



SOURCE : U.S. GEOLOGICAL SURVEY STREAMFLOW RECORDS <54,61>

Figure 3-7



SOURCE : U.S. GEOLOGICAL SURVEY STREAMFLOW RECORDS <54,61>

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 system". <46> Section 2 of Act 1051 of 1985 (see Legal and Institutional Setting) requires the Arkansas Soil and Water Conservation Commission (AS&WCC) to determine instream flow requirements of (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 (riparian uses).

Only those streams with a $7Q_{10}$ discharge greater than 1.0 cfs are addressed in this section of the report. Using this criterion, the two streams investigated in the Red River Basin below Fulton are the Red River and the Sulphur River.

According to the perennial streams map of Arkansas <56>, Days Creek has a $7Q_{10}$ low flow of 1 to 10 cfs. However, the $7Q_{10}$ low flow could not be substantiated from gaging station or other measured data; therefore, instream flow requirements for Days Creek were not developed.

Also, the $7Q_{10}$ discharge of 1.39 cfs for Kelly Bayou computed at the Hosston, Louisana stream gaging station was not extrapolated to the Arkansas reach since extrapolation of the $7Q_{10}$ indices could produce erroneous results.

1. Water Quality Requirements

One of the most important factors influencing the concentration of dissolved solids in streamflow is the volume of water available for dilution. The $7Q_{10}$ low flow characteristic is the criterion used by the Arkansas Department of Pollution Control and Ecology (ADPC&E) in determining the permissible rate of waste disposal into a given stream. The Department manages water quality conditions in streams when flow meets or exceeds the $7Q_{10}$ discharge. The ADPC&E also monitors point-source discharges in streams when the flow is less than the $7Q_{10}$ discharge and requires concentrations of certain pollutants to be maintained below critical levels. Sufficient water is not available at times during the year to dilute the effluent discharges; therefore, streamflow water quality may not meet the quality standards during all times of the year. Regulated streams are addressed on a case-by-case basis to determine instream flow requirements for water quality.

The $7Q_{10}$ discharges were determined at gaging station locations on the two major streams addressed in the Red River Basin below Fulton. The discharges required to meet water quality standards at gaging station locations are:

Red River at Fulton, AR	1,110 cfs
Red River at Hosston, LA	1,650 cfs
Sulphur River at Hwy. 59, South of Texarkana, TX	6 cfs

2. Fish and Wildlife Requirements

Several methods are presently available for determining instream flow requirements for fisheries. Some of these methods require considerable field work to characterize fish habitats. However, Tennant <63> developed a method (sometimes referred to as the "Montana method") which utilizes historic hydrologic records to estimate instream flow requirements for fish and other aquatic life. Results of Tennant's extensive study showed that: (1) 10% of the average annual streamflow is the minimum flow required for short-term survival of most aquatic life forms, (2) 30% of average annual streamflow is required to sustain a good survival habitat, and (3) 60% of the average annual streamflow will provide excellent to outstanding habitat for most aquatic life forms. Tennant also suggested dividing the water year into two seasons and applying appropriate discharge percentages to account for seasonal variability in flow.

Filipek and others <22> 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 required for maintenance of fisheries during each season are described in Table 3-6. The instream flow requirements, as determined by the Arkansas method, are those that apply to fish populations only. 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 streamflow data from the U. S. Geological Survey gaging stations in the Red River Basin below Fulton. Instream flow requirements for fisheries were first determined at the Fulton, Arkansas, gaging station location on the Red River with the results compiled in Table 3-7.

Where instream flow requirements were needed at other ungaged locations on the stream and additional information about the basin was unavailable, the following procedure was used. Mean monthly flows from the gaging station closest to, or most representative of, the point in interest were adjusted based on a ratio of the drainage areas. The Arkansas method was then applied to these estimated mean monthly flows to determine the instream flow requirements at the point in question. This method allows a determination of mean monthly discharges and instream flow requirements at other points of interest. Results of this procedure used to determine the instream flow requirements for the Red River at the AR/LA state line are shown in Table 3-8 and for the Sulphur River at the AR/TX state line in Table 3-9.

Comparison of the instream flow requirements as determined by the Arkansas method with those determined by the Montana method indicates that the flow requirements using the Arkansas method would provide excellent to outstanding habitat for most aquatic life forms. To protect stream fisheries and to satisify water needs for fish and wildlife in the Red River Basin below Fulton, the instream flow requirements as determined by the Arkansas method represents an amount of water that is unavailable for interbasin transfer.

Table 3-6: DESCRIPTION OF PHYSICAL/BIOLOGICAL SEASONS IN THE ARKANSAS METHOD OF INSTREAM FLOW QUANTIFICATION

TIME OF YEAR	NOVEMBER THRU MARCH	APRIL THRU JUNE	JULY THRU OCTOBER
FLOW REQUIRED	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. SPAWNING 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 EGG 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: ARKANSAS GAME AND FISH COMMISSION, FILIPEK AND OTHERS, 1985 <22>

TABLE 3-7: MEAN MONTHLY DISCHARGE AND MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR THE RED RIVER AT FULTON, AR ARKANSAS METHOD

STATION NUMBER: 07341500 PERIOD OF RECORD: 1946-1981

Month	Mean Monthly Discharge (CFS)	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	9,837	50	4,919
November	13,310	60	7,986
December	15,410	60	9,246
January	15,060	60	9,036
February	21,260	60	12,756
March	20,990	60	12,594
April	23,660	70	16,562
May	33,390	70	23,373
June	23,510	70	16,457
July	9,462	50	4,731
August	6,239	50	3,120
September	7,844	50	3,922

TABLE 3-8: ESTIMATED MEAN MONTHLY DISCHARGE AND FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS
RED RIVER AT HOSSTON, LA, ADJUSTED TO THE AR/LA STATE LINE
ARKANSAS METHOD

Month	Mean Monthly Discharge Red River Near Hosston, LA (CFS)	Mean Monthly Discharge Adjusted to State Line (CFS) 1/	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	11,200	11,173	50	5,587
November	13,850	13,817	60	8,290
December	17,840	17,798	60	10,679
January	18,630	18,586	60	11,152
February	20,310	20,262	60	12,157
March	23,500	23,444	60	14,066
April	25,740	25,679	70	17,975
May	37,710	37,621	70	26,335
June	19,100	19,055	70	13,339
July	14,120 2/	14,087	50	7,043
August	7,417	7,399	50	3,700
September	7,616	7,598	50	3,799

1/ Applied drainage area ratio at Hosston, LA and AR/LA state line of 50,984/51,105 to Hosston, LA discharges.

2/ Used median flow of 14,120 CFS in place of mean monthly flow of 12,190 cfs.

TABLE 3-9: ESTIMATED MEAN MONTHLY DISCHARGE AND FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR THE SULPHUR RIVER SOUTH OF TEXARKANA, TX, ADJUSTED TO THE AR/TX STATE LINE ARKANSAS METHOD

Month	Mean Monthly Discharge Sulphur River Near Texarkana, TX (CFS)	Mean Monthly Discharge Adjusted to State Line (CFS) 1/	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	1,846	1,827	50	914
November	2,609	2,582	60	1,549
December	3,487	3,451	60	2,071
January	3,453	3,417	60	2,050
February	3,727	3,688	60	2,213
March	3,783	3,744	60	2,246
April	3,286	3,252	70	2,276
May	4,152	4,109	70	2,876
June	3,962	3,921	70	2,745
July	2,799	2,770	50	1,385
August	777	769	50	385
September	792	784	50	392

1/ Applied area ratio at gaging station and AR/TX State Line of 3443/3479 to station discharge values.

3. Navigation Requirements

The general rule for determination of navigability of a watercourse is that "any watercourse is navigable which the federal government so declares or that can be so found as a matter of fact". <15> When water-related activities affect interstate commerce, Congress can exercise control over these activities through the commerce clause of the U. S. Constitution which authorizes Congress to preempt the state's right to regulate that area. The navigability for purposes of federal control, depends upon, among other things, the volume of water, the regularity of the flow and the availability for navigation. <15>

The Red River and the Sulphur River are the navigable streams of the Red River Basin below Fulton with basin navigable lengths of 71 miles and 26 miles, respectively. <15> At present, minimum flow requirements for navigation have not been established on either river by the U.S. Corps of Engineers. Section 5.05 of the Red River Compact allocates the Red River water from Fulton, Arkansas to the AR/LA state line, but does not specifically provide for a minimum flow for navigation. (See Section 5.05 (d)) <25>

Installation of improved channel and other navigation features are required on the Red River in Arkansas before navigation is practical. Congress authorized a Red River Waterway Project in 1968 which includes the construction of certain navigation features; however, no navigation features are presently authorized for construction on the Red River in Arkansas.

The discharge normally available to support navigation in the Red River at the Fulton, Arkansas streamflow gage is indicated by the mean daily discharge hydrograph shown on Figure 3-8.

Navigation is not considered practical on the Sulphur River and construction of navigation features have not been authorized or planned for the river in Arkansas by the Corps of Engineers. Examination of the hydrograph of daily discharge for 1983 (not included in this report) shows that very low flows can be expected throughout the year in the Sulphur River near Texarkana, Arkansas.

4. Interstate Compact Requirements

Authorized by Act of Congress, Public Law No. 346 (84th Congress, First Session), the consent of the United States was granted for Arkansas, Louisiana, Oklahoma, and Texas to negotiate and enter into a compact providing for an equitable apportionment of water of the Red River. Known as the Red River Compact, its initial purpose was the allocation of the waters in the Red River and its tributaries among the four states. It required 22 years of negotiations for the states to reach agreement. One of the missions of the Red River Commission was to make the Red River navigable as far north as the community of Index, Arkansas near Texarkana.

The Red River reach from Fulton to the AR/LA boundary line is a segment of the reach from Denison Dam to the AR/LA state boundary designated by the Compact as Reach II and includes all tributaries which contribute to the flow of the Red River within this reach. Reach II is one of 5 reaches defining the Red River from the New Mexico/Texas state boundary to the mouth. See Figure 3-9 for delineation of Reaches I-V.

Figure 3-8

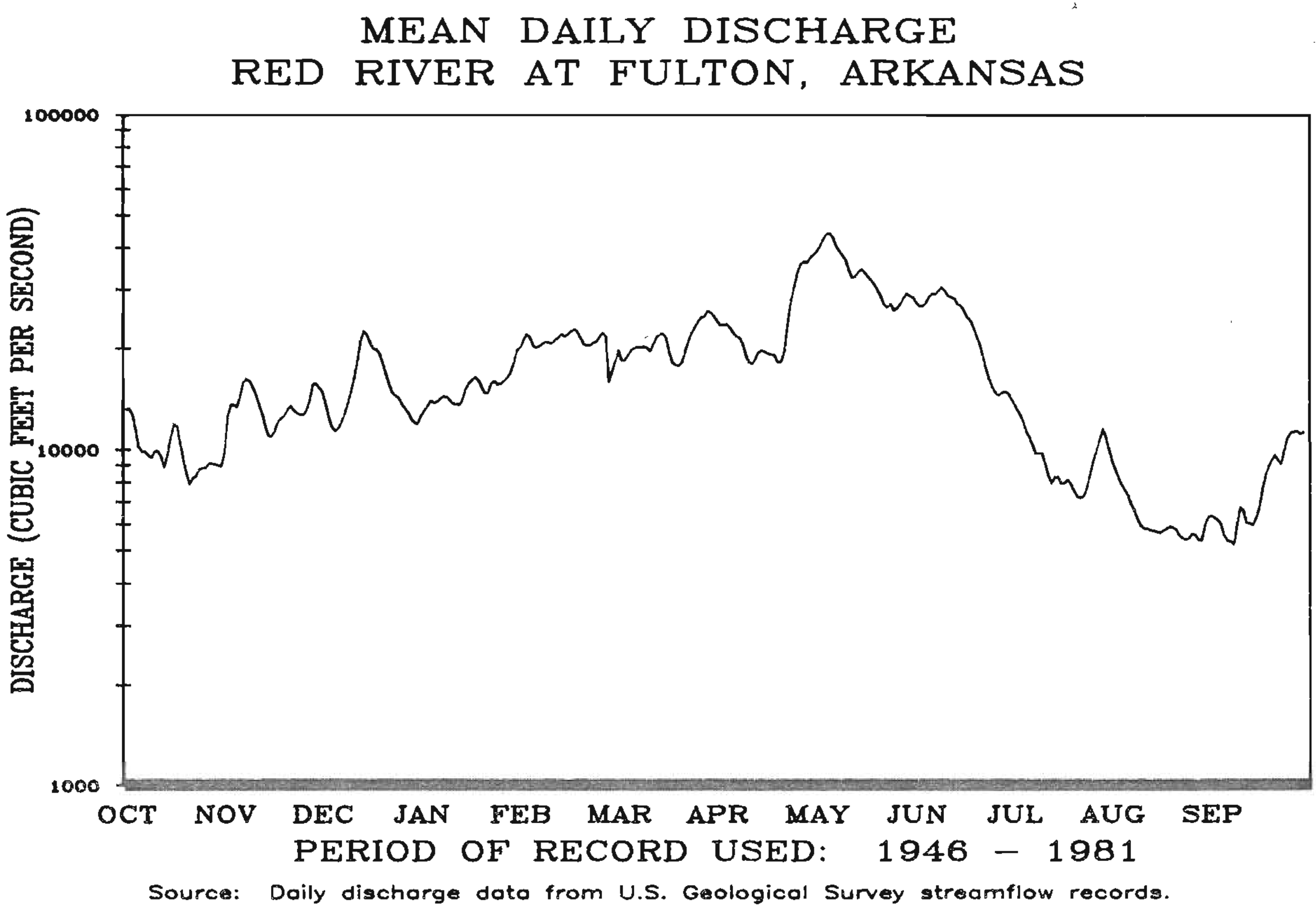
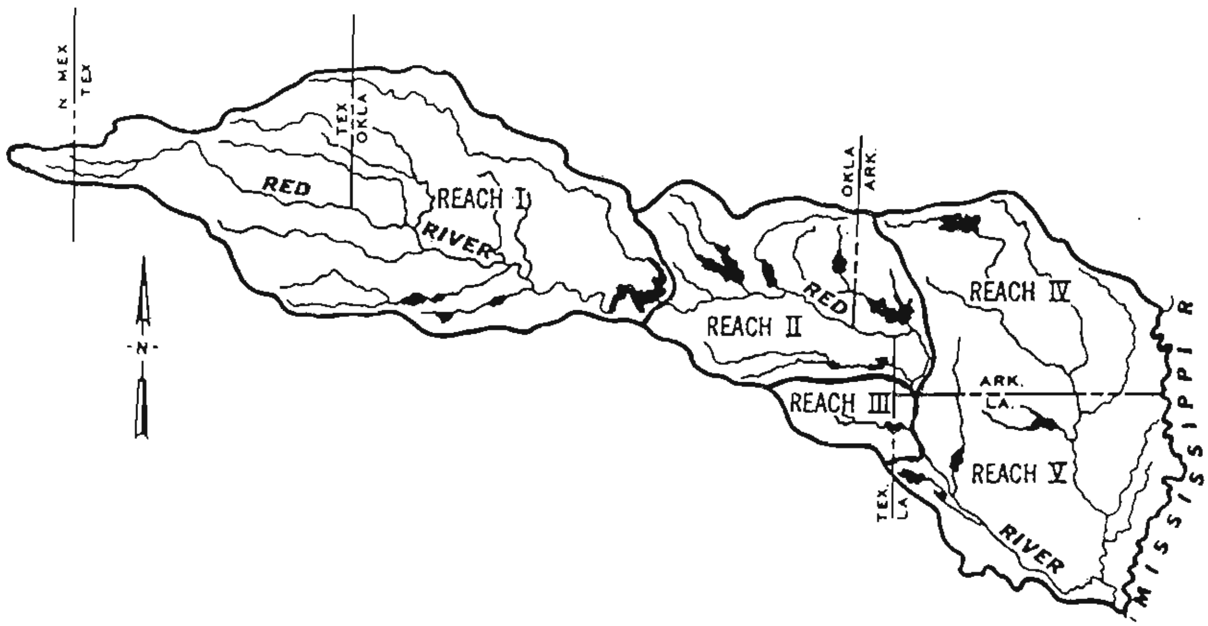
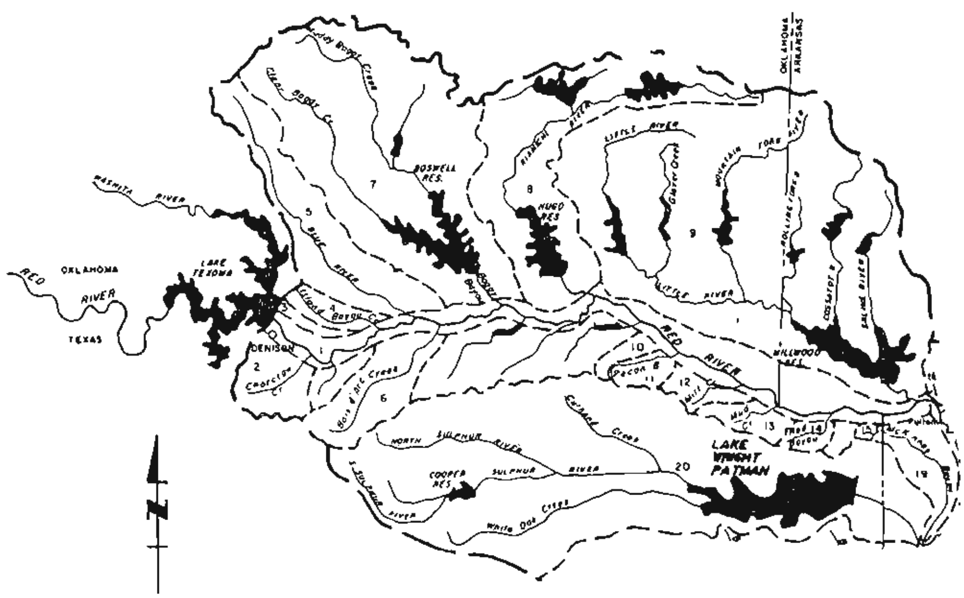

MEAN DAILY DISCHARGE
RED RIVER AT FULTON, ARKANSAS
100000
10000
1000
DISCHARGE (CUBIC FEET PER SECOND)
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
PERIOD OF RECORD USED: 1946 – 1981
Source: Daily discharge data from U.S. Geological Survey streamflow records.

Figure 3 - 9

RED RIVER BASIN COMPACT AREA



REACHES I - V



REACH II

According to Article I of the 1984 Red River Compact, one principal purpose of the compact is to promote interstate comity and remove causes of controversy between each of the affected states by governing the use, control, and distribution of the interstate water of the Red River and its tributaries. <25> According to Article II, Section 2.01 of the Compact, each affected state may use the water allocated to it by this Compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to the availability of water in accordance with the apportionments made by this Compact. <25>

The apportionment of waters of the Red River water within Reach II is set forth in Article V of the Compact. The following information is from Sections of the Red River Compact that pertain to the Red River Basin below Fulton area.

Article V

Apportionment of water - Reach II

Arkansas, Oklahoma, Texas, and Louisiana subdivision of Reach II and allocation of water therein.

Reach II of the Red River is divided into topographic subbasins, and the water therein is allocated as follows:

SECTION 5.04. Subbasin 4 - Interstate streams - Texas and Arkansas.

(a) This subbasin shall consist of those streams and their tributaries above existing, authorized or proposed last downstream major damsites, originating in Texas and crossing the Texas-Arkansas state boundary before flowing into the Red River in Arkansas. These streams and their tributaries with existing, authorized or proposed last downstream major damsites are as follows:

Stream	Site	Ac-ft	Location	
			Latitude	Longitude
McKinney Bayou Trib.	Bringle Lake	3,052	33°30.6'N	94°06.2'W
Barkman Creek	Barkman Reservoir	15,900	33°29.7'N	94°10.3'W
Sulphur River	Texarkana	386,900	33°18.3'N	94°09.6'W

(b) The State of Texas shall have the free and unrestricted use of the water of this subbasin.

SECTION 5.05. Subbasin 5 - Mainstem of the Red River and tributaries.

(a) This subbasin includes that portion of the Red River, together with its tributaries, from Denison Dam down to the Arkansas-Louisiana state boundary, excluding all tributaries included in the other four subbasins of Reach II.

(b) Water within this subbasin is allocated as follows:

(1) The Signatory States shall have equal rights to the use of runoff originating in subbasin 5 and undesignated water flowing into subbasin 5, so long as the flow of the Red River at the Arkansas-Louisiana state boundary is 3,000 cubic feet per second or more, provided no state is entitled to more than 25 percent of the water in excess of 3,000 cubic feet per second.

(2) Whenever the flow of the Red River at the Arkansas-Louisiana state boundary is less than 3,000 cubic feet per second, but more than 1,000 cubic feet per second, the States of Arkansas, Oklahoma, and Texas shall allow to flow into the Red River for delivery to the State of Louisiana a quantity of water equal to 40 percent of the total weekly runoff originating in subbasin 5 and 40 percent of undesignated water flowing into subbasin 5; provided, however, that this requirement shall not be interpreted to require any state to release stored water.

(3) Whenever the flow of the Red River at the Arkansas-Louisiana state boundary falls below 1,000 cubic feet per second, the States of Arkansas, Oklahoma, and Texas shall allow a quantity of water equal to all the weekly runoff originating in subbasin 5 and all undesignated water flowing into subbasin 5 within their respective states to flow into the Red River as required to maintain a 1,000 cubic foot per second flow at the Arkansas-Louisiana state boundary.

(c) Whenever the flow at Index, Arkansas, is less than 526 c.f.s., the states of Oklahoma and Texas shall each allow a quantity of water equal to 40 percent of the total weekly runoff originating in subbasin 5 within their respective states to flow into the Red River. Provided, however, this provision shall be invoked only at the request of Arkansas, only after Arkansas has ceased all diversions from the Red River itself in Arkansas above Index, and only if the provisions of Sub-sections 5.05 (b) (2) and (3) have not caused a limitation of diversions in subbasin 5.

(d) No state guarantees to maintain a minimum low flow to a downstream state.

SECTION 5.06. Special Provisions.

(a) Reservoirs within the limits of Reach II, subbasin 5, with a conservation storage capacity of 1,000 acre feet or less in existence or authorized on the date of the Compact pursuant to the rights and privileges granted by a Signatory State authorizing such reservoirs, shall be exempt from the provisions of Section 5.05; provided, if any right to store water in, or use water from, an existing exempt reservoir expires or is cancelled after the effective date of the Compact the exemption for such rights provided by this section shall be lost.

(b) A Signatory State may authorize a change in the purpose or place of use of water from a reservoir exempted by subparagraph (a) of this section without losing that exemption, if the quantity of authorized use and storage is not increased.

(c) Additionally, exemptions from the provisions of Section 5.05 shall not apply to direct diversions from Red River to off-channel reservoirs or lands.

5. Aquifer Recharge Requirements

Recharge to the major aquifers in the Red River Basin below Fulton is primarily from precipitation and percolation in the outcrop area. High streamflows during the spring may also contribute to aquifer storage through lateral movement of flow from the streams to the aquifers. Conversely, when stream levels are lowest during the fall, the aquifers may discharge water to the streams for several months.

Basin instream flow requirements necessary to recharge aquifer depletions were not investigated for this report. Other surface water requirements, such as minimum stream flows, and other computations, such as excess surface water available for interbasin transfer, were determined independent of aquifer recharge requirements.

6. Riparian Use Requirements

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) requires the Arkansas Soil and Water Conservation Commission to determine surface water needs of public water supplies, industry, and agriculture. In 1984, reported surface water use for irrigation, industry, and public water supply totalled approximately 47,144 acre-feet of water in the Red River Basin below Fulton as determined from Arkansas Soil and Water Conservation Commission's records of registered diversions. The total 47,144 acre-feet of water diverted was used for irrigation. This figure represents current irrigation riparian needs in the Basin.

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 irrigation 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 irrigation, industry, and public water supplies.

7. Aesthetic Requirements

According to the Arkansas National Heritage Commission, nine species of state concern occur in the Red River Basin below Fulton. They are:

Ammocrypta clara 1/	western sand darter
Anodonta suborbiculata	flat floater
Etheostoma parvipinne	goldstripe darter
Nerodia cyclopion cyclopion	green water snake
Notropis bairdi	Red River shiner
Notropis atrocaudalis	blackspot shiner
Notropis maculatus	taillight shiner
Noturus phaeus	brown madtom
Sternotherus carinatus	razorback musk turtle

1/ Potential candidate for listing by the U.S. Fish and Wildlife Service as threatened or endangered.

The western sand darter, Red River shiner, brown madtom, and flat floater (a mussel) are very rare in the basin, each being represented by only a single occurrence.

It is likely that these, as well as other aquatic species, would be adversely affected if basin stream flows are reduced to a point that natural biological and physical processes are disrupted. However, agricultural and non-agriculture development in the basin should be managed so that the detrimental affects on the aquatic and terrestrial biota is minimized.

Minimum Streamflow

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) 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 during low flow conditions which may occur naturally or during periods of significant use 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.

With the exception of fish and wildlife requirements, minimum streamflows for streams in the Red River Basin below Fulton were determined based upon the instream flow requirements described in the Instream Flow Requirements section of this report. The minimum instream flow requirements for fish and wildlife were determined according to the method developed by the ASWCC.

In developing their method, the ASWCC divided the year into the three seasons identified in the Arkansas method <22> to account for the seasonal variability of stream flow. The seasons are based on physical processes that occur in the stream and the critical life stages of the fish and other aquatic organisms inhabiting the stream. The minimum instream flow requirements for fish and wildlife were determined by taking 10 percent of the average seasonal flows. In addition to requirements for fish and wildlife, instream flow requirements were considered for all other identified needs. 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. Minimum streamflows were established at gaging station locations and at other selected sites and are presented in Table 3-10. It should be noted that the instream flows required to satisfy the interstate compact were not quantified in this report although, at times, these flows may govern. Instream flow requirements for the interstate compact, computed according to the compact formulas, may vary considerably with changing streamflow, runoff conditions, withdrawal of water in states upstream of Arkansas, and water rights of Louisiana.

Figure 3-10 portrays graphically the fish and wildlife requirements compared to stream discharges of the Red River at Fulton. This figure shows the fish and wildlife requirements as determined by the Arkansas method and the method recommended by ASWCC. Also, the maximum, median, and minimum daily discharges for the Red River at Fulton for the period of record (1946-1981) are shown for comparison.

TABLE 3-10: MINIMUM STREAMFLOWS IN THE RED RIVER BASIN BELOW FULTON 1/
(by season)

Location	Period of Record	November-March (CFS)	April-June (CFS)	July-October (CFS)
Red River at Fulton, AR	1946-1981	1,721	2,685	1,110 2/
Red River at at Hosston, LA	1958-1968	1,883	2,752	1,650 2/
Red River at AR/LA Line 3/	1958-1968	1,878	2,745	1,006
Sulphur River at Texarkana, TX	1957-1984	341	380	155
Sulphur River at AR/LA Line 3/	1957-1984	338	376	154

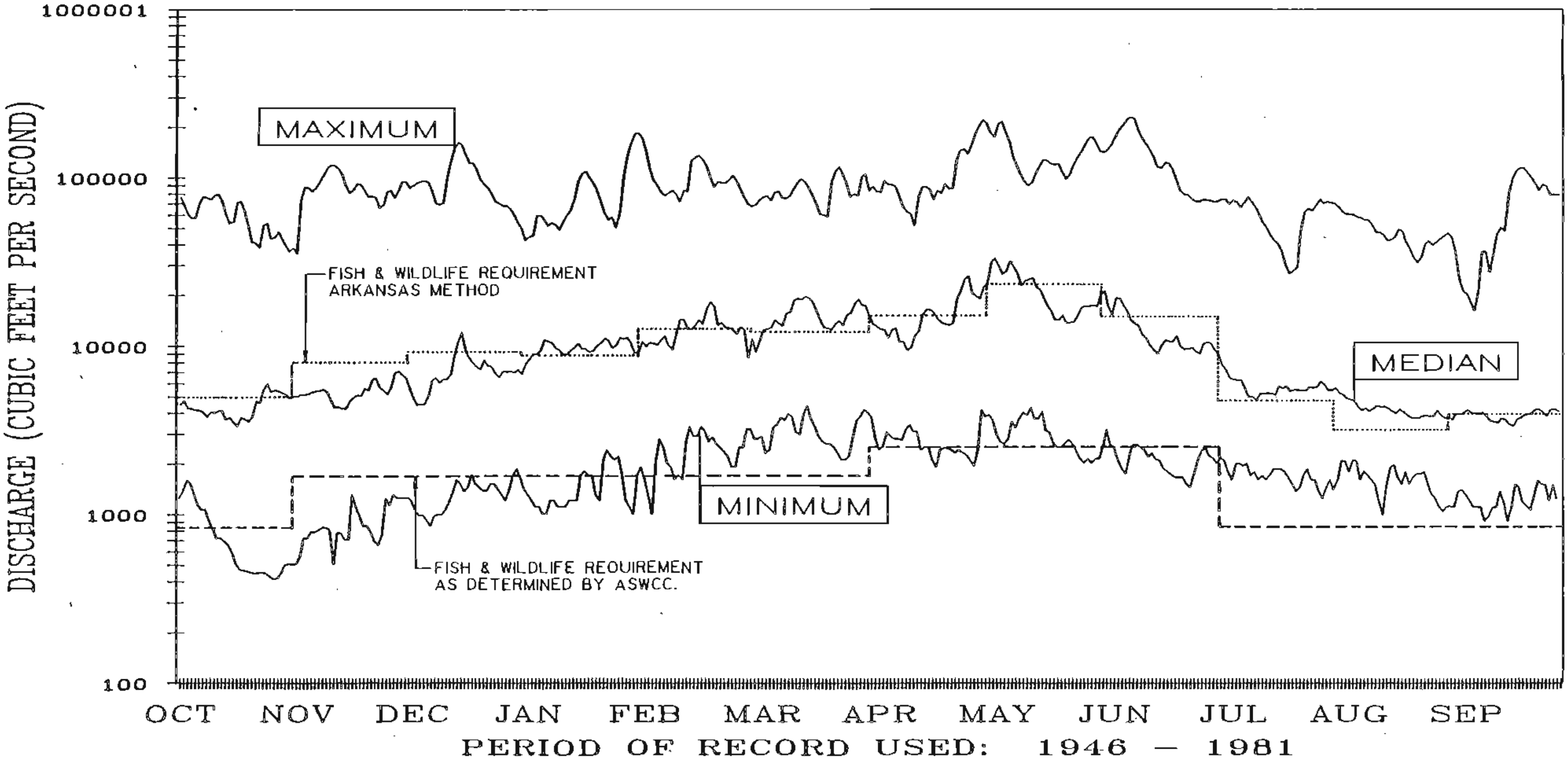
1/ Fish and wildlife is the governing instream requirement unless otherwise noted.

2/ Water quality is the governing instream requirement.

3/ Water quality value was not available for this location.

Figure 3-10

DAILY DISCHARGE VALUES
RED RIVER AT FULTON, ARKANSAS



Source: Daily discharge data from U.S. Geological Survey streamflow records.

Safe Yield

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) 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, or potentially available, on a dependable basis which could be used as a surface water supply.

To quantify the safe yield of streams in the basin, the amount of water available on a dependable basis was 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 on a dependable basis; however, not all of this flow is actually available for use. Minimum streamflows, which have been established for streams and rivers in Red River Basin below Fulton and previously determined in this report, represent discharge that is not available for use. Therefore, the safe yield of a stream or river is 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 period (July - October). See Table 3-5 for flow values which were equaled or exceeded 95 percent of the time.

Table 3-11 shows the safe yield of the Red River at both the Fulton, Arkansas and Hosston, Louisiana stream gaging stations. Minimum streamflow values are streamflow governing values that are taken from instream flow requirements such as water quality, fish and wildlife, or interstate compacts. Not shown in Table 3-11 is a flow of 0.2 cfs which occurred in Bodcau Creek at Stamps, Arkansas 95 percent or more of the time.

Also, flow duration was not shown for the Sulphur River due to limited stream gaging data available.

TABLE 3-11: SAFE YIELD

Stream	Flow Which Was Equaled or Exceeded 95 percent of the time (CFS)	Minimum Streamflow July-October (CFS)	Safe Yield (CFS)
Red River at Fulton, Arkansas	2,200	1,110	1,090
Red River at Hosston, Louisiana	2,900	1,650	1,250

Potential For Development

Safe yield has been addressed by considering existing streamflow conditions, however, the potential for development must be considered to get an accurate portrayal of the water yielding capabilities of the basin. Water supply development, within a given basin, is the construction of reservoirs with water supply being one of the official purposes. These reservoirs store runoff from rainfall so that water may be supplied to users as it is needed.

Studies have been made by the Soil Conservation Service and other agencies to locate flood control or multi-use impoundments in the basin. At present, six artificial impoundments of 50 or more surface acres are in the basin. The largest is Lake Erling with 7,000 surface acres followed by Bois d' Arc Lake with 705 acres. Other impoundments include Mercer Bayou Lake with a surface area of 325 acres and Lake June with 60 acres.

Construction is nearing completion on the 2,600 acre reservoir which will serve as the M & I water supply for the City of Magnolia. The U.S. Geological Survey has identified one potential reservoir site in the basin where surface water could be used for various purposes or to supplement ground water. The site is located on Bridge Creek one mile upstream from Highway Interstate 30. Maximum storage at this site is 16,300 acre-feet with a drainage area of 29.4 square miles.

To date, the SCS has not completed studies in sufficient detail to determine potential reservoirs. The U.S. Army Corps of Engineers has recommended some stream improvements in the basin, but have not identified impoundment locations or recommended the construction of impoundments in the basin.

Although the basin offers some potential for the development of surface water storage, no other specific activities to develop such resources exist at present. Since there are no immediate plans for surface water development, safe yields will not be appreciably affected by potential impoundment storage.

Water Use

For ease of comparison, water use, water use trends, surface water, and ground water are discussed in this section. Surface water use and ground water use were also combined in developing total water use projections. (See Potential Water Use)

In 1980, a total of 61.3 million gallons per day (mgd) of surface water and ground water was used in the Red River Basin below Fulton. This includes 1.7 mgd of ground water used to produce electricity which is not considered as part of the water use because it essentially is returned to the stream for reuse. <12>

Of the total 61.3 mgd used in the basin, 22.9 mgd or 37.4 percent came from surface water sources. Of the total surface water used, 40.6 percent was used for irrigation and 31 percent was used for wildlife impoundments. The remaining 28.4 percent of surface water was used for public water supplies, self-supplied industries, fish and minnow farms, and for the watering of livestock. See Figure 3-11 and Table 3-12 for water use by category.

About 23.3 mgd or 38 percent of the total 61.3 mgd used in the basin was consumed. This consumed portion was either ingested, incorporated into a product, transpired, or evaporated. <12>

Water Use Trends

The necessity of applying procedural differences to development of some water use data caused water use values for 1980, shown in Table 3-12 and Figure 3-11, to disagree slightly with a few water use trend values shown in Figures 3-12 through 3-15.

With the exception of self-supplied industry and electric energy, water use during the period 1960-1980 increased in every use category. (See Table 3-13 and Figures 3-12 through 3-15) The most significant water use increase during the period was for irrigation which increased nearly 8 times over the 1960 rate of 4.3 mgd. Public supply water use increased 160 percent and rural water use increased 117 percent while self-supplied industry water use declined 7 percent. <7, 9, 10, 11, 12>

TABLE 3-12: USE OF WATER IN THE BASIN, BY CATEGORY - 1980
(MILLION GALLONS PER DAY)

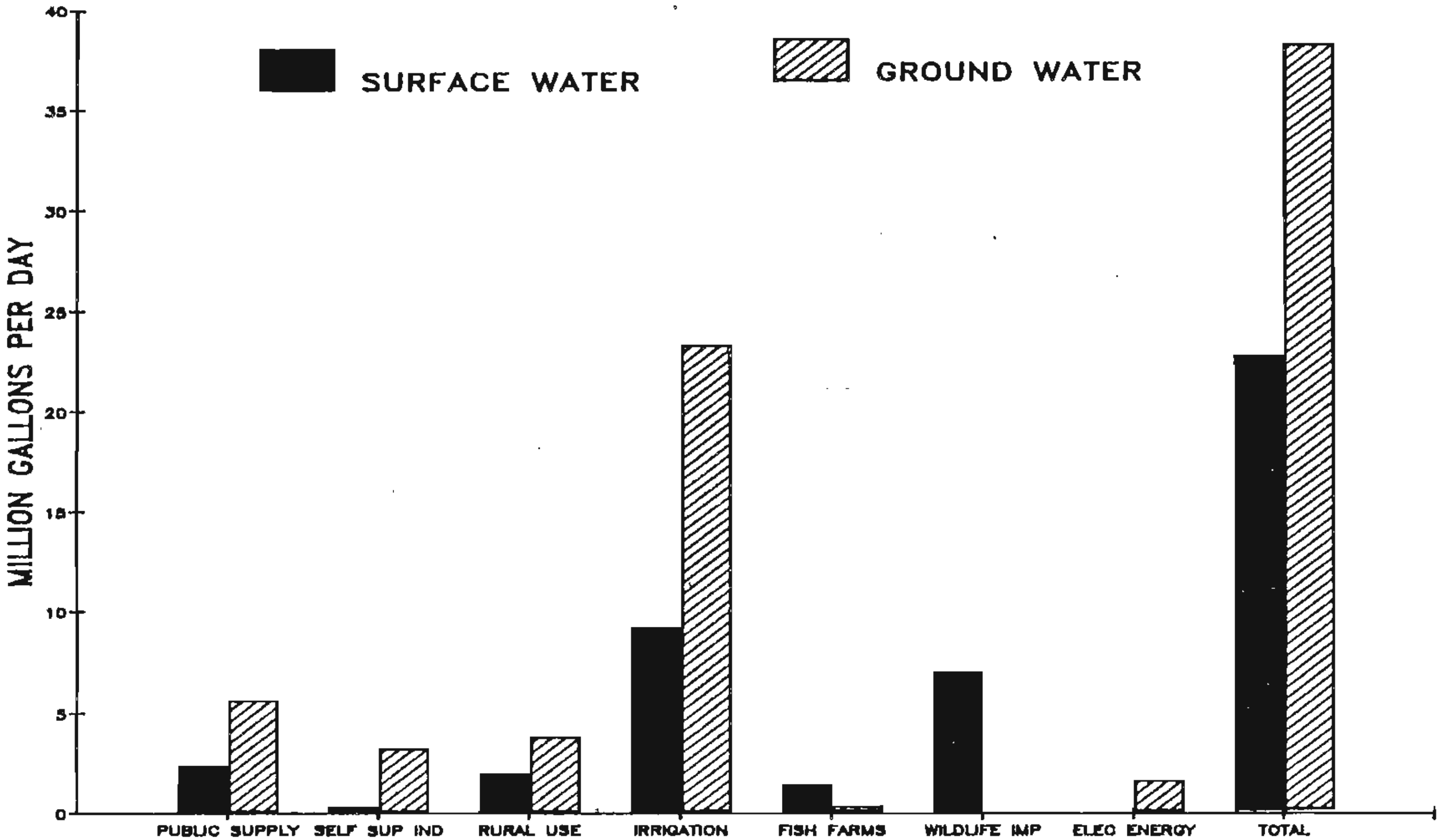
Use Category	Ground Water	Surface Water	Total
Public Supply	5.7	2.5	8.2
Self-Supplied Industry	3.3	0.4	3.7
Rural Use:			
Domestic	2.5	0	2.5
Livestock	1.4	2.1	3.5
Subtotal	3.9	2.1	6.0
Irrigation:			
Rice	18.6	5.2	23.8
Other Crops	4.8	4.1	8.9
Subtotal	23.4	9.3	32.7
Fish Farms	0.4	1.5	1.9
Wildlife Impoundments	0	7.1	7.1
Electric Energy 1/	1.7	0	1.7
Total	38.4	22.9	61.3

1/ This water is used in the cooling and boiler feeding of the AP&L natural gas-fired plant near Stamps, Arkansas. Water source is from six ground water wells in Sparta Sand.

Source: Holland and Ludwig, Arkansas Geological Commission and U.S. Geological Survey <12>

Figure 3-11

SURFACE WATER AND GROUND WATER USED IN THE BASIN - 1980

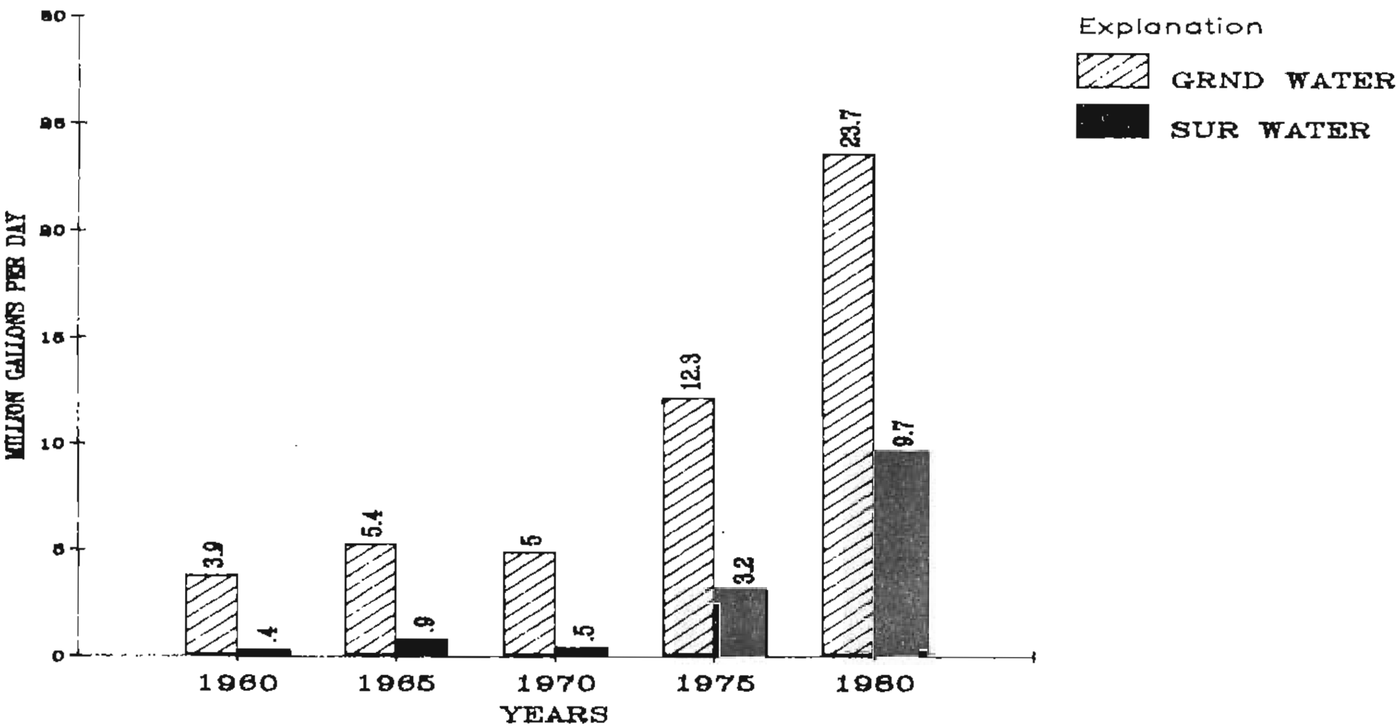


SOURCE: ARKANSAS GEOLOGICAL COMMISSION AND U.S. GEOLOGICAL SURVEY <12>.

Figure 3-12

WATER USE TREND

IRRIGATION



RURAL USE

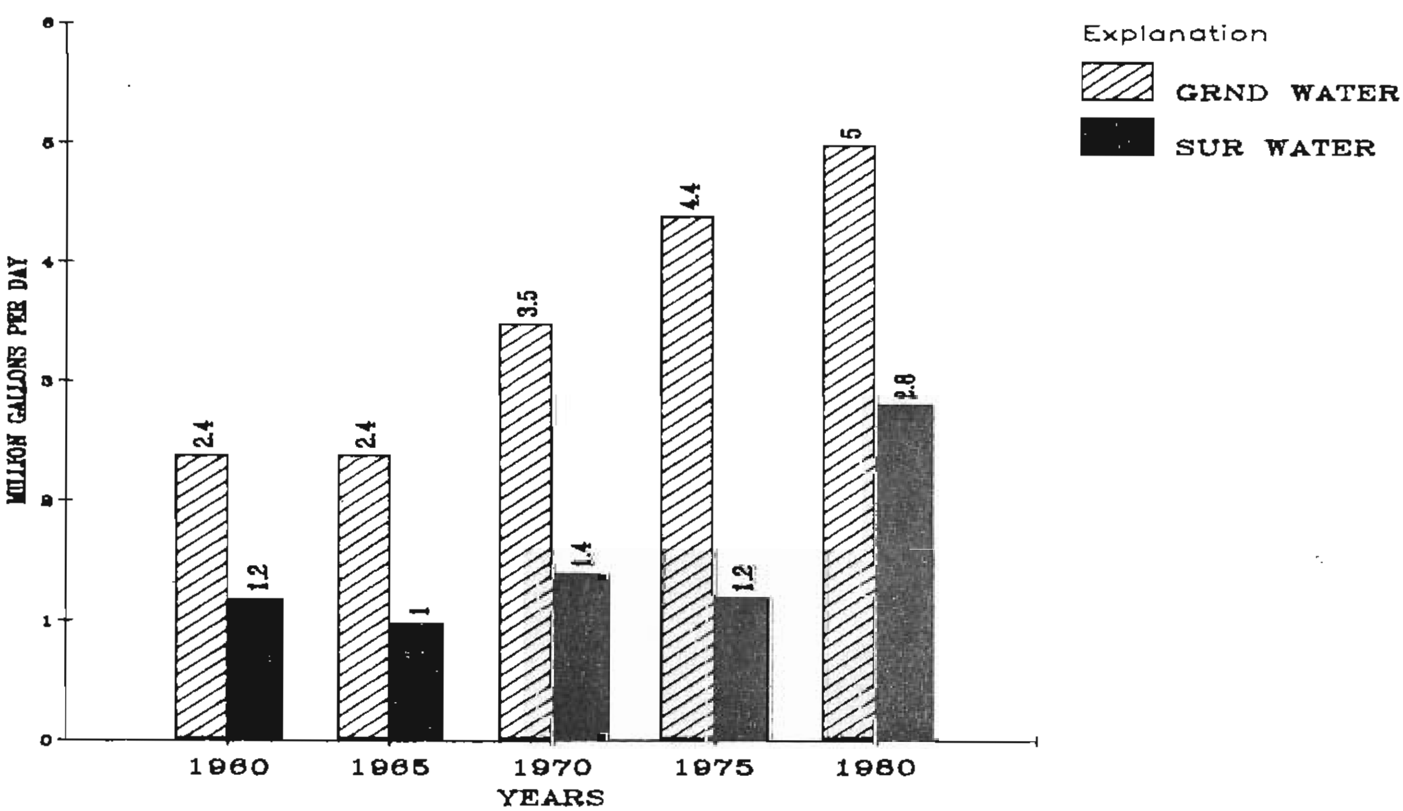
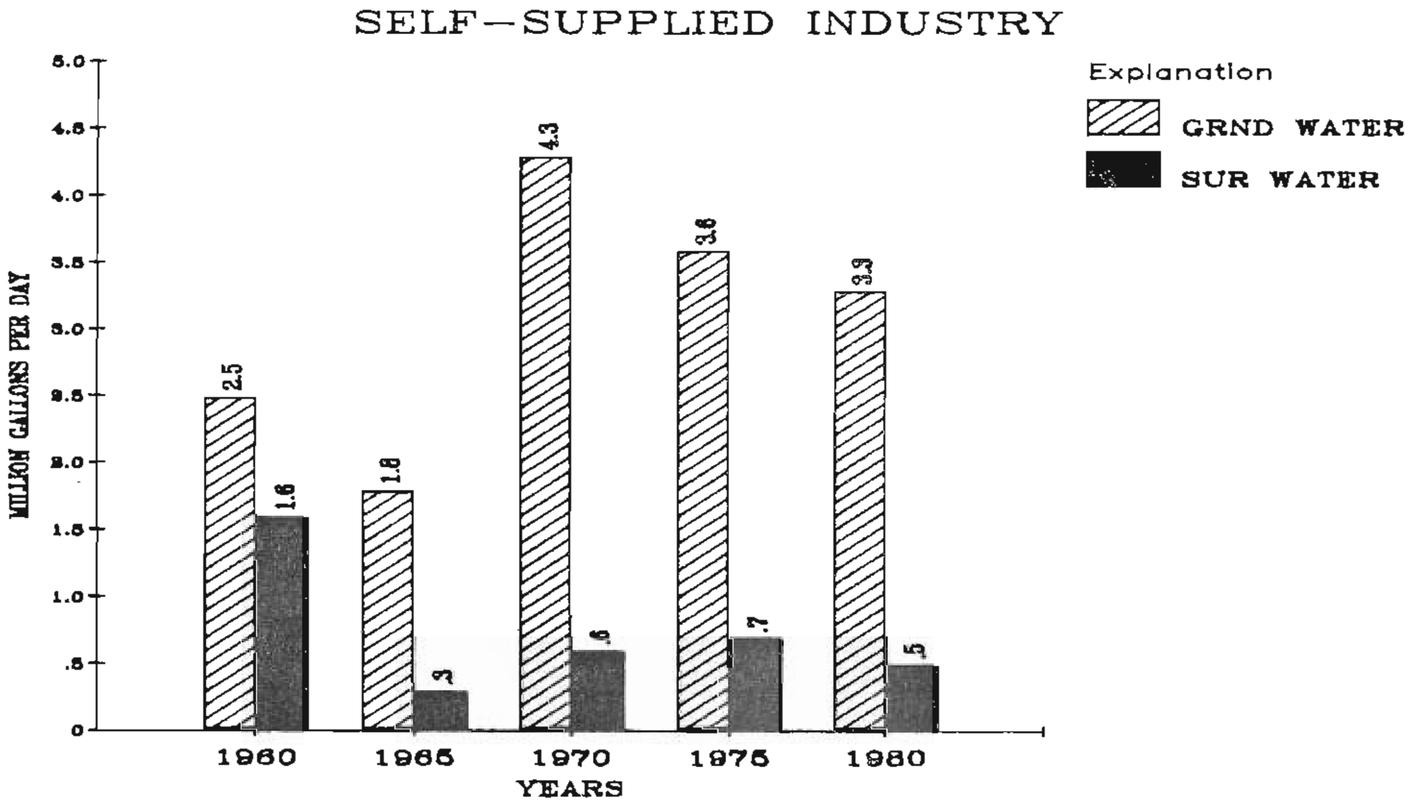


Figure 3-13


SELF-SUPPLIED INDUSTRY
Explanation
GRND WATER
SUR WATER
MILLION GALLONS PER DAY
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
2.5
1.6
1.8
.3
4.3
.6
3.6
.7
3.3
.5
1960
1965
1970
1975
1980
YEARS

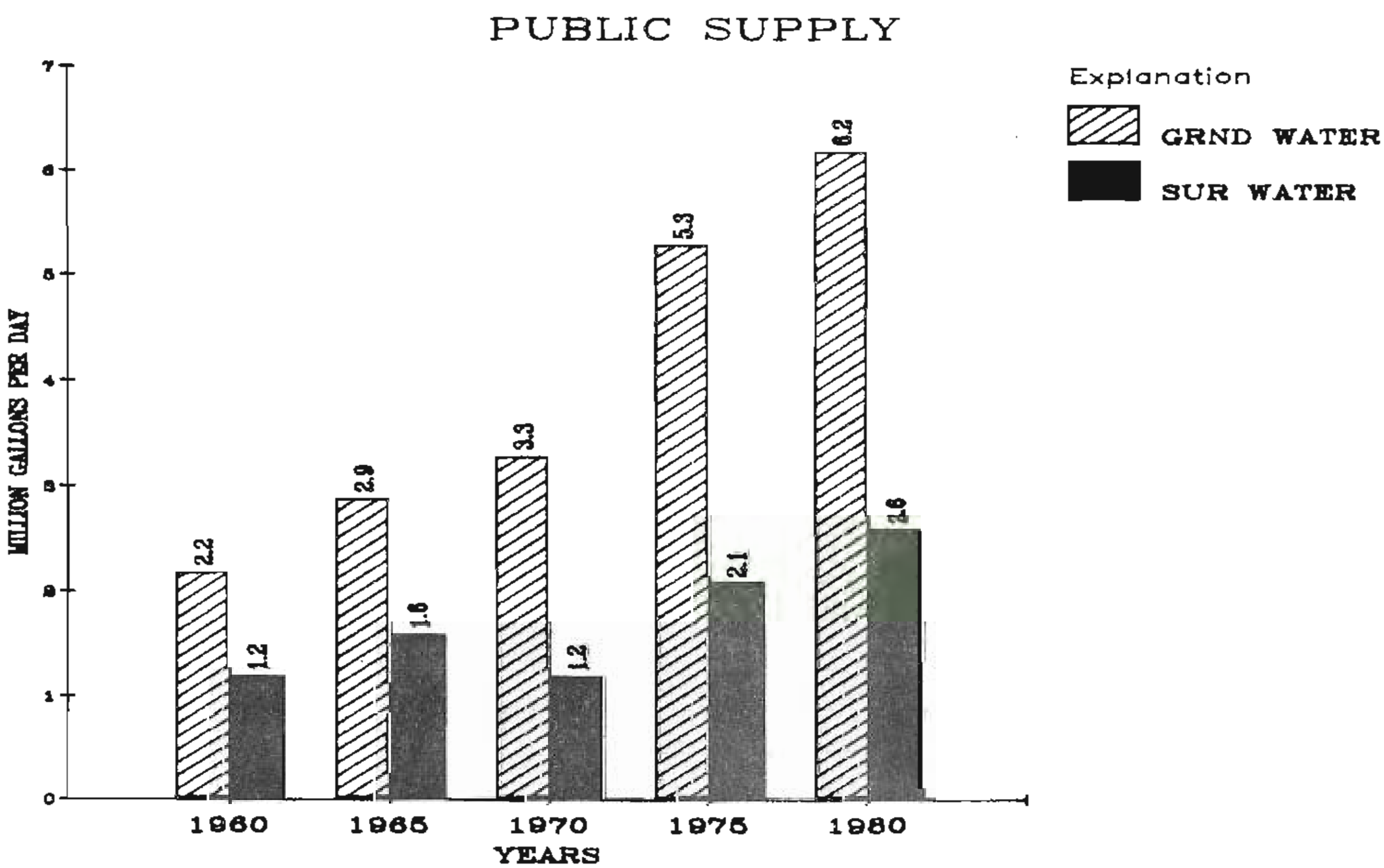
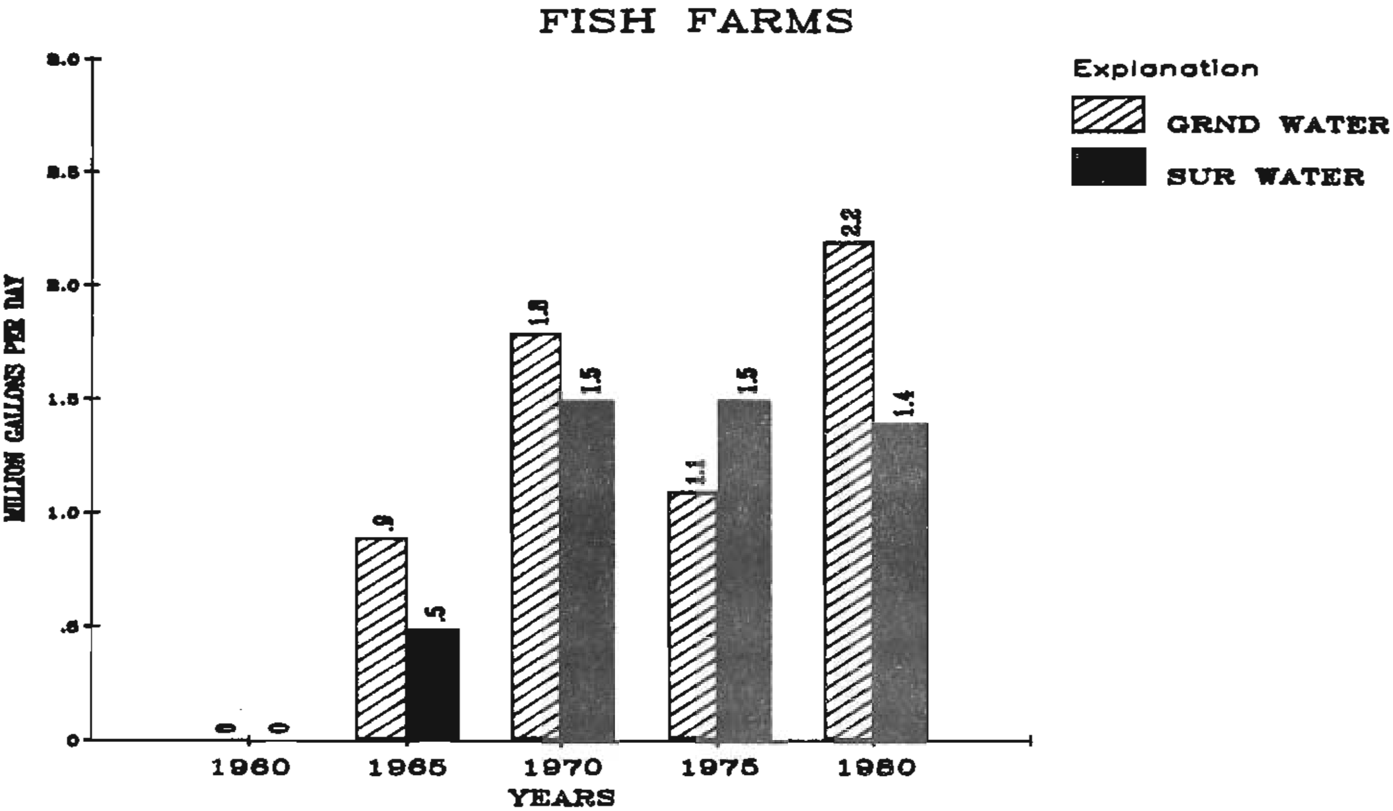

PUBLIC SUPPLY
Explanation
GRND WATER
SUR WATER
MILLION GALLONS PER DAY
7
6
5
4
3
2
1
0
2.2
1.2
2.9
1.6
3.3
1.2
5.3
2.1
6.2
2.6
1960
1965
1970
1975
1980
YEARS

Figure 3-14


FISH FARMS
Explanation
GRND WATER
SUR WATER
MILLION GALLONS PER DAY
3.0
2.5
2.0
1.5
1.0
.5
0
0
0
.9
.5
1.8
1.5
1.1
1.5
2.2
1.4
1960
1965
1970
1975
1980
YEARS

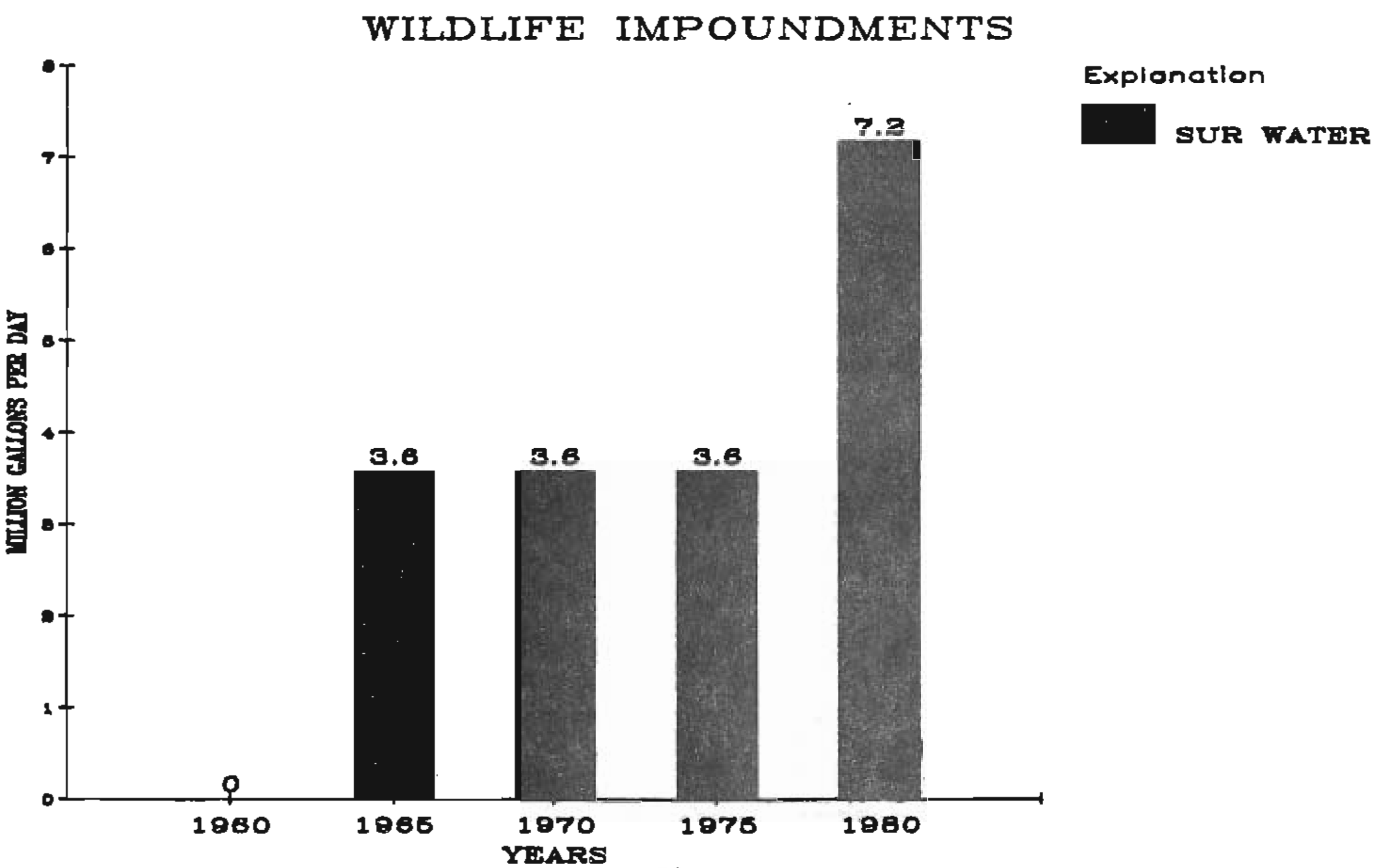
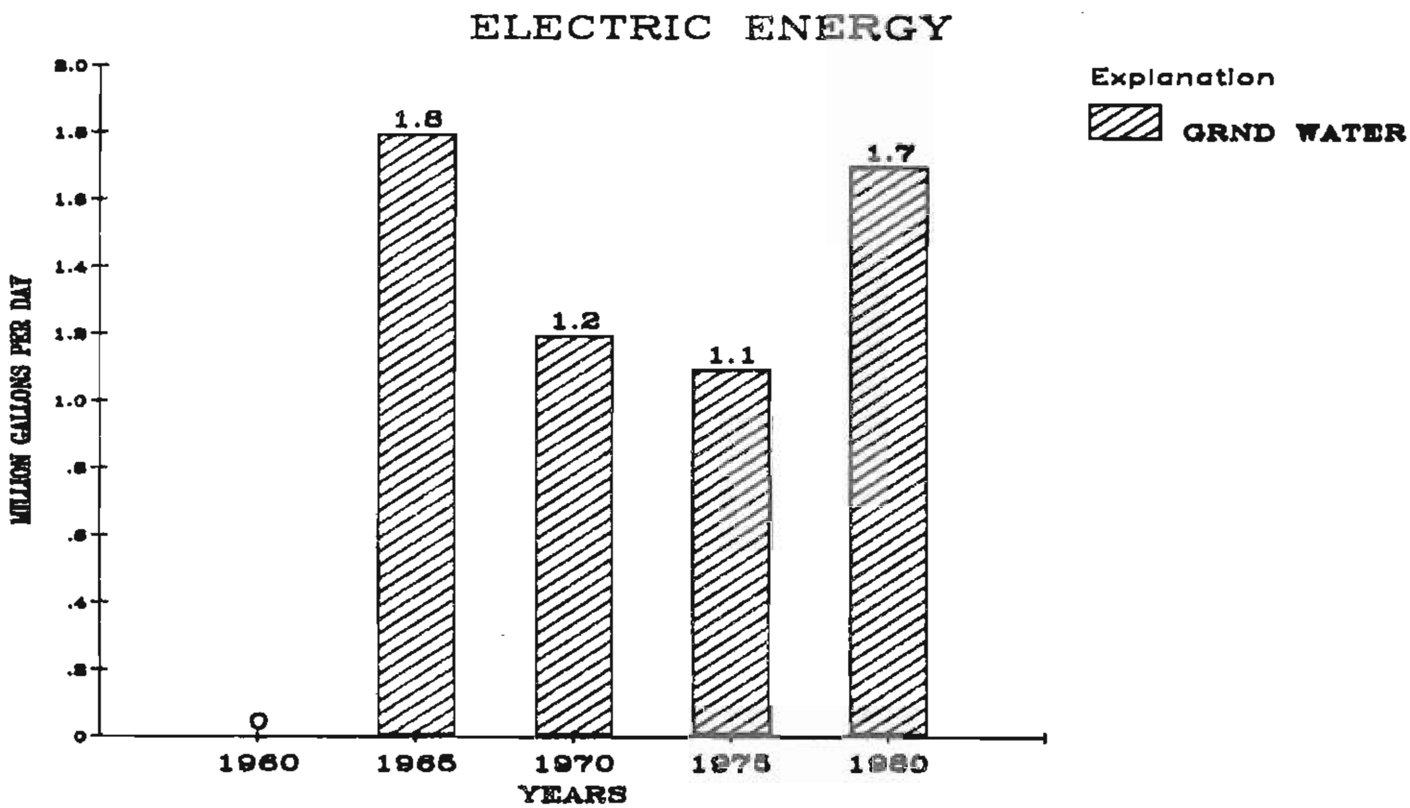

WILDLIFE IMPOUNDMENTS
Explanation
SUR WATER
MILLION GALLONS PER DAY
0
1
4
7
0
3.6
3.6
3.6
7.2
1960
1965
1970
1975
1980
YEARS

Figure 3-15


ELECTRIC ENERGY
Explanation
GRND WATER
MILLION GALLONS PER DAY
YEARS
1960
1965
1970
1975
1980
0
1.8
1.2
1.1
1.7

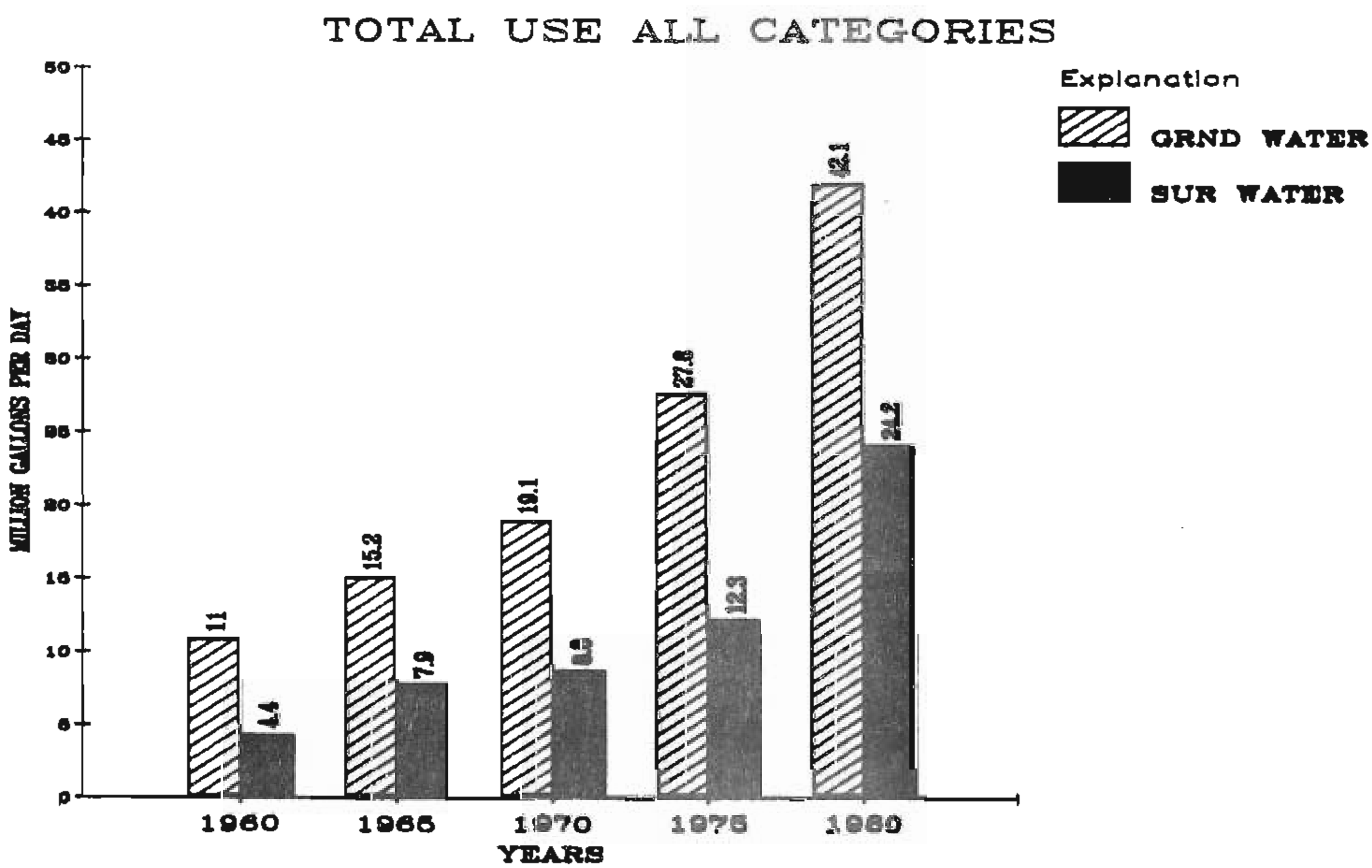

TOTAL USE ALL CATEGORIES
Explanation
GRND WATER
SUR WATER
MILLION GALLONS PER DAY
YEARS
1960
1965
1970
1975
1980
11
4.4
15.2
7.9
19.1
27.8
12.3
24.2

TABLE 3-13: WATER USE INCREASES - 1960 to 1980

Category	Increase Surface Water (MGD)	Increase Ground Water (MGD)	Increase - Surface and Ground Water (MGD)
Public Supply	1.4	4.0	5.4
Self-Supplied Industry	(1.1) 1/	0.8	(0.3)
Rural Use	1.6	2.6	4.2
Irrigation	9.3	19.8	29.1
Fish Farms	1.4	2.2	3.6
Wildlife Impoundments	7.2	-	7.2
Electric Energy	0	1.7	1.7
TOTAL	19.8	31.1	50.9

1/ Numbers in parenthesis are decreases.

Source: Arkansas Geological Commission and U.S. Geological Survey <10><12>

Potential Water Use

Total water use projections in this basin indicate a large increase in the demand for water during the next 20 years. By the year 2000 almost 262 MGD, (over four times the 61 MGD used in 1980), may be required to meet the needs of water users. Projections indicate, for the year 2030, water needs could be as much as 80 percent higher than the year 2000 figures. (See Table 3-14 and Figure 3-16) If future water use efficiencies (especially for irrigation) remain the same, the increase in use from the year 2000 to 2030 could rise to 110 percent. These projections of water demand were made without considering the availability of water or the cost of capital investments. It was assumed that landowners and operators would make additional investments. These investments could be for irrigation equipment and systems, rather than land holdings and dry land farming equipment.

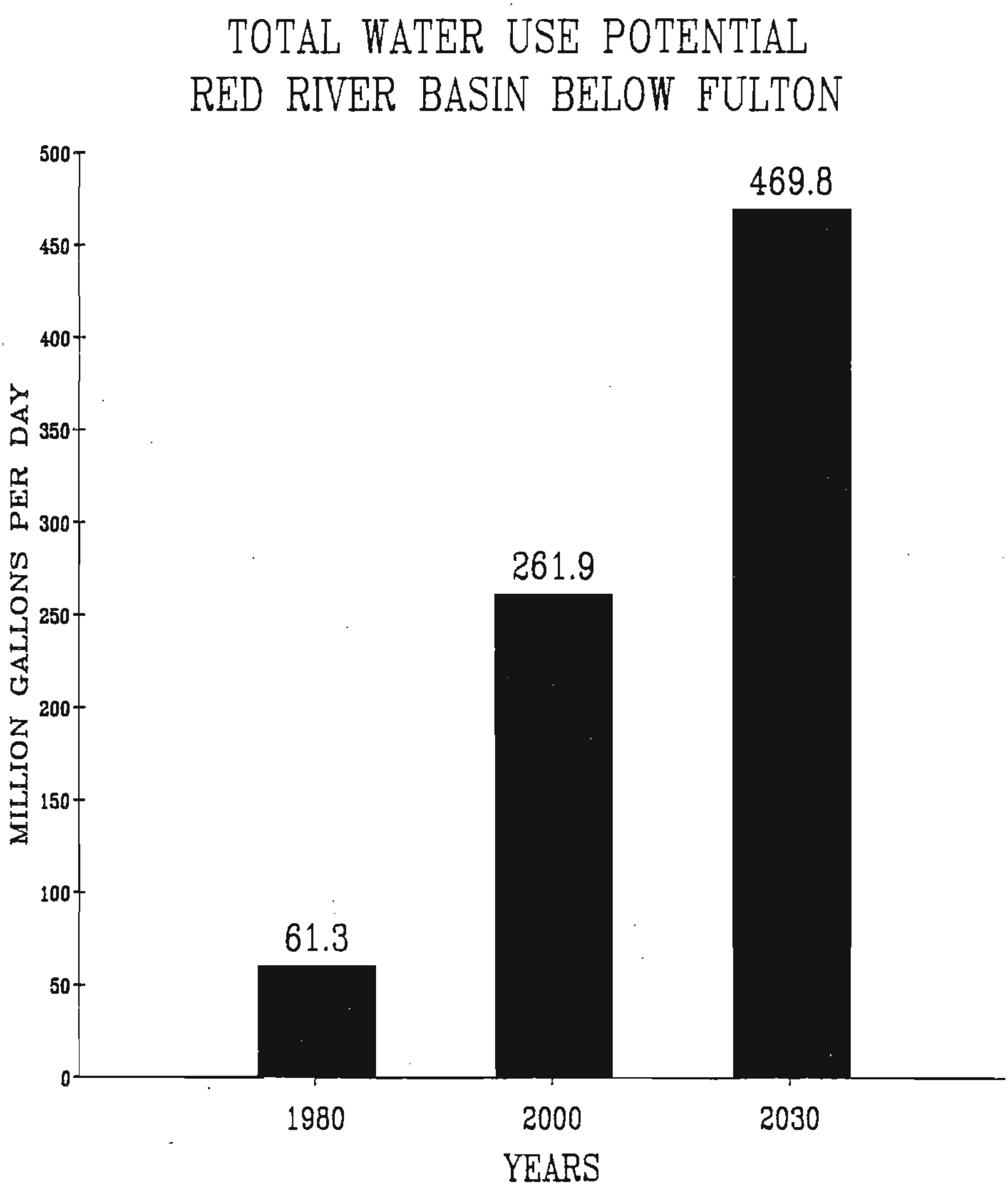
TABLE 3-14: TOTAL WATER USE POTENTIAL
RED RIVER BASIN BELOW FULTON
(MILLION GALLONS PER DAY)

Use Category	Year 1980	2000 1/	2030 1/
Public Supply	8.2	15.6	25.3
Self-Supplied Industry	3.7	4.5	6.0
Rural Use:			
Domestic	2.5	3.5	3.9
Livestock	3.5	5.3	6.1
Subtotal (Rural Use)	6.0	8.8	10.0
Irrigation 2/	41.7	233.0	428.5
Electric Energy 3/	1.7	0	0
TOTAL	61.3	261.9	469.8

1/ USDA Soil Conservation Service.
2/ Includes fish farms and on-farm wildlife and recreation uses.
3/ Water requirement for cooling and boiler feed of the AP&L natural gas-fired plant near Stamps, AR is not expected to continue to the year 2000.

Source: Arkansas Geological Commission, U.S. Geological Survey <12>

Figure 3-16



Source: 1980 – Ark Geo Comm and U.S. Geo Sur; 2000–2030 – USDA, Soil Cons Serv.

In 1980 about 37 percent of the total water used was obtained from surface sources. Surface water will play a major role in meeting future water demands; but to what degree surface water must be utilized cannot be determined until studies now underway (regarding safe ground water yields) are available.

With the exception of energy, all water use categories show moderate to substantial increases of potential water use by the year 2030 over 1980 totals. The percent of increase of all uses is greater during the period 1980-2000 than during the period 2000-2030. This is attributed primarily to increased irrigation efficiency during the latter period. Following is a discussion of potential water uses by category.

1. Public Water Supply

In 1980, public supplies drew 30 percent of their water requirement from surface water sources, and 70 percent from ground water sources. The total water use was 8.2 million gallons per day (MGD). Projections for the year 2000 indicate a 90 percent increase over the 1980 figures. The water use for public supplies in the year 2030 could be about 25.3 MGD, an expected increase of 62 percent over the year 2000 figures. Between 1980 and 2030, public supplies may triple their use of water.

2. Self-Supplied Industries

In 1980, surface water provided only 11 percent of the water requirements for self-supplied industries. Ground water was the predominant source providing 89 percent of the 3.7 MGD used. The projections for the years 2000 and 2030 indicate an increase in water use of 22 and 23 percent, respectively. The 2030 projection for total water use is 6.0 MGD.

3. Rural Use

a. Domestic: Presently, all water used for rural domestic supplies comes from ground water sources. The projections for years 2000 and 2030 show increases in water use, but increases that taper off. The overall projection is a 56 percent increase in 2030 over 1980..

b. Livestock: In 1980, 60 percent of the water supplied to livestock came from surface water sources and 40 percent from ground water sources. The total usage was 3.5 MGD. The livestock water use trend is expected to be similar to the rural domestic use trend. In the year 2000, 5.3 MGD are expected to be needed for livestock, an increase of 51 percent over 1980 figures. The increase in water use between 2000 and 2030 is projected to increase 15 percent to a high of 6.1 MGD. In 2030 livestock could be using approximately 74 percent more water than in 1980.

4. Irrigation

For purposes of water use projections, water use requirements for fish farms, wildlife impoundments, and irrigation were combined under the single category of irrigation. The 1980 combined total of 41.7 MGD for irrigation, fish farms, and wildlife impoundments makes this category the largest user

(68%) of water in the basin. Of all irrigation water used in 1980, 57 percent came from ground water sources. Irrigation is expected to increase significantly by the year 2000. The projections show that by the year 2000 233 MGD (5.6 times the 41.7 MGD utilized for irrigation in 1980) could be needed for irrigation. The projections for the year 2030 predict a use of 428.5 MGD for irrigation, or an increase of 84 percent over the year 2000. The declining percentage increase from 2000 to 2030 is attributed to increased irrigation efficiency during that period. The percentage increases in water for irrigation may vary from 84 percent to 110 percent in 2030 over 2000, depending upon the degree of irrigation efficiency development. Water use for irrigation between the years 1980 and 2030 could increase by as much as 900 percent.

5. Electric Energy

All of the 1.7 MGD used for electric energy came from six ground water sources and was used for cooling and boiler feeding the AP&L natural gas-fired energy plant near Stamps, Arkansas. This need is not expected to continue to the year 2000.

Excess Streamflow

Excess streamflow, defined in Section 5 of Act 1051 of 1985, is 25 percent of the 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 this report, excess water does not allow for the possible restriction of basin streamflow uses to comply with Section 5.05 of the Red River Compact. Therefore, the amount of excess water actually available on an average annual basis could vary significantly from the amount determined here. The Red River and Sulphur River were considered the appropriate sources for determining excess water in the basin since only these two streams had flows significant enough to qualify as sources for instream flow requirements. Table 3-15 shows mean annual discharges for several basin streams in addition to the Red River and Sulphur River. However, the limited and variable discharges of these streams excluded them for instream flow requirement consideration. If the discharges of these streams were reduced by the governing instream flow requirement amount, the excess water remaining would be less than one percent of the total excess water available in the basin.

To determine the excess streamflow in the Red River Basin below Fulton, the U.S. Geological Survey streamflow data compiled at the Hosston, Louisiana, Red River streamflow gage was utilized. This gage is located approximately 10 miles south of the AR/LA state line and is below the confluence of the Sulphur River. Data from this gage will closely approximate discharge values at the AR/LA state line.

TABLE 3-15: MEAN ANNUAL DISCHARGES & INSTREAM FLOW REQUIREMENTS OF SIGNIFICANT STREAMS

Stream	Drainage Area (Sq. Mi)	Mean Annual Discharge (CFS)	Water Quality Requirement 7Q10 (CFS)	Average Annual Fish & Wildlife Requirement (CFS)
Red River at Fulton, AR	52,336 2/	17,190	1,110	10,314
Red River at Hosston, LA	57,041 2/	17,920	1,650	10,752
Sulphur River near Texarkana, TX	3,443	2,889	6	1,733
Bayou Dorcheat near Springhill, LA	605	543	3/	3/
Badcau Creek near Sorepta, LA	546	562	3/	3/
Cypress Creek at AR/LA State Line	82.5	74 1/	3/	3/
Kelly Bayou near Hooston, LA	116	94.9	3/	3/
Crooked Creek at AR/LA State Line	56.7	51 1/	3/	3/
Posten Bayou at AR/LA State Line	36.9	33 1/	3/	3/
Dooley Creek at AR/LA State Line	35.8	32 1/	3/	3/
Dry Fork at AR/LA State Line	35.4	32 1/	3/	3/

1/ Discharge determined from Bayou Dorcheat flow data.

2/ 5,936 square miles, probably non-contributing.

3/ Value not determined.

As previously stated, excess streamflow is 25 percent of the flow available on an average annual basis above the amount needed to satisfy existing and projected water requirements of the basin. Existing streamflow requirements include water quality, fish and wildlife, interstate compacts, riparian, navigation, aquifer recharge, and aesthetic uses. Table 3-15 shows the requirements for water quality (as determined by ADPC&E) and fish and wildlife (as determined by the Arkansas method). Although no less important, values for other categories were excluded from the table because flow requirements for navigation have not been established, interstate compact requirements are variable, aquifer recharge was not determined in this report, riparian uses are withdrawn from the stream prior to measurement, and aesthetic requirements are assumed to be met by fish and wildlife needs.

The instream flow requirements for the streamflow use categories are not additive; therefore, the category with the greatest instream flow need will govern. The instream flow requirements for fish and wildlife (as established by the Arkansas Method), are the highest flow requirements determined in this report. On an average annual basis, sixty percent of the mean annual basin stream yield at the Hosston, Louisana Red River stream gage (17,920 CFS from Table 3-15) or 10,752 CFS will satisfy fish and wildlife instream flow requirements. The value of 17,920 CFS minus 10,752 CFS or 7,168 CFS, represents the net average annual basin discharge available after existing instream flow requirements are met.

To determine projected surface water needs, the total water requirement of 469.8 MGD estimated for the year 2030 (Table 3-14), was reduced by the 1980 surface water use (22.9 MGD) and ground water use (38.4 MGD). The net projected surface water need is 408.5 MGD (632 CFS). The value of 7,168 CFS minus 632 CFS or 6,536 CFS (4,732,064 acre-feet) represents the net average annual discharge available after existing and projected instream flow requirements are met.

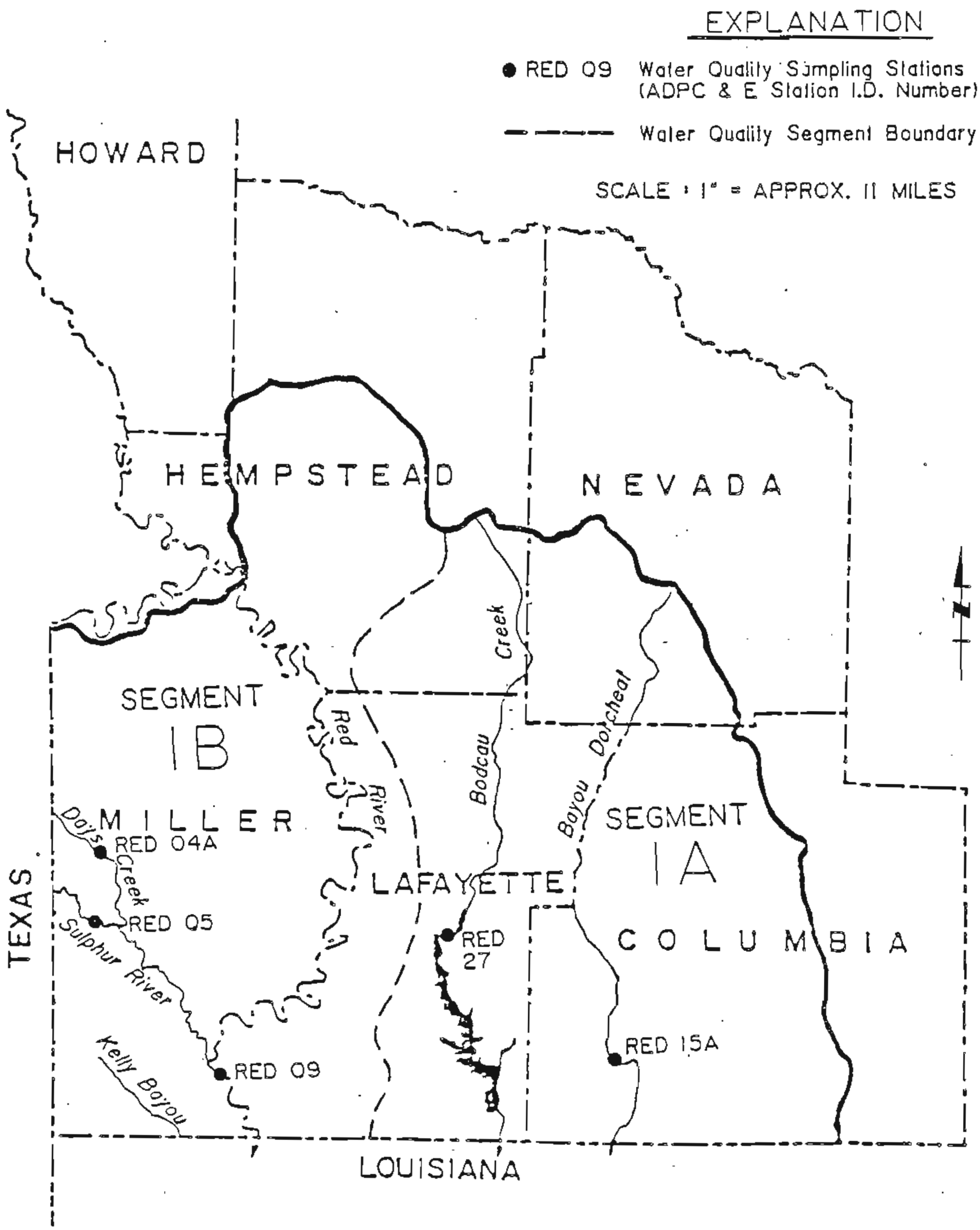
According to Act 1051 of 1985, 25 percent of the 6,536 CFS of surface water (0.25 x 6,536) or 1,634 CFS (1,183,016 acre-feet) is excess surface water in the basin and is available, on an average annual basis, for other uses such as interbasin transfer. It must be remembered that the majority of the excess surface water is available during the period of high flow (December through May) and significantly less available during the period (June through November). Also, the implementation of Red River Compact requirements may alter the discharge available.

Quality of Streamflow

The Red River Basin below Fulton has been divided into Water Quality Segments 1A and 1B by the Arkansas Department of Pollution Control and Ecology. Figure 3-17 shows the boundaries of these two planning segments within the basin and location of water quality monitoring stations. A description of each segment follows:

Figure 3-17

WATER QUALITY PLANNING SEGMENTS AND LOCATIONS OF ACTIVE WATER QUALITY SAMPLING STATIONS



SOURCE : ARKANSAS DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY

Segment 1A - Dorcheat Bayou and Bodcau Creek

Segment 1A comprises 720,715 acres in portions of Columbia, Hempstead, Lafayette, and Nevada Counties. The streams within this segment flow into the Red River in Louisiana. Dorcheat Bayou and Bodcau Creek are the major streams. Land use is 78 percent woodland, 17 percent grassland, 2 percent water, 2 percent urban and mining, and about 1 percent cropland. <5><18>.

Two active water quality monitoring stations are in the basin (Table 3-16 and Figure 3-17). One of these stations is located on Bayou Dorcheat (RED 15A) and the other is located on Bodcau Creek (RED 27). Historical water quality data are available from 10 other stations. <5>

Segment 1B - Red River, Sulphur River, and McKinney Bayou

Segment 1B includes parts of Miller, Lafayette, and Hempstead Counties. <18> Major streams include Red River, Sulphur River, and McKinney Bayou. Land use in the segment includes about 46 percent woodland, 24 percent grassland, 24 percent cropland, 3 percent water, and 3 percent urban and other uses. <18>

Within the basin portion of the segment, three active water quality sampling stations--RED 04A, RED 05, and RED 09-- are located on Days Creek, Sulphur River, and Red River, respectively (Table 3-16 and Figure 3-17). Historical data are available for six other stations. <5>

TABLE 3-16: SUMMARY OF ACTIVE WATER-QUALITY DATA COLLECTION SITES 1/
(ADPC&E STATION NUMBERS CORRESPOND TO THOSE IN FIGURE 3-17)
RED RIVER BASIN BELOW FULTON

ADPC&E Station No.	USGS Station No.	Name	Period of Record	Drainage Area Sq. Miles
RED 04A	07344300	Days Creek Southeast of Texarkana, AR	1973-Present	78.5
RED 05	07344275	Sulphur River South of Texarkana, AR	1968-Present	3,540
RED 09	07344350	Red River near Spring Bank, AR	1968-Present	56,909
RED 15A	07348650	Bayou Dorcheat near Taylor, AR	1973-Present	389
RED 27	07349440	Bodcau Creek near Lewisville, AR	1974-Present	297

1/ Water quality data currently being collected. Historical data is available from 16 other stations not listed.

Source: U. S. Geological Survey, Arkansas Water Resources Data, and Arkansas Department of Pollution Control and Ecology <54><5>

TABLE 3-18: IMPOUNDMENTS UNDER 5 SURFACE ACRES IN THE STUDY AREA

County 1/	Capacity (Acre-feet)	Area (Acres)	Number
Miller	1,355	301	449
Lafayette	800	200	400
Columbia	4,886	1,437	1,272
Hempstead	8,361	2,044	2,636
Nevada	2,553	524	1,500
Total	17,955	4,506	6,257

1/ Excludes Howard County Data.

Source: Arkansas Soil and Water Conservation Commission <17>

Impoundment Water Quality

Raw water from Lake Erling was tested in March, 1983 by Kendall-Stone & Associates, a water treatment consulting firm, located in Longview, Texas. Results of the water analyses are shown below.

	Parts Per Million (PPM) (Except as Noted)
Total Alkalinity	10.00
Plate Alkalinity	0
Free Carbon Dioxide	14.00
Carbonate Hardness	10.00
Non-carbonate Hardness	8.00
Total Hardness	18.00
pH (pH scale)	6.2
Silica	5.35
Iron	0.28
Manganese	<0.05
Calcium	4.00
Magnesium	1.94
Sodium	15.35
Bicarbonate radicle	12.20
Carbonate radicle	0
Sulfate radicle	19.40
Chloride radicle	15.00
Fluoride radicle	0
Nitrate radicle	<0.08
Color (Co-Pt scale)	5
Turbidity (N.T.U.)	18.00
Total Solids (180° C)	115.00
Langelier Corrosion Index	-4.1

This water has a very low hardness and total mineral content. Since it is a surface supply, it will require turbidity removal. At the very low total alkalinity, it will be corrosive to both iron and copper piping and fittings, unless treated for corrosion prevention. There are no iron or manganese problems. Aside from the above, this should be a very good domestic supply.

The U.S. Corps of Engineers has issued a 404 permit for Lake Columbia. The permit requires all oil and disposal wells in the lake bottom to be adequately capped and necessary measures be taken to ensure no leakage or spillage. It also required construction of an oil spill trap on State Highway 344 to retain oil from possible oil spills in upstream pipelines, oil, and gas fields. Effluent from the city of Waldo's sewage lagoon will not be allowed to enter the Lake Columbia watershed.

Impoundment Water Use

Lake Erling's primary use is recreation but the lake also provides a limited amount of flood control.

Upon completion, Lake Columbia will be used primarily as a municipal water supply reservoir for the city of Magnolia, Arkansas. Lake Columbia will also have recreation uses of hunting, fishing, swimming, and skiing.

USDA (SCS) AND CORPS OF ENGINEERS PROJECTS

Soil Conservation Service

Refer to Legal and Institutional Setting for an explanation of the programs mentioned in this section.

Table 3-19 provides information about all the identified watersheds in the basin by name, with corresponding acres in the watershed. Table 3-19 also shows the PL 83-566 status of three watersheds on which applications for PL 83-566 assistance have been submitted. Figure 3-18 shows the location of the watersheds.

TABLE 3-19: RED RIVER BASIN BELOW FULTON WATERSHEDS

Map Watershed Number	Watershed Name	DRAINAGE AREA (Acres)	P. L. 83 - 566 PROJECTS		STRUCTURES NEEDED	
			Potential	Status 1/	Channels	Dams
1	Upper Bayou Dorcheat	88,572	No	-		
2	Middle Bayou Dorcheat	104,039	No	-		
3	Big Creek Columbia County	87,630	No	1		Yes
4	Horsehead Creek	68,225	No	-		
5	Cypress Creek	41,855	No	-		
6	Crooked Bayou	31,948	No	-		
7	Little Bodcau Creek	64,828	No	-		
8	Upper Bodcau Creek	81,769	No	-		
9	Middle Bodcau Creek	55,797	No	-		
10	Lower Bodcau Creek	64,168	No	-		
11	Martin Creek	31,884	No	-		
12	McKinney Bayou	176,695	Yes	2	Yes	
13	Bridge Creek	88,012	No	-		
14	Bois D'Arc Creek	66,595	No	-		
15	Maniece Bayou	88,954	Yes	-		
16	Beech Creek	29,107	No	-		
17	Lower McKinney	20,498	No	-		
18	Posten Bayou	57,007	Yes	-		
19	Big Creek	1,581	No	-		
20	Lower Sulphur River	114,889	No	-		
21	Kelly - Black Bayou (ARK - TX - LA) 2/	51,812	Yes	3	Yes	
		1,415,865				

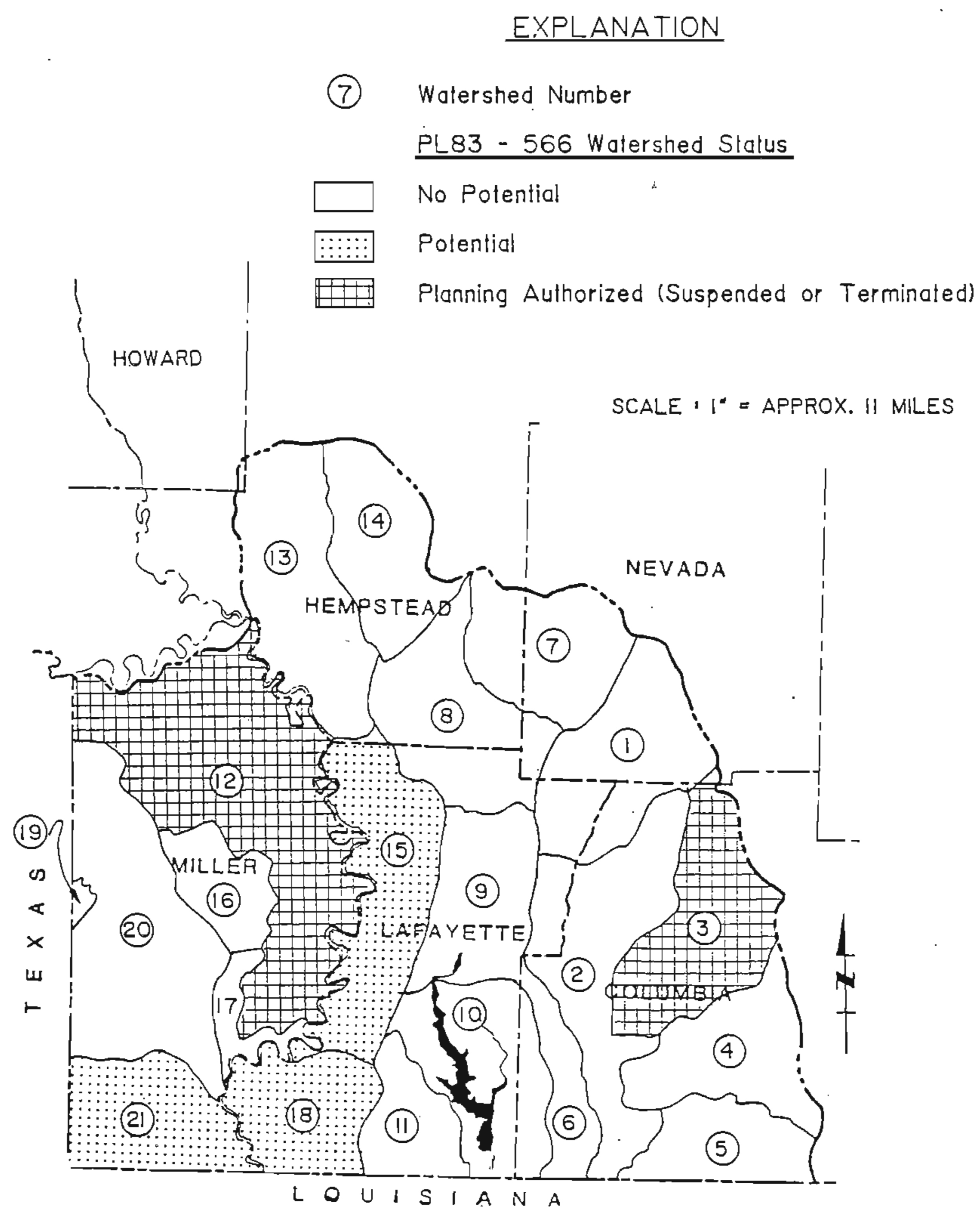
1/ Status Code:
1 - Planning Authorized (suspended or terminated).
2 - Application returned to sponsors.
3 - Active application.

2/ Administered by the Louisana State Office. Presently inactive.

Source: USDA, Soil Conservation Service <30>

Figure 3-18

RED RIVER BASIN BELOW FULTON WATERSHEDS



Although watershed applications have been submitted for the three watersheds, there are no Soil Conservation Service planning activities on them at the present time. McKinney Bayou and Posten Bayou have both been evaluated as potential watershed drainage projects but under the present administration, cost sharing is not available and interest is lacking in sponsorship.

Three Resource Conservation and Development (RC&D) measures have been completed. They consist of a total of 7.3 miles of channel improvement for flood prevention in the towns of Bradley, Taylor, and Stamps. Two additional measures, Spirit Lake and Fulton, Arkansas, are inactive.

<u>U. S. Army Corps of Engineers</u>

Over 150 years ago the River and Harbor Act of 1828 and later authorizations provided for continuous improvement of the Red River from Fulton, Arkansas, in Hempstead County to the mouth of the river near Simmesport, La. The project is carried out by systematic clearing of banks, snagging, dredging, levee work, revetments and related operations. No channel dimensions are specified and the project as authorized is considered complete. Total cost of the project was more than $1.9 million, while maintenance on it through September 1977 was about $2.1 million <40>.

Construction along the Red River from Fulton, Arkansas, to Louisiana is under the U. S. Army Corps of Engineers, Vicksburg District jurisdiction and is managed by the Shreveport Area Office.

Since 1980, the Shreveport Area Office has completed 17 construction contracts. Currently, one revetment project is under construction and one revetment job is programmed for contract award during this fiscal year. No contracts are currently scheduled for award in fiscal year 1987 in Arkansas. All construction on the Red River in Arkansas has been funded either by the Red River Emergency Bank Protection Project or by the Red River below Denison Dam Project.

Table 3-20 contains a list of major projects by the Corps of Engineers and Figure 3-19 shows the corresponding locations.

TABLE 3-20: MAJOR PROJECTS OF THE CORPS OF ENGINEERS
RED RIVER BASIN BELOW FULTON

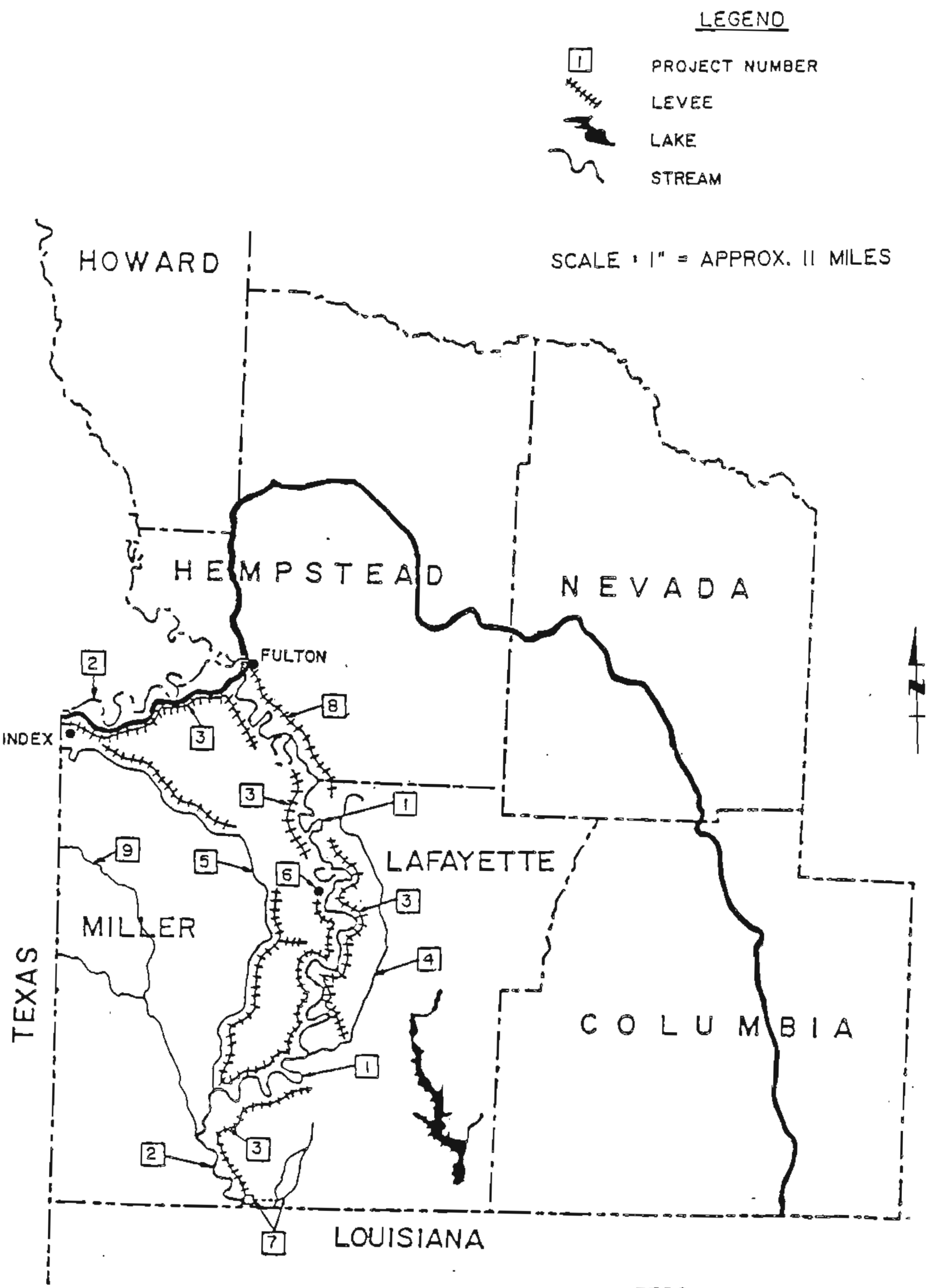
Project Number 1/	Project Name	Status
1	Red River Emergency Bank Protection, AR and LA	Under Construction
2	Red River Waterway, Shreveport, LA, to Index, AR	Under Construction
3	Red River Levees and Bank Stabilization	Under Construction
4	Maniece/Field Bayou	Completed
5	McKinney Bayou	1955 Authorization Completed
6	Garland City	Completed
7	Posten Bayou	Inactive
8	Hempstead County Levee	Completed
9	Days Creek and Tributaries, AR and TX	Inactive

1/ Project numbers in this table correspond to project numbers on Figure 3-19 and in the following narrative.

Source: U.S. Army Corps of Engineers <40>

Figure 3-19

MAJOR PROJECTS OF CORPS OF ENGINEERS



SOURCE : U. S. ARMY CORPS OF ENGINEERS

The following is a description of the Corps of Engineers' projects. Project numbers correspond to project numbers in Table 3-20 and Figure 3-19. <20> <40>

1. Red River Emergency Bank Protection, LA and AR

DESCRIPTION: Authorized by the River and Harbor Act of August 13, 1968, the project provides for realigning and stabilizing the Red River channel by means of cutoffs, training works, and revetments at critical locations. The work to be included in this emergency program will be in agreement with the Red River Waterway project plan. Bank stabilization work was completed at Bushy, Field, Kenny, and Spirit Lake, AR, and channel realinement work was completed at Mays Lake, AR, in FY 1981. Bank protection work has also been completed at Dukedale, LA, Spring Bank, AR, and Young, AR.

The total estimated cost of the project is $67,528,000 comprised of $65,346,000 Federal and $2,182,000 non-Federal. The overall project is estimated to be 95 percent complete.

STATUS: Project is under construction.

SPONSOR: Red River Waterway Commission for work downstream of the Louisiana-Arkansas state line and local levee districts in Arkansas for work within their respective reaches of the river.

2. Red River Waterway, Shreveport, LA, to Index AR

DESCRIPTION: The project authorized by the River and Harbor Act of 1968, provides for realigning the channels of Red River from Shreveport, Louisiana, to the vicinity of Index, Arkansas, by means of dredging, cutoffs, and training works, and for stabilizing its banks by means of revetments, dikes, and other methods. Facilities to provide opportunities for recreation and fish and wildlife development are an integral part of the project.

STATUS: Initial Phase I Advanced Engineering and Design planning funds were appropriated for this reach of the waterway in fiscal year 1977. A general reevaluation study is scheduled to be completed in fiscal year 1990.

SPONSORS: Red River Waterway Commission, Louisiana; Arkansas Soil and Water Conservation Commission; and Governor of Texas.

3. Red River Levees and Bank Stabilization Below Denison Dam, Tx, Ark, & La

DESCRIPTION: Authorized by the Flood Control Act of July 24, 1946, the project is located along the main stem of Red River from Index, Arkansas, to Pineville, Louisiana, and provides for raising and strengthening of levees and construction of bank protection works where levee setbacks are impossible or uneconomical. The levee portion of the project is complete and the bank protection portion of the project is 89 percent complete. Bank protection is under construction at Gahagan, LA and a realignment is under construction at Belcher, LA. The overall project is 95 percent complete.

The total estimated cost of the project is $61,210,000 comprised of $59,650,000 Federal and $1,560,000 non-Federal.

STATUS: Project is under construction.

SPONSOR: Red River Watershed Commission and 11 local levee districts in Arkansas, Louisiana, and Texas.

4. Maniece Bayou

DESCRIPTION: This project was authorized by Congress in 1955 with further modifications authorized in 1960 and 1962 (Public Law 218 of 1955, Public Law 86-645 of 1960 and Public Law 87-874 of 1962). The 1955 authorization provided for realignment and enlargement of the lower eight miles of Maniece Bayou in Arkansas to reduce flood heights and provide an adequate drainage outlet which would benefit about 4,000 acres of cropland.

The modification authorized by the Flood Control Act of 1960 provides for the enlargement of Maniece and Field Bayous below river mile 23, including additional enlargement of Maniece Bayou below mile 8.

Provisions also authorized extension of the left bank Red River levee and construction of an interceptor drainage ditch about 3.5 miles long to the mouth of Maniece Bayou.

STATUS: The 1955 authorization was completed in April 1959 at a federal cost of $128,500.

Work modifying the channel from river mile 0 to mile 8 was completed in January 1968.

Construction of the second phase starting at mile 8 to mile 23 began in April 1968 and was completed in August 1969. Modification of the St. Louis-Southwestern Railway Bridge in the vicinity of mile 16 was completed in June 1967 under a reimbursable agreement with the railroad.

The overall project was completed in August 1969 at a total cost of $1.46 million including a federal cost of $971,000. The non-federal cost, including a $39,300 cash contribution required by Public Law 87-874, was $486,300.

Through September 1979 cumulative benefits from work completed in the project were estimated at $164,000.

SPONSORS: Maniece Bayou Drainage District No. 2.

5. McKinney Bayou, AR and TX

DESCRIPTION: The McKinney Bayou, Arkansas and Texas project, as authorized by the Water Resources Development Act of 1976, consists of three major elements, each containing a major outlet and associated interior drainage improvements. These elements are improvement of the McKinney Bayou channel, construction of a diversion channel and control structure at Buzzard Bluff, and construction of a diversion channel and control structure in Texas about one-half mile west of the Arkansas-Texas State line. The authorized plan includes mitigation measures consisting of the acquisition and development of 3,500 acres of high quality woodland along the periphery of the Bois D'Arc Game Management Area located near Fulton, Arkansas.

STATUS: A draft general reevaluation report of the McKinney Bayou, Arkansas and Texas project was submitted to federal, state, and other agencies and individuals on July 28, 1983. The reevaluation disclosed changed conditions and attitudes in the McKinney Bayou basin sufficient to require modification of the authorized plan. The portion of the project located west of the Arkansas-Texas State line was not recommended for implementation at that time because of lack of support by local interests, and hence was reclassified to inactive in November 1982. The Buzzard Bluff portion was not recommended; all alternatives investigated had benefit-cost ratios less than unity.

The tentatively selected plan presented in the draft reevaluation report consisted of channel improvements of McKinney Bayou to the same dimensions as authorized and a reduced mitigation plan of 2,550 acres of greentree reservior along the periphery of the Bois d'Arc Game Management Area. The estimated first cost of the tentatively selected plan was $11,090,000. Total annual costs were $1,146,000 and the annual benefits were $1,633,000, yielding a benefit-cost ratio of 1.4.

Landowners of Miller County were consulted through the five drainage districts in the county to determine their willingness to provide the items of local cooperation for the plan presented in the draft reevaluation report. The five districts stated in late October 1983 that while they agreed with the formulation of the tentatively selected plan, they found the local cost to be excessive and stated that they could not provide the items of local cooperation.

Because of the lack of local support for the McKinney Bayou channel improvements, and lack of economic justification for the Buzzard Bluff segment, it was recommended that both portions of the project be reclassified from "active" to "inactive." As an inactive project, it will receive no funds for development and all studies on the project will be stopped.

SPONSORS: Miller County Improvement and Drainage District.

6. <u>Garland City</u>

DESCRIPTION: The project was authorized by the Flood Control Act of 1960. It provided for construction of improvements to protect railroad and highway bridges on the Red River at Garland City.

STATUS: The first phase of construction, completed in June 1962, consisted of riprap around one railroad bridge pier, rock work in the left bank between bridges and pile revetment above the railroad bridge. The second phase, finished in 1974, included construction of a dike system along the upstream, right bank from the bridges. Total project cost was more than $1.3 million. Local interests are responsible for maintaining the completed structures.

SPONSORS: Arkansas Planning Commission.

7. Posten Bayou, Arkansas

DESCRIPTION: The project provides for, in lieu of the improvements authorized for the Posten Bayou, Arkansas-Louisiana area by the Flood Control Act of August 3, 1955, a plan consisting of a new major outlet with related control structure and levees from Posten Bayou to Red River, in combination with associated drainage works to be provided by others. All authorized work lies entirely within the State of Arkansas.

STATUS: The Senate Public Works Committee on December 17, 1970, and the House Public Works Committee on December 15, 1970, adopted resolutions approving the subject project under the provisions of Section 201 of the Flood Control Act of 1965. Phase I Advanced Engineering and Design studies were initiated in FY 76. However, studies have been suspended and the project reclassified to an inactive status as of August 11, 1977. This classification resulted because the local sponsors of the authorized project, when asked to furnish their views relative to support of the project and their willingness to provide the local cooperation requirements, stated that the project would be too costly for them to meet. This decision left the project without a local entity willing to indicate an intent to provide the local cooperation requirements.

SPONSORS: None.

8. Hempstead County Levee

DESCRIPTION: Project improvements included levee construction and enlargement, floodgate repair, and construction of an additional floodgate and a new levee segment as well as an outfall sewer and gate along the left bank of the Red River at Fulton.

STATUS: The project was completed in 1940 at a cost of $88,000. It is part of the Comprehensive Red River below Denison Dam, Texas, Oklahoma, Arkansas, and Louisiana Project. Cumulative benefits from prevention of flood damages total nearly $650,000. About 5,000 acres of land at Fulton were protected against the highest flood of record in April 1945. About 4,100 acres of land were protected from flooding between April and June 1957. The following May another 3,800 acres were protected from overflow.

SPONSORS: Hempstead County Levee District No. 1.

9. Days Creek and Tributaries, AR and TX

DESCRIPTION: Improvements proposed in the survey report (House Document 94-647) provided flood protection in the Texarkana, Arkansas-Texas area. The plan provided for enlargement of certain reaches of Days, Nix, Swampoodle, Wagner, and Cowhorn Creeks to increase their carrying capacity and enforcement of flood plain regulations in areas which would remain subject to overflow.

STATUS: This project was authorized by the Water Resources Development Act of 1976 for Phase I Advanced Engineering and Design Planning, with the provision that "this shall take effect upon submittal to the Secretary of the Army by the Chief of Engineers and notification to Congress of the approval of the Chief of Engineers". The Chief of Engineers did not recommend the Days Creek project for construction because of a lack of economic feasibility. Before the Chief of Engineers reconsiders that recommendation, an economic reanalysis must be conducted. Funds to conduct this reanalysis were received in fiscal year 1979. The reanalysis was completed in 1983 and was limited to a review of the benefits analysis and project cost presented in the survey report dated April 1972. The reanalysis indicated a lack of economic feasibility.

SPONSORS: Miller County Court, Board of Directors, City of Texarkana, Arkansas; City Council City of Texarkana, Texas; and County Court, Bowie County, Texas.

Red River Basin, AR, LA, TX, and OK Comprehensive Study

DESCRIPTION: The study investigates measures for the control of floods; development of water supply, treatment, and conveyance facilities; irrigation; generation of hydroelectric power; development and enhancement of recreational potentials and enterprises of the region; improvements of the rivers for navigation and port site development where this would further industrial development at less cost than would the improvement of other modes of transportation; conservation and efficient utilization of land resources; and such other measures as may be found necessary to achieve the objectives of the study.

STATUS: Study authorized by PL 98-63, July 30, 1983. Reconnaissance studies which included the Red River Basin below Fulton area within Arkansas, were initiated in October 1983 by the Tulsa District, Southwest Division. The studies and report primarily focused on that portion of the Red River Basin within the Tulsa District. The Tulsa District completed the reconnaissance report in March 1985.

The feasibility studies, initiated April 1, 1985 (at full Federal expense), are concentrating on flood control, navigation and multipurpose development. Fiscal year 1986 studies focused on projects showing greatest need and economic potential for multipurpose development. Most of the fiscal year 1986 work effort involved consideration of plans for navigation along the Red River from Shreveport to the vicinity of Denison Dam.

SPONSORS: Not applicable.

Flood Plain Management Studies

Magnolia: City officials at Magnolia received a flood plain information report in December 1975 which involved Big Creek and Nations Creek and their tributaries.

Texarkana: A flood plain information study was completed in February 1974 at a cost of $29,000.

Texarkana, Texas-Arkansas: A flood plain study of Days Creek and tributaries in the Texarkana vicinity was presented to officials of Texarkana, Texas-Arkansas, in August 1970.

Table 3-21 lists Red River Basin below Fulton Corps of Engineers' projects completed or scheduled for completion from 1980 through 1986 by the Shreveport, LA, area office.

TABLE 3-21: CORPS OF ENGINEERS' PROJECTS
RED RIVER BASIN BELOW FULTON

Name of Project 1/	Red River Mile # (1967)	Structure Linear Ft.	Purpose of Structure
Young, AR, Revetment (RRE)	411.0-L	15,616	Preserve River Alignment
Tobe Revetment (RRBD)	408.0-R	7,638	Preserve River Alignment
Horseshoe Revetment (RRE)	407.0-L	3,800	Preserve River Alignment
Clipper Revetment (RRE)	406.9-R	10,500	Preserve River Alignment
Mo-Pac Revetment (RRE)	403-R	8,417	Stabilize Channel
Fulton, AR, Dikes (RRBD)	401.6-L	1,600	Preserve Levee and Bridge
Kuykendall Revetment (RRBD)	398-R	4,900	Preserve River Alignment
Bushy, AR, Revetment (RRE/RRBD)	397-L	5,100	Preserve Levee and Alignment
Boyd Revetment (RRE)	383.1-L	10,200	Preserve Mays Lake
Mays Lake, AR, Realignment (RRE)	381.5-L	4,310	Preserve Mays Lake
Kenny, AR, Revetment (RRE)	374	11,130	Preserve River Alignment
Spirit Lake, AR, Revetment (RRBD)	367.6-L	11,538	Preserve Levee & Stabilization
Field, AR, Revetment (RRBD)	362.0-L	14,800	Preserve Levee
Swan Lake, AR, Revetment (RRBD)	356.4-L	1,038	Preserve Channel
OK, AR, Revetment (DS) (RRE) 2/	347.4-R	approx. 8,000	Preserve Channel
Maniece Bayou Revetment (RRE)	352.5-L	5,100	Preserve River Alignment
Goose Lake Realignment (RRE)	351	11,500	Channel Alignment
Spring Bank, AR, Revetment (RRE)	335.5-L	4,900	Preserve Ferry Landing
Little River, AR, Revetment (RRE) 3/	405-L	13,556	Preserve River Alignment

RRE = Red River Emergency Bank Protection Project
RRBD = Red River below Denison Dam Project

1/ Unless noted, all of the listed projects are completed or scheduled for completion from 1980 through 1986.

2/ OK, AR, Revetment (Downstream Extension) is in the program for a construction contract award in September 1986.

3/ Currently Under Construction

Source: U. S. Army Corps of Engineers <39>

Legal and Institutional Setting

Surface Water in Federal Law

Federal laws which relate to surface water exist in this basin. The Clean Water Act was passed to improve or maintain water quality throughout the Nation. The Water Resource Planning Act was passed to provide coordinated planning of water and related land resources; and the Watershed Protection and Flood Prevention Act was passed to prevent damages caused by erosion, floodwaters, and sediment.

Water Pollution Control Act: This law was set up primarily to keep the pollution of water at a minimum, and is a direct descendent of the Refuse Act, which was set up to give the Corps of Engineers control of navigable streams. The Refuse Act generally prohibits the discharge of refuse into navigable waters of the United States, and prohibits discharges into tributaries of navigable waters, if the refuse floats or is washed into navigable waters. Further, the Refuse Act prohibits deposits on the banks of navigable waters and on the banks of tributaries, if the material is likely to be washed into the navigable water, either by ordinary high tide, storms, floods or otherwise, if navigation would thereby be impeded or obstructed. <15>

With the passage of the Water Pollution Control Act, Amendments of 1972 (P.L. 92-500, 33 U.S.C., Sec. 1251), the mission of regulation of water quality by the Environmental Protection Agency was greatly enhanced. In short, the Federal Water Pollution Control Act enabled the Environmental Protection Agency to further carry out the provisions of the Refuse Act by attempting to rid our streams and navigable waters of pollution deposited by industry and non-point pollution. The objectives of the 1972 amendment were to eliminate the discharge of all pollutants into the navigable waters of the United States by 1985. As a result of the passage of this Act, the Environmental Protection Agency was the administrator of our Nation's water quality programs and charged with the responsibility of enforcing existing laws and issuing additional regulations as needed to insure that our waters would remain unpolluted. <15>

Clean Water Act of 1977: Congress recognized the need to amend the Federal Water Pollution Control Act and did so with the Clean Water Act in 1977 (P.L. 95-217, 91 Stat. 1566, 33 U.S.C. 1251). This amendment extends the appropriations as set out in the original act and requires the Environmental Protection Agency to enter into written agreements with the Secretaries of Agriculture, Army and Interior to provide maximum utilization of the laws and programs to maintain water quality. It also deals with the processing of permits for dredged or fill material in any navigable waters of the United States. <15>

Water Resources Planning Act: Congress passed the Water Resources Planning Act, (P.L. 89-90, 79 Stat. 244, 42 U.S.C. 1962), as amended by P.L. 94-112, with the intention of providing for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources. This was achieved, partially, by the establishment of a Water

Resources Council in this Act. Additionally, financial assistance was to be afforded to the individual states in order to increase their participation in all phases of water resources planning. <15>

The responsibilities of the Water Resources Council, composed of the Secretary of the Interior, the Secretary of Agriculture, the Secretary of the Army, the Secretary of Health, Education, and Welfare and chairman of the Federal Power Commission, includes various assessments and reports to be made periodically. These reports, to be submitted biennally, are to report on and assess the adequacy of water supplies necessary to meet the water requirements in each water resource region in the United States. Another responsibility of the council is to continuously study and assess regional or river basin plans and programs to meet the requirements of larger regions of the Nation and administrative and statutory means for the coordination of the water and related land resources policies and programs of the several federal agencies. Recommendations are to be made to the President of the United States with respect to the Federal policies and programs being studied. <15>

Agriculture and Food Act: The RC&D program was authorized under Section 1528-1538 of Public Law 97-98. The purpose of the program which is administered by the SCS is to accelerate the conservation, development, and utilization of natural resources to improve the general level of economic activity, and to enhance the environment and standard of living in authorized RC&D areas. Authorized areas are locally sponsored areas designated by the Secretary of Agriculture for RC&D technical and financial assistance program funds.

Watershed Protection and Flood Prevention Act: This Act, (P.L. 83-566, 1954), declared the intention of Congress to be that a cooperative program should be in effect between the federal government and the states, their political sub-divisions, soil or water conservation districts, and other local public agencies for the purpose of preventing such damages caused by erosion, floodwaters, and sediment in the watersheds of the rivers of the United States. It allows and directs the Secretary of Agriculture to cooperate with the aforementioned entities in flood prevention matters. This act was passed to diminish damages in watersheds causing loss of life and damage to property, and for the purpose of furthering the conservation, development, utilization, and disposal of water and conservation and utilization of land. <15>

Surface Water in State Law

Water Rights: Arkansas water law is based on the old English common law as is the case in most of the humid Eastern States. Under the common law, the right to use water is incidental to ownership of riparian land - land adjacent to surface water or overlying groundwater.

Initially, the legal use of surface water was limited by the "natural flow" rule that each riparian landowner has the right to insist that the water in the stream continue to flow unimpaired in quality or quantity.

The courts have generally decided disputes over water according to a "reasonable use" test which allows each owner to use the water for his own purpose having due regard for the effect of that use upon other riparian owners and on the public in general. What is or is not deemed to be a reasonable exercise of riparian rights, of course, depends upon the circumstances of the case and the philosophy of the courts in the various jurisdictions.

Generally, the following criteria test the "reasonableness" of a given use:

1. The purpose of the use must be lawful and beneficial to the user and suitable to the stream involved;

2. The social utility of a proposed or existing use should be considered;

3. Use of the water must be made on riparian land (used by the riparian owner on land adjacent to the stream or lake);

4. The quantity of water diverted to the exclusive use of the riparian user must be viewed in light of the total flow;

5. The use must not pollute the water so as to significantly harm downstream riparian users;

6. The manner of flow must not be appreciably altered.

Specifically, the Arkansas Supreme Court has declared the following general rules and principles with regard to the reasonable use of water which is subject to riparian rights:

a. The right to use water for strictly domestic purposes--such as for household use--is superior to many other uses of water, such as for fishing, recreation, and irrigation.

b. Other than the use mentioned above, all other lawful uses of water are equal, (some recognized lawful uses are fishing, recreation, and irrigation).

c. When one lawful use of water is destroyed by another lawful use, the latter use must yield or it may be enjoined.

d. When one lawful use of water interferes with or detracts from another use, then a question arises as to whether, under all the facts and circumstances of that particular case, the interfering use shall be declared unreasonable and, as such, enjoined, or whether a reasonable and equitable adjustment should be made having due regard to the reasonable rights of each.

Arkansas statutory law authorized the Arkansas Soil and Water Conservation Commission to allocate surface water during periods of shortage and delineates priority of use during times of scarcity as (1) sustaining life; (2) maintaining health; and (3) increasing wealth.

Water Quality Management: The Arkansas Water Quality Management Plan provides tools by which water quality can be more effectively and efficiently managed. The provisions of the Federal Water Pollution Control Act, as amended, set forth requirements for the establishment of comprehensive statewide water quality planning programs. These programs are marked by three distinct phases of development. Phase I plans were completed in 1976 and provide, for each major basin in Arkansas, an identification of existing water quality problems, programs to control or eliminate those problems and an identification of major sources of water pollution within each basin. The Phase I Basin plans are often referred to as 303(e) plans and are available for review at the Department of Pollution Control and Ecology.

Phase II is defined as the planning, which occurred between 1976 and May 29, 1979, that focused upon the requirements of Section 208 of the Federal Water Pollution Control Act. Phase II planning is often referred to as the initial 208 planning effort. Phase III refers to the continuation of planning initiated under Phase II, including revisions of the initial 208 plan. Phase III planning was authorized by the 1977 amendments to the Federal Water Pollution Control Act (Clean Water Act).

Section 208 of the Clean Water Act directs the governor of each state to identify each area within the state which, as a result of urban industrial concentrations or other factors, has substantial water quality control problems. Section 208 of the Act provides for the designation of areas with substantial water quality control problems which are located in two or more states by the governors of the respective states. If an area fulfills the requirements for designation and the governor (or governors) fail to act, either by designating or determining not to make a designation, Section 208 (a)(4) of the Act provides that the chief elected officials of local governments in the area may designate the area by agreement.

The Governor of Arkansas subsequently designated the following agency in this basin:

1. June 1975 - ARK/TEX Council of Governments, portion of Miller County in Arkansas, and of Bowie and Cass Counties in Texas.

Institutional Setting

Federal and state agencies, as well as local organizations have various responsibilities in water resource management. The following sections describe the responsibilities and objectives of several of these organizations.

Federal Agencies:

1. The Soil Conservation Service (SCS) was established in the United States Department of Agriculture by Congress in 1935 to plan and carry out a national program to conserve and develop our soil and water resources. The mission of the SCS is to provide national leadership in the conservation and wise use of soil, water, and related resources through a balanced cooperative program that protects restores, and improves these resources. SCS directs efforts toward two national priorities:

A. Reduce excessive erosion on crop, range, pasture, and forest lands.

B. Conserve water used in agriculture, and reduce flood damages in small upstream watersheds.

Specific programs of the SCS relating to surface water include technical assistance which is provided to individuals and groups through conservation districts to conserve soil and water resources; water resources activities including watershed projects; river basin investigations; resource conservation and development; technical assistance for the Water Bank Program; and emergency conservation measures.

2. The Corps of Engineers, established in 1779 by Congress, has been assigned a broad range of civil works projects to develop, manage, and conserve the Nation's water resources. The Corps is heavily involved with water resource planning and development. Activities of the Corps include commercial navigation, hydroelectric power development, flood reduction, land and water recreation, irrigation, water supply, shore and beach erosion protection, hurricane protection, water quality management, and studies of urban area problems including wastewater management. In developing and managing water resources, the Corps seeks to balance the developmental and environmental needs of our country. <40>

3. The U. S. Geological Survey was established through legislation of 1879. In 1888 and 1894, legislation authorized the U.S. Geological Survey to survey irrigable lands in arid regions and provided funds for gaging streams and determining the water supply of the Nation. The mission of the U.S. Geological Survey is to provide hydrologic information needed by others and to appraise the Nation's water resources.

The water resources activities of the U.S. Geological Survey are diverse ranging from collecting data on the quantity, quality, and use of surface and groundwater to conducting hydrologic and water-related research. The Survey conducts water resources investigations and also acquires information useful in predicting and delineating water-related natural hazards from flooding, volcanoes, mudflows, and land subsidence.

4. The Environmental Protection Agency was formed in 1970, through executive action termed Reorganization Plan No. 3 which brought together several environmental programs. Enactment of new laws and important amendments to older laws in the 1970's greatly expanded EPA's responsibilities. The Agency now administers the nine comprehensive environmental protection laws listed below. <45>

A. Clean Air Act

B. Clean Water Act

C. Safe Drinking Water Act

D. Comprehensive Environmental Response, Compensation, and Liability Act (superfund)

E. Resource Conservation and Recovery Act

F. Federal Insecticide, Fungicide, and Rodenticide Act

G. Toxic Substance Control Act

H. Marine Protection, Research, and Sanctuaries Act

I. Uranium Mill Tailings Radiation Control Act

State Agencies:

1. The Arkansas Department of Pollution Control and Ecology (ADPC&E) has powers of regulation and enforcement over waters of the state through the authority of Act 472 of 1949. The activities of ADPC&E as they relate to water include making basin surveys, reviewing and approving waste treatment designs, administering funds for the construction of municipal treatment plants, monitoring streams for the construction of municipal treatment plants, monitoring streams to determine water quality, and conducting and sponsoring research. ADPC&E also has the responsibility of the state-level administration of the Clean Water Act mentioned previously. <15>

   ADPC&E has developed regulations to protect the waters of the state, and two of these regulations relate to surface water. One of the regulations was developed for the prevention of pollution by saltwater and other field wastes produced by wells while the second regulation was developed to establish water quality standards for the surface waters of the state.

2. The Arkansas Forestry Commission is the designated management agency for the silvicultural portion of Arkansas' Water Quality Management Plan. In that capacity the Forestry Commission has produced a phamphlet entitled, "Best Management Practices Guidelines for Silviculture," which is available upon request. <70>

3. The Arkansas Game and Fish Commission was established under authority of the Arkansas Constitutional Amendment 35, passed July 1, 1945. In summary, Section 1 of the Amendment, states that the AGFC is responsible for protecting the state's wildlife resources. The AGFC has developed numerous regulations to assist in the conservation and management of all fish and wildlife resources in the state.

4. Arkansas Act 81 of 1957 established the Arkansas Water Conservation Commission, now the Arkansas Soil and Water Conservation Commission. Primary functions given the Commission by this Act were:

   1. Regulate construction of facilities by permit to store surplus streamflow;

2. Inspection of permitted dams annually for safety and maintenance;

3. Allocation of water between persons taking water from streams during periods of shortage;

4. Gather data periodically on the use of surface water and the need;

5. Review petitions for the formation of regional water districts to utilize water stored in federal reservoirs; and

6. Register water diverted from streams, lakes, or ponds to assure proper allocation of water during periods of shortage.

Act 217 of 1969 authorized the Commission to develop the Arkansas State Water Plan which would serve as the state water policy for the development of water and related land resources in the state of Arkansas. All reports, studies, and related planning activities are required to take the State Water Plan into consideration. In 1975, the first State Water Plan was published. Work on revising the 1975 plan began in 1980.

Act 1051 of 1985 outlined many variables that needed to be quantified or delineated and included in the State Water Plan, expected to be released by late 1986. Some requirements of the Act were: (a) current and projected needs of public water supplies, industry, and agriculture; (b) define and quantify the safe yield of all streams, reservoirs and aquifers; (c) quantify requirements of fish and wildlife, navigation, riparian rights, and minimum stream flows. In addition, the act authorized interbasin transfer and non-riparian use contingent upon guidelines developed by the Commission and required all groundwater users to report the quantity of groundwater withdrawn on an annual basis. The Commission will now collect and compile groundwater use data in addition to surface water use data collection authorized by Act 180 of 1969.

Act 417 of 1985 will provide incentives for construction of surface reservoirs in the form of a state tax credit not to exceed 50% of the total construction cost or a maximum of $33,000 over an 11-year period. Any applicant that converts to surface water from groundwater sources may receive a tax credit equal to 10% of the total conversion cost. Persons seeking eligibility for the tax breaks must apply to Arkansas Soil and Water Conservation Commission for evaluation and acceptance.

5. The basin, like all others within the state, is entirely within the boundaries of conservation districts. Districts are legal entities of State Government and are funded in part from funds administered from the various quorum courts and from state funds administered by the Arkansas Soil and Water Conservation Commission. The major function of these districts, organized under authority of Act 197 of the General Assembly of the State of Arkansas in 1937, as amended, is to assist the owners and farm operators in developing individual land use plans on their farms.

These plans show necessary corrective methods, works of improvement and best management practices necessary to control soil erosion, improve surface water quality, lower floodwater and sediment damages, and further the conservation, development and utilization of soil and water resources. Each conservation district has entered into a memorandum of understanding with the U.S. Department of Agriculture and a supplemental memorandum of understanding with the Soil Conservation Service to provide them with the technical assistance. The Department of Agriculture administers a cost sharing program for certain on-farm conservation practices through county offices of the Agricultural Stabilization and Conservation Service.

Local Organizations: Irrigation, drainage, watershed improvement, and levee districts are formed to provide facilities for irrigation, drainage, flood control, recreation, fish and wildlife, and to prevent soil erosion and sediment damages. The districts, through their boards, may assess damages and benefits to all lands within a particular district. <15>

Drainage districts were formed to construct and maintain works of improvement. Drainage districts presently in existance are listed below. The county is shown in parenthesis.

1. Long Prairie (Lafayette)

2. Spirit Lake Drainage District of Red River Levee District (Lafayette)

3. Maniece Bayou Drainage District No. 1 and No. 2 of Red River Levee District (Lafayette)

4. Homan (Miller)

5. McKinney Bayou (Miller)

6. Garland (Miller)

7. Drainage District Nos. 1, 4, 5, 6, and 9 (Miller)

Watershed Improvement Districts are formed to sponsor and maintain watershed projects within their district under the SCS small watershed program (P.L. 83-566). There are no Watershed Improvement Districts currently within the basin.

Levee Districts operate and maintain Waterway Levee Improvement projects planned and constructed by the Corps of Engineers. The following Levee Districts are in the basin:

1. Miller County Levee District No. 2 (Miller)

2. Garland Levee District (Miller)

3. Long Prairie Levee District (Lafayette)

4. Red River Levee District (Lafayette)

The Rural Development Authority presently serves as the local organization for Lake Columbia which is the municipal water supply under construction for Magnolia, Arkansas.

SURFACE WATER RESOURCES PROBLEMS

To insure future productivity and economic growth, adequate water supplies must be available. The overriding policy of the Arkansas Soil and Water Conservation Commission in the area of water management is to insure Arkansans of sufficient water quantity with a quality satisfactory for the intended beneficial use. This basin has a diverse economic base which includes agriculture, forestry, and oil and gas production. Without adequate quantities of suitable water, these economic activities will suffer setbacks in current levels of production and increases in production may be impossible.

A series of public meetings were held within each conservation district to determine the public perception of problems and concerns associated with soil, water, and related resources. The meetings fulfilled the requirements of the Soil and Water Resources Conservation Act (RCA) passed by Congress in 1977. The Act directed the Secretary of Agriculture to conduct a continuing appraisal of the status and condition of our soil, water, and related resources. The purpose of RCA is to insure that programs administered by the Secretary of Agriculture for the conservation of soil, water, and related resources shall respond to the nation's long-term needs. Broad based participation in the RCA effort by groups, organizations, and the general public is a primary objective of the Act and is necessary to ensure that programs respond to the public needs. Included in the following list are those concerns and problems voiced by the public and various state and federal agencies. The categories of expressed concern within the basin were as follows: <1>

1. Flooding
2. Soil Erosion
3. Water Supply
4. Water Quality
5. Drainage
6. Food and Fiber
   Forestry (Non-Federal Land)
   Water Management

This basin has the potential to substantially increase water use. With straight line increases in water use by public supply and industry along with the maximum development of irrigated cropland, this basin could use a total of almost 470 MGD of water. The maximum development of irrigated cropland would require over 429 MGD of the total potential irrigation water need of the basin.

To increase profit margins and to insure against complete crop failure, landowners and operators are expected to increase investments for irrigation systems. Based on 1980 prices, investment cost for irrigation systems in this basin was $246 per acre. This is $73 more than the average for the state <29>. The conversion to irrigation of major crops has the potential to increase from 16,072 acres in 1980 to as much as 234,990 acres in 2030. (See Table 2-3)

Present problems within the basin are discussed in the following pages.

Surface Water Quantity Problems

Availability

As suitable quality ground water for all uses becomes less accessible in the Red River Basin below Fulton, a greater demand will develop for surface water. Surface water demands will stem mainly from irrigation of newly developed cropland and increased irrigation of existing cropland. The demand of surface water has been about half that of ground water in the past, but that trend is expected to reverse in the coming years. A large increase in surface water requirements in the basin would cause severe surface water shortages which could result in the deterioration of surface water quality and higher energy costs during dry periods.

The estimated irrigation demand for surface water in the basin could increase from 17.9 MGD in 1980 to 408.5 MGD in the year 2030. Although much more than 408.5 MGD of water flows through the basin each year, the majority of water is available during very low irrigation demand periods, and the minimum is generally available during peak use periods. As the demand for irrigation increases, the poor distribution of surface water in the demand-versus-availability may require users to develop alternative methods of obtaining adequate water supplies during low flows. These methods could include the development of additional offstream storage reservoirs, interception of water released from rice fields into drainage ditches, interception of tailwater from the irrigation of row crops, and interbasin transfer. Without the incorporation of these methods, shortages would soon develop in the areas of concentrated irrigation. As surface water demands increase, additional and more elaborate and expensive irrigation systems will be required.

The present primary surface water sources for irrigation in the Red River Basin below Fulton are the Red River, Kelly Bayou, Posten Bayou, McKinney Bayou, Maniece Bayou, and Bois D' Arc Creek. Shortages of available surface water do occur at times from these sources but in most areas some storage is available to provide adequate irrigation.

In 1984, eight separate water user entities registered with the Arkansas Soil and Water Conservation Commission for use of surface water primarily for irrigation from various basin streams. Increased irrigation demand may limit development by landowners who are not currently exercising their riparian right.

Flooding

Significant areas of the Red River Basin below Fulton are designated flood-prone. By definition flood-prone areas are, "areas adjoining rivers, streams, watercourses, bays, lakes, alluvial fans and plains, or other areas that in the past have been covered intermittently by floodwater or could be expected to be flooded in the future. Flood-prone areas are the approximate areas subject to inundation by a flood having an average recurrence interval of once in 100 years (floods having a 1 percent chance of occurring in any given year). <60> Likely sources of flood-prone areas are SCS project-type studies such as PL 83-566, Flood Prevention, River Basin, and Resource Conservation and Development. Other SCS sources are flood hazard studies, soil surveys, and aerial photographs of historic floods. Corps of Engineers' sources include flood plain information reports, special flood reports, local protection and flood control project reports. Additional sources are Housing and Urban Development flood insurance study reports; maps by U.S. Geological Survey, Corps of Engineers, and National Oceanic and Atmospheric Administration; studies by private firms and other units of government; U.S. Geological Survey flood-prone areas, quadrangle sheets, and hydrologic maps; stream gage data; and surficial deposits maps.

About 680,702 acres are located in the flood-prone areas of this basin. <38>. The entire 680,702 acres would flood and suffer severe losses if the 100-year frequency flood occurred. Table 3-22 shows the basin land use acres within the flood-prone areas.

TABLE 3-22: LAND USE OF FLOOD PRONE AREAS

RED RIVER BASIN BELOW FULTON

Land Use	Acres	Percent of Total
Cropland	146,450	21
Grassland	189,086	28
Forest Land	345,166	51
TOTAL	680,702	100

Source: USDA, Soil Conservation Service <38>

Many areas of the basin, especially cropland areas, are subjected to some flooding almost each year. The estimated annual damage to all land uses in the basin caused by flooding is 11.2 million dollars (1977 price base). <38> In addition to cropland, grassland, and forest land flood damage, damages occur to urban and other agriculture properties, highways, and utilities. These damages are estimated to be 6.5 million dollars annually and the total annual damages from flooding are 17.7 million dollars (1977 price base). <38>

Surface Water Quality Problems

General descriptions of each of two Water Quality Planning Segments located in the basin have been previously described in the Quality of Streamflow section. Locations of the segments are shown on Figure 3-17. Discussions of problems in each segment follow:

Segment 1A - Dorcheat Bayou and Bodcau Creek

This segment contains 189.7 miles of streams as reported by the Arkansas Department of Pollution Control and Ecology (ADPC&E).

Water quality data from ADPC&E's Arkansas Water Quality Inventory Report 1986 are summarized in Tables 3-23 and 3-24 for two sampling stations within the segment. <5>

TABLE 3-23 SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 15A 1/

DORCHEAT BAYOU EAST OF TAYLOR, ARKANSAS

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	18	17.4	28.0	3.0
Dissolved Oxygen (mg/l)	18	5.8	11.7	0.9
pH	17	5.8	6.7	5.1
Chlorides (mg/l)	18	49.8	101	19
Sulphates (mg/l)	19	7.8	11	6
Total Suspended Solids (mg/l)	18	10.8	28	2
Total Phosphorus (mg/l)	16	0.06	0.11	0.02
Nitrite+Nitrate-N (mg/l)	19	0.05	0.16	0.01
Turbidity, ntu	18	19.6	150	4.5
Fecal Coliforms/100ml	17	530	6000	10
Cadmium (mg/l)	17	0.70	1	0.5
Chromium (mg/l)	18	2.2	11	1
Copper (mg/l)	16	33.0	40	24
Lead (mg/l)	10	36.1	65	15
Zinc (mg/l)	13	53.6	134	33

1/ Data Collected from October 1983 to September 1985.

Source: Arkansas Department of Pollution Control and Ecology <5>

TABLE 3-24 SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 27 1/
BODCAU CREEK NEAR LEWISVILLE, ARKANSAS

Parameter	Number of Samples	Mean	Maximum	Minimum
Temperature, °C	22	18.2	28	3
Dissolved Oxygen (mg/1)	21	5.9	11.8	3.1
pH	21	6.1	6.7	5.4
Chlorides (mg/1)	22	41.5	97	10
Sulphates (mg/1)	22	7.7	12	2
Total Suspended Solids (mg/1)	22	11.2	27	1
Total Phosphorus (mg/1)	20	0.1	0.19	0.04
Nitrite+Nitrate-N (mg/1)	22	0.09	0.24	0.01
Turbidity, ntu	22	12.5	26	4.8
Fecal Coliforms/100 ml	21	185.4	925	4277
Cadmium (mg/1)	22	0.63	1	0.2
Chromium (mg/1)	22	1.5	3	1
Copper (mg/1)	20	31.6	47	15
Lead (mg/1)	14	28.5	50	11
Zinc (mg/1)	16	42	62	10

1/ Data Collected from October 1983 to September 1985.

Source: Arkansas Department of Pollution Control and Ecology <5>

The stream waters within this segment have been designated by the ADPC&E as suitable for the protection and propagation of fish and wildlife, primary contact recreation along with public, industrial, and agricultural water supplies. None of the waters in the segment support the designated use of primary contact recreation because of periodic levels of fecal coliform bacteria which exceed standards for this use. Sources of bacterial contamination have not been adequately identified but are common throughout the Gulf Coastal Region. <5>

In addition to high fecal coliform bacteria, the aesthetic quality of stream waters is poor due to the dark color and soft muddy stream bottom. In many streams, the leech is a common organism which discourages many swimmers. <4><5>

Chloride levels are 5 to 10 times higher than those in least-disturbed streams of the region but are not high enough to preclude beneficial uses. Total dissolved solids are similarly high. Water is slightly acidic during low flow periods and more acidic during higher flows. Concentrations of cadmium, copper, lead, and zinc are above ADPC&E guidelines but are not at levels that impact any of the designated uses. With the exception of short stream segments below point source discharges, water quality is generally suitable for municipal, industrial, and agricultural water supplies. Significant water quality trends include: (1) slightly declining dissolved oxygen concentrations on Bayou Dorcheat; (2) increases of 2 to 4 mg/1 annually in heavy metal concentrations; and (3) a slight annual decline in chloride concentrations. <4><5> Trends in metal and chloride concentrations are representative of the entire segment.

A review of the non-point pollution assessment summary for this segment reveals low erosion rates, no reported major modifications to stream alignment, and only minor sources of other non-point sources of pollution. Septic tanks are a potential pollution problem with over 95 percent of the area having soils with severe limitations for filter fields. The major problem appears to be slow infiltration rates in subsoils <18>.

An inventory of confined animal operations was conducted by the Soil Conservation Service in 1983. This inventory was limited to 22 Arkansas counties which contained the highest numbers of confined animals. Only results from portions of Segment 1A within Hempstead and Nevada Counties were included in this report. A summary of the numbers of confined animals in Hempstead and Nevada Counties is shown in Table 3-25. <32>

TABLE 3-25: SUMMARY OF CONFINED ANIMALS

SEGMENT 1A - HEMPSTEAD AND NEVADA COUNTIES

Type of Operation	Number of Operations	Annual Numbers of Animals Produced
Broilers	79	14,211,600
Layers	5	425,000
Breeders	8	179,450
Pullet Grow-Out	11	930,560
Swine	2	4,050
Dairy	2	95

Source: USDA, Soil Conservation Service <32>

Animal wastes from these operations are applied to agricultural lands (mostly grassland) as a source of fertilizer. The amount of nitrogen and phosphorus available for land application from confined animal waste operations in the segment totals 984 tons and 587 tons, respectively. These quantities equate to 2.68 tons of nitrogen and 1.60 tons of phosphorus per square mile within the portions of the segment that were included in the inventory. In comparison, the overall averages for the 22-county animal waste inventory area were 2.77 tons of nitrogen and 1.37 tons of phosphorus. <32>

Confined animal operators utilized on their own farms an average of 75 percent of the animal waste nutrients available for application. Most of the remaining waste was sold to neighbors for fertilizer. On land owned by confined animal operators, annual application rates of animal waste nutrients per acre averaged 105 pounds of nitrogen and 60 pounds of phosphorus. <32> These rates are well within agronomically recommended application rates for animal waste fertilizer, indicating that offsite nutrient transport from animal waste application areas are minimal. However, the high concentrations of fecal coliform bacteria observed in the segment may be influenced by animal wastes. Specific impacts of confined animal operations on water quality in the segment have not been documented.

Segment 1B - Red River, Sulphur River, and McKinney Bayou

Although only part of Segment 1B occurs in the Red River Basin below Fulton, discussions pertain to the segment as a whole because all waters within the segment ultimately flow into the basin and, therefore, influence water quality of the basin.

The segment contains a total of 389.6 stream miles as reported by the ADPC&E. Water quality data for the three sampling stations within the basin portion of Segment 1A are summarized in Tables 3-26, 3-27, and 3-28 directly from ADPC&E's Arkansas Water Quality Inventory Report, 1986. <5>

TABLE 3-26 SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 04A 1/

DAYS CREEK SE OF TEXARKANA, ARKANSAS

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	24	19.1	34.0	4.0
Dissolved Oxygen (mg/l)	22	4.7	8.1	.9
pH	23	7.2	7.6	6.4
Chlorides (mg/l)	22	84.3	225	16
Sulphates (mg/l)	23	32.0	55	10
Total Suspended Solids (mg/l)	24	27.7	207	6
Total Phosophous (mg/l)	21	1.5	3.7	.37
Nitrite+Nitrate-N (mg/l)	23	.32	.78	.03
Turbidity, ntu	22	19.7	110	6.0
Fecal Coliforms/100ml	18	1,074	5,800	4
Cadmium (mg/l)	23	.50	.6	.5
Chromium (mg/l)	23	3.0	7	1
Copper (mg/l)	22	26.8	55	11
Lead (mg/l)	19	26.2	220	2
Zinc (mg/l)	18	63.5	130	20

1/ Data collected from October 1983 to September 1985.

Source: Arkansas Department of Pollution Control and Ecology <5>

TABLE 3-27 SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 05 1/
SULPHUR RIVER SOUTH OF TEXARKANA, ARKANSAS

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	24	19.5	33.0	4.0
Dissolved Oxygen (mg/l)	22	8.0	12.8	5.1
pH	23	7.5	8.1	6.8
Chlorides (mg/l)	22	24.3	110	9
Sulphates (mg/l)	23	21.6	49	7
Total Suspended Solids (mg/l)	24	57.7	223	9
Total Phosphorus (mg/l)	21	.18	.79	.07
Nitrite+Nitrate-N (mg/l)	23	.20	.05	.04
Turbidity, ntu	22	42.5	100	8.0
Fecal Coliforms/100 ml	21	93.3	800	171
Cadmium (mg/l)	23	.54	1	.5
Chromium (mg/l)	23	2.3	6	1
Coppr (mg/l)	22	18.8	37	8
Lead (mg/l)	19	30.0	290	1
Zinc (mg/l)	18	39.5	81	6

1/ Data collected from October 1983 to September 1985.

Source: Arkansas Department of Pollution Control and Ecology <5>

TABLE 3-28 SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 09 1/
RED RIVER NEAR DODDRIDGE, ARKANSAS

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	24	19.2	32.0	4.0
Dissolved Oxygen (mg/l)	22	8.5	12.7	6.1
pH	24	7.7	8.2	7.4
Chlorides (mg/l)	22	73.3	204	10
Sulphates (mg/l)	23	57.2	165	9
Total Suspended Solids (mg/l)	24	135	371	33
Total Phosphorus (mg/l)	21	.17	.32	.09
Nitrite+Nitrate-N (mg/l)	23	.21	.36	.02
Turbidity, ntu	21	78.5	190	15
Fecal Coliforms/100 ml	21	145	860	4
Cadmium (mg/l)	23	.94	8	.5
Chromium (mg/l)	23	4.8	15	1
Copper (mg/l)	22	18.9	39	10
Lead (mg/l)	19	27.0	113	5
Zinc mg/l	18	36.7	92	3

1/ Data collected from October 1983 to September 1985.

Source: Arkansas Department of Pollution Control and Ecology <5>

The ADPC&E has designated the following uses for stream waters within the segment: habitat for fish, wildlife, and other aquatic and semi-aquatic life, primary and secondary contact recreation, and public, industrial, and agricultural water supplies. However, less than 10 percent of the stream miles within the segment support all of the designated uses. High fecal coliform bacteria concentrations are the major reason that most streams do not support all designated uses. The Red River is generally unsuitable as a drinking water supply due to high concentrations of chloride and total dissolved solids that are caused by runoff from salt flats in Oklahoma. These levels also occasionally impair use of water for agricultural purposes. Other waters within the segment, except Days Creek, are generally suitable for municipal, industrial, and agricultural water supplies. Poor water quality in Days Creek severely impacts fish and other aquatic life. <5>

Overall, water quality in the segment is generally poor, especially Days Creek and the Sulphur River which are impacted by the poor level of treatment of point source discharges and by runoff from oil fields. Numerous point source discharges also occur in the upper tributaries of Bois d 'Arc Creek. Many of the smaller streams are impacted by agricultural activities. The most noticeable water quality trend is a slight increase in metals concentrations during low and high flow periods. <5>

Non-point pollution in Segment 1B is much more significant than in Segment 1A. An estimated 697,900 tons of sediment are annually being delivered to watershed outlets in Segment 1B. Sediment originates as erosion which totals 2,302,911 tons annually. Sources and amounts of erosion from each source are shown in Table 3-29. <18>

TABLE 3-29: ANNUAL EROSION RATES BY SOURCE - SEGMENT 1B

RED RIVER BASIN BELOW FULTON

Erosion Source	Erosion (Tons Per Year)	Percent of Total Erosion
Road Surface	31,157	1.4
Road Bank	34,888	1.5
Gully	9,692	0.4
Streambank	232,274	10.0
Sheet and Rill	1,994,900	86.7
Total	2,302,911	100

Source: Arkansas Soil and Water Conservation Commission <18>

Of the soil loss, sheet and rill erosion comprises 86.7 percent. Cropland is responsible for 68.6 percent of the total sheet and rill erosion and 59.5 percent of the total of all types of erosion. (See Table 3-30) This is especially significant since cropland comprises only 24.3 percent of the total land area within the segment. Other significant sources of erosion include grassland and streambanks which comprise 20 percent and 10 percent of the total erosion from all sources. Average erosion rates on cropland and feedlots are excessive in terms of protecting the long-term productivity of the soil. Grassland erosion rates are not excessive in terms of protecting soil productivity, but with proper management, could be reduced from a present average of 2.33 tons per year to 0.5 ton per year.

TABLE 3-30: AVERAGE SHEET AND RILL EROSION RATES BY LAND USE - SEGMENT 1B

Land Use	Percent of Total Land Use	Average Sheet & Rill Erosion Rate (tons/acre/year)	Percent of Total Erosion
Cropland	24.3	7.19	68.6
Grassland	23.5	2.33	23.2
Forest Land	46.2	0.32	6.5
Urban & Built-Up	1.7	1/	0
Extractive	0.2	0.21	0
Water	3.0	0	0
Feedlots	0.3	15.21	1.7
Other Agriculture	0.8	0	0
TOTAL	100		100

1/ Erosion rate not computed.

Source: Arkansas Soil and Water Conservation Commission <18>

In addition to sediment, another non-point source pollutant is pesticides. In 1977, more than 600,000 pounds of active ingredients of pesticides were applied. <18> However, toxic forms of chlorinated hydrocarbons have not been found in sediment during the last two years. <5>

In 1977, over 50,000 tons of commercial fertilizers were applied in the segment. <18> A 1983 confined animal inventory of Arkansas' 22 counties was conducted by the SCS. This inventory revealed that 1,654 tons of nitrogen and 1,165 tons of phosphorus were annually applied as animal waste in the segment. This equates to 1.93 tons of nitrogen and 1.36 tons of phosphorus per square mile within the portions of the segment that were included in the inventory. In contrast, the average amounts of animal waste nutrients for the entire 22-county area were 2.77 tons of nitrogen and 1.37 tons of phosphorus per square mile. Confined animal operators used on their own farms an average of 84 percent of the animal waste nutrients available for application. Most of the remaining waste was sold to neighbors for fertilizer. On land owned by confined animal operators, annual application rates averaged 124 pounds of nitrogen and 84 pounds of phosphorus. These quantities are within presently accepted animal waste application rates, indicating minimal nutrient impacts to surface waters. Confined animal areas may be contributing to high fecal coliform concentrations during periods of high runoff. However, impacts of confined animals on water quality within the segment have not been adequately studied. Table 3-31 summarizes the types and numbers of confined animals in the segment. <32>

TABLE 3-31: SUMMARY OF CONFINED ANIMALS - SEGMENT 1B

Type of Operation	Number of Operations	Annual Numbers of Animals Produced
Broilers	88	19,639,000
Layers	10	1,548,300
Breeders	5	169,500
Pullet Grow-Out	8	726,360
Dairy	6	610

Source: USDA, Soil Conservation Service <32>

Data Base Problems

Irrigated Cropland

Additional information on irrigated cropland is needed for planning purposes. About 68 percent of the total water use in the basin in 1980 was for irrigation. In order to estimate the amount of irrigation water needed in the year 2030, the total irrigated acreage of each crop should be determined.

Information on irrigated cropland is difficult to obtain. The Agricultural Stabilization and Conservation Service (ASCS) reports rice acreages, and the Crop and Livestock Reporting Service reports estimates of irrigated crops from sampling procedures. The information is only available by county. For planning purposes, information should be reported by hydrologic boundaries (basins). The Soil Conservation Service reported irrigated cropland figures by basin for 1980 in its publication "Agricultural Water Use Study, Phase V, Arkansas Statewide Study" <29>; however, irrigated cropland was only reported for one year.

Reports on irrigated cropland in the Red River Basin below Fulton vary with individual reporting services according to the methods used to gather information. With such a variation in reporting of irrigated cropland, and the difficulty in obtaining information, there is a need for accessibility and consistency in the reporting of irrigated cropland.

Streamflow Data

Streamflow data are collected in the Red River Basin below Fulton by the monitoring of gaging stations in the area. Information for six continuous streamflow gaging stations (one in Arkansas, four in Louisiana, and one in Texas) was used in this report as the data base from which many of the mathematical computations were made. The gage in Texas is monitored by the Corps of Engineers and stage data is recorded in feet. Extrapolation of the gaging station data to other reaches on gaged streams and to other ungaged streams was necessary to determine streamflow characteristics, instream flow requirements, and excess streamflow for the basin. Some error may be introduced into the computations when data are extrapolated, particularly if knowledge of the basin characteristics and the effects of man-made practices are limited.

Due to the limited number of stream gaging stations in the basin (only one in Arkansas), streamflow characteristics for most streams are not well-defined. The Sulphur River entering Arkansas has been regulated since 1956 by the Texarkana Reservoir which is used primarily for recreation. Releases from the reservoir vary from 0 to 15,000 cubic feet per second. The Red River has been significantly regulated since 1943 by Lake Texoma and partially regulated more recently by the construction of Millwood Reservoir in 1966. Bodcau Creek below Lake Erling is subject to some regulation by Lake Erling, constructed in 1956.

Additional stream gages on streams in the basin would be invaluable for collecting and analyzing data especially in areas of intensive farming. Gages on Posten, McKinney, and Maniece Bayou would provide better coverage for determining more accurately the available water supplies for future irrigation and other water requirements.

Diversion Reporting

Annual registration of surface water diversions has been required since the passage of Act 180 of 1969 to amend Act 81 of 1957. All surface water diversions are included except diversions from lakes or ponds owned exclusively by the diverter. Diversion registration is a necessary tool in the planning process for maximum development of the state's water resources. Reporting is beneficial when periods of shortage make allocation necessary. No penalty for non-registration is assessed. However, should allocation become necessary, diverters who are registered may receive preference.

Registration does not constitute a water right. This misconception could be the cause of some extremely high reported use rates. Should a period of allocation become necessary, the portion of the available water to be allowed each registered riparian user would be based upon need and not exclusively on past water use reports. More care should be taken to give an accurate report of water use.

Some diverters choose not to report because they are either not familiar with the diversion registration requirements, or they disregard the law due to the lack of a penalty (other than during allocation). In addition, some diverters initially report, but fail to report in subsequent years even though reporting is required annually.

Determining Instream Flow Requirements

The Arkansas Soil and Water Conservation Commission was 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 such as industry, agriculture, and public water supply in the state of Arkansas. When these needs and future water needs are determined for each basin, the water available for other uses can be determined.

At the present time, limited information is available to quantify instream flow requirements for streams in the Red River Basin below Fulton. Problems for each of the instream flow categories are described below:

(1) Water quality - The $7Q_{10}$ stream discharge has been established as the instream flow requirement for water quality by the Arkansas Department of Pollution Control and Ecology. However, the low flow characteristics have been determined for only a few sites in the Red River Basin below Fulton.

(2) Fish and wildlife - A new method, called the Arkansas method, has been developed by Filipek and others <22> to determine instream flow requirements for fish and wildlife. The instream flow requirements determined by the Arkansas method were used in the computations of excess streamflow, however, the Arkansas method is theoretical and has not been verified with collection of field data.

Instream flow requirements determined by the Arkansas method were not applicable for use in determining minimum streamflows in the basin. Minimum streamflow is defined as the lowest discharge that will satisfy <u>minimum</u> instream flow needs. Instream flow requirements determined by the Arkansas method represent flow requirements for "excellent" fisheries habitat.

(3) Navigation - Instream flow requirements for navigation have not been established for navigable streams in the Red River Basin below Fulton by the Corps of Engineers.

(4) Interstate compacts - The interstate compact requirements have been defined in the Red River Compact and the flows required to satisfy the Compact have been identified.

(5) Aquifer recharge - Instream flow requirements necessary to recharge the aquifers in the Red River Basin below Fulton were not investigated or computed for this report.

(6) Riparian use - Riparian use is recorded in the Arkansas Soil and Water Conservation Commission files of registered diversions. As previously stated, water use reporting poses some problems. Since the water has already been removed from the stream, however; quantification of the amount of water diverted is not required for the determination of excess streamflow in the basin.

(7) Aesthetics - Although the importance of aesthetic value in the Red River Basin below Fulton is recognized, specific minimum instream or terrestrial needs were not addressed in this report. Identification of concerned species furnished by the Arkansas Natural Heritage Commission have been listed in this report. Possible adverse effects on aquatic and terrestrial biota should be evaluated before action, which would disrupt the natural biological and physical processes, is taken.

Critical Surface Water Areas

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) 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 30 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.

With the exception of the Red River, stream gaging data are not available in the basin; therefore, defining critical surface water areas in the Red River Basin below Fulton using available streamflow data is not possible. However, discussions with SCS employees and farmers in the basin have provided some insight regarding streamflow characteristics and water use problems. According to these reports, basin streams such as McKinney, Posten, and Maniece Bayous, serving as sources for irrigation, have significantly reduced flows during summers due to natural streamflow variability. Farmers depending upon these flows for irrigation, resort to increased pumping of ground water or if available, the withdrawal of water from drainage ditches. Generally, the drainage ditch water is of inferior quality to that found in the bayous. Also, the increased ground water pumping has resulted in some deterioration of ground water quality and supplies. In a few areas of the basin, ground water wells are currently producing higher concentration of chlorides due to excessive pumping.

Many basin farmers are reluctant to withdraw water from the Red River for irrigation purposes because of the possibly harmful effect on crops and soils. The runoff characteristics and variable stream flow rates of the Red River preclude the prediction of chloride concentrations and total dissolved solids (TDS) at any given time. Constant monitoring would be necessary to maintain up-to-date water quality information to protect the crops.

Regardless of the potential risk involved, some farmers have elected to use Red River water for irrigation. The long term effect that Red River water usage has on plants and soils is the subject of a cooperative study now being conducted, in an effort to assist these farmers, by the SCS and the University of Arkansas.

To alleviate the uncertainty of adequate supplies of suitable quality water during peak irrigation demands, a few farmers have developed off-stream or on-farm storage capability. Other farmers with similar demands are beginning to develop this same capability. Off-stream storage consists of reservoirs constructed on level terrain or across natural draws and filled from sources such as natural runoff, diversions, drainage ditches or ground water pumped during periods of minimum irrigation demands.

To assist in determining the existence of critical surface water areas in the Red River Basin below Fulton, the estimated demand for irrigation water in the year 2030 was compared with the expected water availability. Irrigated cropland in the basin by the year 2030 has been estimated at 235,000 acres. Estimated acreage of crops grown are: soybeans, 181,440 acres; rice, 34,860 acres; and cotton, 17,570 acres. Dr. James Ferguson, Associate Professor of Agriculture Engineering at the University of Arkansas, has provided the information pertaining to total water used per crop per month. These values are shown in Table 3-32.

From Table 3-33 it can be seen that the maximum irrigation water demand is during August when monthly flow in all streams is generally at a minimum. Ignoring the distribution and water quality factors, the mean monthly flow of the Red River at Fulton during August is 6,239 cubic feet per second. If all of the basin irrigation needs of 3,964 cfs were withdrawn from the Red River, there would be 2,275 cfs remaining for other needs such as fish and wildlife.

Because of the uncertainties that exist regarding the determination of critical surface water areas in the basin, designation of such areas are not appropriate at this time. Erroneous conclusions made from presently available limited data could undermine future planning or development in the basin. Instead, it is suggested that additional research be conducted to analyze the additional specific data necessary for making accurate assessments.

TABLE 3-32: CROP WATER USE PER MONTH
RED RIVER BASIN BELOW FULTON

Crop	Month	Depth (Inches)	Total (Inches)
Rice	June	17	36
	July	10	
	August	9	
Soybeans	June	0.5	18
	July	6.5	
	August	9	
	September	2	
Cotton	June	3.5	18
	July	9	
	August	5.5	

Using the above data, the total irrigation water requirements by month were computed and are shown in Table 3-33.

TABLE 3-33: IRRIGATION WATER DEMAND IN THE YEAR 2030

RED RIVER BASIN BELOW FULTON

Crop	Acres	Month	Irrigation Depth (Inches)	Water Used (ac-ft/mo.)	Water Used (cfs)	Water Required at 70% Irrigation Efficiency (cfs)
Rice	34,860	June	17	49,385	830	
Soybeans	181,440	June	0.5	7,560	127	
Cotton	17,570	June	3.5	5,125	86	
	Subtotal			62,070	1,043	1,490
Rice	34,860	July	10	29,050	474	
Soybeans	181,440	July	6.5	98,280	1,602	
Cotton	17,570	July	9	13,178	215	
	Subtotal			140,508	2,291	3,273
Rice	34,860	August	9	26,145	426	
Soybeans	181,440	August	9	136,080	2,218	
Cotton	17,570	August	5.5	8,053	131	
	Subtotal			170,278	2,775	3,964
Soybeans	181,440	September	2	30,240	508	
	Subtotal			30,240	508	726
	Total			403,096		

SOLUTIONS AND RECOMMENDATIONS

Arkansas has the reputation of having an abundance of water. However, experience has shown that water is not always available when needed, nor of the quality necessary for existing or future needs. Increases in population, industrial activity, and irrigation have resulted in significant annual increases in water demand. In addition, water use in this basin has the potential to dramatically increase during the next 50 years.

As mentioned earlier, about 14 million acre-feet of surface water are available in the basin on a yearly basis. Even with the amount of water available, this valuable resource is not inexhaustible nor is it exempt from misuse or poor management. Every possible effort must be made to protect and enhance the surface water in this basin.

Surface water quantity and quality problems need to be addressed. Solutions and recommendations to surface water quantity problems include alternate water sources such as water storage reservoirs and the possible interbasin transfer of water. Accurate reporting of water use, along with flood prevention and floodplain management, are needed. Additional information on instream flow requirements and gaging station are also recommended. Best management practices (BMPs) can be used to reduce the water quality problems in this basin, and watershed protection projects can help implement BMPs in agricultural areas. Water conservation, if practiced throughout the basin, will provide more water in the basin and of a higher quality.

Surface Water Quantity

Availability

At the present time, a sufficient supply of surface water to meet the surface water demands in the Red River Basin below Fulton is available. For irrigation purposes, the demand is being met from irrigation wells, runoff in the numerous streams, tailwater in drainage ditches, flow in the Red River, and withdrawals from surface water off-stream reservoirs. When ground water quality or quantity diminishes, other surface water sources are developed at considerable more construction and maintenance expense. Some farmers near the Red River are currently developing irrigation capability from the Red River due to chloride concentration in irrigation wells.

Farmers in the basin will have to adapt to supplemental water sources as irrigation demands increase. These are not limited to, but may include: (1)extensive off-stream or on-farm storage capability; (2)greater usage of Red River water; (3)more extensive and efficient irrigation systems; (4)interbasin transfers through formulation of irrigation districts; and (5) significant storage of surface water during periods of high flows to be used during low flow periods.

Off-stream storage is currently being incorporated in irrigation schemes by many of the basin farmers. As other farmers are able, they are likely to develop this source for use in their present irrigation systems.

Although some farmers have initiated use of the Red River for irrigation, long term effects on soil and crops have not been determined. If Red River water quality proves suitable for irrigation, it will provide an important surface water source for many other farmers.

Farmers are developing more efficient irrigation systems and methods as investment capital becomes available. This is expected to continue as irrigation demands rise.

Interbasin transfers, under the guidance of organized irrigation districts, could better distribute the supply of higher quality water. For example, investigations for transferring the high quality excess water from the Little River in the Red River Basin above Fulton to the Red River Basin below Fulton could be considered.

In addition to interbasin transfers, irrigation districts could develop large storage facilities for conserving surface water streamflow and watershed runoff during periods of surplus to be distributed during periods of surface water shortages.

Applications have been submitted for drainage and outlet improvement work under various public law or flood control acts on Posten Bayou, Kelly Bayou, McKinney Bayou, Maniece Bayou, and Garland City. Some improvement work has been completed, however, most projects have been temporarily suspended due to lack of local support or feasibility. The increase of irrigated acreage in the basin could result in greater local support for reactivating these proposed improvement projects.

Also, as ground water supplies diminish and quality deteriorates, municipal and industrial entities look to surface water supplies for meeting their requirements. The city of Magnolia is nearing completion of a 2,600 surface acre M & I reservoir for use in lieu of deteriorating groundwater supplies. The reservoir (Lake Columbia) is located on Beech Creek 8 miles west of Magnolia.

It is not possible to accurately determine the current or potential water availability and demand for each sub-basin without extensive investigations. A Cooperative River Basin Study is needed to accurately identify the current and future water demands, the water quantity and quality available, and the most feasible methods of distributing and conserving surface water supplies. Since Act 1051 of 1985 authorizes interbasin transfer of surface water in Arkansas, the Cooperative River Basin Study should compare water availability in this basin and adjacent basins. Comparisons would also consider water quality, flood reduction, fish and wildlife enhancement, recreational opportunities, and watershed protection.

Governmental Assistance

Act 81 of 1957 gave the Arkansas Soil and Water Conservation Commission the power to allocate surface water during periods of shortage. This is an emergency measure to be used to uniformly distribute surface water to riparian landowners. Act 1051 of 1985 allows the Arkansas Soil and Water Conservation Commission to authorize the transportation of excess surface water to nonriparians for their use. The ASWCC is also authorized to contract, with participants in a transfer project, a specific quantity of water for a specific period of time at a reasonable price to cover the transportation of the water. This new law will allow such projects as the transfer of water from one basin to another basin. Such transfers will allow more equitable use as well as improve the quality of water in basins by dilution of non-point pollutants. An increase in flow and quality will also improve the fish habitat.

The construction of additional on-farm or off-stream storage reservoirs would be of considerable benefit to Red River Basin below Fulton farmers. Act 417 of 1985, as amended, allows a tax credit for the construction or restoration of water impoundments or control structures having a capacity of 20 acre-feet or more.

They are designed for the purpose of storing irrigation water used to produce food and fiber as a business, (excluding aquaculture) and for domestic, or industrial purposes. A maximum credit of $3,000 per year is allowed for a maximum of 11 years or until 50% of the cost is recovered. To qualify, a taxpayer must obtain a construction permit from the ASWCC, or provide proof of exemption from the permit per the requirements of Act 81 of 1957, as amended. Guidelines have been developed by the ASWCC.

Flooding

Flooding and drainage problems can be solved by either structural or non-structural measures. Structural solutions include such measures as channel work and flood water detention dams. Non-structural solutions relate to land treatment measures and floodplain management. Non-structural solutions are probably the most viable alternatives in most areas of the basin since only three watersheds are considered to be potential structural watershed projects (see USDA and U.S. Corps of Engineers Projects).

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) within the Federal Emergency Management Agency (FEMA). The Arkansas Soil and Water Conservation Commission is the coordinating agency for Arkansas.

Act 629 of 1969, enacted by the Arkansas General Assembly, authorizes the cities, towns, and counties, where necessary, to enact and enforce floodplain management which will curtail losses in flood-prone areas.

Flood insurance is available from private insurance firms at reasonable rates. Rural residents who reside in Miller and Howard Counties in the basin have the opportunity to participate in this program. Urban residents who reside in towns identified as having flood hazard areas may also insure their property.

Quality of Surface Water

Surface water quality for agriculture and other purposes varies in the Red River Basin below Fulton. Water quality samples from Lake Erling show the lake to be of a very high water quality suitable for primary contact recreation. The proposed Magnolia, Arkansas M&I water supply (Lake Columbia) located on Beech Creek has been approved by the Arkansas State Health Department for contact recreation use. However, pollution in the form of sediment, plant nutrients, chemicals, pesticides, and M&I wastes has caused some streamflow water quality to be unsuitable for agriculture and other beneficial uses without incorporating precautionary measures or even extensive treatment. Numerous oil and gas fields located in the basin could be a prime source of contamination without adhering to rigid preventive practices.

The Arkansas Department of Pollution Control and Ecology has developed Regulation No. 1 for the prevention of pollution by saltwater and other field wastes produced by oil or gas wells in new fields or pools. This regulation attempts to prevent the saltwater from polluting the "waters of the state."

Implementation of recommended "Best Management Practices" should reduce non-point pollution sources and enhance the environment by improving water quality throughout the region. It is expected that fish habitat will significantly improve in Red River, Mercer Bayou, Sulphur River, and Middle Bayou Dorcheat.

Best Management Practices (BMPs)

The following Best Management Practices for each of the non-point pollution sources listed below are recommended by the local conservation districts. These practices may or may not be considered as all inclusive.

Agricultural BMPs

1. Conservation cropping systems
2. Contour farming
3. Crop residue management
4. Grassed waterways
5. Diversions
6. Terraces
7. Soil testing and plant analysis
8. Field Borders
9. Field Drains
10. Minimum tillage or no-till
11. Establishment and management of permanent pasture and hayland
12. Waste management systems
13. Ponds
14. Spring development
15. Fencing
16. Water Control Structures
17. Poultry disposal sites
18. Water management
19. Irrigation systems
20. Land grading and smoothing
21. Tailwater recovery systems
22. Crop rotations
23. Cover cropping
24. Correct pesticide use
25. Correct pesticide container disposal
26. Debris basins
27. Vegetative filter strips
28. Critical area treatment
29. Brush and weed control
30. Pipedrops
31. Levees
32. Integrated pest control
33. Land use conversion
34. Rotation grazing

Forestry BMPs

1. Critical area planting

2. Tree planting
3. Woodland site preparation
4. Minimize mechanical damage
5. Woodland improvement
6. Livestock exclusion
7. Proper grazing use
8. Firebreak
9. Traffic barriers
10. Correct pesticide application
11. Proper construction and maintenance of roads
12. Selective harvesting
13. Streamside management zone

<u>Construction BMPs</u>

1. Diversions
2. Mulching
3. Grade stabilization structures
4. Debris basins
5. Critical area planting
6. Save topsoil for re-use
7. Traffic barriers
8. Access road design
9. Limited soil disturbance
10. Water control structures
11. Roadside stabilization on existing roads
12. Lined waterways
13. Site planning and proper timing of operations
14. Temporary vegetative cover
15. Conservation of natural vegetation
16. Grassed waterways

<u>Subsurface Disposal BMPs</u>

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

<u>Urban Runoff BMPs</u>

1. Grade stabilization structures
2. Critical area treatment
3. Grass waterways
4. Structures for water control
5. Sediment basins

6. Permanent vegetative cover
7. Flood control structures
8. Mulching
9. Diversions
10. Ponds
11. Lined waterways
12. Water management

Mining BMPs

1. Critical area planting
2. Grass waterways
3. Mine land reclamation
4. Diversions
5. Reshaping strip mines
6. Terraces
7. Temporary vegetative cover
8. Grade stabilization structures
9. Spoilbank spreading
10. Mulching
11. Sediment basins
12. Stockpile topsoil and replace
13. Revegetate bare areas
14. Mandatory reclamation plans for new mines

Hydrological Modifications BMPs

1. Grade stabilization structures
2. Dikes
3. Streambank protection
4. Construction of irrigation reservoirs
5. Irrigation return systems
6. Surface drainage
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. Dam, flood water retarding
13. Rock lined waterways
14. Stream channel stabilization
15. Floodways
16. Critical area planting

Residual and Land Disposal Sites BMPs

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. Country-wide refuse disposal plan
10. Roadside stabilization

Roads BMPs

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. For unpaved roads, use surface material with low content of erosive particles
13. Elimination of regular use of road grader for maintenance work
14. Turnouts

Streambank BMPs

1. Grade control structures
2. Streambank protection
3. Water control structures
4. Streambank vegetation including trees
5. Reshaping banks
6. Rock rip-rap
7. Water retarding structures
8. Concrete mats
9. Sediment basins

Gully BMPs

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. Flood retarding structures

As a result of BMP installations, wildlife habitat will be enhanced because of improved cover and diversity throughout the region. It will be particularly improved in the vicinities of the Red River, Mercer Bayou, Sulphur River, and Middle Bayou Dorcheat.

Animal waste application practices including optimized application rates and composting of animal wastes before application will result in improved soil tilth and fertility. These practices will also improve water quality by keeping nutrients in the soil where they can be utilized by plants, rather than being leached into the ground water or washed into streams.

It will cost an estimated 140 million dollars to install the recommended BMPs in the basin. <18>

Watershed Protection

Although not a significant problem as yet in this basin, almost 2 million tons of sheet and rill erosion are occurring each year. About 67 percent of the basin is forest land; however, only 14 percent of the sheet and rill erosion is occurring on forest land. About 63 percent of the sheet and rill erosion is occurring on cropland which occupies 11 percent of the basin. <38> Watershed protection projects on cropland establish land treatment measures to reduce erosion, sediment, and runoff.

When funds are available, 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. Practices might include such BMPs as conservation tillage, terraces, or even land use conversion. Participation within the watershed is voluntary.

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. <36>

The SCS completed the Crow Creek Watershed (St. Francis County) Plan/Environmental Assessment, Arkansas' first watershed protection plan in 1986. Currently, the SCS has received authorization for developing four other watershed protection plans in Arkansas. An additional watershed has been authorized for flood prevention and watershed protection. Areas with potential for watershed protection projects are watersheds containing highly erodible, fragile soils eroding at excessive rates.

Highest erosion rates in the basin occur in the McKinney Bayou, Posten Bayou, and Maniece Watersheds which lie adjacent to the Red River. The erosion rates of soils in these sub-basins are 5 tons per acre per year and the three combined watersheds deliver almost 400,000 tons of sediment to their respective outlets each year. Applications for assistance in these watersheds have been previously submitted but later placed on inactive status. With the exception of Kelly Bayou, which is administered from Louisiana and presently inactive, no other watershed treatment proposals are under consideration in this basin.

Conservation

Water conservation has not been overly emphasized in this basin because of the high average annual rainfall as observed at three recording stations (Hope, 56.74 inches; Magnolia, 50.33 inches; and Stamps, 50.83 inches). However, water conservation is essential to the future well-being of all Arkansans. Although not sufficient in itself, conservation does offer, at least in part, a means of helping to alleviate some of the basic problems.

Drought periods within the basin emphasize the need for conservation. While the average annual rainfall in the area is high, the erratic monthly rainfall patterns cause some streamflows to cease and storage reservoirs to dry up or become marginally low for most uses. Conservation practiced during dry periods and the sense of emergency that prevails during droughts are soon forgotten in times of plentiful rainfall.

Agriculture

Only 11 percent of the land in this basin is cropland; however, irrigation accounts for about 68 percent of the total water use within the basin. (See Table 3-12) Rice accounted for 60 percent of the total irrigated acreage in 1980 within this basin. (See Table 2-3) Without adequate water for irrigation, farmers would be forced to produce different crops requiring smaller amounts of water. On-farm profits would be lowered and the economy of the basin would be adversely affected.

Since agriculture is the largest user of water in this basin, irrigation water management should be initiated on all agricultural water use. 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. The water conservation practices are each discussed in the following paragraphs.

Infiltration Rates: Water is conserved for agricultural use when rainfall infiltrates the soil and is stored for plant use at a later date. High infiltration rates increase the amount of water that can be stored in the soil. Infiltration of water into the soil may be increased by two methods: (1) practices that keep soil pore space to a maximum; 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 decrease evaporation. Cover crops, when planted, are also effective in maintaining high infiltration rates.

The soil surface may be altered to allow for more time for infiltration. 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 will allow more time for infiltration.

Delivery Systems: Delivery systems used in the basin consist of about 27 miles of earthen irrigation canals, 23 miles of underground pipelines, 29 miles of above ground pipes (gated pipe), and about 2 miles of temporary ditches. <29>

It is advantageous to replace earthen canals with pipelines. The typical earthen canal will lose from 10 to 40 percent of the total volume of water pumped through the canal; however, an underground pipeline should have virtually no water losses. (See Table 3-34.) Replacing canals with pipelines will eliminate seepage and evaporation losses while also reducing labor and system maintenance.

Pipelines also require less land area than canals and allow more positive control in water management. Irrigation water supplied through pipelines will be available for use at the precise time and location it is needed. As delivery systems are upgraded to conserve water, effective methods of applying irrigation water should be chosen to obtain high efficiencies.

TABLE 3-34: ESTIMATED WATER LOSSES IN AGRICULTURAL SYSTEM COMPONENT

Component	Estimated Range of Water Loss (Percent)
Delivery System	
Canal-Main	40 - 10
Pipe-Main	5 - 0
Field Canal	40 - 10
Portable Pipe	10 - 0
Underground Pipeline	0 - 0
Application Method	
Furrow (without return)	70 - 15
Furrow (with return)	20 - 5
Levee (without return)	60 - 20
Levee (with return)	20 - 5
Traveling Sprinkler	25 - 10
Center-Pivot Sprinkler	25 - 10
Solid Set or Portable Set	25 - 10
Drip Irrigation	15 - 5

Source: USDA, Soil Conservation Service <27>

Application Methods: The greatest single on-farm saving of water can be accomplished by selecting the most suitable irrigation application method. Contour levee irrigation and furrow irrigation are the two most common methods of applying water to crops in the basin.

In 1980, about 47 percent of irrigated acreage in the basin was irrigated by contour levee irrigation, and about 26 percent of the irrigated acreage was irrigated by furrow irrigation. Other methods and approximate percentages of total irrigated acreages are: sprinkler methods - 16 percent, level border - 10 percent, and other methods - 1 percent. <36>

Factors to consider when choosing an application method include slope, soil type (infiltration and permeability), crop, as well as, water, and labor availability. Choosing the proper application method is the first step in obtaining high application efficiencies.

Application Efficiency: Application efficiency depends on the uniform application of the water at a proper rate at the proper time. Application efficiencies for furrow and contour levee irrigation average about 50 percent, with a range of 30 to 85 percent efficiency. Water losses from furrow irrigation without return systems range from 15 to 70 percent. With return systems, losses range from 5 to 20 percent. Losses from contour levee irrigation without return systems range from 20 to 60 percent, while losses from contour levee methods with return systems range from 5 to 20 percent. (See Table 3-34) <29>

Application efficiency can be increased if the water is applied at a uniform depth over the entire field. Over-application to the upper end of the field causing water loss by deep percolation is a common problem with furrow irrigation; however, methods such as furrow diking and surge irrigation help to obtain uniform applications.

Precision land leveling and land smoothing are practices that modify the soil surface to allow for a more uniform application increasing application efficiencies. Water can be saved 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 flood will cover the entire field.

As mentioned earlier, about 16 percent of the irrigated acreage was irrigated using sprinkler methods of application. Sprinkler methods of irrigation are more efficient than gravity methods without return systems, ranging from 75 to 90 percent efficiency. <29> Evaporation losses from sprinklers are normally 5 to 10 percent of the total discharge. High efficiencies are dependent upon climatic factors such as wind and heat. The most popular type of sprinkler irrigation is the center-pivot system, and its use is on the increase. Water savings may result when gravity methods of irrigation are replaced with sprinkler methods of irrigation; however, the high cost of conversion must be considered.

Application efficiencies can be increased significantly on gravity methods of irrigation by installing tailwater recovery systems (return systems). As shown in Table 3-34, both furrow and contour levee irrigation are much more efficient with return systems. The reuse of irrigation water captured in tailwater recovery systems not only conserves water, but keeps chemically concentrated water from degrading receiving streams.

Irrigation Scheduling: Regardless of the method of application, irrigation water must be applied in the proper amounts and at the proper time to obtain high efficiencies. Irrigation scheduling allows the irrigator to apply water only when the crop needs it, but in sufficient quantities to satisfy crop requirements.

Important factors in irrigation scheduling are soil properties, plant characteristics, weather, and management practices. Important soil properties include texture, depth to a restricting layer, available water holding capacity, infiltration, and permeability. The type of crop, drought tolerance, and root depth are important plant characteristics while temperature, wind, relative humidity, and rainfall are important climatic factors. Management practices are the farming practices the operator employs and include planting dates, short or long season crop varieties, and row spacing. If all factors are considered, an efficient irrigation schedule may be developed.

Some specific equipment is needed in irrigation scheduling. Moisture monitoring equipment is used to determine how much and when water is needed. Tensiometers, gypsum blocks, feel methods, speedy moisture testers, and nuclear moisture gauges are the most popular moisture monitoring techniques. Flow meters, flumes, or weirs are installed to determine how much total water is, or can be, pumped onto the field. With this equipment, an irrigation schedule may be developed, implemented, and application efficiency may be determined.

Engineering Planning: An overall engineering plan can make maximum use of available water and be very economical. Irrigation and drainage of individual fields must be carefully planned to fit in 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 their outlets, location and size of pipes for water control, and location of wells.

With ground water levels declining, surface water sources are very desirable. A portion of the least productive land can be converted into a reservoir to recover tailwater, and an irrigation storage reservoir developed. Water will be conserved by recovering tailwater and additional water will be available for irrigation by storing winter runoff in the reservoir. Pumping costs will be significantly reduced in most areas by pumping from surface reservoirs rather than wells. Although the initial construction cost is expensive, state tax credits are now available through Act 417, "The Water Resource Conservation and Development Incentives Act of 1985."

Public Supply

About 8.2 million gallons of water per day was used for public supply purposes in 1980. (Table 3-12) This use represents about 13 percent of the total water use in the basin; therefore, significant amounts of water can be conserved by individuals if water conservation is practiced at home.

Several water-saving techniques include installing water-use restrictors, checking for leaks, and watering lawns during the coolest part of the day.

Self-Supplied Industries

Self-supplied industries used a total of 3.7 million gallons of water per day in 1980. (Table 3-12) Some industries may be able to reduce the amounts of water they use by substituting or altering their production procedures. The water used by industries in this basin shows a decreasing trend over the past 10 years. Industries will respond to the increased cost of water treatment by practicing conservation methods. Water conservation is expected to increase also as technology improves. <24>

Wastewater Reuse and Recycling

Wastewater or sewage effluent discharged by municipalities and industries should be recognized as a valuable resource that can be reused or recycled to help meet growing water requirements. Advantages of reuse are savings in money and energy, particularly in the cost of treating wastewaters to make them acceptable for discharge. Due to the availability of high quality water, most municipalities have not sought to develop a market for treated wastewater, rather, wastewater is disposed of as quickly as possible. <24>

Water Pricing

As with any other commodity, increasing the price is a proven and effective means of reducing water consumption. Pricing techniques to encourage the conservation of water rely primarily on the premise that as the price increases, the quantity purchased decreases. The effect of such a price change on quantity is called demand elasticity. A substantial elasticity exists in the demand for water. The price affects the amount consumers will demand. As the price goes up, consumers will use less water. <24>

Data Bases

Irrigated Cropland

The U. S. Department of Agriculture has three agencies involved in reporting irrigated cropland. The Agricultural Stabilization and Conservation Service reports rice acreages while the Crop and Livestock Reporting Service reports irrigated cropland based on sampling procedures. Water resource management is a major function of the Soil Conservation Service, and the SCS has published a report entitled "Agricultural Water Use, Phase V, Arkansas Statewide Study". <29>

A joint effort is needed between these three agencies to accurately report irrigated cropland periodically for planning purposes. Through such an effort, accurate and consistent information will be developed and enhance water resource planning in the state.

Streamflow Data

One solution to the lack of streamflow gaging station data in the Red River Basin below Fulton would obviously be to install more gaging stations on streams in the basin. Gages on Posten Bayou, Maniece Bayou, and McKinney Bayou, for example, would be particularly helpful in defining streamflow characteristics within the basin.

Another solution to the problem of limited streamflow data would be to develop a regionalization technique for statistically estimating discharges for sites on streams where data are limited. Development of a regionalization technique for determining low flow characteristics of streams would be extremely helpful since extrapolation of low flow information to ungaged areas can result in unreliable estimates of low flow discharges. Low flow information is necessary for use in the State Water Plan for determining safe yield of streams, instream flow requirements for water quality, minimum streamflows, and critical use areas. A suitable regionalization technique has not been developed for Arkansas at this time. A report by Hines <64> provides an alternative to a regionalization method; however, this technique is limited since it requires several low flow discharge measurements at each ungaged site to estimate the low flow characteristics. A regionalized low flow investigation would provide a method to determine low flow characteristics of streams in Arkansas through the use of regression equations which would extend the usefulness of the present gaging-station network.

Diversion Reporting

Surface water diversion reqistration was required by Act 180 of 1969. The diversion reports have been useful to determine water use in the state. The importance of the report was magnified by Act 1051 of 1985 requiring the Arkansas Soil and Water Conservation Commission to determine the water requirements of riparian landowners. Without diversion registrations this determination would prove costly and time-consuming. The determination of the amount of water used by riparians is necessary to insure that over-utilization of a stream or lake does not occur or if over-utilized, to what degree.

One solution to the problem of non-reporting or one-time-only reporting of diversion information is to amend the current law to include a penalty, other than non-preference in allocation proceedings. A fine large enough to be an incentive to registration should be considered. Also, the Arkansas Soil and Water Conservation Commission should be able to make adjustments to reports that appear inaccurate. This would not be used to grant water quantity rights. It would only be used for planning purposes to accurately determine water use.

Determining Instream Flow Requirements

Determination of instream flow requirements for water quality, fish and wildlife, aquifer recharge, and interstate compacts for streams in the Red River Basin below Fulton is a problem at the present time. Accurate quantification of the amount of water in the Red River Basin below Fulton available for other uses is not possible until instream flow needs are more closely identified.

The criteria for water quality flow requirements has been established by ADPC&E, but the low flow characteristics have been determined for only a relatively small number of sites in the Red River Basin below Fulton. One possible solution to this problem would be the development of a regionalization technique for statistically estimating low flow discharges for sites on streams where data are limited.

The instream flow requirements for fish and wildlife have been addressed by Filipek and others <22> using the Arkansas method. The accuracy of the Arkansas method could be verified by a study of instream flow requirements using the Instream Flow Incremental Methodology (IFIM) developed by the U. S. Fish and Wildlife Service. This methodology may also be applicable for the determination of minimum instream flow requirements for fish and wildlife.

Section 5.05 of the Red River Compact describes apportionment of the Red River flow between the four involved (signatory) states. The compact also sets forth the restricted usage of Red River water by each state as the river flow decreases to specific rates. Severe testing of the Compact use restriction of the Red River has not, as yet, occurred.

Aquifer recharge requirements have not been incorporated in this report. To further develop aquifer recharge and depletion characteristics in the Red River Basin below Fulton, additional data should be generated for interpretation.

Summary

To summarize the surface water conditions in the Red River Basin below Fulton, most of the water problems center around the marginal quality of much of the available water. Pollution problems within and outside the basin, in general, are detrimental to existing water use entities such as municipal, industrial, rural domestic, livestock, and irrigation; to the propagation of fish and wildlife; and to recreational activities. The pollution problems also result in degradation of aesthetics and the general environment.

The most extensive and serious pollution problems occur in the Upper Red River basin from natural brine emissions and brine discharges of oil field operations. However, development of measures, exclusive of salt control, such as conservation land treatment measures and treatment of waste material, will have a major affect on improvement of water quality in the Red River below Fulton for potential water use.

CHAPTER IV

GROUND WATER

INTRODUCTION

Cretaceous, Tertiary and Quaternary Age aquifers in the Red River Basin below Fulton contain freshwater. Cretaceous rocks are limited to the extreme northern part of the basin and are overlain to the south by southeasterly dipping Tertiary formations. Quaternary alluvium and terraces cover much of the southern and western part of the basin.

In the Red River Alluvial Plain and the Gulf Coastal Plain, layers of sediment have accumulated over long periods of time to form the unconsolidated deposits as they exist today. Fine-grained materials (silt and clay) which yield little or no water to wells are dominant in the geologic column. However, several thick sections of sand, and sand and gravel are sources of ground water for public supply, irrigation and industry. In addition, several small lenses of sand and gravel serve as sources of supply for small, domestic wells.

Quaternary Age deposits cover a significant part of the basin and form a relatively thin layer on the surface. They contain abundant supplies of ground water and constitute one of the most important aquifers in the basin. The Red River alluvial deposit, which averages about 17 miles wide and extends the length of the lower basin for 40 miles, is the largest Quaternary deposit in the basin.

Quaternary deposits overlie Tertiary sediments which dip to the southeast. The Tertiary System includes major aquifers such as the Sparta Sand Formation of the Claiborne Group as well as several other minor aquifers. Most of the minor aquifers are sandy near their outcrop zones and yield water to wells in those areas.

Ground water withdrawal data are provided for four basin counties (Columbia, Hempstead, Lafayette, and Miller). Howard and Nevada Counties make up only about seven percent of the total basin area.

Ground water withdrawals within the four county area in 1980 totaled approximately 39 million gallons per day (MGD). Pumpage from the Quaternary Aquifer (22.7 MGD) and the Sparta Sand (8.5 MGD) accounted for 80 percent of the ground water withdrawn from all aquifers in 1980. The remainder was withdrawn from six other units as follows: Cane River (4.8 MGD), Nacatoch Sand (2.0 MGD), Cockfield (0.4 MGD), Wilcox Group (0.4 MGD), and the Carrizo Sand (0.3 MGD). (See Table 4-1) <12>

The largest percentage of ground water withdrawn in the four county area was used for rice production (48.4 percent). Other crops used 12.5 percent. Withdrawals for self-supplied industry and public supplies were 8.6 percent and 14.8 percent respectively. Most of the water was withdrawn from Lafayette and Miller counties. <12> Ground water withdrawals by aquifer are presented in Table 4-1 and ground water withdrawals in the four-county study area by use in 1980 are shown in Figure 4-1 and Table 4-2.

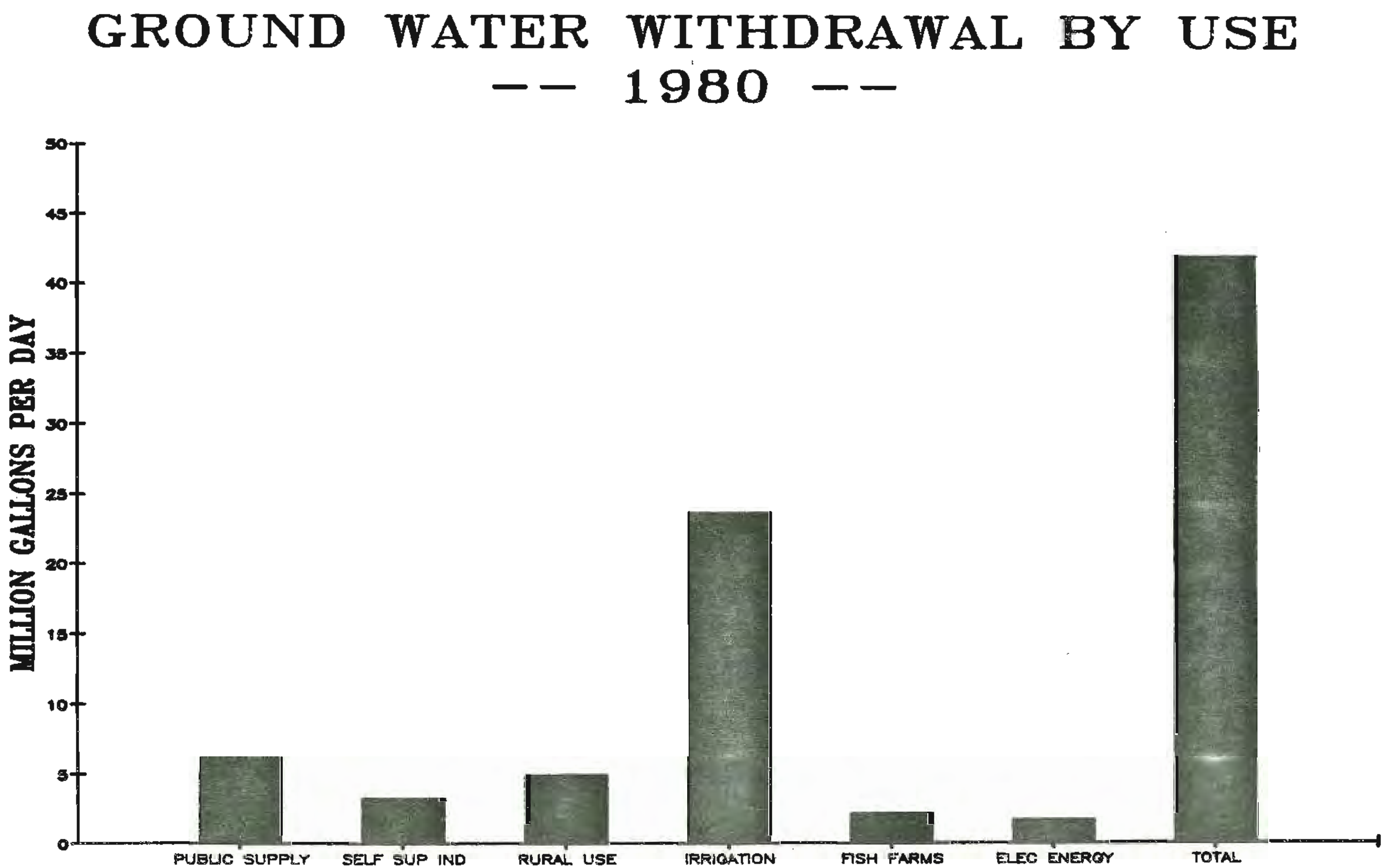
TABLE 4-1: GROUND WATER WITHDRAWALS BY AQUIFER - 1980
(million gallons per day)

Aquifer	Columbia	Hempstead	LaFayette	Miller	Totals
Quaternary	-	-	18.88	3.86	22.74
Cockfield	0.38	-	-	-	0.38
Sparta Sand	7.22	-	0.46	0.80	8.48
Cane River	0.16	-	3.68	0.92	4.76
Carrizo Sand	-	0.10	-	0.18	0.28
Wilcox	-	0.10	-	0.31	0.41
Nacatoch	-	1.98	-	0.06	2.04
Totals	7.76	2.18	23.02	6.13	39.09 1/

1/ Total excludes 3.0 MGD from Tokio Formation in Hempstead County outside the basin.

Source: U.S. Geological Survey, Use of Water in Arkansas 1980 <12>

Figure 4-1



SOURCE: U.S. GEOLOGICAL SURVEY FILE DATA.

Table 4 - 2: GROUND WATER WITHDRAWALS BY USE - 1980

County	Public Supply MGD	Public Supply Percent of County Total	Self-Supplied Industry MGD	Self-Supplied Industry Percent of County Total	Rural and Domestic Use MGD	Rural and Domestic Use Percent of County Total	Irrigation: Rice MGD	Irrigation: Rice Percent of County Total	Irrigation: Other Crops MGD	Irrigation: Other Crops Percent of County Total	Fish and Minnow Farms MGD	Fish and Minnow Farms Percent of County Total	Electric Energy MGD	Electric Energy Percent of County Total	Total MGD
Columbia	2.66	34.3	2.87	37.0	1.06	13.7	-	-	.07	<1.0	1.10	14.2	-	-	7.76
Hempstead	2.56	49.4	.01	<1.0	1.85	35.7	-	-	.74	14.3	.02	<1.0			5.18 1/
LaFayette	.80	3.5	.19	<1.0	.66	2.9	15.27	66.3	3.77	16.4	.65	2.8	1.68	7.3	23.02
Miller	.20	3.3	.23	3.8	1.41	23.0	3.42	55.8	.47	7.7	.40	6.5	-	-	6.13.
Total	6.22		3.3		4.98		18.69		5.05		2.17		1.68		42.09
Percent of Total	14.8		7.8		11.8		44.4		12.0		5.2		4.0		100

1/ Total includes 3.0 MGD from Tokio Formation in Hempstead County outside the basin.

Source: U.S. Geological Survey, Use of Water in Arkansas, 1980 <12>

Water from the Sparta Sand is suitable for most municipal, industrial, agricultural, and domestic uses with little or no treatment necessary. Water from other aquifers in their outcrop zones and a few miles downdip is also suitable for most purposes. Water from the Quaternary deposits is used primarily for agricultural purposes.

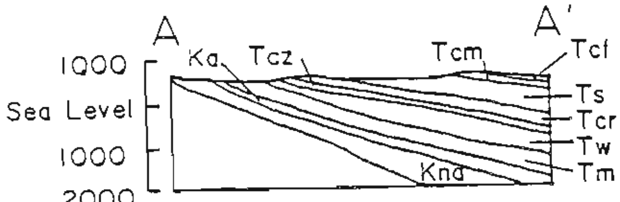
Several factors affect water quality in the formations of the basin. Most beds emerged from a marine environment saturated with mineralized water. Precipitation infiltrating recharge zones tends to flush connate water downdip. Furthermore, as water moves downdip, more minerals are dissolved. Both processes result in formations that yield high quality water near the recharge area and more mineralized water downdip. Overpumping of the ground water may induce saltwater contamination of fresh water aquifers especially in the coastal plain area.

A generalized geologic map (Figure 4-2) shows the surface location of the various geologic units in the basin. The Quaternary deposits are generally found in an area within a few miles of the Red River. The older Tertiary and Cretaceous deposits, which underlie the alluvium and terraces, are shown in a cross-section drawn along line A-A' from northwest to southeast.

Table 4-3 displays a generalized geologic column. This table lists the formation or sub-division, thickness, lithology, and water-bearing characteristics of each geologic unit in the basin.

Figure 4-2

GENERALIZED GEOLOGIC MAP

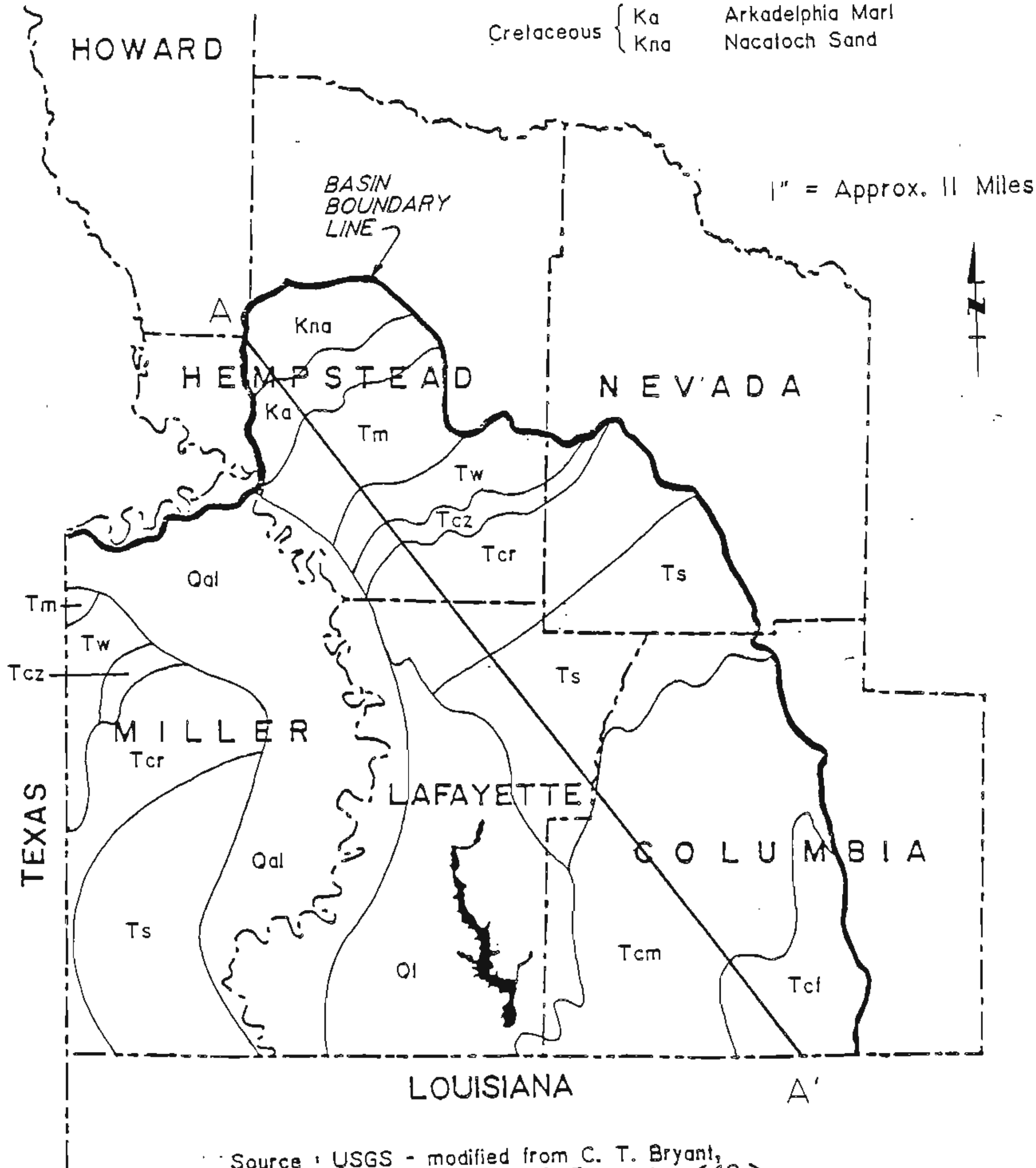


GEOLOGIC CROSS SECTION

EXPLANATION

GEOLOGIC UNITS

Quaternary	Qal	Quaternary Alluvium
	Ql	Quaternary Terrace Deposits
Tertiary	Tcf	Cockfield Formation
	Tcm	Cook Mountain Formation
	Ts	Sparta Sand
	Tcr	Cane River Formation
	Tcz	Carrizo Sand
	Tw	Wilcox Group
	Tm	Midway Group
Cretaceous	Ka	Arkadelphia Marl
	Kna	Nacatoch Sand



Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris, <49>

TABLE 4-3: GENERALIZED GEOLOGIC COLUMN AND WATER-BEARING CHARACTERISTICS OF DEPOSITS

(Water-bearing characteristics: Small yields, 0-50 gpm; moderate yields, 51-500 gpm; large yields, >500 gpm)

Era	System	Series	Group	Formation or Subdivision	Thick-ness (feet)	Lithology	Water-bearing characteristics
Cenozoic	Quaternary	Holocene Pleistocene		Alluvium - - ? ? ? - - Terrace deposits	0-90	Gravel, sand, silt, and clay	Yields moderate to large supplies of hard water to irrigation wells in the Red River Valley.
	Tertiary	Eocene	Claiborne	Cockfield Formation	0-200	Fine lignitic sand and carbonaceous clay	Mainly a source of domestic water supply. Yields small supplies of water to wells in Columbia County.
				Cook Mountain Formation	0-150	Clay, with some silt and fine sand	Not known to yield water to wells.
				Sparta Sand	0-250	Stratified sand, clay and lignite	Yields moderate supplies of water to wells in Columbia, Miller, and Lafayette Counties.
				Cane River Formation	0-400	Sand, clay, glau-conite, lignite, and ironstone	Yields moderate to large supplies of water to wells in Miller, Lafayette, and southern Nevada Counties, and small supplies of water to wells in Columbia County. Contains saline water in Columbia County.
				Carrizo Sand	0-120	Massive-bedded sand	Yields moderate supplies of water to wells in Miller and Lafayette Counties and southern Hempstead and Nevada Counties.
			Wilcox	Undifferentiated	0-400	Interbedded sand, clay, and lignite	Yields small supplies of water to wells in northern Miller and Lafayette Counties and in southern Hempstead and Nevada Counties.
		Paleocene	Midway	Undifferentiated	0-600	Massive-bedded calcareous clay	Not known to yield water to wells.
Mesozoic	Cretaceous	Upper		Arkadelphia Marl	0-150	Calcareous clay and limestone	Not known to yield water to wells.
				Nacatoch Sand	0-400	Sand in upper part; calcareous clay and sand in lower part	Yields moderate supplies of water to wells in northern Miller, Hempstead, and Nevada Counties.

Note: Cretaceous Age formations below the Nacatoch Sand do not yield fresh water to wells in the basin.

Source: U.S. Geological Survey, Water-Supply Paper 1998 <58>

GEOLOGIC UNITS AND THEIR GEOHYDROLOGIC PROPERTIES

Quaternary Deposits

Geology

Approximately half of the surface material in the Red River Basin below Fulton is alluvium or terrace deposits of the Quaternary System. Where these deposits are present, they are always on the surface.

The Quaternary can be divided into the Holocene (Recent alluvium) and the Pleistocene (terrace) Series. The terraces are older but usually are located at higher elevations than the alluvium. In some areas the alluvium and the terraces are highly dissected, consist of slightly different materials, and function as independent aquifers. In other areas the two units are indistinguishable, and with a basal zone connection, can be treated as one hydrologic unit. Generally, the terrace and alluvial deposits are less than 90 feet thick. <58>

Hydrology

The Quaternary Aquifer is the single most important aquifer in the basin. About 58 percent of the ground water used in the study area in 1980 was withdrawn from Quaternary deposits. The quantity used within the study area (22.7 MGD) was almost three times the quantity withdrawn from the second most important aquifer, the Sparta Sand. <12>

In 1980, 83 percent of the Quaternary withdrawals was from Lafayette County and 17 percent was from Miller County. Use has increased in Lafayette County from 4.6 MGD in 1965 to 18.9 MGD in 1980. In Miller County use has increased from 1.7 MGD in 1965 to 3.9 MGD in 1980. <9, 11, 12>

Approximately 56 percent of the total ground water withdrawn from all formations in 1980 (42 MGD) was used for irrigation. Fourty-four percent (18.7 MGD) was used to irrigate rice and 12 percent for other crops.<9, 11, 12>

The importance of the Quaternary aquifer is mainly due to the high yields of fresh water that can be obtained at relatively shallow depths. The aquifer is capable of yielding more than 500 gallons per minute (GPM) in properly constructed wells. Yields within the basin, range from a few gallons per minute to more than 500 GPM, depending on permeability and saturated thickness of the deposit.

Movement of water within the Quaternary aquifer is regionally controlled by the gentle southeastward slope of the Red River Alluvial Plain. Locally, movement is away from or toward streams depending on the season, and toward areas of large withdrawal. <57>

Precipitation is the principal source of recharge to the Quaternary aquifer. Water percolates through the upper fine-grained layers at rates dependent on the permeability of the materials. The aquifer is also recharged from rivers and streams during periods of high flow, and by upward movement of water from units of Tertiary Age beneath the alluvium where the head is higher than that in the alluvium. Recharge varies seasonally. This is reflected in seasonal changes in water levels. <57>

Quality

Water quality in the Quaternary aquifer is generally good. Limitations include a high degree of hardness and local areas of high iron and chloride concentrations.

Chemical analyses of water samples collected from the alluvium in Miller County show hardness (as $CaCO_3$) averages 519 mg/l, an indication the water generally is very hard (greater than 180 mg/l). Chloride concentrations of 198 mg/l have also been measured in Miller County. (See Table 4-4) <58>

Other constitutents and properties of the water do not limit its usefulness. The water is a calcium bicarbonate type and, if treated to remove the iron and reduce the hardness, would be suitable for most uses. The water generally is suitable for irrigation, except in the area near Garland City, Miller County, and Spirit Lake in Lafayette County where the aquifer has been contaminated by oil-field brines. <58>

Chemical analyses of water from wells in the terrace deposits indicate the water is hard (more than 120 mg/l of $CaCO_3$) but otherwise is of good chemical quality. The iron content of the water is variable but generally is less than 0.3 mg/l. <58>

Claiborne Group

The Claiborne Group of Middle Eocene Age crops out over about one-third of the Red River Basin below Fulton, mostly in the eastern and southern portions. The Group has been divided into the Cockfield, Cook Mountain, Sparta Sand, Cane River and Carrizo Sand Formations. These formations were near shore deposits and consist of variable amounts of clay, sand and silt. Generally, the beds are not well-defined due to lateral gradations in lithology. The resulting lenticularity makes identification of individual beds difficult. <47>

Cockfield Formation

The Cockfield is the uppermost and youngest formation in the Claiborne Group. The formation is limited to the southeastern portion of the basin, occurring only in the southern half of Columbia County. Thickness of the formation ranges from 0 to 200 feet. Composition of the Cockfield Formation changes laterally with lenticular beds of sand, silt, clay and thin lignite interbeds. Most of the sand is fine to medium-grained, gray and brown. The clays are usually dark brown, dark gray, and green with thin lignitic layers. <58>

Because of its limited existence in the basin, the Cockfield Formation is not an important source of ground water based on withdrawals in 1980. Withdrawal of waters from the Cockfield Formation within the study area in 1980 amounted to only 0.38 million gallons per day. This quantity represented about 1 percent of the total ground water withdrawn in the study area. Water from the Cockfield Formation is chemically suitable for most purposes without treatment. <12> <58>

Cook Mountain

The Cook Mountain Formation is limited to the southeastern part of the basin occurring only in Columbia County. The formation is underlain by the Sparta Sand and is overlain by the Cockfield Formation.

The formation is primarily composed of carbonaceous clay, lignite, and lenticular beds of sand with the amounts varying considerably depending on the mode of deposition. Thickness of the formation ranges from 0 to 150 feet thick, and dip of the beds is generally oriented east and southeastward.

The Cook Mountain Formation is relatively impermeable due to the fine-grained character of the deposits and is not an aquifer in this basin. However, it is important because the confining character of the bed retards vertical movement between the Sparta and Cockfield Formations and limits Sparta recharge to the Sparta outcrop area. <65> <58>

Sparta Sand Formation

Geology

The Sparta Sand is overlain by the Cook Mountain Formation and underlain by the Cane River Formation. The Sparta crops out in portions of Miller, Lafayette, Columbia, and Nevada Counties. Much of the outcrop is overlain by Quaternary alluvial and terrace deposits. <57>

South-eastward from the outcrop area, the Sparta becomes buried deeper under progressively younger formations. The formation reaches a thickness of about 300 feet in southeastern Lafayette County and is composed of gray fine to medium sand, brown and gray sandy clay, and lignite. Lenses of lignite in the formation, as much as 2 feet thick, are exposed in the side of a bluff at Spring Bank in southern Miller County. Local drillers identify the Sparta Sand in well borings by its "salt and pepper" appearance. <12>

Hydrology

Based on withdrawals, the Sparta Sand is the second most important source of ground water in the basin. This is primarily due to the large yields of good quality water that can be obtained from the formation in the southern part of the basin. <12> <58>

Withdrawals from the Sparta Formation within the study area in 1980 totaled 8.5 million gallons per day representing 20 percent of the total ground water withdrawn from all aquifers in the study area. Withdrawals increased 29 percent from 1975 (6.6 MGD) to 1980 (8.5 MGD). From 1970 to 1975, no significant changes in withdrawal rates from the Sparta Sand occurred. <7, 9, 12>

Water from the Sparta Sand is used primarily for public supply and self-supplied industry. The Sparta Sand water is used for these purposes because the high yields and high quality require little or no treatment for use. <14> <12> Yields average about 400 GPM in the basin and commonly range from about 100 GPM near the outcrop area to as much as 500 GPM in the southern and eastern parts of the basin. Many variables affect yields of wells penetrating the Sparta Sand. The two most important are the permeability of the sand in the formation and thickness of the unit. <8, 58, 59>

While it is generally accepted that the sand beds in the Sparta are hydraulically connected due to overlapping and have one potentiometric surface, many beds may act as independent aquifers for short distances. Locating ancestral stream channels where the percentage of sand and thickness of the unit is large appears to be the key to higher yielding wells tapping the Sparta Sand. <21, 23, 58>

Water movement on a large scale within the Sparta aquifer is generally southeastward in the direction of dip. Recharge is primarily from precipitation and percolation in the outcrop area. Except where significant withdrawals have occurred, water in the Sparta Sand is contained under artesian pressure and rises above the top of the formation in cased wells that are screened in the sand. On a small scale, movement is along ancestral flow-ways, down gradient, and toward areas of large withdrawal. <59> <58>

The average well depths and the average depth to water vary considerably over the basin depending on many factors discussed previously. Water levels in the Sparta Sand range from about 10 feet to more than 260 feet below land surface. The greatest depths to water are in wells near Magnolia in Columbia County, whereas, in southern LaFayette County, reported water levels are a few feet below the land surface. A well in the Sparta Sand near the Walker Creek settlement in southeastern Lafayette County is reported to have flowed for several months after it was drilled in 1960. <58>

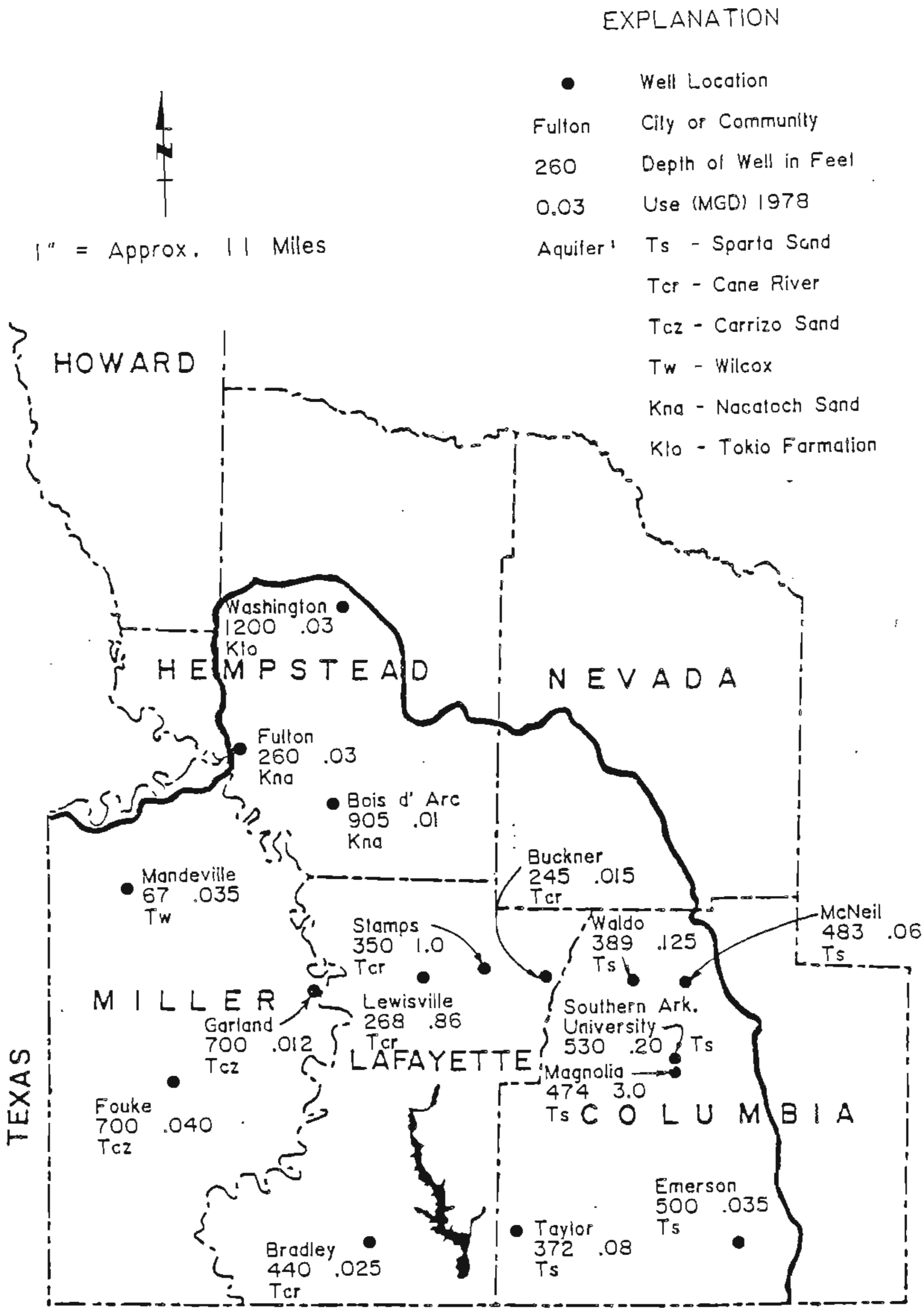
Quality

The Sparta Sand contains, throughout the basin, fresh water generally suitable for most purposes with only minimal or no treatment required. Water from the formation is a soft or moderately hard sodium bicarbonate type, low in dissolved solids and chloride content but generally high in iron. Iron concentrations of water from the Sparta Sand are as much as 2.76 mg/l. Drillers and city officials report that high iron concentrations are present in many places. For example, water from the Sparta Sand at the town of Bradley reportedly contains more than 5 mg/l of iron. <58>

Locations of public supply wells are shown on Figure 4-3. Six communities or cities in the basin currently use water from the Sparta Sand for public supply. Chemical analyses of samples taken from non-municipal wells is presented in Table 4-4. Water quality data for these wells in addition to public supply wells in underlying aquifers are shown in Table 4-5.

Figure 4-3

LOCATIONS OF PUBLIC SUPPLY WELLS



Source: Arkansas Soil and Water Conservation Commission, 1978. <14>

TABLE 4-4: CHEMICAL ANALYSES OF SAMPLES TAKEN FROM NON-MUNICIPAL WELLS

AQUIFER	NUMBER OF SAMPLES	COUNTY	YEAR	TEMP (°C)	COLOR (platinum cobalt units)	SPECIFIC CONDUCTANCE (umho)	pH	BICARBONATE (HCO_3) (mg/L)	CARBONATE (CO_3) (mg/l)	HARDNESS as $CaCO_3$ (mg/L)	NONCARBONATE HARDNESS (mg/L)	DISSOLVED CALCIUM (Ca) (mg/L)	DISSOLVED MAGNESIUM (Mg) (mg/L)	DISSOLVED SODIUM (Na) (mg/L)	SODIUM ADSORPTION RATIO	DISSOLVED POTASSIUM (K) (mg/L)	DISSOLVED CHLORIDE (Cl) (mg/L)	DISSOLVED SULFATE (SO_4) (mg/L)	TOTAL FLUORIDE (F) (mg/L)	DISSOLVED SILICA (SiO_2) (mg/L)	DISSOLVED IRON (Fe) (mg/L)	DISSOLVED SOLIDS (sum of constituents) (mg/L)	DISSOLVED NITRATE (NO_3) (mg/L)
Quaternary alluvium	6	Miller	51-68	18	3	1,386	7.3	313	0	519	317	118	35.6	91	-	4.2	198	204	-	11.5	-	756	2.0
Quaternary terrace	1	Columbia	50	20	-	669	7.2	328	0	266	0	59	29	47	1.3	3.3	60	-	0	18	40	-	0.6
	4	LaFayette	55-68	17	5	423	8.0	202	5	197	10	46	19	20	0.8	1.0	29	18	-	19	0	223	0.2
Cockfield	1	Columbia	50	20	-	70	6.1	20	0	13	0	3	1	7	0.9	1.6	7	4	0.1	42	0	77	0.6
Sparta	12	Columbia	50-55	21	28	353	7.8	195	0	51	0	13	4	64	6.2	3.2	13	10	0.1	13	206	216	2.3
	6	LaFayette	46-68	21	4	164	7.6	105	0	42	0	14	3	26	1.8	3.5	7	5	0	13	490	141	0.7
	2	Miller	68	13	4	127	6.4	12	0	34	24	5	5	7	-	6.7	23	4	-	14	-	87	16.1
Cane River	2	Columbia	50	20	-	510	8.0	268	0	38	0	10	3	106	7.6	4.8	37	1	0.1	11	100	304	1.0
	2	Hempstead	51-68	14	4	70	4.9	2	0	15	14	1	2	13	1.7	2.0	23	7	-	25	-	81	7.0
	10	LaFayette	46-68	20	7	479	8.0	219	5	29	0	8	2	110	10.6	2.7	42	6	0.2	12	235	304	0.9
	9	Miller	51-68	19	6	311	7.9	157	1	30	0	9	2	62	2.1	3.3	11	11	-	11	-	200	1.5
Carrizo	3	Miller	64-68	-	12	424	8.1	230	3	6	0	2	1	95	14.0	1.6	13	2	-	11	-	241	0.2
Wilcox	1	Hempstead	51	-	-	90	7.4	33	0	26	0	-	-	-	-	-	6	1	-	-	-	-	3.7
	1	LaFayette	68	18	4	225	7.5	124	0	36	0	11	2	35	-	2.1	3	7	-	10	-	131	0
	7	Miller	51-68	23	9	930	8.1	279	14	24	4	5	1	276	-	1.9	146	1	-	12	-	694	13.1
Nacatoch	15	Hempstead	51	-	-	723	8.6	238	11	46	3	-	-	-	-	-	75	43	-	-	-	-	1.4
	15	Miller	51-68	21	4	1,387	8.5	300	8	41	0	3	0.3	160	-	1.1	233	24	-	12	-	423	2.5

Source: U.S. Geological Survey, Modified from J.E. Terry, C.T. Bryant, A.H. Ludwig, and J.E. Reed, 1979 ⟨58⟩

TABLE 4-5: WATER QUALITY - PUBLIC SUPPLY WELLS WITHIN THE BASIN

AQUIFER	CITY OR COMMUNITY	NO. OF SAMPLES	YEAR	pH	TOTAL SOLIDS	NA	TOTAL AKL.	TOTAL HARD.	CA	MG	FE	MN	CL	SO4	F	NO3 (N)
Sparta	Emerson	1	84	8.4	167	53	109	5	4	<5	.02	<.01	<2.0	<10.0	<0.2	<.04
Sparta	McNiel	1	85	8.0	176	48	130	19	<2	<5	.18	.02	<2.0	10.0	<0.2	<.04
Sparta	So. AR Univ.	1	84	8.2	288	89	224	15	5	<5	.04	.04	5.6	11.0	.31	<.04
Sparta	Magnolia 1/	8	84	8.2	261	76	198	3	1	<5	.04	.03	5.9	8.0	.29	0.04
Sparta	Taylor	1	83	6.8	132	28	82	27	7	<5	.53	.02	9.0	<10.0	<0.2	<.04
Sparta	Waldo	1	83	8.0	234	73	172	8	3	<5	.06	<.01	8.3	<10.0	.26	<.04
Cane River	Bradley	1	84	8.1	770	200	386	18	<2	<5	.12	.01	144	<10.0	.97	<.04
Cane River	Buckner	1	84	5.0	35	4	4	14	5	<5	1.18	.02	11.7	11.0	<0.2	<.04
Cane River	Lewisville	1	81	6.5	208	40	97	9	<2	<5	.05	.01	7	<10.0	-	<.04
Cane River	Stamps	1	83	-	-	-	-	-	-	-	.41	.06	-	-	-	-
Carrizo Sand	Fouke	1	84	8.2	303	57	157	<5	<2	<5	.09	.01	7.4	<10.0	.32	<.04
Carrizo Sand	Garland	1	84	8.2	247	66	133	<5	4	<5	.18	<.01	35.9	<10.0	.21	<.04
Wilcox	Mandeville	1	84	5.8	210	34	17	21	6	<5	.06	<.01	44.0	<10.0	<0.2	2.6
Nacatoch	Bois d' Arc	1	85	8.4	828	260	265	<5	<2	<5	.04	.03	252	36.0	1.05	<.04
Nacatoch	Fulton	1	83	7.8	293	74	208	53	14	<5	<.01	<.01	5.6	16.0	<0.2	<0.4
Tokio	Washington	2	83-84	8.0	256	85	140	<5	<2	<5	.14	<.01	21.3	33.0	.34	<.04

ALL DATA IN mg/L

Na - Sodium dissolved as Na
Ca - Calcium dissolved as Ca
Mg - Magnesium dissolved as Mg
Fe - Iron dissolved as Fe
Mn - Manganese dissolved as Mn
Cl - Chloride dissolved as Cl
SO4 - Sulfate dissolved as SO4
F - Fluoride dissolved as F
NO3 - Nitrates dissolved as N
\- - NO READING

1/ Data represents Mean of eight wells.

Source: Arkansas Department of Health, File Data <2>

Cane River

The Cane River Formation is underlain by the Carrizo Sand and overlain by the Sparta Sand. The formation crops out in a broad band through central Miller County and southern Hempstead and Nevada Counties and dips to the south and east at a rate of about 40 feet per mile. The formation is composed of sand, silt, clay, and lignite and ranges in thickness from 200 to about 450 feet. The thickest section of the formation is in southwest Miller County. The formation is cut by several northeast-southwest-trending faults which displace the formation as much as 280 feet within the fault zone. However, the faulting apparently affects neither the movement nor the quality of water in the formation. <58>

The Cane River Formation is the third most important source of ground water in the study area based upon withdrawal rates of 1980. <12> Most of the wells are contructed for domestic or stock use and are equipped with small-capacity pumps. However, municipal wells at Lewisville, Stamps, and Bradley are screened in the Cane River Formation and yield 300, 920, and 120 gallons per minute respectively. Wells of similar capacity probably could be developed in many places in the formation. During 1980 water was withdrawn from the Cane River Formation at the rate of 4.8 MGD. This quantity represented 11 percent of the total ground water withdrawn from all aquifers in the study area. Most of the water was used for municipal and industrial supplies in Lafayette County. <58> <12>

Measured and reported water levels in wells that tap the Cane River Formation range from the land surface in the Red River Valley to 134 feet below the land surface in southern Nevada County. Interpretation of electric logs and chemical analyses of water samples from wells that tap the Cane River Formation indicate that, although water from the formation becomes progressively more mineralized in a downdip direction, the formation probably contains fresh water throughout its extent except in Columbia County where it becomes saline. The water at Bradley contains 770 mg/l of dissolved solids and 144 mg/l of chloride. The iron content of the water generally is less than 0.3 mg/l. <58>

Carrizo Sand

The Carrizo Sand is the basal formation of the Claiborne Group, overlain by the Cane River Formation and resting on the Wilcox Group. The Carrizo Sand crops out in a narrow band, 2-5 miles wide through central Miller, southern Hempstead, and central Nevada Counties. The formation ranges in thickness from a few feet in the outcrop area to about 100 feet in Lafayette County. Within the fault zone, which strikes northeast-southwest through Garland City, the formation is as much as 125 feet thick. <58>

The Carrizo Sand contains fresh water throughout its extent in the basin, except in south-central Lafayette County. Interpretation of electric logs indicates the formation is composed of a massive sand unit in much of the area. However, the sand is generally fine-grained and yields less than 100 GPM to wells. The percentage of sand in the formation decreases westward. <58>

The Carrizo Sand is not used extensively as an aquifer in the basin. Most of the wells are for small domestic supplies and have low discharges. The use of water from the Carrizo Sand was 0.28 MGD in 1980, most of which was produced from wells in Miller County. The cities of Fouke and Garland City obtain their water supply from wells screened in the Carrizo Sand. Elsewhere, development of the aquifer for water supplies is negligible. <58>

Well-performance data have been determined for the city well at Fouke. The well, which is pumped at the rate of 100 GPM, has a specific capacity (yield per foot of drawdown) of about 3 GPM per foot. Static water level in the well is about 115 feet below land surface. The permeability of the Carrizo Sand, determined in laboratory tests on samples collected from the outcrop, is about 190 gallons per day (GPD) per square foot. This value compares favorably with the permeability determined for the formation in Texas (Baker and others, 1963). <58>

Development of the Carrizo Sand has been limited because water supplies adequate for present needs generally are available from the overlying Cane River Formation. However, as requirements for water increase, the Carrizo Sand could supply large quantities of water. Wells tapping the sand sections of the Carrizo Sand and Cane River Formation probably could yield as much as 500 GPM. <58> Analyses of two water samples taken from wells in Carrizo Sand indicate water in the formation is a soft sodium bicarbonate type, low in dissolved solids, and similar to water from the overlying Cane River Formation. <58>

Wilcox Group

The Wilcox Group is the lowermost geologic unit of Tertiary Age that contains fresh water. The unit crops out in a broad band through northern Miller, southern Hempstead, and central Nevada Counties. The Wilcox ranges in thickness from about 100 to 450 feet in the subsurface and is composed of interbedded layers of sand, clay, and lignite. Sand beds comprise from 20 to 60 percent of the unit. <58>

Fresh water is available from the Wilcox in the outcrop area and for a few miles downdip. The formation is tapped by several small-capacity domestic or stock wells. The formation generally yields only small quantities of water, owing to the lenticularity and fine-grained texture of the water-bearing sand beds. During 1980 water was withdrawn from the Wilcox Group in the study area at the rate of 0.41 MGD. This quantity represented about 1 percent of the total ground water withdrawn from all aquifers in the study area. Most of the water (0.31 mgd) was used in Miller County. <12> The permeability of sands in the Wilcox Group, as determined by laboratory tests made on samples collected from the outcrop area of the formation, is 30 GPD per square foot; whereas, the permeability of the Wilcox in Bossier Parish, La, is 90 GPD per square foot (Page and May, 1964). Measured and reported water levels in wells tapping the Wilcox range from land surface to about 125 feet below land surface; the greater depths are in areas of greater surface relief. Water levels in wells tapping the Wilcox Group in the Red River Valley are at, or near, the land surface. A few wells in the valley, near Garland City, have continued to flow since they were drilled in the late 1930's. <58>

Water in the Wilcox is soft or moderately hard, and based on three water samples, is a sodium bicarbonate type in Miller County and a calcium bicarbonate type in Nevada County. The southern extent of fresh water in the formation coincides with the fault system that extends through central Miller, Lafayette, and Nevada Counties. Based on the interpretation of electric logs and chemical analyses of water samples, water in the Wilcox south of the fault zone contains more than 1,000 mg/l of dissolved solids. The fault zone apparently retards the downdip movement of fresh water in the formation. Supplies sufficient for domestic use can be obtained from the Wilcox throughout the area where it contains fresh water. <58>

Midway Group

The Midway Group of Paleocene Age crops out in small irregular patches in a narrow band across the northern part of the basin, mostly in Hempstead County. The Midway Group, which is the basal clay sequence of Tertiary age deposits, ranges up to 600 feet thick and does not yield water to wells. <58>

Cretaceous Rocks

Arkadelphia Marl

The Arkadelphia Marl is a non-water bearing calcareous clay and limestone. This formation, which varies between 0 to 150 feet in thickness, is overlain by the Midway Group and is underlain by the Nacatoch Sand. <57>

Nacatoch Sand

The Nacatoch Sand crops out as a wide, low ridge in the extreme north-central tip of the basin. The outcrop area measures about 6 miles wide and 10 miles long. The dip of the Nacatoch Sand is about 50 feet per mile southeastward. The formation is approximately 320 feet thick in the area and is composed of clay and fine glauconitic sand. The upper part of the formation is composed of sand and is the principal water-bearing part of the Nacatoch. The general direction of ground water movement in the Nacatoch Sand is to the southeast. <58> The results of tests made in wells that tap the Nacatoch Sand at Hope show a transmissivity of 3,600 GPD per foot. Yields of a few gallons per minute may be obtained from flowing wells in the Nacatoch Sand in the lower stream valleys in Nevada County. Wells tapping the formation in Hempstead County and in northwestern Nevada County can be expected to yield 150 to 300 gpm. Depths of the wells range from a few feet in the outcrop area to about 700 feet near Hope. <58>

During 1980, water was withdrawn from the Nacatoch Sand in the study area at the rate of about 2.0 MGD. This quantity represented about 5 percent of the total ground water withdrawn from all aquifers in the study area. Virtually all of this amount was from Hempstead County. <12>

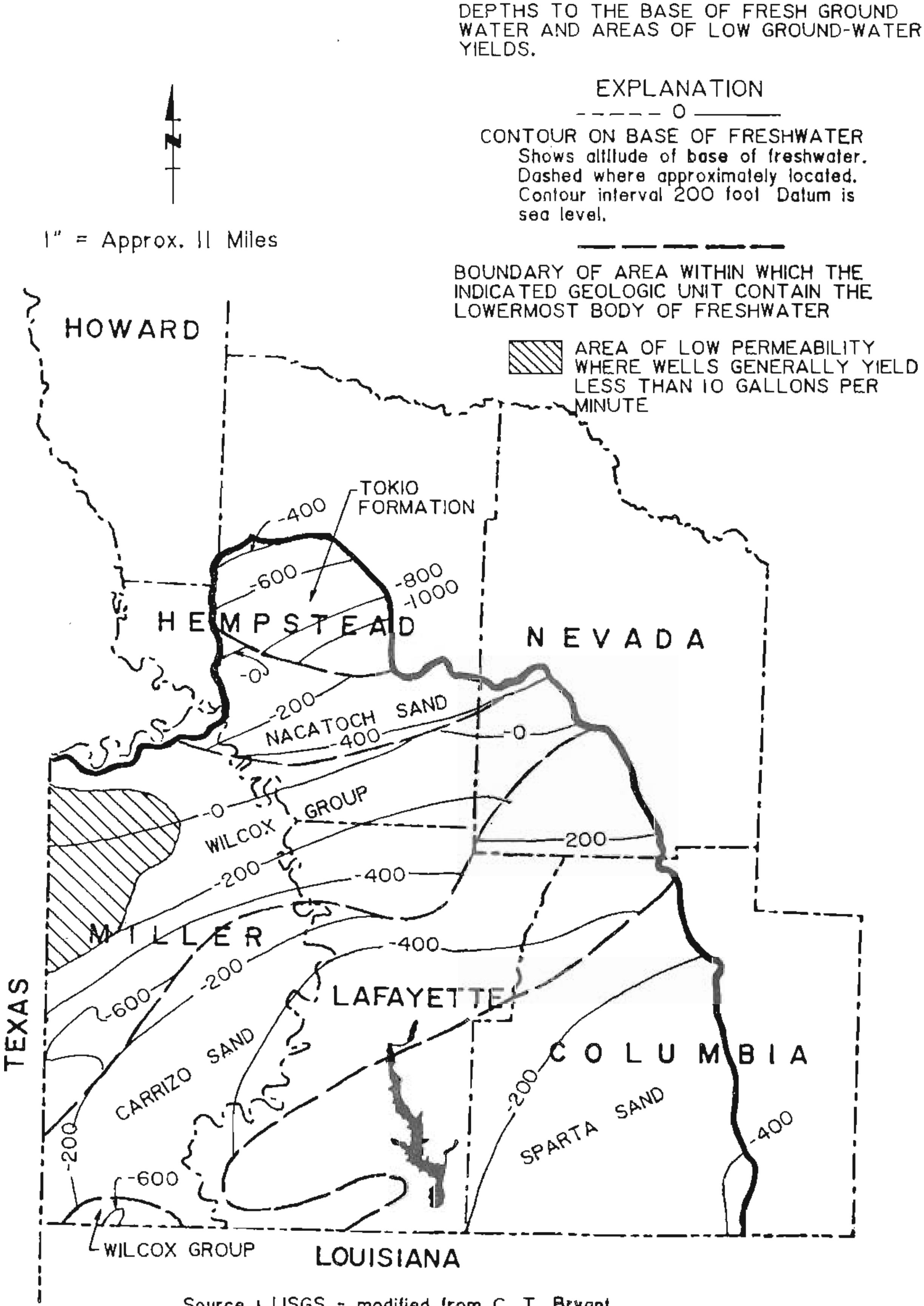
Water from the Nacatoch Sand generally is soft or moderately hard near the outcrop area. Calcium and bicarbonate are the principal constituents. Downdip for a distance of about 20 miles in the formation, the sodium and chloride content increases with a corresponding increase in dissolved-solids content. The concentration of iron in the water generally is less than 0.3 mg/l. <58>

Formations below the Nacatoch Sand do not yield fresh water to wells in the study area except for one well in the Tokio Formation at the town of Washington in Hempstead County. Although the Tokio Formation yields water to wells in northern and central Hempstead County, it is not considered a suitable source of fresh water in the basin due to high salinity. <57>

The southern extent of fresh water in the Tokio Formation extends through central Hempstead and northwestern Nevada Counties. Water from wells at Hope contains more than 1,000 mg/l of dissolved solids. Until a few years ago water from the Tokio Formation was mixed with water from the overlying Nacatoch Sand to reduce the dissolved solids and chloride content. <58> This process was abandoned a few years ago and now the city of Hope obtains more than 90 percent of its water from Millwood Reservoir <57>

Figure 4-4

GEOHYDROLOGIC CONSTRAINTS



Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris, <49>

LEGAL AND INSTITUTIONAL SETTING

Ground Water in Federal Law

No comprehensive federal ground water law exists comparable to the legislation covering surface water or ocean pollution. This may reflect a federal view that ground water quality problems are susceptible to local or state resolution and do not affect "interstate commerce" as directly as do surface waters. Federal measures for the control of ground water pollution are listed in several different laws that are not primarily concerned with ground water. Each of the laws are discussed below.

Clean Water Act of 1977 - Congress delegated authority to the U.S. Environmental Protection Agency over surface water and ground water; however, the scope of EPA authority over ground water pollution has been ambiguous partly because of the phrasing of Section 309 which refers to "navigable waters" which limits its applicability to ground water.

Safe Drinking Water Act of 1974 - The Act protects ground water through its Underground Injection Control Program and sets limits on some substances that may occur in public water supplies.

> Section 1424(e) of the Gonzales Amendment provides state agencies with a legal mechanism to protect the recharge zones of special or "sole source" aquifers. In such areas, federally assisted projects which are found to endanger the quality of the water as set forth in the maximum contaminant levels set by the Safe Drinking Water Act, could have their funding halted by EPA.
>
> Once designated as a "sole source" aquifer, section 3004 and 4002 of the Resource Recovery and Conservation Act (1976) come into play which allow state agencies to prohibit facilities in the recharge areas, require a leachate monitoring system and design specifications for landfills and surface impoundments thus giving the state legal support in restricting or prohibiting waste facilities within the recharge zone.

Resource Conservation and Recovery Act of 1976 (RCRA) - The EPA recently promulgated approximately 2,000 pages of regulations involving the classification, handling, testing, and disposal of hazardous substances as a result of this Act which also sets standards for the construction and monitoring of RCRA sites, including the digging of monitoring wells.

Toxic Substances Control Act of 1976 (TOSCA) - TOSCA overlaps with RCRA in some respects and also deals with toxic substances, particularly polychlorinated biphenyls (PCBs).

Surface Mining Control and Reclamation Act of 1977 - The act deals with the release and disposal of mine water.

National Environmental Policy Act (NEPA) - NEPA requires consideration of the effects of federal action on ground water in the writing of environmental impact statements. The federal reservation of water rights doctrine has been expanded to include ground waters (1 Harv. Env. L. Rev. 173). In Cappaert v. United States (426 U.S. 128, 1976), the U.S. Supreme Court held that "since the implied reservation-of-water doctrine is based on the necessity of water for the purpose of the federal reservation....the United States can protect its water from subsequent diversity, whether the diversion is of surface or ground water." The court cited no cases to support this holding, relying instead on two National Water Commission publications and simple logic.

The federal government seems reluctant to tackle the socio/economic and technical problems involved in preparing a comprehensive ground water resource management policy. There is no ground water legislation equivalent to the Clean Water Act. In September of 1984, EPA released its long awaited ground water protection strategy. Consistent with its past pronouncements on ground water, EPA's current strategy lays the economic burden of protection on the states. It calls upon them to build their ground water programs using existing appropriations. New funds are to be used mainly for "information gathering and planning," with implementation reserved for those states who have completed their basic planning.

To assist the states, EPA has recently set up a new office on ground water to coordinate programs. New regulations concerning the formerly unregulated underground storage tanks and surface impoundments will be promulgated along with further specifications for the protection and cleanup of aquifers.

Aquifers will be protected according to their "highest and best use", according to 3 classifications:

A. Special aquifers - those vulnerable to surface contamination, i.e. karst formations, sand and gravel aquifers. Those defined as ecologically vital, irreplaceable, or essential to the public.

B. Drinking water sources - currently used or potential sources.

C. All other aquifers.

Special aquifers will receive special attention; i.e., superfund sites located over special aquifers will be cleaned up first. More stringent regulations for the storage and disposal of chemicals will be applied over special aquifers. A special casing will be needed for disposal wells drilled through them. Further rules for land applications of nutrients and for new facilities over these aquifers will be applied.

Drinking water sources now in place will have the same protection. If a contaminant enters an aquifer used as a source of drinking water, it will be cleaned up with the best available technology, or, if that is not possible, the contaminant plume will be monitored.

Aquifers too salty to be used as drinking water sources will be monitored so that as little contamination as possible escapes from them into cleaner aquifers that are or could be used as drinking water sources.

EPA's recommendation for monitoring systems called for the utilization of monitoring already in place. They did agree some selected monitoring could be funded if it fit within the general framework of the state strategy for ground water. Monitoring that fell within the routine structure of the state system would not be eligible for funding.

Landfills, surface impoundments, and leaking storage tanks will be given special attention by EPA through programs designed to study the threat to ground water presented by these sources of contamination. The first study which addresses leaking underground storage tanks is presently (1986) underway under the direction of the Office of Pesticides and Toxic Substances (OPTS).

Most of the actions to be taken by EPA involve the further use of existing regulations such as FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) which will be used to control pesticides that may leach into the ground water. TOSCA (Toxic Substances Control Act) guidelines will be used to regulate new chemicals.

Ground Water in State Law

Ground waters are generally subject to the same treatment given to watercourses, and it follows that the Arkansas position, with respect to ground waters, conforms to the riparian doctrine. Therefore, ground waters also come within the framework of the reasonable use theory as applied to watercourses. Disputes over water have generally been decided according to a reasonable use test which allows each owner to use the water for his own purposes having due regard for the effect of that use upon other riparian owners and on the public in general.

Arkansas Case Law

A leading case which deals with the questions of ground water use, Jones vs. Oz-Ark-Val Poultry Company, was a case of conflict between the industrial use of ground water and domestic wells. The court held that industry interference with the ground water was unreasonable and an injunction was issued to prevent excessive pumping by the industrial users. The court applied the "reasonable use doctrine" to resolve the conflict. The court recognized that under our law, the domestic use of ground water prevail. The court further stated that, where two or more tracts of separately-owned land join with a common underground reservoir, each owner has common and correlative right to the use of the water on his land if the common supply is sufficient. However, if the supply is limited and one use interferes with another use, then each person is limited to a reasonable share in order not to hamper the use of the other party.

The Arkansas Supreme Court has not rigidly defined reasonable use. The court has ruled "that we are not necessarily adopting all the interpretations given it be the decisions of other states, and that our own interpretation will be developed in the future as occasions arise." [Harris vs. Brooks, 225 Ark. 436, 283 S.W. 2d 129 (1955)]. Clearly, the definition of reasonable use is evolving as the court addresses more complex water problems. The court recently reversed a previous ruling requiring riparian owners to use water on riparian lands and demonstrated a willingness to adapt to changing needs.

In Lingo vs. the City of Jacksonville, [258 Ark. 63, 522 S.W. 2d 403, 1975] the court ruled the city of Jacksonville could legally buy land, drill wells, remove the water to a distant point, and sell it to its customers. The Arkansas high court has consistently tried to guarantee maximum beneficial use of the State's water resources. The court concludes:

> "In all our consideration of the reasonable use theory, as we have attempted to explain it, we have accepted the view that the benefits accruing to society in general from a maximum utilization of our water resources should not be denied merely because of the difficulties which may arise in its application." [Harris vs. Brooks, 225 Ark. 436, 283 S.W. 2d 129, 1955].

Domestic use is preferred over other uses of ground and surface water. In times of scarcity, surface water use is allowed in the following order: (1) sustaining life, (2) maintaining health and (3) increasing wealth. The correlative rights rule (giving overlying owners a proportionate or prorated share) governs ground water use during times of scarcity.

The courts decide which uses are reasonable or unreasonable on a case by case basis as conflicts arise. The Arkansas high court has modified the common law on several occasions in order to allow maximum beneficial use of the state's water resources and seems willing to make further changes as needed.

To summarize, Arkansas Water Law is based on a riparian/reasonable use rule for both surface and ground water (whether percolating or flowing). Riparian owners are allowed to make reasonable beneficial use of the water "with due regard to the rights of others similarly situated."

Agency Regulations and Authority

A. Arkansas Department of Pollution Control and Ecology

1. Act 472 of 1949 as amended; Arkansas Water and Air Pollution Control Act

   Under the authority of Act 472 of 1949, the ADPC&E has broad powers of regulation and enforcement over "waters of the state", both "surface and underground". Hence, it follows that all the kinds of monitoring, classifying, and regulating that have been done for surface water, can be done for ground waters (given, of course, the physical limitation imposed by geology).

2. Regulation #1, ADPC&E November 1, 1958.

   The regulation was for the Prevention of Pollution by Saltwater and Other Field Wastes Produced by Wells in New Fields or Pools.

   This attempted to prevent brine from the oil fields from polluting the "waters of the state". It applied only to wells established after July 1, 1957. It provided for underground injection whenever possible and outlawed holding ponds over porous or gravelly soils and was supplemented by Safe Drinking Water Act's Underground Injection Control Program.

3. Regulation #2, ADPC&E as amended, September, 1981. Arkansas Water Quality Standards

   The regulation deals mostly with surface water but refers occasionally to ground water protection as in Section 4, Part E (2C) as related to ephemeral and intermittent streams. There is not any legal reason why the classification of ground water could not be included within this framework in the same comprehensive manner surface water is addressed.

4. Regulation #3 Underground Injection Control Code, March, 1982.

   The regulation adopts by reference most of the Federal regulations dealing with the construction and control of injection wells.

5. Act 134 of 1979 as amended by Act 647 of 1979.

   The program, in regard to ground water, consists of a permit system which would allow for the assessment of the effect a mining activity might have on the ground water resources, either quality or quantity. Again, this is accomplished on a case by case basis only in the areas of proposed activity. The Department does have authority to prevent a given activity if adverse impacts warrant such action.

B. Arkansas Soil and Water Conservation Commission

1. Act 217 of 1969 authorized the Commission to develop the Arkansas State Water Plan that would serve as the state water policy for the development of water and related land resources in the state. All reports, studies, and related planning activities were required to take the State Water Plan into consideration. In 1975, the first State Water Plan was published. In 1980, work on revising the 1975 plan began.

2. Act 1051 of 1985 outlined many variables that needed to be quantified or delineated and included in the State Water Plan expected to be released by late 1986. Some requirements of the act were: (a) to define current and projected needs of public water supplies, industry, and agriculture, (b) define and quantify the safe yield of all streams, reservoirs and aquifers, (c) quantify requirements of fish and wildlife, navigation, riparian rights and minimum stream flows. In addition, the act authorized interbasin transfer and nonriparian use contingent upon guideline development by the Commission and required all ground water users to report the quantity of ground water withdrawn on an annual basis. The Commission will now collect and compile ground water use data in addition to surface water use data authorized by Act 180 of 1969.

3. Act 417 of 1985 provided incentives for construction of surface reservoirs in the form of a state tax credit not to exceed 50 percent of the total construction cost or a maximum of $33,000 over a 11-year period. Any applicant who converts to surface water from ground water sources may receive a tax credit equal to 10 percent of the total conversion cost. Persons seeking eligibility for the tax breaks must apply to Arkansas Soil and Water Conservation Commission for evaluation and acceptance.

C. Arkansas Geological Commission - Act 16 of 1963 charges the Commission with the collection and dissemination of data regarding water and other natural resources. This Act also states that the Commission will engage in cooperative agreements with the U.S. Geological Survey to perform investigations concerning water resources, which includes quantitative and qualitative analysis of ground water.

D. Arkansas Oil and Gas Commission - Act 105 of 1939 consists of a permitting system for the underground injection of any industrial waste into existing aquifers. The permits are considered on a case by case basis in regard to means and level of injection, quality of water injected, use of ground water in area, etc. An informal agreement exits between this Commission and the Department of Pollution Control and Ecology which indicates the Commission will deal with all impacts from the well head down and the Department of Pollution Control and Ecology will deal with problems related to surface water pollution (in execution of the Department Reg. 1). The Department of Pollution Control and Ecology will, in instances of hazardous waste inspections, work with potential subsurface impacts.

E. Arkansas Health Department - Act 402 of 1977 pertains primarily to the permitting of waste treatment systems for individual dwellings, with the limitation being the quantity of wastewater treated. Permits are considered on a case by case basis with the exception being that certain requirements are particularly applied to certain areas of the State to protect ground water sources, specifically. The Department has authority to prevent and/or stop ground water contamination sources by declaring them "public health nuisances". The Department is also authorized by Act 71 of 1973 to control septic tank pumpers and the disposal of sludge. Septic tank installers are also permitted by the Health Department. The Department not only considers septic tanks but any accepted method of waste treatment. Numerous alternatives are available and considered by the Health Department whenever physical conditions and economic justifications warrant.

F. University of Arkansas - Act 737 of 1977 calls for research funds to be appropriated for septic tank design at the University's Agricultural Experiment Farms. The research is ongoing and is currently funded as a line item in the University's budget.

G. Water Well Construction Committee, Act 641 of 1969, as amended, gave the Committee the authority to issue water well drillers contractors licenses, test and register water well drillers, and register and issue rig permits. The Committee insures that proper construction and abandonment standards are followed and investigates complaints against contractors. The Committee maintains files of well-completion reports submitted by drillers.

H. Related Legislation

Mining Legislation:

The Arkansas Open Cut Land Reclamation Act, Act 336 of 1977, as amended by Act 824, regulates reclamation of land disturbed by open cut mining and requires a permit for open cut mining.

The Arkansas Surface Coal Mining and Reclamation Act, Act 134 of 1979, as amended by Act 647, establishes a program for coal mining and reclamation of mining areas.

Solid Waste Legislation:

Arkansas Solid Waste Management Act, Act 237 of 1971, requires proper and permitted disposal of solid waste management plans; authorizes county courts to provide solid waste management systems.

Solid Waste Facilities and Finance Authorization Act, Act 238 of 1971, authorizes counties and municipalities to use available revenues for establishment of solid waste disposal systems, to impose rates and discharges, to issue bonds, and to prescribe regulations for refuse disposal.

Arkansas Hazardous Waste Act, Act 406 of 1979, establishes a program of regulation over the generation, storage, transportation, treatment, and disposal of hazardous wastes.

Joint County and Municipal Solid Waste Disposal Act, Act 699, authorizes counties and municipalities to participate in the joint construction, operation, and maintenance of facilities for disposal of solid waste, and authorizes the creation of sanitation authorities to issue bonds for financing costs of solid waste management systems.

GROUND WATER PROBLEMS

Major Aquifers

Quaternary Aquifer

Declining Water Levels

No major problems which relate to declining water levels presently exist in the Quaternary aquifer. Between 1975 and 1980, water level declines of about 4 to 8 feet have been noted in three observation wells in Lafayette and Miller Counties. In Lafayette County, an average annual decline of 1.51 feet occurred in two observation wells between 1975 and 1980. (See Table 4-6) However, data collected from the same two observation wells in Lafayette County between 1980 and 1985 showed an average annual rise in water levels of 0.01 feet. In addition, the observation well in Miller County showed a reduced decline rate to 0.42 feet between 1980 and 1985 compared to a decline rate of 0.48 feet between 1975 and 1980. In summary, declining water levels are not a current significant problem in the basin Quaternary aquifer. (See Table 4-6)

Quality Degradation

Quality degradation caused by salt water contamination in the Quaternary alluvium is a local problem in a portion of Miller and Lafayette Counties. Chloride concentrations as high as 46,250 mg/l have been found in the alluvium near Garland City in Miller County. The high chloride content of the water in the alluvial aquifer has made ground water in this area unsuitable for irrigation. The contamination is associated with oil-field activity in the area and is related directly to effluent seepage from brine-storage pits, some of which have been in use for as long as 40 years.

The problem was first reported in 1967 when owners of farms in the area noted drastic increases in the chloride content of water from their irrigation wells. The area affected includes about 25 square miles in an area located from 1 to 5 miles west and northwest of Garland City. <58>

Results of a drilling and sampling program conducted by the U.S. Geological Survey and Arkansas Geological Commission show that the highly contaminated water (water containing more than 500 mg/l of chloride) is associated with existing or abandoned brine-disposal pits. Calculations, based on the areal extent of the contamination and the thickness and porosity of the aquifer, indicate that approximately 60 million gallons of water in the aquifer has been highly contaminated. In addition, a large but undetermined part of the alluvial aquifer adjacent to the highly contaminated areas contains water that has chloride concentrations of from 250 to 500 mg/l. Concentrations of chloride in the alluvial aquifer, where it is not contaminated, are generally less than 100 mg/l. <58>

A smaller area also contaminated by salt water is located a few miles east of Garland City in Lafayette County. This site includes an area about 7 miles long and 3 miles wide near Spirit Lake. Contamination of the alluvial aquifer at this site has been traced to an abandoned oil well in the Spirit Lake oil and gas field. <57> The location of these contaminated areas is shown in Figure 4-5.

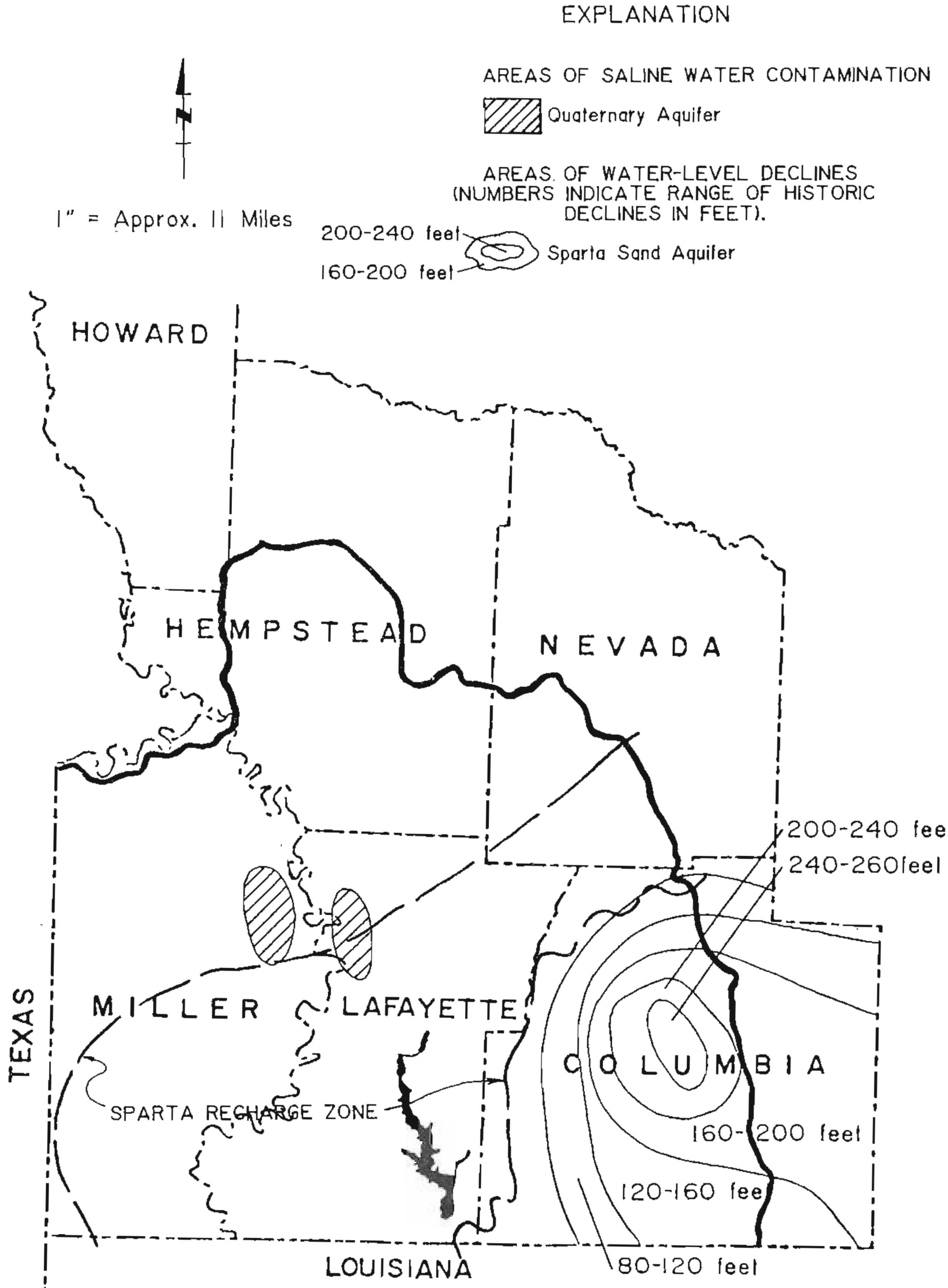
TABLE 4-6: WATER LEVEL CHANGES IN THE QUATERNARY DEPOSITS WITHIN THE BASIN (feet)

	Number of Wells	1975 - 1980		1980 - 1985		1975 - 1985	
		Net	Annual	Net	Annual	Net	Annual
Lafayette	2	-7.57	-1.51	+0.05	+0.01	-7.52	-0.75
Miller	1	-2.41	-0.48	-2.11	-0.42	-4.52	-0.45

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975 - 1985 <57>

Figure 4-5

GROUND WATER PROBLEMS



Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris, <49>

The underlying aquifers of Tertiary age are not affected by salt-water intrusion from the alluvium. Analyses of water samples taken from deep domestic wells in the contaminated areas show that the water is a sodium bicarbonate type, low in chloride and sulfate, and similar in quality to water from the same formations at other places in the study area. <58>

Sparta Sand

Declining Water Levels

Water levels are declining in the Sparta aquifer in part of the study area. Most of the problem is centered around Magnolia in Columbia County where water levels have exceeded 2 feet of average annual decline for the past 60 years. Pre-development levels were about 250 feet higher than today's levels. <49> The area of large historic withdrawal around Magnolia is readily apparent in Figure 4-5 by contour lines showing the area of water level declines. This figure shows declines of as much as 240-260 feet in and near Magnolia, and as much as 120 feet about 16 miles south and west of Magnolia. In recent years, however, the water level decline in Columbia County and in the Magnolia area has slowed considerably. Data from eight observation wells in Columbia County show the average annual water decline to be 0.35 feet between 1980 and 1985 compared to an average annual decline of 0.66 feet during the 1975-1985 period. (See Table 4-7) The annual water decline in one Nevada County observation well in this basin averaged 0.64 feet during the 1980-1985 period. The average annual change in water levels in Lafayette County shows an increase in two observation wells of 0.46 feet in the 1975-1985 period and 0.24 feet during the 1980-1985 period.

Figure 4-6 illustrates the historic spring water levels in selected wells in the Sparta Sand in Columbia County for approximately 20 years. From these hydrographs, it is apparent that the major water level declines occurred during the early observation period and that the recent declines have slowed in most wells.

Figure 4-7 illustrates the trend in Sparta Sand water levels for parts of Columbia, Lafayette, and Miller Counties.

Water level declines may also be shown by potentiometric contours which indicate cones of depression. The cones develop because the withdrawal rate exceeds the recharge rate, thereby causing steep gradients in the vicinity of the withdrawal areas. Figure 4-8 shows the potentiometric contours defining the potentrometric surface in this area and indicates the general direction of ground water flow which is perpendicular to the contours. The cone of depression is centered near Magnolia, Arkansas. Increased gradients increase the rate of movement toward wells. However, transmissivity of the aquifer material controls the rate of water movement into the aquifer. Thus, when withdrawals exceed the rate of recharge, the result is lowered water levels, increased pumping lifts, high pumping costs and the potential for quality degradation. <58> <59>

TABLE 4-7: WATER LEVEL CHANGES IN THE SPARTA SAND WITHIN THE BASIN (Feet)

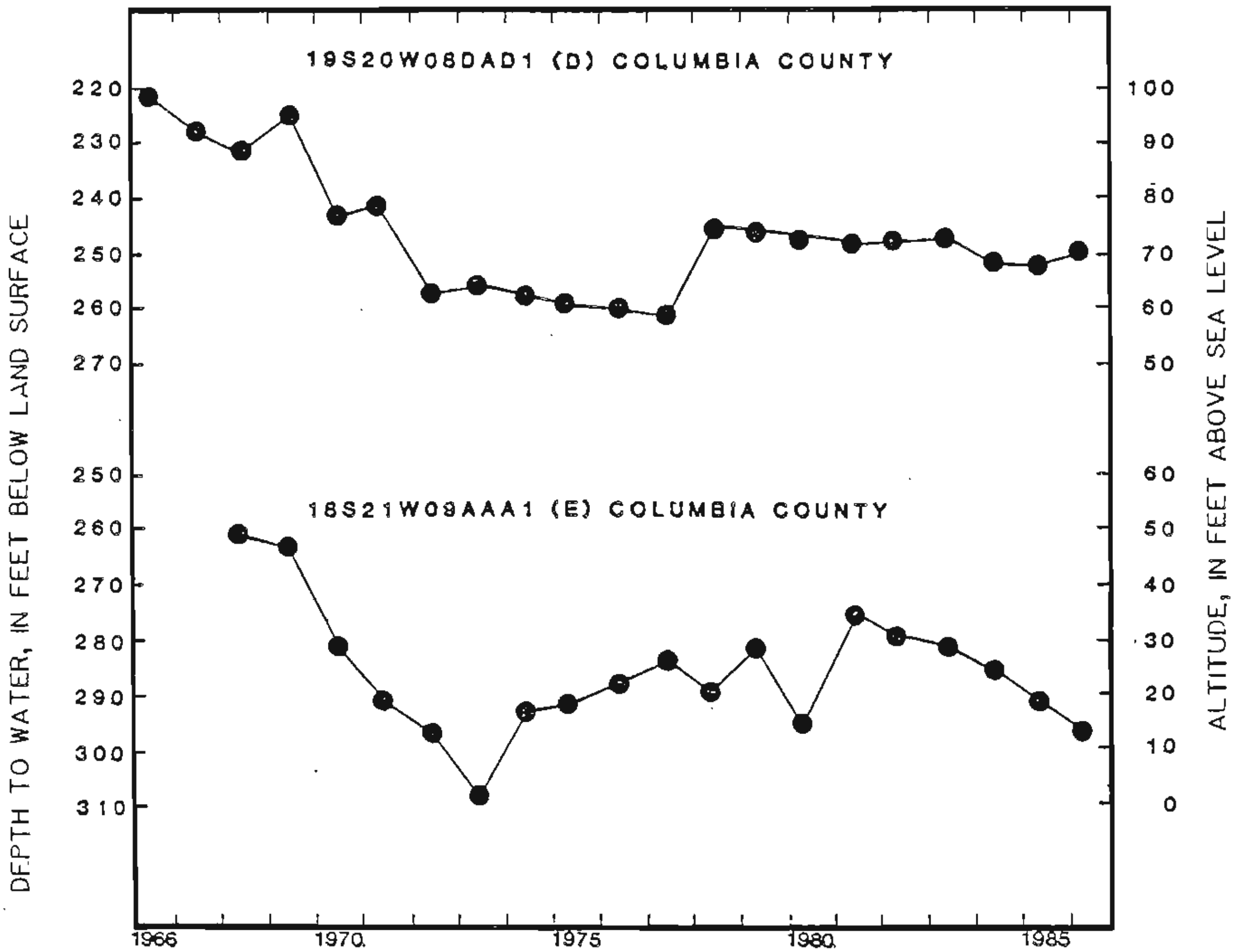
	Number of Wells	1975 - 1980		1980 - 1985		1975 - 1985	
		Net	Annual	Net	Annual	Net	Annual
Lafayette	2	+2.28	+0.46	+1.22	+0.24	+3.50	+0.35
Columbia	8	-3.29	-0.66	-1.75	-0.35	-5.04	-0.50
Nevada		1/	1/	-3.18	-0.64	1/	1/

1/ Data Not Available.

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975 - 1985 <71>

Figure 4 - 6

AQUIFER HYDROGRAPHS FOR SELECTED WELLS COMPLETED IN THE SPARTA SAND



SOURCE - U.S. GEOLOGICAL SURVEY, FILE DATA

Figure 4 - 7

CHANGES IN WATER LEVELS IN THE SPARTA SAND AQUIFER SPRING 1980 TO SPRING 1985

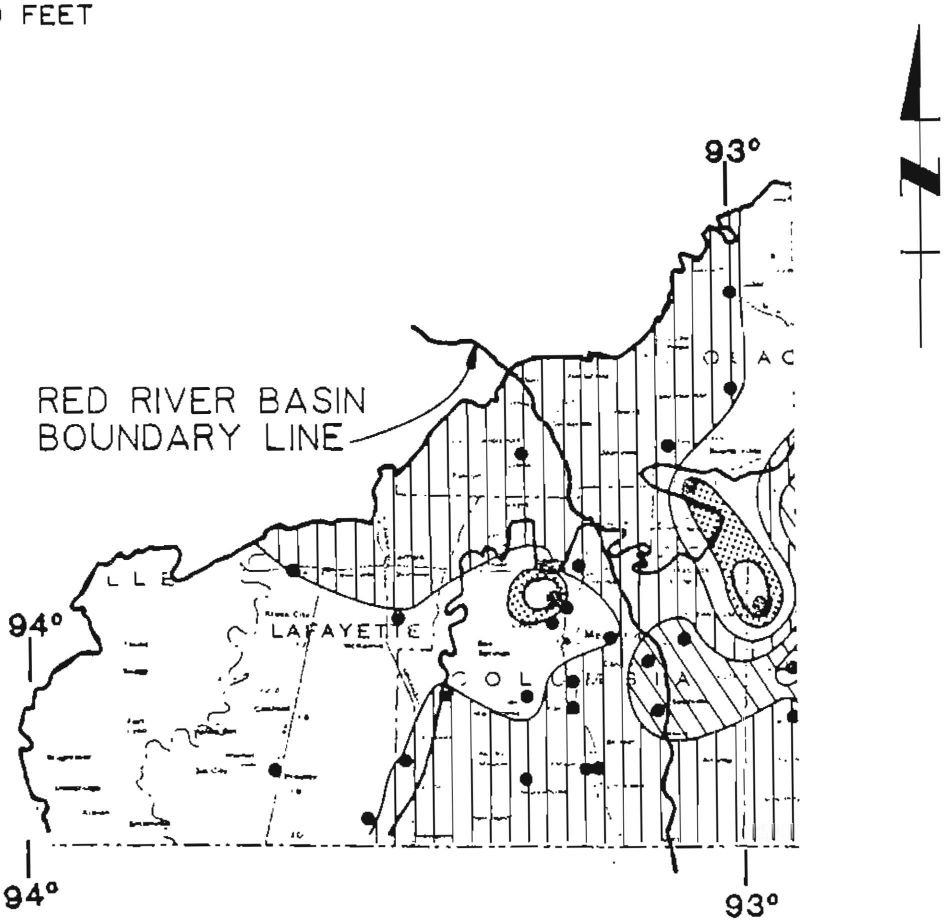
EXPLANATION

DECLINE IN WATER LEVEL

- 0 TO 5 FEET
- 5 TO 10 FEET

RISE IN WATER LEVEL

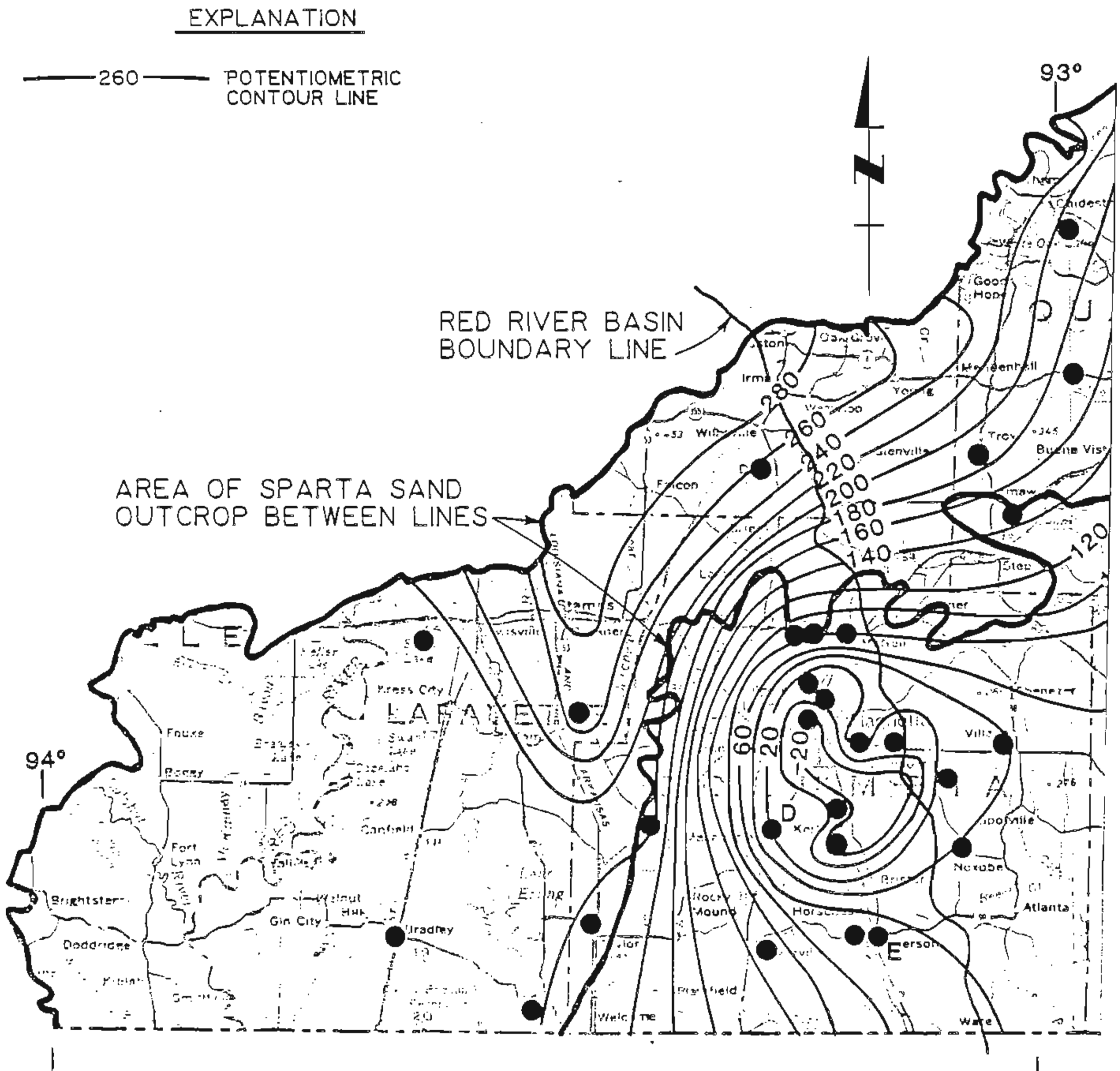
- 0 TO 5 FEET
- 5 TO 10 FEET
- >10 FEET



SOURCE : U.S. GEOLOGICAL SURVEY <72>

Figure 4 - 8

ALTITUDE OF THE POTENTIOMETRIC SURFACE IN THE SPARTA SAND - 1985 FEET ABOVE OR BELOW SEA LEVEL



94° SOURCE : GEOLOGICAL SURVEY <72> 93°

The "water level-formation top" relationship is also important because when the water level is below the top of the formation tapped, overlying aquifers may become dewatered and the reduced head pressure can allow saline waters to intrude and pollute the aquifer being used. In addition, yields decrease with decreasing saturated thickness and subsequent formation compaction can make the situation permanent. Part of Columbia County is in the outcrop area of the Sparta Sand and has had large withdrawals resulting in water levels below the top of the formation as is shown in Figure 4-9. <51>

Quality Degradation

Signs of increased chloride concentration have been observed around El Dorado in the Ouachita River Basin. High concentrations are apparently related to overdraft. The water quality degradation problem area is located east of the study area and no known instances of salt water contamination are in the Sparta Sand in the Red River Basin below Fulton. <48>

Cane River Formation

Declining Water Levels

Total ground water withdrawal from the Cane River Formation in the basin amounted to 4.76 MGD of which 3.68 MGD of withdrawal occurred in Lafayette County. From Table 4-8, the single Lafayette County observation well shows that the average annual water level increased by 1.6 feet during the 1980-1985 period compared to an average annual decline of 2.22 feet during the earlier 1975-1980 period. For the period 1968-1986, the water level increased a net of two feet.

The Miller County observation wells also shows an average annual increase of 0.15 feet for the 1980-1985 period.

The Cane River Formation observation well in Columbia County shows an average annual increase in water level of 0.11 feet during the 1975-1980 period but an average annual decline during the later 1980-1985 period.

At the present time, declining water levels in the basin are not considered a significant problem.

Quality Degradation

Serious ground water quality problems have not been identified at present in the basin.

TABLE 4-8: WATER LEVEL CHANGES IN THE CANE RIVER FORMATION WITHIN THE BASIN (feet)

	Number of Wells	1975 - 1980		1980 - 1985		1975 - 1985	
		Net	Annual	Net	Annual	Net	Annual
Lafayette	1	-11.11	-2.22	+8.00	+1.60	-3.11	-0.31
Columbia	1	+ 0.54	+0.11	-1.55	-0.31	-1.01	-0.10
Miller	3	1/	1/	+0.75	+0.15	1/	1/

1/ Data Not Available.

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975 - 1985 <71>

Figure 4-9

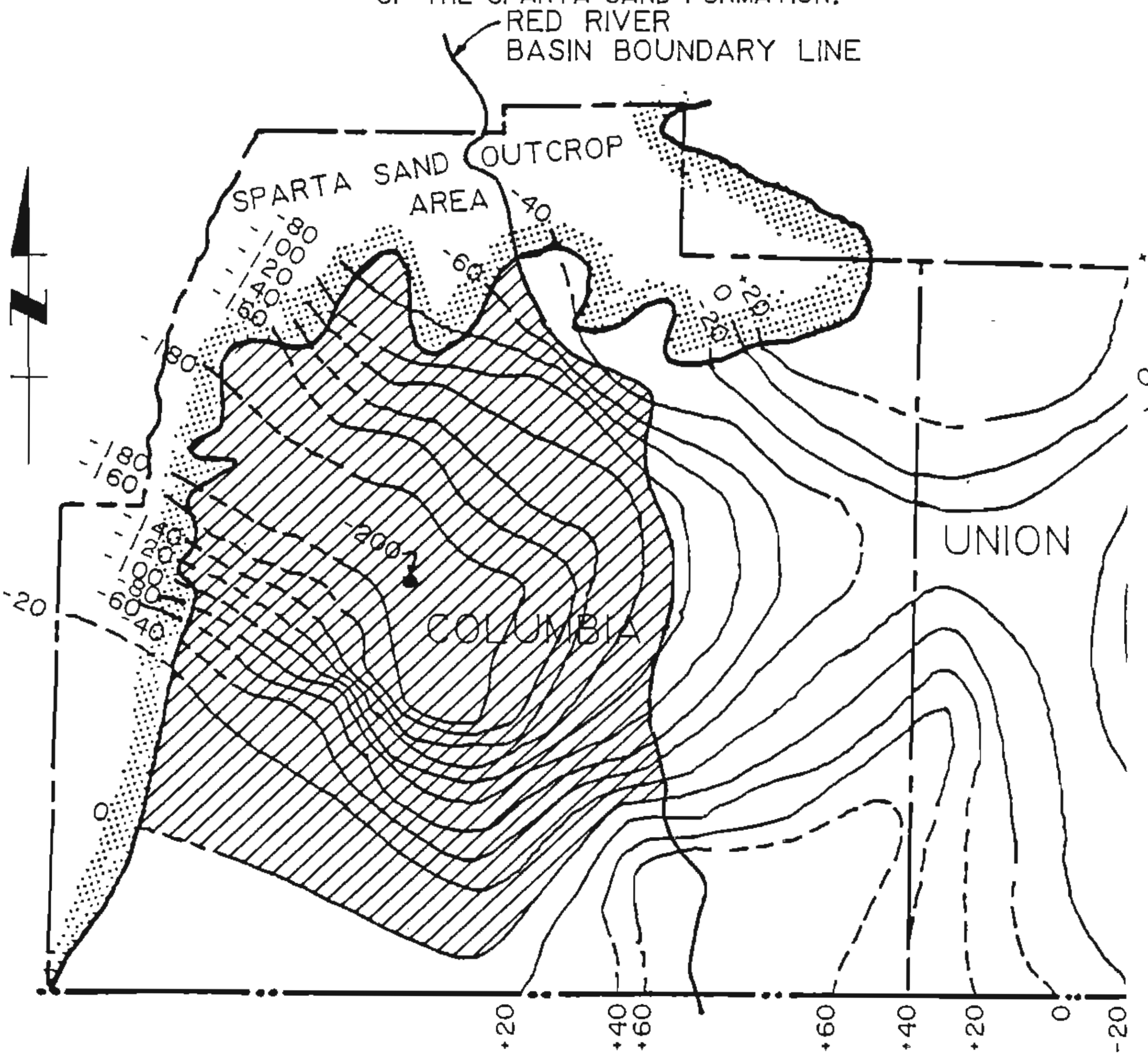
RELATIONSHIP OF THE TOP OF THE SPARTA FORMATION AND THE POTENTIOMETRIC SURFACE 1985

EXPLANATION

——— ISOLINES CONNECTING AREAS OF EQUAL RELATIONSHIP BETWEEN THE STRUCTURAL TOP OF THE SPARTA SAND AND THE POTENTIOMETRIC SURFACE.

EXAMPLE : -60 MEANS THE POTENTIOMETRIC SURFACE IS 60 FEET BELOW THE TOP OF THE SPARTA FORMATION.

[hatched box] AREA IN THE BASIN WITH THE POTENTIOMETRIC SURFACE BELOW THE TOP OF THE SPARTA SAND FORMATION.



SCALE : 1" APPROX. 6.5 MILES

SOURCE : 1985 POTENTIOMETRIC MAP OF THE SPARTA <72>
U.S. GEOLOGICAL SURVEY REPORT NO. 85-4116 <74>

Critical Use Area

Quaternary

The criteria for critical ground water use areas for aquifers under water table conditions are: Water levels have been reduced such that 50 percent or less of the formation thickness is saturated; and/or, average annual water level declines of one foot or more occur the preceding five years; and/or, ground water quality has been degraded or trends indicate probable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer.

From Table 4-6, the observation wells indicate that the water level is increasing in Lafayette County and declining less than one foot per year in Miller County during the 1980-1985 period. Based on declining water levels, no critical use areas of the Quaternary exist in the basin.

The Quaternary deposit thickness has not been mapped to the degree where 50 percent or less saturation of the thickness can be determined. As a result, critical use areas cannot be accurately defined based on 50 percent or less saturated thickness.

However, critical use areas based upon the degradation of water quality do exist in Lafayette and Miller Counties.

The principal reason for designating these areas critical use areas is the excessive chloride contamination. Davis and DeWiest estimated that water containing chlorides in excess of 300 mg/l is poor quality irrigation water. <73> For purposes of this report, a chloride concentration of 250 mg/l (maximum level for secondary drinking water) and above is used as the criteria for designating the area as critical use. Irrigation is the principle ground water use in these areas where chloride concentrations exceed 250 mg/l. The critical use area in Miller County is shown on Figure 4-10. The area in Lafayette County has not been specifically defined but the general critical use area is shown on Figure 4-5. Although the Quaternary aquifer was once used as the principal source for irrigation water is these areas, the large increase in chloride concentrations have forced the users to find alternative irrigation water sources.

Figure 4 - 10

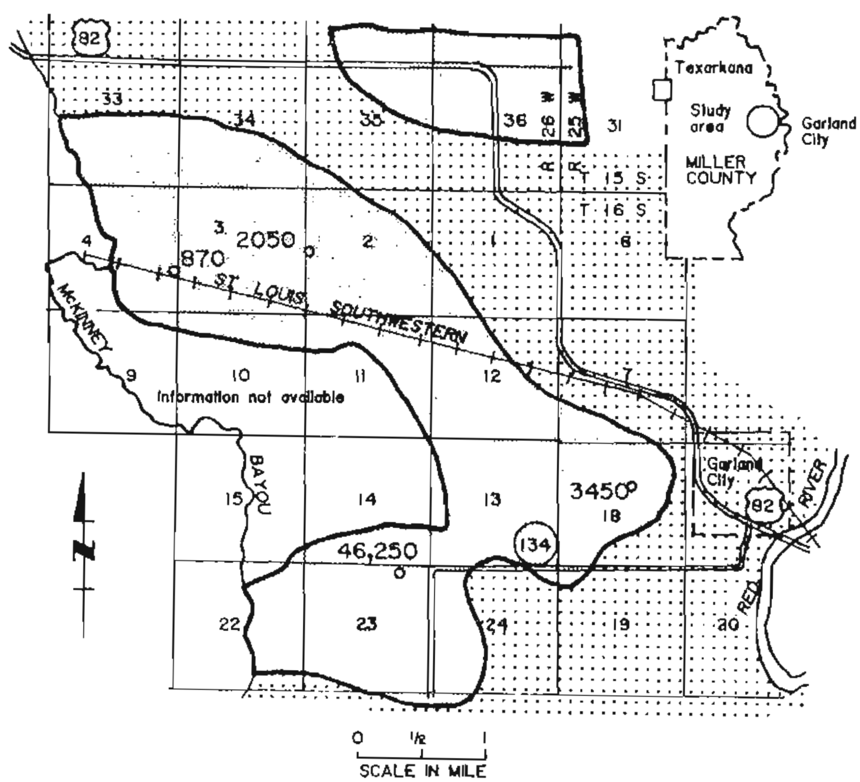
AREAS OF CHLORIDE CONTAMINATION IN THE ALLUVIAL AQUIFER MILLER COUNTY

EXPLANATION

CHLORIDE CONTENT OF GROUND WATER
MILLIGRAMS PER LITER

- (dotted pattern) LESS THAN 250
- (shaded pattern) 250 AND ABOVE
- 2050 ° SAMPLING POINT

Number indicates chloride content water mg/l



SOURCE : U.S. GEOLOGICAL SURVEY <58>

Sparta Sand

The criteria for critical ground water use areas in artesian aquifers are: potentiometric surface is below the top of the formation; and/or, average annual water level declines of one foot or more occur for the preceding five years; and/or, ground water quality has been degraded or trends indicate problable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer.

The critical use area in the basin Sparta Sand is based solely on the potentiometric surface being lower than the top of the formation. The formation is threatened as a drinking water source on the basis of water quality but no maximum contaminant levels have been established for sodium and studies on the effects of different concentrations result in ambiguous findings.

Figure 4-9 shows the potentiometric surface contours above and below the top of the Sparta formation. The shaded area within the zero contour line indicates the critical use area. This area covers a majority of Columbia County from the Sparta Sand outcrop boundary.

Water level declines or water quality degradation in the Sparta did not exceed the limits defined for critical use areas.

Cane River Formation

The same criteria for critical ground water use areas for aquifer conditions that apply to the Quaternary also apply to the Cane River Formation. Based on these criteria, no critical use areas are designated in the Cane River Formation. Water levels increase on an average annual basis during the preceding five years in both Lafayette and Miller Counties and decline 0.31 feet per year in Columbia County.

Water quality degradation has not curtailed the use of this ground water for their primary purposes.

Since the Cane River Formation thickness has not been accurately mapped in the areas of use in the basin, critical use areas were not determined based on 50 percent or less saturation of the formation thickness.

POTENTIAL GROUND WATER PROBLEMS

Potential exists over much of the basin for contamination of ground water from several sources. Permeable materials that allow water to recharge aquifers will also allow contaminants to enter the ground water system. Therefore, the potential for contamination is closely related to the recharge rate. <49> Generalized recharge zones and potential ground water contamination sources are delineated on Figure 4-11.

Potential hazards to ground water in the basin include landfills, hazardous waste, improperly constructed and abandoned wells, and surface impoundments (waste holding).

Landfills

Many open landfills and dumps exist in the basin. The contents of many of these fills are basically unknown. Some have remained as open dumps while others are sanitary landfills. Hazardous materials that could eventually percolate into the surface aquifer may be stored in these areas. <49>

Hazardous Waste

Hazardous materials generated or stored in the basin exceeded 100 tons in 1982. Eighty-three percent of the waste generated in the state is in the form of brine, a by-product of oil and bromine production. Although not listed as a hazardous waste, brine is potentially a major source of ground water contamination. <49>

Improper Well Construction and Abandonment

Oil and Gas Wells

The potential for contaminating the Sparta Sand with brine from the Nacatoch Sand (below the Midway Group) increases with continuing water level declines in the Sparta Sand. During the early days of oil field development, the tools and methods used today for oil reservoir management and conservation were not available. Peak production was reached a few years following discovery, after which oil production dropped off and brine production increased. <48>

> "The oil wells in Columbia County were drilled by the rotary method, except for some cable tool drilling in the producing zones. Most of the wells were constructed with 12 1/2 inch diameter iron surface casing, set, uncemented, to a depth of about 200 feet below land surface. The wells were then cased to the top of the Nacatoch Sand with steel liners. <57> Some were completed as open holes, but most were completed with perforated pipe or screen. Most of the wells are abandoned and some are unplugged. Oil operators have been required to plug abandoned wells drilled since 1939 according to rules of the Arkansas Oil and Gas Commission." <48>

Figure 4-11

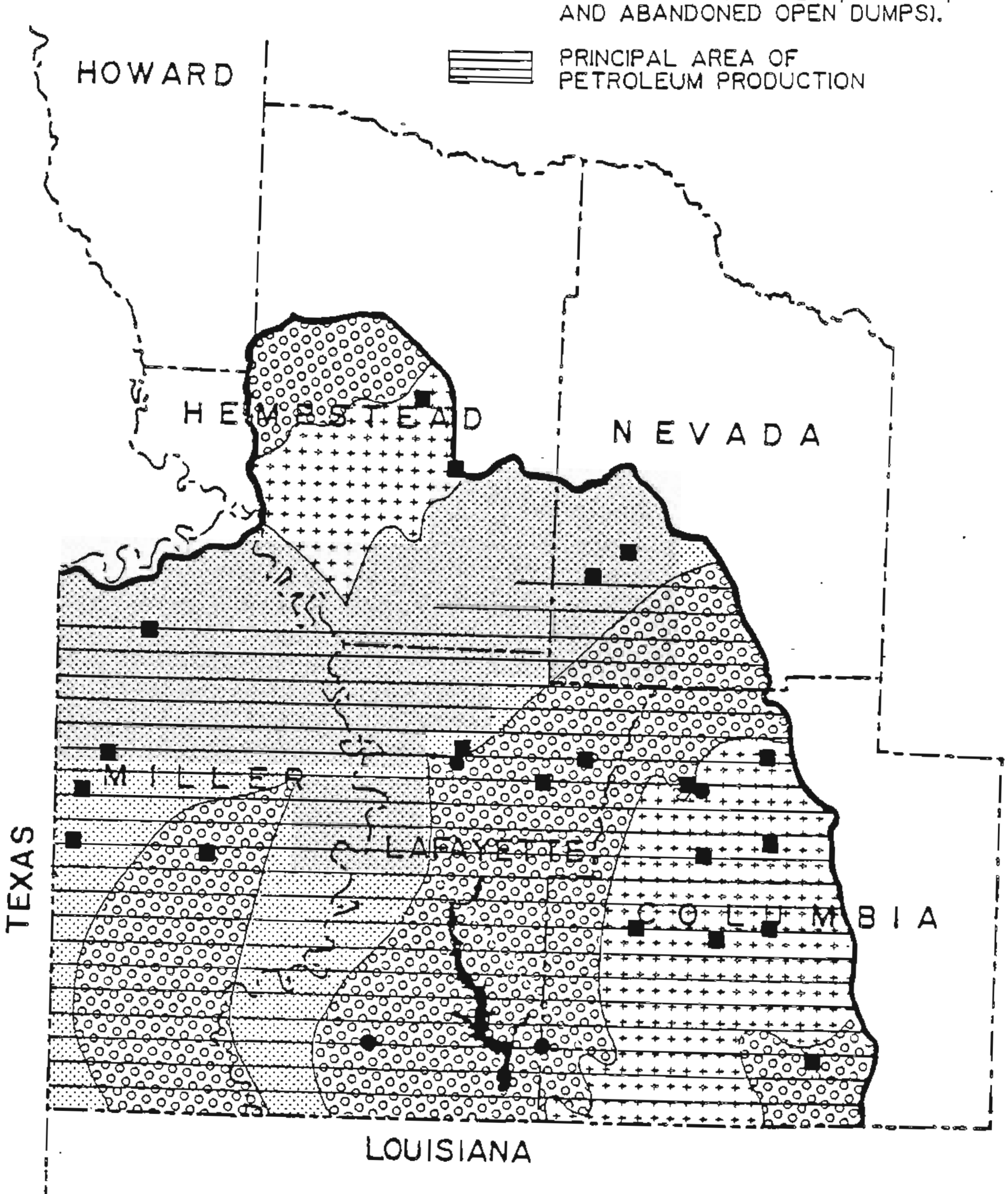
POTENTIAL GROUND WATER PROBLEMS

EXPLANATION

GENERALIZED RECHARGE ZONES AND POTENTIAL GROUND-WATER CONTAMINATION SOURCES.

- High recharge potential
- Moderate recharge potential
- Low recharge potential
- IMPOUNDMENT
- LANDFILL (INCLUDES MUNICIPAL AND INDUSTRIAL LANDFILLS, ACTIVE, CLOSED AND ABANDONED OPEN DUMPS).
- PRINCIPAL AREA OF PETROLEUM PRODUCTION

1" = Approx. 11 Miles



Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris, <49>

"All units deeper than the Nacatoch Sand yield saltwater or brine. Under natural controls, fluid movement between Cretaceous and Tertiary units is prevented by the confining Midway Group. The hydrostatic head differences between the Nacatoch Sand, the Wilcox Group, and the Lower Sparta are evidence that the confining beds are highly effective in preventing fluid mixing.

Apparently then, with the exception of fractures related to faulting, the only plausible means of mixing between the Lower Sparta and the underlying saltwater-bearing units is through "leaky" wells. Leaky wells can result from inappropriate methods and materials used during construction of the wells and from deterioration of casings and liners. Previous investigators, have expressed concern that substantial declines in the hydraulic head or potentiometric surface of the Lower Sparta aquifer might result in some leakage of brine from old abandoned oil wells. Those concerns had merit then as they do now, particularly in view of the methods of oil-well construction, the age of many of the wells and project water needs in the basin." <48>

Heat Pump Installation

The escalating incidence of heat pump installation by unlicensed drillers is a potential problem of unknown proportions. To date, this type of installation is not controlled by the Water Well Construction Committee. The variety of different heat pump systems aggravates the problem. Some systems use a single water well for withdrawing water to be circulated through a heat exchanger and then discharge the water out on the ground; others use two wells, one for withdrawal and one for injection. Other variations include closed loop systems where ground water circulates through field lines or a heat exchanger down in the well itself. Since the potential for contamination of ground water exists from these systems, regulations to insure that the well construction phase of installation is conducted properly are necessary.

Surface Impoundments (Waste Holdings)

The best available source of information on pits, ponds, and lagoons is the Surface Impoundment Assessment (SIA) funded by ADPC&E and conducted in Arkansas in 1978 and 1979 by the Arkansas Soil and Water Conservation Commission and the Soil Conservation Service. The study found 7,640 impoundments at 872 sites in the state. Five hundred and six impoundments were then selected for assessment of pollution potential. <16>

About 10 percent of the industrial sites have monitoring wells and less than 2 percent of the municipal sites assessed have monitoring wells. The fact that 95% of the sites on which information was available have no monitoring wells attests to the need for a strategy for developing a statewide monitoring system. <16>

Surface impoundments are distributed throughout localities where little or no protection of ground water is afforded by an impermeable surface layer. Some unlined ponds have been constructed at sites which apparently are potentially hazardous because of the lack of natural protection. A more detailed investigation at each site would be required to quantify the validity of this concern. Seventy-eight percent of the impoundments surveyed reported no liner, 95 percent have no monitoring wells, and 32 percent are within 1 mile of a well used for drinking water. <16>

Based on the data collected during the SIA, and previous cases of known ground water pollution, the activities and geographic regions of Arkansas with the highest potential for ground water contamination was: "Highest Hazard - Oil and Gas Activity in Southern Arkansas". The reason for the high hazard rating was the number of impoundments and poor construction practices. <20> The lack of attention to ground water protection is reflected in the few state and federal programs which regulate construction and modification of waste holding impoundments in the state. Several state agencies are empowered to issue and enforce orders to abate contamination, and in the past, such orders have been issued in cases of reported ground water contamination, but effective preventive programs have not been developed. A unified program is needed to prevent contamination using ground water quality management planning, proper siting, and construction requirements, and site surveillance of ground water.

LEGAL AND INSTITUTIONAL PROBLEMS

Water-Wells

The authority to regulate the construction of water wells is vested in the Water Well Construction Committee. The Committee licenses water well contractors, provides drilling rig permits, and tests and registers water well drillers. The Committee also conducts hearings on well drillers' complaints concerning improper construction practices.

The problems center around enforcement of existing legislation concerning proper construction techniques and changing the law to address and alleviate current and potential problems. All well drillers are required to submit a construction report within 30 days after the completion of a well.

It has been estimated that approximately one-half of all wells drilled in certain parts of the state do not have construction reports on file. The Committee has a staff of two people to maintain files, investigate complaints and inspect well sites. Lack of time and funds hinders the enforcement of well construction regulation and is creating difficulty among contractors competing with those attempting to ignore regulations.

Public Supply Systems

Many Arkansas communities have water supply systems which are improperly maintained and operated. The 1980 drought caused a vast majority of Arkansas' public water systems to reach record demands. The heavy consumption placed unexpected strain on existing sources, pumps, treatment facilities, and distribution systems. Many customers experienced service interruptions due to an inadequate source, pump failure, single well systems, inadequately trained personnel and undersized piping systems. During this time period, five water systems in the state were forced to haul water to meet demands, and the Arkansas Department of Health issued boiling orders to water systems due to suspected contamination when these systems experienced pressure loss.

In addition, many water systems managers had to impose voluntary or mandatory water conservation practices. The extreme climatic conditions of the summer of 1980 focused attention on the importance of proper planning, operation and maintenance of water systems. Due to a lack of sufficient funds, many small water systems have only a part-time operator and excessive personnel turnover is a common problem. Needed operation and maintenance is minimally performed, resulting in costly water projects having a shortened operational life.

Many of the public water supply systems do not have backup wells for use during periods when repairs are being made on equipment. In addition, insufficient storage is available to supply the sustaining needs of customers. A total of 16 public water supply systems, most of which are one-well systems, are in the basin.

Surface Impoundments (Waste Holdings)

Large quantities of brine have been pumped from the Nacatoch Sand during more than 50 years of oil development in the area. Most of this brine was discharged to the south-southeastward draining streams.

Appreciable amounts of brine were injected through wells back into the Nacatoch Sand for disposal and formation repressurization. Generally the brine has been held in surface ponds before going to streams or to injection wells. <18> Regulatory control over impoundments receiving waste materials in Arkansas is primarily vested in the Arkansas Department of Pollution Control and Ecology Commission. Many of the impoundments in which petroleum waste and brines are stored are used without liners for oil and gas. Several pits have been abandoned and the owners are difficult to locate.

The Arkansas Department of Pollution Control and Ecology operates under authority of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended), which confers broad powers of regulation and enforcement to the agency.

The Arkansas Hazardous Waste Management Act (Act 406 of 1979) has direct applicability to surface impoundments holding toxic wastes but brine is not considered to be hazardous. This Act, which is to be enforced through the ADPC&E, requires permits for the construction, alteration and operation of hazardous waste treatment or disposal facilities or the storage of hazardous wastes.

The most stringent state requirements concerning impoundments have resulted from ADPC&E Regulation No. 1 (1958) concerning disposal of wastes resulting from oil and gas field operations. Regulation No. 1 requires disposal of brines and wastes from new fields or pools by using underground injection wherever possible and denies disposal in earthen pits unless the pits are underlain by tight soil or are lined with asphalt or other water tight material. However, a procedure for requiring testing of permeability for new impoundments does not exist and enforcement is difficult.

Ground Water Use Data

Various state and federal agencies have limited authority over ground water. This has resulted in several different ground water data bases, each slightly different in nature, and reflecting the authority and interest of the individual agency. The problems stem from various sources including conflicting data and estimation methodology utilized in lieu of legislation requiring ground water users to report their actual use on an annual basis. The best source for data on the quantity of ground water withdrawn is from the U.S. Geological Survey. Heavy reliance on many agencies, organizations, industry, and individuals to report their use of data causes delays in compilation, adjustments, and interpretation of data.

Consequently, the U.S.G.S. publications on water use run approximately two years behind. In order for current issues to be addressed properly, data of ground water must be made available with much less time lag between actual use and published use reports.

Ground Water Quality Data

For ground water quality, one of the best sources is the Chemical Data, 1982, released by the Arkansas Health Department about every two years. It includes chemical analysis of samples submitted by cities or communities using public water supplies every three years. Similar chemical analyses are done by the University of Arkansas Cooperative Extension Service for farmers who provide irrigation well samples to their county agents. A computer printout of these analyses is available from the UA Extension Office. Additional chemical data from the sampling stations of the USGS is presented in the publication entitled Water Resources Data for Arkansas, published annually. These analyses are also placed in the Federal computer systems, WATSTORE and STORET.

Another data source on the quantity and quality of ground water in the state is in the ADPC&E publication, Nonpoint Source Pollution Assessment Summaries, 1979, for each of the five major river basins in the state. This can be supplemented with the ground water section of ADPC&E's, Arkansas Water Quality Inventory Report, 1984, which also summarizes recent reports issued by the Soil and Water Commission, the United States Geological Survey, Arkansas Geological Commission, and the ADPC&E. The State Water Plan of 1975, produced by the Arkansas Soil and Water Commission contains much information on municipal supplies.

In addition, valuable ground water use and quality data are scattered throughout the numerous reports published by the USGS and the Arkansas Geological Commission. The Arkansas Water Resources Research Center also publishes studies dealing with all aspects of ground water.

Problems associated with gathering information on ground water stem mainly from data accessibility. Data entry commonly runs far behind data gathering. Many data bases are not compatible from agency to agency. In-house terminal link-ups, or a central data base system to share information are needed among ADPC&E, U.S. Geological Survey, and Arkansas Department of Health. Efforts are underway to have all the quality data from state and federal agencies centrally located at USGS offices in Little Rock. The time and effort required to secure the needed information from scattered files seems prohibitive and not cost effective. These sources possess valid, reliable, and accurate data but the data is currently not directly accessible by enough state and federal agencies.

GROUND WATER PROBLEMS, SOLUTIONS, AND RECOMMENDATIONS

Major Aquifers

Problems

The potentiometric surface is below the top of the Sparta Sand in much of Columbia County. Problems associated with this phenomenon include increased pumping lifts, decreased yields, and the potential for salt water intrusion. If not corrected, the drawdown can lead to compaction of the aquifer material and subsidence of the land surface.

Chloride concentration has contaminated a portion of the alluvial aquifer in Miller and Lafayette Counties. The use of this aquifer has been essentially curtailed for irrigation over approximately a 25 square mile area. Curtailment has resulted in the extensive development of expensive alternative irrigation water sources for users of the alluvial aquifer.

No severe water quality or declining water level problems have presently been identified for aquifers associated with the Cane River Formation in the basin.

Solutions and Recommendations

Nonstructural solutions for the conservation of ground water and improvement of water quality include: (A) Conservation; (B) Best Management Practices; (C) Conversion Incentives; (D) Research; (E) Ground Water Use Data; and (F) Reduced Aquifer Contamination Potential.

(A) Conservation: Many studies in other parts of the United States have documented up to 40 percent savings in efficiency and reduction of losses and waste by utilizing data obtained from studies of various application techniques, pumping plant efficiency tests and soil moisture monitoring. Additional monitoring of ground water levels in wells and more data on stream-aquifer connections are needed to develop ground water conservation programs.

(B) Best Management Practices (B.M.P.): B.M.P.'s as outlined in the surface water chapter will also conserve the quantity and quality of ground water available in the basin. Surface water and ground water systems are interconnected and what happens on the land surface will affect, if not determine ground water availability and quality.

(C) Incentives: Although not a current serious problem in this basin, ground water overdraft was addressed in the 1985 General Legislative Session with passage of Act 417, entitled "Water Resource Conservation and Development Incentives Act of 1985."

This Act stated that existing water use patterns were depleting underground water supplies at an unacceptable rate because alternative surface water supplies were not available in sufficient quantities and quality at the time of demand. The Act provides ground water conservation incentives in the form of tax credits to encourage construction and restoration of surface water impoundments and conversion from ground water to surface water use.

Tax credits cannot exceed 50 percent of the actual construction costs for impoundments or $3,000 annually for a period of 11 years. The impoundment or water control structure must store a minimum of 20 acre feet and be used for the production of food and fiber as a business or for industrial purposes. This would include rice, wheat, soybeans, cotton, corn, milo, fruit, vegetable crops, and domestic uses. The Arkansas Soil and Water Conservation Commission will administer the program with assistance from the Conservation Districts. All plans, designs, and specifications must be submitted to the Commission for approval. If acceptable, a "certificate of tax credit approval" will be issued as proof of eligibility.

Conversion Credits are limited to 10 percent of the actual cost of abandoning or reducing the extraction of ground water and utilizing surface water as an alternative. Applicants must furnish proof to the Commission that ground water was being used previously and eligible equipment and construction costs will directly reduce the quantity of ground water withdrawn. The specific rules and regulations for eligibility in both programs can be obtained from the Arkansas Soil and Water Conservation Commission.

(D) Research: In 1985, Act 816 was passed which provided $200,000 for water related research. The money will be made available for a 2-year period ending June 30, 1987. An amount of $60,000 annually will be used to contract for modeling and continuing research on conjunctive use of ground water and surface water. The results and techniques developed from this research will be made available to water users.

Act 417 of 1985 will provide incentives to develop reservoirs and convert to surface water sources. Research should evaluate potential reservoir sites and encourage conversion to surface water supplies, when possible. Some industries and municipalities in the basin have recently shifted from ground water to surface water. The City of Magnolia has just completed a public supply reservoir.

Research could reveal many characteristics of the Sparta Sand Aquifer which are still unknown. A recent cost-sharing agreement between the Arkansas Soil and Water Conservation Commission and the U.S. Geological Survey (Arkansas District) for three years at a cost of $40,000 per year will result in the U.S. Geological Survey developing a ground water model of the Sparta Sand in Arkansas and Louisiana.

The Sparta Sand Model and investigation will develop methods for evaluating the impact of present and proposed aquifer development on water-level declines and ultimately, ground water availability.

The objectives of the study are as follows: (1) Evaluate the hydrogeologic characteristics of major units that control flow in the Sparta Sand Formation within the project area, including recharge, vertical leakage, nature of the flow system and hydraulic characteristics, (2) Evaluate areas of major withdrawal in Arkansas and adjacent states with regard to their potential impact on water level declines in this aquifer, (3) Construct and calibrate a ground water flow model, in coordination with the U.S. Geological Survey (Louisiana District), to be used in assessing the feasibility of proposed withdrawals from the Sparta Sand Aquifer in Louisiana and Arkansas. The study area will include much of the Lower Ouachita Basin and Red River Basin below Fulton. A report will be prepared that will describe the hydrogeology of the study area, flow system within the aquifer, the digital model, and provide examples of how the model will run. The report will be part of the cooperators technical report series in Arkansas and Louisiana. The report will be submitted for ASWCC directors approval prior to the end of FY 1987.

Another larger regional study will have an impact on current and future modeling investigations. This is the West Gulf Coast Regional Aquifer Systems Analysis (RASA) whose major objective is to define the magnitude of flow and direction of flow within regional aquifer systems. A digital computer model will be developed to define the framework flow pattern within the Quaternary and Tertiary (Alluvium, Cockfield, and Sparta) Systems in Texas, Arkansas, Louisiana, Missouri, Kentucky, Tennessee, and Mississippi.

The major advantage of this modeling approach will be the elimination of artificial boundaries present in most aquifer models. Two levels of modeling will be utilized. The regional offices will work on a 10-mile grid system while state level involvement will be on a 5-mile grid pattern.

The expected results will include: (1) digital computer model, (2) definition of overall flow pattern within the aquifers, (3) increments of movement within each node, (4) revision of data bases, and (5) a base for more detailed modeling studies. The project should be completed late in 1987.

(E) Ground water Use Data: The problems of time lag with ground water use data could be lessened with the passage of Act 1051 of 1985. The mandatory reporting of all ground water use by quantity, location, type of use and name of user on an annual basis is now state law. The exceptions are wells of 5" or less inside diameter or those used for domestic purposes.

Reporting of use will be on the same form and time frame as Surface Water Diversion Registration is today. Inaccurate reporting of ground water use can be avoided by the use of flowmeters made available through the Eastern Arkansas Water Conservation Project. Users can have their pumping plants rated at 1/4, 1/2, 3/4 and full throttle (diesel units) and keep records of the time that a particular rate of flow occurred. Electric bills can be used to determine flow rates for electric powered pumps. The use of flowmeters to rate pumps, such as tailwater recovery pumps, powered by internal combustion engines, will also reduce the error in reporting surface water use.

(F) Reduced Aquifer Contamination Potential: Under ADPC&E Regulation #1 (1958) construction of new pits for oil field disposal has been reduced significantly. Regulation #1 should be modified to include pre-existing pits currently not covered under the regulation. Percolation tests and borings should be required for materials underlying new pits.

In 1982, a report was published by the Wright-Pierce Engineering Firm of Topsham, Maine. The report established criteria for siting impoundments and landfills of hazardous and non-hazardous waste, indicated areas highly vulnerable due to permeability, and identified areas posing a significant threat to ground water quality. The report outlines in detail the siting criteria that should be required by ADPC&E. The nature of unconsolidated lensed formations in the basin requires each site to be physically inspected and adequately evaluated.

The siphoning of brine from pits into local streams was and still may be a common practice. Reduction or elimination of brine holding pits by requiring all waste to be injected into the ground might be the only method of dealing with this hazard to surface water and ground water. Injection, however, may not be economically practical, and legislative authority for such action does not exist. ADPC&E expects to have regulation #1 rewritten soon. Under consideration is; (A) grandfather old pits, (B) five-year phase out of existing pits, (C) no pit policy, (D) double shut-offs for producing and injection wells, (E) emergency pit defined, and (F) impervious liners defined.

Under the Resource Conservation and Recovery Act (RCRA), all open dumps should be upgraded to sanitary landfills. This upgrading would provide a data base for further control. Impoundments holding hazardous waste could be controlled by the permit process of site evaluation. If the program was properly administered, the danger of ground water contamination from hazardous wastes should no longer be a significant threat in Arkansas. Although it will be several years before the program is fully implemented, the "interim status" requirements for permit applicants will provide some control on the impoundments as the program progresses.

For impoundments containing non-hazardous materials, the state still must exercise some initiative in developing programs of control but can request funds in support of such projects through the Solid Waste Management Program of RCRA or the Water Quality Management Program under the Clean Water Act. All such impoundments should be permitted.

This program could be used to contribute to the overall protection of ground water by limiting the quantities of brine held in surface impoundments in the Red River Basin below Fulton. ADPC&E is currently updating information on the location and nature of surface holding impoundments in the basin.

Programs that could result in increased ground water protection are hindered by inadequate funding and staffing of state offices. The addition of any new commitments to ground water protection will require increased staffing and considerable financial, legislative, and public support.

The major emphasis in the past has been on surface water contamination and the result has been Federal Legislation to control the nature and extent of same. Commonly, ground water protection has occurred as a spinoff of surface water pollution regulations. This approach, as evidenced by ground water pollution problems in this basin, is inadequate to protect this resource. The requirements for ground water protection that do exist are too easily ignored and underfunded when they are secondary components of larger programs. Accountability for ground water protection is too easily hidden among plans for protection of surface waters.

Legal and Institutional

Public Supply Systems

Act 406 of 1985 was passed to make an appropriation to the Arkansas Soil and Water Conservation Commission to contract with the Arkansas Rural Water Association to provide technical assistance and training to the water systems operators in the state. For the biennial period ending June 30, 1987, $50,000 will be available to provide an additional circuit rider to investigate complaints, problems, or inspect water systems. The Circuit rider will be an experienced, licensed operator that can assist with accounting procedures, inventory, maintenance, and management problems. This program will complement the Arkansas Department of Health training and licensing program for water system operators.

Approximately 3,000 man-hours of training are provided by the Engineering Division of the Health Department to water operators in any given year. The licensing program is an ongoing process that involves periodic training for the operators and a stepped series of exams that can possibly extend over a four year period. Training of water system operators is essential but the value of a circuit rider to help operators with specific on-site problems is invaluable. These programs by the Arkansas Soil and Water Conservation Commission and the Arkansas Department of Health will hopefully aid in reducing costly errors in operations, maintenance and management of rural and municipal water supply systems.

Improperly Constructed and Abandoned Wells

In the 1985 legislative session new laws were passed that will help to alleviate some of the problems concerning improperly constructed and abandoned wells.

Oil and Gas Wells

Oil and gas well construction guidelines have been state law since the passage of Act 105 in 1939. The strict regulations on drilling and exploration after 1939 had no effect on wells drilled prior to that date. The Arkansas Geological Commission has estimated that as many as 75,000 wells may exist in southern Arkansas. Most of these wells are located east of the Red River Basin below Fulton. As each new case of pollution is documented, old abandoned wells are commonly on the list of prospective causes. Research is needed to evaluate the number of unplugged wells, their locations and actual contribution to quality degradation in aquifers used as drinking water supplies.

Several methodologies are available to locate abandoned and unplugged wells including historical methods such as record searching and the use of metal detectors. Geophysical methods such as electrical resistivity, electromagnetic conductivity and ground penetrating radar have been used in some areas. Remote sensing data has also been used to some degree, for example, black and white aerial photographs, color photographs, color infrared imagery and thermal imagery. The initial research should evaluate the different methodologies available and recommend the most cost efficient method for southern Arkansas.

Water Wells

The objective of Act 783 of 1985 was to amend section 14 of Act 641 of 1979 to increase certain fees levied and to provide funds for the administration of the Waterwell Construction Act by the Waterwell Construction Committee. New fees are as follows: (A) Certificate of registration - $70, (B) Contractors license - $200 and (C) rig permits - $80. Additional funding provided by this Act will offset costs due to inflation, expanded duties by the committee; and pay increases to personnel.

Act 822 of 1985 addressed heat pump well construction practices. The objective of the law was to provide the Waterwell Construction Committee with regulatory control for wells drilled for the purpose of ground water source heat pump installations. The definition of "water well" in Act 641 of 1969 was amended to include excavations made for the purpose of exchanging geothermal energy found in the earth, termed heat pump wells.

Heat pump wells were defined as any excavation that is drilled, redrilled, cored, bored, washed, driven, dug, jetted or otherwise artifically constructed for the purpose of obtaining or exchanging geothermal energy for use with ground water source air conditioning or heat pump systems. The excavation may have pipes installed inside the excavation to circulate or discharge various fluids and the well may or may not be backfilled after excavation.

This Act will regulate the heat pump well drillers to the same degree as water well drillers. The same construction and abandonment procedures will apply to wells for heat pump sources as those wells for water supply. This should reduce the potential for contamination from heat pump systems that have been previously unregulated.

DEFINITIONS

ALLUVIUM: Earth, sand, gravel, and other transported matter which has been deposited by rivers. Usually a good, porous storage medium for ground water.

AQUIFER: A water-bearing layer of rock that will yield water in a usable quantity to a well or spring.

BEDROCK: A general term for the consolidated (solid) rock that underlies soils or other unconsolidated surficial material.

BEST MANAGEMENT PRACTICE (BMP): A practice or practices that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

CONE OF DEPRESSION (Or drawdown cone): A conical concavity (or dimple) in the potentiometric surface around a pumping well caused by the withdrawal of water.

CONFINED (or artesian) AQUIFER: An aquifer that is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

CONFINING BED: A body of "imperishable" material statigraphically adjacent to one or more aquifers, the hydraulic conductivity of which may range from nearly zero to some value distinctly lower than that of the aquifer. Synonyms: aquitard; aquiclude; and aquifuge.

CONSUMPTIVE USE: Use of water in a manner that makes it unavailable for use by others because of absorption, evaporation, transpiration or incorporation in a manufactured product. In some instances, when water is returned to a stream at a distance downstream from the point of diversion, the use may be consumptive as to users immediately below the point of diversion but nonconsumptive as to users below the point where the water is returned.

CRITICAL GROUND WATER AREAS

Water Table Condition: Water levels have been reduced such that 50 percent of the thickness of the formation, or less, is saturated; and/or average annual declines of one foot or more have occurred for the preceeding five years; and/or 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.

Artesian Condition: Potentiometric surface has declined below the top of the formation; and/or average annual declines of one foot or more have occurred for the preceeding five years; and/or 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.

CRITICAL SURFACE WATER AREA: 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.

DATUM PLANE: An arbitrary surface (or plane) used in the measurement of ground water heads. The datum most commonly used is the National Geodetic Vertical Datum of 1929, which closely approximates sea level.

DEPENDABLE WATER SUPPLY: The amount of water of desired quality that can be expected to be available at a given point a stated percentage of the time.

DISCHARGE: Outflow of water from a drainage basin, reservoir of other facility through a channel, pipe or other outlet, including the release of polluted water into a stream or waterbody. Also, the rate of discharge measured in units of volume per unit of time, either for an entire outlet or for a specified cross-sectional area of the outlet.

DRAWDOWN IN A WELL: The vertical drop of the water level in a well caused by pumping.

EROSION: The wearing away of the land surface by the detachment and transport of soil materials through the action of moving water, wind or other geological agent.

EVAPOTRANSPIRATION: Evaporation from water surfaces, plus transpiration from plants.

EXCESS STREAMFLOW: 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.

FAULT: A fracture in the Earth's crust accompanied by displacement of one side of the fracture with respect to the other.

FRACTURE: A break in rock that may be caused by compressional or tensional forces.

GROUND WATER: Water in the saturated zone that is under a pressure equal to or greater than atmospheric pressure.

GROUND WATER, CONFINED: Ground water which is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

GROUND WATER, PERCHED: Unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table.

GROUND WATER, UNCONFINED: Water in an aquifer under atmospheric pressure that has a water table and is free to rise and fall.

HEAD (or static head): The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point.

HYDRAULIC CONDUCTIVITY: The capacity of a rock to transmit water. It is expressed as the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

HYDRAULIC GRADIENT: The change in static head per unit of distance in a given direction. If not specified, the direction generally is understood to be that of the maximum rate of decrease in head.

HYDROLOGIC CYCLE: The constant movement of water in the atmosphere and on and beneath the earth's surface.

INFILTRATION: The movement of water from the earth's surface into the soil zone.

INSTREAM FLOW REQUIREMENTS: The flow regime which will best meet the individual and collective instream uses and off-stream withdrawals of water. 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 supply, and cooling water.

INTERBASIN TRANSFER: The physical conveyance of water from one watershed to another.

IRRIGATION SCHEDULING: The process that enables an irrigator to apply irrigation water in the proper amounts and at the proper time to efficiently alleviate moisture shortages.

MINIMUM STREAMFLOW: The lowest daily mean discharge that will satisfy minimum instream flow requirements. The minimum streamflow represents the discharge at which all withdrawals from the stream will cease.

NONCONSUMPTIVE USE: Use of water with return to the stream or waterbody of substantially the same amount of water as withdrawn. A use in which only insignificant amounts of water are lost by evapotranspiration or incorporation in a manufactured product.

NONPOINT SOURCE: The entry of a pollutant into a body of water in a diffuse manner with no definite point of entry and where the source is not readily discernable.

PERCOLATION: Movement under hydrostatic pressure of water through the openings of rock or soil, except movement through large openings such as caves.

PERMEABILITY: A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient.

pH: A measure of the relative acidity of water. Below 7 is increasingly acid, 7.0 is neutral, and above 7 is increasingly alkaline (basic).

POINT SOURCE: The release of a pollutant from a pipe or discrete conveyance into a body of water or a watercourse leading to a body of water.

POROSITY: The voids or openings in a rock. Porosity may be expressed quantitatively as the ratio of the volume of openings in a rock to the total volume of the rock.

POTENTIOMETRIC SURFACE: A surface that represents the total head in an aquifer; that is, it represents the height above a datum plane at which the water level stands in tightly cased wells that penetrate the aquifer.

PRIME FARMLAND: Land well-suited to the production of food and fiber. Prime farmland has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when managed according to acceptable farming methods.

RCRA SITES: Resource Conservation and Recovery Act sites where hazardous wastes are treated under authorization of regulatory agencies.

RECHARGE: The entry into the saturated zone of water made available at the water table surface; together with the associated flow away from the water table within the saturated zone.

RECHARGE AREA OR ZONE: That position of a drainage basin in which the net saturated flow of groundwater is directed away from the water table.

RECHARGE, ARTIFICIAL: The addition of water to the ground water by activities of man at a recharge rate greater than normal.

RIPARIAN DOCTRINE: The system of law in which owners of lands along the banks of a stream or waterbody have the right to reasonable use of the waters and a correlative right protecting against unreasonable use by others that substantially diminishes the quantity or quality of water. The right is appurtenant to the land and does not depend upon prior use.

RIPARIAN RIGHTS: The rights accompanying ownership of land along the bank of a stream or lake under the riparian doctrine.

RUNOFF: (1) That portion of precipitation which does not return to the atmosphere through evapotranspiration nor infiltrate the soil to recharge ground water, but leaves the hydrologic system as streams as streamflow; also (2) that portion of precipitation delivered to streams as overland flow to tributary channels.

ROCK: Any naturally formed, consolidated or unconsolidated material (but not soil) consisting of two or more minerals.

SAFE YIELD:

Surface Water: The safe yield of a stream or river is the amount of water that is available on a dependable basis which could be used as a surface water supply. The safe yield is 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).

Ground Water: The safe yield of an aquifer is roughly equal to the recharge rate to the system. Due to the temporal and spatial variability of recharge, the safe yield can most easily be expressed as the quantity of ground water that can be withdrawn while maintaining static water levels over the long term.

SALTWATER INTRUSION (Seawater intrusion): The migration of saltwater into freshwater aquifers under the influence of ground water development (pumping).

SATURATED ZONE: The subsurface zone occurring below the water table where the soil pores are filled with water, and the moisture content equals the porosity.

SHEET AND RILL EROSION: A combined process caused by runoff water, that removes a fairly uniform layer of soil from the land surface and forms many small channels in the land surface.

SOIL: The layer of material at the land surface that supports plant growth.

SPECIFIC CAPACITY: The discharge from a pumping well (the pumping rate) divided by the drawdown in the well; it is a measure of the productivity of a well.

SPECIFIC RETENTION: The ratio of (1) the volume of water which the rock or soil, after being saturated, will retain against the pull of gravity to (2) the volume of rock or salt.

SPECIFIC YIELD: The ratio of (1) volume of water which the rock or soil, after being saturated, will yield by gravity to (2) the volume of the rock or soil.

STORAGE COEFFICIENT: The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In an unconfined aquifer, the storage coefficient is equal to the specific yield.

STRATIFICATION: The layered structure of sedimentary rocks.

TRANSMISSIVITY: The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It equals the hydraulic conductivity multiplied by the aquifer thickness.

UNCONFINED AQUIFER: An aquifer in which the upper surface of the saturated zone is free to rise and fall.

UNSATURATED ZONE: The subsurface zone, usually starting at the land surface, that contains both water and air.

WATER TABLE: The level in the saturated zone at which the pressure is equal to the atmospheric pressure.

WATERSHED: The area of contribution to a surface water body or a central discharge point. It is defined by topographic high points.

WATERSHED PROTECTION: Establishing land treatment measures within a particular watershed to reduce erosion, sediment, and/or runoff.

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July 16, 1986

REC'D	✓ ROUTE
Davis	✓
Murphy	✓
ASTC(O)	
*Dennis	✓
Foltz	
Peters	
Williams	
SAO	
File	Dennis
* Action by	

CC: Randy Young, Dir Sux Sect 71

Mr. Jack Davis, State Conservationist
Soil Conservation Service
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, AR 72201

Dear Mr. Davis:

The following comments comprise the input of the staff of the Department of Pollution Control and Ecology concerning the draft copy of the Arkansas State Water Plan - Red River below Fulton Basin. The seriousness with which we view the long term directions set out by the State Water Plan and the potential effects of this plan on the water resources of our state cannot be overstated. It is with these concerns that we make these constructive comments.

The groundwater section of the report attempts to discuss and develop a plan based on surface water drainage basins. It is well documented that groundwater aquifers and recharge areas are not congruent with surface drainages. In its recent publication on groundwater problems, USGS abandoned the surface drainage basins as a vehicle for dividing its report and this resulted in a much more logical, concise and comprehendable document than its first draft which, like the State Water Plan, was based on a surface approach. While it is true that aquifer recharge requirements are not known for each aquifer, elaborate models are not needed for entire aquifers to figure recharge requirements as they relate to minimum stream flows. Recharge as a percentage of streamflow can be figured by either physical or chemical means using methods and formulas available in basic hydrology texts. The applicable principle is that to maintain base flow in a stream, the water table in the adjoining aquifer has to be sufficiently high to allow for lateral movement into the stream bed. That depth can be readily ascertained and pumping limits established so that sufficient recharge is maintained. To allow the water table to fall below the streambed has the result of eliminating the flow entirely when runoff is absent, thus making minimum streamflow questions academic.

The data used in Table 3-4 are 30-40 years old and should be updated to be useful.

The contamination in Miller County referred to under Groundwater Problems of the Quarternary Aquifer was caused primarily by a failure of a Class II injection well. Seepage from pits was a relatively minor contributor.

It should be made clear to all readers of this document that there is a significant paucity of data on the quantity and quality of groundwater in Arkansas and that much of the available data is self-supplied by the users and may be heavily biased by their preconception of the uses of the data. An additional source of data which is available concerning groundwater quality is the RCRA industrial monitoring data available through STORET.

We are very concerned about the methodology used in the draft document to establish minimum streamflows for surface waters and the negative impact these will have on the biotic uses of the streams. These minimum streamflows are proposed to be only 10 percent of the historical flows of the driest months of the year, (i.e., July, August, September and October). This minimum streamflow, hereafter referred to as SWC plan, is proposed to supply all instream flow needs, including fish and wildlife, during all seasons of the year. This approach is totally unacceptable and will drastically alter the designated beneficial uses of the streams. By statutory definition, minimum streamflows are the point at which "all diversions should cease"; however, there remains no effective mechanism to control diversions above this level. Without such controls, diversions will cause the minimum streamflows to become the average streamflow and "worst case" conditions for instream aquatic life will become the standard.

The Clean Water Act was a mandate from Congress to reverse the trends of degradation of the nation's waters and to restore and maintain the chemical, physical and biological integrity of these waters. Such a mandate is not limited to water quality control and is so recognized in the Act. In the goal of the Clean Water Act "...that provides for the protection and propagation of fish, shellfish and wildlife and recreation in and on the water," it further recognizes and mandates the protection of all life stages of the aquatic biota, specifically including the propagation stage. It is intimately clear that maintaining the "biological integrity of the nation's waters" must include maintenance of a flow regime that will be fully protective of the biotic designated beneficial uses of these waters.

It should be recognized that the proposed "Arkansas Plan" for establishing minimum streamflows for fish and wildlife represents acceptable streamflow conditions which may become average or standard conditions without significant damage to the aquatic resources. Although, it is realized that there will be both natural and artificial flow conditions above and below these "target" flows. We feel that an acceptable allocation plan must be a part of the State Water Plan if minimum streamflows are established lower than those proposed by the "Arkansas Plan." If a rigid and effective allocation plan is developed and implemented which is automatically initiated before streamflows reach a minimum level, then minimum streamflows could be set at relatively low levels. Without an active allocation plan, minimum streamflows must be set high enough to ensure protection of the aquatic resources and waste assimilation capacity in the streams.

There have been recent discussions concerning the development of a stream classification system. The intent of such a system would be to establish minimum flows reflecting a stream's historic flow pattern and recognizing the variation in uses of the state's surface waters. We feel that development of such a system could be a valuable asset to the State Water Plan and to numerous other water resource management activities. Therefore, to establish minimum streamflows before this option is thoroughly investigated would be inappropriate.

It is imperative that minimum streamflows be established on a seasonal scale since the instream flow needs for fish and wildlife are drastically different in the spring of the year than during the late summer. The needs are more critical during the reproductive season of the fish than at any other time. To assume that there will always be sufficient water for fish reproduction in the springtime and that removal of water from the streams during this period could not be of significant magnitude to affect the fishery is erroneous. Our studies have shown that higher water quality standards requiring more sophisticated treatment procedures and/or higher background flows are necessary during the springtime when the most sensitive life stages of various aquatic organisms are present. Therefore, allocation level flows and/or minimum streamflows should mimic the general hydrological pattern of the stream.

We fail to find the rationale or justification for the SWC plan for establishing minimum streamflows (i.e., 10 percent of historical flows of July through October). We are also convinced that these levels will have severe negative impacts on the stream biota.

Since there appears to be several factors which may influence the establishment of minimum streamflows - e.g., allocation procedures and stream classification - we suggest the establishment of minimum streamflows be delayed until all of the basin plans can be thoroughly reviewed and the factors mentioned above resolved.

Sincerely,

Phyllis Garnett

Phyllis Garnett, Ph.D.
Director

PG/sy

Arkansas **DEPARTMENT OF HEALTH**

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BEN N. SALTZMAN, M.D.
DIRECTOR

September 22, 1986

Mr. Charles Hearnden
Soil Conservation Service
Room 2405, Federal Office Building
700 West Capitol Avenue
Little Rock, AR 72201

RE: Arkansas State Water Plan
Red River Below Fulton Basin
Draft
87 E 29

Dear Mr. Hearnden:

The draft of the report referenced has been reviewed by this office and we have the following comments:

1. In the section entitled "Quality" on Page 3 and the section entitled "Quality Degradation" on Page 38 of Chapter IV entitled GROUND WATER, reference is made to high iron concentrations in public water supply wells utilizing the Sparta Sands aquifer, and specifically the City of Bradley. The inorganic chemical analyses performed on samples collected by our staff from various water utilities in the study area do not support this conclusion. For your consideration we are including some figures on iron concentration in water supplies utilizing the Sparta Sands in this area.

Utility	Date of Sample	Iron Concentration
Bradley	9/19/84	0.12 mg/l
Magnolia	5/25/84	0.04 mg/l
Hope	10/20/83	0.09 mg/l
Garland	11/15/84	0.18 mg/l
Fulton	3/19/86	0.23 mg/l
Stamps	10/22/83	0.41 mg/l

As you will note, this averages to 0.178 mg/l, which we consider to be more representative of iron concentrations in the Sparta Sands as a whole. We have representative samples from all the utilities in the area if you would like to examine the analyses.

2. In the section entitled "Public Supply Systems" on Page 59 of the same chapter, the statement regarding 2000 to 3000 graduates a year from the Health Departments' training and short courses is highly optimistic. While approximately 3000 man hours of training are provided by the Engineering Division of the Health Department to water operators in any given year, the licensing program is an ongoing process that involves perodic training for the operators and a stepped series of exams that can possibly extend over a four year period.

3. We strongly support the designation of the Sparta Sands as a critical use area as noted on Page 39 of Chapter IV for the purposes of regulating withdrawals. Also, the statement on Page 56 of Chapter IV regarding the prioritizing and protection of the Sparta Sands for use as a municipal drinking water supply we consider to be important, as some of the largest withdrawals from the Sparta in Columbia County are for industrial users that could easily be converted to surface supplies.

The draft copy is being retained for our files. When submitting correspondence pertaining to this project please utilize our reference number 87 E 29.

Sincerely,

Harold Seifert

Harold Seifert
Assistant Director
Division of Engineering

HRS:UP:PS:ps

Arkansas GEOLOGICAL COMMISSION
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NORMAN F. WILLIAMS
STATE GEOLOGIST
501-371-1488

September 22, 1986

Mr. Charles Herndon
USDA - Soil Conservation Service
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, AR 72201

Dear Mr. Herndon:

I have completed review of the Arkansas State Water Plan for the Red River below Fulton Basin. I have enclosed copies of pages with comments for your consideration. One general comment on the organization of the water plan is to separate out the water plan from the description of physical characteristics of the area. The length of the document is very long and the amount of data throughout the report hides the specifics of the plan. In fact, an introduction with the purpose of the water plan would be most helpful.

If you have any questions, please call me.

Yours very truly,

William V. Bush

WVB:kh

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ARKANSAS COMMITTEE ON WATER WELL CONSTRUCTION
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LITTLE ROCK, ARKANSAS 72204
phone 501 666-8379

September 19, 1986

Soil Conservation Service
700 West Capitol Avenue
Little Rock, Arkansas 72201

Reference: Arkansas State Water Plan Draft
Red River Below Fulton Basin

To whom it may concern:

The Committee staff reviewed the draft copy of the Arkansas State Water Plan, Red River Below Fulton Basin.

An error was found in table 3-12 (Use of water in the basin by category). The 7.1 or 1.7 reference Electric Energy should be corrected. Also under Improper Well Construction and Abandonment, Water Wells, 2nd paragraph, 60 days should be 30 days.

The Committee staff feels the Report considered most areas for a basin summary adequately, however, the report should also expand its parameters to include cost considerations and crucial dates and times.

Cost considerations should include the cost of obtaining any additional information needed for planning. The report included a section on water pricing. Additional information regarding the cost of providing surface water per acre or person (by water use) and the cost of ground water per acre or person (use) versus no action regarding water should be included along with the economic benefit or detriment for each option. Comparisons should be made so water is made available at the least cost (i.e. is it economically feasible to pump waste water to areas lacking water for irrigation?). The economic benefit or cost is the "bottom line" and determining factor for any action that will be taken. It must be included in the plan.

Time tables regarding what corrective action/activity and economic disaster/detriment will take place is needed so that priorities can be established and appropriate action taken at the appropriate time. This will insure the most benefit for the dollar.

The report stated in Chapter 3, Critical Surface Water Areas, last paragraph that the area can be defined as not being a critical surface water area and then states that specific data is not readily available. The data mentioned would seem to be critical in making an accurate assessment. The staff feels that a determination should not be made until the information mentioned is made available. A plan/recommendation on how best to obtain the information would be more appropriate at this time. This would insure that no steps are skipped in future planning and future planning would not be undermined by possible erroneous conclusions made from this summary.

More emphasis could be given to planning and recommendations by dedicating one chapter to conclusions, recommendations, and planning.

The report is very comprehensive in that a great deal of information was summarized and references noted. The staff feels that this report is very useful and is necessary for planning.

Thank you for allowing the Water Well Committee to review the draft.

Sincerely,

Kenneth T. Acklin
Executive Secretary

cc

Soil and Water

James H. Phillips
Exec. Director
Phone: 501-371-1173

Arkansas Waterways Commission

1515 West Seventh Street, Suite 505
Little Rock, Arkansas 72202

July 14, 1986

JUL 15 1986

Mr. Jack C. Davis
State Conservationist
Room 2405 Federal Office Building
700 W. Capitol Avenue
Little Rock, Arkansas 72201

Dear Mr. Davis:

This has reference to the "draft" of the Red River Below Fulton portion of the State Water Plan forwarded to us June 19, 1986.

I have reviewed the draft and have no comments or recommendations.

Sincerely,

James H. Phillips

James H. Phillips
Executive Director

JHP/cjf

Encl. - to Tom D.

REC'D	ROUTE
Davis	✓
Murphy	
ASTC (O)	
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Fultz	
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July 14, 1986

Mr. Jack C. Davis, State Conservationist
Soil Conservation Service
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, AR 72201

Dear Mr. Davis:

Thank you for the opportunity to review the draft Arkansas State Water Plan for the Red River below Fulton Basin.

The term "forestland", used in the Land Use section of your report, should be defined. Does it refer to all lands with forest cover or only to those lands with commercial timber production? It is reported on page 13 that the forestland is "commercially managed". This term should also be defined. It creates the impression that all forestland in the study area is commercially owned. Additionally, although I would hope <u>most</u> of the forestland in the study area is being managed, I can't believe <u>all</u> of it is being managed, as is reported on page 13.

The Arkansas Forestry Commission is the Designated Management Agency for the silvicultural portion of the Arkansas' Water Quality Management Plan. In that capacity, the Arkansas Forestry Commission has produced a booklet entitled <u>Best Management Practices Guidelines for Silviculture</u>. You may want to make reference to this booklet in the appendix of the Water Plan.

Finally, the U.S. Forest Service prepared a forest survey for Arkansas in 1980 and will soon release a 1985 update. You may want to compare this information to your RIDS data.

Sincerely,

Edwin E. Waddell
State Forester

Garner Barnum

By: Garner Barnum
Assistant State Forester, Management

JGB:dr

c: Mr. J. Randy Young

Arkansas Game & Fish Commission

2 Natural Resources Drive   Little Rock, Arkansas 72205

July 21, 1986

Cy to Randy Young
sent 7/30

Mr. Jack C. Davis
State Conservationist
Soil Conservation Service
Rm. 2405, Federal Office Bldg.
700 West Capitol Ave.
Little Rock, AR 72201

Dear Mr. Davis:

We are in receipt of your letter of June 19, 1986 and attached draft report on the Red River below Fulton (Lower Red Basin - LRB). Biologists of this agency have reviewed the draft plan based on fish and wildlife resource concerns and make the following comments to be considered by your agency.

The Arkansas Game and Fish Commission (AGFC) agrees with and supports the Soil Conservation Service's (SCS) statement that optimum development of the surface water resource in the LRB requires storage of high winter and spring flows for use in summer and fall.

In the text it is difficult to reference page numbers since none are printed, but under surface water resources a statement is made that the low flow period for the LRB is June through December. Table 3.3 shows that the low flow season is actually July through October in the two significant rivers in the basin, the Red and Sulphur Rivers.

As mentioned in this report, high flows in the spring contribute to aquifer recharge. Since stream levels are low in the summer and fall and aquifers may discharge water to adjacent streams, if groundwater recharge is a high priorty in the state, then plans to and incentives for use of high water flows instead of use of summer and fall low flows should be implemented.

"Minimum" streamflow is defined as the lowest mean discharge that will satisfy minimum instream flow requirements and are established for the purpose of protection of all instream flow needs during low flow conditions. The exception of disallowing fish and wildlife instream flow requirements as a minimum discharge is not valid. The statement that the Arkansas Soil and Water Conservation Commission (ASWCC) found that the minimum daily stream flow in Bayou Bartholomew (a highly agriculturally impacted stream) required for fish and wildlife was exceeded during most months of the year is misleading and only partially true. It can also be said that conversely there was a significant number of days during the year on Bayou Bartholomew when daily flow were alone the fish and wildlife requirement. Since the Arkansas method during the low flow season is based on reserving 50% of the mean monthly flow, it is logical that there will be available for diversion and there will be days when surface water pumping will not be possible and the groundwater resource (main irrigation source) will need to be utilized. If not, the fish and wildlife resources of that stream will not be protected as mandated in Section 2 of Act 105 of the Arkansas Legislature. The ASWCC's alternative "method" for establishing minimum streamflow requirements for fish and wildlife was developed by engineers with little or no education, experience or knowledge of fisheries biology as it relates to Arkansas' lotic environment. Such an extremely low and unjustified level as 10% of the mean monthly flow during July-October is unacceptable as a fish and wildlife minimum streamflow and violates the definition of minimum streamflow as stated earlier in this report that minimum streamflow "protect all instream flow needs during periods of low flow". The ASWCC's "method" does not approach protection of the aquatic and terrestrial biota associated with a river system.

The AGFC strongly disagrees with SCS's use of a significant drought year (1980) as an example to show the relationship of mean flows to fish and wildlife instream flows on the Red River near Fulton (Fig. 3-7). A more logical and unbiased approach to this would be to show mean monthly flows for the period of record with fish and wildlife flow requirements for the Red River near Fulton. These same points apply to the Sulphur River where another extreme drought year (1983) is illustrated as the example. Obviously, during extreme natural droughts when severe impacts of a farmer's livelihood from lack of water can be demonstrated, the fish and wildlife requirements as determined by the AGFC, Dept. of Pollution Control and U.S. Wildlife Service (Arkansas method) may be adjusted downwards to take this into consideration.

Use of a method (ASWCC's) that recommends flows exceeded 99.9% of the time at Index, Arkansas to set fish and wildlife minimum stream flows is unrealistic, unacceptable and is basically non-regulation of the surface water resource. The failure to regulate surface water usage now, when its use is increasing, is mismanagement of the surface water resource in our state. It is also in direct conflict with the intent of carrying out Act 1051. For these reasons, the AGFC cannot endorse ASWCC's or SCS's "method" of stream flow determination during critical low flow months and recommends the use of the Arkansas method of instream flow reservation which is based on a proven technique (Tennant Method) and supported by Instream Flow Incremental Methodology (IFIM) analysis.

SCS's determination of the safe yield of water from a basin is not consistent with that outlined by the coordinating agency, the ASWCC. It is not the water above and beyond the "minimum" streamflow that is available for use as a surface water supply, but that water above and beyond the instream flow requirements as outlined and explained earlier in this report and in the ASWCC's Lower Ouachita Basin report. This error in calculation of safe yield needs to be corrected before the second draft report is sent out for review. This correction also needs to be made on related tables.

Relative to the section on Surface Water in State Law, the AGFC should be included as an agency with responsibility for the water resource in Arkansas. The AGFC is mandated by the people of Arkanas to protect, conserve and manage the fish and wildlife resources in the state and has two regulations (#32.18 and #32.19) prohibiting blockage and pumping of water from streams to the point where the fishery is endangered.

The AGFC encourages the SCS to emphasize what it has stated under surface water problems that adequate water supplies can be developed through construction of offstream storage reservoirs, interception of water released from rice fields to drainage ditches and interception of tailwater from irrigation of row crops as well as more efficient distribution and irrigation systems. AGFC would like to point out that oxbow lakes are extremely productive relative to fisheries and diversion from them to the point of affecting the fishery is against the law (Comm. regs. 32.18 and 32.19).

Significant use of winter and spring high flows by agricultural and industrial diversion would diminish damaging effects of floods on the basin.

Under the section "Data Base Problems-Determination of Instrem Flow Requirements", the statement that the Arkansas method is theoretical is incorrect. The Arkansas method is a modification of an established technique, the Tennant or Montana method used on hundreds of stream reaches throughout the U.S. There has also been considerable agreement between the Arkansas method's recommendations and values computed from field work conducted by AGFC, ASWCC and U.S. Geological Survey personnel. These data were analyzed using the U.S. Fish and Wildlife Service's IFIM by the Corps of Engineers Waterway Experiment Station in Vicksburg. For the above reasons and those mentioned in the report by Filipek et al (1985), the fish and wildlife instream flow requirements determined by the Arkansas method are the most applicable for determining levels of adequate protection for fish and wildlife during the low flow period in streams in the LRB.

The statement that the Arkansas method's flows represent flows required for "excellent" fisheries habitat is an incorrect statement stemming from an earlier misunderstanding that ASWCC staff had with instream flow methodology terminology. The Arkansas method's recommendations are those needed to maintain the existing fishery. Therefore, excellent fisheries are maintained basically in their current condition, and less than excellent fisheries are also maintained at their current statue. This change needs to be incorporated into your report.

Under Critical Surface Water Areas, fish and wildlife needs, as determined by the Arkansas method, need to be used for the Red River at Fulton instead of ASWCC's "method".

Under the Best Management Practices section, fish habitat may improve in the Red and Sulphur Rivers, Mercer Bayou and Middle Bayou Dorcheat only if BMP's are followed and adequate streamflow is left in these streams to protect the fishery resource.

The AGFC lauds SCS for bringing out that the greatest single on-farm saving of water can be accomplished by selection of the most suitable irrigation application method. Improvements in applicaton efficiency will conserve water use and carry it further during times of scarcity.

Under the section "Determining Instream Flow Requirements", and IFIM study has been done on the L'Anguille River in eastern Arkansas. Preliminary results show flow recommendations by the IFIM are much higher than ASWCC's 10% mean monthly "method" and closer to the flows recommended by the Arkansas method. Please include this information on the L'Anguille River IFIM in your revision of this draft report.

Finally, in reference to the section on groundwater, the AGFC encourages the push towards regulation of our state's groundwater resources. The need to use groundwater conjunctively with surface water is apparent if Arkansas is to realize the full potential of the water resources in this state. This does, however, place responsibility on management of surface water on ASWCC and therefore use of their 10% monthly mean value for minimum flows is not consistent with wise water management. Heavy use of surface water has been shown to add to declines in groundwater especially near streams from which water is being pumped or diverted. Attached (Appendix 1) are effects on the fish and wildlife populations that will occur if certain flow regimes are followed. Mandated by the people of Arkansas through Ammendment 35 to the state constitution to protect, conserve and manage the state's fish and wildlife resources, the AGFC cannot allow degradation of the resources by unwise water management practices.

The AGFC appreciates the opportunity to comment on the draft LRB report. We will do everything we can to expedite the process of defining and setting instream flows with SCS short of substantially damaging one of the state's most invaluable resources - its streams.

Cordially,

Steve N. Wilson
Director

SNW:SF:tab

Attachment

APPENDIX 1

(1) Concerning the effects of river flows at and below the recommended instream flow levels mentioned in the minimum stream flow section, the following levels and results are discussed. Using the instream flow recommendations as computed by the Tennant or Montana method, 60% of the average annual flow is the base flow recommended to provide excellent habitat for most aquatic and related species during their primary periods of growth and for the majority of recreational uses. Most of the normal channel substrate will be covered with water, including riffles, shoals and side channels. Few gravel bars will be exposed so aquatic invertebrate diversity and production should be high, which is the basis for most aquatic food chains. Riparian vegetation will have plenty of water allowing for wildlife nesting, denning, nursery and refuge habitat. Fish production, spawning and nursery areas will be accessible and usable, and spawning migrations will not be hindered by shallow riffle areas. Recreational boating, canoeing, swimming, and rafting will all have an excellent quantity of water available. Some flooding of associated wetlands for waterfowl habitat will be possible.

At 30% of the average annual flow, most aquatic organisms experience good survival since the majority of the substrate is covered with water, except for wide, shallow shoal areas. Most side channels carry some water, and riparian vegetation is not diminished. Most islands and stream banks will provide adequate nesting, denning, nursery and refuge habitat for associated wildlife species. Most pools and many runs will have deep enough water for fish, and many riffle or shoal areas are able to be transversed. Water temperatures are not expected to be a limiting factor in most stream segments. Aquatic invertebrate levels decrease but usually not to the point where fish production is substantially reduced. General recreational activities such as swimming, canoeing, and rafting are possible. Boating usually is limited to shallow, draft boats. Flooding of associated wetlands for waterfowl habitat will not occur.

Ten (10) percent of the average annual flow is a minimum recommendation only to sustain short-term survival habitat for most aquatic life. The aquatic habitat is degraded since channel widths, depths, and velocities are greatly reduced. The stream substrate will be nearly half exposed except in shallow shoal areas where exposure will be higher. Side channels may be severely or totally dewatered and islands and stream bank areas will usually no longer function as wildlife nesting, denning, nursery and refuge habitat. Fish will be crowded into the deepest pools or areas of a river since many wetted areas will be too shallow. Upstream migration by spawning stocks of fish will be hindered, if not stopped. Water temperature will be a limiting factor, especially from July through September. Aquatic invertebrates (benthos) will be severely reduced. Recreational activities are limited to swimming (if esthethics are acceptable) and some shallow water canoeing and/or rafting. Overharvest of fish can occur due to their concentration and accessibility by fishermen.

The instream flows quantified by the Arkansas method and based on principles of the Tennant method follow the natural hydrograph of Arkansas streams and provide adequate but practical protection of associated fish and wildlife. Following the recommended levels will maintain existing fish and wildlife populations inhabiting or depending on the streams in question. Failure to achieve the recommended levels (by whatever means) will cause degradation of the fish and wildlife resource, a decline in survival of the various species associated with our rivers including various fish, waterfowl, furbearers, and terrestrial wildlife, and a shift from desirable forms to more pollution tolerant types will occur. A reduction in flows below those recommended by the Arkansas method will cause a decline in fish spawning due to migration problems and reduced flushing of spawning areas making them unacceptable. Those desirable species able to spawn will experience a decrease in egg and fry survival and more tolerant types will succeed (i.e. carp, gar etc.). Lower flows contribute to increased water temperatures and lower dissolved oxygen levels. Fish kills may occur due to this as well as the increasing concentration of pollutants and sediments in the water. Aquatic invertebrates production decreased, causing proportional decreases in fish production. Septic wastes are not flushed from the system. The natural ability of the stream to accept and dilute human waste products is decreased and groundwater recharge (into the aquifers) is decreased.

At the level set by the ASWCC as a minimum flow (10% of the mean flow for the period of July through October), extreme degradation to the fish and wildlife resource in a stream has already occurred. Water temperatures have significantly increased, mirrored by a substantial decrease in dissolved oxygen content in the water. Shoal or riffle areas are dewatered or essentially out of production. Spawning and survival of desirable fish types is greatly reduced. A shift to more tolerant and less diverse fish and invertebrate populations is occurring. Riparian vegetation and associated wildlife is greatly reduced. Flushing of sediment and septic wastes in the system is essentially nil, magnifying dissolved oxygen depletion, fish kills, pollution, and groundwater contamination. Waterfowl habitat is decimated and terrestrial wildlife dependent on the river become more susceptible to dependent limiting factors such as predation, disease, lack of reproductive success and starvation. Recreational activities are greatly reduced due to extreme reductions in water quality and quantity affecting swimming and other water contact sports (canoeing, boating, etc.). In general, flows lower than those recommended by the Arkansas method and on down to the ASWCC's "minimum" level cause degradation of fish and wildlife to varying degrees, depending on the distance below the acceptable levels (Arkansas method).

Harold K. Grimmett
Director

ARKANSAS NATURAL HERITAGE COMMISSION

THE HERITAGE CENTER, SUITE 200
225 EAST MARKHAM
LITTLE ROCK, ARKANSAS 72201
Phone: (501) 371-1706

Bill Clinton
Governor

Date: August 20, 1986
Subject: State Water Plan, Red River below Fulton
ANHC Job #SCS-17
Dated June 19, 1986
Received June 20, 1986

REC'D / ROUTE
Davis
Murphy
ASTC (C)
* Dennis
Fultz
Peters
Williams
SAO
File
* Action by:

Mr. Jack Davis, State Conservationist
Soil Conservation Service
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, Arkansas 72201

re: State Water Plan, Red River below Fulton

Dear Mr. Davis:

The staff of the Arkansas Natural Heritage Commission has reviewed the draft state water plan for the Red River Basin below Fulton and wishes to provide the following information and comments. In a search of our information system, we have determined that nine species of state concern occur in this basin. They are as follows:

*Ammocrypta clara**	western sand darter
Anodonta suborbiculata	flat floater
Etheostoma parvipinne	goldstripe darter
Nerodia cyclopion cyclopion	green water snake
Notropis bairdi	Red River shiner
Notropis atrocaudalis	blackspot shiner
Notropis maculatus	taillight shiner
Noturus phaeus	brown madtom
Sternotherus carinatus	razorback musk turtle

*potential candidate for listing by the U.S. Fish and Wildlife Service as Threatened or Endangered

The western sand darter, Red River shiner, brown madtom, and flat floater (a mussel) are very rare in the Red Basin, each being represented by only a single occurrence. It is highly likely that these animals, and many other aquatic species as well, would be affected adversely if flows of basin streams are reduced to a point that natural biological and physical processes are disrupted. Reproduction and growth of fishes and aquatic invertebrates, cleansing of aquatic habitats, and recharge of groundwater tables all depend upon substantial flows of water, flows that exceed the Arkansas Soil and Water Conservation Commission's (ASWCC) minimum instream flow recommendation of ten percent of the mean flow discharge during the months of July to October.

A state minimum instream flow standard that allows extremely low flows in all streams at any time of the year, as recommended by ASWCC, could have catastrophic consequences for our fish and wildlife species. Even Tennant's short-term survival figure of ten percent of the the average annual flow is inadequate as a minimum standard for wildlife, except from July to October, when normal seasonal low flows in Arkansas coincide closely with his figure.

The Arkansas method is superior to the methods of both Tennant and the ASWCC because it follows the natural hydrographs of the state's streams and gives greater consideration to the biological needs of fish and wildlife. Some margin for error also is built into the seasonal percentages of the Arkansas method. The bare survival figure of ten percent flow, on the other hand, does not permit any "cushion" at all. Given the unpredictability of Arkansas weather, lack of stream gaging stations, poor existing flow data, etc., a considerable margin for error should be included in any method used to determine minimum instream flows.

Much more could be said in favor of the Arkansas method over that of the ASWCC, but we will wait until the executive summary of the basin reports is prepared to provide additional comments. In the meantime, the staff of the Natural Heritage Commission will provide summaries of special species and natural communities that occur within each of the basins covered by water plans.

Sincerely,

Harold K. Grimmett

Harold K. Grimmett
Executive Director

cc: Charles Herndon
Craig Uyeda
John Giese

United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
Arkansas District
2301 Federal Office Building
Little Rock, Arkansas 72201-3287

REC'D	ROUTE
Davis	
Murphy	
ASIC (O)	
* Dennis	
Fultz	
Peters	
Williams	
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* Action by:	

August 5, 1986

Mr. Jack C. Davis, State Conservationist
U.S. Department of Agriculture
Soil Conservation Service
2405 Federal Office Building
Little Rock, Arkansas 72201

Dear Mr. Davis:

Enclosed is the draft copy of the Red River below Fulton portion of the State Water Plan you sent to us on June 19, 1986 for review. Our review was generally limited to chapters 3 and 4 dealing with hydrology. Attached is a review summary. In addition, there are review comments in the text.

Thank you for the opportunity to review the report draft. This report along with the other State Water Plan reports, is a great step in solving Arkansas' water problems.

Sincerely yours,

E. E. Gann
District Chief

Enclosures

CTB:rkc

DEPARTMENT OF THE ARMY
LITTLE ROCK DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 867
LITTLE ROCK, ARKANSAS 72203-0867

REPLY TO
ATTENTION OF

July 8, 1986

Planning Division
Special Studies Branch

Mr. Jack C. Davis
State Conservationist
Soil Conservation Service
Room 2405 Federal Office Building
700 West Capitol Ave.
Little Rock, Arkansas 72201

Dear Mr. Davis:

We have reviewed the draft Red River Below Fulton Basin Report of the State Water Plan. Our comments are as follows.

1. Chapter III. Excess Streamflow. Allowance is not made for increased withdrawal of water in states upstream of Arkansas under terms of the Red River Compact.

2. Chapter IV. Page 3615a(50). There is a contradictory statement saying P.L. 83-566 floodwater retarding structures will increase groundwater recharge when it is stated earlier that the groundwater recharge requirements are unknown.

3. Other miscellaneous editorial comments are marked in the draft report which is returned as requested..

Thank you for the opportunity to review this report.

Sincerely,

David L. Burrough

David L. Burrough
Chief, Planning Division

Enclosure

DEPARTMENT OF THE ARMY
VICKSBURG DISTRICT, CORPS OF ENGINEERS
P. O. BOX 60
VICKSBURG, MISSISSIPPI 39180-0060

REPLY TO
ATTENTION OF:

July 15, 1986

Planning Division
Western Tributaries

Mr. Jack C. Davis
State Conservationist
Soil Conservation Service
Water Resources Staff
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, Arkansas 72201

Dear Mr. Davis:

I refer to your letter of June 19, 1986, in which you forwarded the draft report on the Red River Below Fulton portion of the Arkansas State Water Plan for our review.

We have reviewed primarily the section describing the Corps of Engineers projects located within that portion of the Red River Basin. As requested, we are returning the draft report with revisions marked in red beginning at page 33685(76) (enclosure 1).

When the report is finalized, we would appreciate receiving a copy.

Sincerely,

V. C. Ahlrich

V. C. Ahlrich
Chief, Planning Division

Enclosure

Revisions Completed 8/27/86

REC'D	ROUTE
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* Action by:	

(1)

United States Department of Agriculture

Soil Conservation Service

121 West Sypert Street
Nashville, Arkansas 71852

390-7-5

Subject: PDM - Review of Red River Below Fulton Draft Report

Date: July 8, 1986

To: Jack C. Davis, State Conservationist
Soil Conservation Service
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, Arkansas 72201

I have no other comments or recommendations on the attached draft of the Red River Below Fulton portion of the State Water Plan.

Clinton T. Ramsey

Clinton T. Ramsey,
District Conservationist

cc: Charles E. Childress, AC/Hope

Encl - Tom D.

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UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE John L. Dobbins, D.C.

915 Hickory
Texarkana, AR 75502

SUBJECT: PDM -Review of Red River Below Fulton Draft Report

DATE: July 10, 1986

TO:

Jack C. Davis
State Conservationist
Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, AR 72201

Enclosed is the draft report on Red River below Fulton. I have reviewed this report and found it has a lot of good information in it. The only thing I see different is the acreage on page ten for land use for Miller County. Our workload analysis shows Miller County land use acreage as follows:

Cropland 94,900
Pastureland 85,700
Forestland 186,200
Urban 8,900

John L. Dobbins
John Dobbins, D.C.

Enclosure - to Dennis

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United States Department of Agriculture

Soil Conservation Service

P. O. Box 128
Magnolia, AR 71753

390-7-5

Subject: PDM - Review of Red River Below Fulton Draft Report

Date: July 7, 1986

To: Jack C. Davis
State Conservationist

The draft of the Red River Below Fulton portion of the State Water Plan appears to be a well written document.

I have only one comment: On page 10 the total acres in Columbia County is shown as 491,520. The soil survey of Columbia County gives the total acreage as 490,944.

Bobby J. Cook

Bobby J. Cook
District Conservationist

Arkansas State Water Plan
Red River Below Fulton, Draft

Comments From Lewisville Field Office
Lewisville, Arkansas

Section: Land Use
Page: 4118H(7)

Table 2-1 Land Use By County

More recent data is available for each county from the Arkansas Agricultural Statistics publication by the Crop and Livestock Reporting Service. The most recent one available now is for calendar year 1984, but in August 1986, the publication for calendar year 1985 will be out. Either one of these would be more recent than that being used.

Section: Irrigated Cropland
Page: 4118H(9)

The publication mentioned above would furnish some more recent figures than the ones being used.

Section: Surface Water Inventory
Page: 3368S(24)

Table 3-1 Summary of Selected Streamflow Collection Sites

There is a streamflow gage located on Maniece Bayou before it enters the Red River. Maniece Bayou and Field Bayou drain the western half of Lafayette County north of Canfield to the southern end of Hempstead County. This stream flows year around with a reduced flow during summer months.

Section: Critical Surface Water Areas
Page: 3372S(21) Reverse of this sheet

In the second paragraph is a statement that says, "With the exception of the Red River and Kelly Bayou, stream gaging data is not available for streams in the basin used primarily as irrigation sources." There is a gage on Maniece Bayou in Lafayette County and this stream is used for irrigation purposes. This is not the primary use of this stream as it was originally dug to facilitate drainage but it is also used for irrigation purposes. The upper end of Maniece Bayou, Field Bayou, is also used for irrigation. Beaver dams and low water weirs installed by some landowners help stabilize the flow, especially during peak use months.

6/26/86

(4)

United States Department of Agriculture

Soil Conservation Service

Room 2405 Federal Office Building
700 West Capitol Avenue
Little Rock, Arkansas 72201

Subject: PDM - Review of Red River Below Fulton Draft Report **Date:** JUN 18 1986

To: Charles E. Childress
Area Conservationist
Soil Conservation Service
Hope, Arkansas

File Code: 390-7-5

Enclosed is a draft of the Red River Below Fulton portion of the State Water Plan prepared by the Soil Conservation Service, Little Rock, Arkansas, for the Arkansas Soil and Water Conservation Commission.

Please review the draft and make comments or recommendations, especially on the contents directly concerning your agency. After your review, return the copy to the Soil Conservation Service, Water Resources Staff, no later than July 14, 1986.

JACK C. DAVIS
State Conservationist

Enclosure

TO: Water Resources Staff

I have reviewed this rather hurriedly and I didn't see anything I would question.

Charles E. Childress

4376H

INTERNATIONAL PAPER COMPANY
P.O. BOX 809024, DALLAS, TEXAS 75380-9024

ENVIRONMENTAL SERVICES (WEST)
DAVID H. CRITCHFIELD, Manager
PHONE (214) 934-4078

April 21, 1986

Mr. Thomas H. Baskins
Soil Conservation Service
Federal Building, Room 5401
700 Capital Avenue
Little Rock, Arkansas 72201

Dear Mr. Baskins:

Enclosed are copies of the water quality reports we promised you last week. As I mentioned, Lake Erling is not subject to any formal classification system that we are aware of. Nevertheless, the data show that as a result of years of careful management the lake is a very high quality natural resource suitable for fishing and primary contact recreation.

If you have any further questions, please call me.

Very truly yours,

David H. Critchfield
Manager
RES-West

DHC:jk

Enclosures

cc: Ernest Cook
Alan Lindsey

USDA SOIL CONSERVATION SERVICE

LIST OF PREPARERS

NAME	TITLE
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CHARLES HERNDON	CIVIL ENGINEER
RAY LINDER	BIOLOGIST
JIMMY ARRINGTON	GEOLOGIST

THE NATURAL STATE ®

Arkansas