Water Resources of Hempstead, Lafayette, Little River, Miller, and Nevada Counties, Arkansas

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1998

Prepared in cooperation with the Arkansas Geological Commission

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By A. H. LUDWIG

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WATER RESOURCES OF HEMPSTEAD, LAFAYETTE, LITTLE RIVER, MILLER, AND NEVADA COUNTIES, ARKANSAS

By A. H. LUDWIG

ABSTRACT

The five-county area in southwest Arkansas that consists of Hempstead, Lafayette, Little River, Miller, and Nevada Counties possesses abundant water resources. Although nearly all water supplies are obtained from ground water, the resource has not been fully developed. Surface water is used primarily for municipal supply at Texarkana and for industrial supply at a papermill near Ashdown.

Ground water occurs in sand aquifers of Cretaceous age (Tokio Formation and Nacatoch Sand), Tertiary age (Wilcox Group, Carrizo Sand, Cane River Formation, and Sparta Sand), and Quaternary age (terrace and alluvial deposits). The aquifers of Cretaceous age are the principal sources of fresh water in northern Hempstead and Nevada Counties, where wells that tap these formations yield as much as 300 gallons per minute of good-quality water from depths as great as 1,200 feet. The quality of water in these aquifers deteriorates downdip and becomes saline in northern Miller, southern Hempstead, and central Nevada Counties.

Aquifers of Tertiary age are good sources of water in Miller and Lafayette Counties and in southeastern Nevada County. Wells that tap these formations generally do not exceed 400 feet in depth, but some wells are as much as 700 feet deep. Yields as great as 920 gallons per minute are obtained from the formations of Tertiary age; however, yields ranging from 100 to 300 gallons per minute are more common. Water from the formations of Tertiary age is suitable for municipal and industrial use; but, because of the high-sodium and high-salinity hazard, the water generally is not suitable for irrigation. Much of the water would require treatment for the removal of iron.

Terrace deposits of Quaternary age are good sources of water in Little River and Lafayette Counties. Wells in these deposits generally yield sufficient quantities of water for domestic use and, in some places, for municipal and irrigation use. However, in parts of western Little River County, these deposits do not yield sufficient quantities of water even for domestic use. Yields of 800 gallons per minute have been measured from wells tapping terrace deposits in eastern Little River County, and a yield of 1,100 gallons per minute was reported from a well in Lafayette County.

Wells that tap the alluvial aquifer in the Red River Valley generally yield as much as 1,200 gallons per minute; however, yields of 1,500 gallons per minute are possible. The water is used primarily for irrigation but, because of its high iron content and high degree of hardness, would require extensive treatment for other uses.

The Red River is the largest source of surface water in the project are It drains about 48,000 square miles upstream from the area and has a average flow of 12,180 cubic feet per second at Index. The principal rese voirs in the area are Millwood Reservoir on Little River (capacity, 1,858,0 acre-feet) and Lake Erling on Bodcau Creek (capacity, 49,000 acre-feet More than 5,500 lakes and farm ponds of 5 acres or less in the study are have a combined storage capacity of more than 14,000 acre-feet.

The tributary streams are potential sources of supply; however, deper ing on the need, storage facilities would be required on most of the stream to provide adequate flow during dry periods. Streams having the highe sustained flows, and consequently the greatest supply potential, include Oza Creek, Bois d'Arc Creek, and Terre Rouge Creek. Base flows in these stream are sustained by seepage from the Tokio Formation and the Nacatoch San

Reservoirs could be constructed at many sites in the upland area. Top graphic relief and an average annual runoff rate of 1.2 cubic feet per secor per square mile are favorable for the construction of reservoirs, which cou supply many times the amount of water used in 1969.

Water in the Red River is high in chloride and dissolved solids and co sequently is chemically unsuitable for most uses unless treated. The chemic quality of water in the tributary streams is good. The quality is similar that of water in the geologic formations underlying the basin, unless altere by industrial or oil-field wastes. During low flow, water in Caney Creek co tains as much as 2,800 milligrams per liter of chloride as the result of oi field pollution.

The presence of pesticides in samples of water and sediment taken fro Posten Bayou, Walnut Bayou, and Ozan Creek has been established. Ho ever, the concentration of pesticides in the water does not exceed the allo able limits.

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this report is to define the geologic and hydr logic conditions relating to the occurrence, quantity, and qualit of the water in Hempstead, Lafayette, Little River, Miller, an Nevada Counties, Ark. The information contained in this repo is to be used as an aid in the development of the water resourc of the area.

Data are presented to show the vertical and lateral extent the water-bearing formations or aquifers, the hydrologic pro erties of the aquifers, and the chemical quality of the wate Streamflow measurements from partial-record and daily-di charge stations are used to define low-flow frequency, flow dur tion, and floodflows.

GENERAL DESCRIPTION OF THE AREA

Hempstead, Lafayette, Little River, Miller, and Nevada Counties constitute 3,061 square miles in southwest Arkansas (fig. 1). According to the 1970 census, the population of the area is 84,016. Texarkana, Ark., population 21,682, is the only city having a population of more than 10,000. Other principal cities and their populations are: Hope, 8,810; Prescott, 3,921; Ashdown, 3,522; Stamps, 2,427; Lewisville, 1,653; and Foreman, 1,173.

The five-county area is in the West Gulf Coastal Plain (Fenneman, 1938). The principal topographic features in the area are the flat alluvial valley of the Red River, and hilly uplands.

The alluvial valley includes about 540 square miles in Arkansas, extending from the Louisiana to the Oklahoma State lines. The favorable climate, rich soil, and abundant water supply in the Red River Valley support the growth of many types of crops, principally cotton, rice, and soybeans. Streams in the flood plain

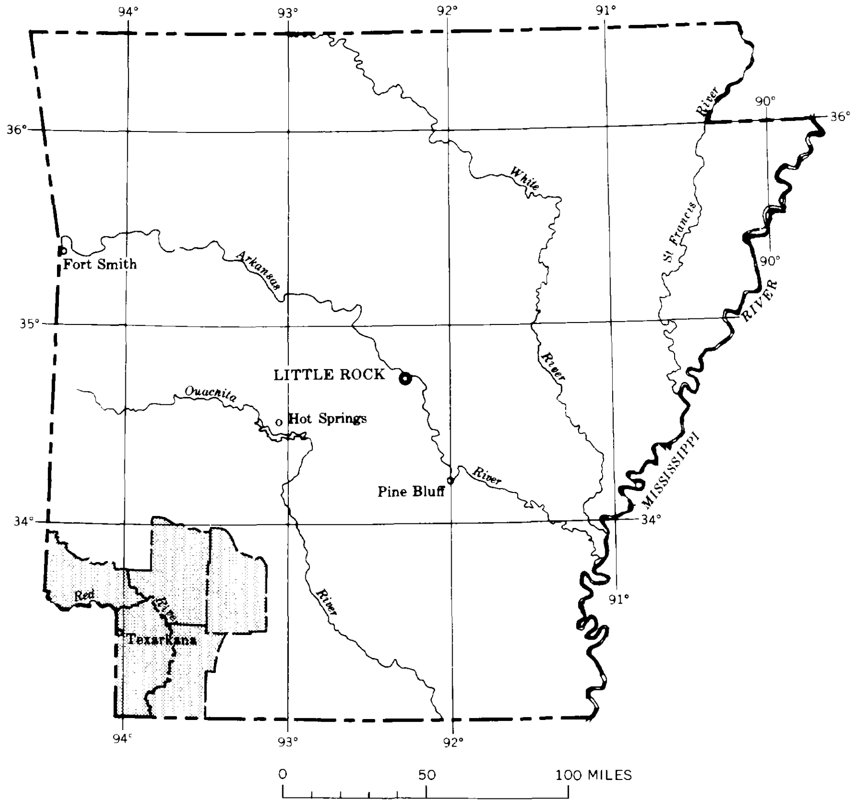

FIGURE 1.—Location of report area.

are sluggish, generally having gradients of less than 2 feet p mile. The slow runoff of surface water aids recharge to the all vial aquifer. There are many cutoff lakes along the present (197 channel of the Red River.

The uplands are characterized by gently rolling to hilly topo raphy. The general slope of the land surface is to the south, fro an altitude of about 600 feet in northern Hempstead County about 200 feet in the Red River Valley at the Louisiana Sta line. Except for parts of northern Hempstead and Nevada Cou ties, which are drained by the Little Missouri River and its trib taries, the principal drainage is to the Red River. Lumberin cattle raising, and poultry production are the principal industri in the uplands.

The climate of the area is "moist-subhumid" (Thornthwai 1952): precipitation equals or exceeds potential evaporation. T mean annual precipitation at Texarkana is about 49 inches, a the average monthly precipitation there, in inches, is as follow

January	4.84	May	4.87	September	2.
February	4.02	June	3.89	October	2.
March	4.74	July	3.84	November	4.
April	5.30	August	3.07	December	4.

The average precipitation is not well distributed throughout t years: it differs by almost 100 percent from September to Apr Droughts of short duration are frequent and are accentuated high evaporation rates during the growing season.

The mean annual temperature in the area is about 18°C. T average growing season ranges from 205 to 225 days.

ACKNOWLEDGMENTS

The information and assistance given by local residents, w drillers, city and county officials, and representatives of Sta and Federal agencies are gratefully acknowledged. Well owne in the area freely supplied information on their wells and pe mitted access to their properties. Water-well contractors, inclu ing Mr. William Pender, of Foreman, and Hamline and Nol Drilling Contractors, of Taylor, provided well logs and other su surface information. Municipal-pumpage figures and well co struction data were provided by city officials at Texarkana, Hop Prescott, Ashdown, Lewisville, and Stamps. County Agricultur Extension agents provided data on crop acreages and on the u of pesticides in the report area. Most stage and discharge da for the Red River were obtained from the U.S. Army Crops Engineers.

GEOLOGY

The rocks pertinent to the water resources of the report area are shown in stratigraphic sequence, from near the top of the Lower Cretaceous through the Holocene Series, in table 1, and their outcrop areas are shown on plate 1. The geologic sections show the stratigraphic position of the geologic units and the approximate location of the lower limit of fresh water in the formations. As used in this report, water containing less than 1,000 mg/l (milligrams per liter) of dissolved solids is considered to be fresh.

Except for the formations of Quaternary age, which locally overlie all older rocks along major stream courses, the formations generally dip to the southeast at a rate of 30–50 feet per mile and are successively overlain by younger rocks in the dip direction. The general dip of the formations is uniform in most of the report area, except where locally altered by a northwest-trending system of faults, extending from about the central part of Miller County to the southeast corner of Nevada County (pl. 1). The faults, having displacements of as much as 280 feet, influence the movement and quality of the water in some formations of Tertiary age. The dip of the formations in southern Miller and Lafayette Counties is to the north or northeast along the flanks of the Sabine uplift, a structural dome centered in northwestern Louisiana.

The Upper Cretaceous rocks in the report area consist largely of marine-deposited clay, limestone, and chalk. Two sequences of relatively permeable sand in the Upper Cretaceous rocks were deposited mostly under continental conditions. These sands make up all or parts of the Tokio and Nacatoch Formations, and constitute the only significant water-bearing rocks or aquifers in the Upper Cretaceous Series. Accordingly, these sand aquifers are discussed in more detail in following sections of this report. Other Upper Cretaceous rocks either contain mineralized water or do not yield much water.

The rocks of Tertiary age are about 1,800 feet thick and consist largely of alternate sequences of sand and clay, deposited mostly under continental and transitional marine conditions. The basal clay sequence, the Midway Group (undifferentiated), does not yield water. Geologic units above the Midway Group include, in ascending order, the Wilcox Group (undifferentiated), the Carrizo Sand, the Cane River Formation, and the Sparta Sand. These units are the significant aquifers in the Tertiary System.

TABLE 1.—*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	Thickness (feet)	Lithology	Water-bearing characteristics
Cenozoic	Quaternary	Holocene		Alluvium	0–90	Gravel, sand, silt, and clay	Yields moderate to large supplies of hard water to irrigation wells in the Red River Valley and to public-supply wells at Ashdown and Foreman.
		Pleistocene		——?——?—— Terrace deposits			
	Tertiary	Eocene	Claiborne	Sparta Sand	0–250	Stratified sand, clay, and lignite	Yields moderate supplies of water to wells in Miller and Lafayette Counties.
				Crane River Formation	0–400	Sand, clay, glauconite, lignite, and ironstone	Yields moderate to large supplies of water to wells in Miller, Lafayette, and southern Nevada Counties.
				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, southern Little River, Hempstead, and Nevada Counties.
				Saratoga Chalk	0–60	Calcareous clay and chalk	Not known to yield fresh water to wells.
				Marlbrook Marl	0–200	Calcareous clay	
				Annona Chalk	0–100	Calcareous clay and chalk	
				Ozan Formation	0–250	Calcareous clay	
				Brownstown Marl	0–200	Calcareous clay and sand and limestone	
				Tokio Formation	0–350	Sand; contains some gravel, clay, and lignite	Yields moderate supplies of water to wells in northern Hempstead and Nevada Counties and small supplies to wells in northwestern Little River County.
				Woodbine Formation	0–350	Clay, sand, gravel, and volcanic material	Not known to yield fresh water to wells.
		Lower		Kiamichi Formation and Goodland Limestone	0–50	Clay and marl; contains lenses of limestone	

The rocks of Quaternary age are as much as 90 feet thick in th flood plain of the Red River and consist largely of sand an gravel in the lower part and silt and clay in the upper part. Th alluvium and terrace deposits (combined) constitute the mos productive aquifer in the report area.

GROUND-WATER RESOURCES—AVAILABILITY AND QUALITY

AQUIFERS OF QUATERNARY AGE

ALLUVIUM

Alluvial deposits of Quaternary age underlie the flood plains c many tributary streams and all the principal rivers in the are Data are not available for an accurate appraisal of the wate supply potential of the alluvial deposits other than those in th Red River flood plain. Alluvium in the tributary valleys is simil to, but thinner than, Red River alluvium and is the source c water for many dug or driven wells. However, the yields of th wells generally are small, and much of the water is hard (Coun and others, 1955, p. 29).

The alluvial deposits of the Red River Valley underlie an are of about 540 square miles and consist of clay, silt, sand, ar gravel, as much as 90 feet thick. The upper part generally is con posed of silt and clay, and the lower part consists of materi ranging in size from fine-grained sand to gravel. Plate 1 show the thickness of the aquifer in different locations in the valley.

Plate 1 also shows the configuration of the potentiometric su face during the spring of 1968. The direction of movement c ground water can be inferred from the contour lines because th hydraulic gradient is normal to the equipotential lines. The illu tration shows that movement of water in the aquifer is towar the river and downvalley. Most ground-water discharge from th alluvial aquifer is by seepage to the river and by evapotranspir tion.

Static water levels in the alluvium range from 5 feet below th land surface in backswamp areas to 20 feet below the land su face along the crest of a natural-levee deposit. Water levels ge erally fluctuate as much as 10 feet as the result of seasonal vari tions in the volume of water stored in the aquifer. Figure 2 show for comparison, water levels in a well in the alluvium and nearb precipitation for the period 1965–68. Water levels fluctuate pr marily in response to precipitation and irrigation pumpage. Hov ever, pumpage in the vicinity of the well apparently has caused no general decline in water levels in the alluvium.

The transmissivity (average conductivity of the section multiplied by the thickness) and storage of an aquifer, which can be obtained from a pumping test, can be used to compute the long-term drawdown that would occur near a pumping well. The hydraulic conductivity of the alluvial aquifer ranges from 1,100 to 1,500 gpd per sq ft (gallons per day per square foot). Conductivity values have been determined from pumping tests made in the alluvium near Foreman, in Little River County, and in Bossier and Caddo Parishes, La. (Page and May, 1964, p. 89). The transmissivity determined during these tests ranged from 29,000 to 100,000 gpd per ft. The storage coefficient (the volume of water taken into or released from storage in a column of aquifer 1 ft sq when the head changes 1 ft) ranged from 0.002 to 0.0002. Storage values less than 0.01 indicate that water is contained under artesian conditions: that is, the water is confined under pressure, and water levels in wells tapping the alluvial aquifer rise above the base of the confining clay.

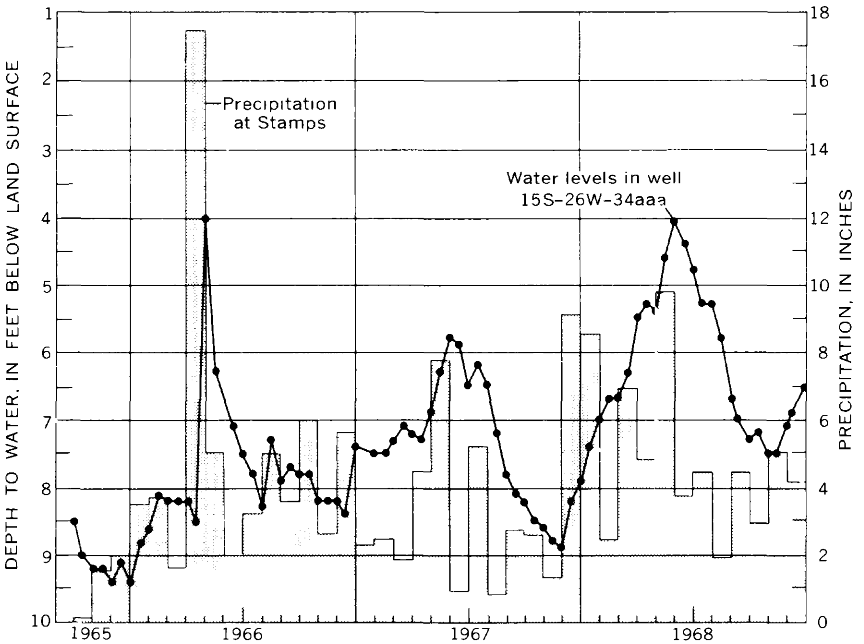

FIGURE 2.—Water levels in the Red River alluvium and precipitation at Stamps.

Transmissivity and storage values provide the means for quantitative measurement of recharge, ground-water movemen and evapotranspiration. These values may also be used to predi the effects on water levels around pumping wells. For exampl suppose two wells, each supplying 500 gpm (gallons per minute are to be installed in the alluvium along U.S. Highway 67 ne Fulton (pl. 1). The maximum period of continuous pumpage is be 100 days and the distance between the wells is to be 1,000 fee Estimated transmissivity and storage values in the area a 52,000 gpd per ft and 0.002, respectively. Based on these value the theoretical drawdown that would occur around a well pum ing continuously at the rate of 500 gpm for 100 days would be shown in figure 3*A*. However, for the two-well network used the example, the water-level decline in each well would be shown in figure 3*B*. The resultant drawdown in each well reflect (1) water-level decline caused by pumping each well individual (22.5 ft) plus (2) mutual interference of one well on the oth (7.4 ft).

Drawdown is directly proportional to discharge. That is, if t discharge is doubled, the drawdown at a given time and at a giv distance will also be doubled. If the two wells in the previous e ample were replaced by one well discharging at the rate of 1,0 gpm, the theoretical drawdown at the well after 100 days pumping would be twice that shown in figure 3*A*, or 45 feet. T alluvium in the area under consideration is about 55 feet thi (pl. 1). Allowing 12 feet for the depth to static water level a 10 feet for the length of screen, the thickness of alluvium ava able for drawdown is 33 feet, or 12 feet less than the drawdov caused by pumping at the rate of 1,000 gpm. Considering a 10 day pumping period, it is apparent that two wells, each pumpi 500 gpm, could be developed here; but, one well pumping 1,0 gpm would exceed the capacity of the aquifer at this location.

The drawdown values shown in the previous example may greater than those actually observed in the field because (1) t storage coefficient may increase after extended periods of pum ing because of a change from artesian to water-table conditio and (2) the calculations are based on the assumption that no r charge takes place during the pumping period. Obviously, the will be some recharge, probably considerable recharge.

Irrigation wells in the valley yield from 200 to 1,200 gpm. T larger yielding wells are in the southern part of the area whe the alluvium is thicker. Because of the high conductivity of t

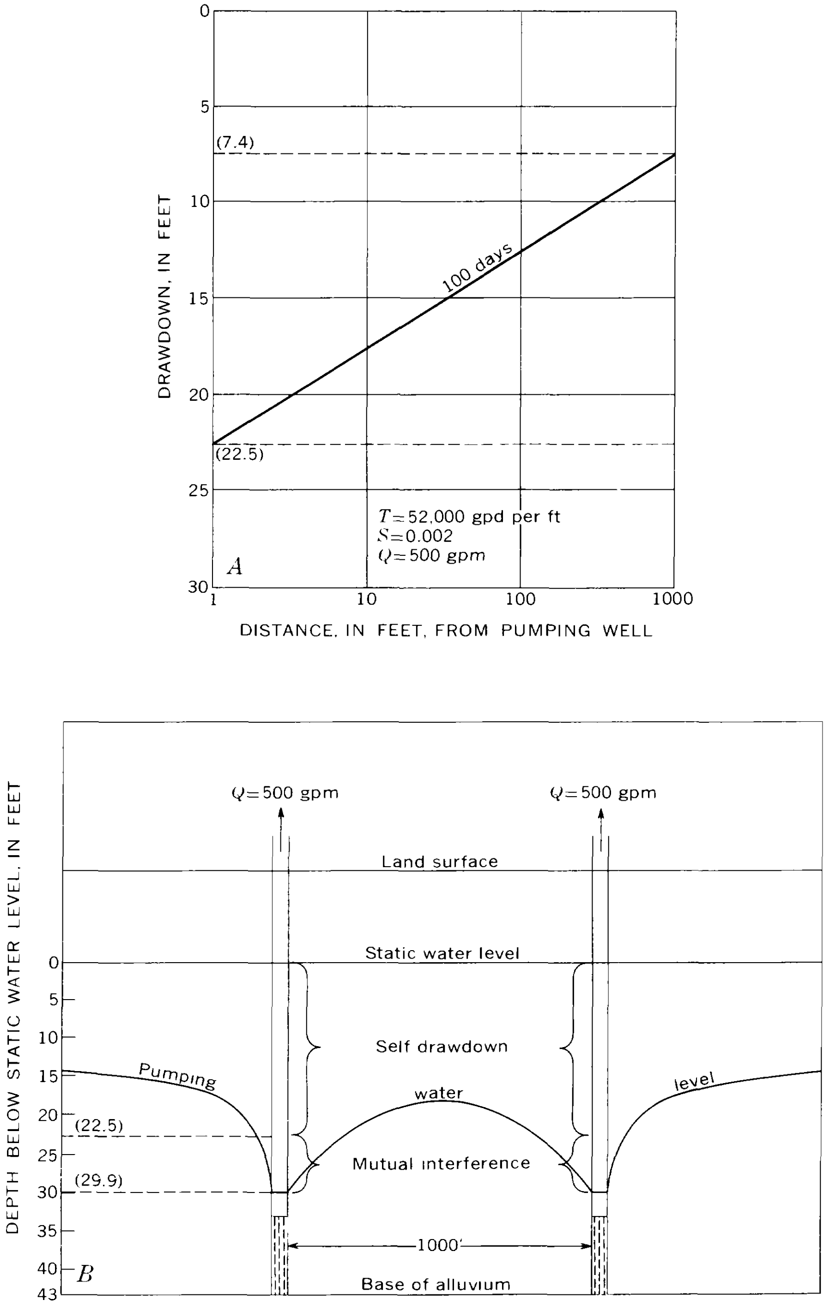

FIGURE 3.—*A*, Relation of drawdown to distance from a pumping well. *B*, Effect of interference due to pumping two wells.

aquifer, wells of sufficient size could be constructed to yield as much as 750 gpm in places in Little River County and as much as 1,500 gpm in parts of Miller and Lafayette Counties.

Water in the alluvial aquifer generally is unsuitable for most domestic or industrial uses because of the high degree of hardness and high iron content. Chemical analyses of water samples collected from the alluvium show that hardness ranges from 3 to 864 mg/l and averages 385 mg/l, an indication that the water generally is very hard (greater than 180 mg/l). Except for one sample, the concentrations of iron ranged from 0.06 to 5.2 mg/l, and averaged 2.3 mg/l. Iron exceeded the recommended limit (U.S. Public Health Service, 1962) of 0.3 mg/l in six of the nine samples tested. An iron concentration of 109 mg/l was found in a water sample taken from well 22aaa in T. 16 S., R. 26 W. Chloride concentrations of 625 mg/l were also noted from the same well. Similarly high values of chlorides have been found in water from the alluvial aquifer in parts of Ts. 15 and 16 S., R. 26 W. (See also the section on "Salt-Water Pollution in the Alluvium.")

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

TERRACE DEPOSITS

Terrace deposits, ranging in thickness from a few feet to about 40 feet, flank the valleys of the Little Missouri, Sulphur, and Red Rivers in Miller, Hempstead, and Nevada Counties (pl. 1). Based on information obtained from drillers and from local residents, these deposits generally can yield sufficient quantities of water for domestic and stock use. The yields generally are small because of the relatively thin saturated thickness of the deposits.

Terrace deposits of Quaternary age underlie most of Little River and Lafayette Counties. These deposits, consisting of sediments grading from fine-grained materials at the surface to coarse sand or gravel in the basal part, are as much as 95 feet thick. The saturated thickness of terrace deposits is highly variable, ranging from zero to 60 feet (pl. 1).

Wells that tap the terrace deposits in Lafayette County yield sufficient water for domestic or stock use. One well in the south ern part of the county reportedly yields 1,100 gpm of water from terrace gravels. However, the wells generally are small in diameter, range in depth from 40 to 70 feet, and are constructed to yield only a few gallons of water per minute. Wells that tap the terrace deposits in Bossier Parish, La., yield 75–100 gpm (Page and May, 1964, p. 53). Wells of similar capacity probably could be developed in many places in Lafayette County.

In parts of western Little River County, saturated sediments are thin or absent (pl. 1). Domestic water supplies in the area are obtained either from cisterns, or, where conditions permit, from dug wells which intercept water seeps at the base of the terrace deposits.

Dug or drilled wells in the central part of Little River County, between Foreman and Ashdown, now yield sufficient water for domestic purposes. However, as per capita water demand increases, owing at least in part to increases in the use of automatic washing appliances, many of the wells in the area may not be capable of supplying the additional demand. Alternate sources of ground water in this area, as well as in most places in Little River County, are not available because the formations of Cretaceous age underlying the terrace deposits either contain salt water or do not yield much water.

The area east and south of Ashdown is underlain by 20–60 feet of saturated sand and gravel. These deposits probably can yield from 750 to 1,000 gpm of water to wells. Yields of 800 gpm have been reported from irrigation wells southeast of Ashdown.

Hydraulic characteristics of the terrace deposits have been determined at two places in Little River County. Pumping-test data from the Foreman city well, 7 miles southeast of the town, showed the hydraulic conductivity to be 120 gpd per sq ft. From a similar test at Ashdown, the conductivity was 170 gpd per sq ft (Counts and others, 1955). Storage coefficients for the tests were 0.06 and 0.001, respectively, an indication that water in the terrace deposits is contained under both water-table and artesian conditions. Hydraulic conductivity has not been determined for similar deposits in Lafayette County. However, a conductivity value of 900 gpd per sq ft was determined from tests in terrace deposits in Bossier Parish, La. (Page and May, 1964, p. 50).

Chemical analyses of water from wells in the terrace deposits show that 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. Nitrate concentrations of as much as 560 mg/l have been noted from water in shallow wells near Alleene and Crossroads, in northwestern Littl River County. The high nitrate content probably is caused by contamination from barnyard wastes or from septic tanks. The U.S Public Health Service recommends that water containing mor than 44 mg/l of nitrates not be used for drinking purposes.

AQUIFERS OF TERTIARY AGE

SPARTA SAND

The Sparta Sand is the youngest formation of Tertiary age in the area, and except where overlain by deposits of Quaternary age, crops out in Nevada, Lafayette, and Miller Counties (pl. 1) The formation reaches a thickness of about 300 feet in southeastern Lafayette County and is composed of gray, fine to mediur sand, brown and gray sandy clay, and lignite. Lenses of lignit in the formation, as much as 2 feet thick, are exposed in the sid of a bluff at Spring Bank, in southern Miller County. Local drillers identify the Sparta Sand in well borings by its "salt anc pepper" appearance.

Water levels in the Sparta Sand range from about 10 to 75 fee below land surface. The greatest depths to water are in wells ir areas of higher altitudes, near Lewisville; whereas, in the vicinity of Lake Erling, in southern Lafayette County, reported wate levels in wells are a few feet below the land surface. A well in th Sparta Sand, near the Walker Creek settlement, in southeasterr Lafayette County, is reported to have flowed for several months after it was drilled in 1960. About 0.10 mgd (million gallons pe day) of water was withdrawn from the Sparta Sand in the study area in 1965, entirely from the formation in Lafayette County.

The Sparta Sand contains fresh water throughout its occurrence in the study area. Water from the formation is a soft o 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 ar present in many places. For example, water from the Sparta Sanc at the town of Bradley reportedly contains more than 5 mg/l o iron.

CANE RIVER FORMATION

The Cane River Formation crops out in a broad band througl central Miller County and southern Hempstead and Nevada Counties (pl. 2) and dips to the south and east at a rate of about 4(

feet per mile (pl. 1). 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.

Few wells have been developed in the Cane River Formation. Most of the wells are constructed for domestic or stock use and are equipped with small-capacity pumps. Municipal wells at Lewisville, Stamps, and Bradley are screened in the Cane River Formation and yield 300, 920, and 120 gpm, respectively. Wells of similar capacity probably could be developed in many places in the formation. During 1965 water was withdrawn from the Cane River Formation in the study area at the rate of 3.04 mgd. Most of the water was used for municipal and industrial supplies in Lafayette County.

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. As shown by the generalized potentiometric contours on plate 2, water levels have not been affected by pumpage.

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 in the study area. The water at Bradley contains 679 mg/l of dissolved solids and 142 mg/l of chloride. The iron content of the water generally is less than 0.3 mg/l, but concentrations as high as 3.9 mg/l have been found.

CARRIZO SAND

The Carrizo Sand crops out in a narrow band, 2–5 miles wide, through central Miller, southern Hempstead, and central Nevada Counties (pl. 3). The formation ranges in thickness from a few feet in the outcrop area to about 100 feet in Lafayette County. Within the fault zone (pl. 3), the formation is as much as 125 feet thick. The Carrizo Sand contains fresh water throughout its extent in the study area, except in south-central Lafayette County. Interpretation of electric logs indicates that the formation is composed of a massive sand unit in much of the area. The percentage of sand in the formation decreases westward.

The use of water from the Carrizo Sand was 0.23 mgd i 1965, most of which was produced from wells in Miller Count The city of Fouke gets its water supply from a well screened i the Carrizo Sand. Elsewhere, development of the aquifer for wate supplies is negligible. A domestic well at Bluff City is the onl known well that taps the Carrizo Sand in Nevada County.

Well-performance data have been determined for the city we at Fouke. The well, which is pumped at the rate of 100 gpm, ha a specific capacity (yield per foot of drawdown) of about 3 gpr per ft. Static water level in the well is about 115 feet below lan surface. The permeability of the Carrizo Sand, determined i laboratory tests on samples collected from the outcrop, is abou 190 gpd per sq ft. This value compares favorably with the perme ability determined for the formation in Texas (Baker and others 1963).

Development of the Carrizo Sand has been limited becaus water supplies adequate for present needs generally are availabl from the overlying Cane River Formation. However, as require ments for water increase, the Carrizo Sand could supply larg quantities of water. Wells tapping the sand sections of the Carriz Sand and Cane River Formation probably could yield as much a 500 gpm.

Analyses of two water samples taken from wells in the Carriz Sand indicate that water in the formation is a soft sodium bicar bonate type, low in dissolved solids, and similar to water fror the overlying Cane River Formation. Concentration of iron in th water is zero at Fouke and 1.1 mg/l at Bluff City. The well a Bluff City taps the Carrizo Sand near its outcrop area. Here partial oxidation of iron-bearing minerals in the formation migh release significant amounts of iron to solution.

WILCOX GROUP

The Wilcox Group is the lowermost geologic unit of Tertiar age that contains fresh water. The unit crops out in a broad ban through northern Miller, southern Hempstead, and central Ne vada Counties (pl. 4). The Wilcox ranges in thickness from abou 200 to 450 feet in the subsurface and is composed of interbedde layers of sand, clay, and lignite. Sand beds comprise from 20 t 60 percent of the unit.

Fresh water is available from the Wilcox in the outcrop are and for a few miles downdip. Rosston is the only community i the area that uses water from the Wilcox for its water suppl (about 30,000 gpd). The formation is tapped elsewhere 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. 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 sq ft; whereas, the permeability of the Wilcox in Bossier Parish, La., is 90 gpd per sq ft (Page and May, 1964).

Measured and reported water levels in wells tapping the Wilcox range from at the land surface to about 125 feet below land surface; the greater depths are in areas of greater relief. The maximum depth to water (125 ft) was reported for the city well at Rosston. 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.

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.

About 0.22 mgd of water was pumped from the Wilcox in the area in 1965. This amount includes 0.14 mgd from wells in Miller County and 0.08 mgd from wells in Nevada County. Supplies sufficient for domestic use can be obtained from the Wilcox throughout the area where it contains fresh water.

AQUIFERS OF CRETACEOUS AGE

NACATOCH SAND

The Nacatoch Sand crops out as a wide, low ridge extending northeastward from the Little River valley to the Little Missouri River valley (pl. 2). In an area extending across Little River County, the Nacatoch Sand is covered by Quaternary alluvial and terrace deposits. 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. In southwestern Little River County, from the vicinity o Bull Creek westward, the formation is composed primarily o clay and is not considered to be a source of water supply. Th upper part of the formation is composed of sand and is the prin cipal water-bearing part of the Nacatoch. The sand percentage shown on plate 2 are given only for the upper sand section.

The general direction of ground-water movement in the Naca toch Sand is to the southeast (pl. 2). The pattern of flow is altere by pumpage of water from the formation at Hope, where wate levels in the Nacatoch Sand have declined from an altitude o 185 feet above mean sea level in 1942 to 145 feet in 1969.

The results of tests made in wells that tap the Nacatoch San at Hope and Prescott show a transmissivity of 3,600 gpd per f Yields of a few gallons per minute may be obtained from flowin wells in the Nacatoch Sand in the lower stream valleys in Nevad County. Wells tapping the formation in Hempstead County an in northwestern Nevada County can be expected to yield 150–30 gpm. Depths of the wells range from a few feet in the outcro area to about 700 feet near Hope and Prescott.

Diagrams of the chemical characteristics of water from th Nacatoch Sand are shown on plate 2. The water generally is sof or moderately hard. Near the outcrop area, calcium and bicar bonate are the principal constituents. Near the downdip limit o fresh water in the formation, the sodium and chloride conten increases with a corresponding increase in dissolved-solids con tent. The concentration of iron in the water generally is less tha 0.3 mg/l.

TOKIO FORMATION

The Tokio Formation yields water to wells in northern an central Hempstead County and in northern Nevada Count (pl. 3). Wells tapping the formation range in depth from a fe feet near the outcrop area in northern Hempstead County t about 1,200 feet at Hope and Prescott. Fresh water is also ob tained from the Tokio Formation in the vicinity of the town o Winthrop, in Little River County. Yields of as much as 300 gpr may be obtained from wells in the formation in Hempstea County. Wells flowing as much as 90 gpm may be obtained in th Little Missouri River valley, in northeastern Hempstead an northern Nevada Counties (Counts and others, 1955). Water lev els range from above the land surface in the area of flowing well to about 100 feet below the land surface at Hope. Plate 3 show the configuration of the potentiometric water surface in the Toki

Formation. Records indicate that water levels in the formation did not decline appreciably during 1950–68, and, as shown on plate 3, water levels have not been greatly affected by withdrawal of water at Hope and Prescott.

Chemical analyses of water from wells in the Tokio Formation show that the water is a soft or moderately hard sodium carbonate type. In some places, the iron content of the water is high, as much as 54 mg/l (Counts and others, 1955). However, the high iron content generally is not indicative of water from the formation but is the result of the mixing of water, in uncased holes, from the shaly formations above the Tokio. The temperature of the water from the Tokio is the highest of any water-supply source in the State and ranges from 17°C near the outcrop area to 37°C in the vicinity of Hope. The high temperature of the water near Hope precludes its use for cooling purposes.

The Tokio Formation is a source of water for domestic wells in the vicinity of Winthrop, in northwestern Little River County. Information obtained from drillers' logs indicates that a 15–20-foot section of fresh-water-bearing sand underlies the area at a depth of from 30 to 80 feet below the land surface. The wells yield less than 10 gpm, and static water levels in the wells range from 15 to 20 feet below land surface. South of Winthrop, the sand section is either absent or contains saline water (William Pender, driller, oral commun., 1969).

The southern extent of fresh water in the Tokio Formation extends through central Hempstead and northwestern Nevada Counties. Water from wells at Hope and Prescott contains more than 1,000 mg/l of dissolved solids. Water from the Tokio Formation in these cities is mixed with water from the overlying Nacatoch Sand; the dissolved-solids and chloride content is thereby reduced to an acceptable level.

SALT-WATER POLLUTION IN THE ALLUVIUM

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 30 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 T. 15 S., R. 26 W., and T. 16 S., Rs. 25 and 26 W. (fig. 4).

Drilling programs conducted by the Geological Survey and the Arkansas Geological Commission were undertaken to determine the source and extent of contamination in the area. About 40 test holes were drilled into the alluvium, and water samples were col-

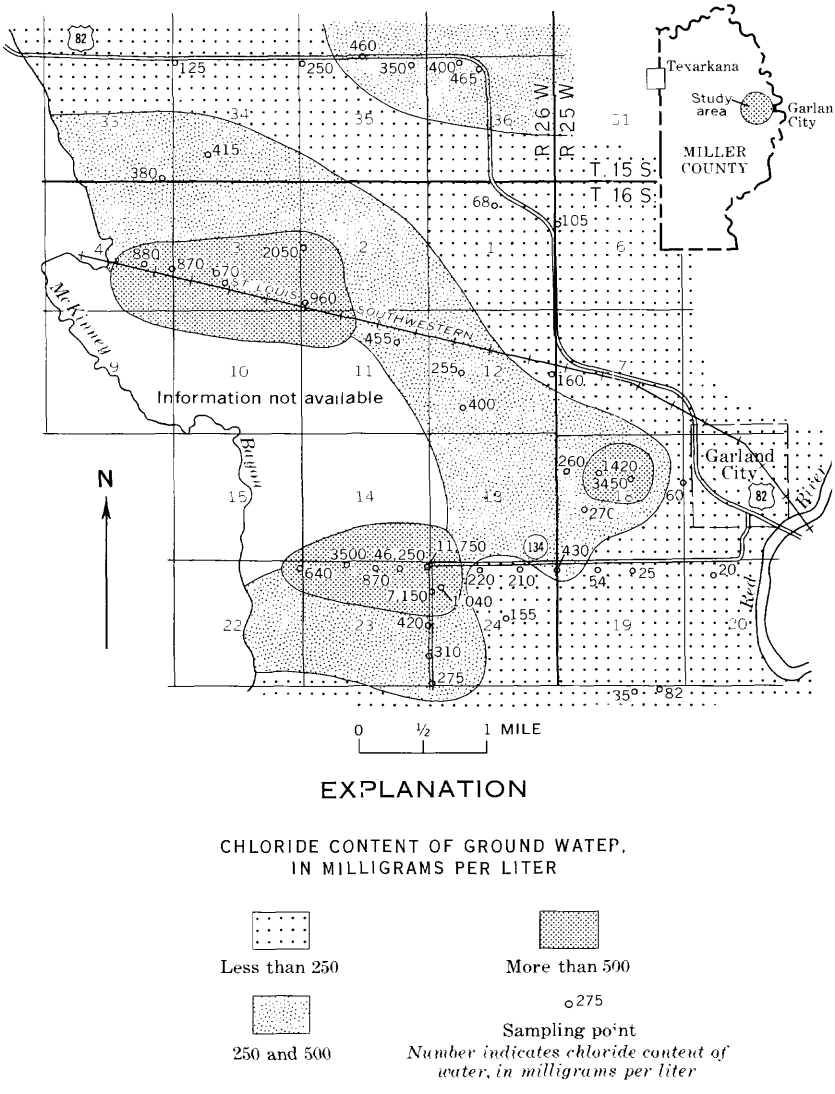

FIGURE 4.—Areas of chloride contamination in the alluvial aquifer, Miller County.

lected from each of the test holes and analyzed for chloride. Additional samples were collected throughout the suspected area from irrigation wells, brine pits, and from deep domestic wells. Field and laboratory chloride determinations were made by the Arkansas Pollution Control Commission, the Arkansas Geological Commission, and the Geological Survey.

Results of the sampling program show that the highly contaminated water (water containing more than 500 mg/l of chloride) is in three separate areas, each associated with existing or abandoned brine-disposal pits. The locations of the highly contaminated areas are shown in figure 4. 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.

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.

SURFACE-WATER RESOURCES

The largest source of surface water in the project area is the Red River, which has an average flow of 17,600 cfs (cubic feet per second) at Fulton. Reservoirs, such as Millwood Reservoir on Little River and Lake Erling on Bodcau Bayou, are also sources of large quantities of water. In addition, there are more than 5,500 lakes and farm ponds of 5 acres or less in the area. Tributary streams that drain the upland areas are not dependable sources of supply because they do not have well sustained flows during periods of drought.

An average of 48 inches of precipitation falls on the area during a year. Runoff ranges from 12.2 inches in southwest Miller County to about 16 inches along the northern part of the area.

Streams in the area generally are sluggish. Stream gradients range from less than 2 feet per mile in the Red River flood plain to about 6 feet per mile in the upper reaches of the tribut streams. There are many swampy areas along the Red Riv Little River, and Little Missouri River.

STREAMFLOW CHARACTERISTICS

The water-supply potential of a stream is determined by frequency with which streamflow recedes to minimal amou (frequency distribution of annual low flows) and the length time given flows are equaled or exceeded (duration of da flows). The length of time during which streamflow will minimal depends on the size of the drainage area, the type soil mantle, the length of time without rainfall, and whet there is any sustained base flow from ground water. Statisti analyses of flow data are necessary to determine the amount water available in a stream. A summary of flow analyses for tributary streams is presented in table 2. The values shown w determined by comparing the flow of streams within the area w concurrent flow at nearby regular gaging stations for which lo term data are available. The locations of the gaging stations shown on plate 5 and are numbered in downstream order, acco ing to the method used by the Geological Survey.

TABLE 2.—*Low-flow characteristics of tributary streams*

Station				Estimated flow (	
No.	Name	Period of record	Drainage area (sq mi)	7-day 2-year low flow	Flo excee 9(perce the t
3369	Walnut Bayou near Foreman	1958–63	83.6	0	
3402	West Flat Creek near Foreman	1962–63, 1965–66	10.6	0	
3407.5	Lick Creek near Wilton	1964–present	19.1	0	
3416.9	Bois d'Arc Creek near Hope	1964–present	36.0	1.3	
3423.7	Beech Creek near Fouke	1967–69	[1] 27	.1	
3443.1	Mill Creek near Fouke	1967–69	[1] 5	.5	
3486	Bayou Dorcheat near Buckner	1958–65	101	0	
3494.2	Whetton Branch near Bodcaw	1964–present	3.3	.3	
3494.3	Bodcau Creek at Stamps	1958–present	234	0	
3611.5	North Fork Ozan Creek above McCaskill	1967–69	[1] 18	.2	
3611.6	North Fork Ozan Creek near McCaskill	1964–present	72.3	.2	
3612	Ozan Creek near McCaskill	1961–present	148	0	
3612.1	Ozan Creek near Blevins	1967–69	[1] 161	.2	
3616.3	Terre Rouge Creek near Hope	1964–present	37.4	1.2	
3616.4	Little Terre Rouge Creek near Emmet	1964–present	38.0	.3	
3616.5	Terre Rouge Creek near Prescott	1958–64	231	.7	
3617	Caney Creek near Bluff City	1958–67	167	1.2	

[1] Estimated.

LOW-FLOW FREQUENCY

The minimum average flow for 7 consecutive days that is expected to occur once each 2 years is considered a good index of the stream's low-flow character. This streamflow characteristic is referred to as the 7-day 2-year low flow and is a measure of the stream's ability to meet a required need.

Many of the tributary streams in the area do not have significant flow for at least several consecutive days each year. Streams in Little River County (West Flat Creek, 3402; Lick Creek, 3407.5; and Walnut Bayou, 3369) have 7-day 2-year low flows of zero, an indication that considerable storage would be required on these streams if they were to be developed as sources of supply. Similarly, Bodcau Creek, at the station near Stamps (3494.3), and Bayou Dorcheat near Buckner (3486), recede to zero flow for several days each year. Upstream from the gaging stations, these streams are not incised deeply enough into the underlying geologic formations to intersect the water table.

Bois d'Arc Creek (3416.9) and Terre Rouge Creek (3616.5) have 7-day 2-year low flows of 1.3 and 0.7 cfs, respectively, at the gaging stations. Low flows in these streams are sustained by ground-water discharge from the Nacatoch Sand, which underlies the upper drainage basins of the streams. These streams are considered dependable sources of water to the extent of their low-flow values. Ozan Creek, which has a 7-day 2-year low flow of 0.2 cfs at the gaging station near Blevins (3612.1) and 0.2 cfs at the station near McCaskill (3611.6), is sustained by base flow from sands in the outcrop of the Tokio Formation, which underlies the upper basin, and by discharge from a large number of flowing wells which tap the Tokio Formation in the Little Missouri River flood plain. The 7-day 2-year low-flow value of zero at the gaging station on Ozan Creek near McCaskill (3612) is unexplained, but is probably due to diversion of water from the main stem of the stream. Flows in Mill Creek near Fouke (3443.1), Beech Creek near Fouke (3423.7), and Whetton Branch near Bodcaw (3494.2) are sustained by springs upstream from the gaging stations.

FLOW DURATION

Flow-duration data indicate the percentage of time that a given flow was equaled or exceeded and is another factor used for determining the suitability of a stream for water supply. Table 2 shows values of the 90-percent flow duration for low-flow partial-record stations in the area. The values listed are those that would be equaled or exceeded 90 percent of the time at the respect gaging stations.

Flow characteristics have also been determined for the I River, Little River, and Little Missouri River (table 3). ' period of record for the Red and Little Missouri Rivers coinci with the regulated period for the rivers. The flow of the Li River at Horatio is regulated to a lesser extent.

DRAFT STORAGE

The amount of storage required to provide selected rates draft of as much as 0.3 cfs per sq mi can be estimated from

TABLE 3.—*Frequency of low flows and duration of daily flows*

[Period of record: Red River at Index, 1944-66; Little River near Horatio, Oct. 1930-66; Little Missouri River near Murfreesboro, 1950-67]

Station No.	Station Name	Period (days)	Annual low flow (cfs) for indicat recurrence interval (years) 2	5	10	2
3370	Red River at Index	1	1,600	1,000	660	
		3	1,750	1,100	700	
		7	2,000	1,250	790	
		14	2,250	1,370	870	
		30	2,700	1,650	1,050	
		60	3,200	1,950	1,250	
3400	Little River near Horatio	1	25	6.0	2.7	
		3	27	6.4	2.8	
		7	29	6.8	2.9	
		14	34	7.6	3.3	
		30	52	10.5	4.1	
		60	88	17.5	6.9	
3610	Little Missouri River near Murfreesboro	1	14	8	5.6	
		3	18	10	6.8	
		7	25	12	8.7	
		14	36	15	10	
		30	65	24	16	
		60	120	60	42	
			Daily mean flow (cfs) which wa equaled or exceeded for indicated percentage of time 95	90	85	8
3370	Red River at Index	----	1,430	2,000	2,400	
3400	Little River near Horatio	----	19	48	88	
3610	Little Missouri River near Murfreesboro	----	21	37	59	

7-day 2-year low flow and the size of the drainage area in conjunction with regionalized draft-storage relation curves (fig. 5). Values of median 7-day 2-year low flow for gaging stations in the study area, along with the corresponding drainage areas, are given in table 2. For sites other than those noted in table 2, the median 7-day 2-year low flow must be determined by (1) making a series of discharge measurements and comparing them with concurrent discharges at stations for which long-term records are available or (2) assuming that the median 7-day 2-year low flow would be zero.

The storage-required frequency curves (fig. 5) show the frequency of needed storage to maintain selected draft rates. For example, suppose it is desired to determine the allowable draft rate from a reservoir at North Fork Ozan Creek above McCaskill (station 3611.5). The drainage area upstream from the gage is 18 sq mi and the 7-day 2-year low flow is 0.2 cfs, or 0.011 cfs per sq mi (0.2 cfs divided by 18 sq mi). A site has been found that would provide 900 acre-ft, or 50 acre-ft per sq mi (900 acre-ft divided by 18 sq mi), of storage. It is further assumed that a deficiency can be tolerated on the average of once in 20 years.

Referring to the graph for the 20-year recurrence interval in figure 5, a draft rate of 0.15 cfs per sq mi, or 2.7 cfs (0.15 cfs per sq mi multiplied by 18 sq mi), could be maintained. Allowance is not made in this analysis for evaporation, dead storage, or seepage. If a deficiency could be tolerated at more frequent intervals, a larger draft rate could be maintained for the same amount of storage. For example, a draft rate of 0.27 cfs per sq mi, or 4.86 cfs, could be developed, but the user should expect a deficiency of flow on the average at least once every other year (2-year recurrence interval).

Because the curves in figure 5 are not defined for a draft rate of more than 0.3 cfs per sq mi, the storage required for sites having higher draft requirements cannot be estimated this way. Draft rates greater than 0.3 cfs per sq mi can be estimated by using the procedure outlined by Patterson (1968).

Five of several potential reservoir sites in the area were chosen as examples where surface water could be used as alternate sources of supply or to supplement ground water. These representative reservoir sites are shown on plate 5, and pertinent information for each site is given in the following summary.

Reservoir site	Location	Drainage area (sq mi)	Average flow of stream at site (acre-ft per yr)	Pool elevation (feet above mean sea level)	Height of dam (feet)	Length of dam (feet)	Sto cap (ac
1	West Flat Creek near Foreman	10.6	9,400	400	50	4,700	[illegible]
				390	40	3,200	[illegible]
				380	30	2,600	[illegible]
2	Calton Creek near Foreman	9.0	8,000	400	35	3,200	[illegible]
				390	25	2,900	[illegible]
				380	15	2,200	
3	Gibson Creek	14.3	10,500	350	35	3,600	1[illegible]
				340	25	3,100	[illegible]
				330	15	2,700	[illegible]
4	Bridge Creek	29.4	25,700	280	35	4,000	1[illegible]
				270	25	3,400	[illegible]
				260	15	2,200	[illegible]
5	Terre Rouge Creek	32.9	29,000	320	45	5,200	1[illegible]
				310	35	4,700	1[illegible]
				300	25	3,900	

Alternate pool elevations are shown, along with the correspo ing storage capacities. These values can be used to determine size of a reservoir required for a given amount of storage for a specific draft rate.

The storage capacity at each of the sites exceeds the limits the storage-required curves shown in figure 5. At site 5, example, a reservoir whose pool elevation is 320 feet would h a storage capacity of 17,700 acre-ft, or approximately 540 acr per sq mi (17,700 acre-ft divided by 32.9 sq mi). However, al ance should be made for evaporation, dead storage, seepage, sediment accumulation. Other considerations might include rec tion and flood-control storage. Assume, for illustrative purpo that only 20 percent (108 acre-ft per sq mi) of the storage pacity is available for water supply and that the 7-day 2-y low flow at the site is zero. The allowable draft rate for a 20-y recurrence interval (fig. 5) would be 9.2 cfs (0.28 cfs per sq multiplied by 32.9 sq mi), or 2.9 mgd. By comparison, this amo is 2.4 times the quantity of water now used at Hope. (See sect on "Pumpage and Use of Water.")

FLOOD FREQUENCY

The magnitude of floods on the Red River main stem has b reduced considerably by the construction of Denison Dam other flood-control structures upstream. However, flooding occurs; the most notable flood was in 1945. Figure 6 shows water-surface profiles for the floods of 1945, 1953, and 1957 for the Red River from Index, Ark., to Shreveport, La. Most of the data for the profiles were provided by the U.S. Army Corps of Engineers, New Orleans District.

Floods on tributary streams, though generally not so spectacular as those on the Red River, pose a problem of local damage. Therefore, information pertaining to the magnitude and frequency of floods is essential to projects throughout the area that involve flood control or the design of structures in, across, or adjacent to streams.

A comprehensive analysis of flood-flow characteristics of streams in Arkansas has been made by the Geological Survey in cooperation with the Arkansas Geological Commission (Patterson, 1964). Figures 7–9, which are modified from the study by Patterson, show the magnitude and frequency of floods for streams in the study area. If the drainage area of the site in question is known, the information given in these figures can be used to estimate the magnitude of floods having a recurrence interval of 2.3, 5, 10, 25, and 50 years. To illustrate the use of the curves, assume that the probable discharge of the 10-year flood for the station on Bodcau Creek at Stamps (drainage area, 234 sq mi) is needed. From figure 7, the probable discharge for the stated condition would be approximately 8,000 cfs.

The recurrence interval does not imply any regularity of occurrence but is the probable average interval between floods of a given magnitude during a long period of time. Two 10-year-interval floods could conceivably occur in consecutive years, or even in the same year.

Regulation of the Red River by Lake Texoma has significantly altered the flow characteristics of the river below Denison Dam and has caused a reduction in peak flows for a given recurrence interval. Table 4 shows values of peak discharge and stage for recurrence intervals of 2, 10, 25, and 50 years on the Red River for the regulated period 1943–68. The values shown are an average of 60,000 cfs smaller in discharge and 3.9 feet lower in stage than the corresponding values for unregulated conditions prior to 1943. Comparing the data in table 4 to the flood profile of the Red River (fig. 6) shows that the stage of the 1945 flood exceeded by several feet the stage for a flood having a recurrence interval of 50 years.

LAKES AND RESERVOIRS

Lakes and reservoirs constitute a significant part of the wa resources of the study area. The principal reservoirs in and ne the area include Millwood Reservoir (maximum storage, 1,850,0 acre-ft), Lake Erling (49,000 acre-ft), and Whiteoak Lake (2,6

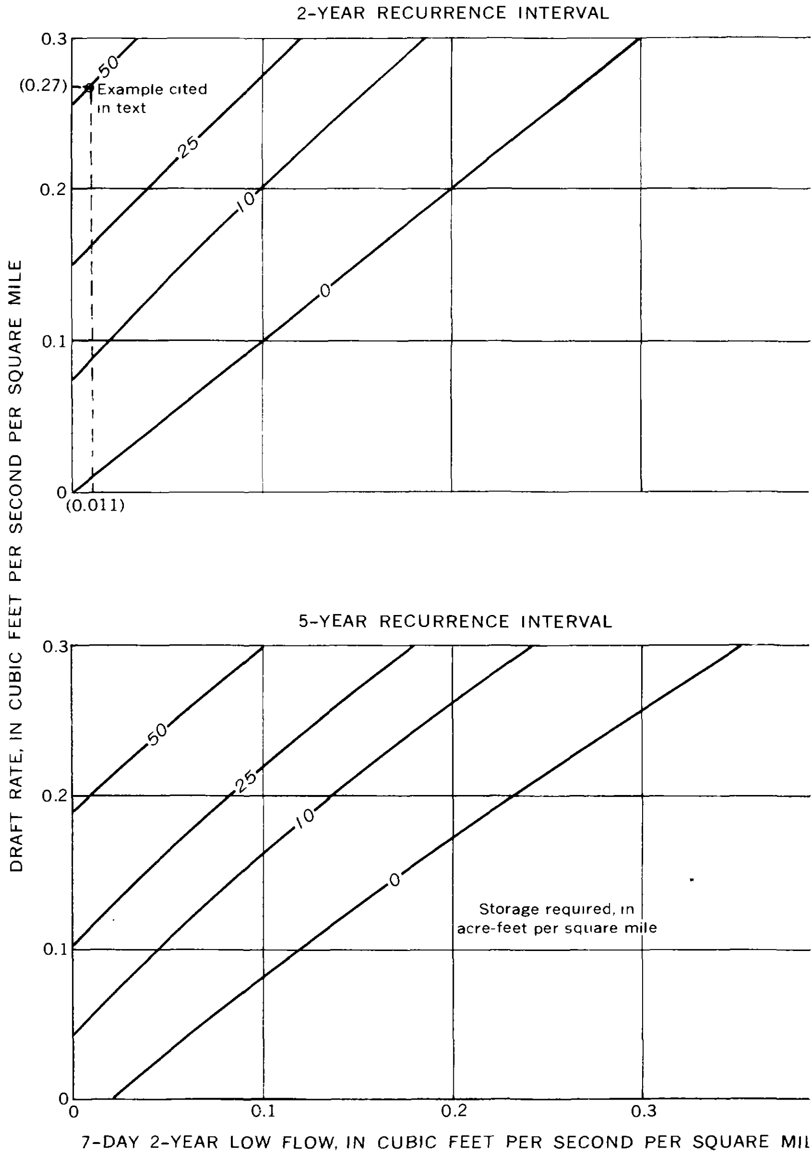

FIGURE 5.—Draft-storage relations for selected recurrence intervals.

acre-ft). Lake Texarkana (2,654,300 acre-ft), although outside the study area, is the source of municipal water supply for Texarkana.

There are 5,542 farm ponds of 5 acres or less in the area. These ponds generally are individually owned and are used primarily

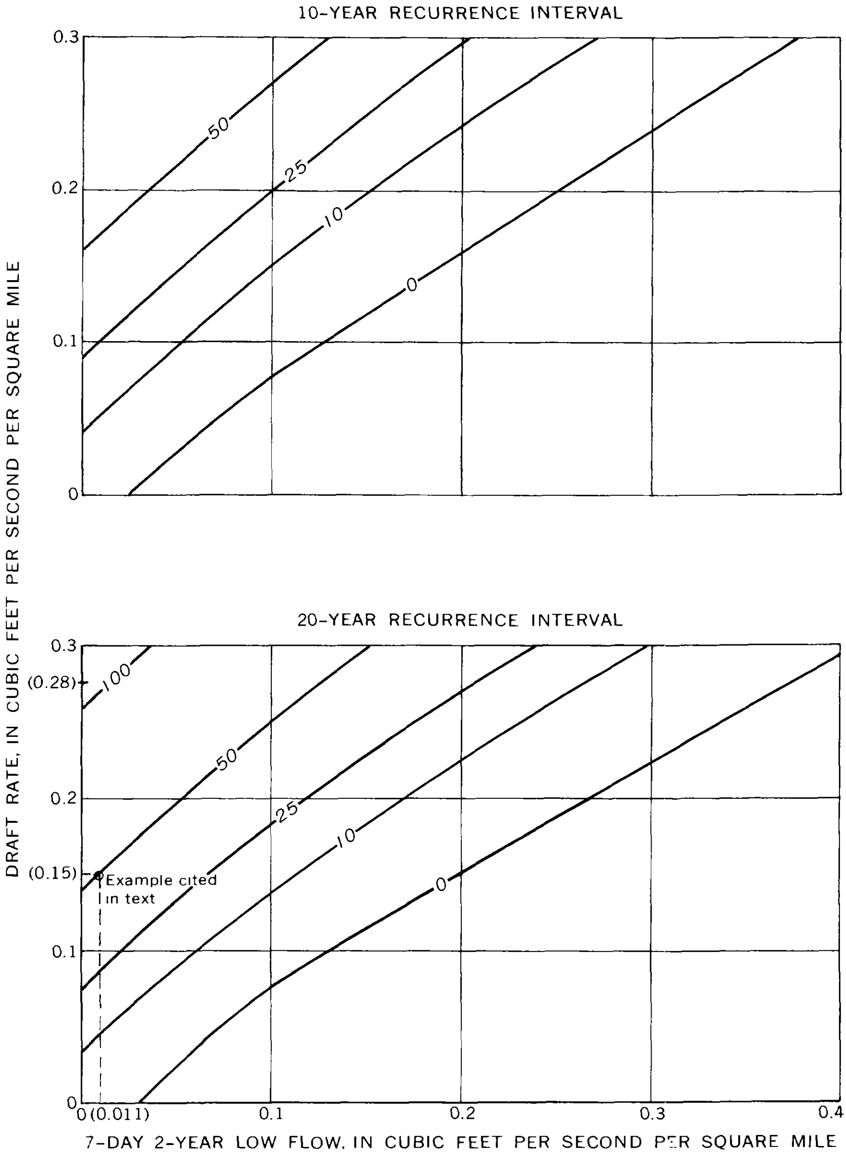

FIGURE 5.—Continued.

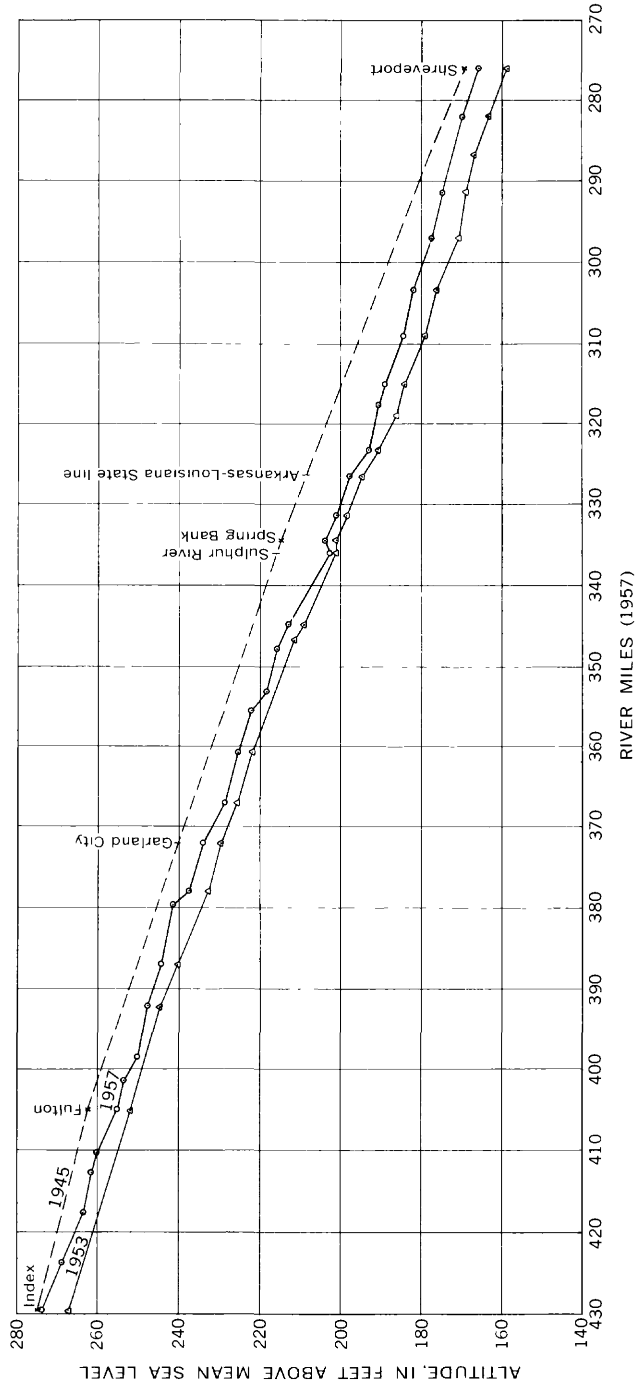

FIGURE 6.—Water-surface profiles for selected floods on the Red River, Index, Ark., to Shreveport, La.

TABLE 4.—*Flood frequency and stages of Red River at Index*

[Datum of gaging station on Red River at Index is 246.87 ft above mean sea level, datum of 1929; altitude of bankfull stage, 271.9 ft. Period of record, 1943–68]

Recurrence interval (years)	Peak discharge (cfs)	Stage (feet above mean sea level)
2	88,000	268.37
10	140,000	273.37
25	165,000	274.87
50	205,000	277.57

for watering stock. A small number are used as sources of water for irrigation. The ponds are distributed by counties as follows: Hempstead, 2,500; Lafayette, 306; Little River, 975; Miller, 600; and Nevada, 1,161. The ponds collectively occupy an area of 3,600 acres and have a combined storage capacity of 14,372 acre-ft (Arkansas Soil and Water Conservation Commission, 1968).

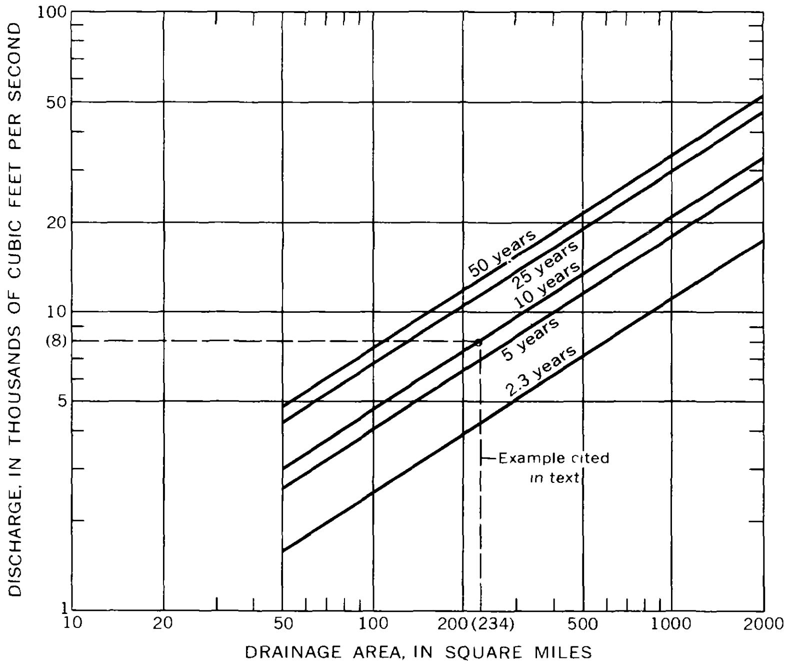

FIGURE 7.—Relation of peak discharge to drainage area for Bois d'Arc Creek, Bodcau Creek, and Bayou Dorcheat.

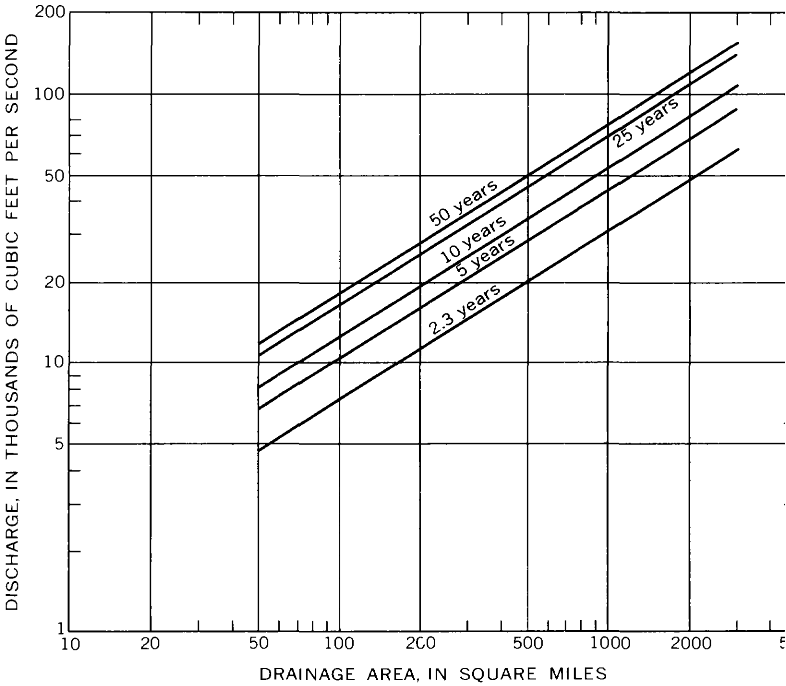

FIGURE 8.—Relation of peak discharge to drainage area for streams in L
River County and for Ozan Creek, Terre Rouge Creek, and Caney Cree

In addition to manmade structures, there are a large num of natural lakes that are remnants of the river channel in the fl plain of the Red River. There is a total of 63 such lakes al the Red River in Little River, Miller, and Lafayette Coun These lakes range in size from less than 10 acres to about acres. Average depths range from 2 feet to about 8 feet. The c bined storage capacity of the lakes is about 9,000 acre-ft. M of the lakes occupy closed drainage basins and receive runoff f only a small area surrounding the lake. As a result, lake le fluctuate primarily in response to local precipitation. Water le in many of the lakes can decline sharply, and many lakes bec marshy areas during droughts. Some of the larger lakes are c enough to intersect the water table and are sustained in par inflow from the ground-water reservoir. However, tests mad First Old River Lake and Keller Lake indicate that there is p ably only a slight connection between the lakes and allu aquifer. A comparison of water levels in an observation v about 200 feet from First Old River Lake, and stage reading the lake indicates that for extended periods of time the grou

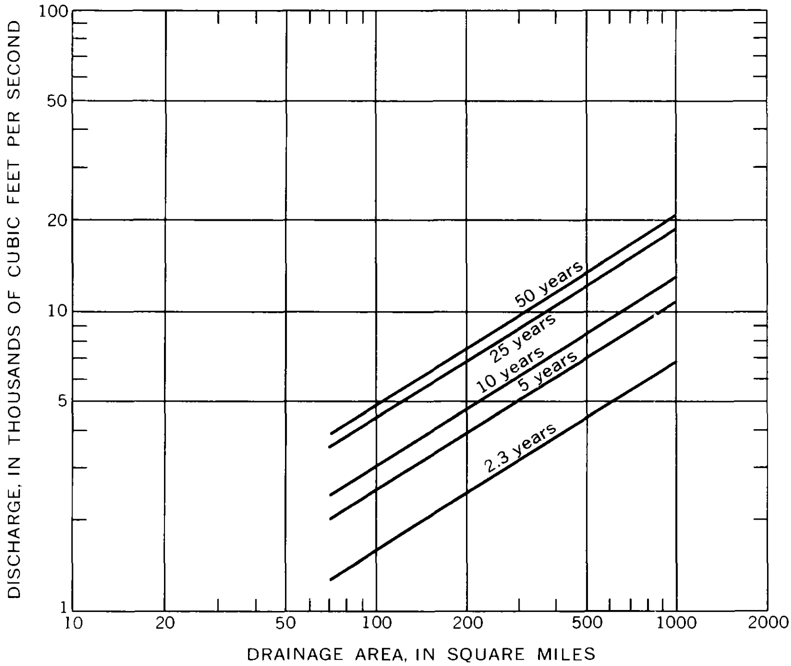

FIGURE 9.—Relation of peak discharge to drainage area for McKinney Bayou, Kelly Bayou, and Posten Bayou.

water levels near the lake and the lake level may differ as much as several feet. Movement of water to and from the lake is retarded by a layer of fine-grained organic material that blankets the lakebed.

QUALITY OF SURFACE WATER

CHEMICAL QUALITY

Chemical-quality data for Red River at Index during 1961–63, for Red River at Fulton during 1952–61, and for Red River near Hosston, La., during 1957–69, are given in U.S. Geological Survey water-supply papers, part 7. A tabulation of the maximum and minimum values for selected chemical constituents in water collected from Red River at Index, October 1960 to September 1963, is given in table 5. Information on the quality of water in tributary streams in the area is given in table 6. The locations of sampling sites are shown on plate 5.

The water in the Red River is high in degree of hardness and chloride and sulfate content and, unless it is extensively treated, it is chemically unsuitable for many uses, including irrigation.

During 1960–63, the average SAR (sodium-adsorption-ratio) water of the Red River during the growing season, May throu September, was 3.6. SAR values of less than 10 signify lit danger of developing harmful levels of exchangeable sodium in soil. The average specific conductance for the same period 1,220 micromhos. According to quality criteria established by U.S. Salinity Laboratory Staff (1954), water having a spec conductance of from 750 to 2,250 micromhos can be used c tinuously only on crops that have a high salinity tolerance. Ho ever, where the soil is well drained and sandy, water contain from 750 to 2,250 micromhos probably could be used for supp mental irrigation.

The annual sediment load of Red River at Index is 25 mill tons, or 520 tons per square mile of drainage area (U.S. Ar Corps of Engineers, New Orleans District, 1966, p. I–23). Th sediments, which are composed of about 25 percent sand and percent silt, are derived primarily from bank and bed erosion a secondarily from tributary streams.

Analyses of samples collected from tributary streams dur periods of low flow indicate that most of the water is of good excellent chemical quality. Except for iron, the concentrations mineral constituents are within acceptable limits for most uses

Water in Little River (station 3413.01, table 6 and pl. 5) a in Little Missouri River (3616) is a calcium bicarbonate ty low in dissolved solids and chloride, and similar in quality water from the geologic formations that underlie the respect drainage basins. Water in Ozan Creek (3612, 3612.1) is similar chemical characteristics to water in the Little Missouri River a to water from the underlying Tokio Formation. Water in W nut Bayou near Foreman (3369) is high in dissolved solids, ch ride, and sulfate. Formations of Cretaceous age, which unde

TABLE 5.—*Ranges of concentrations of selected chemical constituents in water of the Red River, 1960–63*

[Data in milligrams per liter except as indicated]

Constituent	Maximum	Minimum
Sulfate	275	24
Chloride	405	23
Hardness	445	86
Dissolved solids	1,260	157
Specific conductance micromhos at 25° C	2,080	151
pH	9.2	7.1
Temperature °C	30	0

the upper part of the basin, are probably the source of the mineralized water. The quality of water in Caney Creek (3616.7 and 3617) is affected by the addition of oil-field wastes. The high chloride content precludes the use of the water for municipal, industrial, or agricultural uses. Analyses of water samples collected from three cutoff lakes along the Red River indicate that the water is chemically similar to ground water from the alluvium but is more dilute.

PESTICIDES

Pesticides are used extensively in the area, particularly in the Red River Valley. Five sites were sampled to determine the residual amounts of pesticides in sediments in the area (pl. 5). The sampling sites were chosen on the basis of geographic location and land use—two in the Red River Valley and three in the uplands. Upstream from the sites on Posten Bayou and Walnut Bayou, the land is used primarily to produce rice, cotton, and soybeans. The drainage basins of Ozan, Terre Rouge, and Bodcau Creeks are in the hilly upland area, which is mostly forested, and are used for the production of cattle, poultry, and fruit. The samples, consisting of both water and streambed material, were analyzed at the U.S. Geological Survey Water Quality Laboratory in Washington, D.C. The results of the analyses are shown in tables 7 and 8.

Concentrations of pesticides did not exceed the permissible limits established for public-water supplies by the National Technical Advisory Committee to the Secretary of the Interior (1968). Insecticides were not found in the water samples. However, significant amounts of DDT and its degradation products, DDE and DDD, were found in sediment samples from Posten Bayou. The permissible limit for DDT is 42 μg/l (micrograms per liter). The only herbicide found was 0.07 μg/l of Silvex from the water sample taken from Posten Bayou. The established criteria permit 100 μg/l of herbicides.

PUMPAGE AND USE OF WATER

Approximately 18 mgd of water was used for all purposes in the study area in 1965. Of this amount, about 14 mgd (80 percent) was obtained from ground water, and the rest (4 mgd) was supplied from surface-water reservoirs. A summary of water use in the area is given in table 9. The data have been assembled by county, by principal use, and by source of water. The information shown in table 9 is adapted from a detailed report on water use

TABLE 6.—*Chemical quality of water in selected streams*

[Locations of sampling sites shown on pl. 5. Results in milligrams per liter except as indicated]

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25° C)	pH	Color	Dissolved oxygen: Oxygen (mg/l)	Dissolved oxygen: Percentage saturation
3369 Walnut Bayou near Foreman:																					
Sept. 23, 1960		6.5	0.0		124	30	145	5.2	336	167	210	0.5	0.6	913	433	158	1,480	6.9	5		
Aug. 16, 1962	0.10	9.8	.0		91	19	147	3.6	273	117	205	.1	.2	727	305	82	1,260	8.1	4		
3413.01 Little River below Millwood Dam:																					
Nov. 9, 1967	1,700	5.0	.11	0.1	4.7	1.0	4.0	1.8	22	3.6	4.1	.1	.3	42	16	0	58	7.1	19	10	92
Feb. 8, 1968	23,500	6.3	.04	.05	8.4	1.1	2.5	1.7	22	7.2	6.4	.0	.2	60	26	8	82	6.2	22	9.3	79
May 15, 1968	39,500	6.4	.03	.0	4.4	1.1	1.9	1.0	12	2.7	2.7	.0	.5	43	16	6	46	6.9	38	7.0	80
Aug. 20, 1968	155	6.6	.37	.51	9.7	1.5	5.1	1.8	39	2.9	8.1	.1	.2	64	30	0	92	7.2	10	7.0	91
3413.1 Hudson Creek near Red Bluff:																					
Aug. 27, 1968	[1] 1.5	7.0	1.4	.46	26	7.9	28	3.3	133	18	22	.2	.6	191	98	0	317	7.5	25	1.8	21
3421.4 Spirit Lake near Lewisville:																					
Aug. 28, 1968		8.6	.44	.28	36	6.3	15	6.5	125	2.7	29	.1	5.4	197	116	14	306	7.3	20	12	156
3423.4 First Old River Lake near Texarkana:																					
Aug. 28, 1968		5.4	.18	.0	21	5.2	2.0	4.6	89	3.1	3.0	.1	5.1	118	74	1	170	7.2	11	7.0	93
3423.6 Keller Lake near Garland City:																					
Aug. 28, 196[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

3443.1 Mill Creek near Fouke:																					
Aug. 27, 1968	1.0	22	1.0	.0	9.8	2.6	12	1.9	22	2.1	30	.1	1.2	113	35	17	140	7.1	17	5.4	61
3443.4 Sulphur River near Fort Lynn:																					
June 18, 1952		9.7	.51	-----	29	4.0	18	3.4	92	20	24	.5	1.5	170	89	13	260	6.9	45	-----	-----
3467.9 West Fork Kelly Bayou near Doddridge:																					
Aug. 27, 1968	[1] .5	16	4.0	.93	7.7	2.0	10	2.1	24	5.6	18	.1	1.9	113	28	8	198	6.8	78	7.6	92
3486 Bayou Dorcheat at Buckner:																					
Sept. 25, 1947		11	.12	-----	30	4.4	46	2.6	3.0	4.7	133	.1	.2	300	93	90	476	8.3	-----	-----	-----
Apr. 27, 1950					7.1	2.4	14	-----	9.0	4.0	32	------	1.6	111	28	20	126	6.1	54	-----	-----
3494.4 Bodcau Creek near Lewisville:																					
Aug. 29, 1968	[1] 2.5	7.5	2.6	.5	7.1	2.1	20	1.3	10	7.7	37	.1	1.0	138	26	18	160	6.3	94	4.8	54
3611.5 North Fork Ozan Creek above McCaskill:																					
Aug. 26, 1968	2.7	7.0	1.8	.24	5.4	1.0	4.0	2.4	10	4.2	6.4	.0	3.6	49	18	10	60	6.4	3	5.4	66
3612 Ozan Creek near McCaskill:																					
Sept. 8, 1960	.3	.7	.0	-----	17	.8	2.0	1.6	51	6.0	3.0	.0	.1	76	46	4	101	6.8	6	-----	-----
Aug. 15, 1962	.1	5.5	.01	-----	28	1.7	2.0	1.8	84	5.4	5.0	.2	.5	91	77	8	165	6.4	10	-----	-----
3612.1 Ozan Creek near Blevins:																					
Aug. 30, 1968	1.9	4.3	.85	.1	31	.4	3.1	19	93	6.5	3.5	.1	.2	112	79	3	177	7.4	12	7.0	82
3616 Little Missouri River near Boughton:																					
Nov. 2, 1965	39.4	4.8	.22	.0	4.3	1.3	4.0	1.0	20	3.0	3.2	.0	.0	28	16	0	46	7.3	17	9.3	-----
3616.1 Garland Creek near Boughton:																					
Aug. 29, 1968	.7	5.3	.42	.0	20	2.4	8.0	2.4	69	13	7.0	.2	.1	109	60	4	170	7.3	7	6.6	80
3616.7 Caney Creek near Rosston:																					
Aug. 29, 1968		11	.87	.20	127	34	1,710	11	161	34	2,800	.1	.2	4,910	465	333	8,370	7.5	26	7.3	84
3617 Caney Creek near Bluff City:																					
Sept. 8, 1960	.7	.0	.0	-----	58	16	580	9.5	30	18	1,040	.9	.7	2,000	210	186	3,400	6.5	7	-----	-----
Aug. 15, 1962	.3	2.9	.0	-----	69	19	561	12	2	14	1,050	.3	.4	1,730	250	249	3,350	5.4	4	-----	-----

[1] Estimated.

TABLE 7.—*Pesticide content of sediment samples from selected streams*

[Results in micrograms per liter. Not found: Aldrin, Dieldrin, Endrin, and Heptachlor]

Station No.	Stream	Date of collection	DDD	DDE	DDT	Lindane
3369.1	Walnut Bayou	10- 1-68	0.00	0.00	0.00	0.73
3443.6	Posten Bayou	10- 1-68	19.50	22.50	18.50	5.50
3612.1	Ozan Creek	10- 1-68	.39	.68	.00	.00
3616.5	Terre Rouge Creek	9-30-68	.00	.00	.00	.00

TABLE 8.—*Pesticide content of water samples from selected streams*

[Results in micrograms per liter. Not found: Aldrin, DDD, DDE, DDT, Dieldrin, Endrin, Heptachlor, and Lindane]

Station No.	Stream	Date of collection	Silvex
3369.1	Walnut Bayou	10- 1-68	0.00
3443.6	Posten Bayou	10- 1-68	.07
3494.3	Bodcau Creek	9-30-68	.00
3612.1	Ozan Creek	10- 1-68	.00
3616.5	Terre Rouge Creek	9-30-68	.00

in Arkansas, prepared by the Geological Survey in cooper with the Arkansas Geological Commission (Halberg and Steph 1966).

Public-supply-use figures for Miller County are shown only Texarkana, which obtains its water supply from Lake Texarka it is the only city in the study area that uses surface water municipal supply. An average of 7 mgd is withdrawn from lake for use in the Texarkana metropolitan area.

Rural use includes water pumped for both domestic and l stock. All the water derived from surface-water sources is livestock.

Most of the water used for irrigation is obtained from w nearly all of which are located in the Red River Valley. Of total amount of water used for irrigation in 1965 (6.89 mg about half (3.01 mgd) was used for the irrigation of rice. amount of water used for irrigation differs significantly f year to year, depending on the amount and frequency of rain In 1968, for example, water for irrigation was used almost clusively on rice.

TABLE 9.—*Pumpage and use of water, 1965*

[Data in millions of gallons per day]

County	Public		Rural		Irrigation		Industrial		County total		
	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Total
Hempstead	1.08	0.0	0.75	0.33	0	0.32	0.22	0.01	2.05	0.66	2.71
Lafayette	.36	0	.35	.18	3.87	.20	2.98	.17	7.56	.55	8.11
Little River	.31	0	.37	.23	.60	.08	.34	.0	1.62	.31	1.93
Miller	0	1.63	.64	.31	1.50	.28	.08	.11	2.22	2.33	4.55
Nevada	.32	0	.39	.16	0	.04	.0	.01	.71	.21	.92
Total	2.07	1.63	2.50	1.21	5.97	.92	3.62	.30	14.16	4.06	18.22

A total of 3.92 mgd of water was used for industrial purposes in 1965. The water was used for self-supplied businesses and for fish and poultry farms. Also included in this amount is 1.8 mgd of water used by a steam-electric generation plant near Stamps. Water for the plant is obtained from wells screened in the Cane River Formation.

Records of municipal pumpage for 1960, 1965, and 1969 are shown in table 10. Significant increases are noted in the pumpage since 1965. The increases are attributed largely to population growth, industrial development, and increased per capita water use. Pumpage at Texarkana increased during 1965–69 by 1.1 mgd, the 1969 rate being 70 percent more than the 1965 rate.

A papermill near Ashdown is the largest single user of water in the area. The mill, which went into production in 1968, has a design water-use capacity of 25 mgd. Water used by the mill is obtained from Millwood Reservoir.

TABLE 10.—*Record of municipal pumpage*

City	Pumpage (mgd) for indicated year		
	1960	1965	1969
Ashdown	0.20	0.23	0.35
Foreman	.05	.08	----------
Hope	1.2	1.03	1.2
Lewisville	.10	.10	.3
Prescott	.28	.27	.35
Stamps	.18	.19	----------
Texarkana	1.2	1.6	2.7

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